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FRESHWATER SNAILS OF THE PHILIPPINES*

J. B. Burch

INTRODUCTION

Freshwater malacology is of considerable importance to the Philippines because of the human parasitic diseases transmitted by some of the country's indigenous snail species. But, in spite of this importance, there are no manuals or handbooks available to help workers identify Philippine freshwater mollusks, or to place the native snail fauna into a modern frame of classification. Therefore, this guide to the identification and classification of the nation's freshwater snails is presented as a step toward strengthening malacology in the Philippines.

Appreciation is expressed to Dr. B.C. Dazo, the World Health Organization (Western Pacific Regional Office), and the Philippine Ministry of Health (Schistosomiasis Research and Control Service) for supporting these efforts.

IDENTIFICATION

Characters of the shells of freshwater gastropods are very important in species recognition and usually for generic and familial placement as well. Especially useful are the size (Fig. 1) and general form of the shell (Figs. 2-6). Among the many species, the shell may take various shapes, yet, for any one species, the shell shape is usually quite constant (excepting, of course, minor clinal, populational and ecophenotypic variations exhibited by some species). The shells among the different species may vary from very elongate (e.g., Fig. 2a,b) to nearly globose (e.g., Fig. 3a), depressed (e.g., Fig. 2e) and discoidal (Fig. 4). The shell may be longer than wide (e.g., Fig. 2a-d), or wider than long (e.g., Fig. 2e) [the columella determining the antero-posterior shell axis (see Fig. 7)]. The shell's coils (whorls) may turn either to the left (Figs. 8a, 9a) or to

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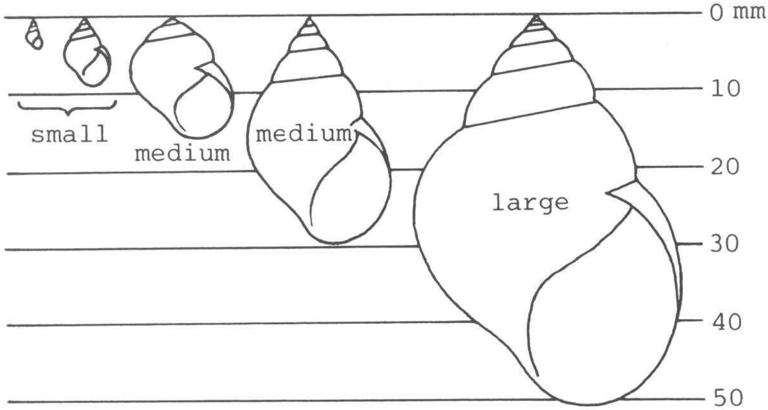


FIG. 1. Shell sizes: up to 10 mm = small; 10-30 mm = medium; over 30 mm = large.

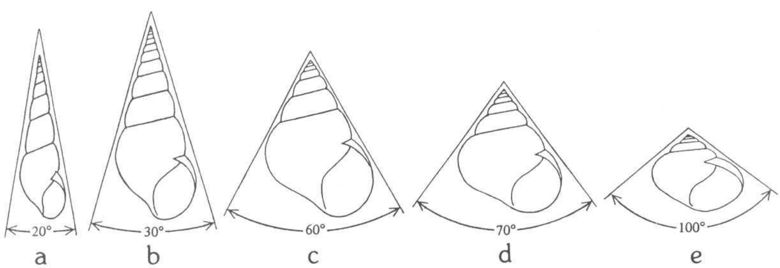


FIG. 2. Shell shapes. **a,** Narrowly conic; **b,** elongately conic; **c,** broadly (ovately) conic; **d,** globosely conic; **e,** depressed conic.

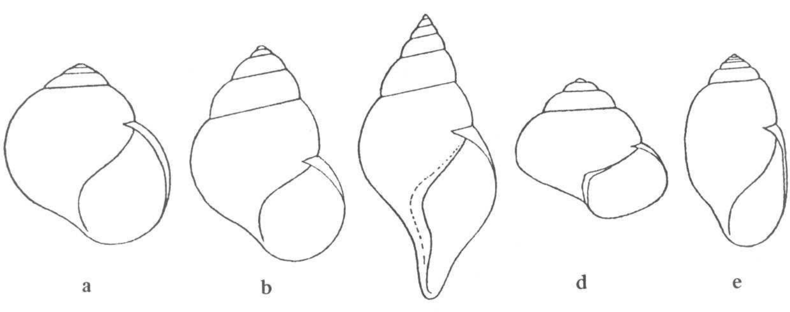
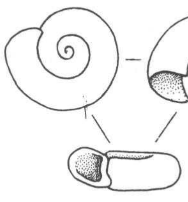


FIG. 3. Shell shapes. **a,** Subglobose; **b,** oval; **c,** fusiform or spindle-shaped; **d,** turbiniform; **e,** cylindrical.



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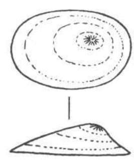

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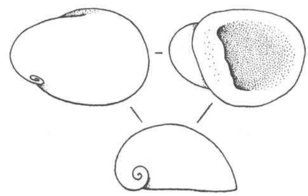

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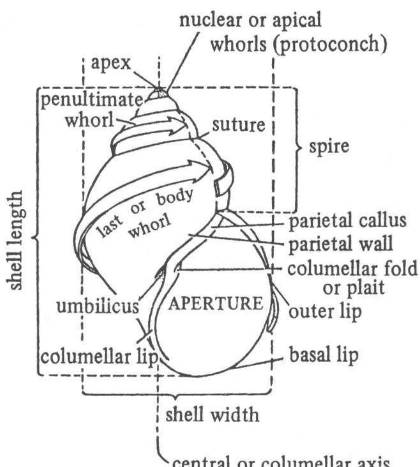
FIG. 4. Planorbiform or discoidal shell. FIG. 5. Ancyliform or limpet-shaped shell. FIG. 6. Neritiform shell.



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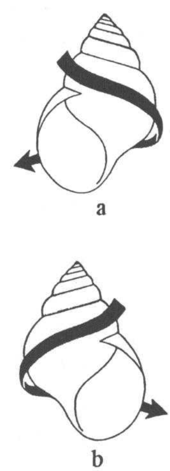

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FIG. 7. Shell terminology. FIG. 8. Direction of coiling of gastropod shells. **a,** Shell coiled to the left, i.e., sinistral; **b,** shell coiled to the right, i.e., dextral.

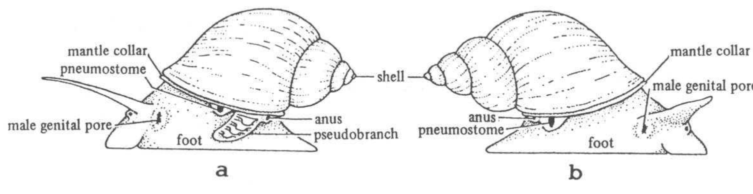
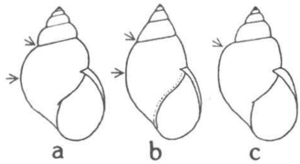


FIG. 9. **a,** A snail with sinistral organization of its body, i.e., respiratory, excretory and reproductive openings are on the left side; **b,** a snail with dextral organization of its body, i.e., respiratory, excretory and reproductive openings are on the right side.



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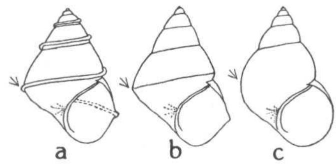

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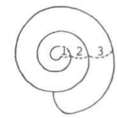

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FIG. 10. a, Shell with well-rounded whorls and indented sutures; **b,** shell with flattened whorls and shallow sutures; **c,** shell with shouldered whorls. **FIG. 11. a,** Shell with a keel or carina; **b,** shell with angular periphery; **c,** shell with rounded periphery. **FIG. 12. Method of counting whorls. This shell has 3¼ whorls.**

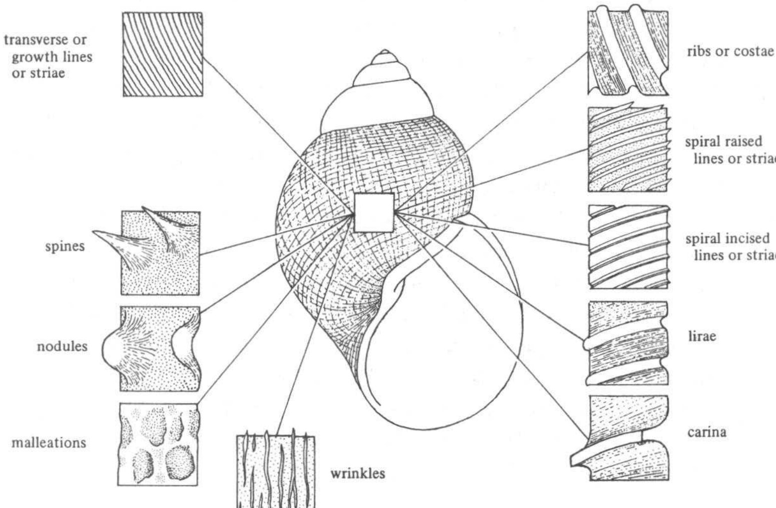

FIG. 13. Shell surface sculpture.

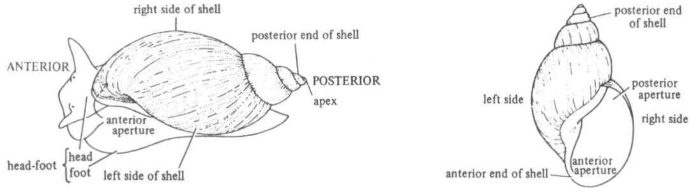

FIG. 14. Orientation of the shell.

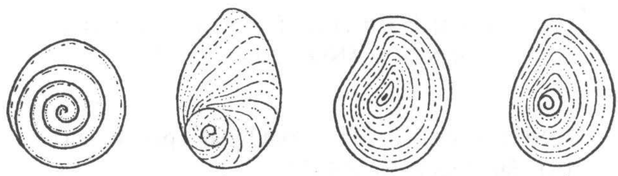

FIG. 15. Types of opercula. a, Multispiral; b, paucispiral; c, concentric; d, concentric with spiral nucleus.

the right (Figs. 8b, 9b), be round (Figs. 10a, 11c), angular (Fig. 11b), shouldered (Fig. 10c) or flattened (Fig. 10b), and have shallow (Fig. 10b) or impressed sutures (Fig. 10a). The shell may have few or many whorls, but all the shells of adults of any particular species will have approximately the same number of whorls (see Fig. 12 for method of counting whorls). The shell may lack an opening (umbilicus) at its base, or may have either a narrow or wide opening. The columella or central axial column of the shell may be either twisted or straight and may or may not end abruptly. The outer lip of the shell may be either straight or variously curved and is sometimes turned back or reflected. The surface of the shell may be marked in various ways (Fig. 13), i.e., differentially colored or sculptured, or may be simply unicolored and smooth. The outline of the shell aperture ("mouth") (see Figs. 7, 14) may take many forms due to the shape and relation of the whorls to each other. The aperture may or may not be closed by an operculum, which itself has important recognition characters (Fig. 15). The operculum may be round (Fig. 15a), oval (Fig. 15b, c, d) or spindle-shaped, and concentric (Fig. 15c, d), paucispiral (Fig. 15b) or multispiral (Fig. 15a), depending on the way it is formed.

KEY TO THE HIGHER TAXA AND TO THE GENERA AND SUBGENERA[1]

1 Aperture of shell, in life, closed by an operculum (Fig. 16). Subclass Prosobranchia[2] 2

Aperture of shell not closed by an operculum in life. Subclass Pulmonata, Order Limnophila [= Basommatophora, in part][2] 32

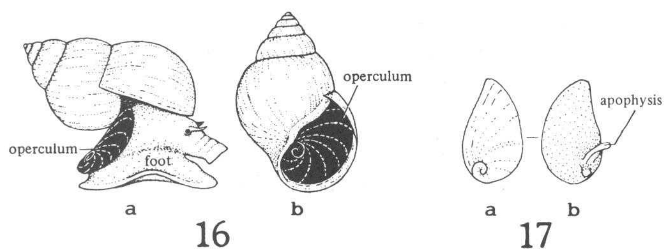

FIG. 16. An operculated snail, i.e., one which carries an operculum attached to its dorsal posterior foot. **a,** Position of the operculum when the snail is active; **b,** position of the operculum when the snail has withdrawn into its shell. FIG. 17. Operculum. **a,** External view; **b,** inner surface (which in life is attached to the dorsal foot). [Apophyses occur only in the Neritidae.]

2(1) Shell neritiform, i.e., with relatively very large body whorl and very small coiled spire (Fig. 6); operculum in most species with elongate attachment processes (apophyses) on its inner surface (Fig. 17). Order Neritacea, Superfamily Neritoidea[3], Family Neritidae[4] 3

Shell not neritiform, spire generally pronounced; inner surface of operculum relatively smooth, without elongate attachment processes on its inner surface. Order Mesogastropoda 12

[1] Superscript numbers given in the Key and Outline which follow refer to corresponding comments under Notes (pp. 103-104).

