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A NEW SPECIES OF FRESHWATER SNAIL FOR THAILAND (PROSOBRANCHIA: BITHYNIIDAE)

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ABSTRACT. – A new species of Bithyniidae, *Gabbia erawanensis* Chitramvong & Upatham, is described from Erawan Waterfall, Kanchanaburi Province, Thailand. Characters of the reproductive system and alimentary canal relate this bithyniid snail to the genus *Gabbia* as it is currently understood in eastern Asia. *Gabbia erawanensis* is distinguished from other members of the genus *Gabbia* in Thailand by its smaller, more openly perforate shell with stronger spiral sculpture. Additional minor differences are found in its soft anatomy.

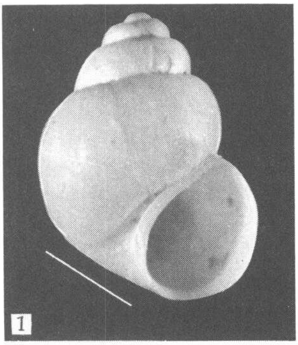
Key words: *Gabbia erawanensis* n. sp., conchology, anatomy, habitat.

Previous studies on the Bithyniidae of Thailand are those of Habe (1964) and Brandt (1968, 1974). In the latest study (Brandt, 1974), ten species of Bithyniidae were recognized for the country. These species were placed in the genera *Bithynia, Hydrobioides* and *Wattebledia*. The six species of *Bithynia* were placed into two subgenera, *Digoniostoma* and *Gabbia*, each with three species. The species in the subgenus *Gabbia* were *B.* (*G.*) *pygmaea* Preston, *B.* (*G.*) *walkeri* Brandt, and *B.* (*G.*) *wykoffi* Brandt, three species which were distinguished mainly by size: "larger than 7 : 4 mm" (*G. walkeri*); "average size 4.6 : 3.2 mm" (*G. wykoffi*); and "smaller than 3.6 : 2.6 mm" (*G. pygmaea*). We are now raising *Gabbia* to a full genus and adding a fourth species to the snail fauna of Thailand.

Methods. Measurements from which averages are given below were made on five males and five females of the new species. Shell measurements such as length, width, the degree of the spire angle, and the number of whorls follow Burch (1982, 1985), as does the terminology used. The internal organs were drawn at a magnification of 16x from live, anesthetized snails using a binocular stereoscopic microscope with a camera lucida. To determine sizes, the organs were measured from the camera lucida drawings. The terminology used in describing the organs of the genital system are adapted from Baker (1928), Lilly (1953), Fretter & Graham (1962) and Itagaki (1965).

Gabbia erawanensis, new species
(Figs. 1-8)

Diagnosis: A very small bithyniid snail (average shell length = 2.6 mm; shell length of holotype = 3.0 mm) possessing a perforate shell sculptured with fine but distinct transverse spiral lines, having an ovate, continuous peristome, rounded anteriorly ("basally"), and having a calcareous operculum with a large paucispiral nucleus.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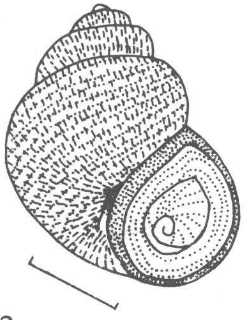
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FIG. 1. Shell of the holotype of *Gabbia erawanensis*, MUFS 0001, Erawan Waterfall, Kanchanaburi Province, Thailand. FIG. 2. Drawing of shell and operculum of *G. erawanensis*. Measurement lines = mm.

Types: Holotype (Fig. 1): MUFS (Mahidol University Faculty of Science) 0001, collected on 15 September 1983 by R. Chantanawat, V. Baidikul and E. S. Upatham. Paratypes: MUFS 3500; UMMZ 250672.

Type locality. Erawan Waterfall, 14°20' (latitude), 90°10' (longitude), Kanchanaburi Province, Thailand (Fig. 3). The snails were collected from the slow-moving stream just before the waterfall.

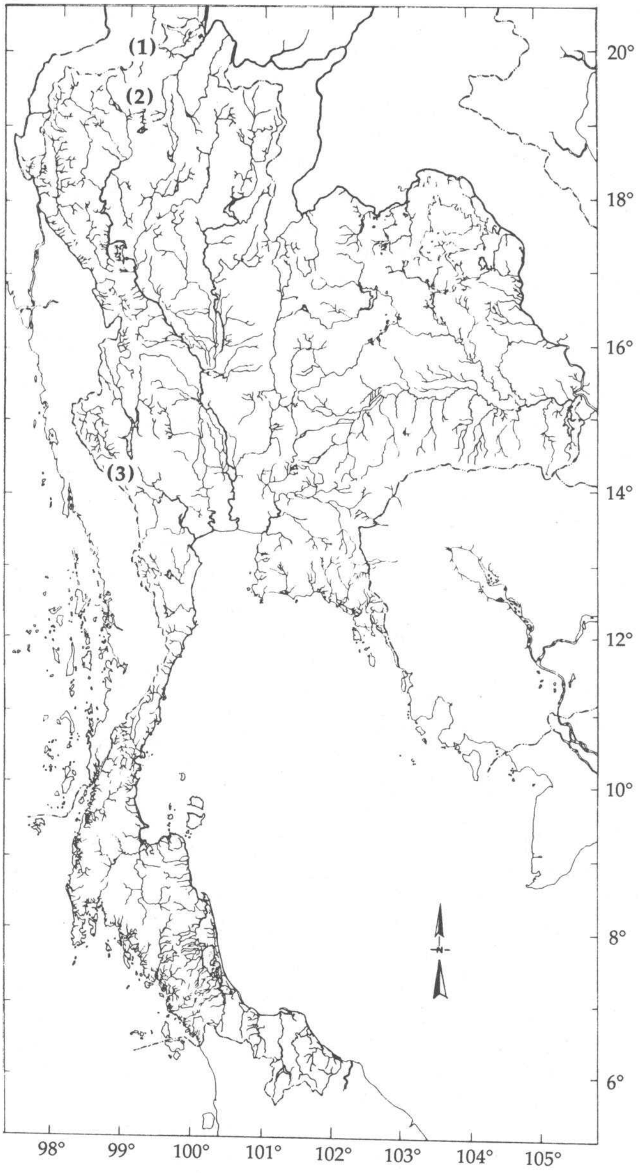


FIG. 3. Map of Thailand, showing (1) the locality of Erawan Waterfall, the type locality of *Gabbia erawanensis*, and the localities of comparative material of (2) *G. wykoffi* and (3) *G. pygmaea*.

Habitat: This species is thus far known only from the stream just before the Erawan Waterfall. It was found in a moderately deep pool on decaying leaves. This pool has many stones of various sizes as substrates, but most specimens were found on decaying leaves rather than on rocks.

Etymology: The species name *erawanensis* is from the name of the waterfall, Erawan, as yet the only known locality for the species.

Description: *Shell.* The holotype (Fig. 1) measures 3.00 mm (height) x 2.22 (width) mm and has 4 1/5 whorls. Two paratypes measure 2.78 x 2.12 and 2.76 x 1.98 mm, with 4 and 4^+ whorls, respectively. The average shell size of another five measured specimens with 3 3/4 to 4^+ whorls was 2.60 x 1.69 mm. The shell has an ovately (broadly) conic shape with an average spire angle of 62.56°. The whorls are well-rounded, and the sutures are indented. The shell is opaque, dull and solidly constructed. The color of the shell is grey. The surface sculpture consists of fine transverse growth lines and spiral lines. The apex of the shell is usually not eroded, but occasionally old shells are found with some erosion on their apices. The umbilicus is represented by a narrow perforation. The outer peristome is nearly straight to slightly sinuous. The anterior ("basal") lip of the aperture is rounded.

Operculum. The operculum is concentric with a very large, paucispiral, centrally placed nucleus (Fig. 2).

External Pigmentation. The melanin granules of various external soft parts are found as follows: they are dense all over the body, but the area around the mouth is devoid of melanin pigment; melanin is spread evenly over the tentacles; there is little or no melanin on the verge; melanin pigment is scattered over all of the flap (siphon); light grey melanin is along the anterior margin and both left and right anterior corners of the mantle. The rest of the mantle has dense black melanin mixed with some small white areas spread densely all over and with some moderately large white areas in between the melanin along the right side and at the posterior part; the foot is light grey all over, but is a little darker grey at the anterior margin of the ventral part of the foot.

The yellow pigment granules of various external soft parts are as follows: there is no yellow pigment at all on the head; yellow pigment occurs densely only at the bases of the tentacles; yellow pigment is scattered over all of the flap, but is dense at the base of the flap; and yellow pigment is scattered at the midportion of the ventral part of the foot.

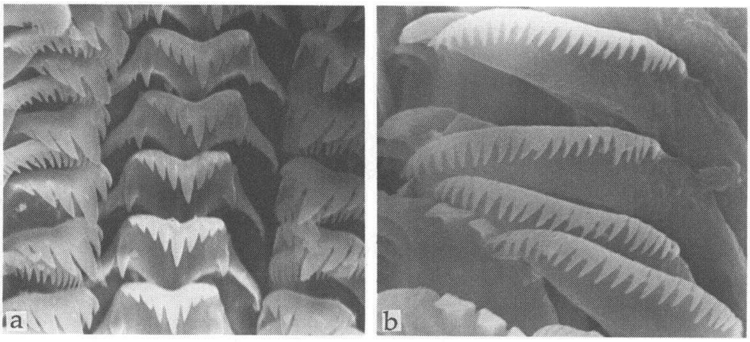
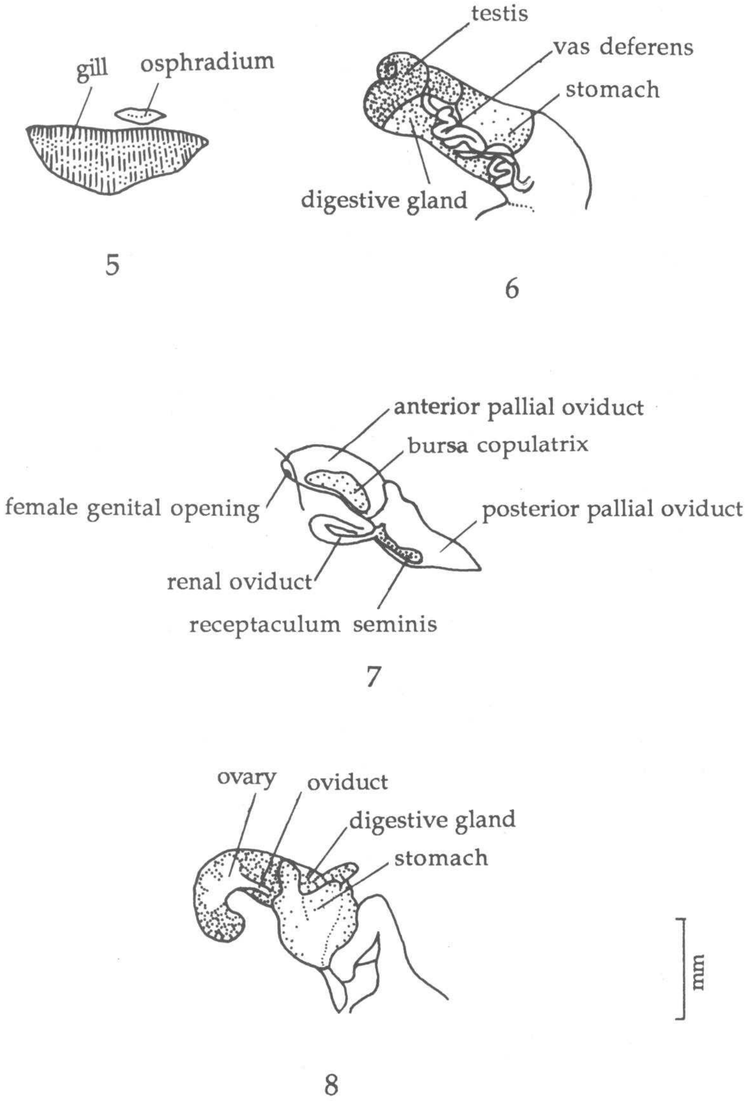


FIG. 4. Scanning Electron Micrographs of radular teeth of *Gabbia erawanensis*. **a**, central, lateral and marginal teeth, x672; **b**, inner marginal teeth, x1120.

Radula. Scanning Electron Microscope photographs of radular teeth are shown in Fig. 4. Characteristics of the central tooth are as follows: the basal mesocone of the anterior cusps is about twice as wide as that of the ectocones; the anterior cusp formula is 5-1-5 (usually) or 4-1-4 or 8-1-8; and the basal cusp formula is usually 3-3. The lateral tooth formula is 3-1-3 (usually) or 4-1-3. The number of cusps of the inner and outer marginal teeth are, respectively, 23 (usually) or 25, and 16 (usually) or 18.

Anatomy. The osphradium is broadly fusiform in shape. Its position is at the posterior part of the gill (Fig. 5). The average length in mm of the osphradium was 0.90. The average length of the gill was 1.85 mm. The average number of gill filaments was 39.

The testis (Fig. 6), orange in color, takes up all of the apical whorl, and, of the next several whorls, all of the dorsal part, all of the right and half of the upper left part. The testis ends in front of the stomach. The average length of the testis was 2.15 mm. Its vas deferens is located only beneath the ventral part of the stomach, which also is in the ventral spire whorls. The verge, like that of other bithyniid snails, is bifid, having an accessory gland duct going into one branch and a penial duct (a continuation of the vas deferens) going into the other branch (the penis). The average lengths in mm of the various male reproductive organs were as follows: vas deferens, 5.84; renal vas deferens, 0.77; pallial vas deferens, 0.64; prostate gland, 0.78; penis, 2.03; penial duct, 3.00; accessory gland, 0.53; and duct of the accessory gland, 8.19.



FIGS. 5-8. Anatomical structures of *Gabbia erawanensis*. FIG. 5. Gill and osphradium. FIG. 6. Testis and vas deferens, *in situ*. FIG. 7. Ventral view of female organs in the mantle cavity. FIG. 8. Ovary, *in situ*.

The light yellow ovary (Fig. 8), which has many lobes, starts enveloping the digestive gland at the second coil and extends to the posterior end of the third coil of the spire whorls, which is in front of the stomach. The point of entry of the renal oviduct into the pallial oviduct is at the anterior end of the posterior pallial oviduct (Fig. 7). The average lengths in mm of female reproductive structures were as follows: ovary, 0.15; oviduct, 1.26; renal oviduct, 1.58; and pallial oviduct, 1.98. The receptaculum seminis, which is a well-developed knob-like structure, is on the ventral pallial oviduct and has an average length of 0.53 mm. The spermatheca or bursa copulatrix extends ventrally from the anterior end of the anterior pallial oviduct for almost the entire length of the anterior pallial oviduct. Its average length is 0.68 mm. The genital aperture is terminal and is on the latero-ventral side of the muscular oviduct.

Comparisons: The shell of *Gabbia erawanensis* differs from *G. walkeri* and *G. wykoffi* by its smaller size. *Gabbia walkeri* is especially larger, and Brandt (1974) doubted if it really belonged to *Gabbia*. *Gabbia erawanensis* (shell length of holotype = 3.00 mm; average size of five other species = 2.65 mm) is in the same size range as *G. pygmaea* (shell length = 2.6 - 3.5, Brandt, 1974; average of five specimens in this study = 2.38 mm). However, the shell of *G. erawanensis* is perforate, gray in color, and has stronger spiral sculpture than does *G. pygmaea*. The shell of *G. pygmaea* is imperforate, straw colored, and has very weak spiral sculpture.

Other differences between *Gabbia erawanensis* and *G. pygmaea* are in some aspects of body pigmentation, radular teeth, ovarian lobes, shape of the receptaculum seminis and position of the female genital aperture. In contrast to *G. pygmaea*, the head of *G. erawanensis* is more densely pigmented, the melanin pigment is more evenly spread over the tentacles, the verge has little or no melanin pigment, the flap is pigmented, the dorsum and ventrum of the foot has yellow pigment and more melanin pigment, the central radular tooth has wider basal mesocones and more (5-8, rather than 3) anterior cusps on each side of the central cusp, the ovary has many (rather than few) lobes, the shape of the receptaculum seminis is knob-like, rather than long and broad, and the female genital aperture is terminal rather than subterminal.

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LITERATURE CITED

BAKER, Frank Collins. 1928. The fresh water Mollusca of Wisconsin. *Wisconsin Geological and Natural History Survey, Bulletin* 70, Pt. 1, pp. i-xx, 1-507, pls. 1-28. (pp. 31-89).

BRANDT, Rolf A.M. 1968. Descriptions of new non-marine mollusks from Asia. *Archiv für Molluskenkunde,* 98: 213-289, pls. 8-10.

BRANDT, Rolf A.M. 1974. The non-marine aquatic Mollusca of Thailand. *Archiv für Molluskenkunde,* 105: 1-423, pls. 1-30.

BURCH, J. B. 1982. *Freshwater snails (Mollusca: Gastropoda) of North America.* Environmental Monitoring and support Laboratory, Office of Research and Development, United States Environmental Protection Agency, Cincinnati, Ohio, EPA-600/3-82-026, pp. i-vi, 1-294.

BURCH, J. B. 1985. Malacology. Pp. 123-128. In: Burch, J.B. (Ed.), *Handbook on schistosomiasis and other snail-mediated diseases in Jordan.* The University of Michigan, Ann Arbor. Pp. i-xvi, 1-224.

FRETTER, Vera & GRAHAM, Alastair. 1962. *British prosobranch molluscs.* Ray Society, London. Pp. 1-755.

HABE, Tadashige. 1964. Freshwater molluscan fauna of Thailand. Pp. 45-66. In: Kira, T. & Umesao, T. (Eds.), *Nature and life in Southeast Asia.* Vol. 3, Fauna and Flora Research Society, Kyoto, Japan, Pp. 1-466.

ITAGAKI, Hiroshi. 1965. Anatomy of *Parafossarulus manchouricus* Bourguignat (Bithyniidae). *Venus,* 24: 169-180.

LILLY, M. M. 1953. The mode of life and the structure and functioning of the reproductive ducts of *Bithynia tentaculata* (L.). *Proceedings of the Malacological Society of London,* 30: 87-111.

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CULTURE AND MAINTENANCE OF BITHYNIIDAE (PROSOBRANCHIA: MESOGASTROPODA)

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ABSTRACT. - For culturing and maintaining bithyniid snails, attention was paid to providing proper containers, substrates, water, light, temperature and food. Adults of the larger species were fed a mixture of powdered dried rice, powdered dried leaves, powdered milk, vitamins, $CaCO_3$ and agar. This was supplemented with cultured diatoms. An alternative food was commercial fishfood flakes. The smaller species were fed diatoms only. Hatchlings and baby snails of all species were fed powdered green leaves with or without diatoms.

Key words: Bithyniidae, laboratory culture, food, diatoms.

In Thailand, some snail species of the family Bithyniidae are the intermediate hosts of *Opisthorchis viverrini* (Poirier), which causes opisthorchiasis (liverfluke disease) in humans. In studying the parasite and its transmission, it is advantageous to maintain and culture its snail intermediate hosts in the laboratory. This paper describes successful methods for the maintenance and culture of the various bithyniid snails of Thailand, and augments the methods already described by Chung (1984) for successfully culturing two Korean bithyniid species and the European/American *Bithynia tentaculata* (Linnaeus).

Snail Culture

Containers

Round white plastic bowls (22 cm in diameter and 9 cm in height) or square plastic trays (30 x 20 x 7.5 cm) were employed as aquaria for cultivating the snails. Small, round plastic bowls (12 cm in diameter and 6.50 cm in height) were used for the cultivation of egg masses and newly hatched snails. Plastic bowls were used as aquaria because they were easy to handle and economical.

Environmental Parameters

Water

In Bangkok, tap water was maintained in a large ceramic jar (approximately 70 gallons in volume) and was aerated for 3-4 days for dechlorination. The pH of the dechlorinated tap water was 6.9-7.2. In Ann Arbor, tap water was conditioned in a square plastic container (approximately 50 gallons in volume). To adjust the pH and to remove chlorine, 0.50 ml of N HCL solution and 0.50 ml of 5% sodium thiosulfate solution were added into each gallon of water. This water was then aerated for one week prior to use. Following this treatment, the pH of the conditioned water was 6.5-7.0.

Light

A 40-watt cool, white fluorescent tube was attached 25 cm above the aquaria. The aquaria were exposed alternately to 12 hours of artificial light and 12 hours of darkness.

Aeration

Air, either from small air pumps or from a centrally located air compressor, travelled through sub-branching air hoses to the aquaria. Each final branch went into a single aquarium. and had This terminal branch had a cramp somewhere along its length to control the amount of air travelling through the tube and an air stone at its end to more finely disperse the air being released into the water. For effective aeration, the quality of the air bubbles issuing from the air stone should be checked everyday and the air stones cleaned once a week.

Temperature

The room temperature and water temperature in the culture room was maintained from 25° C to 28° C and was controlled by an air-conditioner in the summer and rainy seasons in Thailand or by the heater in winter in Ann Arbor. Thermometers were attached to the wall and put into the control aquaria (which were just like the experimental aquaria, but lacked the snails). Water and room temperatures were checked every day.

Food

The special food formula used to feed the adult bithyniid snails (except *Bithynia tentaculata, Wattebledia baschi* Brandt and *Gabbia erawanensis* Chitramvong & Upatham) is given in Table 1. This food was always prepared fresh and fed to the snails once or twice a week. Half of a spatula was added each time to each aquarium. Also, a concentrated solution of cultured diatoms (*Achnanthes exigua* Grunom) was used as a food supplement. Five ml of the concentrated diatom solution was inoculated in each aquarium once a week.

TABLE 1. Ingredients and composition of synthetic food* used for bithyniid snails.

Ingredients	Composition
Powdered rice	21.0 g
Powdered dried leaves of *Leucaena glaura* (Leguminosae)	21.0 g
Powdered milk	7.0 g
Multivitamin complex	3.0 g
$CaCO_3$ powder	1.0 g
Agar	0.1 g
Distilled water	400.0 ml

* See Sumethanurugkul (1970).

For the smallest snails (*Gabbia wykoffi* Brandt, *G. pygmaea* Preston, *G. erawanensis* and *W. baschi*) only diatoms were used for food. For these small snails, 5 ml of the concentrated diatom solution were inoculated into each aquarium twice a week. *Wattebledia baschi* was fed additionally with decaying leaves from its habitat. Young *Bithynia tentaculata* were fed with powdered green leaves (commercial Ceralife) twice a week. Adult *B. tentaculata* were fed commercially prepared fishfood flakes (Tetra SML®) once a week. Ingredients and composition of Tetra SML were shown in Table 2. An excess of food in the aquaria was avoided because it caused a fungus bloom, which made conditions unfavorable for the snails.

TABLE 2. Ingredients and composition of the tropical fish food Tetra SML®*

Ingredients		Composition	
Fish meal	Plankton	Crude Protein	46%
Oat gruel	Cyclops	Crude fat	5%
Roe	Agar agar	Crude fiber	8%
Shrimp meat	Wheatgerm oil		
Salmon eggs	Cod-liver oil		
Fishliver meal	Carotene		
Squid	Fishbone lime		

*Tetra Company, D 452 Melle, Federal Republic of Germany.

Ceralife® powder together with diatoms, or Ceralife alone, was used to feed baby snails. A very small amount of Ceralife powder was given to the baby snails once a week. However, 2 ml or more of the concentrated diatom solution was also given to the young snails once a week as a food supplement when they began growing larger.

To protect from unwanted periphyton and associated small invertebrates that might inhibit the growth and fecundity of the snails, natural food sources, e.g., periphyton growing on rock substrates, was avoided.

Substrates

Mud substrates collected from each snail habitat were used as the laboratory substrates for culturing *Bithynia funiculata* Walker, *Hydrobioides nassa* (Theobald), *Gabbia wykoffi* and *Wattebledia crosseana* (Wattebled). The mud from each location was well mixed with dechlorinated tap water. Then, it was spread and pressed on the bottom of the aquarium in order to make a mud slope of 4-5 cm in height. The aquaria were 2/3 filled with dechlorinated tap water. In addition, two or three pieces of small stream rocks that were sterilized by heat at 160° C for 6 hours were also provided as substrates in each aquarium. The prepared aquaria were moderately aerated (using air stones and pumping air through plastic tubes, also see "aeration") for one week. If the water was clear and there were no arthropods (*e.g.*, ostracods), or unwanted periphyton growing, then the aquaria were ready to used for rearing and maintaining snails. If there was a lot of scrum on the water surface, unwanted periphyton or invertebrates present, the aquaria were not used. In the contaminated aquaria, the mud collected from each location was removed and put into aluminum trays. Each tray was then covered with aluminum foil and heated in a hot air oven at 100° C to 120° C for at least 24 hours. The cooled mud was then prepared as the artificial substrate as mentioned above.

The silt substrates that were collected from the habitats of *Bithynia tentaculata* and *Wattebledia baschi* were brought back to the laboratory and used as artificial substrates for culturing these particular snails in the laboratory. For making artificial substrates for culturing *B. tentaculata,* the silt was mixed with conditioned and aged tap water and a small slope 2-3 cm high was spread in the bottom of a square green tray. For *W. baschi,* a silt slope 4-5 cm in height was spread in the bottom of each of the aquaria. Also, decaying leaves collected from these two snails' natural habitats were put into the aquarium and used as substrates and food sources.

Two or three pieces of small stream rocks that had been heated at 160° C for six hours were provided as the substrate in each aquarium of *Bithynia siamensis goniomphalos* Morelet, *B. siamensis siamensis* Lea, *Wattebledia siamensis* Moellendorff, *Gabbia pygmaea* and *G. erawanensis.* Also, the algae that were collected from the natural habitat of each species of snail were rinsed well 3-4 times with dechlorinated tap water and the aquatic insects, other snails and snail eggs were removed from the algae and four stalks of algae per aquarium were also used as the artificial substrate for *B. siamensis goniomphalos, B. siamensis siamensis* and *W. siamensis.* Moreover, a moderate amount of clean decaying leaves (the leaves were devoid of organisms and were rinsed well several times with dechlorinated tap water) that were collected from the snails' habitat, together with two or three pieces of small stream rocks were put in each aquarium of *G. erawanensis.* For the aquarium of *G. pygmaea,* the clean accessory roots that were collected from the natural habitat of the snails were rinse several times with dechlorinated tap water in order to get rid of unwanted aquatic organisms and then used as the artificial substrate.

Snail Maintenance

The number of snails per aquarium depended on the size of the snails: 10 males and 10 females of each species for the medium sized snails (average shell lengths 10.29 - 12.45 mm) such as *Bithynia tentaculata, Hydrobioides nassa, B. siamensis goniomphalos* and *B. funiculata;* 15 males and 15 females of each species for the small snails (the average shell lengths from 2.70 - 8.46 mm) such as *Gabbia wykoffi, Wattebledia siamensis, W. crosseana* and and *B. siamensis siamensis;* and 20 males and 20 females of each species for the small snails (average shell lengths 2.70 mm) such as *G. erawanensis* and the minute snails (average shell lengths from 1.89 to 2.34 mm) such as *G. pygmaea* and *W. baschi.*

Eggs

After the snails had laid eggs in the aquaria, egg masses were gently scraped from the aquarium walls or the small rock substrates with an artist's brush and placed into the small, white and round plastic bowls (6.5 cm in height and 12 cm in diameter) containing dechlorinated tap water. The egg masses were continuously and moderately aerated until the baby snails hatched. The egg masses were maintained under constant fluorescent illumination on a shelve unit that had the same arrangement as that of the adult snails. The temperature was maintained between 25° C to 28° C until the baby snails hatched.

Sexing Snails

The Bithyniidae are monosexual, *i.e.*, each species has separate males and females (they are not hermaphroditic as are all of the Opisthobranchia and the Pulmonata). In many types of research it is necessary to know the sex of the experimental snails. The sexes of bithyniid snails may be determined as follows. The apexes of the snails' shells are struck (with the right side of the snails up) into plasticene or modelling clay placed around the margin of a petri dish filled with dechlorinated water. Then, when the head-foot of the snail protrudes from the shell during the snail's attempt to right itself, the presence or absence of the relatively large verge (male intromittent organ) can be seen clearly. Males and females can then be marked appropriately.

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LITERATURE CITED

CHITRAMVONG, Yaowaluk & UPATHAM, E.S. A new species of freshwater snail (Mesogastropoda: Bithyniidae) for Thailand. *Walkerana*, 3(10): 179-186.

CHUNG, Pyung-Rim. 1984. A comparative study of three species of Bithyniidae (Mollusca: Prosobranchia): *Parafossarulus manchouricus, Gabbia misella* and *Bithynia tentaculata*. *Malacological Review*, 17(1/2): 1-66.

SUMETHANURUGKUL, P. 1970. *Studies on physical effects on snail intermediate hosts of a liver fluke* (Opisthorchis viverrini). M. Sc. Thesis, Mahidol University, Bangkok, Thailand. Pp. 1-28.

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ON THE RADULAE OF THREE SPECIES OF NEOTROPICAL *POMACEA* (MOLLUSCA: MESOGASTROPODA: PILIDAE)

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ABSTRACT. The characteristics of the radula of three species of *Pomacea* from Buenos Aires were studied by means of light microscopy and by a scanning electron microscope. Traits used to distinguish among the species are: (1) the form of the silhouette of the mesocone; (2) the crests of the central tooth; (3) the proximal process of the lateral tooth; (4) the extension of the embedded part of the proximal marginal tooth. The functioning of the taenioglossate radula is discussed.

Key words: Radula; *Pomacea canaliculata, P. insularum, P. scalaris*; morphology, function.

INTRODUCTION

In the vicinity of Buenos Aires, there are three species of *Pomacea* Perry 1810: *P. canaliculata* (Lamarck 1801), *P. insularum* (d'Orbigny 1835), and *P. scalaris* (d'Orbigny 1835).