3(2) Shell almost bilaterally symmetrical, cap-shaped, limpet-like; operculum without apophyses; operculum does not entirely close shell aperture (Figs. 18-20). Genus *Septaria* 4

Shell with typical gastropod spiral symmetry; shell may be, but generally is not, cap-shaped or limpet-like; operculum with two apophyses on the inner anterior end; operculum completely closes aperture 6

4(3) Apical whorls extending beyond posterior apertural margin 5

Apical whorls not extending beyond posterior apertural margin (Fig. 18) . . . . Subgenus *Navicella*

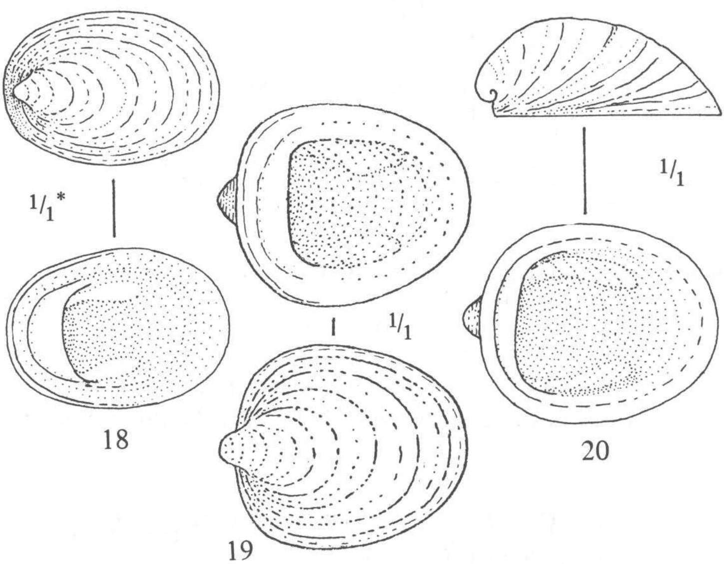

FIG. 18. *Septaria (Navicella)*. FIG. 19. *Septaria* s.s. FIG. 20. *Septaria (Sandalium)*.

*Size of figure to actual size of specimen is given throughout the key by a ratio; 1/1 = natural size; 2/1 = twice natural size; 3/1 = enlarged three times; etc.

5(4) Apex more or less medianly curved; inhabitant of fast-flowing water (Fig. 19) . . . . Subgenus *Septaria* s.s.

Apex laterally recurved inhabitant of standing water, found on plants (Fig. 20) . . . . Subgenus *Sandalium*

6(3) Shell surface nearly always with one or more spiral rows of long projecting spines (Fig. 21) . . . . Genus *Clithon*

Shell surface without spines 7

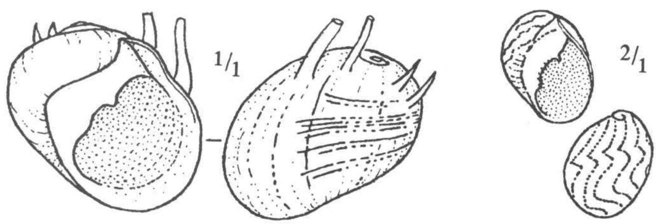

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FIG. 21. *Clithon.* FIG. 22. *Smaragdia.*

7(6) Adult shell large, more than 1 cm and up to 3 cm or more in length 8

Adult shell small, less than 1 cm in length (Fig. 22) . . . . Genus *Smaragdia*, Subgenus *Smaragdella*

8(7) Posterior ("superior") apophysis longitudinally grooved, the ridges ending in pointed projections on the free (left) end (Fig. 23) . . . . Genus *Neritodryas*

Posterior apophysis not longitudinally grooved. Genus *Neritina* 9

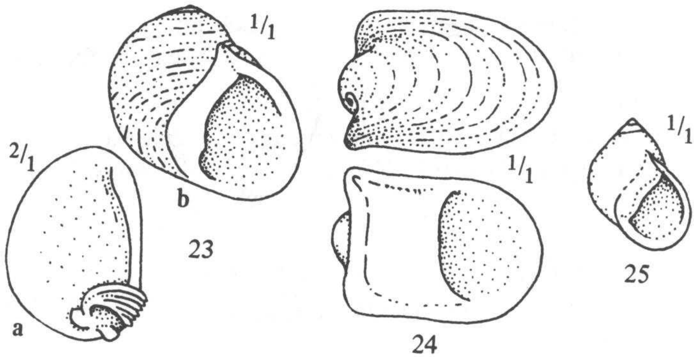


FIG. 23. *Neritodryas.* **a,** Operculum; **b,** shell. FIG. 24. *Neritina (Neripteron).* FIG. 25. *Neritina (Vittina).*

9(8) Shell cap-shaped and limpet-like (Fig. 24) . . . . Subgenus *Neripteron*

Shell subglobose, not cap-shaped or limpet-like 10

10(9) Shell high-spired (Fig. 25) . . . . Subgenus *Vittina*

Shell spire greatly reduced and depressed 11

11(10) Groove present where the right apertural lip meets the parietal shell wall; apophyses on operculum well developed (Fig. 26) . . . . Subgenus *Neritina* s.s.

Right apertural lip meets the parietal shell wall without producing a groove; apophyses on operculum reduced to a plate (Fig. 27) . . . . Subgenus *Neritona*

12(2) Adult shell large, more than 1 cm and up to 7 cm or more in length 13

Adult shell small, less than 1 cm in length 28

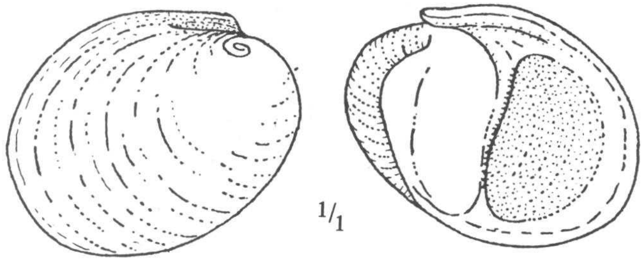
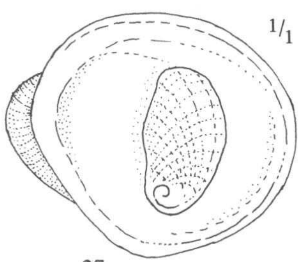


FIG. 26. *Neritina* s.s.

13(12) Shell spire elongate, more than ½ the total shell length . . . 14

Shell spire depressed, less than ½ the total shell length. Superfamily Ampullarioidea (in part). Family Ampullariidae (Fig. 28) . . . . Genus *Pila*



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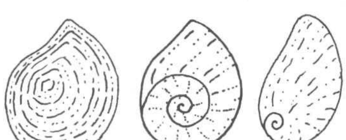

a b c

29

FIG. 27. *Neritina (Neritona).* FIG. 28. *Pila.* FIG. 29. Opercula. **a**, Concentric; **b**, multispiral; **c**, paucispiral.

14(13) Operculum concentric (Fig. 29a). Superfamily Ampullarioidea (in part). Family Viviparidae[5] 15

Operculum multispiral or paucispiral (Fig. 29b,c). Superfamily Vermetoidea 19

15(14) Shell carinate, with only one carina, which is at the circumferal periphery of the whorls (Figs. 30, 31). Genus *Angulyagra* 16

Shell with or without carinae, but if present the carinae are usually subobsolete and more than just one, but if with only one carina it is not usually at the circumferal periphery of the whorls 17

16(15) Carina continuous, without spines (Fig. 30) . . . . Subgenus *Angulyagra* s.s.

Carina with periodic hollow outwardly turned spines (Fig. 31) . . . . Subgenus *Acanthotropis*

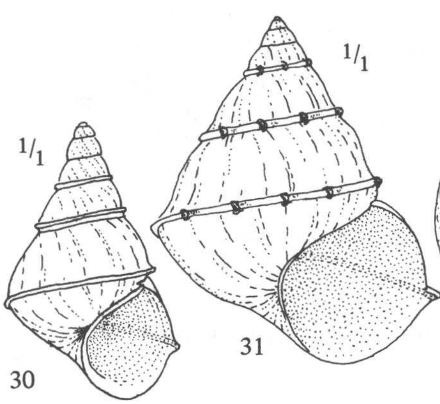

FIG. 30. *Angulyagra* s.s. FIG. 31. *Angulyagra (Acanthotropis)*. FIG. 32. *Cipangopaludina*.

17(15) Adult shells large, globose, 4 cm or longer in length (Fig. 32) . . . . Genus *Cipangopaludina*[6]

Adult shells medium to large, but if large (4 cm or more in length) the shells are elongate, conical, turreted and with carinae 18

18(17) Shell globose, generally with numerous close-set keels, imperforate (Fig. 33) . . . . . Genus *Taia*, Subgenus *Torotaia*

Shell globose or turbinate to broadly conical or turreted; if the shell is globose or turbinate it is generally smooth, but if carinae are present they are usually obsolete or subobsolete; shell narrowly umbilicate, perforate or imperforate (Fig. 34) . . . . . . Genus *Bellamya*

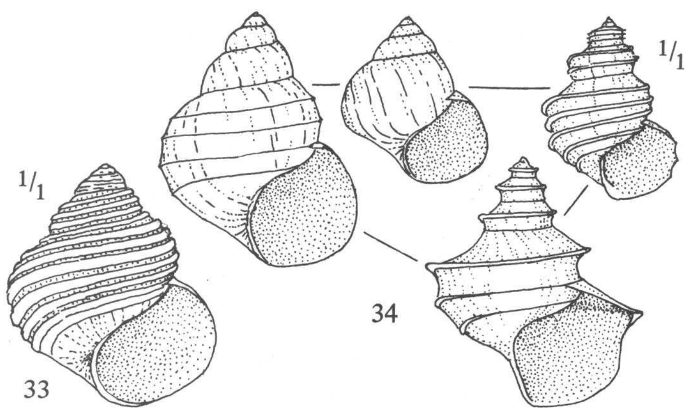

FIG. 33. *Taia*. FIG. 34. *Bellamya*.

19(14) Shell ovate, broadly to globosely conical, never with spines 20

Shell elongate, narrowly or elongately conical, or if not elongate, with spines. Family Thiaridae (in part) 21

20(19) Shell aperture ovate, less than ½ the total shell length. Family Paludomidae (Fig. 35) . . . . Genus *Paludomus*

Shell aperture broadly spindle-shaped, more than ½ the total shell length. Family Thiaridae (in part) (Fig. 36) . . . . Genus *Balanocochlis*

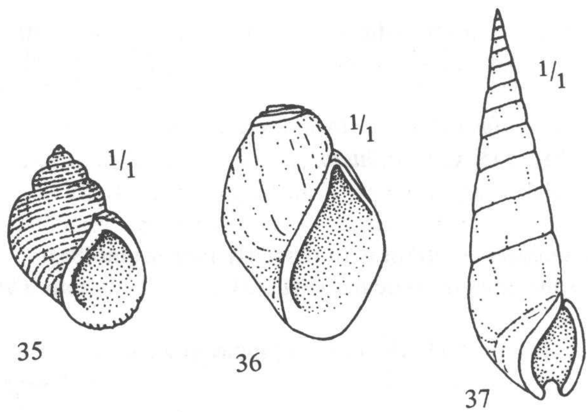

FIG. 35. *Paludomus.* FIG. 36. *Balanocochlis.* FIG. 37. *Faunus.*

21(19) Shell aperture with a deep notch in the anterior (basal) margin. Family Potamididae (Fig. 37) . . . . . . Genus *Faunus*

Shell aperture without a deep notch in the anterior (basal) margin. Family Thiaridae (in part) 22

22(21) Operculum multispiral, nucleus nearly central (Fig. 29b); adult shell large, more than 3.5 cm and up to 7 cm or more in length, elongately conic; surface sculptured with ribs, spiral cords or carinae, nodules or low spines, or with two or more of these features in combination (Fig. 38) . . . . Genus *Brotia*

Operculum paucispiral, nucleus near or at the anterior (basal) margin (Fig. 29c); shell medium (1.5-3 cm in length) to large (3-8+ cm in length), but if over 4 cm the shell is without spines, very narrowly conic and with the first part of the spire almost needle-like (if not eroded); shells smooth or variously sculptured 23

23(22) Shell surfaces smooth or variously sculptured, but without spines or sharp nodules 25

Shell surface sculpture includes spines or sharp nodules (Fig. 39). Genus *Thiara*[7] 24

24(23) Shoulders of whorls with relatively short or medium spines or sharp nodules (Fig. 39) . . . . . Subgenus *Thiara* s.s.

Shoulders of whorls with long spines (Fig. 40) . . . . Subgenus *Setaeara*

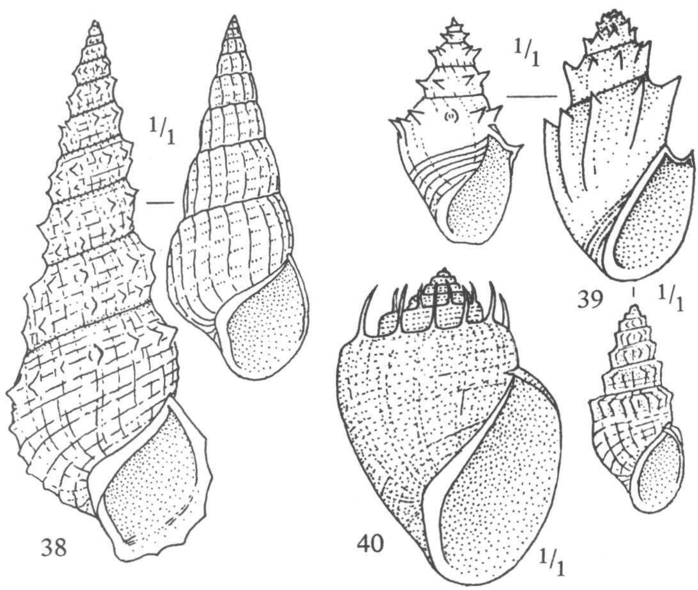

FIG. 38. *Brotia.* FIG. 39. *Thiara* s.s. FIG. 40. *Setaeara.*

25(23) Shell surface smooth or with ribs, lirae, or spiral striae and cords, but without tubercles 26

Shell surface with tubercles, which may or may not be located on ribs 27

26(25) Shell smooth or with weak axial ribs, without noticeable spiral sculpture except on anterior (umbilical) side of last whorl (Fig. 41) . . . . Genus *Stenomelania*

Shell usually with axial ribs and with numerous spiral striae or cords (Fig. 42) . . . . Genus *Melanoides*

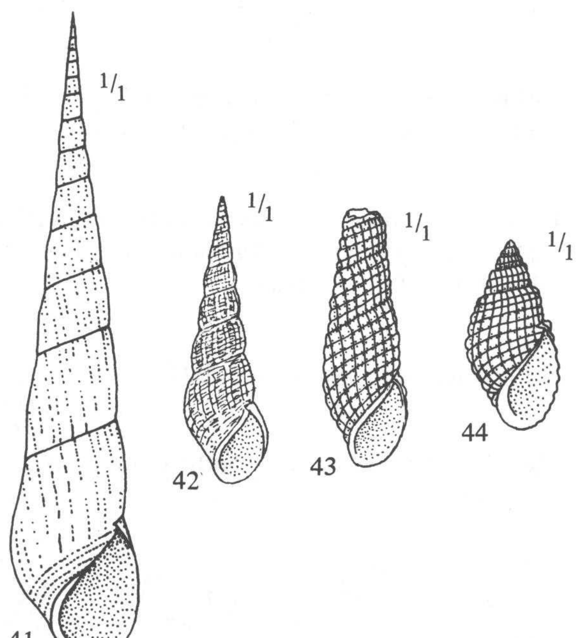

FIG. 41. *Stenomelania.* FIG. 42. *Melanoides.* FIG. 43. *Tarebia.* FIG. 44. *Sermyla.*

27(25) Shell elongately conic (Fig. 43) . . . . Genus *Tarebia*

Shell narrowly conic (Fig. 44) . . . . Genus *Sermyla*

28(12) Operculum concentric (Fig. 15c), calcareous. Superfamily Ampullarioidea (in part). Family Bithyniidae . . . 29

Operculum paucispiral (Fig. 15b), corneous. Superfamily Truncatelloidea 30

29(28) Shell globose, aperture and spire nearly equal in length (Fig. 45) . . . . Genus *Petroglyphus*

Shell more elongate, spire length noticeably greater than aperture length (Fig. 46) . . . . Genus *Bithynia*

30(28) Last part of body whorl and aperture deflected and reduced in size (Fig. 47). Family Stenothyridae . . . . Genus *Stenothyra*

Entire body whorl and aperture follow the shell's initial spiral symmetry and gradual increase in size (Figs. 48, 49). Family Pomatiopsidae 31

31(30) Shell conical, with rounded whorls (Fig. 48) . . . . Genus *Oncomelania*

Shell conical, with flattened whorls; or shell ovoid (Fig. 49) . . . . Genus *Tricula*[8]

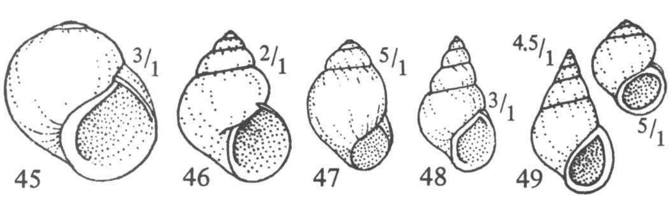

FIG. 45. *Petroglyphus.* FIG. 46. *Bithynia.* FIG. 47. *Stenothyra.* FIG. 48. *Oncomelania.* FIG. 49. *Tricula.*

32(1) Shell cap-like (limpet-shaped; ancyliform), not coiled (Fig. 50). Superfamily Ancyloidea (in part). Family Ancylidae . . . . Genus *Pettancylus*[9]

Shell coiled, not cap-like 33

33(32) Shell planorboid (planispiral; discoidal), coiled in one plane (Figs. 51-55). Superfamily Ancyloidea (in part). Family Planorbidae (in part) 34

Shell elongate, coils not restricted to one plane (Figs. 56-60) 38

34(33) Adult shell small, less than 1 cm in diameter 36

Adult shell large, more than 1 cm in diameter 35

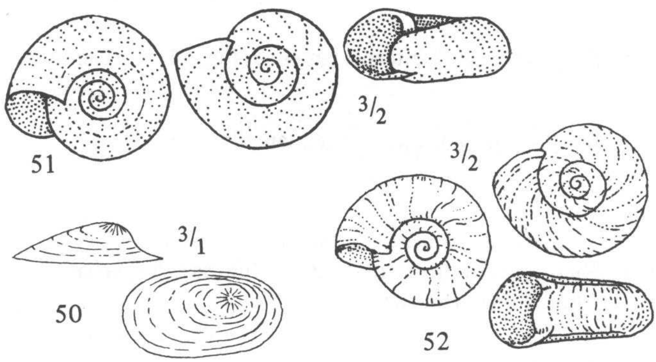

FIG. 50. *Pettancylus.* FIG. 51. *Biomphalaria.* FIG. 52. *Indoplanorbis.*

35(34) Sides of shell spire (see Fig. 4) evenly excavated (Fig. 51) . . . . Genus *Biomphalaria*[6]

Sides of shell spire (see Fig. 4) ascending in steps (Fig. 52) . . . . Genus *Indoplanorbis*[6]

36(34) Basal side of shell flattened, except near periphery; inverted spire wide and shallow; angulation of whorl, when present, near middle of whorl; shell dull to moderately glossy (Fig. 53) .... Genus *Gyraulus*

Basal side of shell roundly convex; inverted spire more or less narrow and deep; angulation (shoulder) of periphery near top of whorl; shell moderately to very glossy 37

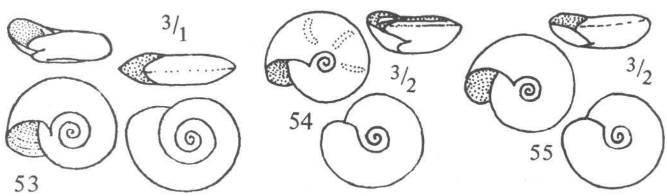

FIG. 53. *Gyraulus.* FIG. 54. *Polypylis.* FIG. 55. *Helicorbis.*

37(36) Body whorl with internal lamellae (Fig. 54) .. Genus *Polypylis*

Body whorl without internal lamellae (Fig. 55) .... Genus *Helicorbis*

38(33) Shell coiled to the left (sinistral) (Fig. 8a). Superfamily Ancyloidea (in part) 39

Shell coiled to the right (dextral) (Fig. 8b). Superfamily Lymnaeoidea. Family Lymnaeidae. Genus *Lymnaea*[10] 41

39(38) Shell spire relatively long; shell dull to moderately glossy, smooth or spiral striae; mantle margin smooth, without fleshy finger-like projections; blood color red. Family Planorbidae (in part) 40

Shell spire relatively shorter; shell glossy; mantle margin fringed with several fleshy, finger-like protuberances; blood more or less colorless. Family Physidae (Fig. 56) . . . . Genus *Physella*[11]

40(39) Shell smooth, dark brown, without spiral color bands (Fig. 57) . . . . Genus *Physastra*

Shell with well-developed spiral striae and spiral color bands (Fig. 58) . . . . Genus *Camptoceras*

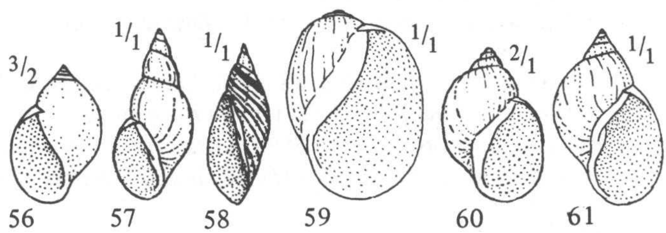

FIG. 56. *Physella.* FIG. 57. *Physastra.* FIG. 58. *Camptoceras.* FIG. 59. *Bullastra.* FIG. 60. *Austropeplea.* FIG. 61. *Radix.*

41(38) Spire depressed, very short, flush with or hardly raised above the body whorl (Fig. 59) . . . . . . Subgenus *Bullastra*

Spire elongate, pointed 41

42(41) Columella generally straight, without a fold or plait at the apertural margin (Fig. 60) . . . . Subgenus *Austropeplea*

Columella generally twisted, making a fold or plait at the apertural margin (Fig. 61) . . . . Subgenus *Radix*

OUTLINE OF CLASSIFICATION

Class GASTROPODA Cuvier 1797 (Duméril 1806)
  Subclass PROSOBRANCHIA Milne Edwards 1848 [Streptoneura Spengel 1881]
    Order NERITACEA [Neritopsina Cox & Knight 1960]
      Superfamily Neritoidea[3] Rafinesque 1815
        Family **NERITIDAE**[4] Rafinesque 1815
          Subfamily Neritinae Rafinesque 1815
            Genus *Clithon* Montfort 1810 (*Nerita corona* Linnaeus)*
            Genus *Neritina* Lamarck 1816 (*Nerita pulligera* Linnaeus)
              Subgenus *Neritina* s.s.
              Subgenus *Neripteron* Lesson 1830 (*Neripteron taitensis* Lesson)
              Subgenus *Neritona* Martens 1869 (*Neritina labiosa* Sowerby)
              Subgenus *Vittina* Baker 1923 (*Nerita roissyana* Recluz)
            Genus *Neritodryas* Martens 1869 (*Nerita cornea* Linnaeus)
            Genus *Septaria* Férussac 1807 (*Patella borbonica* Bory Saint Vincent)
              Subgenus *Septaria* s.s.
              Subgenus *Navicella* Lamarck (in Bruguière, etc.) 1816 (*Navicella tesselata* Lamarck)
              Subgenus *Sandalium* Schumacher 1817 (*Sandalium picta* Schumacher)
          Subfamily Smaragdinae H. B. Baker 1923
            Genus *Smaragdia* Issel 1869 (*Neritina feulleti* Audouin)
              Subgenus *Smaragdella* H. B. Baker 1923 (*Neritina souverbiana hellvillensis* Crosse)
    Order MESOGASTROPODA Thiele 1927 [Taenioglossa Troschel 1848; Monotocardia Mörch 1865]
      Superfamily Ampullarioidea Guilding 1828 [Ampullariacea; Cyclophoroidea Gray 1847 or Cyclophoracea]
        Family **VIVIPARIDAE** Gray 1847[5]
          Subfamily Bellamyinae Rohrback 1937
            Genus *Angulyagra* Rao 1931 (*Paludina oxytropis* Benson)
              Subgenus *Angulyagra* s.s.
              Subgenus *Acanthotropis* Haas 1939 (*Vivipara partelloi* Bartsch)

*Type species are placed in parentheses after each generic-group name.

Genus *Bellamya* Jousseaume 1886 (*Paludina bellamya* Jousseaume)

Genus *Cipangopaludina* Hannibal 1912[6] (*Paludina malleata* Reeve)

Genus *Taia* Annandale 1818 (*Vivipara naticoides* Theobald)

Subgenus *Torotaia* Haas 1939 (*Vivipara clemensi* Bartsch)

Family **AMPULLARIIDAE** Guilding 1828

Genus *Pila* Bolten (in Rӧding) 1798 (*Helix ampullacea* Linnaeus)

Family **BITHYNIIDAE** Gray 1857

Genus *Bithynia* Leach (in Abel) 1818 (*Helix tentaculata* Linnaeus)

Genus *Petroglyphus* Moellendorff (in Quadras & Moellendorff) 1894 (*Petroglyphus mindanavicus* Moellendorff)

Superfamily Truncatelloidea Gray 1840 (Rissooidea H. & A. Adams 1954)

Family **POMATIOPSIDAE** Stimpson 1865

Genus *Oncomelania* Gredler 1881 (*Oncomelania hupensis* Gredler)

Genus *Tricula* Benson 1843[8] (*Tricula montana* Benson)

Family **STENOTHYRIDAE** Fischer 1887

Genus *Stenothyra* Benson 1856 (*Nematura deltae* Benson)

Superfamily Vermetoidea Rafinesque 1815 [Cerithioidea Flemming 1822]

Family **PALUDOMIDAE** Gill 1871

Genus *Paludomus* Swainson 1840 (*Melania conica* Gray)

Family **THIARIDAE** Troschel 1857

Genus *Balanocochlis* Fischer 1885 (*Melania glans* von dem Busch)

Genus *Brotia* H. Adams 1866 (*Melania pagodula* Gould)

Genus *Melanoides* Olivier 1804 (*Melanoides fasciolata* Olivier = *Nerita tuberculata* Müller)

Genus *Sermyla* H. & A. Adams 1854 (*Melania mitra* Dunker = *Melania tornatella* Lea)

Genus *Stenomelania* Fischer 1885 (*Melania aspirans* Hinds)

Genus *Tarebia* H. & A. Adams 1854 (*Melania semigranosa* von dem Busch)

Genus *Thiara* Rӧding 1798[7] (*Helix amarula* Linnaeus)

Subgenus *Thiara* s.s.