The characteristics of the radula (*e.g.*, the arrangement, number and shape of the teeth) are often useful for identification of species (*e.g.*, see Runham, 1975). With this in mind, we were interested in determining if the three local species of *Pomacea* could be distinguished on the basis of the shapes of their radular teeth.

In light microscopy, an "*in toto*" mount of the radula gives only a general idea of its structures. The scanning electron microscope (SEM) detects morphological details which are useful for fine identifications and for interpretation of the radular function. In the radula of *Pomacea canaliculata,* structures connected with the central and lateral teeth were observed by SEM in a previous study (Moretto & Nahabedian, 1983). It was found that a projection or proximal process from the lateral tooth functions in concert with a structure of the posterior corner of the corresponding central tooth. Together, they form a hinge which works as a stop, facilitating the

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scraping and the raking of food. When the odontophore is still, this process from the lateral tooth also fixes the angles of the walls of the radular groove.

In the present paper, we present a comparative study of the tooth structure of *Pomacea canaliculata* in relation with the radulae of other *Pomacea* from Buenos Aires. The goal of this investigation was to assess the usefulness of these structures for taxonomic purposes and to analyse the function of the taenioglossate radula in general.

MATERIALS AND METHODS

The radulae of 58 specimens of *Pomacea canaliculata*, 75 specimens of *P. insularum* and 42 specimens of *P. scalaris* were studied. All of the radulae came from individuals maintained or reared in the laboratory. The radulae of *P. canaliculata* were from second generation specimens whose progenitors were collected in the "El Vivero" pond of Bosque de Palermo (Buenos Aires). The radulae of *P. insularum* were from first generation specimens hatched from egg capsules collected in the Delta de Paraná de las Palmas (Escobar, Provincia de Buenos Aires). The specimens of *P. scalaris* were from offspring of snails collected in the "El Vivero" pond of Bosque de Palermo (Buenos Aires).

The radulae were placed in 19% KOH solution for 1 hour and then in 1% acetic acid solution. Then they were cleaned with 0.5% detergent solution. Some were prepared for light microscopy and others for SEM (JEOL model JSM-35CF).

Light microscopy observations were made on "in toto" preparations of the radulae; some radulae were unstained and others were stained with the techniques of: (1) Bowell (Hoffmann's violet); (2) Eckert (picrocarmin-aniline blue) (Gray, 1975; Séguy, 1949).

SEM observations were made on: (1) whole radulae; (2) radula sections; (3) tooth taken out of the radular membrane by treatment of the clean radula with (2:1) clorohydric aqueous solution for 5 to 10 minutes, then cleaned with distilled water, dehydrated and treated ultrasonically.

The observations were made on teeth from transverse rows situated in the half of the radula where they are not worn out.

RESULTS

The radulae of the *Pomacea* from Buenos Aires are of the taenioglossan type (see Figs. 1 and 2).

(A) Central tooth

The principal cusp or mesocone is flanked symmetrically by accessory cusps. There are six accessory cusps in *Pomacea canaliculata* and *P. insularum* (Fig. 3), and four in *P. scalaris*. Forked accessory cusps may be present on some radulae of all three species. The silhouettes of the mesocone are different in the three species. The morphological simplifications of its outlines differ: pentagonal in *P. canaliculata*, hemioctagonal in *P. insularum*, and triangular in *P. scalaris* (Fig. 4).

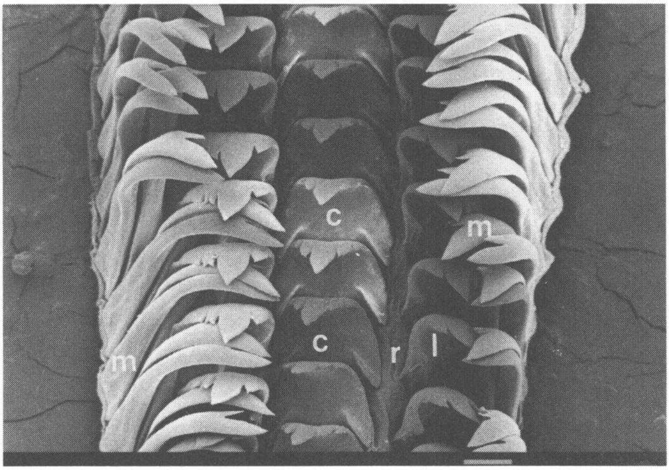

FIG. 1. A scanning electron micrograph showing a posterior-dorsal view of the radula of *Pomacea scalaris*. c = central tooth; l = lateral tooth; m = marginal tooth; r = radular membrane. Scale = 100 µm.

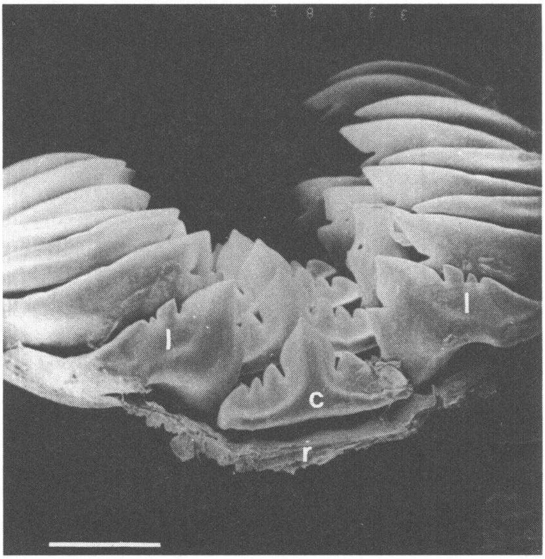

FIG. 2. A scanning electron micrograph showing a transverse section of the radula of *Pomacea canaliculata*. c = central tooth; l = lateral tooth; r = radular membrane. Scale = 200 µm.

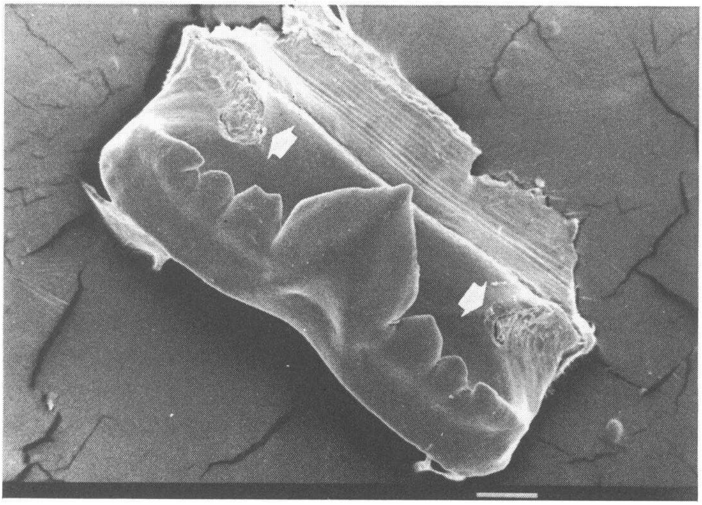

FIG. 3. A scanning electron micrograph showing an interior-dorsal view of a central tooth of *Pomacea insularum*. The crests are indicated by arrows. Scale = 100 μm.

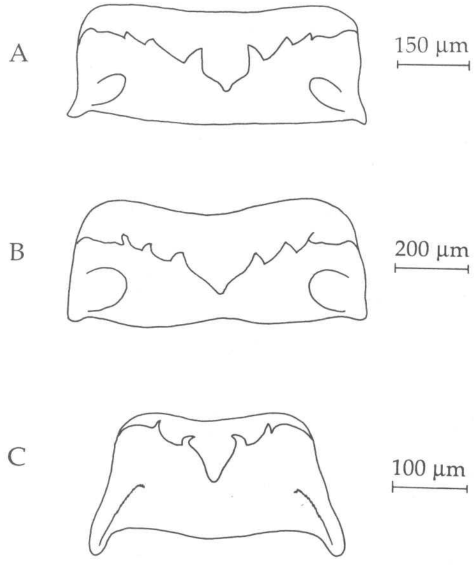

FIG. 4. Silhouettes of the central teeth of three species of *Pomacea*: (A) *Pomacea canaliculata;* (B) *P. insularum* and (C) *P. scalaris*. Drawn with aid of a light microscope.

The dorsal silhouettes of the basal plates are also shown in Fig. 4. Those of *Pomacea canaliculata* and *P. insularum* are more elongate; those of *P. scalaris* are trapezoidal.

The posterior corners of the basal plate carry a elevation (crest). The morphology of the crest depends on the species. In *Pomacea canaliculata* it delimits a somewhat concave surface. In *P. insularum* it is similar but the surface is wider than in *P. canaliculata.* In *P. scalaris* it is a vertical elevation limited on the side of its base by a concavity. The outer concavity is deeper and thereon rests the proximal process of the lateral tooth (Fig. 5).

The next basal plates of the *Pomacea canaliculata* and *P. insularum* are independent. In *P. scalaris* the anterior part of the posterior basal plaque covers the zone between the crests of the anterior tooth (Fig. 6).

(B) Lateral tooth

The basal plate of the lateral tooth has an irregular rhomboidal form. The mesocone is flanked by one internal and three external accessory cusps. In its internal side there is a proximal process which serves as surface of contact with the central tooth (Moretto & Nahabedian, 1983). The teeth of *Pomacea insularum* are similar to those of *P. canaliculata.* The teeth of *P. scalaris* are narrower, higher than those of the other two species and of slender aspect.

The proximal process of the lateral tooth is different in the three species. In *Pomacea canaliculata* it is a grooved structure. The wall of the groove is a helicoidal surface of short pitch. The basal plaque forms a "fork" upward whose perimeter limits the proximal process (Moretto & Nahabedian, 1983). In *P. insularum* the pitch of the helicoidal surface is longer and the "fork" wider than in *P. canaliculata* (Fig. 7). In *P. scalaris* the process occupies nearly all of the interior edge of the tooth. It does not project outside. Its surface is very elongate and very tilted and has a little cusp on the upper edge (Fig. 6).

(C) Marginal teeth

In *Pomacea canaliculata* the part of the proximal tooth which is embedded in the radular membrane has an extension (Moretto & Nahabedian, 1983), which is also present, albeit with some modifications, in the other two species. In *P. canaliculata* it is short and thick; in *P. insularum* it is of the

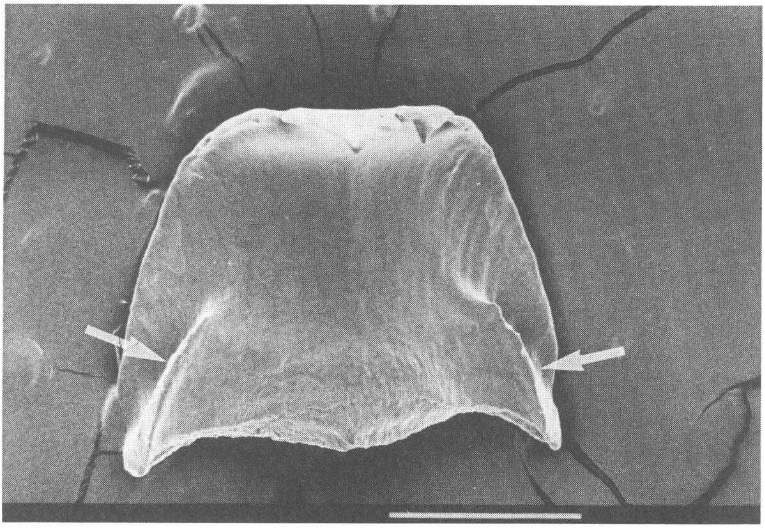

FIG. 5. A scanning electron micrograph showing a posterior view of the basal plaque of a central tooth of *Pomacea scalaris*. The crests are indicated by arrows. Scale = 100 µm.

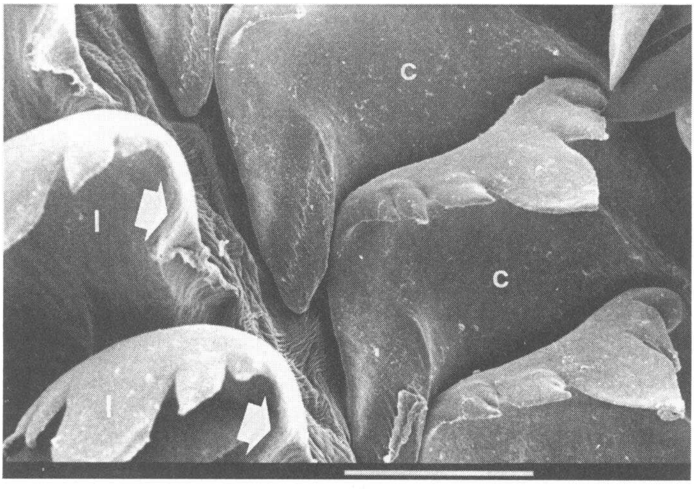

FIG. 6. A scanning electron micrograph showing a post-dorsal view from left side of the contacts between the next central teeth of *Pomacea scalaris*. SEM. The proximal processes (arrows), the crests and the contact between basal plates can be seen. c = central tooth; l = lateral tooth; r = radular membrane. Scale = 100 µm.

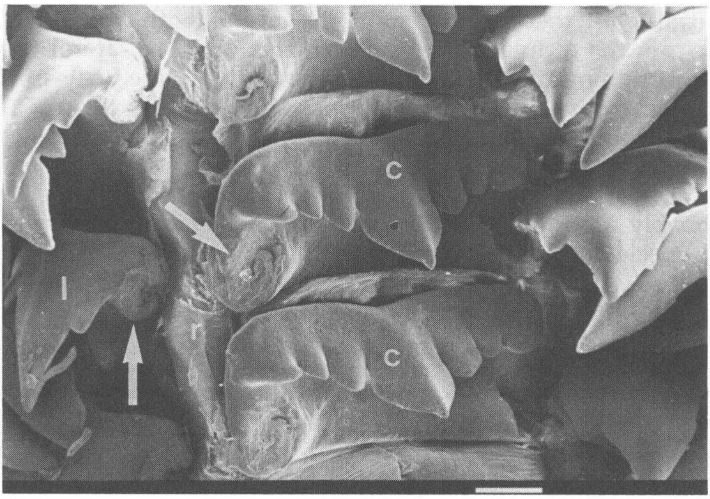

FIG. 7. A scanning electron micrograph showing a nearly dorsal view of several central teeth and their corresponding lateral teeth in *Pomacea insularum*. The surface of contact of the basal plate of the central tooth and the proximal process of the corresponding lateral tooth are indicated by arrows. c = central tooth; l = lateral tooth; r = radular membrane. Scale = 100 µm.

same thickness but longer, and in *P. scalaris* it is slender and long.

DISCUSSION AND CONCLUSIONS

In some gastropods, the morphology and size of the central radular teeth are species-specific characteristics. Different authors have used the form of the mesocone and the relative size of the basal plates as taxonomic characters (Mandal-Barth, 1968; Brown, 1980). Besides these characters, in *Pomacea* we propose that the following have taxonomic usefulness: (1) the crests of the central tooth; (2) the proximal process of the lateral tooth; and (3) the extension of the embedded part of the proximal marginal tooth. These minor taxonomic characters are not useful for routine identifications, but they are indicative of specific morphologic variations for the same radular function.

In taenioglossate radulae, the central tooth, together with the lateral teeth of the same row, form an effective arrangement for scraping and raking of the food: the lateral teeth lean their proximal processes against the crests of the central tooth, thereby preventing the central tooth from coming off from the radular membrane by traction. The lateral teeth also form hinges which would fix the angles of the walls of the radular groove. In *Pomacea scalaris* these pressures on the central tooth are increased because its next posterior central tooth is engaged with it. This arrangement of the central teeth and the weak extension of the proximal marginal teeth is probably an adaptation to shifts in the dietary behaviour of the species.

ACKNOWLEDGEMENTS

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LITERATURE CITED

BROWN, D.S. 1980. New and little known gastropod species of fresh and brackish water in Africa, Madagascar and Mauritius. *Journal of Molluscan Studies*, 46: 208-223.

GRAY, P. 1975. *The Microanatomist's Formulary and Guide*. R. Krieger, N.Y. 794 pp.

MANDAHL-BARTH, G. 1968. Freshwater molluscs. *Exploration hydrobiologique Bangweolo-Lauapula*, 12: 1-96.

MORETTO, H.J.A. & NAHABEDIAN, D.E. 1983. La rádula de *Ampullaria canaliculata* (Prosobranchia, Mollusca). *Comunicaciones del Museo Argentino Ciencias Naturales "Bernardino Rivadavia", Hidrobiología*, II (9): 107-117.

RUNHAM, N.W. 1975. Alimentary canal. Pp. 53-104. In: Fretter, Vera and Peake, John (Eds.), *Pulmonates*. Academic Press, London. 417 pp.

SÉGUY, E. 1949. *Le microscope. Emploi et Applications*. P. Lechevalier Ed. Paris. 1062 pp.

Walkerana, 1989, 3(10): 203-209

CONCHOLOGICAL STUDIES OF *THIARA* (*MELANOIDES*) *TUBERCULATA* (MOLLUSCA: GASTROPODA: THIARIDAE) IN THE FRENCH WEST INDIES

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ABSTRACT

ABSTRACT. - Conchological studies carried out on several West Indian populations of *Thiara* (= *Melanoides*) *tuberculata* showed presence of several distinct morphs. In Martinique and Guadeloupe, four morphs have been distinguished, two of which are close to the syntypes of "*Nerita*" *tuberculata* described by Müller in 1774. The two others present several differences based on morphology of shells and also on nucleus/ first whorl diameters. At the present time, no intermediate forms were found in Martinican sympatric populations.

Key words: *Thiara* (*Melanoides*) *tuberculata*, conchology, French West Indies.

INTRODUCTION

Thiara (= *Melanoides*) *tuberculata* (Müller, 1774) is a parthenogenetic prosobranch which sometimes has males present in some populations, as recorded by Jacob (1957, 1958) in India, and by Livshits & Fishelson (1983) and Livshits *et al.* (1984) in Israel. This oriental freshwater snail was introduced to the Caribbean area during the last decade. In the Lesser Antilles, it was found in 1975 in the island of Dominica (Pointier & Delplanque, unpublished data) and its presence was confirmed in 1979 by Starmühlner (1984). In 1978, samples from Dominica were successfully transferred to laboratory tanks in Saint Lucia and were then used in field experiments (Prentice, 1983). In Martinique, the species was first observed in 1979 in the Madame River, Fort-de-France (Pointier & Guyard, unpublished data). It appeared at the same time in Guadeloupe (Cornély, personal communication).

In the French islands of Martinique and Guadeloupe, the spread of *Thiara tuberculata* has been very rapid. In 1986 more than 60% of the water bodies were colonized by this species. A study carried out on several Martinican and Guadeloupean populations showed a great diversity of their conchological characteristics. This paper presents the results of the study carried out on shells of juveniles and adult snails.

MATERIALS AND METHODS

Samples were collected in different localities of Guadeloupe, Martinique and also from other islands and countries, e.g., Cuba, Dominican Republic, Dominica, Saint Lucia and Venezuela. Shells were cleaned with a commercial solution of sodium hypochlorite. Protoconch studies were carried out on newly liberated juveniles from females collected in the field or reared in the laboratory (25°C). The females of several cohorts in culture had the same age (30 months, corresponding to a mean shell height of 25.0 mm, 25.2 mm and 28.6 mm respectively). Females collected in the field came from Martinique (two sympatric populations with a mean shell height of 16.4 mm and 19.4 mm, respectively). Diameters of nucleus, of the first half whorl and the first whorl were measured according to the methods of Warren (1974) and Verduin (1977).

RESULTS

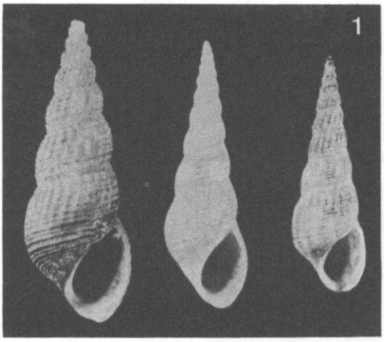
The adult shells measure between 15 and 25 mm in height. Four distinct morphs can be distinguished as follows:

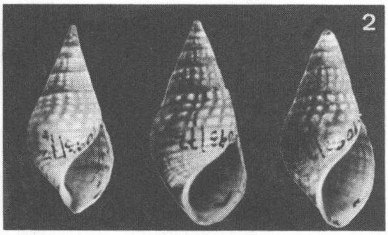
"Madame" morph (Pl. 1, Fig. 6) was collected for the first time in Madame River, Fort-de-France, Martinique. The shells are pale to dark brown with numerous reddish brown flames. The body whorls are slightly rounded with spiral grooves and axial undulating ribs which flatten on the later whorls (Pl. 1, Fig. 6). In 1987, this morph was found in 22 sites in Martinique but at only one in Guadeloupe (Marie-Galante Island).

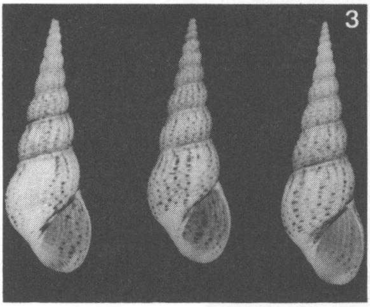
The "Falaise" morph (Pl. 1, Fig. 3) was collected in a watercress bed located in the Falaise valley, Martinique. The shells are white with numerous reddish brown flames and spots. The body whorls are well rounded with spiral grooves, and axial and spiral rows of small tubercles. In 1987, this morph was very common in Martinique (37 sites), but rare in Guadeloupe (4 sites).

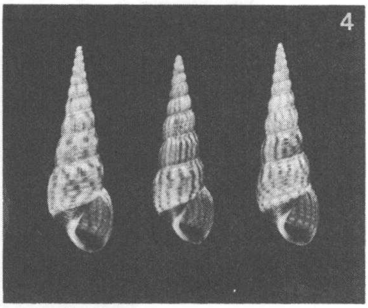
The "Gosier" morph (Pl. 1, Fig. 4) was collected in a small stream in Gosier, Guadeloupe. The shells are pale brown with numerous reddish-brown flames and spots. The body whorls are well rounded with spiral grooves, and have axial and spiral rows of small tubercles like the "Falaise" morph. However, this sculpture is less marked than in the "Falaise" morph. There is also a brown band in the columellar region (Pl. 1, Fig. 4).

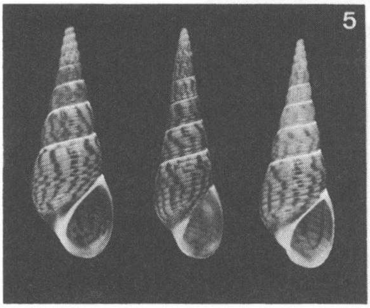
The "Pointe-à-Pitre" morph (Pl. 1, Fig. 5) was first collected in urban canals in Pointe-à-Pitre, Guadeloupe. The shells are











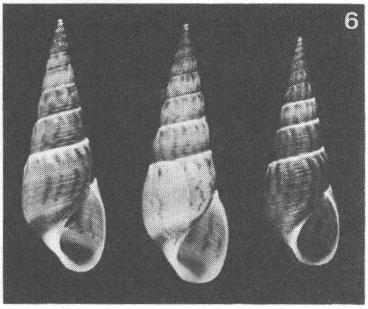


PLATE 1. Caribbean Thiaridae.

FIG. 1. *Nerita tuberculata* Müller, 1774, Syntypes (26.0 mm, 23.0 mm, 20.0 mm). FIG. 2. *Melania granifera* Lamarck 1822, Syntypes (24.9 mm, 27.0 mm, 26.1 mm). FIG. 3. *Thiara tuberculata*, Martinique, "Falaise" morph (23.3 mm, 21.9 mm, 24.5 mm). FIG. 4. *T. tuberculata*, Guadeloupe, "Gosier" morph (24.2 mm, 23.3 mm, 25.2 mm). FIG. 5. *T. tuberculata*, Guadeloupe, "Pointe à-Pitre" morph, (25.3 mm, 26.0 mm, 24.3 mm). FIG. 6. *T. tuberculata*, Martinique, "Madame" morph (25.2 mm, 27.0 mm, 23.2 mm).

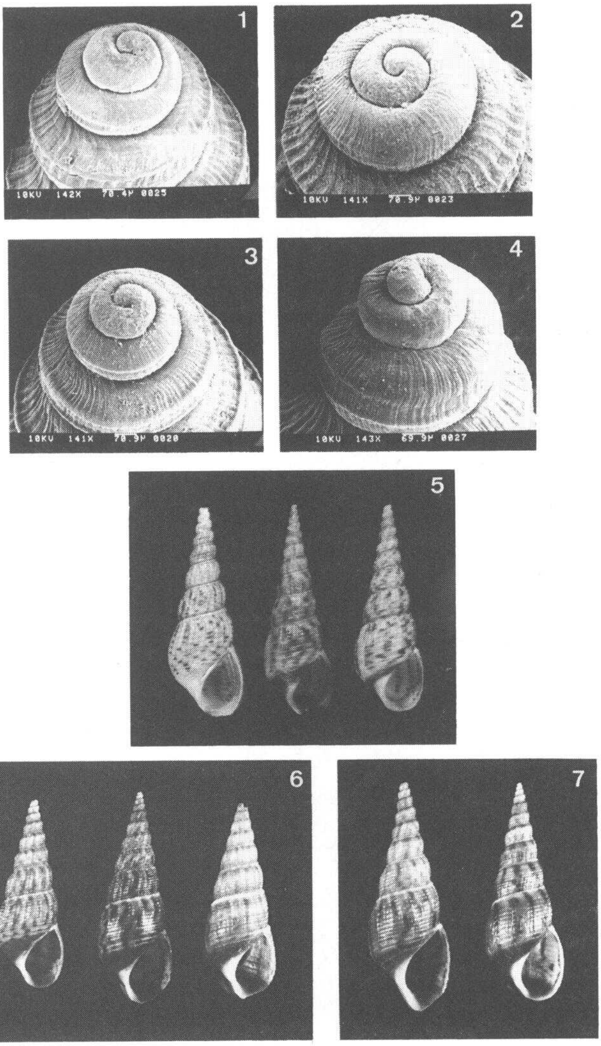


PLATE 2. *Thiara tuberculata* (Müller, 1774).

FIGS. 1-4. Protoconchs. FIG. 1. Martinique, "Falaise" morph. FIG. 2. Guadeloupe, "Gosier" morph. FIG. 3. Guadeloupe "Pointe-à-Pitre" morph. FIG. 4. Martinique, "Madame" morph. FIGS. 5-7. Shells of *Thiara*. FIG. 5. *T. tuberculata*, from left to right, "Falaise" morph, Martinique; "Gosier" morph, Guadeloupe; "Gosier" morph, Dominican Republic. FIG. 6. *T. tuberculata*, "Madame" morph, from left to right, Cuba, Dominican Republic, Dominica. FIG. 7. *T. tuberculata*, "Madame" morph; left, Saint Lucia; right, Venezuela.

pale to dark brown with numerous red brown flames. The body whorls are slightly rounded and have spiral grooves. The axial ribs disappear very quickly and the last 6 to 7 whorls have only spiral grooves. In 1987, this morph was very common in Guadeloupe (found in 23 sites) and Martinique (found in 17 sites).

DISCUSSION AND CONCLUSIONS

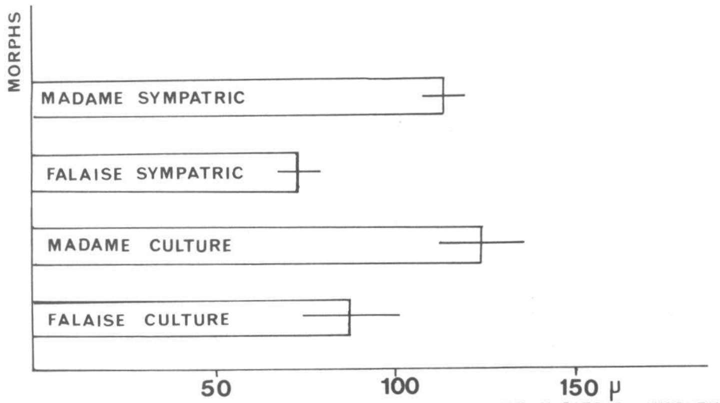
Thiara tuberculata often has been confused with *T. granifera*, a closely related species which was introduced to the Caribbean area some decades ago. *Thiara granifera* was described by Lamarck (1822) on the basis of shells from Timor (Pl. 1, Fig. 2). Typically, the shells have axial and spiral sculpture which determine nodes, and the body whorls are flat. *Thiara granifera* does not show the great morphological variability evidenced by *T. tuberculata*.

TABLE 1. Measurements of different parameters on shells of newly liberated juvenile *Thiara tuberculata*.

MORPHS:	Pointe-à-Pitre	Madame	Falaise	Gosier
Diameter of nucleus	86.6 μ (s.d. = 13.7)	124.0 μ (s.d. = 12.0)	88.0 μ (s.d. = 13.1)	84.2 μ (s.d. = 11.3)
Diameter of the first half whorl	191.1 μ (s.d. = 20.6)	239.4 μ (s.d. = 23.1)	170.0 μ (s.d. = 14.6)	182.0 μ (s.d.= 15.6)
Diameter of the first whorl	277.4 μ (s.d. =22.0)	324.0 μ (s.d. = 34.3)	237.1 μ (s.d. = 16.0)	277.8 μ (s.d. = 21.8)
Mean height of shell	2.42 mm (s.d. = 0.47)	4.30 mm (s.d. = 0.64)	2.35 mm (s.d. = 0.46)	2.26 mm (s.d. = 0.41)

The morphs "Falaise" and "Gosier" seem very close to the syntypes of *"Nerita" tuberculata* described by Müller (1774) from Coromandel, India (Pl. 1, Fig. 1). The two other morphs, "Madame" and "Pointe-à-Pitre", present several differences: their body whorls are less rounded, and axial and spiral tubercles are lacking.

Scanning electron micrographs of protoconchs of all of the morphs do not show any particularly peculiar characteristics (Pl. 2, Figs. 1-4). Measurements made on newly liberated juveniles by females of the same age show significant differences between diameters of the nucleus, the first half whorl, and the first whorl of the "Madame" morph and the others (Table 1). These differences are confirmed when comparing sympatric populations of morphs "Madam" and "Falaise" from Martinique (Text-Fig. 1).



TEXT-FIG. 1. *Thiara tuberculata*: Mean size of nucleus and standard deviation of "Falaise" and "Madame" morphs in cultivated and natural sympatric populations, Martinique.

Study of samples from other Caribbean islands and other countries shows that at least two of these morphs are present: morph "Madame" in Cuba, Dominican Republic, Dominica, Saint Lucia and Venezuela, and morph "Gosier" in the Dominican Republic (Pl. 2, Figs. 5-7).

At the present time, no intermediate forms have been found, even in several sympatric populations which occur in Martinique. A study is underway to determine if these conchological differences are correlated with genetic differences.

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LITERATURE CITED

JACOB, J. 1957. Cytological studies of Melaniidae (Mollusca) with special reference to parthenogenesis and polyploidy. I. Oogenesis of the parthenogenetic species of *Melanoides* (Prosobranchia - Gastropoda). *Transactions of the Royal Society of Edinburgh*, 63: 341-352.

JACOB, J. 1958. Cytological studies of Melaniidae (Mollusca) with special reference to parthenogenesis and polyploidy, II. A study of meiosis in the rare males of the polyploid race of *M. tuberculata* and *M. lineatus*. *Transactions of the Royal Society of Edinburgh*, 63: 433-444.

LAMARCK, M. le Chevalier de. 1822. *Histoire naturelle des animaux sans vertèbres, présentant les caractères généraux et particuliers de ces animaux, leur distribution, leur classes, leurs familles, leurs genres, et la citation des principales espècies qui s'y rapportent.* Vol. 6, Pt. 2, pp. 1-232. Chez l'auteur, au Jardin du Roi.

LIVSHITS, G. & FISHELSON, L. 1983. Biology and reproduction of the freshwater snail *Melanoides tuberculata* (Gastropoda: Prosobranchia) in Israel. *Israel Journal of Zoology*, 32: 21-35.

LIVSHITS, G., FISHELSON, L. & WISE, S. 1984. Genetic similarity and diversity of parthenogenetic and bisexual populations of the freshwater snail *Melanoides tuberculata* (Gastropoda: Prosobranchia). *Biological Journal of the Linnean Society*, 23: 41-54.

MÜLLER, Othone Friderico. 1774. *Vermium terrestrium et fluviatilium, seu animalium infusoriorum, helminthicorum et testaceorum, non marinorum, succincta historia.* Heineck et Faber, Havinae et Lipsiae. Vol 2, pp. i-xxxvi, 1-214, 10 pp. index.

PRENTICE, M.A. 1983. Displacement of *Biomphalaria glabrata* by the snail *Thiara granifera* in field habitats in St. Lucia, West Indies. *Annals of Tropical Medicine and Parasitology*, 77(1): 51-59.

STARMÜHLNER, F. 1984. Occurrence, longitudinal distribution and geographical range of the fresh and brackish water molluscs of the Lesser Antillean islands (Guadeloupe, Dominica and Martinique). *Soosiana*, 12: 83-102.

VERDUIN, A. 1977. On a remarkable dimorphism of the species in many groups of sympatric closely related marine gastropod species. *Basteria*, 41: 91-95.

WARREN, A. 1974. Revision of the Arctic-Atlantic Rissoidae. *Zoologica Scripta*, 3: 121-135.

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FIRST RECORD OF *BIOMPHALARIA ORBIGNYI* IN CUBA

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ABSTRACT. - The finding of a well-established population of *Biomphalaria orbignyi* Paraense in Soledad pond near Havana, Cuba, constitutes a new species record for the Cuban freshwater molluscan fauna. Previously *B. orbignyi* was known only from Argentina. The appearance of this freshwater snail in Cuba is probably due to its transport and introduction by migratory birds. *Biomphalaria orbignyi* is not known to be susceptible to larval forms of any human trematode parasites.

Key words: *Biomphalaria orbignyi*, Cuba, morphology.

As a result of the increased interest in medical malacology in Cuba, an intensive survey of freshwater mollusks is being carried out in the country. This survey previously has expanded surprisingly the documented distribution of the known fresh-water molluscan fauna, and it also has produced information on some species that were not previously recorded. For example, new additions to Cuba in the family Planorbidae are *Planorbella duryi* (Wetherby) (Perera *et al.*, 1984), *Biomphalaria schrammi* (Crosse) (Yong *et al.*, 1984) and *B. peregrina* (Orbigny) (Yong *et al.*, 1988). We believe that these three species were introduced into the country by intercontinental flights of migrating birds. In this current paper, we show that another planorbid species has been introduced into Cuba: *Biomphalaria orbignyi* Paraense (Fig. 1).

The presence of *Biomphalaria orbignyi* in Cuba was first detected in Soledad pond near Havana. This finding is only the second record for this species. Previously, *B. orbignyi* was known only in Argentina (from its original description; Paraense, 1975). We do not know if this is a recent introduction to Cuba or if the species has been here for a long time, since Soledad pond was not surveyed previous to October 1988.

Soledad is a shallow pond (Fig. 2), formed in a karstic depression with a hard muddy bottom and abundant aquatic

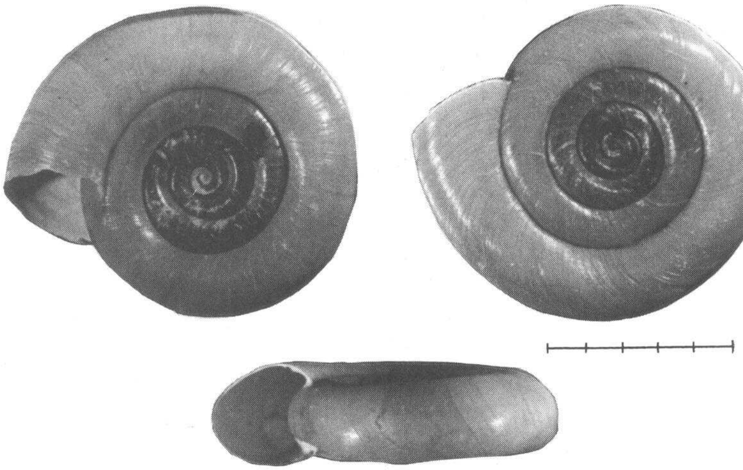


FIG. 1. Shell of *Biomphalaria orbignyi* Paraense found in Cuba. Scale line = 5 mm.

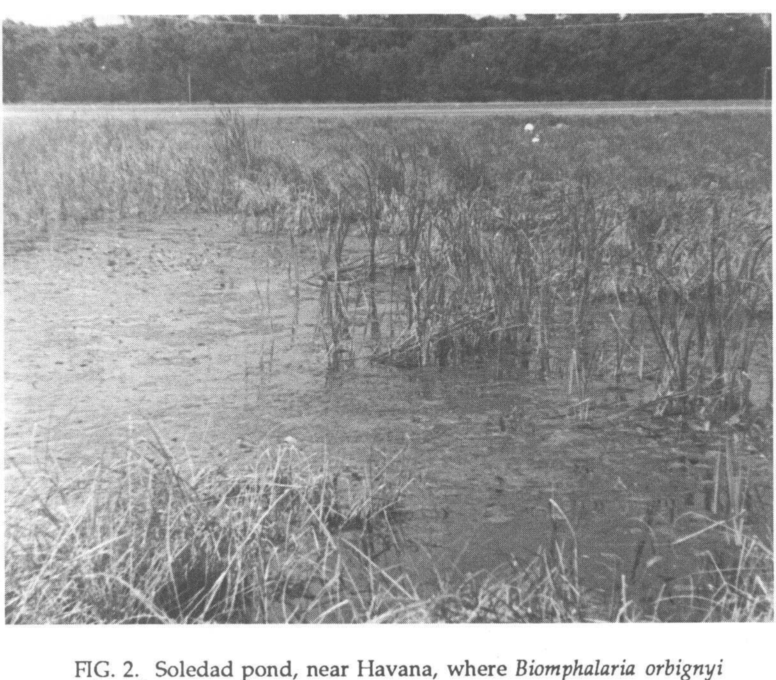


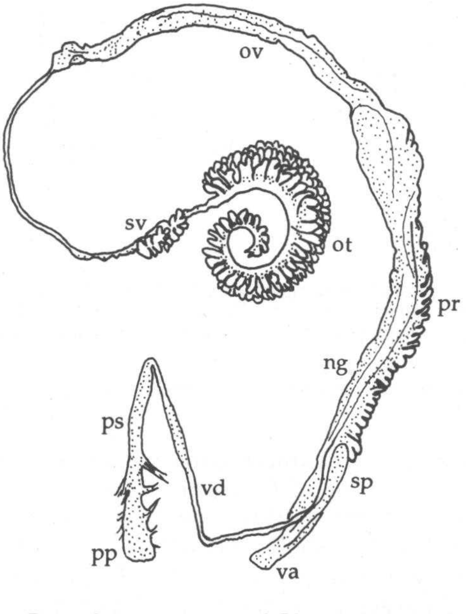
FIG. 2. Soledad pond, near Havana, where *Biomphalaria orbignyi* was found.

vegetation. It seems to be similar to the lentic habitats in which *Biomphalaria orbignyi* is found in its type locality (Paraense, 1975).

Soledad pond contains a dense population of *B. orbignyi*. The snails can be found on the leaves of *Nymphoides grayanum* Gris., or creeping along the stems of *Typha dominguensis* Persoon. which covers the shores of the pond. Sharing this habitat with *B. orbignyi* are *Physella cubensis* Pfeiffer, *Fossaria cubensis* (Pfeiffer), *Drepanotrema cimex* (Moricand), *D. lucidum* (Pfeiffer) and *D. anatinum* (Orbigny).

The shell of the Cuban specimens reaches a maximum diameter of 13 mm. In a shell of this size, five to six whorls are plainly visible on both spire and umbilical sides. The shell periphery is rounded, as is the outer apertural lip.

The foot is elongated and is covered with a diffuse dark pigmentation. The pulmonary wall of the body whorl has gray dots on its surface.



FIGS. 3. Reproductive system of *Biomphalaria orbignyi*. nd = nidamental gland, ot = ovotestis, pp = preputium, pr = prostate, ps = penial sheath, sp = spermatheca, va = vagina, vd = vas deferens, vs = seminal vesicle.

The internal anatomy of *Biomphalaria orbignyi* (Fig. 3) was studied in 126 specimens following the methodology described by Yong *et al.* (1989). The spermatheca is club-shaped and shorter than the preputium. In some specimens (which may be the oldest), the vaginal pouch appears corrugated. The penis sheath and preputium are both of the same length. Of the two, the penis sheath is the narrower. The preputium has a set of retractor muscles pointing to the caudal region and a set of protractor muscles pointing to the dorsal region (Fig. 4). The ovotestis has between 50 and 60 diverticula, most of which are bifurcated. The prostate gland has both single and bifurcate diverticula (Fig. 5).

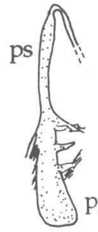


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FIG. 4. Preputium of *Biomphalaria orbignyi*, showing the protractor and retractor muscles. FIG. 5. Prostate, showing its characteristic diverticula. pp = preputium, pr = prostate, ps = penial sheath.

The radular teeth have characteristic triangular cusps (Fig. 6).

The morphological characteristics of *Biomphalaria orbignyi* are very similar to those of *B. havanensis* and *B. peregrina*. This is especially true in young specimens, which are also indistinguishable by shell characters. Anatomically, *B. orbignyi* can be distinguished from *B. havanensis* and *B. peregrina* by characters of the vaginal pouch, which can be corrugated, and by the characteristic penial complex with its particular retractor and protractor muscles, which cannot be

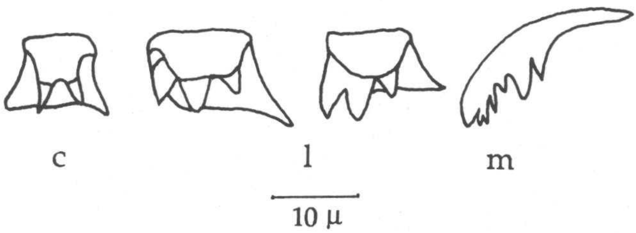

FIG. 6. Radular teeth of *Biomphalaria orbignyi*; c = central tooth; l = two of the lateral teeth; m = one of the marginal teeth.

found in either *B. havanensis* or *B. peregrina.*

Biomphalaria orbignyi has no known epidemiological importance, since it is apparently not able to transmit *Schistosoma mansoni* Sambon, either in nature or under laboratory conditions (Malek, 1985).

Voucher specimens of *Biomphalaria orbignyi* have been deposited in the Instituto de Ecologia y Sistemática, Academia de Ciencias de Cuba, Havana, Cuba.

LITERATURE CITED

MALEK, Emile A. 1985. *Snail hosts of schistosomiasis and other snail transmitted diseases in tropical America: A manual.* Pan American Health Organization, Scientific Publication No. 478, 325 pp.

PARAENSE, W. Lobato. 1975. *Biomphalaria orbignyi* sp. n. from Argentina (Gastropoda: Basommatophora: Planorbidae). *Revista Brasileira de Biologia,* 35(2): 211-222.

PERERA, Gloria, YONG, Mary & POINTIER, Jean-Pierre. 1984. First report for Cuba of a population of *Planorbella (Helisoma) duryi* in the Isle of Youth (Isle of Pines). *Walkerana,* 2(7): 125-130.

YONG, Mary, HUBENDICK, Bengt, RODRIGUEZ, José & PERERA, Gloria. 1984. *Biomphalaria schrammi* in Cuba. *Walkerana,* 2(7): 141-144.

YONG, Mary, PERERA, Gloria & POINTIER, Jean-Pierre. 1989. Presence of *Biomphalaria peregrina* in Hanabanilla, Cuba. *Journal of Medical and Applied Malacology,* 1(1): (in press).

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GYRAULUS (TORQUIS) HURONENSIS, A NEW SPECIES OF FRESHWATER SNAIL (LYMNOPHILA, PLANORBIDAE) FROM THE NORTH AMERICAN GREAT LAKES [1]

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ABSTRACT. – A new species of Planorbidae, *Gyraulus (Torquis) huronensis* Burch & Jung, is described from the northwestern shore of Lake Huron. Characters of the reproductive system and alimentary canal relate this planorbid snail to the *Gyraulus* subgenus *Torquis*. *Gyraulus (Torquis) huronensis* is distinguished from other members of the *Torquis* group by its habitat (the rocky wave-swept shore of Lake Huron) and by characters of its thick, mahogany red or Hay's russet-colored shell with deflected body whorl and deep and narrow spire, its dense body pigmentation and, in the reproductive system, the prostate gland with each follicle connected directly to the sperm duct.

Key words: *Gyraulus (Torquis) circumstriatus, G. (T.) huronensis*, n. sp., *G. (T.) parvus*, conchology, anatomy, habitats.

During the past several summers while collecting mollusks in northern Michigan, we have found a small freshwater snail heretofore undescribed in the malacological literature. This snail, a member of the pulmonate family Planorbidae, occurs along the rocky wave-swept northern shores of Lake Huron and, because of its habitat, it seems to have been overlooked in previous collecting in the state. The purpose of this paper is to describe and name this species. The anatomical descriptions below are all based on observations made on live animals.

Gyraulus (Torquis) huronensis, new species

(Figs. 1-4)

Diagnosis: A small North American planorbid snail having a thick, solid shell, mahogany red or Hay's russet in color, with a characteristic spireward deflection of the body whorl and a relatively (to other *Torquis* members) deep and narrow inverted spire. The whorls on the spire side (the topo-

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[1] Contribution from The University of Michigan Biological Station.

graphically lower side in an active snail) are rounded. The body (head-foot, mantle) is heavily pigmented with melanin. In the reproductive system, the prostate gland follicles appear to be each connected directly to the sperm duct, rather than to a prostate gland duct as in *Gyraulus parvus* and *G. circumstriatus.*

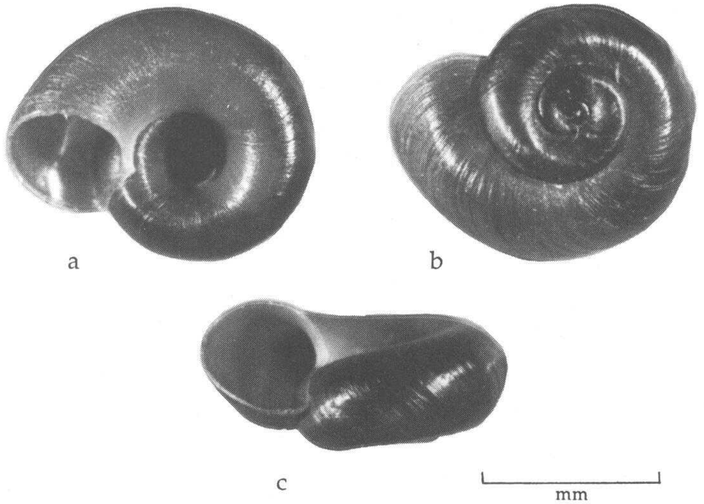

FIG. 1. Spire (a), umbilical (b), and apertural (c) views of the shell of the holotype of *Gyraulus (Torquis) huronensis*, n. sp. UMMZ 250571.

Type specimens: Holotype UMMZ 250571 (Fig. 1), collected by the authors on November 18, 1988; paratypes UMMZ 250572. The holotype is a shell with 3.75 whorls, measuring 3.7 mm in greatest diameter, and 1.9 mm in height (height/diameter ratio = ca. 0.51). The width of the spire is 1.1 mm (ratio of spire width to shell width = ca. 0.30), the width of the umbilicus is 1.8 mm, and the width of the aperture is 1.55 mm.

Type locality: Shore of Lake Huron, north of Hammond Bay, T. 37 N., R. 2 E., Section 14, Bearinger Township, Presque Isle County, Michigan, U.S.A.

Description: Shell. Shell (Fig. 1) small, discoidal, with inverted spire and a somewhat dome-shaped umbilical side (the topographically right side, but actually the dorsal side in reference to the way the crawling snail carries its shell). The shell is thick, mahogany red or Hay's russet in color

(Ridgeway's (1912) color standards) and has a relatively narrow and deeply inverted spire (on topographically the left side, but actually the "base" or ventral side in reference to the active shell). The major diameter of the shell of large specimens with four whorls reaches 5 mm.

External Features. In frontal view, the visible head-foot in an active snail is wedge-shaped, tapering inwardly up from the sole. In side view, the head has a blunt, rounded anterior end. On its ventral side, the velum is separated from the head and anterior foot by a deep groove or invagination. The foot, when compared to the size of the shell, is noticeably short. Posteriorly, in side view, the foot tapers distally and ventrally to a terminal point. In dorsal view, this terminus is bluntly rounded.

The surface of the sole of the foot appears homogeneous when the snail is active, having no longitudinal or transverse furrows or any areas of apparent different structure or texture. The sides of the foot and the head (sides and front) are black. On the front of the head there is a median longitudinal stripe with less pigment. The sole is uniformly dark-gray in color, except for the edges, where a narrow band surrounding the sole lacks pigment. The translucent surface layer of the sole itself does not appear to have melanin granules. The sole of the foot in outline when the snail is crawling is a modified oval, tapering behind and truncated in front. However, this outline is rather flexible, changing with the different motions and activities in which the snail is engaged.

The ventral surface of the velum, just anterior to the anterior part of the foot, appears as a broad isosceles triangle, creased medially by the mouth. The mouth, when the snail is not feeding, appears as a longitudinal ventral slit (sometimes Y- or T-shaped), dividing the triangular velum into two equal smaller isosceles triangles. When the snail is feeding, the sides of the longitudinal slit expand laterally, making a fusiform opening of varying widths.

Covering the entire viscera externally, from the apex distally to the mantle collar, is the thin mantle. It is heavily pigmented with melanin pigment.

The mantle collar usually rests at the rim of the shell aperture in an active snail, but it may also extend slightly past

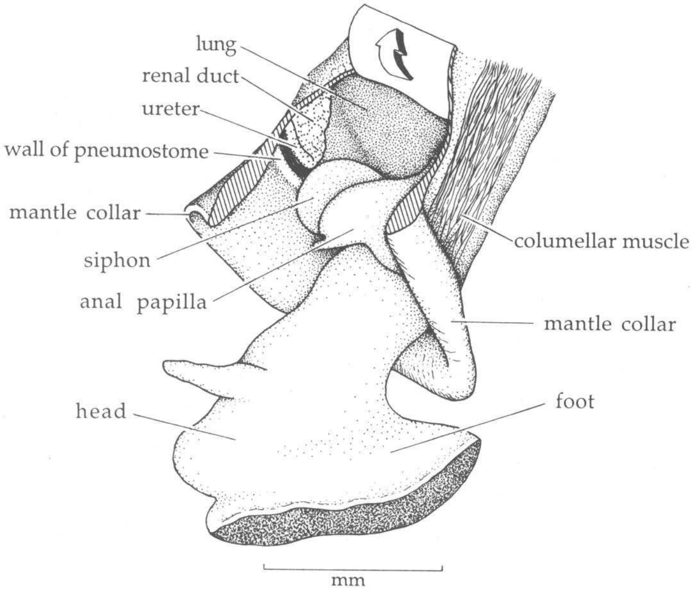

FIG. 2. Left side of lower animal of *Gyraulus huronensis* with the lower mantle cut away to show the siphon, anal papilla, lower renal duct and the lung.

the aperture, especially on the spire side. The collar is rounded in contour, and encircles the body stalk. The central core of the mantle collar has black melanin pigment.

The siphon [also called "pseudobranch"], located on the left side of the animal just anterior to the anal papilla (Fig. 2), hangs ventrally between the snail's body and the overhanging mantle. It is a thin flap-like structure, capable of considerable extension.

The tentacles in active snails are elongate, relatively thin structures located on the anterior dorsal head. They are capable of considerable extension and contraction. They taper gradually distally and end as bluntly rounded truncations. The base of each tentacle, where it joins the snail's body, is broad and tapers more rapidly than does the remainder of the tentacle. The central core of the tentacle is blackly pigmented. The eye, also blackly pigmented, is located at the anterior base of the tentacle, in the area of the tentacle's maximum expansion. The male genital pore is located at the posterior end of the base of the left tentacle.

The anterior end of the head, the "snout" or "face," is roundly and bluntly truncated.

Immediately behind the mantle collar, there is a short cavity, which terminates at a transverse septum which forms the anterior wall of the lung. The septum contains the pneumostome, nephridiopore, anal papilla and the siphon.

Internal Anatomy. The lung, which begins a short distance behind the mantle collar, extends apically for about half of the last (body) whorl. It occupies the outer part of the whorl on the umbilical side (which, on a crawling snail, is the upper side). The lung is bordered on the inner dorsal side by the esophagus and lower reproductive system (the nidamental and prostate glands) and on the outer ventral side by the kidney and renal duct.

The kidney and renal duct, on the opposite side of the whorl laterally from the esophagus, intestine and lower reproductive tract, together are also quite long, extending from the mantle collar for about 3/4 the length of the last whorl. The apical end of the kidney is adjacent to the pericardium. The kidney tissue is filled with pale yellow granules or concretions. The convoluted renal duct, which extends from the kidney to the anterior septum, has crenulated margins due to sigmoid convolutions. The margins of the duct are highly pigmented with melanin. Its opening is toward the left side of the animal. The renal tube is composed of milky-white granula.

The pericardium lies at the apical end of the lung, about 3/4 of the last whorl apically from the mantle collar. Within the pericardium is the heart, with its single auricle and ventricle. The ventricle lies distally and is a non-pigmented, highly contractile cone. The auricle lies apically, and is a round, thin-walled, highly pigmented (with melanin) sac. Adjacent to the heart apically is the multilobed albumen gland. Just apical to the albumen gland is the blackly pigmented stomach, which is located at the apical end of the last whorl.

The esophagus (Fig. 3) proceeds in a more or less straight line (a little curved, due to the curvature of the last whorl) from the posterior end of the buccal mass to the stomach. The esophagus runs along the edge of the lung, on the median inner side of the

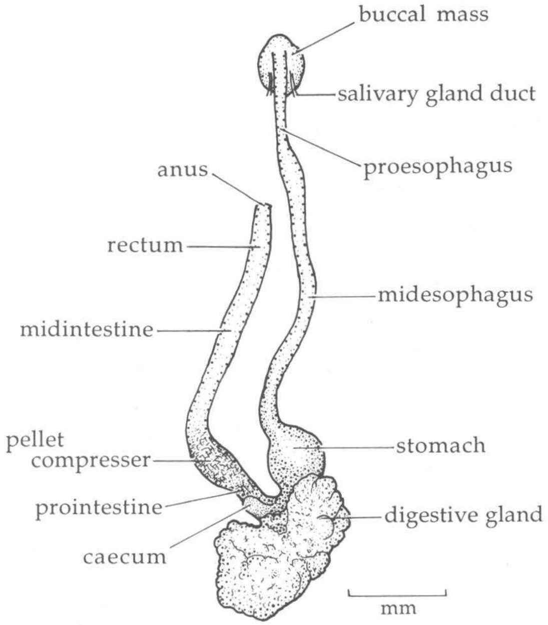

FIG. 3. Digestive tract of *Gyraulus huronensis*.

body whorl. The esophagus is very long, extending apically nearly the entire volution of the last whorl. The esophagus extends to the stomach from the lateral right side of the animal. The proesophagus is a little more bulbous posterior to the salivary glands, then returns to the normal diameter where it joins the midesophagus. The midesophagus continues posteriorly unchanged until it meets the postesophagus, where there is another enlargement of the esophageal diameter. The postesophagus is a little constricted before it enters the cardiac part of the stomach. The proesophagus and the postesophagus are each shorter than the long midesophagus.

The stomach consists of the thin cardiac and pyloric parts and the very muscular gizzard. The gizzard is located between the cardiac and pylorica parts of the stomach. The pyloric part joins the wide, very muscular prointestine, which forms a pellet compressor. The duct of the digestive gland opens into the pyloric part of the stomach, and the small gastric caecum branches off from the pyloric part of the stomach in the opposite direction of the opening from the liver. At (*i.e.*, after) the stomach, the alimentary canal flexes sharply (180°), so that the intestine runs near the esophagus in the opposite direction. The intestine is straight, not looped or coiled as it generally is in other basommatophoran snails. The mid-intestine, which is little narrower in width than the pellet compressor, runs to the rectum and anus. The more or less straight intestine leaves to the dorsal, left side of the animal. The position of the anus is a little to the left of the siphon under the mantle border. The digestive gland is a large organ, which consists of many dark yellow lobes. It covers the ovisperm duct, seminal vesicles and free portion of the duct between the seminal vesicle and the ovotestis. The proximal end of the digestive gland overlaps the distal end of the ovotestis on the spire-side of the animal. Melanin pigmentation is distributed broadly along all of the alimentary tract. It is especially dense in the area of the postesophagus, stomach and prointestine.

The penultimate whorl in an average-sized snail of about four whorls is taken up largely by the tannish, highly lobulated, digestive gland. The seminal vesicle and hermaphroditic duct run along the inner (sutural) side of the digestive gland. The hermaphroditic duct reaches the carrefour region at about the beginning of the last whorl.

Fig. 4 shows the entire reproductive system. The male genital pore opens on the left side just below the left tentacle. The preputium and penis sheath are located immediately to the left of the proesophagus. The preputium is cylindrical in form, and generally appears narrower in the middle. The penis sheath enlarges at the proximal end, and is elongate-ovate in shape. The distal end of the penis sheath is about half the width of the preputium. The preputium is composed of opaque white granules with little melanin in the covering epithelium. The penis sheath is muscular and covers a narrow penis. The prostate gland (Figs. 4, 5) is composed of 13-16 long, wide, cylindrical diverticulae which are connected to the prostate tubule. The prostate tubule in turn is connected at its distal end to the sperm duct. These diverticular lobes are arranged in one layer that makes the prostate gland elongate in form. The vas deferens runs from the prostate gland to the penis sheath. It is a narrow tube, which is wider near the prostate gland. The

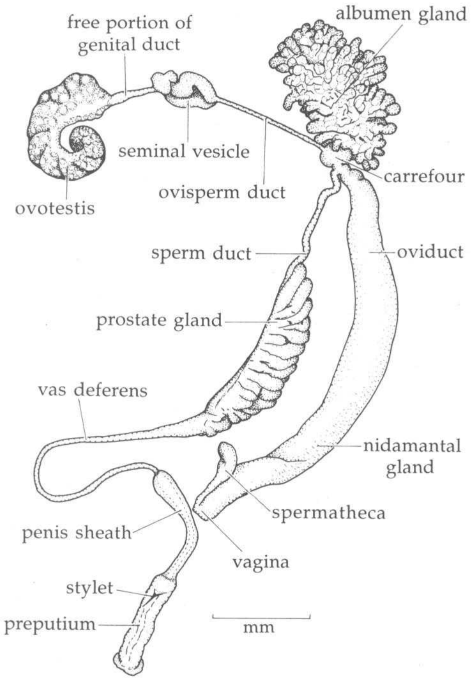

FIG. 4. Reproductive system of *Gyraulus huronensis*.

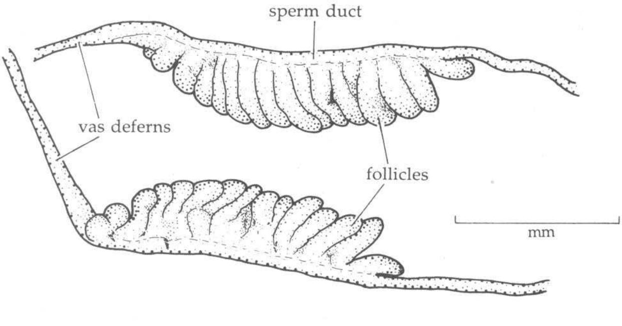

FIG. 5. Two views of a prostate gland of *Gyraulus huronensis*.

prostate gland overlaps the nidamental gland when viewed from the umbilical side of the animal.