Subgenus *Setaeara* Morrison 1952 (*Thiara cancellata* Rӧding)

Family **POTAMIDIDAE** H. & A. Adams 1853
Genus *Faunus* Montfort 1810 (*Strombus ater* Linnaeus)
Subclass PULMONATA Cuvier 1817
Order LIMNOPHILA Férussac 1812 [Basommatophora Keferstein 1864, in part]
Superfamily Lymnaeoidea Rafinesque 1815
Family **LYMNAEIDAE** Rafinesque 1815[10]
Genus *Lymnaea* Lamarck 1799 (*Helix stagnalis* Linnaeus)
Subgenus *Austropeplea* Cotton 1942 (*Limnea papyracea* Tate)
Subgenus *Bullastra* Bergh 1901 (*Bullastra velutinoides* Bergh = *Lymnaea cumingiana* Pfeiffer)
Subgenus *Radix* Montfort 1810 (*Radix auriculatus* Montfort = *Helix auricularia* Linnaeus)
Superfamily Ancyloidea Rafinesque 1815
Family **PHYSIDAE** Fitzinger 1833
Genus *Physella* Haldeman 1843 (*Physa globosa* Haldeman)[11]
Family **PLANORBIDAE** Rafinesque 1815
Subfamily Planorbinae Rafinesque 1815
Tribe Planorbini Rafinesque 1815
Genus *Gyraulus* Charpentier 1837 (*Planorbis hispidus* Draparnaud = *Planorbis albus* Müller)
Tribe Biomphalariini Watson 1954
Genus *Biomphalaria* Preston 1910[6] (*Biomphalaria smithi* Preston)
Tribe Camptoceratini Dall 1870
Genus *Camptoceras* Benson 1843 (*Camptoceras terebra* Benson)
Tribe Miratestini Sarasin 1897
Genus *Physastra* Tapparone-Canefri 1883 (*Physa (Physastra) vestita* Tapparone-Canefri)
Tribe Segmentinini F.C. Baker 1945
Genus *Helicorbis* Benson 1855 (*Planorbis (Helicorbis) umbilicalis* Benson)
Genus *Polypylis* Pilsbry 1906 (in Pilsbry & Ferriss) 1906 (*Planorbis hemisphaerula* Benson)
Subfamily Bulininae Herrmannsen 1847 [emend.]
Genus *Indoplanorbis*[6] Annandale & Prashad 1920 (*Planorbis exustus* Deshayes)
Family **ANCYLIDAE** Rafinesque 1815
Subfamily Ferrissinae Walker 1917
Genus *Pettancylus* Iredale 1943[9] (*Ancylus tasmanicus* Tenison-Woods)

NOTES

[1] In a dichotomous "key" such as the one presented here, the reader with a snail to identify is presented with a successive series of two opposing choices ("couplets") about one or more characters (usually morphological) possessed by the animal whose identity is to be determined. In each successive couplet of the key, only one of the opposing sets of characters should fit the specimen in question, the choice of which leads the reader to the next couplet of opposing choices. This procedure is followed until a couplet leads the reader to a taxon name (in this key, to a genus or subgenus) rather than the number of another couplet. This taxon name identifies the animal in question.

[2] Higher taxonomic categories (subclass, order, superfamily, family, subfamily, tribe) are given at the appropriate places in the key. However, the couplet characters are for the purpose of identifying only the Philippine freshwater snails, and therefore the characters used in the couplets are not necessarily diagnostic for the higher taxonomic categories on a worldwide basis.

[3] The ending *-oidea* for superfamilies is recommended by the International Commission on Zoological Nomenclature instead of *-acea*, which is used commonly in malacological literature.

[4] Neritidae is used here instead of Neritinidae. The latter name, based on Rafinesque's (1815, *Analyse de la nature . . .* , Palerme, p. 144) Familie Neritinia. Neritinidae has been used previously by Benthem Jutting (1956, *Treubia,* 23(2): 311) and Burch (1978, *J. Conchyliol.,* 115(1/2): 3; 1979, *Malacol. Rev.,* 12(1/2): 97; 1980, *Malacol. Rev.,* 13(1/2): 128; 1982, U.S. Environ. Protect. Agency, Cincinnati, EPA-600/3-82-026, p. 15). However, Neritidae is well entrenched in the literature and Neritinidae can be considered a *nomen oblitum*. Further, although Rafinesque included both *Neritina* and *Nerita* in his Family Neritinia, he may have intended *Nerita* as the root, judging from his (1815, p. 143) formation of the family name Helicinia from the root *Helix.*

[5] In older literature, all Philippine Viviparidae were placed in the Holarctic genus *Viviparus*. However, members of the subfamily Viviparinae to which that genus belongs do not occur in southern and southeastern Asia. The classification used here follows Haas (1939, *Zool. Ser. Field*

Mus. nat. Hist., 24(8): 93-103), although it is realized that future research on Philippine Viviparidae undoubtedly will modify Haas' classification and nomenclature.

[6] Artificially introduced by man in recent times.

[7] Morrison (1954, *Proc. U.S. natl. Mus.*, 103(3325): 378) is of the opinion that *Tiaropsis* Brot 1874 (type species *Melania winteri* von dem Busch [Fig. 39, center, this key]), *Plotiopsis* Brot 1874 (type species *Melania balonnensis* Conrad), and *Pseudoplotia* Forcart 1950 (type species *Buccinum scabra* Müller 1776 [Fig. 39, right, this key]) are all congeneric and therefore synonyms of *Thiara* Röding 1798 (type species *Helix amarula* Linnaeus [Fig. 39, left, this key]), the differences between these taxa being of specific value only. Morrison recognizes one subgenus as distinct from *Thiara* s.s., viz., *Setaeara* Morrison 1952 (type species *Thiara cancellata* Röding 1798) (Fig. 40).

[8] *Tricula expansilabris* Quadras & Moellendorff and *T. hidalgoi* Quadras & Moellendorff are provisionally left in the genus *Tricula* until a proper study of their anatomy can be made.

[9] *Pettancylus* has been found in Leyte and southern Luzon.

[10] In many reports, all lymnaeids in the Western Pacific are included in the Holarctic genus *Lymnaea*. However, the southern and southeastern Asian and Australasian lymnaeids belong to a different stock from the Holarctic *Lymnaea stagnalis*, the type species of the genus *Lymnaea*. Two species groups (genera or subgenera) of Lymnaeidae occur in the Western Pacific region, *Radix* and *Austropeplea*. Additionally, *Bullastra*, which was named for the Philippine species *cumingiana*, may prove to belong to a third group generically or subgenerically distinct from *Radix* and *Austropeplea*; or it may be congeneric with one of the latter two. If *Bullastra* is shown to be congeneric with *Austropeplea*, then *Bullastra* will replace that name.

[11] *Physella* has not been recorded yet, to my knowledge, from the Philippines. However, due to its recent rapid spread throughout the Pacific area (e.g., Hawaii, Guam, New Zealand, Australia), it may turn up eventually in the Philippines.

GLOSSARY

Ancyliform. Having a shell shape like the gastropod genus *Ancylus* or any of the Ancylidae, i.e., a low, uncoiled cone (Fig. 5).

Angular, angulate. Having an angle (or having the tendency to form an angle) (Fig. 11b), rather than a round contour (see Fig. 11c).

Angulation. A low ridge; edge along which two surfaces in different planes meet at an angle.

Aperture. The opening or "mouth" of a snail shell through which the head-foot protrudes when the snail is active (see Figs. 7, 14).

Apex. The tip of a gastropod shell farthest from the aperture (see Figs. 7, 14).

Apophysis (pl. apophyses). A calcareous protuberance or elongate structure, such as that on the inner side of a neritid operculum (Fig. 17b).

Axial. Parallel to the axis or columella of a shell, i.e., transverse to the direction of the shell's spiral coil.

Bilaterally symmetrical. Having a symmetry in which the body is divided along a longitudinal axis into two equal sides which are mirror images of each other.

Body whorl. The last complete whorl or volution of a spiral snail shell, measured from the outer lip back to a point immediately above the outer lip (see Fig. 7). It is normally the largest whorl of the shell and is called the body whorl because it encloses the greatest part of the snail's body.

Calcareous. Composed of carbonate of lime (calcium carbonate).

Carina (pl. carinae). A sharp spiral edge, ridge or "keel" on the outer shell surface (see Figs. 11a, 13).

Carinate. Having one or more sharp spiral edges, ridges or keels on the outer shell surface.

Class. A higher taxonomic category or group between the order and phylum in the hierarchy of animal classification. Each class contains one or more orders. The living mollusks are divided into seven classes, the Gastropoda (snails, slugs, limpets, etc.), Bivalvia or Pelecypoda (clams, mussels, oysters, etc.), Scaphopoda (tusk and tooth shells), Aplacophora (solenogasters), Monoplacophora, Polyplacophora (chitons) and Cephalopoda (squid, cuttlefish, octopusses).

Classification. The arrangement of different kinds of organisms into groups, reflecting relationships, and the groups into a scheme or system, usually hierarchial in nature.

Columella. The internal column around which the whorls revolve; the axis of a spiral shell.

Concentric. Having the same center, e.g., the nucleus, and expanding outward in parallel (i.e., equidistant) lines, as in the lines of growth of an operculum (Fig. 15c,d).

Conical. Shaped like a cone, i.e., tapering evenly from a wide, circular base to a point (see Fig. 2).

Cord. A raised, coarse, rounded spiral ridge on a gastropod shell; larger than striae, but smaller than lirae.

Corneous. Resembling horn or consisting of a horn-like material.

Costa (pl. costae). A transverse rib or rounded ridge of considerable size on the surface of a shell (see Fig. 13).

Costate. Refers to a shell in which the surface is sculptured with heavy, regular transverse ridges or ribs.

Depressed. Flattened dorso-ventrally or postero-anteriorally, as the spire of a shell.

Dextral. Wound or spiraled to the right, i.e., with a clockwise spiral. When the shell aperture faces the observer and the shell apex is directed upward, the aperture is on the right (Fig. 8b).

Discoidal. Round and flat like a disc (Fig. 4).

Elongate. Lengthened; extending length-wise; especially higher than wide.

Elongately conic. Designation for a gastropod shell with a spire angle of about 30° (± 5°) (Fig. 2b).

Family (adj., familial). A taxonomic group of genera sharing certain basic features that set them off from other such groups of genera. The family is a level of classification between the genus and the order. Names of families end in *-idae.*

Gastropod. A member of the molluscan class Gastropoda; a snail, slug, limpet, etc.

Genus (pl. genera; adj., generic). A basic category of biological classification above the species level which contains (usually) two or more related species which share certain features. A few genera are monotypic, i.e., contain only one species.

Globose. Globular or spherical; approaching a globe or sphere in shape.

Glossy. Smooth and shining; highly polished.

Growth lines. Minute lines on the outer shell surface indicating minor rest periods during growth. Not to be confused with the major "rest marks" or varices, caused by prolonged growth arrest (as during winter) (see Fig. 13).

Imperforate. Refers to a spiral gastropod shell which has no opening or external cavity at its base. In such a case, the inner sides of the coiled whorls are appressed, leaving no cavity, or, if they are not appressed and a cavity is formed, then its opening is completely covered by a callus or the reflected columellar apertural lip.

Keel. A sharp edge; carina (Fig. 11a).

Limpet. A gastropod with a low, conical, unspiraled (or nearly so) shell (Fig. 5).

Lip. Edge of the aperture of a shell; peristome; peritreme (Fig. 7).

Lira (pl. lirae). A large ridge, specifically a spiral ridge, on the outer surface of a snail shell (see Fig. 13).

Lirate. Refers to a shell with spiral ridges on its external surface.

Multispiral. Refers to an operculum in which there are numerous, very slowly enlarging spirals, coils or whorls (Fig. 15a).

Narrowly conic. Designation for a gastropod shell with a spire angle of about 20° (± 5°) (Fig. 2a).

Neritiform. Shaped like the shell of a typical member of the family Neritidae, i.e., subglobose or hemispherical, with few rapidly enlarging whorls, very reduced spire, and a heavily calloused and expanded parietal apertural margin (Fig. 6).

Nodule. A small rounded node, lump or knot (see Fig. 13).

Nucleus (of operculum). The center of growth around which succeeding concentric layers develop (see Fig. 15d).

Obsolete. Rudimental; poorly developed; obscure; indistinct; atrophied.

Operculum (pl. opercula). A corneous or calcareous plate borne on the dorsal posterior foot of prosobranch snails which closes the aperture when the snail withdraws into its shell (Fig. 16).

Order (adj., ordinal). A higher taxonomic category or group between the family and class in the hierarchy of animal classification. Each order contains a group of families related to one another by common morphological characteristics.

Oval, ovate. In the shape of the longitudinal section of a hen's egg, i.e., oblong and curvilinear, with one end narrower than the other (Fig. 3b).

Paucispiral. Refers to an operculum in which there are few rapidly enlarging spirals, coils or whorls (Fig. 15b).

Perforate. Refers to a spiral gastropod shell which has a very narrow perforation at its base, formed where the inner sides of the coiled whorls do not join.

Periostracum. The thin proteinaceous external layer covering most mollusk shells.

Periphery. The edges of a shell as seen in outline.

Plait. A fold on the columella (see Fig. 7).

Planispiral. Coiled in one plane (Fig. 4).

Planorboid. Having a shell shaped like the gastropod genus *Planorbis*, i.e., coiled in one plane (Fig. 4).

Punctate. Covered with small pits.

Punctum (pl. puncta). A small pit.

Rib. A transverse elevation or ridge of considerable size on the surface of a shell; costa (see Fig. 13).

Rounded. Having a more or less evenly curved contour, in contrast to being angular (Figs. 10a, 11c).

Sculpture. The natural surface markings, other than those of color, usually found on snail shells, and often furnishing identifying marks for species recognition (Fig. 13).

Sinistral. Wound or spiraled to the left, i.e., with a counter-clockwise spiral. When the shell aperture faces the observer and the shell apex is directed upward, the aperture is on the left (Fig. 8a).

Species (pl. species; adj., specific). A taxonomic group comprising the same 'kinds' of closely related individuals potentially able to breed with one another, and unable to breed with other 'kinds'.

Spiral. Winding, coiling or circling around a central axis; winding around a fixed point and continually receding from it; the form of the shell of most snails.

Spiral sculpture. Surface markings of a snail shell which pass continuously around the whorls more or less parallel to the suture (see Fig. 13).