The female genital pore is located on the left side of the animal posterior and dorsal to the male genital pore and below the anus. The spermatheca on the one side and the nidamental gland on the other side join distally to form the small short vagina. The spermatheca is composed of a sac and its duct. The sac is small and ovate in shape, and has a yellowish-orange colored material inside. The duct of the spermatheca is a narrow, short tube the same length as the sac. The spermatheca is located between the last diverticulum of the prostate gland and the prostate tubule; the blind end of the sac is directed toward the prostate tubule in most specimens. The nidamental gland and oviduct together form a longitudinal tube; the two structures cannot be distingushed as two separate organs. The distal part of the nidamental gland (on the side opposite the spermatheca and the distal part of the prostate gland) has a white opaque color and a different texture from the rest of the nidamental gland. The albumen gland in its natural position is small, thin and subtriangular in shape. It is composed of many relatively large white cylindrical diverticular lobes. The albumen gland covers the upper half of the gizzard. The carrefour is connected to the sperm duct, oviduct and ovisperm duct and the opening to the albumen gland. The ovisperm duct is a relatively short tube a little narrower than the sperm duct. The white, irregular, tube-like seminal vesicle is much wider than the ovisperm duct. The seminal vesicle is twisted. Between the seminal vesicle and the ovotestis there is a short free portion of the genital duct. The free portion of the genital duct, the seminal vesicles, and the ovisperm duct are covered by the digestive gland. The ovotestis consists of small yellowish-orange lobes which are arranged in one layer on its outer side. It is a lobulated structure of slightly different appearance and texture than the digestive gland. The first two whorls (approximately) are taken up by the ovotestis.

Comparisons: *Gyraulus huronensis* has basically the same type of soft body structure as *G. parvus* and *G. circumstriatus.* However, the general color of the animal of *G. huronensis* is much darker (i.e., much more heavily pigmented) than that of the other two species.

Specific differences were noted in the prostate glands of *Gyraulus huronensis,* when compared to the other two species. The prostate gland diverticulae in *G. huronensis* appear to be connected directly to the sperm duct. In *G. parvus* and *G. circumstriatus,* the prostate diverticula are connected to a prostate gland duct which joins the sperm duct from the distal end of the prostate gland. Also, the overall shape of the prostate gland is different in *G. huronensis* in comparison to *G. parvus* and *G. circumstriatus.* In *G. parvus* and *G. circumstriatus,* the distal-most prostate gland diverticulum is not noticeably smaller than those diverticula next to it. In some specimens it is larger. In *G. huronensis,* on the other hand, the size of the distal-most diverticula decrease gradually in length. Further, in *G. huronensis,* the proximal end of the vas deferens is noticeably wider than in the other two species. *Gyraulus huronensis* has more diverticula (ca. 13-16), while in *G. parvus* and *G. circumstriatus* the numbers of diverticula are less, generally 7-10.

The characteristics (other than heavier pigmentation in *Gyraulus huronensis*) of the digestive system in *G. parvus, G. circumstriatus* and *G. huronensis* are so similar that no specific differences could be discerned. Many black melanin pigment granules are distributed around the stomach, renal tube and kidney in all three species, but the melanin is more dense in *G. huronensis.*

The habitat differences among the three species of *Torquis* are striking. *Gyraulus huronensis* is found on rocks on the open shore exposed to heavy wave action. *Gyraulus parvus* is found in quieter habitats - in small lakes, ponds, swales and roadside ditches (but in perennial waters). *Gyraulus circumstriatus* is found in more ephemerial habitats - temporary woods pools, intermittent streams, transient seepage areas, etc.

In comparison with Eurasian species (*e.g.,* see Meier-Brook, 1983), the species that seems closest to *Gyraulus huronensis* in morphological characters is *G. piscinarum* (Beck). The type locality of *G. piscinarium* is Baalbeck [Baalbek, eastern Lebanon]; Meier-Brook's material was from Diyarbakir, Turkey. *Gyraulus huronensis* differs from *G. piscinarum* in shell color, shape and sculpture, and internally in the shape of the spermatheca. The shell of *Gyraulus piscinarum* is described as "dark-corneous to light brown," and is shown to be more depressed, to have an angular body whorl and patches of spiral striae. The prostate gland of *G. piscinarum* is illustrated as being similar to that of *G. huronensis*, except for the equal-sized distal folicles. The spermatheca of *G. piscinarum* is described as "the spherical tadpole type," which differs from that of *G. huronensis* (Fig. 4).

REFERENCES

BAKER, Frank Collins. 1928. *The fresh water Mollusca of Wisconsin*. Wisconsin Geological and Natural History Survey, Bulletin 70, Pt. 1, pp. i-xx, 1-507, pls. 1-28.

BAKER, Frank Collins. 1945. *The molluscan family Planorbidae*. Pp. 1-530, University of Illinois Press, Urbana, Illinois.

BURCH, J. B. 1989. *North American freshwater Snails*. Malacological Publications, Hamburg, Michigan, U.S.A. Pp. i-viii, 1-365.

RIDGEWAY, Robert. 1912. *Color standards and color nomenclature*. Published by the author, Washington, D.C., U.S.A. Pp. i-iv, 1-44, 53 pls.

MEIER-BROOK, Claus. 1983. Taxonomic studies on *Gyraulus* (Gastropoda: Planorbidae). *Malacologia*, 24(1-2): 1-113.

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LOPING LOCOMOTION IN TERRESTRIAL GASTROPODS

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ABSTRACT: When gastropods lope, the sole forms arches and contact points through which the body and sole of the gastropod flow, leaving a dotted mucous trail. Contrary to earlier reports, loping is not faster than ordinary gliding locomotion in which the whole sole is in contact with the substrate. Loping may benefit the gastropod by conserving moisture, or by reducing contact with irritating substrates. Loping is reported for the first time in a terrestrial slug, and for some other species not previously known to lope.

Key words: locomotion, loping, galloping, terrestrial gastropod, Stylommatophora, land snail, slug.

INTRODUCTION

Loping is an uncommon form of progression known in only a few species of land gastropods. Loping differs from the ordinary gliding progression of most large land pulmonates. In loping motion, first described by Carlson (1905), the gastropod lifts its head from the substrate and thrusts it forward, then replaces its head on the substrate forming a low arch in the sole, behind the head, through which the rest of the body flows to the new point of contact (Fig. 1). More than one arch may be present at a time. The process is repeated with the body flowing steadily through arches and points of contact, until the animal reverts to ordinary gliding progression.

The points of contact with the substrate remain stationary, so that the mucous trail left during loping motion consists of a series of more or less elongated dots. This is in contrast to the continuous mucous trail formed during ordinary gliding progression, when the entire sole of the foot is in contact with the substrate. Dotted mucous trails have been illustrated for *Helminthoglypta dupetithouarsi* by Carlson (1905) and for *Helix aspersa* by Taylor (1910: 243).

Here I review the literature on loping in land gastropods, I discuss four hypotheses for the utility of loping motion, I show that loping is not faster than ordinary progression, I provide

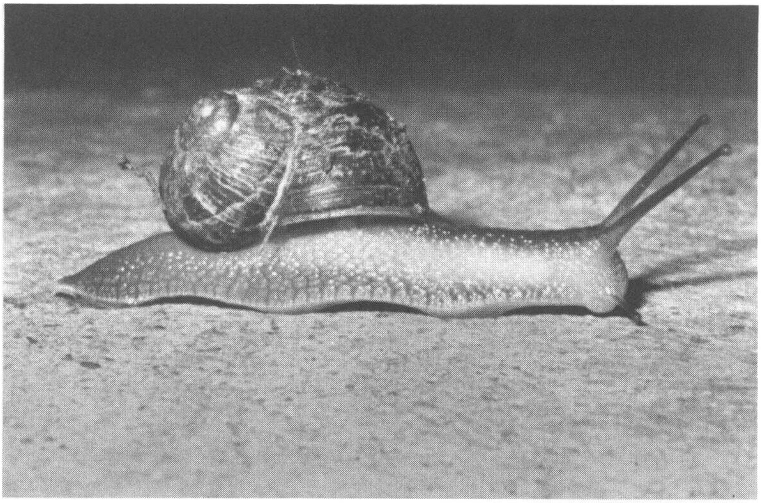

FIG. 1a. *Helix aspersa* loping on dry concrete, with three arches and four points of contact between the sole and the concrete. The shell in Figs. 1a-1c is about 28-30 mm in diameter.

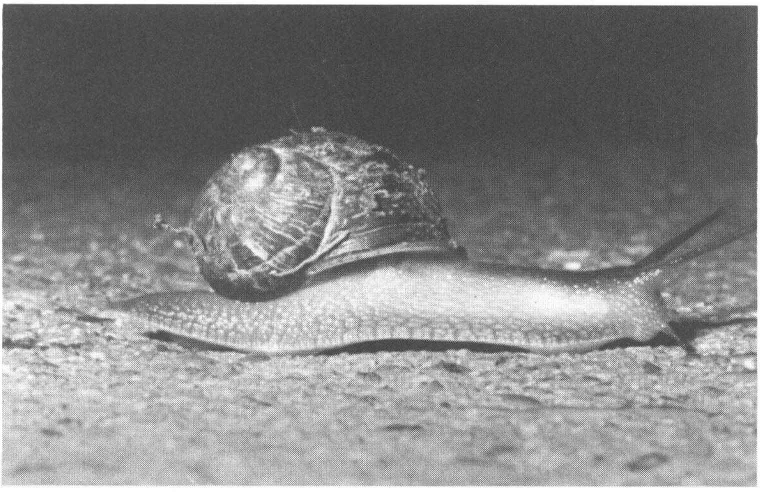

FIG. 1b. *Helix aspersa* loping on dry concrete, with one arch and two points of contact between the sole and the concrete. The same individual is pictured in Figs. 1a and 1b.

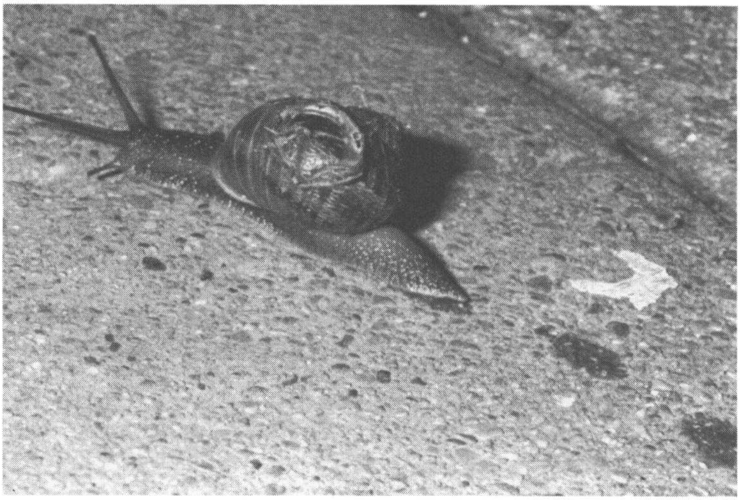

FIG. 1c. *Helix aspersa* loping on dry concrete. Two spots of the dotted mucous trail are visible behind the snail, and a third dot is apparent beneath the tail. The circular mark on the shell is the remains of a mucous seal where another snail had been estivating.

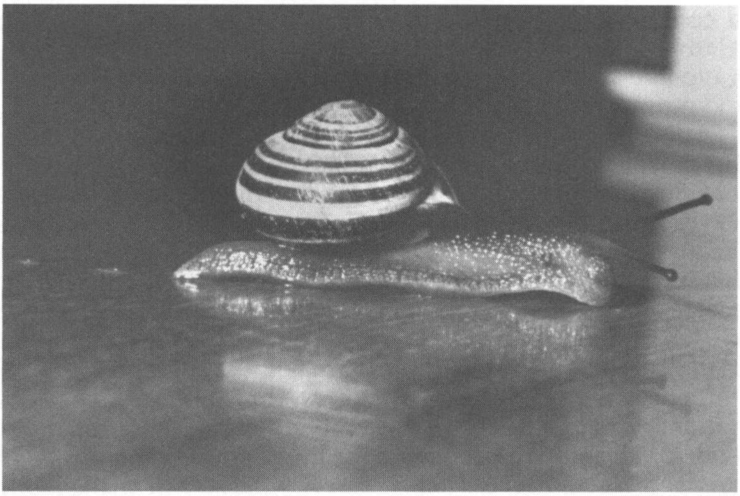

FIG. 1d. *Cepaea nemoralis* loping on a dry formica table top. Note the two clumps of mucus behind the snail showing where the foot had been in contact with the table top. The shell is about 20-22 mm in diameter.

the first verified account of loping in terrestrial slugs, and I report loping in species not previously known to lope.

I use the term loping (used by Parker, 1937; Gray, 1968; Trueman, 1975) rather than galloping (used by Carlson, 1905; Parker, 1911) to describe this form of locomotion in land gastropods because loping connotes steady motion, while galloping implies incorrectly that this form of locomotion is more rapid and discontinuous. Furthermore, the term galloping has been applied to a similar but distinct form of retrograde locomotion in the sea hare *Aplysia californica* Cooper 1863 (Parker, 1917; Morton, 1964; Audesirk & Audesirk, 1985). Galloping has been studied neurologically in *Aplysia,* and galloping seems an appropriate term for that discontinuous form of locomotion that is more rapid than ordinary locomotion (Parker, 1917; Audesirk & Audesirk, 1985; Carefoot, 1987).

LOPING

Carlson (1905) suggested that loping is an exaggeration of the small waves of progression in ordinary gliding locomotion. However, subsequent authors have recognized loping as a phenomenon different from gliding motion (Parker, 1937; Gray, 1968; Jones, 1973). In ordinary gliding progression, small waves of contraction move along the foot from posterior to anterior relative to the body and relative to the ground. In loping, the wave-like arches are stationary with respect to the ground, and move posteriorly relative to the body.

Ordinary contraction waves moving anteriorly are called direct waves. Some gastropods move using retrograde waves that move posteriorly. Some authors have referred to loping waves as retrograde, because they move posteriorly relative to the animal. However, Jones (1978) stressed the importance of distinguishing what he termed stationary waves that move posteriorly relative to the animal, but are stationary relative to the ground, from ordinary retrograde waves that move posteriorly relative to both the animal and the ground.

Because the body flows smoothly through the arches and stationary points of contact in loping motion, there must be a mode of locomotion propelling the body through the stationary points. Indeed, Parker (1937) observed the sole of snails loping on glass and found that the direct waves of progression of ordinary gliding are present in combination with stationary waves. The two types of waves occur simultaneously and without interference, and direct waves always precede loping

(Parker, 1937; Jones, 1973). This pattern is similar to the two modes of locomotion in land planarians, in which loping waves are superimposed on the ordinary ciliary mode of progression (Gray, 1968; Jones, 1978).

UTILITY OF LOPING

I discuss four hypotheses for the utility of loping. The most prevalent hypothesis in the literature is that (1) loping is faster than ordinary gliding. Other hypotheses are that (2) loping conserves water, (3) loping decreases contact with irritating substrates, and (4) loping discourages trail following by predators.

(1) The idea that loping is faster than ordinary gliding is prevalent in the literature (Carlson, 1905; Parker, 1937; Gray, 1968; Jones, 1975; Trueman, 1983: 166). This idea is apparently prevalent because authors have uncritically repeated anecdotal accounts that loping is faster.

The original description of loping (Carlson, 1905) suggested that loping is faster than ordinary gliding, and that snails may employ loping when escaping from an enemy. However, Carlson illustrated mucous tracks from both fast and slow moving snails in loping motion (larger snails crawling slower have areas of contact with the substrate that are larger and closer together, sometimes fused), and reported that loping sometimes occurs when no threat is apparent, indicating that the speed of loping snails may vary from fast to slow.

A biomechanical analysis of loping suggests most forward propulsion comes from ordinary motion, and that stationary waves alone can provide little forward propulsive force. Jones (1978) reported that loping has been noted in three species of land planarians, and provided a theoretical model for loping in those species. Planarians glide using cilia rather than the small contraction waves of terrestrial pulmonates, but otherwise loping motion in the two groups of animals is very similar. The model suggested that loping in combination with ordinary gliding would be theoretically faster than ordinary progression alone due to the thrusting forward of the head. The slight increase of speed in loping might not be large enough to observe easily.

My observations of loping in *Xerarionta kelletti, Helix aspersa, Cepaea nemoralis* and *Arion circumscriptus* do not confirm the assertion that loping is faster than gliding progression. My measurements of speed in *C. nemoralis* moving on dry and wet concrete blocks show that loping speed is not significantly faster from gliding speed (p>0.05) (ordinary motion on wet concrete: mean 57.1 mm/min, st. dev. 12.7, maximum 74 mm/min, N=13; loping on wet concrete: mean 51.1 mm/min, st. dev. 7.6, maximum 64 mm/min, N=7).

(2) Land gastropods may lope to preserve moisture. Pantin (1950) suggested that loping in land planarians is much more economical of mucus and water than is ordinary gliding, as loping animals leave a dotted slime trail. Jones (1978) noted that the land planarian *Microplana terrestris* (Müller) does not lope in air near maximum humidity, but will lope at lower humidity. Jones (1978) suggested loping might conserve water in gastropods as well as in land planarians. Pilsbry (1939: 136-137) noted that Carlson's (1905) snails may have loped because they were on a dry surface. My observations (unpubl.) suggest that the incidence of loping increases as moving snails become drier.

Loping gastropods have been observed on various dry substrates. Carlson (1905) observed loping on a dust covered table, but not on a paper coated with lampblack. I have observed loping on formica table surfaces, a vinyl chair, a human hand, and on concrete walkways. I have not succeeded in inducing gastropods to lope on glass, although Parker (1937) observed snails loping on glass, and Pantin (1950) observed land turbellarians loping on glass in the laboratory.

A difficulty with the hypothesis that loping conserves moisture is that animals have been observed to lope on wet surfaces. Loping seems less common on moist surfaces, but *Helix aspersa* has been observed loping on damp brick walkways (Parker, 1937) and I have observed loping in *Cepaea nemoralis* on a moist concrete block.

(3) Animals may lope when traveling on irritating substrates. My observations suggest that snails are more easily induced to lope on concrete than on the other substrates mentioned above. Some of the ingredients used in making concrete are caustic. The foot of *Cepaea nemoralis* was shorter and the snails moved more slowly when on a concrete block than on a formica table top. If concrete is chemically irritating to snails, they might lope to reduce contact with the irritant. This might explain why snails lope more on moist concrete than on other moist substrates.

(4) Leaving dotted mucous trails might discourage mucous trail following by predators. If loping is useful for discouraging trail following by predators, predatory snails should have less

success at tracking loping snails than ordinarily gliding snails. However, many predators can readily detect airborne odors, so dotted mucous trails may not be effective in deterring trail following. This hypothesis could be tested with experiments using predatory snails such as *Euglandina rosea* (Férussac 1821).

If loping is beneficial to gastropods, one might expect loping to occur more often and to be more widespread among gastropods than present knowledge indicates it is. Perhaps loping progression is more energetically costly than gliding. Loping may also have certain physical constraints. For example, I have never observed loping on vertical surfaces, which suggests that loping snails may be less tenacious than gliding snails.

Loping can be predicted to occur more often in water-stressed animals (that have already lost a certain amount of moisture), in low humidity situations, and in animals moving on absorbant or irritating surfaces. Experiments could assess the relative contribution of these various factors to loping. Comparing weights of freshly-made mucous trails from gastropods in loping and those in gliding motion would demonstrate whether loping reduces the loss of water in dotted mucous trails more than continuous mucous trails. Experiments could examine whether the major benefit to the gastropod is from conserving water, or conserving the non-water part of mucus.

TAXONOMIC DISTRIBUTION OF LOPING

Jones (1975) and Trueman (1983) speculated that loping may be widespread among terrestrial pulmonates. However, the few reports of loping in land snails indicate a narrow taxonomic distribution of loping (Table 1).

Loping in terrestrial slugs has not been verified previously. Carlson (1905) did not observe loping in the slugs *Limax* or *Deroceras*. I have been unable to induce loping in the slugs *Arion subfuscus* (Draparnaud 1805) or *D. reticulatum* (Müller 1774). Jones (1975) suggested that observed dotted slime trails may have been made by unidentified species of slugs, but the slugs were not observed making the slime trails. Pilsbry & Brunson (1954) showed a photograph of the slug *Magnipelta mycophaga* with a wave in the foot that may have been the start of a lope, but they did not discuss it. My observations of loping in *A. circumscriptus* are the first verified reports of loping in land slugs.

The fact that some land Turbellaria and some stylommatophoran Pulmonata lope raises the question whether loping may

TABLE 1. Species of land gastropods known to lope.

Species	Reference
Arionidae	
Arion circumscriptus Johnston 1828	personal observation
Magnipelta mycophaga Pilsbry 1953	Pilsbry & Brunson, (1954) (photo only)
Helminthoglyptidae	
Helminthoglypta dupetithouarsi (Deshayes 1840)	Carlson (1905), Parker (1937)
Xerarionta kelletti (Forbes 1850)	personal observation
Helicidae	
Helix aspersa Müller 1774	Taylor (1910: 243), Parker (1937), personal observation
Helix pomatia Linnaeus 1758	Biedermann (1905)
Cepaea hortensis (Müller 1774)	Biedermann (1905), Robert (1908)
Cepaea nemoralis (Linnaeus 1758)	personal observation
Helicodonta obvoluta (Müller 1774)	Pilsbry (1939: 137)

be primitive to the common ancestor of Turbellaria and Gastropoda, or whether loping represents convergence in locomotion by the Turbellaria and Stylommatophora. Because the ordinary locomotion upon which stationary waves of loping is superimposed differs between the two groups (ciliary in Turbellaria, by direct waves in those Stylommatophora known to lope), and loping is unknown in the majority of terrestrial gastropods, it is more likely that loping has been developed independently in Turbellaria and Stylommatophora, and possibly more than once within Stylommatophora.

LITERATURE CITED

AUDESIRK, T. & AUDESIRK, G. 1985. Behavior of gastropod molluscs. Chapter 1, pp. 1-94. In: Willows, A.O.D. (ed.), *The Mollusca, Volume 8, Neurology and Behavior, Part 1.* Academic Press, London, etc. 415 pp.

BIEDERMANN, W. 1905. Studien zur vergleichenden Physiologie der peristaltischen Bewegungen. II. Die locomotorischen Wellen der Schneckensohle. *Archiv für die Gesammte Physiologie des Menschen und der Thiere*, 107: 1-56.

CAREFOOT, T.H. 1987. *Aplysia*, its biology and ecology. *Oceanography and Marine Biology, Annual Review*, 25: 167-284.

CARLSON, A.J. 1905. The physiology of locomotion in gastropods. *Biological Bulletin of the Marine Biology Laboratory of Woods Hole*, 8: 85-92.

GRAY, J. 1968. *Animal locomotion*. Norton & Company, Inc. New York. 479 pp.

JONES, H.D. 1973. Mechanism of locomotion of *Agriolimax reticulatus* (Mollusca - Gastropoda). *Journal of Zoology*, London, 171: 489-498.

JONES, H.D. 1975. Locomotion. Pp. 1-32. In: Fretter, V. & Peake, J. (eds.), *Pulmonates. I. Functional Anatomy and Physiology*. Academic Press, London, etc. 417 pp.

JONES, H.D. 1978. Observations on the locomotion of two British terrestrial planarians (Platyhelminthes, Tricladida). *Journal of Zoology*, London, 186: 407-416.

MORTON, J.E. 1964. Locomotion. Chapter 12, pp. 383-423. In: Wilbur, K.M. & Yonge, C.M. (eds.), *Physiology of Mollusca*. Academic Press, London, etc. 1: 1-473.

PANTIN, C.F.A. 1950. Locomotion in British terrestrial nemertines and planarians: with a discussion on the identity of *Rhynchodemus bilineatus* (Mecznikow) in Britain, and on the name *Fasciola terrestris* O.F. Müller. *Proceedings of the Linnean Society of London*, 162: 23-37.

PARKER, G.H. 1911. The mechanism of locomotion in gastropods. *Journal of Morphology*, 22: 155-170.

PARKER, G.H. 1917. The pedal locomotion of the sea-hare *Aplysia californica*. *Journal of Experimental Zoology*, 24: 139-145.

PARKER, G.H. 1937. The loping of land snails. *Biological Bulletin of the Marine Biological Laboratory of Woods Hole*, 72: 287-289.

PILSBRY, H.A. 1939. *Land mollusks of North America (north of Mexico)*. Academy of Natural Sciences of Philadelphia, Monograph 3, 1(1): i-xvii, 1-573, i-ix.

PILSBRY, H.A. & BRUNSON, R.B. 1954. The Idaho-Montana slug *Magnipelta* (Arionidae). *Notulae Naturae*, (262): 1-6.

ROBERT, A. 1908. Seconde note sur la progression des gastéropodes. *Bulletin de la Société Zoologique de France*, 33: 151-157.

TAYLOR, J.W. 1910. *Helix aspersa* Müller. Pp. 236-273. In: Taylor, J.W., 1907-1914, *Monograph of the Land and Freshwater Mollusca of the British Isles*. Taylor Brothers Publishers. Leeds. 522 pp.

TRUEMAN, E.R. 1975. *The locomotion of soft-bodied animals*. Arnold, London. 200 pp.

TRUEMAN, E.R. 1983. Locomotion in molluscs. Chapter 4, pp. 155-198. In: Saleuddin, A.S.M. & Wilbur, K.M. (eds.), *The Mollusca, Volume 4, Physiology, Part 1*. Academic Press, London, etc. 523 pp.

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Walkerana, 1989, 3(10): 239-261

DISTRIBUTIONAL RECORDS FOR FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE) IN FLORIDA AND SOUTH ALABAMA, WITH ZOOGEOGRAPHIC AND TAXONOMIC NOTES

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ABSTRACT - New distributional records are presented for Florida and south Alabama unionids. The data represent recent collections, unpublished museum records and corrected literature records. The first substantiated records of *Ptychobranchus jonesi* in Florida, from specimens collected over 50 years ago in the Choctawhatchee River system, are given. *Anodonta suborbiculata*, not collected in Florida for 70 years, has recently been rediscovered in the Escambia River. The type locality for *Lampsilis haddletoni*, known only from the two specimens of the type series, is corrected to read Choctawhatchee River, West Fork, seven miles southeast of Ozark, Dale County, Alabama. Earlier reports of *Amblema perplicata* from the Yellow River are in error; the published locality data actually represent a Choctawhatchee River system record. In addition to *A. perplicata*, *Villosa villosa* also occurs in the Choctawhatchee River system, thus representing eastward and westward, respectively, range extensions for these two species. The ranges of *Anodonta grandis* and *A. peggyae* are extended westward to the Escambia River system. *Lampsilis teres* has been found in the Hillsborough River, thus extending its range southward. No longer considered an endemic of the Choctawhatchee River system, *V. choctawensis* also occurs in the Yellow and Escambia river systems. New drainage records for *Elliptio icterina* (Aucilla River), *Glebula rotundata* (Choctawhatchee River), *Medionidus penicillatus* (Choctawhatchee River), *Toxolasma paulus* (Alafia River), *Uniomerus caroliniana* (Waccasassa River), *V. vibex* (Alafia and St. Marys rivers) and *V. villosa* (Alafia, St. Marks and Waccasassa rivers) are herein reported. *Elliptio icterina* represents the only unionid record known from the Aucilla River system. These records add from one to four species to the known unionid fauna of nine drainages in the Apalachicolan Region of Florida and south Alabama and Peninsular Florida.

One genus (*Elliptoideus*) and at least 32 species are endemic to the Apalachicolan Region and Peninsular Florida, an important area for speciation and endemism, where endemics comprise 56% of the unionid fauna. The Apalachicola River system and secondarily the Escambia and Choctawhatchee rivers are thought to have been major centers of species origin. Lowland species and species generally found in small streams draining into the Gulf of Mexico may have extended their ranges via lowland dispersal routes created by broadscale flood events, possibly during sea level recessions. Mainstem convergences during sea level regressions of the Late Miocene and Late Pliocene have possibly facilitated dispersal of several species characteristic of larger rivers.

Stream captures are also thought to have played a substantial role in the dispersal of unionids characteristic of headwater tributaries, especially in the Apalachicolan Region. Evidence suggests two major centers of dispersal in the Apalachicolan Region; from the Escambia east towards the Choctawhatchee River, and from the Apalachicola River eastward. An Early Pliocene marine terrace, the Cody Scarp has apparently influenced the distributions of *Amblema perplicata*, *Fusconaia rotulata* and *Glebula rotundata*; the Apalachicolan Region distribution of all three species is restricted to localities downstream of the Cody Scarp. The possibility of valid but presently synonomized species is discussed. The current state of taxonomic confusion hinders attempts to clarify unionid zoogeography.

Key words: freshwater Bivalvia, distribution, zoogeography, taxonomy, Florida, Alabama.

INTRODUCTION

Florida and south Alabama unionid clams have been of considerable interest to malacologists. During the 1800's studies consisted primarily of descriptions of new species. Walker (1905) reported on collections of shells from the Chipola River and a tributary of Econfina Creek in northwest Florida. Based on extensive collections made primarily by C. A. and J.A. Burke between 1915 and 1918, van der Schalie (1940) discussed unionid distributions in the Chipola River, an Apalachicola River tributary.

In the early 1950's, Clench & Turner (1956) made numerous collections in drainages from the Escambia to the Suwannee rivers. Combined with earlier records, their work remains the benchmark treatise of the region's unionid fauna. Athearn (1964) described two new species from the Choctawhatchee River and presented conchological evidence for separating *Villosa australis* (Simpson 1900) from *Ptychobranchus jonesi* (van der Schalie 1934), two species which Clench & Turner (1956) considered to be synonyms.