Spire. The whorls of a snail shell, excepting the last or body whorl. The spire is measured as the distance (parallel to the columella) from the suture where the apertural lip meets the body whorl to the shell apex (see Fig. 7).

Stria (pl. striae). A slight superficial spiral groove or furrow on the outer shell surface, or a fine spiral threadlike line or streak. Commonly used also, in a less precise sense, for raised spiral ridges on the shell surface (see Fig. 13).

Striate. Refers to a shell having spiral incised lines on its surface. Also used, less precisely, for shells with spiral raised lines, or for shells covered with fine transverse lines.

Subclass. A higher taxonomic category or group between the order and class in the hierarchy of animal classification. Subclasses are used when it is necessary to divide a class into more than one group of orders. The subclasses of the Class Gastropoda (snails, slugs, limpets) are the Prosobranchia (gill breathers; gills anterior to the heart), Opisthobranchia (generally gill breathers; gills, when present, posterior to the heart) and Pulmonata (lung breathers).

Subfamily (adj., subfamilial). A taxonomic category or group between the genus and family in the hierarchy of animal classification. Subfamilies are used when it is necessary to divide a family into more than one group of closely related genera. The subfamily is therefore a subordinate category to the family. Each subfamily contains one or more genera. Names of subfamilies end in *-inae.*

Subgenus (pl. subgenera; adj., subgeneric). A taxonomic category or group between the species and genus in the hierarchy of animal classification. Subgenera are used when it is necessary to divide a genus into more than one group of closely related species. The subgenus is therefore a subordinate category to the genus. Each subgenus contains one or more species.

Subspecies (pl. subspecies; adj., subspecific; syn., race). One or more populations of a species which inhabit a distinct geographic area and which share morphological features setting them off from other populations of the species.

Superfamily. A taxonomic category or group between the family and order in the hierarchy of animal classification. Superfamilies are used when it is necessary to divide an order into more than one group of closely related families. Names of superfamilies end in *-oidea* (although it also has been common practice in malacology to use *-acea*).

Taxon (pl. taxa). Any taxonomic group, e.g., a race, subspecies, species, genus, family, order, etc.

Taxonomy (adj., taxonomic). The practice, study, methodology, science, etc., of dealing with kinds of organisms.

Tribe. A taxonomic category or group between the genus and subfamily in the hierarchy of animal classification. Tribes are used when it is necessary to divide a subfamily into more than one group of closely related genera. The tribe is therefore a subordinate category to the subfamily. Each tribe contains one or more genera. Names of tribes end in *-ini.*

Tubercle. A nodule or small eminence, such as a solid elevation occurring on the shell surface of some gastropods.

Tuberculate. Covered with tubercles or rounded knobs.

Turbinate, turbiniform. Shaped like a turban; refers to a shell in which the whorls decrease rapidly in diameter and taper broadly from a circular base to the apex (Fig. 3d).

Turreted; turriform. Tower-shaped; spire whorls shouldered, forming a regularly stepped outline.

Umbilicate. Refers to a spiral gastropod shell which has an opening or cavity at its base, and more specifically to one in which the opening is more than a very narrow perforation. This cavity is formed in those shells in which the inner sides of the coiled whorls do not join.

Whorl (spelled 'whirl' in early literature). One complete turn or coil of a spiral gastropod shell (see Fig. 7).

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EFFECTS OF SOME PHYSICO-CHEMICAL FACTORS ON THE SURVIVAL OF *TRICULA APERTA*[1]

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ABSTRACT. – Water temperature, salinity and pH were found to affect the survival of all three races of *Tricula aperta* under laboratory conditions. Among the three races, alpha was the most tolerant and beta the least tolerant. Of these three factors, salinity concentrations exerted the least effect on the survival of the snails during the seven-day exposure periods. The optimum concentrations of salinity to which all snails were exposed were between 0 and 400 mg/l. At a concentration of 3,200 mg/l, the mortality rates of all snails reached 100%. The optimum temperatures to which snails were exposed for seven days were 15-30°C. Temperatures above or below the optimum temperatures caused damage to physiological functions of snails and death. The optimum pH values for all snails were between 6 and 7. Snails were slightly more tolerant in alkaline water at pH 8-9 than in acidic water at pH 4-5, during the seven-day exposure periods.

The freshwater hydrobiid (or pomatiopsid) snail *Tricula aperta* (Temcharoen) is the intermediate host of the human blood fluke *Schistosoma mekongi* Voge, Bruckner & Bruce. Three races of *T. aperta* are known, which are referred to as the alpha, beta and gamma races. The alpha and gamma races are found in the Mekong River, whereas the beta race is found in a tributary of the Mekong, the Mun River, Ubol Ratchathani Province, Thailand. The main differences among the three races are shell size, shape, mantle pigment pattern and ecology. All three races are susceptible to *S. mekongi* (Harinasuta et al., 1972; Kitikoon et al., 1973; Sornmani et al., 1973; Davis et al., 1976; Sornmani, 1976; Kitikoon, 1981).

In laboratory and field studies, some physico-chemical factors such as water temperature, salinity and hydrogen-ion concentration have been

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considered to affect growth, reproduction, distribution and survival of mollusks (Gunter, 1957; Harrison & Agnew, 1962; Sturrock & Sturrock, 1972; Castagna & Chanley, 1973; Van der Schalie & Berry, 1973; Chitramvong et al., 1981).

This study reports on the effects of water temperature, salinity and hydrogen-ion concentration on the survival of *Tricula aperta*.

MATERIALS AND METHODS

The specimens of *Tricula aperta* used in this study were obtained from the Mekong (alpha and gamma races) and Mun rivers (beta race), Ubol Ratchathani Province, Thailand. In the laboratory, they were maintained in flasks containing aged tap water and were fed with the diatom *Achnanthes exigua*.

For each experiment, a total of 1200 active snails were used (alpha and beta races, 3.0 mm shell length; gamma race, 2.8 mm shell length) and each experiment was replicated once. The snail exposure periods are 24 hrs and seven days. For the seven-day exposure periods, the snails were fed daily with *Achnanthes exigua* and the water was changed every two days to remove snail metabolic wastes. Snail mortality rates were assessed 48 hrs after exposure.

Water temperature

The snails were exposed in various water temperatures, ranging from 5-40°C at 5°C intervals. Twenty-five snails of each race were placed separately in 250 ml flasks containing aged tap water. The flasks were covered with pieces of cotton gauze to prevent snails from crawling out.

At water temperatures of 5°, 10°, 15° and 20°C, the flasks containing snails were placed in low-temperature incubators; at 25°C, they were placed in an air-conditioned room; and at 30° (control temperature), 35° and 40°C, they were placed in waterbaths.

Salinity

A graded series of seven sodium chloride (NaCl) concentrations were used, with a two-fold increase ranging from 100 to 6400 mg/l. These concentrations were prepared with deionized water. Sixteen 250 ml Flasks were used for containing each race of snails: 14 for experimental snails and two for control snails. Each flask contained 25 snails, and snails were exposed in various sodium chloride concentrations at room temperature (30°C).

Hydrogen-ion concentration

Snails were exposed to pH values ranging from 3 to 10, at 1 pH value intervals. Using deionized water, the acidic pH values were adjusted with 0.1 N hydrochloric acid and the alkaline pH values were adjusted with 0.1 N sodium hydroxide. All pH values were measured with a radiometer and adjusted accordingly before exposure for the 24-hr exposure period, and before exposure and at every 24 hrs thereafter for the seven-day exposure period. Sixteen 250 ml flasks were used for containing each race of snails. Each flask contained 25 snails, and snails were exposed in various hydrogen-ion concentrations at room temperature (30°C).

RESULTS AND DISCUSSION

Water temperature

The results of the 24-hr exposure period are shown in Fig. 1. The alpha race exhibited the highest tolerance to adverse water temperatures. At 5° and 40°C, mortality rates of the beta and gamma races were 100%, whereas those of the alpha race were 10% and 90% respectively. The best survival temperatures for all snails were between 10° and 35°C.

The results of the seven-day exposure period are shown in Fig. 2. Snail mortality rates exhibited similar patterns to those of the 24-hr exposure period. But, the rates were higher with the longer exposure period. At 5° and 40°C, mortality rates of all snails were 100%. At 10°C, mortality rates were 100% for the beta and gamma races and 38% for the alpha race. The best survival temperatures for all snails were between 15° and 30°C. Again, the alpha race exhibited the greatest tolerance to undesirable water temperatures.

Upatham et al. (1980) reported that water temperatures in natural habitats of *Tricula aperta* ranged from 24-28°C. Diurnal variation in water temperatures was very little, being only a few degrees lower at night than during the day. Therefore, water temperatures would not be expected to exhibit an effect on *T. aperta* in its natural habitat, and they do not seem to do so.

Salinity

The effects of sodium chloride on snails are shown in Figs. 3 and 4. The alpha race was least affected and the beta race was most affected by sodium chloride. For the 24-hr exposure period, snails could tolerate concentrations up to 3200 mg/l. At concentrations lower than 1600 mg/l, snail mortality rates were lower than 10%. At concentrations higher than 800 mg/l, snail mortality rates increased with increasing concentration of sodium chloride. At 6400 mg/l, mortality rates of all snails reached 100%. For the seven-day exposure period, the effects of sodium chloride on snails were the same at the 24-hr exposure period, but snail mortality rates were higher with the longer exposure period. Snails could tolerate concentrations of sodium chloride up to 1600 mg/l. At concentrations lower than 1600 mg/l, snail mortality rates were lower than 20%. At concentrations higher than 1600 mg/l, snail mortality rates reached 100%.

Upatham et al. (1980) reported a slight seasonal fluctuation in sodium chloride concentrations in the habitats of *Tricula aperta*, ranging

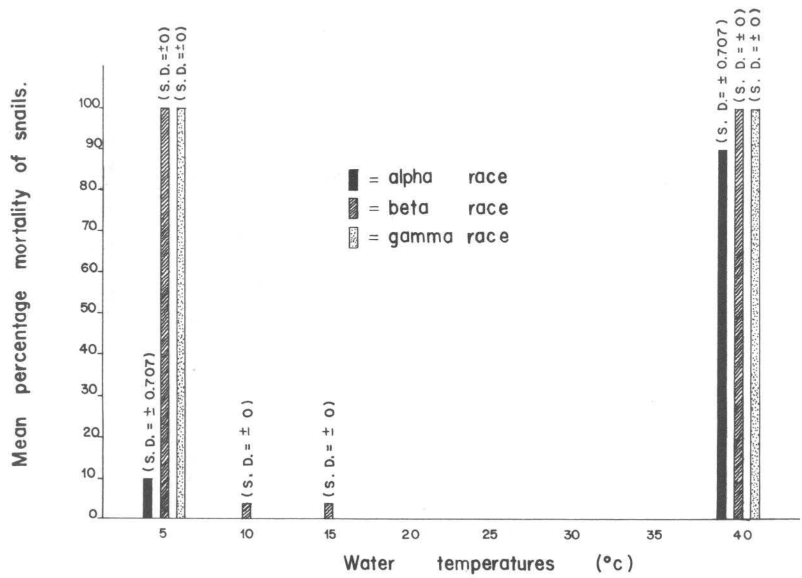

FIG. 1. Effects of water temperatures on *Tricula aperta*, exposed for 24 hours.

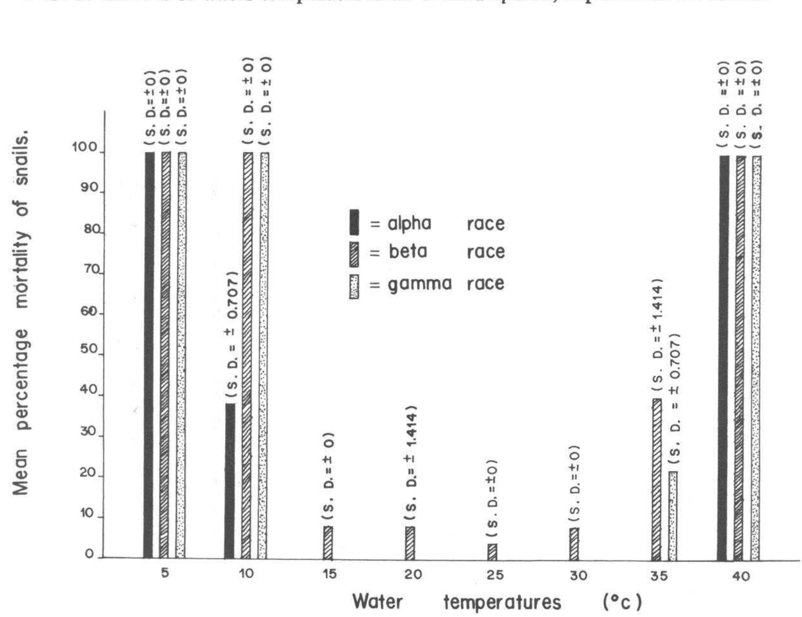

FIG. 2. Effects of water temperatures on *Tricula aperta*, exposed for seven days.

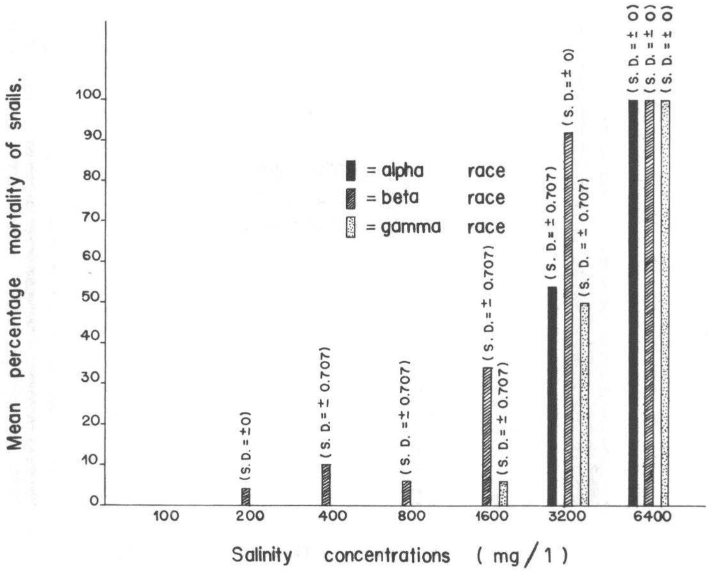

FIG. 3. Effects of sodium chloride on *Tricula aperta*, exposed for 24 hours.

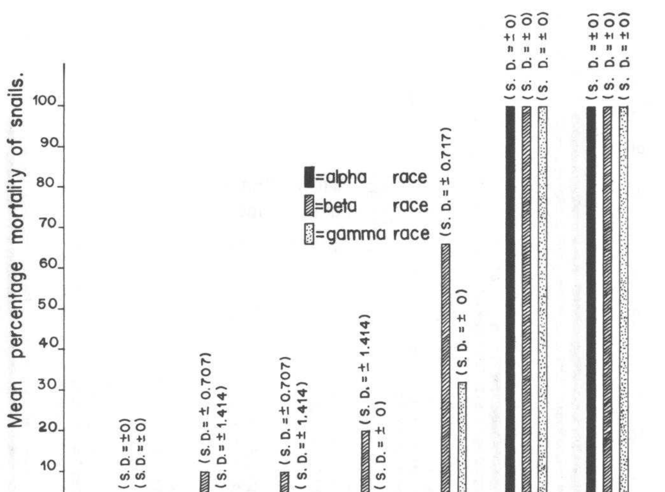

FIG. 4. Effects of sodium chloride on *Tricula aperta*, exposed for seven days.

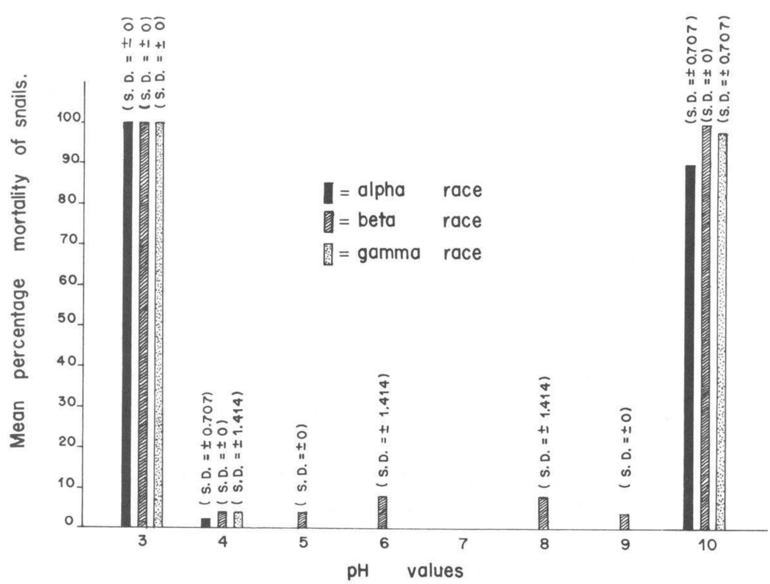

FIG. 5. Effects of pH values on *Tricula aperta*, exposed for 24 hours.

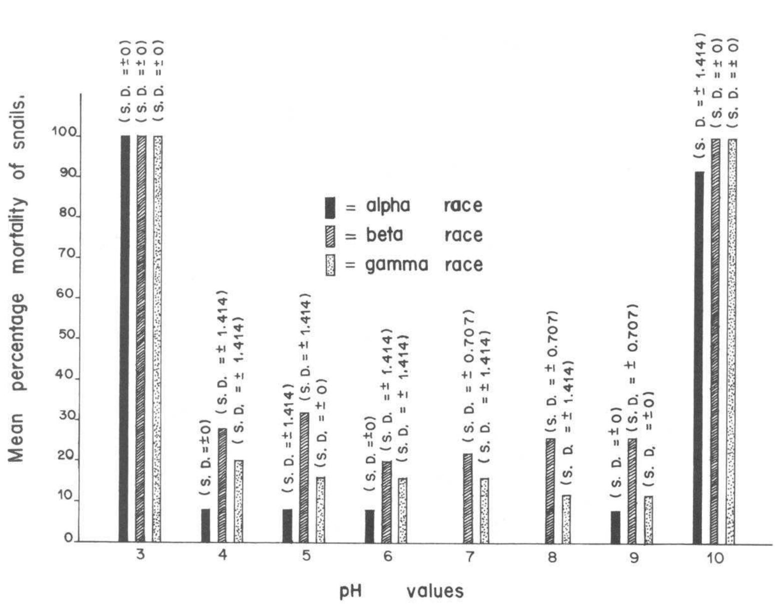

FIG. 6. Effects of pH values on *Tricula aperta*, exposed for seven days.

from 3.30 mg/l to 26.40 mg/l during low and high water periods, respectively. Thus, under natural conditions such as these, salinity would not be expected to, nor does it seem to, exert an effect on *T. aperta*.

Hydrogen-ion concentration

The effects of pH values are shown in Figs. 5 and 6. At pH 3, snail mortality rates reached 100%; at pH 10, snail mortality rates were 100% for the beta and gamma races and 90-92% for the alpha race. The alpha race was least affected and the beta race was most affected by pH of the water. For the 24-hr exposure period, snails could tolerate pH values from 4 to 9, where snail mortality rates were lower than 10%. For the seven-day exposure period, snail mortality rates at pH values from 4 to 9 were lower than 30%.

Observations of pH in the habitats of *Tricula aperta* showed that the water was regularly alkaline, ranging from 7.70 to 8.65 (Upatham et al., 1980). Hence, under natural conditions with pHs in this range, hydrogen-ion concentrations would not be expected to, and do not seem to, have an effect on *T. aperta*.

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A PRELIMINARY STUDY OF THE FRESHWATER MOLLUSKS OF THE ISLE OF YOUTH (ISLE OF PINES), CUBA

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An intensive study of the Cuban freshwater mollusks is needed, not only to learn more about their biology, but also because many of them are intermediate hosts of parasites afflicting both man and animals. For example, in regard to their medical importance, Aguayo (1938a,b) reported about 100 species of Cuban mollusks that act as intermediate hosts of trematodes.

During 1979-80, a study was made of the freshwater mollusks of the Isle of Youth (Isle of Pines), Cuba. Although there have been a few previous reports of the mollusks of this island (Henderson, 1916; Aguayo, 1938a,b; Jaume & Milera, pers. comm. [1977]), ours is the most intensive survey that has yet been made. Samples were taken in all of the bodies of water located between the northern coast of the island and Lanier Swamp in the southern half of the island (see Fig. 1). The selection of stations was by random sampling. The shores of these bodies of water were soft and the banks mostly steep, so samples were taken from a boat using a long-handled sieve. Two samplers (sieves) were used, one of 1 mm mesh and the other of 3 mm mesh. The sampler with the smaller mesh was towed on the bottom until it went down about 10 cm in the substrate. The larger-meshed sampler was used to take samples among the water plants. Voucher specimens of the species collected have been deposited in the Instituto de Zoologia, Academia de Ciencias de Cuba, and in the Museum of Zoology, The University of Michigan, Ann Arbor, Michigan, U.S.A.

Of the 12 species we found on the Isle, only six had been reported previously. Henderson (1916) listed *Galba* [= *Fossaria*] *cubensis* (Pfeiffer), *Planorbis* [= *Drepanotrema*] *lucidus* (Pfeiffer), *Ancylus radiatilis* (Moricand) [= *Gundlachia radiata* Guilding], *Ampullaria reflexa* (Sowerby) [= *Pomacea paludosa* (Say)], *Amnicola* [= *Pyrgophorus*] *coronatus* (Pfeiffer) and *Cyrene* [= *Cyrenoida*] *americana* (Moricand). In addition

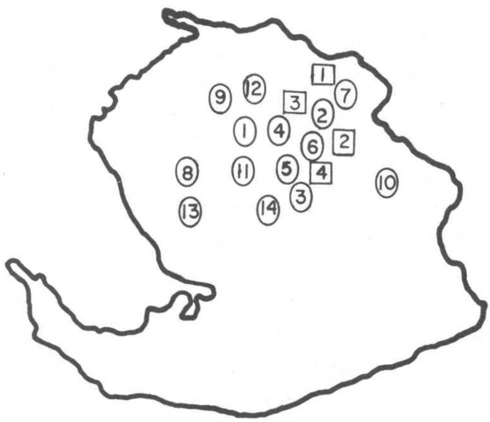

FIG. 1. Stations surveyed for freshwater mollusks on the Isle of Youth, Cuba. ○ = dams; □ = rivers. For key to station numbers, see Table 1.

TABLE 1. Occurrence of mollusks at each station on the Isle of Youth, Cuba.

Collecting stations	Species of snails											
	Pomacea paludosa	*Pyrgophorus coronatus*	*Fossaria cubensis*	*Pseudosuccinea columella*	*Physella bermudezi*	*Physella cubensis*	*Biomphalaria helophila*	*Drepanotrema anatinum*	*Drepanotrema cimex*	*Drepanotrema lucidum*	*Gundlachia radiata*	*Cyrenoida americana*
Dams ○												
1 Viet-Nam Heroico	X											
2 Guanabana	X											
3 La Fe	X	X	X	X		X	X		X			
4 Casas I	X			X		X		X		X	X	
5 Mal Pais I	X						X				X	
6 Mal Pais II	X											
7 Sierra Maestra	X											
8 Cristal	X											
9 Las Nuevas	X		X	X		X		X		X	X	
10 Briones Montoto	X											
11 El Enlace								X				
12 El Abra	X											
13 Los Indios	X											
14 Libertad												
Creeks and rivers □												
1 Cienaga Chacon	X		X			X						
2 Carretera Jucaro	X											X
3 Secundaria 53			X		X							
4 Rio La Fe	X		X	X		X					X	

to these species, Jaume & Milera (pers. comm. [1977]) reported *Biomphalaria helophila* (d'Orbigny) and *B. havanensis* (Pfeiffer); we did not find the latter species in our survey. We found five species new to the Isle: *D. anatinum* (d'Orbigny), *D. cimex* (Moricand), *Pseudosuccinea columella* (Say), *Physella bermudezi* (Aguayo) and *P. cubensis* (Pfeiffer).

Table 1 shows the distribution of the various species of mollusks on the Isle of Youth. In general, the abundance of mollusks was low in the 17 freshwater stations that were sampled. *Pomacea paludosa* was the most common species. Of the 14 dams* on the Isle of Youth, we found mollusks in all except Libertad Dam. This was the last dam to be built. It is worth mentioning that, although mollusks are present in most of the sampled biotopes, their abundance is low at present, since many of the water bodies have been constructed only recently and thus their fauna and flora is not yet balanced. Also, the bodies of water on the Isle, in general, stand over metamorphic rocks, indicating a low proportion of calcium carbonate (an influential chemical compound for the development of mollusks). Further, adequate vegetation is not found in many of the dams. Lack of calcium and vegetation may be additional reasons for the poor snail fauna in many of the dams and rivers on the island.

ACKNOWLEDGEMENTS

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*"Dam" as used here means an artificially empounded body of water, rather than the water-retaining barricade itself.

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FIRST REPORT FOR CUBA OF A POPULATION OF *PLANORBELLA* ("*HELISOMA*") *DURYI* IN THE ISLE OF YOUTH (ISLE OF PINES)

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ABSTRACT. – The finding of a well-established population of *Planorbella duryi* in Casas I Dam on the Isle of Youth (Isle of Pines), Cuba, constitutes a new species record for the Cuban freshwater mollusk fauna. Since Casas I Dam and other localities on the Isle of Youth had been carefully monitored for two years previous to the discovery of *P. duryi*, it is certain that this snail did not occur on the island previous to 1981. The sudden appearance of *P. duryi* in Cuba is probably due to the snail being transported by migratory birds.

Members of the genus *Planorbella* have been reported (as "*Helisoma*") to occur in Guatemala, Nicaragua, Panama, Mexico, St. Croix, Puerto Rico and Cuba (Ferguson & Gerhardt, 1956; Harry & Hubendick, 1964), and in Peru, Ecuador, Columbia and Brazil (Paraense, 1976a,b). Aguayo & Jaume (1947) reported *P. caribaeum caribaeum* (d'Orbigny), *P. c. cubense* (F.C. Baker) and *P. foveale* (Menke) in Cuba, and noted also the occurrence of *P. trivolvis* (Say) in tropical fish aquaria, introduced from the United States. A species new to Cuba, *P. (Seminolina) duryi* (Wetherby), has now been found (1981) well established in Casas I Dam, a body of artificially empounded water on the Isle of Youth. Monthly malacological surveys of the Isle of Youth, made for two years (1979-80) previous to the discovery of *P. duryi* in Casas I Dam, failed to produce the species, indicating that it first arrived in 1981.

HABITAT, MATERIAL AND METHODS

Casas I Dam (Figs. 1, 2), located south of Nueva Gerona city, has an

FIG. 1. Casas I Dam during a low water period.

FIG. 2. *Planorbella duryi* habitat, Casas I Dam.