Johnson (1965, 1967a, 1968, 1969, 1970) reported on unionid distributions and systematics in eastern Gulf of Mexico drainages and the St. Marys River of the Atlantic Slope while adding to the fauna a new species, *Anodonta peggyae* Johnson 1965, and several species overlooked by previous investigators. Johnson (1972) also published on the unionids of Peninsular Florida, covering drainages south of the Suwannee and St. Marys rivers.

Fuller & Bereza (1973) and Burch (1975) further refined the ranges of some eastern Gulf drainage endemics. The genus *Medionidus* was monographed by Johnson (1977), and included the known distributions of the three Gulf drainage species. The only comprehensive work encompassing the unionid fauna of Florida was Heard's (1979) identification manual, which included species lists for most of the state's major drainage systems.

Despite the number of studies that have considered unionid distributions in Florida and south Alabama, large sections of numerous rivers and their tributaries remain inadequately, or sometimes totally, unsampled. Athearn (1964) made note of the fact that streams in west Florida were poorly collected. Because of the dearth of records from the Yellow River and other small streams entering the Gulf of Mexico, Clench & Turner (1956: 105) omitted them completely in a table summarizing unionid occurrences in eastern Gulf drainages. The Florida portions of the Escambia, Yellow, Apalachicola, Ochlockonee (below Talquin Reservoir) and Aucilla river mainstems are virtually unsurveyed. Although numerous lots of material from sites along the mainstem Choctawhatchee River are housed at the Florida Museum of Natural History, most of the collections were made over half a century ago.

The intent of this study is to augment and further clarify unionid distributions in this region. Miscellaneous notes concerning zoogeography and taxonomy of study area unionids are also included.

METHODS

The distributional records presented herein were obtained from recent collections (personal or otherwise), unpublished museum records and corrected literature records. The author is understood to be the collector unless otherwise stated. Museum records were gathered from Florida Museum of Natural History (UF), Ohio State University Museum of Zoology (OSUM) and The University of Michigan Museum of Zoology (UMMZ). The number of specimens in a lot appears in parentheses after the museum designation and catalog number. Voucher specimens for new records collected by the author are deposited in the Florida Museum of Natural History. Scientific and common names generally follow Turgeon *et al.* (1988).

The Apalachicolan Region as defined by Clench & Turner (1956) is used in this study (Gulf of Mexico drainages from the Escambia to the Suwannee rivers). Peninsular Florida is considered to include the remaining drainages of Florida inclusive of the Waccasassa and St. Johns rivers south (Johnson, 1972), in addition to the St. Marys River, which has a lowland unionid fauna very similar to that of the St. Johns. These two regions are collectively referred to as the study area. The Panhandle comprises Florida portions of drainages from the Escambia to the Ochlockonee rivers, while the Big Bend region encompasses small, lowland drainages between, but not including, the Ochlockonee and Suwannee rivers. Species ranges generally consider only that portion occurring in the study area (for complete range information, see Burch, 1975). Fig. 1 identifies river systems for which new drainage records are presented as well as drainages mentioned in the discussion. Econfina Creek of the Florida Panhandle should not be confused with Econfina River, located to the east in the Big Bend region. Standard state and directional (compass) abbreviations are used in locality information. Distances appearing in locality data of personal collections are expressed in kilometers (km) while distances for many museum records may be expressed in miles (mi). Where measurements (in millimeters) appear in the text, L = length (anterior to posterior extremities), H = height (dorsal to ventral extremities) and W = width (obesity).

SPECIES ACCOUNTS

Amblema perplicata (Conrad 1841)
(Roundlake)

Amblema perplicata is reported from the Escambia and Yellow rivers in Alabama and Florida (Johnson, 1970; Burch, 1975). The Yellow River record was based on Johnson's (1970: 270) assumption that Picket Wretch Lake, Walton County, Florida, is in that system, when actually it is in the Choctawhatchee River system. Specimens from this site collected in August 1934 by L. M. Rushing are cataloged UF 1481 (3) and UF 3231 (1). The following additional collections are from the Choctawhatchee River, Walton County, Florida: Cowford Ferry, August 1934, L. M. Rushing, UF 3237 (2); Yellow Bluff, UF 3236 (2); and Oakey Bend, UF 3233 (1); the latter two collections made presumably in October 1933 by D. B. Gillis.

Anodonta grandis Say 1829
(Giant floater)

Johnson (1970) listed the range of *Anodonta grandis* in the Apalachicolan Region as the Choctawhatchee, Apalachicola

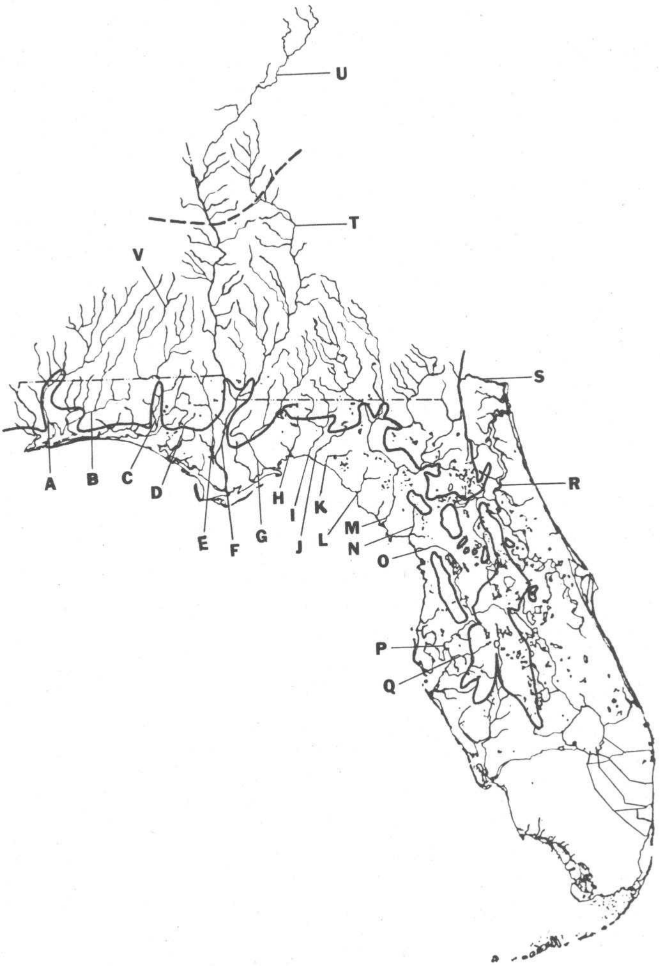

FIG 1. Drainage map (modified from Heard, 1979) of river systems comprising the Apalachicolan Region and Peninsular Florida. Drainages with new unionid records and other drainages mentioned in the discussion are identified: A) Escambia; B) Yellow; C) Choctawhatchee; D) Econfina Creek; E) Chipola; F) Apalachicola; G) Ochlockonee; H) St. Marks; I) Aucilla; J) Econfina River; K) Fenholloway; L) Steinhatchee; M) Suwannee; N) Waccasassa; O) Withlacoochee; P) Hillsborough; Q) Alafia; R) St. Johns; S) St. Marys; T) Flint; U) Chattahoochee; V) Pea. The bold solid line depicts the approximate location of the Cody Scarp, an Early Pliocene high-sea stand about 30 m above present mean sea level. The bold dashed line depicts the approximate location of the Fall Line, the divide between the Piedmont and Coastal Plain physiographic provinces.

and Ochlockonee river drainages. Johnson (1970) also stated that Clench & Turner's (1956) records for *Anodonta gibbosa* Say, 1824 in this area were apparently *A. grandis*. *Anodonta grandis* also occurs in the Escambia River system, Conecuh River, Alabama, author and W.H. McCullagh: US hwy. 231 crossing, Pike County, 27 August 1988, UF 134931 (1); and US hwy. 29 crossing, below Gantt Dam, Covington County, 28 August 1988, UF 134932 (1). An additional collection is representative of the Escambia River system, Florida: Chumuckla Springs, Santa Rosa County, 3 June 1988, author, R. S. Howard and D. Nowling, UF 134929 (2).

Anodonta peggyae Johnson 1965
(Florida floater)

In his description, Johnson (1965) reported that *Anodonta peggyae* ranged from the Choctawhatchee to Hillsborough rivers. Heard (1979) also included the Yellow River in Florida as being within the species range. The range of *A. peggyae* is extended to the Escambia River system based on the following collections from Santa Rosa County, Florida, May 1917, C. A. Burke: Chumuckla Springs, UMMZ 163896 (24); and Escambia River, near McDavis, UMMZ 163571 (1).

Anodonta suborbiculata Say 1831
(Flat floater)

In 1917, C. A. Burke collected a specimen of *Anodonta suborbiculata* from Chumuckla Springs, Escambia (actually Santa Rosa) County, Florida, UMMZ 101375 (1). W. H. Heard (pers. comm.) considered this the only known record for Florida. Recent efforts to secure additional specimens at Chumuckla Springs proved unsuccessful. However, the species was rediscovered in the Escambia River, Florida hwy. 4 crossing, Escambia-Santa Rosa counties, Florida, 3 June 1988, UF 134930 (1). The small specimen was estimated to be about four years old and found in riverine habitat, generally non-typical for *Anodonta suborbiculata* (Johnson, 1980; Gordon, 1984), at a well collected site. The occurrence of *A. suborbiculata* in Florida should be considered sporadic at best.

Elliptio icterina (Conrad 1834)
(Variable spike)

Elliptio icterina is a highly variable form with numerous synonyms (Johnson, 1970, 1972) and is most likely a species complex. Since the type locality is in the Savannah River, it is possible that *E . icterina sensu stricto* does not occur in the study area. However, due to the fact that the specific epithet has been widely used in the literature in referring to Florida region forms (Johnson, 1970, 1972; Burch, 1975; Heard, 1979), *icterina* is used here simply for the purpose of reducing confusion.

Although *Elliptio icterina* has been reported from most drainages in the study area (Johnson, 1970, 1972; Heard, 1979), records were, up to now, not available for the Aucilla River. Specimens of *E. icterina,* collected at the US hwy. 27 crossing of the Aucilla River, Taylor-Jefferson counties, Florida, 28 September 1986, H. G. Lee and W. H. McCullagh, UF 134938 (2), represent the only record for unionids in the Aucilla River system.

Glebula rotundata (Lamarck 1819)
(Round pearlshell)

The Apalachicolan Region distribution of *Glebula rotundata* was reported to be the Escambia and Apalachicola rivers (Clench & Turner, 1956; Johnson, 1970; Heard, 1979). The following represent new drainage records for the Choctawhatchee River system, Walton County, Florida: Oakey Bend Lake, October 1933, D. B. Gillis, UF 3878 (3); and Bushy Point Lake, 1933, D. B. Gillis, UF 3877 (2); both Choctawhatchee River; and Dainley Fish Lake, August 1934, L. M. Rushing, UF 3876 (12) and UF 8401 (1). The present status of *Glebula rotundata* in this system is unknown.

Clench & Turner (1956: 192) considered *Glebula rotundata* to be "exceedingly rare" in the Apalachicolan Region. *Glebula* *rotundata*, however, is actually one of the most commonly en-encountered unionids in Dead Lake (Chipola River) and the lower Apalachicola River. *Glebula rotundata* should be looked for in the lower mainstems of the Yellow and Ochlockonee rivers.

Lampsilis haddletoni Athearn 1964
(Haddleton lampmussel)

Lampsilis haddletoni is known only from the type locality: Choctawhatchee River, West Fork, seven miles southwest of Ozark, Dale County, Alabama (Athearn, 1964; Johnson, 1967a). The West Fork, however, flows east of Ozark, thus making the locality erroneous. The type locality is corrected to read: Choctawhatchee River, West Fork, 7 mi. southeast of Ozark, Dale County, Alabama. This locality is mentioned elsewhere in the publication of the original description (Athearn, 1964: 138)

Lampsilis teres (Rafinesque 1820)
(Yellow sandshell)

In the study area, *Lampsilis teres* was reported in Gulf drainages from the Escambia to the Withlacoochee rivers (Heard, 1979). The range of *Lampsilis teres* is extended south to the Hillsborough River, Hillsborough County, Florida: Florida hwy. 582 crossing, 19 April 1974, H. G. Lee, UF 47282 (17); and Florida hwy. 579 crossing, 4.4 km SSW of Branchton, 7 April 1988, UF 134939 (2).

Medionidus penicillatus (Lea 1857)
(Gulf moccasinshell)

An Apalachicolan endemic, *Medionidus penicillatus* has been collected in Econfina Creek, Chipola and Apalachicola rivers and disjunctly in the Yellow River, Alabama (Johnson, 1977). Museum lots from several sites in the Choctawhatchee River system, Walton County, Florida, were examined: Choctawhatchee River, east of Red Bay, October 1933, D. B. Gillis, UF 4139 (2); Limestone Creek, August 1933, D. B. Gillis, UF 4151 (8); Sandy Creek, September 1933, D. B. Gillis, UF 4147 (1); and Bruce Creek, July 1933, D. B. Gillis, UF 4157 (1). The current status of *Medionidus penicillatus* in the Choctawhatchee River system is uncertain.

Ptychobranchus jonesi (van der Schalie 1934)
(Southern kidneyshell)

Burch (1975) stated that the distribution of *Ptychobranchus jonesi* was the Choctawhatchee River system of Alabama and Florida and the Escambia River system in Florida. However, there was no mention of specific Florida records for *Ptychobranchus jonesi* by van der Schalie (1934), Athearn (1964), Johnson (1967a), Fuller & Bereza (1973) nor Heard (1979). The first substantiated Florida records are from the Choctawhatchee River system, Walton County: Sam Stacey's Landing, Choctawhatchee River, (presumably 1933), D. B. Gillis, UF 8429 (1); and Sandy Creek, September 1933, D. B. Gillis, UF 8430 (1). The present status of *P. jonesi* in Florida is unknown.

Toxolasma paulus (Lea 1840)
(Iridescent lilliput)

Toxolasma paulus, as *T. parvus* (Barnes, 1823), has been collected in most of the major drainages of the study area from the Hillsborough and Kissimmee rivers north (Johnson, 1972; Heard, 1979). A small Peninsular Gulf drainage south of the Hillsborough River, the Alafia River system also contains *T. paulus*: Fish Hawk Creek, 3.8 km southwest of Lithia, Hillsborough County, Florida, 2 March 1988, UF 134933 (26).

Uniomerus caroliniana (Bosc 1801)
(Florida pondhorn)

Heard (1979) reported *Uniomerus caroliniana* from most of the major drainages of Florida. A population also exists in Waccasassa River, Alternate US hwy. 27 crossing, Levy County, Florida, 6 July 1988, UF 134928 (9). Other small, poorly surveyed rivers draining Florida's Gulf coast may harbor additional populations of *Uniomerus caroliniana*.

Villosa choctawensis Athearn 1964
(Choctaw bean)

Villosa choctawensis was thought to be endemic to the Choctawhatchee River system (Athearn, 1964; Johnson, 1967a, 1970; Burch, 1975; Heard, 1979), recent collections extend the range of *Villosa choctawensis* into the Yellow River in Alabama and Florida and the Escambia River system in Alabama. Yellow River mainstem localities include: 12.3 mi south southeast of Andalusia, Covington County, Alabama, 16 September 1973, B. Wall and H. Harima, OSUM 34713 (2); and Florida hwy. 2 crossing, 7.2 km east of Blackman, Okaloosa Co., Florida, 2 June 1988, UF 135794 (2). The following represent records for the Escambia River system, Alabama: Pigeon Creek, 7.7 mi east southeast of Greenville, Butler County, 9 October 1986, F. G. Thompson, UF 123279 (1); Patsaliga River, at Horton's Lake, 10 mi N of Searight, Crenshaw County, July 1915, C. A. Burke, UF 134937 (1); and Little Patsaliga Creek, Alabama hwy. 50 crossing, at Potsburg, Crenshaw County, 1 October 1967, H. G. Lee, OSUM 23432 (1). Although no specimens are known from the Florida portion of the Escambia River system, *Uniomerus caroliniana* may also occur there.

Villosa vibex (Conrad 1834)
(Southern rainbow)

Villosa vibex is generally distributed throughout most of the study area (Johnson, 1970, 1972; Burch, 1975; Heard, 1979).

However, published records for the St. Marys River system were, up to now, lacking. Specimens from the St. Marys drainage were collected from the following tributary: Brandy Branch, US hwy. 301 crossing, Nassau County, Florida, 19 June 1988, author and J. D. Williams, UF 134934 (1).

Although Johnson (1972: 189) failed to note *Villosa vibex* in the Alafia River, his list of specimens examined (Johnson, 1972: 238) included a record (under Hillsborough River System) for Fish Hawk Creek, near Lithia, Hillsborough County, Florida. The presence of *Villosa vibex* in the Alafia River system has been substantiated by a recent collection from Fish Hawk Creek, 3.8 km southwest of Lithia, Hillsborough County, Florida, 2 March 1988, UF 134935 (16).

Villosa villosa (Wright 1898)
(Downy rainbow)

Villosa villosa has been recorded from most of the major rivers from the Chipola River eastward to the St. Marys River and southward to the St. Johns and Myakka rivers (Johnson, 1972; Heard, 1979), but has not been reported from several of the smaller drainages within this range. The range of *V. villosa* is extended westward to the Choctawhatchee River system, Florida: Horseshoe Lake, 1933, D. B. Gillis, UF 3159 (42) and September 1934, L. M. Rushing, UF 3161 (5); both Washington County; Bushy Point, UF 3168 (26) and UF 8456 (1); Oakey Bend, UF 3160 (9); and Inlet Lakes, UF 3156 (13); all Walton County, October 1933, D. B. Gillis. Although specimens from these localities are somewhat shinier with more prominent green rays than typical *V. villosa,* they are very similar in most other shell characters. Other Florida drainage records are: St. Marks River, US hwy. 27 Bridge, 1 mi. east of Chaires Crossroads, Leon County, 10 November 1983, G.H. Burgess *et al.*, UF 42670 (2); Waccasassa River, US hwy. 27A crossing, Levy County, 6 July 1988, UF 134936 (10); and Alafia River system, branch of Howell's Creek, 3 mi. south of Plant City, Hillsborough County, 8 November 1934, A. O. Baynard, UF 3638 (5).

Reported to be a rare inhabitant of spring-fed streams and clear rivers (Clench & Turner, 1956), *Villosa villosa* was noted by Johnson (1972: 235) as occurring also in "the rather acidic and muddy St. Marys River." *Villosa villosa* may actually occur abundantly in habitats with slack current, murky water and muddy substrate such as Talquin (Ochlockonee River) and Mosquito Creek (Apalachicola River drainage) reservoirs and Dead Lake of the Chipola River. In such lacustrine habitats specimens may reach great size. The largest of 48 specimens examined from Mosquito Creek Reservoir measured L=85, H=40, W=30. Peninsular riverine populations (*e.g.*, Hillsborough, Withlacoochee and Waccasassa rivers), where the species may also occur commonly, are diminutive in size. Of 29 specimens collected from the Hillsborough River the largest measured only L=42, H=25, W=15.5. Heard (1979) hypothesized that *V. villosa* populations displayed differential life spans; specimens achieve great size (*e.g.*, Mosquito Creek Reservoir) simply because they live longer. Further studies are needed to determine the effects of genetic and environmental factors on growth in *V. villosa.*

DISCUSSION

New Drainage Records

The newly reported drainage records add from one to four species to the previously known unionid faunas of nine streams in the Apalachicolan Region and Peninsular Florida. The addition of *Amblema perplicata, Glebula rotundata, Medionidus penicillatus* and *Villosa villosa* to the Choctawhatchee River fauna brings the total number of species reported there to 24. The presence of *Anodonta grandis, A. peggyae* and *V. choctawensis* in the Escambia River makes 29 species known for the drainage. Six species are recorded from the Alafia River system with the addition of *Toxolasma paulus, V. vibex* and *V. villosa. Villosa villosa* in both the St. Marks and Waccasassa rivers, as well as *Uniomerus caroliniana* in the latter river system, bring the total number of species in these two small drainages to five and four, respectively. The Aucilla River

Elliptio icterina record reported here is the first unionid record known for the Aucilla River system. *Lampsilis teres* in the Hillsborough River, *V. vibex* in the St. Marys River and *V. choctawensis* in the Yellow River increase the totals to nine, five and 14 species, respectively, for these three river drainages.

Not surprisingly, the lack of reported drainage records in much of the study area can generally be attributed to artifacts of sampling. The St. Marys, Alafia and other small river systems with depauperate faunas generally have not been given the collecting effortequivalent to that given larger drainages. Several species may be added to these faunas with more adequate sampling.

Inaccessability is the primary reason for the lack of unionid collections from Panhandle rivers. Few highways have bridged the wide bottomland swamps commonly associated with them. Like large rivers elsewhere in southeastern United States, low water conditions are imperative for adequate sampling. The larger rivers should be floated to ensure better access to mussel beds. In addition, SCUBA is necessary to determine the presence of unionids in deeper river channels.

Speciation and Endemism

Prolonged marine isolation of large river systems has promoted a high degree of speciation and endemism in the study area, especially in the Apalachicolan Region. Portions of the upper Apalachicola River system (Chattahoochee and Flint rivers) occur above the Fall Line, the topographic boundary between the Piedmont and Coastal Plain physiographic provinces (Fig. 1). Drainages of the upper Apalachicola River system have existed since at least Late Mesozoic (Swift *et al.*, 1986) and persisted during subsequent high sea level stands (*e.g.*, Middle Miocene and Early Pliocene) that obliterated several of the adjacent drainages. The age and isolation of the upper Apalachicola River system have made the area an important center of speciation.

The Escambia and Choctawhatchee river drainages have apparently served as important centers of origin as well. The size of their drainage basins, intermediate location between the faunistically rich Mobile Bay and Apalachicola River systems and presence of several species endemic to one or both rivers (and in many cases the intermediate Yellow River) are evidence for this assertion. The origin and dispersal of the unionid fauna of these rivers will be discussed at length in the following section. The Chipola, Ochlockonee and Suwannee rivers may have fostered speciation also; each system contains at least one endemic species (Johnson, 1970; Heard, 1979). Occurrence of endemics possibly indicates either relatively recent evolution or inability of these species to disperse, possibly due to ecological restrictions of the mussels themselves or their host fishes. One endemic genus (*Elliptoideus*) and at least 32 endemic species presently comprise the fauna of the Apalachicolan Region and Peninsular Florida. Endemic species comprise 56% of the unionid fauna in these areas.

Methods and Routes of Dispersal

Considering the lowland nature of much of the Big Bend portion of eastern Gulf coastal Florida, some species should be more generally distributed than past studies have indicated. Dispersal of lowland or small stream species via low, swampy regions could be facilitated during unusually high fresh water conditions that have occurred periodically in Recent as well as over geologic time. Furthermore, drainage divides between many systems in the Big Bend region are ill-defined. Many of the new distribution records presented herein may conceivably be explained via such a dispersal method.

According to Swift *et al.* (1986), the freshwater fish fauna of Big Bend drainages are nearly identical. The fish family Centrarchidae, with several species generally distributed in this area, has been very successful at invading new drainages via swampy, lowland routes (Swift *et al.*, 1977; Bermingham & Avise, 1986), particularly during sea level regressions. It is interesting to note that as a family, centrarchids serve as glochidial host for 35% of the North American unionids for which fish host species are known (Fuller, 1974). Fish hosts for study area unionids are virtually unknown. Centrarchids are excellent candidates, however, due to their widespread distribution, abundant populations and the relatively high percentage of species composing the fish fauna.

With these considerations in mind, rivers such as the St. Marks, Aucilla, Econfina, Fenholloway and Steinhatchee (Fig. 1) would be expected to have very similar unionid faunas. Although Swift *et al.* (1986) showed that the Waccasassa River freshwater fish fauna clustered with rivers to the south (and not Big Bend drainages), its unionid fauna is probably similar to other small, lowland Big Bend streams. However, it should be kept in mind that poorly understood ecological factors may preclude occurrence of certain species from specific drainages, thus accounting for actual gaps in species distributional patterns in the absence of sampling bias. Most of these systems probably contain at least species of the *Elliptio icterina* complex, *Uniomerus caroliniana, Villosa vibex* and *V. villosa.* Prior to this study, from zero to three species were reported from Big Bend streams (Heard, 1979).

Distributions of many large river forms may best be attributed to mainstem convergence, *i.e.,* presently marine-flooded mainstems that were common to two or more existing drainages. Vail & Hardenbol (1979) have traced several sea level regressions of approximately 100 meters since the Late Oligocene. The last major drops occurred during the Late Miocene and Late Pliocene (other lesser sea level regressions took place during the Pleistocene). At these intervals, which lasted up to 1-2 million years for the Late Miocene event, Peninsular Florida was nearly double in size. The area was thought to resemble present-day Florida with low gradient streams and sinkholes (Swift *et al.,* 1986). The occurrence of *Lampsilis teres* in the Hillsborough River could possibly be attributed to mainstem convergence between it and the Withlacoochee River to the north.

Although the Panhandle landmass did not expand to the degree of Peninsular Florida during major sea level regressions, Panhandle mainstems lengthened substantially nonetheless, particularly drainages from the Apalachicola River east. Convergence of river mainstems may account for the limited distribution of *Elliptoideus sloatianus* (Lea, 1840) and *Villosa subangulata* (Lea, 1840) to the Apalachicola and Ochlockonee river systems. A sea level drop of only a few meters could have allowed a union of the Escambia and Yellow rivers (both rivers presently flow into Pensacola Bay) and conceivably resulted in the passage of *Fusconaia escambia* Clench & Turner, 1956 and possibly other species.

Previously known in extreme west Florida from the Escambia River only, the presence of *Amblema perplicata* and *Glebula rotundata* in the Choctawhatchee River may be attributed to a past mainstem confluence between these two drainages. Deviating from its southerly course, the lower Choctawhatchee River (including Choctawhatchee Bay) turns abruptly west for 65 km before emptying into the Gulf of Mexico. The mouth of Choctawhatchee Bay is 55 km east of the mouth of the Escambia River (Pensacola Bay). A number of Apalachicolan Region endemics are shared exclusively by the Escambia and Choctawhatchee rivers, and in most instances the intermediate Yellow River (*e.g.*, *Fusconaia succissa* (Lea, 1852), *Pleurobema strodeanum* (Wright, 1898), *Ptychobranchus jonesi*, *Villosa australis* and *V. choctawensis*, not to mention several more widely distributed species). Furthermore, the freshwater fish fauna of the Escambia and Choctawhatchee rivers is essentially the same (Bailey *et al.*, 1954). Although one or both species may eventually be found in the lower Yellow River, an absence of *Amblema perplicata* and *Glebula rotundata* from the Yellow could possibly be attributed to the smaller size of the drainage and lack of necessary large river habitat.

The occurrence of *Glebula rotundata* in the Apalachicola River system, the easternmost drainage within its range (Burch, 1975), suggests a lowland dispersal route, possibly during lowered sea levels. The endemic *Amblema neislerii* (Lea, 1858) replaces *A. perplicata* in the Apalachicola River system.

Headwater stream captures have probably facilitated dispersal of several unionid species. It is unrealistic to assume that the distributions of the Apalachicolan Region endemics mutually shared by the Escambia, Yellow and Choctawhatchee rivers (see above) is solely attributable to lowland or convergent mainstem dispersal methods. The present configuration of the Pea River, the major western tributary of the Choctawhatchee River (Fig. 1), suggests that it may have once flowed westward into the Yellow River. If this hypothetical capture took place subsequent to a drop in sea level, a passageway would have conceivably been created for westward species (*i.e*, those originating in the Escambia River) to reach the Choctawhatchee River.

An eastward transfer of species is favored over a westward transfer in the western portion of the Apalachicolan Region for other reasons as well. For instance, the Escambia has more species (29) than does the Choctawhatchee (24). The discrepancy in number of species is probably a result of the proximity of the Escambia to the Mobile Bay basin, faunistically the most speciose system among eastern Gulf drainages (Johnson, 1970). Secondly, a major faunal break occurs between the Choctawhatchee and Apalachicola rivers. Of the 17 Apalachicolan Region endemics found in either the Choctawhatchee or Apalachicola river systems, only *Medionidus penicillatus* is reported from both drainages. Several Apalachicolan Region endemics that probably originated in the Apalachicola River system (*e.g.*, *Elliptoideus sloatianus*, *Pleurobema pyriforme* (Lea, 1857), *Quincuncina infucata* (Conrad, 1834) and *Villosa subangulata*) have apparently dispersed only eastward into the Ochlockonee and in some cases the Suwannee River system. Eastward dispersal of some unionids may have been hastened by stream capture. The channel of Telogia Creek, a major western tributary of the Ochlockonee River that flows southwesterly before completely reversing its course to the northeast, suggests that it may have been captured from the Apalachicola River (Gilbert, 1987). A westward dispersal of species originating in the Apalachicola River system, therefore, appears unlikely in most instances. The presence in the Escambia River of *Fusconaia* (represented by three species, *F. escambia*, *F. rotulata* (Wright, 1899) and *F. succissa*) and *Ptychobranchus*, genera present in the Mobile Bay basin but not the Apalachicola River system, is further basis for a western origin of the fauna. Therefore, it is probable that at least these three *Fusconaia* species and *P. jonesi* evolved in the Escambia River system from stock originating in the Mobile Bay basin. The three species endemic to the Choctawhatchee River (*Elliptio macmichaeli* Clench & Turner, 1956, *Lampsilis haddletoni* and *Q. burkei* Walker, 1922) possibly indicate recent evolution.