FIG. 3. *Planorbella duryi* on a submerged oar.

area of 2.28 km^2 and can accumulate up to 4.75 x 10^6 cubic meters of water. Its maximum depth is 16 m. Its malacological fauna is composed of *Pomacea paludosa* (Say), *Drepanotrema anatinum* (d'Orbigny), *D. lucidum* (Pfeiffer), *Physella cubensis* (Pfeiffer), *Pseudosuccinea columella* (Say) and *Gundlachia radiata* (Guilding). Aquatic vegetation is abundant in the dam and is composed mainly of *Eleocharis interstincta* (Vahl). *Planorbella duryi* is commonly found on the stems of this plant. Hand-collected specimens of *P. duryi* (Fig. 3) were kept in a 0.1% alcohol-menthol solution in order to relax the animal and make dissections easier. Afterwards, the soft parts were exposed by gently crushing the shell, and dissections were made of the female and male reproductive systems. Voucher specimens have beeen deposited in the Instituto de Zoologia, Academia de Ciencias de Cuba, and in the Museum of Zoology, The University of Michigan, Ann Arbor, Michigan, U.S.A.

RESULTS AND DISCUSSION

Anatomical characteristics of the reproductive organs of Cuban *Planorbella duryi* are shown in Fig. 4. When the anatomical structures of the

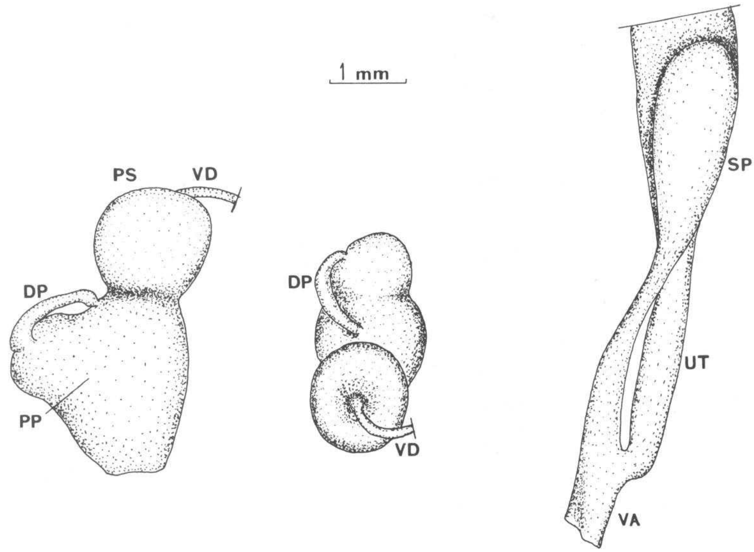

FIG. 4. Parts of the reproductive system of *Planorbella duryi*.
Abbreviations: DP = duct of preputial organ; PP = prepuce; PS = penis sheath; SP = spermatheca; UT = uterus; VA = vagina; VD = vas deferens.

snails from Casas I Dam were compared with those described by other researchers (Baker, 1945; Ferguson & Gerhardt, 1956; Paraense, 1976a,b), it is obvious that our specimens are *P. duryi*, a species native to Florida, U.S.A. The external duct on the preputial organ is shorter than on *Planorbella* s.s. species. (*Helisoma* s.s. species have an even shorter duct.) Further, in *P. duryi* the penis and sheath are short and globose, rather than elongate as in *P. trivolvis*, and the spermathecal duct is short.

Shells of species of the genus *Planorbella* may resemble the snail intermediate hosts of the genus *Biomphalaria*, but the two genera can be distinguished by differences in anatomical characters (Paraense, 1961, 1975). More recently, Jelnes (1982) has shown biochemical differences between species of the two genera.

During our surveys in 1979 and 1980 of the Isle of Youth, a total of 12 gastropod species were recorded (Yong & Perera, 1984). *Planorbella* was not among them, nor had it been reported previously for Cuba. It seems probable that migratory birds may be mainly responsible for the current spread and dissemination of freshwater pulmonate snails, not only in Cuba, but also in many parts of the South American continent as well, since it is well known that many aquatic bird species traverse this area during their annual migrations from north to south and vice versa (Todd, 1916; Lincoln, 1950; Bellrose, 1981).

Some species of the genus *Planorbella* might possibly play an important role in the control of snail hosts of *Schistosoma mansoni* Sambon in certain types of transmission sites in the Americas by acting as effective competitors, but clear evidence of this phenomenon under natural conditions remains to be demonstrated. Under laboratory conditions, *P. duryi* has been reported to compete with planorbid snail hosts for food, to produce mechanical effects on their egg masses, and to have a superior reproduction rate and low mortality (Frandsen & Christensen, 1977; Frandsen & Madsen, 1979). McCullough (1981) has reviewed the principle of exclusion and competitive displacement: when two species are biologically similar and occupy the same habitat, the stronger species may eliminate the weaker. Even in circumstances where total elimination is not achieved, competition *per se* may possibly play a significant role in depressing the weaker population.

The competitive interactions of *Planorbella* species with other freshwater gastropods in natural habitats in Cuba have not yet been studied, but plans to do so are under consideration.

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THE INFLUENCE OF SOME ABIOTIC FACTORS ON THE DISTRIBUTION OF FRESHWATER MOLLUSKS ON THE ISLE OF YOUTH (ISLE OF PINES), CUBA

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ABSTRACT. – The effect of temperature, pH, rainfall and Cl^- ions on the populations of freshwater mollusks in 12 different habitats on the Isle of Youth (Isle of Pines), Cuba, were studied. These four factors affect the presence of mollusks; pH is a limiting factor. During the dry season, which is characterized by droughts and high temperatures, mollusks survive under a layer of organic matter, and then re-populate the habitats once the conditions are favorable again. The existence of the planorbid snails seems to be facilitated by a low concentration of Cl^- ions.

Studies carried out in the Isle of Youth (Isle of Pines) confirm the presence of some species of freshwater mollusks which elsewhere transmit diseases to man and animals (Yong & Perera, 1981, 1984, and in press). The mollusks belong mainly to the gastropod families Lymnaeidae, Planorbidae and Pilidae (Ampullariidae). Pilid snails have been reported as natural intermediate hosts of *Angiostrongylus cantonensis* (Chen) (Schneider et al., 1974) and most recently our local snail, *Pomacea paludosa* (Say), has been reported to carry this parasite (Aguiar et al., 1981).

Other freshwater mollusks on the Isle of Youth are also of interest, since they may possibly act as predators or competitors of the vector snails (e.g., see Frandsen & Christensen, 1977), thereby perhaps leading to the biological control of the undesirable mollusks. The biological control of snail intermediate hosts requires intensive studies of the ecology of both the control and target species. Biological control is being considered in some areas because of the lack of or inefficiency of other methods, some of which might also cause a serious imbalance in aquatic faunas (Pointier, 1974).

Climatic factors have an important role in the distribution of freshwater mollusks, mainly in regions struck by seasons of drought, as in the

West Indies (Pointier et al., 1977). Some laboratory studies have been made on the influence of desiccation on populations of snail hosts (Olivier & Barbosa, 1956; Richards, 1967; Sturrock, 1970), while other studies have been made on the effects of the dry season upon the demography of snails in their natural habitats (e.g., Pointier & Combes (1976) in Guadeloupe). Pointier & Combes (1976) found that the large number of empty shells present in different habitats indicates that a great segment of the population is destroyed during the dry season; during the rainy season, the population reaches its former level and thus parasitosis begins again.

Chernin (1967) conducted laboratory tests using temperature gradients and showed that *Biomphalaria glabrata* (Say) thrives best in the 27-32°C zone. Reproduction of *B. glabrata* also is affected by temperature (Jobin, 1970; Sturrock & Sturrock, 1972). Long exposures to high temperatures cause thermal castration in *B. glabrata* (Michelson, 1961), and, if they remain in temperatures exceeding 30°C, genetic changes seem to take place because second generation snails are unable to reproduce (Perera & Yong, 1981).

MATERIALS AND METHODS

Our study was carried out in 1980-81 during a full-year cycle (dry and rainy seasons) in which the 12 most important dams* on the Isle of Youth (Figs. 1, 2) were tested. A previous pilot sampling was undertaken so as

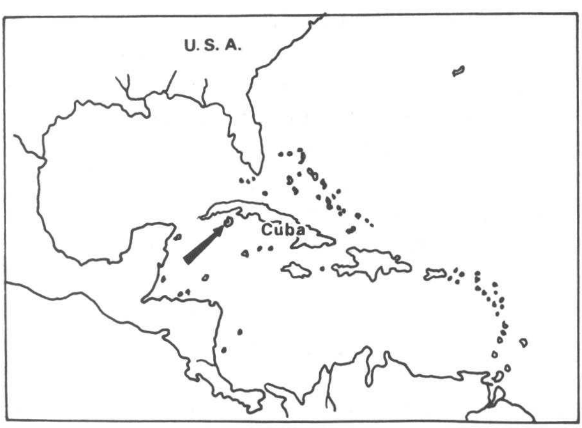

FIG. 1. Map of the Caribbean area showing the location of the Isle of Youth (arrow).

*"Dam" as used here means an artificially empounded body of water, rather than the water-retaining barricade itself.

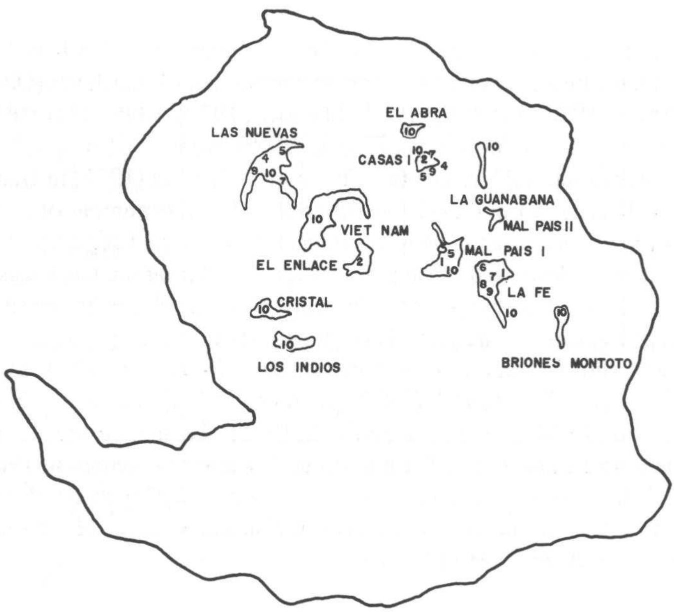

FIG. 2. Map of the Isle of Youth, showing the dams and their species of mollusks. 1, *Biomphalaria helophila*; 2, *Drepanotrema anatinum*; 3, *D. cimex*; 4, *D. lucidus*; 5, *Gundlachia radiata*; 6, *Fossaria cubensis*; 7, *Pseudosuccinea columella*; 8, *Pyrgophorus coronatus*; 9, *Physa cubensis*; 10, *Pomacea paludosa.*

to learn about the freshwater species and their presence in the various localities. The hydrochemical parameters measured were: concentration of Ca^{++}, Na^{+} and Mg^{++} cations; concentrations of SO_4^{-2}, HCO_3^-, NO_2^-, NO_3^- and Cl^- anions; electrical conductivity, total soluble salts; and pH. The percentage of oxygen saturation, temperature and rainfall also were measured. Voucher specimens of the mollusks have been deposited in the Instituto de Zoologia, Academia de Ciencias de Cuba, and in the Museum of Zoology, The University of Michigan, Ann Arbor, Michigan, U.S.A.

RESULTS

The 12 dams studied and the snails found in them are shown in Fig. 1 and are given in Table 1. Physical characteristics of each of the dams are given in Table 1.

The graphs (Figs. 3, 4) show the variations of climatic (temperature

TABLE 1. Characteristics of the dams and the mollusks inhabiting them.

Dams	Location	Surface	Volume	Depth	Species of mollusks
Las Nuevas	W Nueva Gerona	13.3 km^2	44.5 x 10^6 m^3	12.30 m	*Fossaria cubensis* *Pseudosuccinea columella* *Pomacea paludosa* *Physella cubensis* *Gundlachia radiata* *Drepanotrema lucidus* *Drepanotrema anatinum*
Viet Nam Heroíco	SW Nueva Gerona	9.8 km^2	42.5 x 10^6 m^3	23.55 m	*Pomacea paludosa*
El Enlace	E La Melvis	3.42 km^2	19.0 x 10^6 m^3	40.30 m	*Drepanotrema anatinum*
Mal Pais I	W Mal Pais	3.9 km^2	13.0 x 10^6 m^3	23.20 m	*Biomphalaria helophila* *Gundlachia radiata* *Pomacea paludosa*
La Fe	NW La Fe	3.6 km^2	12.5 x 10^6 m^3	15.50 m	*Pomacea paludosa* *Physella cubensis* *Biomphalaria helophila* *Pseudosuccinea columella* *Drepanotrema cimex* *Pyrgophorus coronatus* *Fossaria cubensis*
Briones Montoto	E La Fe	1.26 km^2	4.51 x 10^6 m^3	22.00 m	*Pomacea paludosa*
Mal Pais II	W Jucaro	2.95 km^2	8.0 x 10^6 m^3	9.00 m	*Pomacea paludosa*
La Guanabana	S Coyugales	3.5 km^2	3.5 x 10^6 m^3	–	*Pomacea paludosa*
Casas I	S Nueva Gerona	2.28 km^2	4.75 x 10^6 m^3	16.30 m	*Pomacea paludosa* *Drepanotrema anatinum* *Physella cubensis* *Pseudosuccinea columella* *Gundlachia radiata* *Drepanotrema lucidus* *Planorbella duryi*
El Abra	SW Nueva Gerona	1.04 km^2	2.5 x 10^6 m^3	22.00 m	*Pomacea paludosa*
Cristal	W A. Cajigal	1.94 km^2	6.25 x 10^6 m^3	37.00 m	*Pomacea paludosa*
Los Indios	W La Victoria	2.49 km^2	10.2 x 10^6 m^3	25.50 m	*Pomacea paludosa*