The well known interregional capture of the upper Chattahoochee River by the Savannah River may have allowed transfer of certain fishes (Swift *et al.*, 1986; Bermingham & Avise, 1986) and unionids (Johnson, 1969, 1970). Transfer of faunal elements by this capture, however, more likely resulted in species dispersing from the Chattahoochee into the Savannah River system. Johnson (1969) assumed that the occurrence of *Anodonta couperiana* Lea, 1840 in the Apalachicola and Ochlockonee river systems of Florida could be attributed to the Chattahoochee/Savannah stream capture. However, *A. couperiana* is restricted in distribution to the Coastal Plain. A much more likely scenario might be dispersal via lowland routes, possibly during sea level regressions. The present disjunct distribution of *A. couperiana* may be attributed to local extinctions in intervening drainages, especially in north Florida where only the Aucilla and Suwannee rivers separate extant lowland populations in the St. Johns River system from populations in the Panhandle. Interregional headwater captures for species primarily restricted to the Coastal Plain (as are most study area unionids) are not considered to be an important means of fish dispersal (Bermingham & Avise, 1986).

Sepkoski & Rex (1974) suggested that inter-drainage unionid transfers between streams within both the Gulf and Atlantic slopes may have taken place via salt-tolerant, secondary fishes. Seawater, however, is generally considered an absolute barrier for the dispersal of organisms restricted to freshwater. Furthermore, the passage of viable glochidia on secondary fishes through saline waters has not been proven. Until studies determine that it is possible for unionids to be transferred between marine isolated drainages by salt-tolerant fishes, this means of dispersal should be considered questionable.

Influence of Cody Scarp on Zoogeography

Physiography, as affected by sea level transgressions, has undoubtably influenced unionid zoogeography in the study area. The Cody Scarp is a conspicuous marine terrace formed during the Early Pliocene (Puri & Vernon, 1964) that has produced a physiographic break in topography approximately 30 m above present mean sea level (Fig. 1). Previous studies have shown the scarp to be of considerable zoogeographic importance, at least for certain fishes (Swift *et al.*, 1977; Swift *et al.*, 1986; Gilbert, 1987). Streams below the scarp are typically lowland (sluggish or swampy) in nature, while streams of the rolling Northern Highlands above the scarp have flowing, meandering channels (Gilbert, 1987).

The known distributions of *Amblema perplicata* and *Glebula rotundata* in the study area are in lowland rivers exclusively below the Cody Scarp. The Escambia River endemic *Fusconaia rotulata* also appears to be limited to the portion of the mainstem from the Cody Scarp downstream. However, the distributions of other large river species in the Apalachicolan Region, such as *Amblema neislerii, Elliptoideus sloatianus, Megalonaias boykiniana* (Lea, 1840) and *Elliptio crassidens* (Lamarck, 1819), seem to be uninfluenced by this physiographic feature and these species are generally found both above and below the scarp. Biological or ecological factors have probably played major roles in the zoogeography of these species.

Taxonomic Considerations

In addition to the obvious need for further, more thorough collections, future taxonomic work is required to determine the possible validity of other forms. At present, practically nothing is known concerning the anatomy and genetics of study area species. Detailed internal and external soft anatomy studies, as well as molecular or biochemical investigations, are necessary to elucidate unionid taxonomy.

Dozens of nominal species have been described from the Apalachicolan Region and Peninsular Florida. Numerous forms were described by S. H. and B. H. Wright between 1883 and 1934 (Johnson, 1967b). Many of the Wright's *Unio's* have been synonomized under various *Elliptio* species, primarily in the work of Johnson (1972).

Similar to *Elliptio icterina* (see Species Accounts), the Peninsular endemic *E. buckleyi* (Lea, 1843) is also most likely a species complex. Nominal forms described from upland lakes and streams may have been isolated for long enough periods during high sea level stands of the Miocene and Pliocene to differentiate from ancestral stock. A good example may be *E. subluridus* (Simpson, 1900), described from Orange Creek of the St. Johns River system. The type locality is from an area known for disjunct populations of several fish species (Burgess *et al.*, 1977; Burgess & Franz, 1978; Swift *et al.*, 1986; Gilbert, 1987). Species occupying the upland-most portion of the St. Johns River basin, Orange Creek and a few other adjacent streams (Burgess & Franz, 1978: fig. 2) were isolated during at least the Middle Miocene and Early Pliocene (Vail & Hardenbol, 1979). The duration of isolation was sufficient to allow for the evolution of several unrelated invertebrate taxa which are now endemic to the area (Burgess & Franz, 1978). Previously more widely distributed fishes survived in these upland refugia with rising sea levels (Gilbert, 1987). Ecological barriers may then have prevented certain fish species from reestablishing marine extirpated populations when sea levels dropped, thus accounting for the present disjunct distributions.

Considered a synonym of *Elliptio buckleyi* by Johnson (1972), *E. subluridus* completely lacks the sharp posterior ridge of *E. buckleyi*, and also displays an oval outline uncharacteristic of typical specimens of *E. buckleyi*. The habitat of Orange Creek is unsuitable for *E. buckleyi*. Furthermore, no records exist for *E. buckleyi* in other streams (*e.g.*, Black, Rice and Deep creeks) draining uplands in this area (Johnson, 1972). Taxonomic studies are needed to unequivocally verify the validity of *E. subluridus*.

Other nominal species of *Elliptio* described from the St. Johns River include forms considered synonyms of *E. dariensis* (Lea, 1842) by Johnson (1972). *Elliptio dariensis* is found elsewhere only in the Altamaha River (Johnson, 1970). *Elliptio monroensis* (Lea, 1843) was recognized by Morrison (1973); considerably smaller and thinner shelled than *E. dariensis, E. monroensis* is very possibly a distinct taxon. This and other nominal *Elliptio* species from the St. Johns River may have specifically recognized counterparts in other Atlantic Slope drainages (J. D. Williams, pers. comm.). The presence of *E. crassidens* in the St. Marys River led Johnson (1970, 1972) to believe that the unionid fauna of this drainage was more closely linked with unionids of the Apalachicolan Region (as defined by Clench &

Turner, 1956) and not other Atlantic Slope drainages. It is possible that the species called *E. crassidens* in the St. Marys is another species with affinities to more northern *Elliptio* species.

Beyond the *Elliptio* confusion, southeastern species of *Anodonta, Lampsilis, Pleurobema, Toxolasma, Uniomerus* and *Villosa* require thorough systematic investigations to delineate species boundaries. Once accomplished, distributional data may provide information towards a better understanding of unionid zoogeography in the Appalachicolan Region and Peninsular Florida.

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LITERATURE CITED

ATHEARN, H. D. 1964. Three new unionids from Alabama and Florida and a note on *Lampsilis jonesi*. *The Nautilus*, 77(4): 134-139.

BAILEY, R. M., WINN, H. E. & SMITH, C. L. 1954. Fishes of the Escambia River, Alabama and Florida, with ecologic and taxonomic notes. *Proceedings of the Academy of Natural Sciences of Philadelphia,* 106: 109-164.

BERMINGHAM, E. & AVISE, J. C. 1986. Molecular zoogeography of freshwater fishes in the southeastern United States. *Genetics,* 113: 939-965.

BURCH, J. B. 1975. *Freshwater Unionacean clams (Mollusca: Pelecypoda) of North America.* Malacological Publications, Hamburg, Michigan. 204 pp.

BURGESS, G. H., & FRANZ, R. 1978. Zoogeography of the aquatic fauna of the St. Johns River system with comments on adjacent Peninsular faunas. *American Midland Naturalist,* 100(1): 160-170.

BURGESS, G. H., GILBERT, C. R., GUILLORY, V. & TAPHORN, D. C. 1977. Distributional notes on some north Florida freshwater fishes. *Florida Scientist,* 40: 33-41.

CLENCH, W. J., & TURNER, R. D. 1956. Freshwater mollusks of Alabama, Georgia, and Florida from the Escambia to the Suwannee River. *Bulletin of the Florida State Museum, Biological Sciences,* 1(3): 97-239.

FULLER, S. L. H. 1974. Clams and mussels (Mollusca: Bivalvia). Pp. 215-273. *In*: Hart, C.W. and Fuller, S.L.H. (eds.). *Pollution Ecology of Freshwater Invertebrates*. Academic Press, New York.

FULLER, S. L. H. & BEREZA, D. J. 1973. Recent additions to the naiad fauna of the eastern Gulf drainage (Bivalvia: Unionida: Unionidae). *Association of Southeastern Biologists Bulletin*, 20: 53.

GILBERT, C. R. 1987. Zoogeography of the freshwater fish fauna of southern Georgia and Peninsular Florida. *Brimleyana*, 13: 25-54.

GORDON, M. E. 1984. First record for *Anodonta suborbiculata* Say (Unionidae: Anodontinae) in Oklahoma. *The Southwestern Naturalist*, 29(2): 233-234.

HEARD, W. H. 1979. Identification manual of the freshwater clams of Florida. *Florida Department of Environmental Regulation, Technical Series*, 4(2): 1-83.

JOHNSON, R. I. 1965. A hitherto overlooked *Anodonta* (Mollusca: Unionidae) from the Gulf drainage of Florida. *Breviora*, 213: 1-7.

JOHNSON, R. I. 1967a. Additions to the unionid fauna of the Gulf drainage of Alabama, Georgia and Florida (Mollusca: Bivalvia). *Breviora*, 270: 1-21.

JOHNSON, R. I. 1967b. Illustrations of all the mollusks described by Berlin Hart and Samuel Hart Wright. *Occasional Papers on Mollusks*, 3: 1-35.

JOHNSON, R. I. 1968. *Elliptio nigella*, overlooked unionid from Apalachicola River system. *The Nautilus*, 82: 22-24.

JOHNSON, R. I. 1969. Further additions to the unionid fauna of the Gulf drainage of Alabama, Georgia and Florida. *The Nautilus*, 83(1): 34-35.

JOHNSON, R. I. 1970. The systematics and zoogeography of the Unionidae (Mollusca: Bivalvia) of the southern Atlantic slope region. *Bulletin of the Museum of Comparative Zoology*, 140(6): 263-449.

JOHNSON, R. I. 1972. The Unionidae (Mollusca: Bivalvia) of Peninsular Florida. *Bulletin of the Florida State Museum, Biological Sciences*, 16(4): 181-249.

JOHNSON, R. I. 1977. Monograph of the genus *Medionidus* (Bivalvia: Unionidae) mostly from the Apalachicolan Region, southeastern United States. *Occasional Papers on Mollusks*, 4: 161-187.

JOHNSON, R. I. 1980. Zoogeography of North American Unionacea (Mollusca: Bivalvia) north of the maximum Pleistocene glaciation. *Bulletin of the Museum of Comparative Zoology*, 149(2): 77-189.

MORRISON, J. P. E. 1973. Sympatric species of *Elliptio* living in the St. Johns River, Florida. *Bulletin of the American Malacological Union*, 1972: 14.

PURI, H. S. & VERNON, R. O. 1964. Summary of the geology of Florida and a guidebook to the classic exposures. *Florida Geological Survey Special Publication*, 5: 1-312.

SEPKOSKI, J. J., JR. & REX, M. A. 1974. Distribution of freshwater mussels: coastal rivers as biogeographic islands. *Systematic Zoology*, 23: 165-188.

SWIFT, C. C., YERGER, R. W. & PARRISH, C. H. 1977. Distribution and natural history of the fresh and brackish water fishes of the Ochlockonee River, Florida and Georgia. *Bulletin of Tall Timbers Research Station*, 20: 111 pp.

SWIFT, C. C., GILBERT, C. R., BARTONE, S. A. BURGESS, G. H. & YERGER, R. W. 1986. Zoogeography of the freshwater fishes of the southeastern United States: Savannah River to Lake Pontchartrain. Pp. 213-265. *In*: C.

H. Hocutt and E. O. Wiley, E. O. (eds.). *Zoogeography of North American Freshwater Fishes*. John Wiley and Sons, New York.

TURGEON, D. D., BOGAN, A. E., COAN, E. V., EMERSON, W. K., LYONS, W. D., PRATT, W. L., ROPER, C. P. E., SHELTEMA, A., THOMPSON, F. G. & WILLIAMS, J. D. 1988. *Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks.* American Fisheries Society Special Publication, 16. 277 + i-vii pp.

VAIL, P. R., & HARDENBOL, J. 1979. Sea-level changes during the Tertiary. *Oceanus*, 22(3): 71-79.

VAN DER SCHALIE, H. 1934. *Lampsilis jonesi*, a new naiad from southeastern Alabama. *The Nautilus*, 47: 125-127.

VAN DER SCHALIE, H. 1940. The naiad fauna of the Chipola River, in northwestern Florida. *Lloydia*, 3: 191-208.

WALKER, B. 1905. List of shells from northwestern Florida. *The Nautilus*, 18: 133-136.

Walkerana, 1989, 3(10): 263-276

THE TAXONOMIC STATUS OF *ANODONTA LACUSTRIS* LEA (BIVALVIA: UNIONIDAE)

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ABSTRACT: Conchological and allozymic evidence is consistent with the taxonomic distinction of *Anodonta lacustris* Lea 1857 (= "*A. marginata*" *sensu* F. C. Baker 1928, *non* Say 1817) from *A. grandis* Say 1829. In addition, allozymic evidence supports the distinction of *A. lacustris* from *A. cataracta* Say 1817 and *A. fragilis* Lamarck 1819. Furthermore, justification is provided for the use of the name *A. lacustris* Lea 1857 in lieu of *A. marginata* Say 1817.

Key words: *Anodonta lacustris*, taxonomy, nomenclature, distribution.

INTRODUCTION

The freshwater mussel genus *Anodonta* (Bivalvia: Unionidae) is Holarctic in distribution and comprises approximately 16 species in North America, north of Mexico (Burch, 1975). Due to the phenotypic plasticity of shell characters and the relatively low levels of variation displayed in soft part anatomy (but see Kat, 1983a, 1986), species limits as well as interspecific relationships within this genus are poorly understood. Used in conjunction with morphological analyses, molecular data sets, such as those produced by starch gel electrophoresis of proteins (allozymes), may give fresh insight on long standing taxonomic debates as to the veracity of certain species determinations in this genus (Kat, 1983a, 1986). When a parapatric or sympatric distribution occurs, the absence of morphologically and/or molecularly intermediate individuals in the zone of contact dictates the rejection of the hypothesis of a single gene pool and, therefore, the acceptance of multiple species (Wiley, 1981). In the case of

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allopatric distributions, the determination of gene pool discreteness is virtually impossible. However, since certain measures of molecular differentiation (*e.g.*, genetic distance and number of fixed allelic differences) are correlated with levels of taxonomic separation (Thorpe, 1983), these measures may provide provisional support for species level distinctness in the case of allopatric taxa (*e.g.*, Davis, 1983; Richardson *et al.*, 1986). Based on empirical observations, Davis (1983) suggested that, for two allopatric unionid taxa, the probability of having distinct species is high if an allozymic analysis with 14 or more loci indicates a Nei's Distance (Nei, 1972) ≥ 0.222. The purpose of this paper is to reestablish *Anodonta lacustris* Lea 1857 among the recognized species of North American freshwater mussels, to discuss the reasons for this resurrection, to reaffirm the conchological basis for this decision, and to present allozyme data that corroborate these conclusions.

MATERIALS

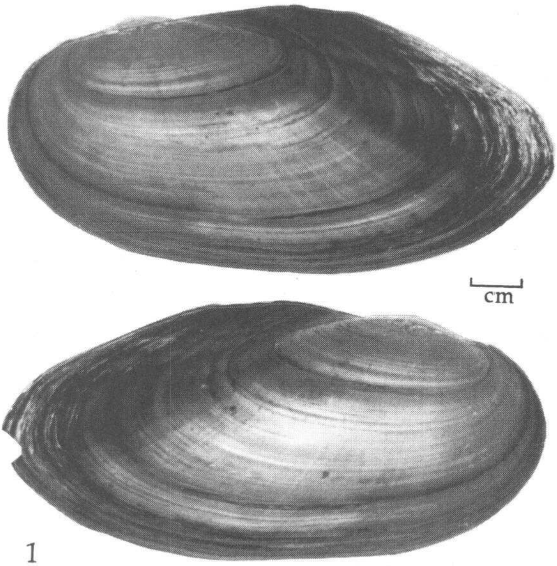
The specimens on which this study is based include those from our collecting in Indiana, Michigan and Pennsylvania, R. G. Noseworthy's collecting in Newfoundland, specimens from the University of Michigan Museum of Zoology, the National Museum of Canada, and the National Museum of Natural History, Smithsonian Institution. Included in the latter collection is the "Holotype" (see Johnson, 1970, p. 356) of Lea's (1857) *Anodonta lacustris* (USNM cat. no. 86597, Fig. 1) and Lea's (1861) *Anodonta simpsoniana* (USNM cat. no. 86434, Fig. 8). The allozyme data were obtained by standard starch gel techniques (Selander *et al.*, 1971; Ayala *et al.*, 1973). Locality data for the Michigan specimens in Figs. 3, 4, 6, 7 are as follows: *Anodonta lacustris* Lea, beach pool, Lake Michigan shore, Section 19, Bliss Township, R. 6 W., T. 39 N., Emmet County, July, 1988, UMMZ 250670; *Anodonta grandis* Say, North Fishtail Bay, Douglas Lake, Section 22, Munro Township, R. 3 W., T. 37 N., Cheboygan County, July, 1988, UMMZ 250671.

NOMENCLATURE

Anodonta lacustris Lea was recognized by the early North American naturalists (*e.g.*, Latchford, 1882; Latchford & Poirier, 1885; Marshall, 1892, 1895; Taylor, 1892; Letson, 1905). Later it was placed in the synonymy of *A. marginata* Say 1817 (e.g., Simpson, 1900; Wright & Walker, 1902; Dall, 1905; Baker, 1916, 1928; Frierson, 1927). This concept of "*A. marginata*," which we do not believe to represent the actual species Say named, was best presented by Baker (1928). More recently, van der Schalie (1938) doubted the validity of "*A. marginata*" *sensu* Baker and others, believing it to be only a variation of *A. grandis* Say 1829. Johnson (1970) placed both *A. lacustris* and *A. marginata* in the synonymy of *A. cataracta* Say 1817. *Anodonta lacustris* ("'*Anodonta marginata* Say' of authors but not of Say, 1817" [Clarke, 1973]) has been placed in the synonymy of *A. grandis simpsoniana* Lea 1861 by Clarke (1973). Justification for recognizing *Anodonta lacustris* over *A. marginata* is based on the following: all type material of *A. marginata* is lost, its type locality is unknown, the original description (both figure and text) is uninformative as to the most essential diagnostic character, *i.e.*, beak sculpture, and remarks accompanying the original description (Say, 1817) indicate that *A. marginata* was "very common in our rivers." A "type" of *A. lacustris* from the Isaac Lea collection, on the other hand, is available (USNM cat. no. 86597, Figs. 1, 5), the type locality is known, the shell is well described and illustrated (Fig. 2), and the species is common only in lakes and ponds, and is rarely found in flowing water (Baker, 1928; Hoeh and Burch, unpublished data). The latter, *i.e.*, the habitat difference, indicates to us that the two nominal species, *A. marginata* Say and *A. lacustris* Lea, are not synonymous, so there seems to be no point in subordinating Lea's *A. lacustris* to Say's species, as has been done sometimes in the past. The identity of Say's *A. marginata* should be determined, if possible, because of the name's priority, but whatever the species turns out to be, we are confident that it will not be the same as *A. lacustris.*

DESCRIPTIONS OF *ANODONTA LACUSTRIS*

In 1857, Isaac Lea named and described *Anodonta lacustris,* one of approximately 90 species of *Anodonta* that he described during his life. As was his usual procedure, he published the first description as several lines of Latin (the language required at the time for new descriptions of undescribed species) and a locality. This established the name as his and fixed the publication date, the latter of prime importance in regard to nomenclatural priority. Then, as was also his custom, Lea later published an English translation of the original Latin description, a more detailed description of the shell, sometimes described (as was the case for *A. lacustris*) the external features



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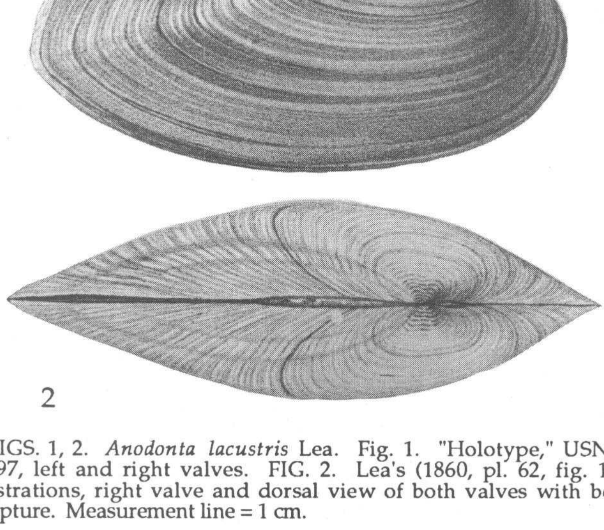

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FIGS. 1, 2. *Anodonta lacustris* Lea. Fig. 1. "Holotype," USNM 86597, left and right valves. FIG. 2. Lea's (1860, pl. 62, fig. 188) illustrations, right valve and dorsal view of both valves with beak sculpture. Measurement line = 1 cm.

of the soft anatomy, made additional comments regarding the species, and gave an excellent figure of the shell (Fig. 2). Lea's (1860) translation of his original Latin description of the shell of *Anodonta lacustris* is as follows: "Shell smooth, transverse, somewhat inflated, very inequilateral, subangular behind; valves thin; beaks slightly prominent, closely undulate at the tips; epidermis yellowish olive, eradiate or obsoletelyradiate, transversely banded; nacre white or reddish brown and iridescent." He (*loc cit.*) expanded on this brief diagnosis as follows: "Shell smooth, transverse, somewhat inflated, very inequi-lateral, subangular behind; substance of the shell thin; beaks slightly prominent, with numerous closely set, irregular undulations at the tips; ligament long, thin and dark brown; epidermis yellowish olive, without rays or obscurely rayed, transversely banded; umbonial slope raised and rounded; posterior slope carinate, rather wide, with two slightly impressed and three dark lines from the beaks to the margin on each valve; anterior cicatrices confluent, large and slightly impressed; posterior cicatrices confluent, large and very slightly impressed; dorsal cicatrices placed in the center of the cavity of the beaks; cavity of the shell rather deep and wide; cavity of the beaks very shallow, scarcely perceptible; nacre bluish white or reddish brown and iridescent." F. C. Baker (1928), referring to "*Anodonta marginata,*" improved on Lea's description, and described so completely our concept of *A. lacustris* that we believe it needs little or no modification: "Long-ovate or elongate elliptical, moderately inflated, usually with thin valves; anterior end rounded; posterior end elongated, pointed, biangulate; ventral margin slightly rounded; dorsal margin straight, slightly sloping at the extremities; beaks slightly raised above the dorsal margin, rather full in some specimens, slightly compressed in others; beak sculpture consisting of 4-5 (rarely 6), somewhat irregularly looped bars, of which the posterior loop is short and v-shaped, and the anterior loop is long and broadly rounded; posterior ridge rounded, faintly double, ending in a rather bluntly biangulate point, which is midway of the posterior margin, the dorsal and ventral margins declining and inclining to meet it; surface with raised growth lines which are more conspicuous on the posterior end, and which are larger and edged with black at rest periods; epidermis olive greenish, brownish, sometimes blotched with reddish-brown on the anterior slope, or the shell may have a brownish cast over a yellowish-green background; region of umbones sometimes of a rich golden color; green rays are more or less distinct on the surface; nacre usually a peculiar dull, silvery tint, iridescent at the posterior end, frequently stained with salmon near the beak cavities, which are shallow. Hinge edentulous."

TYPE LOCALITY OF *ANODONTA LACUSTRIS*

The localities given by Lea with the original description of *Anodonta lacustris* were "Crooked Lake and Little Lakes, New York." The specimens were sent to him by James Lewis, M.D., of Mohawk, N.Y. Whittemore two years later (1859) gave a description of this area of New York, including the Little Lakes. "Little Lakes", shown on an 1829 map ("Entered according to Act of Congress June 5th, 1829, by David H. Burr of the State of New York."; Accession 75350, Maps and Charts, General Library, University of Michigan), are located in the southern end of Warren Township in Herkimer County (Susquehanna River drainage). The two lakes are joined by a stream, and Warren Post Office is located about halfway between the two lakes. An east-west highway, leading eastward to Albany, runs between the two lakes and next to Warren Post Office. Schuyler's Lake is 3.5 miles west southwest of Warren Post Office. The upper of the two "Little Lakes" is now called Weaver Lake and the lower one Young Lake (U. S. Geological Survey topographic map, Richfield Springs, New York, SW/4 Richfield Springs 15' Quadrangle, printed 1960 [data 1943]). On the current quadrangle map, Weaver Lake is shown as surrounded by swamp, and Young Lake is bordered on its west side by swamp. Warren Post Office is now the town of Warren, and the highway bisecting it is U. S. 20. Schuyler's Lake is now called Canadarago Lake, although the town just south of it is named Schuyler Lake. We have not been able to locate "Crooked Lake." It may be Schuyler's Lake (= Canadarago Lake).

DISTRIBUTION OF *ANODONTA LACUSTRIS*

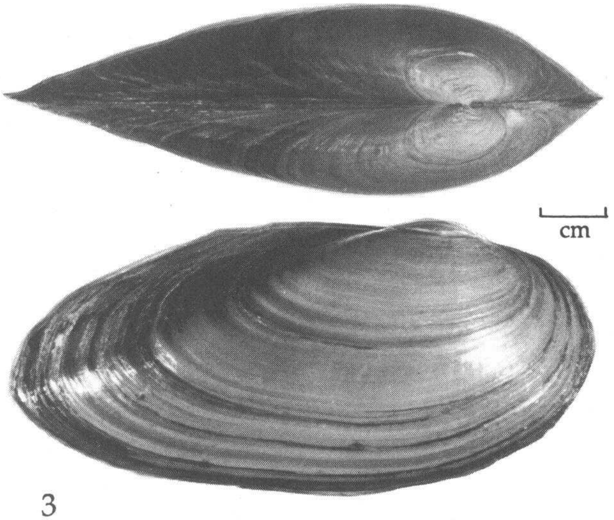
A geographic distribution for *Anodonta lacustris* was given by Marshall (1895): "Occurs in the Eastern [Susquehanna and Hudson River drainages] and St. Lawrence drainage systems. Found in both systems in New York. Confined to a limited area in the Eastern system. Generally distributed in the St. Lawrence system." Baker (1928) gave the general distribution of "*A. marginata*" as: "'St. Lawrence drainage' (Simpson). Specimens from Lake Chetek and lakes in the Wisconsin and Rock drainage indicate that this species also inhabits the Mississippi drainage." Two lots labeled *A. grandis simpsoniana* (National Museums of Canada cat. nos. 31630 [Klotz Lake, 30 miles east of Longlac, Ontario] and 31635 [unnamed lake north of Savant Lake, Ontario]) were found to contain both *A. grandis* and *A. lacustris.* These specimens were collected from the Hudson Bay drainage of the Canadian Interior Basin. From the above, the known distribution of *A. lacustris* comprises the St. Lawrence, upper Susquehanna and Hudson, upper Mississippi, and southern Hudson Bay drainages of North America.

HABITAT OF *ANODONTA LACUSTRIS*

The localities for *Anodonta lacustris* in the original description were lakes. Baker (1916) found it in Oneida Lake, New York, described its habitat, including associated organisms, and compared its habitats in Oneida Lake to those in Tomahawk Lake (Wisconsin) and Saginaw Bay (Michigan). Baker (1928) gave the habitat of "*A. marginata*" in Wisconsin as "Shallow, quiet lakes in mud bottom. Lake Chetek, sand and mud bottom, water .6-1 m. deep, near shore; Sturgeon Bay, near canal, in fine sand, in 1.1 m. of water. This species is for the most part a mussel of lakes and is seldom found in rivers."

OBSERVATIONS AND DISCUSSION

A comparison of shell shape and beak sculpture for *Anodonta lacustris* and *A. grandis* is presented in Figs. 3, 4, 6, 7. According to Baker (1928), ..."*Anodonta marginata* [= *A. lacustris*] may be distinguished from *grandis* by its thinner shell, more pointed



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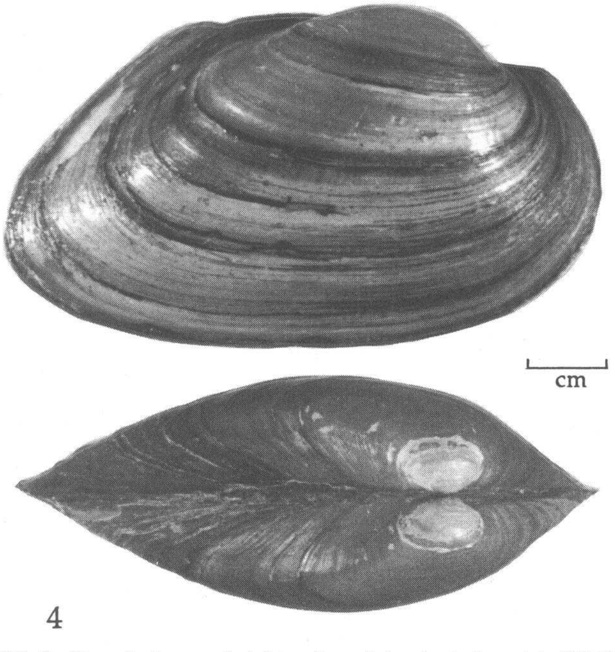

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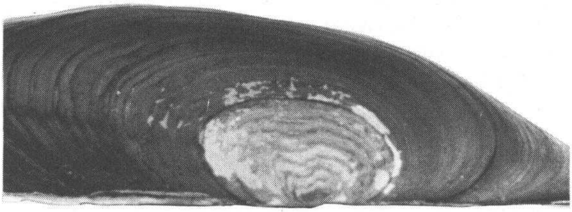
FIG. 3. Dorsal view and right valve of *Anodonta lacustris* (UMMZ 250670). FIG. 4. Right valve and dorsal view of *A. grandis* (UMMZ 250671). Measurement line = 1 cm.



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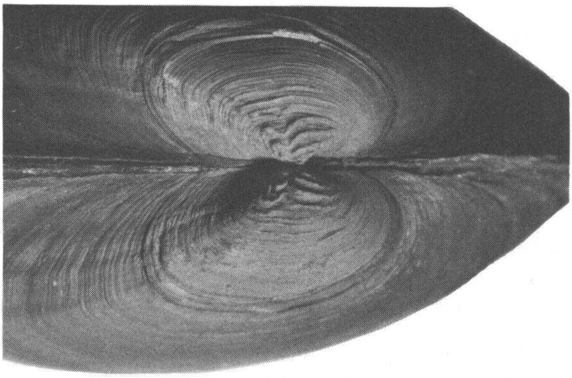

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FIG. 5. Beak sculpture of the "Holotype" of *Anodonta lacustris* (USNM 86597). FIG. 6. Beak sculpture of *A. lacustris* (UMMZ 250670). FIG. 7. Beak sculpture of *A. grandis* (UMMZ 250671).

TABLE 1. Nei's genetic distance and number of fixed allelic differences between *Anodonta lacustris*[1] (4)[2] and conchologically similar species of *Anodonta* (based on 24 presumptive loci).

Species		Nei's genetic distance	No. of fixed allelic diff.
A. cataracta[3]	(5)[2]	0.325	6
A. fragilis[4]	(5)	0.372	7
A. grandis[5]	(5)	0.301	5

[1] Lancaster Lake, Cheboygan County, Michigan.
[2] ( ) = Number of individuals scored in allozymic survey.
[3] Pickering Creek, Pennsylvania State Highway 23, Phoenixville, Pennsylvania.
[4] Birds Pond, Whitbourne, eastern Newfoundland, Canada.
[5] Mill Creek, below Starve Hollow Lake, Jackson County, Indiana

and elongated posterior end, less elevated and more compressed umbones, peculiar silvery nacre, and the umbonal markings which are finer than *grandis*, differently looped (anterior much longer than posterior), and not nodulous. ... In the *grandis* group the dorso-anterior margin forms a sharp angle with the rounded anterior end, while in the *marginata* from Wisconsin this feature is wholly lacking or only slightly developed." Therefore, at least in the upper St. Lawrence River drainage, *A. lacustris* and *A. grandis* are conchologically quite distinct. Based on an allozymic comparison of allopatric populations, there is a relatively large degree (*sensu* Davis, 1983) of genetic differentiation between *Anodonta lacustris* and *A. grandis* (Table 1). In addition, an allozymic analysis of syntopic individuals of *A. lacustris* and *A. grandis* from Four Mile Lake, Washtenaw Co., Michigan, revealed fixed allelic differences (no intermediates) at three of seven presumptive loci (Hoeh, unpublished data). The conchological and allozymic evidence strongly suggests that *A. lacustris* and *A. grandis* have distinct gene pools and, therefore, are specifically distinct. As mention-

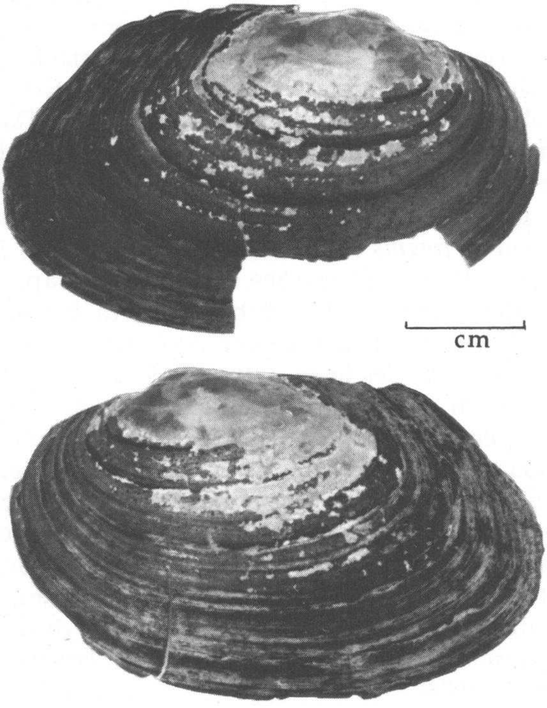

FIG. 8. *Anodonta simpsoniana*, Holotype, USNM 86434. Measurement line = 1 cm.

ed above, *A. grandis* and *A. lacustris* occur sympatrically in the southern Hudson Bay drainage. The maintenance of morphological distinctness in sympatry along with the obvious conchological differences between *A. lacustris* (Figs. 1, 2, 3) and the type of *A. simpsoniana* (Fig. 8) strongly suggest that *A. lacustris* is not a synonym of *A. simpsoniana*. Morphological distinction of *Anodonta lacustris* from congeners located in the lower St. Lawrence River drainage area is more difficult. Simpson (1914) believed that *A. fragilis* was conspecific with *A. lacustris*. However, beak sculpture differences distinguish these two taxa (compare Fig. 6 with fig. 4 in Clarke, 1973). Morrison (personal communication) stated that "... *marginata* [= *A. lacustris*] from the lower St. Lawrence drainage is hard to tell from *A. cataracta*. It is more fragile, has a brilliant nacre, more loops in the beak sculpture, also more slender than is usual in *cataracta*." From the above, it is apparent that Morrison thought *A. lacustris* (as *A. marginata*) and *A. cataracta* could be distinguished conchologically. In addition, the relatively high levels of allozymic differ-entiation (*sensu* Davis 1983) observed between *A. lacustris* and both *A. cataracta* and *A. fragilis* corroborate the species level status of *A. lacustris* (Table 1). The geographic distributions of *Anodonta lacustris, A. cataracta* and *A. fragilis* (cf. Marshall, 1895; Johnson, 1970; Kat, 1986) suggest that these species may occur parapatrically or sympatrically. Efforts should be made to locate areas of contact and test the common gene pool hypothesis. Further corroboration of species level status for *A. lacustris* should also be sought from a phylogenetic hypothesis of relationships within the genus *Anodonta.* This hypothesis would provide information on character state distributions and, therefore, on additional characteristics potentially diagnostic for *A. lacustris.* Lastly, it is hoped that this work, in conjunction with that of others (Kat, 1983a, 1983b, 1986; Kat & Davis, 1984), will put to rest the presumed subspecific relationships implied by the continued use of trinomials in the case of distinct species such as *Anodonta cataracta, A. fragilis* and *A. lacustris* (*e.g.*, see Turgeon *et al.*, 1988).

LITERATURE CITED

AYALA, F. J., HEDGECOCK, D., ZUMWALT, G. S. & VALENTINE, J. W. 1973. Genetic variation in *Tridachna maxima*, an ecological analog of some unsuccessful evolutionary lineages. *Evolution*, 27: 177-191.

BAKER, Frank Collins. 1916. *The relation of mollusks to fish in Oneida Lake*. The New York State College of Forestry at Syracuse University, Technical Publication No. 4, 16(21): 1-366, 1 map.

BAKER, Frank Collins. 1928. *The fresh water Mollusca of Wisconsin*. Wisconsin geological and natural history Survey, Bulletin 70, Pt. 2, pp. i-vi, 1-495, pls. 29-105.

BURCH, J. B. 1975. *Freshwater unionacean clams (Mollusca: Pelecypoda) of North America*. Revised edition. Malacological Publications, Hamburg, Michigan. pp. i-xviii, 1-204.

CLARKE, Arthur H. 1973. The freshwater molluscs of the Canadian Interior Basin. *Malacologia*, 13: 1-509.

DALL, William Healey. 1905. *Land and fresh water mollusks of Alaska and adjoing regions*. Pp. vii-xii, 1-171, pls. 1, 2. In: Merriam, C. Hart (ed.), *Alaska*, vol. 8, pp. i-xii, 1-250, pls. 1-15. [Reprinted 1910 as the *Harriman Alaska Series* of the Smithsonian Institution, vol. 13].

DAVIS, George M. 1983. Relative roles of molecular genetics, anatomy, morphometrics and ecology in assessing relationships among North

American Unionidae (Bivalvia). In: Systematics Association Special Volume 24, "*Protein Polymorphism: Adaptive and Taxonomic Significance*", edited by Oxford, G.S. and Rollinson, D. Academic Press, London and New York. Pp. i-xii, 1-405. (Pp. 193-222).

FRIERSON, L. S. 1927. *A classified and annotated check list of the North American naiades*. Published by the author. Pp. 1-111.

JOHNSON, Richard I. 1970. The systematics and zoogeography of the Unionidae (Mollusca: Bivalvia) of the southern Atlantic slope region. *Bulletin of the Museum of Comparative Zoology, Harvard University,* 140(6): 263-449.

KAT, Pieter W. 1983a. Genetic and morphological divergence among nominal species of North American *Anodonta* (Bivalvia: Unionidae). *Malacologia,* 23: 361-374.

KAT, Pieter W. 1983b. Conchiolin layers among the Unionidae and Margaritiferidae (Bivalvia): Microstructural characteristics and taxonomic implications. *Malacologia,* 24: 298-311.

KAT, Pieter W. 1986. Hybridization in a unionid faunal suture zone. *Malacologia,* 27: 107-125.

KAT, Pieter W. and DAVIS, George M. 1984. Molecular genetics of peripheral populations of Nova Scotian Unionidae (Mollusca: Bivalvia). *Biological Journal of the Linnean Society,* 22: 157-185.

LATCHFORD, Frank R. 1882. Notes on the Ottawa Unionidae. *Transactions of the Ottawa Field-Naturalist Club,* 1: 48-57.

LATCHFORD, Frank R. & POIRIER, Pascal. 1885. Report of the Conchological Branch. *Transactions of the Ottawa Field- Naturalist Club,* 2: 263-266,

LEA, Isaac. 1857. Description of eight species of Naiades from various parts of the United States. *Proceedings of the Academy of Natural Sciences of Philadelphia,* 9: 84.

LEA, Isaac. 1860. New Unionidae of the United States and northern Mexico. *Journal of the Academy of Natural Sciences of Philadelphia,* new series, 4: 327-374, pls. 51-66.

LEA, Isaac. 1861. Descriptions of two new species of Anodontae, from Arctic America. *Proceedings of the Academy of Natural Sciences of Philadelphia,* 13: 56.

LETSON, Elizabeth J. 1905. Check list of the Mollusca of New York. *New York State Education Department Bulletin,* (341): [*New York State Museum Bulletin,* 88, zool. 11]: 1-112.

MARSHALL, William B. 1892. Preliminary list of New York Unionidae. *Bulletin of the New York State Museum,* 1(1): 3-17.

MARSHALL, William B. 1895. Geographical distribution of New York Unionidae. 48th *Annual Report of the Regents, New York State Museum, 1894, University of the State of New York, Albany.* pp. 47-99.

NEI, M. 1972. Genetic distance between populations. *American Naturalist,* 106: 283-292.

RICHARDSON, B. J., BAVERSTOCK, P. R. & ADAMS, M. 1986. *Allozyme Electrophoresis.* Academic Press, Sydney. Pp. i-xii, 1-410. (p. 304-309)

SAY, Thomas. 1817. Conchology. 15 pp., 4 pls. *In*: Nicholson, William, 1816-17, *American edition of the British encyclopedia, or dictionary of arts and sciences comprising an accurate and popular view of the present improved state of human knowledge.* First edition. Vol. 1, 1816; vols. 2-6, 1817 [vol. 2, B.....E]; no pagination. Samuel A. Mitchell and Horace Ames, Philadelphia.

SELANDER, R. K., SMITH, M. H., YANG, S. Y., JOHNSON, W. E. & GENTRY, J. B. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I. Variation in the old-field mouse (*Peromyscus polionotus*). *Studies in Genetics, IV, University of Texas Publication* 7103: 49-90.

SIMPSON, Charles Torrey. 1900. Synopsis of the naiades, or pearly freshwater mussels. *Proceedings of the United States National Museum,* 22: 501-1044, pl. 18.

SIMPSON, Charles Torrey. 1914. *A Descriptive Catalogue of the Naiades or Pearly Freshwater Mussels.* Bryant Walker, Detroit, Michigan. Pp. i- xi, 1-1540.

TAYLOR, George W. 1892. Preliminary check-list of the land and fresh water Mollusca of Canada. *Ottawa Naturalist,* 7: 33-37.

THORPE, J. P. 1983. Enzyme variation, genetic distance and evolutionary divergence in relation to levels of taxonomic separation. In: Systematics Association Special Volume 24, "*Protein Polymorphism: Adaptive and Taxonomic Significance*", edited by Oxford, G.S. and Rollinson, D. Academic Press, London and New York. Pp. i-xii, 1-405 (pp. 131-152).

TURGEON, D. D., BOGAN, A. E., COAN, E. V., EMERSON, W. K., LYONS, W. G., PRATT, W. L., ROPER, C. F. E., SCHELTEMA, A., THOMPSON, F. G. & WILLIAMS, J. D. 1988. *Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Mollusks.* American Fisheries Society Special Publication 16. (p. 28)

VAN DER SCHALIE, Henry. 1938. The naiad fauna of the Huron River, in southeastern Michigan. *Miscellaneous Publication of the Museum of Zoology, University of Michigan,* (40): 1-83, pls. 1-12, 1 map insert (Map 16)

WHITTEMORE, T. J. 1859. Some notes taken at Mohawk, Herkimer Co., N. Y., in August, 1859. *Proceedings of the Boston Society of Natural History,* 7: 150-151.

WILEY, E. O. 1981. *Phylogenetics: the theory and practice of phylogenetic systematics.* Wiley, New York. Pp. i-xvi, 1-439 (pp.58-69).

WRIGHT, Berlin Hart & WALKER, Bryant. 1902. *Check list of North American naiades.* Printed for the authors, Detroit, Michigan. Pp. 1-19.

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Walkerana, 1989, 3(10): 277-300

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El Dr. Carlos Guillermo Aguayo fue un conocico cientifico cubano que publicó muchos articulos significativos sobre la malacologia cubana. La lista que se presenta a continuación contiene todas las publicaciones sobre moluscos del Dr. Aguayo.

Esta Bibliografía brevemente comentada, ha sido extraída de los tarjeteros de la Biblioteca de nuestro Laboratorio de Zoología, todas las cuales pueden ser consultadas en nuestro local de la calle 42 No. 3307, Municipio Playa, provincia Ciudad de la Habana. La misma aparece en orden cronológico, bajo el nombre del autor o de autores en colaboración.

1931

Entovalva (Devonia) perrieri (Malard) in the western Atlantic. *Occasional Papers of the Boston Society of Natural History,* 8: 5-7. (W. J. Clench & C. G. Aguayo)

Es un estudio zoogeografica del moluscos de referencia.

1932

New species of *Opisthosiphon* from Eastern Cuba. *The Nautilus,* 45(3): 91-96, lam. 6, figs. 1-5.

Describe, como nuevos para la ciencia: *Opisthosiphon caroli* y *O. aguilerianum holguinensis.*

Two new Cuban *Urocoptis. The Nautilus,* 45(3): 96-98, fig. 15.

Descripción de las nuevas especies: *Urocoptis tenuistriata* y *U. tenuistriata clenchi,* de la Sierra del Grillo, La Habana, Cuba.

Two subspecies of Cuban *Liguus.* (West Indian Mollusks 3). *The*

Nautilus, 45(3): 98-100, Fig. 9-10. (W. J. Clench & C. G. Aguayo)

Dan a concocer *Liguus fasciatus nobilis* y *L. blainianus jaumei.*

Notes and descriptions of Cuban Mollusks. *Occasional Papers of the Boston Society of Natural History,* 8: 31-36, pl. 3.

Describe las nuevas especies y/o subespecies: *Eutrochatella holguinensis, Chondropoma ernesti clenchi, Urocoptis acus bartschi* y *Ramsdenia garciana.*

New Haitian mollusks. West Indian mollusks no. 5. *Proceedings of the New England Zoological Club,* 13: 35-38. (W. J. Clench & C. G. Aguayo)

Describen los nuevos taxones malacológicos: *Lucidella manni, Odontosagda alleni,* subgénero *Haitia, Physa (Haitia) elegans* y *Helisoma eyerdami.*

1933

Marine and freshwater mollusks new to the fauna of Cuba. *The Nautilus,* 46(4): 116-123. (H. A. Pilsbry & C. G. Aguayo)

Describen dos nuevas especies de moluscos de agua dulce de Cuba: *Hydrobia torrei* y *Hebetancylus cubensis.*

A new fossil *Cepolis* from Cuba (West Indian Mollusks 6). *The Nautilus,* 47: 21-22, 1 lam. (W. J. Clench & C. G. Aguayo)

Describen *Cepolis (Jeanneretia) torrei,* de Hato Nuevo, provincia de Matanzas, Cuba (en estado subfósil).

On the synonymy and distribution of *Planorbis anatinus* d'Orbigny. *The Nautilus,* 47(2): 65-68.

El autor estudió la extensa distribución de esta especie fluviátil, indicando los nombres que aparacen en su sinonimia.

1934

Notas y adiciones a la fauna malacológica habanera. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 8(1): 9-14, 1 fig. (C. G. Aguayo & M. L. Jaume)

En éste trabajo los autores describen: *Vertigo torrei;* se accepta como valido el nombre *Polygyra lingulata* (Férussac) y reportan como nuevas para la fauna cubana de moluscos a: *Gyraulus santacruzensis* y *G. filocinctus, Architectonica krebsi* e *Ithycythara psila,* mencionando también una nueva subespecie del género *Liguus.*

Mollusca cubana. Addenda et Corrigenda. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 8(2): 87-96, 1-5 Figs.

En éste trabajo el autor describe, como nuevos, los siguientes moluscos terrestres cubanos: *Urocoptis camagueyana holguinensis, U. creola, Annularia spurca, Chondropoma laetum asperulum, C. edouardi, Opisthosiphon sainzi, Zachrysia (Chrysias) provisoria lowei, Urocoptis creola* y *U. camagueyama holguinensis,* con observaciones ecológicas.

Acerca del status del género Annularia. (Moll.). *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 8(3): 135-144, lam. 9.

El autor sostiene que el género *Annularia* debe aceptarse como sinónimo valido, precursor de *Choanopoma.*

Meioceras bermudezi, new name for *M. constrictum. The Nautilus,* 47: 112. (H. A. Pilsbry & C. G. Aguayo)

Por motivo de homonimia, los autores proponen el nuevo nombre indicado en el título del trabajo.

1935

El género *Troschelvindex. Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 9(1): 1-5, lam. 1.

El autor expone un estudio sobre la posición sistemática del género *Troschelvindex* (molusco de la familia Pomatiidae), basado en el estudio radular.

A new Jamaican Poteria. *The Nautilus,* 49: 51, lam. 3, figs. 5-6. (W. J. Clench & C. G. Aguayo)

Describen *Poteria caribaea,* molusco terrestres de la familia Cyclophoridae. Los doctores Bartsch y Morrison (1942) colocan esta especie en su nuevo género *Cyclopilsbrya.*

Espicilegio de Moluscos Cubanos. *Memorias de la Sociedad*

Cubana de Historia Natural "Felipe Poey," 9(2): 107-128, lam. 9.

El autor discute sobre la posición sistemática de varios moluscos terrestres y fluviátiles de Cuba y propone como nuevas especies a: *Physa bermudezi, Spiroceramus amplus barbouri* y *Microceramus orientalis.*

La Clonorchiasis la Ciudad de la Habana, por Dr. Pedro Kouri y Alejandro del Frade. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 10(1): 77-89 (pp. 83-84).

Ofrece una relación de los moluscos fluviatiles cubanos de las citadas familias, como posibles vectores de parasitos.

1936

New Marine Mollusks from Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 9: 263-268, 1 lam. (C. G. Aguayo & Harald A. Rehder)

Los autores describen las siguientes nuevas especies marinas colectadas en Cuba: *Diadora jaumei, Arene venustula, Rissoina (Folinia) bermudezi, Turbonilla (Carelipsis) bartschi, Vexillum cubanum* y *Acteon torrei.*

A New Pleistocene *Mecoliotia* from Cuba. *The Nautilus,* 49: 91-93, lam. 5, fig. 3. (W. J. Clench & C. G. Aguayo)

Describen la nueva especie: *Mecoliotia bermudezi* del Pleistoceno de la formación Canímar, Matanzas, Cuba.

Sobre algunos moluscos marinos de Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 10(2): 115-122, figs. 1-3. (C. G. Aguayo & M. L. Jaume)

Relacionan numerosas especies de moluscos marinos nuevos para la fauna cubana, y como nuevo para la ciencia a *Turbonilla (Pyrgiscus) palmerae.*

Nuevo Molusco fluviátil Cubano. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 10(3): 169-171, figs. 1-3.

En este trabajo da a conocer una nueva especie de la familia Pleuroceridae: *Pachychilus fuentesi,* de Baracoa, Oriente (ahora provincia de Guantánamo) Cuba.

1937

Notes and descriptions of some new land and freshwater mollusks from Hispaniola. *Memorias de la Sociedad Cubana Historia Natural "Felipe Poey,"* 11(2): 61-76, lam. 7. (W. J. Clench & C. G. Aguayo)

En este trabajo se precisa el genotipo de *Chondropoma* Pfeiffer (determinado por Petit), y se incluyen notas anatómicas sobre *Planorbis albicans* Pfeiffer, que permiten colocarlo en el género *Tropicorbis.*

1938

Pseudopineria, un nuevo género de moluscos. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 12(1): 71-73.

El autor propone un nuevo género: *Pseudopineria,* moluscos de la familia Urocoptidae, para la especie *Bulimus viequenis* Pfeiffer, de Vieques.

Moluscos Pleistocénicos de Guantánamo, Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 12(2): 97-118, 1 mapa, lam. 14.

En este trabajo se hace un inventario de las especies de moluscos terrestres y fluviátiles del Pleistoceno de la localidad, entre los cuales se encuentran los géneros *Liguus, Mytilopsis, Neritina,* etc.

Los moluscos fluviátiles cubanos. Parte I. Generalidades. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 12(3): 203-242, figs. 1-4, mapas A-C.

Monografía de los moluscos de agua dulce y salobre hallados en Cuba, con una reseña histórica.

Los moluscos fluviátiles cubanos. Parte II. Sistemática. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 12(4): 253-276, figs. 1-4, lam. 18.

En esta parte de los moluscos fluviátiles de Cuba, el autor trata sobre las familias Physidae y Lymnaeidae.

Sobre algunos Moluscos. *Revista Estudiantil "Varona"*, La Habana, 1:15.

Consideraciones sobre la introducción en Cuba de moluscos extranjeros.

Un Molusco terrestre Africano de reciente introduccion en Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 12(5): 367-373, figs. 1-2.

Además de dar a conocer el hallazgo en Cuba del molusco africano *Tenostele musaecola*, se revisan las demás especies introducidas, citando otra nueva: *Euconulus fulvus*.

Notes and descriptions of new species of *Calliostoma, Gaza* and *Columbarium* (Mollusca); obtained by the Harvard-Havana Expedition off the coast of Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 12(5): 375-384, lam. 28. (W. J. Clench & C. G. Aguayo)

En este trabajo los autores describen, como nuevas para la ciencia, las siguientes especies: *Calliostoma blakei, C. schroederi, C. bigelowi, Columbarium atlantis* y *C. bermudezi*.

1939

Notas sobre *Onchidella* de Cuba. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 13(1): 5-7. (W. J. Clench & C. G. Aguayo)

Los autores reportan por vez primera en Cuba a: *Onchidella armadilla* (Mörch) (de La Milpa, Cienfuegos) y *O. floridana* (Dall) (de: Rio Quibú, La Habana)

Dos nuevos Moluscos del género *Chondropoma*. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 13(2): 103-105, lam. 9.

Da a conocer, como nuevos para la ciencia, los moluscos terrestres de la familia Pomatiidae: *Chondropoma cleti* (de P. Betancourt, Matanzas) y *C. tenuisculptum* (de Sao Arriba, Holguin) de Cuba.

Notes and descriptions of new deep-water Mollusca obtained by the Harvard-Havana Expedition off the coast of Cuba. II. *Memorias de la Sociedad Cubana de Historia Natural "Felipe*

Poey," 13(3): 189-197, lams. 28-29. (W. J. Clench & C. G. Aguayo)

Los autores describen las siguientes nuevas especies de moluscos abisales: *Solariella pourtalesi, Calliostoma (Astela) hassleri, Oocorys sulcata caribbaea, O. barbouri, Latiaxis juliae, Tylotia cadenasi, Terebra evelynae* y *Cadulus (Gadila) iota nanus.*

Moluscos Semifósiles del Bosque de la Habana. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 13(4): 229-245, figs. 1-2. (C. G. Aguayo & M. L. Jaume)

El estudio de los moluscos 'semi-fósiles' de un corte situado en una loma del lugar indicado, ha permitido analizar el material recolectado y hacer consideraciones sobre la ecología de la fauna malacológica primitiva. Aunque se reconocen algunas especies marinas, la mayoría del material encontrado corresponde a especies terrestres y fluviatiles. Se identifican entre dicho material: *Alcadia elatior* y *Hemitrochus gilva.* Los autores consideran también que los ejemplares de *Chondropoma sagra* colectados, pertenecen a la forma típica, lo que es importante ya que esta especie es el genotipo del género *Chondropoma.* La riqueza de las formas encontradas contrastan notablemente con las formas vivientes que aun persisten en el "Bosque de la Habana".

A New Species of *Orthaulax* from Western Cuba. (5) *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 13(5): 357-358, lams. 47-48. (W. J. Clench & C. G. Aguayo)

Describen la nueva especie: *Orthaulax bermudezi* del Oligoceno-Mioceno de la provincia de Pinar del Rio, Cuba.

Bibliografía de los Moluscos Terrestres y Fluviatiles de la Isla de Cuba. La Habana, 168 pp.

Esta trabajo que fue presentado en la Sesión del mes de enero de 1939, ante la Sociedad Cubana de Historia Natural "Felipe Poey," aún permanece inédito.

1940

Notes and descriptions of new deep-water Mollusca obtained by the Harvard-Havana Expedition off the coast of Cuba. III. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 14: 77-94, pls. (W. J. Clench & C. G. Aguayo)

Los autores describen moluscos abisales nuevos para la ciencia, como sigue: *Calliostoma* (*Calliostoma*) *cubanum, C.* (*C.*) *torrei, C.* (*C.*) *carcellesi, C.* (*C.*) *atlantis, Gaza superba cubana, Ficus howelli, F. atlantis, Columbarium bartletti, Aurinia dohrni florida, A. bermudezi, A. neptunia,* género *Bathyaurinia, B. piratica,* y *Ancystrosyrinx radiata cubana.*

1941

Notes and descriptions of new deep-water Mollusca obtained by the Harvard-Havana Expedition off the coast of Cuba. IV. *Memorias de la Sociedad cubana de Historia Natural "Felipe Poey,"* 15(2): 177-180, 1 lam. (W. J. Clench & C. G. Aguayo)

En este nuevo trabajo sobre los moluscos marinos abisales recolectados por el Ketch "Atlantis", los autores describen, nuevos para la ciencia: el género *Howellia, H. mirabilis, Latirus* (*Hemipolygona*) *mcmurrayi, Metula fusiformis* y *M. agassizi.*

1942

Estado actual del problema sobre el orígen de la fauna Cuba. *Proceedings, American Science Congress, 1942,* Vol. 3, Washington, D.C., U.S.A., pp. 475-476.

Es un aporte del Dr. Aguayo, sobre el orígen de la fauna cubana, al Congreso Cientifico Americano de Washington, en 1942.

1943

Centenario de los "Moluscos" de D'Orbigny en la obra De La Sagra. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 1(1): 37-40, 1 foto.

El autor hace un análisis exhaustivo, señalando fecha de publicación de los "Moluscos" de la Sagra, por Alcides d'Orbigny, tanto de la edición francesa, como de la española.

Nuevos operculados de Cuba oriental. *Revista de la Sociedad Malacológica "Carlos de la Tore",* 1(2): 69-80, lam. 1-2, 14 figs, 1 texta fig.

El autor ofrece nuevos taxones malacológicos de Cuba, como sigue: *Torreviana,* n. subg. de *Eutrochatella, E.* (*T.*) *spinopoma, Opisthosiphon caroli rivorum, O. quesadai, Tudora* (*Wrightudora*) *enode brevilabris; T. gibarana, Limadora garciana quiñonesi, Jaumeia,* n. subg., *Annularia*

(Jaumeia) milagrosae, Chondropoma lactum, C. appendiculatum, C. laetum asperulum, C. rolandoi, C. ernesti hortensiae, C. ernesti quiñonesi, C. ernesti unguiculatum, C. solidulum lucreciae, C. solidulum isabelae y *C. solidulum melanaxis.*

The Genera *Xenophora* and *Tugurium* in the Western Atlantic. *Johnsonia,* (8): 7 pp., lams. (W. J. Clench & C. G. Aguayo)

En esta monografia se incluyen todas las especies conocidas de los géneros citados en el título.

The Voyage of the H.M.S. "Challenger." *Johnsonia,* (8): 7-8. (W. J. Clench & C. G. Aguayo)

Una interesante exposición de la famosa expedición oceanológica de la nave inglesa "Challenger."

Aspectos de la oceanografia Biologica. Publicación aparte de la publicada on la Revista Universidad de la Habana, con distinta paginacion: 1-42.

1944

Nuevos operculados de la region oriental de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 2(1): 1-6, 1 lam.

El autor describe las siguientes nuevas especies: *Annularia (Subannularia) storchi laevior, Parachondria holguinensis, Tudora (Wrightudora) banensis, Limadora auriculta, Chondropoma (Chondropomisca) unilabiatum maisianum, C. (Chondropomisca) solidulum banesense* y además una nota sobre *C. (Chondropomisca) solidulum lucreciae.*

Los Moluscos Comestibles de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 2(1): 17-20.

El autor ofrece una lista de los moluscos cubanos comestibles, o de posible consumo y otra de los que con fines culinarios se utilizan en otras regiones del mundo, comparando los con sus equivalentes cubanos.

Guia para la descripción de Moluscos Gasterópodos. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 2(2): 41-46, lam. 7. (C. G. Aguayo & M. L. Jaume)

En este trabajo se ofrecen sugerencias y recomendaciones para la realización de publicaciones taxonómicas sobre los moluscos gasterópodos.

Leptinaria lamellata y otros moluscos introducidos en Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 2(2): 51-58, 1 fig.

A New Tropical *Buccinum* from Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 2(2): 67-68, 2 figs. (W. J. Clench & C. G. Aguayo)

Los autores describen como nueva especie, de mares profundos (240-300 brazas) a *Buccinum canetae*, colectado por el "Atlantis" frente a la Habana.

Notas y variedades. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 2(2): 69-70.

Reporta observaciones sobre los siguientes moluscos: El subgénero *Potamanax* Pilsbry - Sobre *Cepolis (Cysticopsis) naevula* (Morelet). El tamaño de *Haplotrema paucispira* (Poey) y *Strobilops hubbardi*.

1945

Parachondria pfeifferi, nom. nov. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 3(1): 32.

Propone este nuevo nombre para *Cyclostoma luridum* "Gundlach" Pfeiffer 1858 (non *Cyclostoma (Cyclotus) luridum* Pfeiffer 1852).

Notas y variedades. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 3(2): 63-64.

El autor comenta sobre various cambios recientes introducidos en la sistemática de moluscos, tales como: *Sulcoretusa* Burch, *Bulla, Atys, Vesica, Uzita, Drupa, Lyrodes*. También reporta a *Liguus blainianus fairchildi* Clench, de la provincia de Camaguey.

Notas y variedades. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 3(3): 84.

El autor se refiere a recientes investigaciones que han demostrado la susceptibilidad de nuestro común molusco fluviátil: *Tropicorbis havanensis* (Pfeiffer) para ser infestado por los miracidios del Tremátodo *Schistosoma mansoni*. En cambio *Helisoma caribaeus* no lo es para dicha infección. También discute el 'status' de *Phasianella umbilicata* d'Orbigny, sugiriendo que para esa especie se debe utilizar el binomio *Tricolia mollis* (Olsson, 1922).

Novedades Malacológicas cubanas. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 3(3): 95-98, lam. 9. (C. G. Aguago & M. L. Jaume)

Se describen como nuevos para la ciencia: *Rhytidopoma honestum barroi, Opisthosiphon quinti petri* y *Zachrysia lamellicosta freirei.* Se añade a la fauna cubana a *Retinella indentata paucilirata* (Morelet) de las montañas de Trinidad, Cuba Central. Ilustran una interesante anomalía hereditaria de *Caracolus sagemon.*

1946

Nuevos Moluscos del Terciario Superior de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(1): 9-12, lam. 1.

En este nuevo trabajo sobre moluscos fósiles de Cuba, los autores describen (de la formación "Yumuri", Matanzas: Mioceno Superior) las especies nuevas siguientes: *Cyclostremiscus euglyptus, C. bermudezi, Climacina* (nom. nov. para *Climacia* Dall, 1903, *non* M. Lechler, 1869), *"Liotia" canimarensis* y *Caecum (Fartulum) sanchezi.*

Notas y variedades. (III). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(1): 33-35.

En este artículo reporta sobre recientes publicaciones malacológicas; visitas de malacológicas; isitas de malacológos extrajenros a nuestro país, etc.

Algunos Moluscos Terciarios de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(2): 43-49, lam. 3.

Los autores dan a conocer nuevas especies cubanas fósiles del terciario, como sigue: *Vitrinella tenuisculpta, Bathyspira,* subg. nov. *Cyclostremiscus (Bathyspira) hoffi, Canimarina,* subgen. nov., *Cyclostremicus (Canimarina) crassilabris, Caecum contortum* y *Limopsis pentodon.*

Nuevo operculado de la región oriental de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(2): 51-53, 1 fig. (W. J. Clench & C. G. Aguayo)

Los autores ofrecen notas sobre el género *Parachondria,* creando el subgénero *Parachondrodes,* para la nueva especie: *Chondropoma (Parachonrodes) tejedori.*

Gundlachia y *Hebetancylus* en Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(2): 55-62.

El autor revisa los representantes hallados en Cuba de los moluscos fluviatiles de los géneros del título.

Notas y variedades. (V). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(2): 63-64.

Comentarios del autor sobre: El Prof. Huxley visita el Museo Poey; *Subulina octona* como hospedero de trematodos; *Johnsonia,* No. 19, 20 y 21; *Minutes of the Conchological Club of Southern California*; *Donax variabilis* para el estudio de las variaciones intraespecíficas; sobre *Helisoma caribaeum cubense*; índice de infestación trematódica en Moluscos.

Una interesante especie nueva del género *Cerion*. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(3): 85-87, figs. 1-6. (W. J. Clench & C. G. Aguayo)

Los autores describen *Cerion disforme,* colectado en Punta Manolito, Península de Ramon, Antilla, Cuba.

Notes and descriptions of two new species of *Calliostoma* from Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(3): 88-90, 1 fig. (W. J. Clench & C. G. Aguayo)

Los autores describen las siguientes especies de moluscos marinos: *Calliostoma (Calliostoma) jaumei* y *Calliostoma (Astele) barbouri,* con notas sobre *Calliostoma (Astele) javanicum* Lamarck.

Notas y variedades. (VI). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 4(3): 91-92.

Expone información sobre los temas siguientes: El Dr. Harald A. Rehder. - Algunos homónimos de la familia Vitrinellidae - Catalogue of the genus *Liguus*. - Speciation in limpets of the genus *Acmaea*. - Vitrinellidae from Florida, IV - Las especies cubanas del género *Condylocardia* - Los caracoles aceptan los dulces.

1947

Una nueva especie Antillana del género *Conus*. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 5(1): 11-12, 1 lam. (C. G. Aguayo & Isabel Perez Farfante)

Los autores describen *Conus havanensis*, n. sp.

Notas y variedades - (VII). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 5(2): 45-46.

El autor sostiene que *Chondropoma confertum* Poey debe prevalecer sobre *Chondropoma canescens* Pfeiffer. Además notas comentades sobre literatura malacológica recientemente recibida.

Nuevos Gasteropodos de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 5(2): 53-58, figs. 1-3. (C. G. Aguayo & M. L. Jaume)

Los autores describen como nuevas especies para la ciencia: *Amphithalamus vallei, Troschelvindex freirei* y *T. alayoi*. Se propone el nombre nuevo: *Polygyra (Daedalochila) poeyi*, para *P. notata* (Poey) cuyo nombre original bajo el género *Helix* está preocupado.

Notas y variedades (VIII). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 5(3): 81-83, 3 lams.

Describe a *Lyrodes coronatus bermudezi* (de Lago Enriquillo, R. Dominicana) - Sobre la posición sistemática de *Chondropomatus*, indicando que dicho grupo ofrece características suficientes para separarlo en un género diferente de *Annularella* y que por otra parte *Annularella, Annularex* y *Annularosa*, debieran ser considerados como subgéneros de *Annularisca*. Status de *Cubadamsiella:* Sostiene que les especies cubanas se apartan conquiológicamente de las de Jamaica, siendo su opérculo muy parecido al de *Blaesospira echinus*, sugiriendo: 1) Reunir *Blaesospira* y *Cubadamsiella*, en la subfamilia Adamsiellinae, y 2) incluir ambos géneros en la subfamilia Annulariinae, en lugar de Adamsiellinae.

Sinopsis de los géneros de moluscos hallados en Cuba. Museo "Felipe Poey," Universidad de la Habana, XVII, pp. 1-44. (Mimeografiado)

Es una lista de los géneros y subgéneros de moluscos de Cuba, organizada sistemáticamente.

1947-1952

Catálogo de los moluscos de Cuba. La Habana, (Publicación privada) Mimeografiada. 725 pp. (Mas index). (C. G. Aguayo & M. L. Jaume)

Este es el catálogo más moderno sobre la fauna malacológica cubana, aunque aun no esta terminado, estimándose que el mismo podrá alcanzar mas de 1,500 paginas.

1948

Nueva subespecie de *Turrithyra. Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(1): 9, 2 figs. (C. G. Aguayo & M. L. Jaume)

Se da a conocer a *Turrithyra canaliculata dominguezi*, procedente de Hoyo de la Palma, San Andrés, provincia de Pinal del Río.

Notas y variedades - (IX). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(2): 52.

En este artículo se comentan diversas obras de malacología recientemente publicadas.

Un nuevo *Chondropoma* de la provincia de oriente, Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(2): 53-54, 1 fig. (W. J. Clench & C. G. Aguayo)

Describen *Chondropoma alberti*, procedente de: Media Milla al sur de Cabo Lucrecia, Banes, Cuba.

Moluscos fosiles de la Provincia de Oriente, Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(2): 55-63, figs. 1-8.

El autor identifica numerosas especies de moluscos fósiles de varias localidades de la provincia de Oriente, Cuba, entre las cuales se designan como nuevas para la ciencia: *Cyclostremiscus caridae, C. hemiglyptum* y *Cyclostrema cubana*.

Precisa estudiar mejor nuestros moluscos de importancia médica. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(2): 64-66.

Se destaca la importancia del mejor conocimiento de nuestros moluscos fluviátiles, que pueden ser hospederos intermediarios de vermes parasitos del hombre y otros animales, sugiriendo un plan de trabajo.

Un singular género nuevo de moluscos terrestres. *Torreia,* Museo Poey, Univ. Habana, (13): 1-6, figs. 1-3. (C. G. Aguayo & M.

L. Jaume)

Los autores describen el nuevo género *Cupulella*, con dos nuevas especies: *Cupulella vallei* y *C. dominguezi*, procedentes de localidades de La Palma, provincia de Pinar del Rio, Cuba.

1949

Ofrece peligro para la Caña de Azúcar una plaga de babosas gigantes. *Diario "Informacion"*, La Habana, (Marzo 4).

Se advierte el peligro de la introducción en Cuba del molusco terrestre *Achatina fulica*, oriunda de Africa y muy extendida actualmente en islas del océano Pacífico, por su extrema voracidad para los vegetales en general.

Ofrece peligro para la Caña de Azúcar una plaga de babosas gigantes. *Circulares del Museo Biblioteca de Malacología, Habana*, p. 131.

El mismo artículo anterior.

Ofrece peligro para la Caña de Azúcar una plaga de babosas gigantes. *Revista "Carteles"*, La Habana, 1949.

Sobre la *Achatina fulica* y su peligrosidad la agricultura cubana.

Malacology and the Official List of Generic Names. *The Nautilus*, 63(1): 17-19.

Comenta sobre las Reglas Internacionales de la Nomenclatura Zoológica, aplicados a nombres genéricos de moluscos.

Malacology and the Official List of Generic Names. *The American Malacological Union, News Bulletin & Annual Report, 1949*, 16: 2-3.

Es el mismo artículo anteriormente relacionado.

Infraspecific units in malacology. *The American Malacological Union, News Bulletin and Annual Report, 1949*, 16: 8-10.

Sobre categorias intraespecíficas en Malacología.

Dos nuevos moluscos cubanos del género *Opisthosiphon*. *Revista* *de la Sociedad Malacológica "Carlos de la Torre,"* 6(3): 89-90, 2 figs. (W. J. Clench & C. G Aguayo)

Describen: *Opisthosiphon sainzi insolutus* y *O. caroli angusti.*

Nuevos moluscos fósiles de la República Dominicana. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(3): 91-92, 1 pl.

En este trabajo se describen como nuevas para la ciencia: *Circulus quadricristatus* y *Haplocochlias? dominicensis* de la formación "Gurabo", Mioceno Medio.

Notas y variedades. (X). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 6(3): 97-103.

El autor trata sobre los siguientes temas: "El status de *Alcadia* elatior (Pfeiffer). - "Sobre la naturaleza del depósito negro interior de los *Ammonites* de Cuba." - "*Tritonalia* Fleming, 1828, posible nombre generico valido para nuestro Triton Gigante." - "Las Cypraeas a la luz del estudio de los 'Circulos de Razz' - "Estimado del número de especies de Moluscos" - Nota Bibliografica sobre "The Family Tonnidae in the Western Atlantic", por Ruth D. Turner.

Tres nuevos moluscos operculados Cubanos. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 7(1): 7-10, 1 lam. (C. G. Aguayo & Marid Sanchez Roig)

Dan a conocer las nuevas especies de moluscos terrestres cubanos siguientes: *Opisthosiphon (Bermudezsiphona) conicus, Wrightudora (Aguayotudora) levistria* y *Annularella holguinensis alcaldei.*

Nuevos moluscos fósiles de Cuba y Panamá. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 7(1): 11-14, 1 pl.

Entre las nuevas especies descritas, las siguientes pertenecen a nuestro territorio: *Borsonia sanchezi, Cordieria baracoensis* y *Scobinella cubana,* todas del Mioceno Medio de Baracoa, provincia Guantanamo, Cuba.

Notas y variedades - (XI). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 7(1): 19-24.

Entre los tópicos expuestos se encuentran: Sobre el Mioceno de "Somorrostro", la Habana. "Dragas para laboratorios Marinos"; "la Evolución Bioquímica"; "Status de las especies previamente referidas a *Leuconia* y *Phytia.*

Don Carlos de la Torre y Huerta - 1858-1950. *Revista de la*

Sociedad Malacológica "Carlos de la Torre," 7(2): 41-42, 1 lam.

Obituario - Deceso del sabio malacólogo cubano.

Nuevos helicinidos de la provincia de Oriente, Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 7(2): 61-66, 1 lam. (W. J. Clench & C. G. Aguayo)

Describen: *Glyptemoda; Emoda (Glyptemoda) torrei freire, E. clementis; Alcadia quinonesi* y *Alcadia euglypta.*

Notas y variedades - (XII). *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 7(2): 67-72, 3 figs.

Se destacan los siguientes artículos: "El género *Cupulella* Aguayo y Jaume en la familia Achatinidae, resuelto por el estudio anatómico del animal. Este género fue colocado tentativamente en la familia Sagdidae." - "Sobre la alimentación de los *Liguus* y *Polymitas* (con leche malteada)." "Un método para limpiar moluscos, por medio de la congelación." - "Nota sobre *Cepolis (Eurycampta) bonplandi* (Lamarck), con descripción de la nueva subespecie: *pinarensis.*"

Algunas especies de Cerriónidos (Mollusca - Gasteropoda). *Torreya,* Museo Poey, Univ. Habana, (14): 1-10, fig. 1-25. (W. J. Clench & C. G. Aguayo)

Los autores describen las siguientes nuevas especies del género *Cerion* de las costa norte de la antigua Provincia de Oriente: *Cerion alberti, C. humberti, C. geophilus, C. josephi, C. banesense* y *C. hessei.*

1950

Caracoles trotamundos. *Boletin de Historia Natural de la Sociedad Poey,* 1(2): 75-82.

Es un trabajo de divulgación en el cual se exponen especies de moluscos de distribución universal.

Don Carlos de la Torre y Huerta. *Circulares Sociedad Malacológica "Carlos de la Torre,"* 1: 273-275.

Oración fúnebre pronunciada por el Dr. Aguayo en el sepelio del sabio malacólogo cubano, Dr. Carlos de la Torre y Huerta.

Bibliografía Malacológica de Don Carlos de la Torre. *Agonía,* Univ. Habana (Mayo-Dic.), pp. 119-129.

Se relacionan los trabajos científicos realizados en el campo de la Malacológia por el Dr. Carlos de la Torre y Huerta, comentando y señalando las nuevas especies para la ciencia publicadas por él y sus colaboradores.

1951

Los Moluscos y la Civilización. *Boletin de Historia Natural de la Sociedad Poey,* 2(5): 15-26.

Notas divulgitivas sobre las íntimas relaciones de los moluscos y el hombre.

El Ostion: Nuevos datos sobre su ciclo vital. *Boletin de la Sociedad de Historia Natural "Felipe Poey,"* 2(5): 30-36. (C. G. Aguayo & Isabel Perez Farfante)

Los autores ofrecen los resultados de sus estudios sobre la biología de *Crassostrea rizophorae,* en aguas cubanas.

Don Carlos: El Naturalista. *Boletin de Historia Natural de la Sociedad Poey,* 2(6): 51-58.

Algunos datos biográficos del destacado malacólogo cubano, Dr. Carlos de la Torre y Huerta.

Novedades en el género *Caracolus* en Cuba. *Memorias de la Sociedad cubana de Historia Natural "Felipe Poey,"* 20(2): 65-69, 2 lams. (W. J. Clench & C. G. Aguayo)

Además de ofrecer una discusión taxonómica y ecológica del género *Caracolus,* propoenen las siguientes especies: *Caracolus sagemon contini,* (Nibujón, Baracoa), *C. sagemon exhuberans* (Cercanía de Baracoa), *C. sagemon turgidus,* (Mina Caledonia, Mayarí), *C. sagemon blanesi* (Silla de Gibara), *C. najazensis* (El Cacaotal, Najaza, Camaguey.).

The Cuban Genus *Jeanneretia. Revista de la Sociedad Malacológica "Carlos de La Torre,"* 7(3): 81-90, 2 lams. (W. J. Clench & C. G. Aguayo)

En esta revisión del género *Jeanneretia* se proponen los siguientes nuevos taxones: *Jeanneretia parraiana arangoi, J. parraiana depressa, J. parraiana carinata, J. jaumei, Guladentia,* como nuevo subgénero; *J.* (*Guladentia*) modica y *J.* (*G.*) *gundlachia.*

Nuevos Ceriónidos de Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 8(1): 1-15, 2 lams.

> Los autores dan a conocer las siguientes nuevas especies del género *Cerion*, de Cuba: *Cerion vulneratum pandionis, C. vulneratum vallei, C. v. herrerae, C. gundlachi bermudezi, C. g. tantilum, C. g. parvulum, C. ebriolum, C. royi, C. cobarrubiae, C. manatiense, C. manatiense sangeti, C. dorotheae, C. scopulorum, C. macrodon, C. circumscriptum, C. santhaemariae, C. sanctacruzensis,* y *C. bioscai.*

Nuevos Ceriónidos de la costa Norte de Matanzas. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 8(1): 19-22, 4 figs. (C. G. Aguayo & Alfredo de la Torre)

> Describen: *Cerion infandulum, C. caroli, C. caroli aedili* y *C. ceiba canasiense.*

Some new Cerionids from Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 8(2): 69-80, 2 lams. (W. J. Clench & C. G. Aguayo)

> Los autores dan a conocer nuevas especies y subespecies de moluscos terrestres cubanos del género *Cerion,* como sigue: *Cerion mariolinum dominicanum, C. blanesi, C. ricardi, C. cisnerosi, C. iostomum moreleti, C. laureani, C. sagraianum peracutum, C. vulneratum lepidum, C. torreimorelesi, C. vanattai* y *C. orientalis.*

Nuevos Moluscos operculados de Matanzas, Cuba. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 8(3): 127-128, 2 figs.

> Describen las nuevas subespecies: *Chondropoma obesum falconi* y *C. moestum arieli.*

1952

Morfología de la concha vs: Anatomía interna. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 9(1): 3-4.

> Es una crítica sobre la importancia del estudio tanto de la morfología externa de la concha, como de su estructura anatómica.

Posición genérica de *Chama cubana* Mulleried. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 9(1): 34.

> El estudio de esta especie fósil permite colocarla en el género *Pseudochama.*

The *Scalarinum* species complex (*Umbonis*) in the genus *Cerion. Occasional Papers on Mollusks,* Havard University, 1(17): 413-440, 7 pls. (W. J. Clench & C. G. Aguayo)

Además de monografiar las especies del subgénero *Umbonis,* describen como nuevos a: *Cerion rehderi,* (Great Inagua, Bahamas); *C. turnerae* (Great Inagua, Bahamas), *C. paucisculptum* (Sama, Banes, Cuba), *C. sisal* (Mosquito, Mariel, Cuba), y *C. shrevei* (Little Inagua, Bahamas.)

Nueva subespecie de *Cerion* de la costa de Mantanzas. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 9(1): 35-36, 1 fig. (C. G. Aguayo & Alfredo de Torre)

Dan la descripción de *Cerion ceiba minusculum,* del Este de la Boca del Rio Canasí, Matanzas, Cuba.

Nuevo helicinido de la provincia de Matanzas. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 9(2): 67-68, 1 fig. (C. G. Aguayo & Alfredo de la Torre)

Describen *Eutrochatella (Ustronia) chrysostoma aedilii.*

1953

Nuevos moluscos cubanos del genero *Cerion. Torreia,* Museo Poey, Univ. Habana, (18): 1-5, 1 lam. (W. J. Clench & C. G. Aguayo)

Los autores ofrecen consideraciones sobre *Cerion sculptum* (Poey), precisando su localidad y describen los nuevos taxonomes siguientes: *Cerion tridentatum rocai, C. peracutum jaumei, C. vulneratum feriai,* y *C. sanchezi.*

Moluscos terrestres de la región de Baracoa, Habana. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 21(3): 267-280, 1 lam.

Además de enumerar sistemáticamente todas las especies de moluscos terrestres encontradas en la localidad, se dan a conocer como nuevos para la ciencia: *Eutrochatella (Ustronia) gouldiana camoensis, E. (U.) gouldiana maris, Chondropoma (Chondropoma) pfeifferianum haasi, Rhytidopoma isabelae, Cerion salvatori striatissimum, C. marielinum constrictum, Oleacina (Laevoleacina) rangelina* y *Gongylostoma* sp.

Dos nuevos moluscos de la región oriental de Cuba. *Torreia,* Museo Poey, Univ. Habana, (19): 1-4, figs. 1-6. (C. G. Aguayo & Alberto R. Quiñones)

Los autores dan a conocer las siguientes especies nuevas de moluscos terrestres del territorio oriental de Cuba: *Chondropoma (Chondropomisca) cuyaguanensis* (Cerro de Cayajuaní, entre Bariay y puerto Naranjo) y *Cepolis (Coryda) nigropicta rota* (Pan de Samá, Banes.)

Nuevos moluscos cubanos de la familia Cerionidae. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 21(3): 283-298. (C. G. Aguayo & Mario Sanchez Roig)

Proponen las nuevas especies cubanas del género *Cerion: C. mumia cabrerai, C. m. wrighti, C. m. feriae, C. microdon cardenense, C. sagraianum saguaense, C. herrerai subcostulatum, C. strigis, C. circumscriptum tenicallum, C. c. romanoensis, C. c. cuspidata, C. pseudocyclostomum, C. sanzi seliare, C. josephi portuspatris, C. chaparra, C. paucicostatum harringtoni, C. tenuilabre jaucosensis santacruzensis, C. poey, C. arangoi alcaldei* y *C. pineria hernandezi.*

1954

Notas sobre el genero *Emoda. Torreia,* Museo Poey, Universidad de Habana, (21): 13 pp., 2 lam.

Además de ofrecer consideraciones sobre la taxonomía del género *Emoda,* los autores describen las sigulentes nuevas especies: *Emoda pujalsi, E. mayarina, E. mayarina gutierrezi, E. mayarina mirandensis, E. najazaensis, E. bermudezi, E. sagraiana percrassa* y *E. zayasi.*

Descripción de nuevas especies de moluscos terrestres cubanos. *Revista de la Sociedad Malacológica "Carlos de la Torre,"* 9(2): 47-66, 2 lams., 3 textas figss.

En éste trabajo los autores dan a conocer nuevas especies y subespecies de moluscos terrestres cubanos, como sigue: *Opisthosiphon (Cylindrosiphona) bacillum vallei, Opisthocoelicum (Opisthocoelops) excurrens curvilabre, Torrella immersum persea, Wrightudora (Aguayotudora) clenchi, W. (Wrightudora) gundlachi dominguezi, Eutudora (Eutudora) limbifera saguaensis, E. (E.) transitoria torrei, E. (E.) transitoria roblensis, E. (Eutudorisca) catenata pipianensis, Alcadia balteata, Melaniella alcaldei, M. fuentesi, M. camagueyana, M. camagueyana rodriguezi, M. bermudezi, M. gracillima pinensis, M. quinonesi, Cepolis (Cysticopsis) exauberi, C. (Hemitrochus) compta iolabiata, Zachrysia guanensis leucozoa* y *Z. guanensis castanea.*

Indice al Catálogo de los moluscos de Cuba, por (1947-1952). *Circulares Museo y Biblioteca de Zoología de la Habana*, pp. 1359-1374. (C. G. Aguayo y Miguel L. Jaume)

En este indice aparacen todos los taxones malacologícos contenidos en las primeras 725 hojas del "Catálogo".

1955

Valoraciones Científicas - Recuerdos del Maestro. *Folleto de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 16 pp., lams.

En homenaje al gran maestro de la ciencias naturales cubanas, doctor Carlos de la Torre.

1957

Adiciones a la Fauna Malacologica cubana. - I. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 23(2): 117-148, 1 lam.

En este trabajo se continuan añadiendo nuevas especies de moluscos terrestres para la ciencia, como sigue: *Bakerviana* nuevo subgénero para *Eutrochatella*, de la familia Helicinidae; *Eutrochatella (Bakerviana) littoricola maisiana, E. (Microviana) petrosa pilsbryi, E. (M.) tumidula* Clench & Aguayo, *E. (Troschelviana) jaumei* Clench & Aguayo, *Alcadia bermudezi, A. (Penisoltia) camagueyana, A. (P.) camagueyana porosa, A. (P.) camagueyana ecarina, Proserpina depressa rubrocincta, Chondropoma (Chondropomisca) virgineum mayariense, C. (Gutierrezium) alayoi, Chondropomatus latus pujalsi, Annularella trochoidalis, Cepolis (Coryda) alauda canescens, C. (C.) alauda incrustata, C. (C.) alauda quinonesi* Clench & Aguayo, *C. (C.) ovumreguli ramsdeni, C. (Hemitrochus) alleni, C. (H.) beattiei, C. (H.) hendersoni, C. (H.) maisiana, Zachrysia (Chrysias) gundlachiana garciai, Lyobasis acicularis, L. petricola, L. paradoza arangoi, L. basilissa, L. saugeti, Cerion barroi* y *C. blanesi bariayi.*

1958

Adiciones a la fauna malacológica cubana. II. *Memorias de la Sociedad Cubana de Historia Natural "Felipe Poey,"* 24(1): 91-104, 1 lam.

Los autores continuan aportando nuevas especies para la ciencia en Moluscos Terrestres cubanos, como sigue: *Helicina (Subglobulosa) leoni,* *Alcadia (Hjalmarsona) selenipoma, Eutrochatella (Microviana) alcaldei, E. (M.) purioensis, E. (M.) clenchi, E. (M.) subangulata, E. (M.) subangulata cienfuegosensis, Semitrochatella,* género nuevo de la famila Helicinidae, *S. conica anafensis.* Se discuteden además, por estudio radulares, sobre la posición sistemática de varios subgénros de la familia Helicinidae.

1961

Aspecto general de la fauna malacologica puertorriqueña. *Caribbean Journal of Science,* 1(3): 89-105.

El autor ofrece una lista taxonómica de las especies de moluscos terrestres y de agua dulce de Puerto Rico, con un análisis de dicha fauna y conclusiones.

Notas sobre moluscos terrestres antillanos. *Caribbean Journal of Science,* 1(4): 143.

El autor propone incluir en el género Stoastomops cuyo genotipo es de Puerto Rico, a les especies cubanas incluídas anteriormente en el género *Microviana* H. B. Baker, siguientes: *continua* (Pfeiffer) *pfeifferiana* (Arango) y *emmerlingi* (Pfeiffer), bajo el subgénero *Swiftella* dentro del subgénero *Torreviana* a las especies *holguinensis* y *spinopoma,* ambas de Aguayo.

1962

Notas sobre moluscos terrestres antillanos-II. *Caribbean Journal of Science,* 2(1): 9-12.

Es un documentado estudio sobre el 'status' de los moluscos de la familia Helicinidae, géneros *Ustronia, Cubaviana* y *Excavata,* enumerando las especies cubanas pertenecientes a los mismos y señalando aquellas cuyas radulas no ha sido posible examinar aún, para poder diagnosticar su verdadera posición sistemática.

Notas sobre Moluscos Antillanos-III. *Caribbean Journal of Science,* 2(3): 108-112.

El autor expone los resultados de un estudio sobre "Conchas halladas en depósitos cuaternarios de Guanajibo, Puerto Rico" y "Adiciones a la lista de los Moluscos de Puerto Rico."

1963

Notas sobre moluscos antillanos (IV). *Caribbean Journal of Science,* 3(1): 69-71.

El autor se refiere a sus estudios sobre: La familia Sphaeriidae en Cuba y Puerto Rico (Bivalvia: Sphaeriidae) y "Sobre el hallazgo de *Gyraulus parvus* en Cuba. (Familia Planorbidae.)

1964

Notas sobre distribución de la babosa *Vaginulus plebeius* (Mollusca-Veronicellidae). *Caribbean Journal of Science,* 4(4): 549-551, 2 figs.

Reporta por primora vez para Cuba y la Florida, USA, la especie citada en el título y informa su presencia también en Brasil, St. Thomas, R. Dominicana, Jamaica y Puerto Rico.

1965

Sobre el status de *Veronicella portoricensis* (Mollusca - Pulmonata.) *Caribbean Journal of Science,* 5(1-2): 25-28, 2 figs.

El autor hace un estudio exhaustivo sobre la citada especie de Puerto Rico.

1966

Una lista de los Moluscos Terrestres y Fluviales de Puerto Rico. *Stahlia,* (5): 17 pp.

El Dr. Aguayo ofrece un catálogo sistemático de los moluscos terrestres y dulce-acuícolas de la isla de Puerto Rico.

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Manuscripts may be in English, French, Spanish or German (English is preferred) and should follow *Walkerana* style. All research articles must contain a concise but adequate **abstract**, which should be an informative digest of significant content and should be able to stand alone as a brief statement of the conclusions of the paper. Review papers and short notes do not need an abstract. Key words that indicate the main subjects of the paper should be provided by authors. Papers are accepted on condition that copyright is vested in the journal. All statements made and opinions expressed in any article are the responsibility of the author.

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