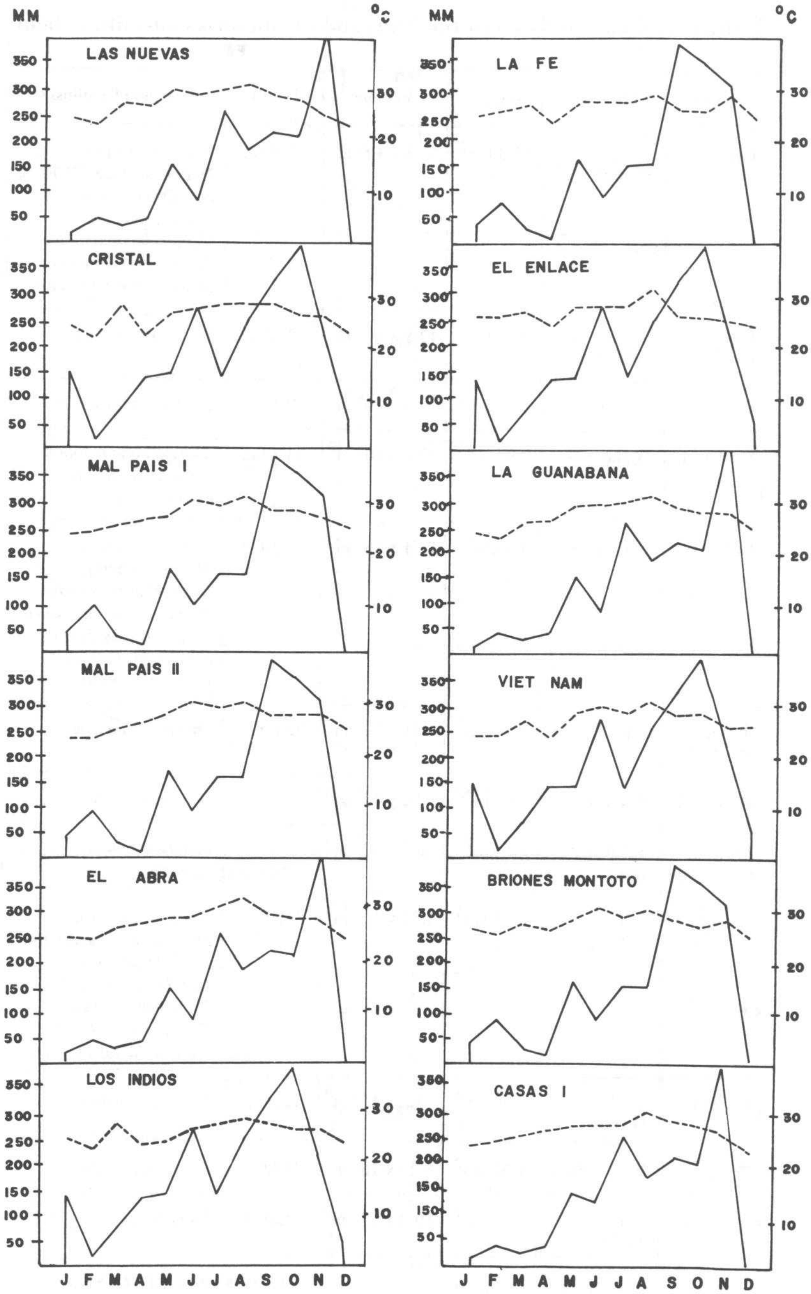

FIG. 3. Graphs of the climatic factors measured in relation to the dams. Temperature – – – (°C); rain —— (mm).

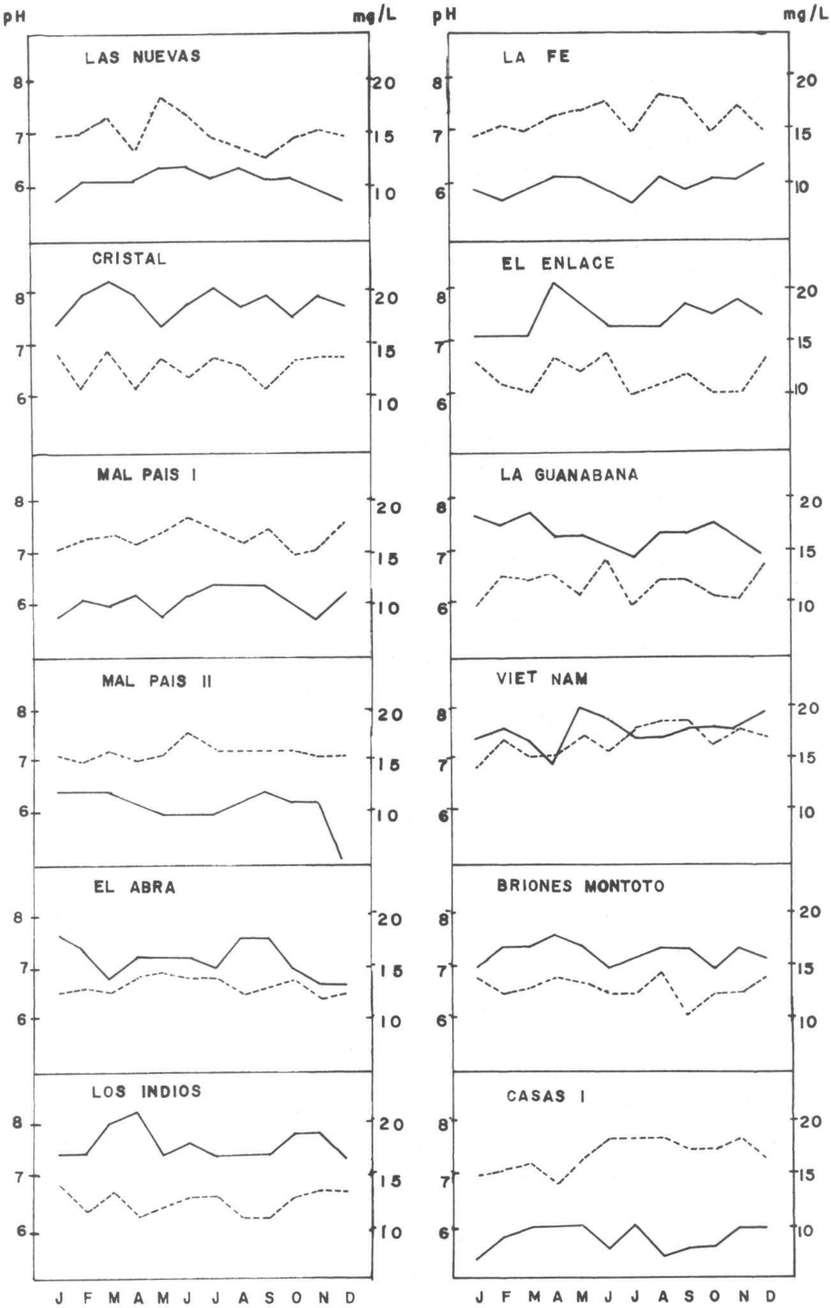

FIG. 4. Graphs of the two chemical factors measured in the dams.
pH – – –; Cl^- —— (mg/l).

and rainfall) and chemical (pH and concentration of Cl^- ions) factors, i.e., those that exert the greatest influence on the freshwater molluscan fauna on the Isle of Youth. It is worth noting the lower pHs registered in the Los Indios, Cristal and Briones Montoto dams, located in the central part of the island. Only one species of mollusk (*Pomacea paludosa*) was found in these dams. Similar lower pHs were found in El Abra, El Enlace and La Guanabana dams, each of which also had only one species of mollusk (*P. paludosa*, except for El Enlace, which had *Drepanotrema anatinum* (d'Orbigny)).

The variations in the concentration of Cl^- ions also seem to be important; they reach high levels in La Guanabana, El Abra, Los Indios, Cristal, El Enlace, Viet Nam Heroíco and Briones Montoto dams, all of which were inhabited by only one species of mollusk (*Pomacea paludosa*, except for El Enlace with *Drepanotrema anatinum*).

Finally, it should be mentioned that the results of our snail surveys may have been affected somewhat by the drought that took place during December and April, as well as the high temperatures that occurred during May and September, i.e., in some habitats some species of snails may have disappeared due to the unfavorable conditions or the snails were at such low concentrations that we did not encounter them, and during our subsequent surveys the snails had not had time to build up their populations. Further studies in the future may modify slightly our present results.

DISCUSSION

Hydrogen ion concentration seems to be an important factor in the distribution of freshwater mollusks on the Isle of Youth, because snails did not occur in waters having a pH lower than 6.0, as was the case in many creeks and Libertad Dam, which were visited during the pilot sampling phase. In waters with an acid reaction, but pH higher than 6.0, the only mollusk found was *Pomacea paludosa*.

The most interesting factor was the concentration of Cl^- ions, this being a limiting one in the distribution of pulmonates, but not for *Pomacea paludosa*. It should be outlined that the high levels found in La Guanabana, El Abra, Los Indios, Cristal, Viet Nam Heroíco and Briones Montoto dams fit with the lack of freshwater mollusks, with the exception of *P. paludosa*, which seems to be more resistant to high concentrations of Cl^-. The case of El Enlace Dam is an exception; it contained *Drepanotrema anatinum* while showing a peak level of Cl^- in March.

As to adverse climatic conditions, we have observed that during the months of acute droughts there are planorbid snails remaining alive under a layer of organic matter or between roots of grass to a depth of more than 10 cm. They are thus protected from droughts, as well as from high temperatures, staying alive to re-populate the habitat when favorable conditions return. *Biomphalaria helophila* (d'Orbigny), *Drepanotrema anatinum, D. cimex* (Moricand) and *D. lucidus* (Pfeiffer) are especially resistant to drought situations.

Due to the mechanisms of protection that many of the freshwater mollusks have which enable them to endure adverse conditions, climatic factors exert a less drastic influence on mollusk distribution than do chemical factors.

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BIOMPHALARIA SCHRAMMI IN CUBA

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In Cuba, the genus *Biomphalaria*, which contains some species which serve as intermediate hosts of *Schistosoma mansoni* Sambon, is represented by *B. havanensis* (Pfeiffer), *B. helophila* (d'Orbigny) and *B. obstructa* (Morelet). In November 1981, a fourth species of the genus, *B. schrammi* (Crosse) (Fig. 1), was found in a shallow seasonal pond (Fig. 2) called El Jorobado, located 10 km east of Cocodrilo Village in the southwestern part of the Isle of Youth (formerly Isle of Pines) (Fig. 3). The pond covered about 70 m^2 at the time of collecting (during a dry period), had a medium depth of 1 m, and was rich in aquatic vegetation. The pH was between 6.7 and 6.9, and the water temperature was 24°C. (The mean water temperature year round is 24.5°C.) At high water level, the pond is connected with three other such ponds by natural canals from 8-30 m in length. This whole system is completely isolated from other water systems on the island by a distance of approximately 15 km.

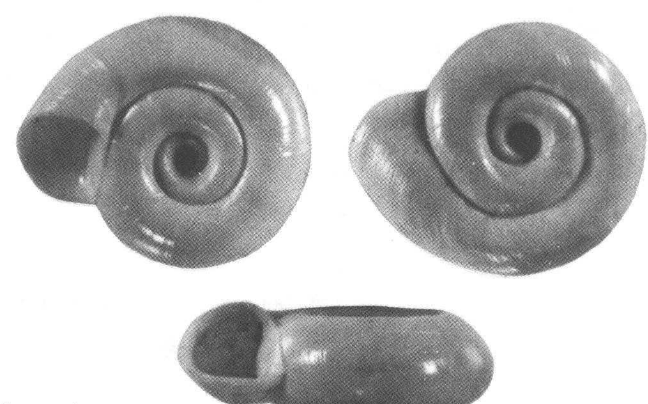

FIG. 1. Shell of *Biomphalaria schrammi*. Scale = mm.

FIG. 2. El Jorobado seasonal pond, southwestern Isle of Youth.

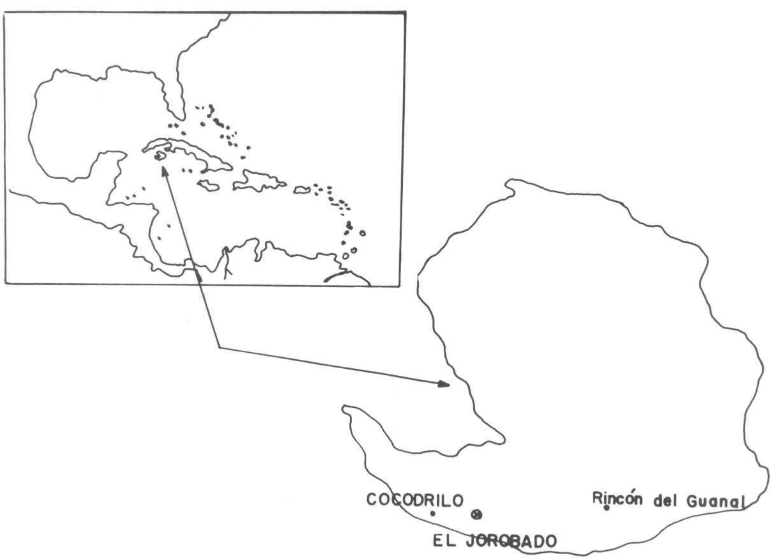

FIG. 3. Map of the Caribbean Sea, showing the location of the Isle of Youth and El Jorobado seasonal pond.

Biomphalaria schrammi was first described in 1864 by Crosse from specimens from Pointe-à-Pitre, Guadeloupe, French Antilles. More recently, the species has been studied in some detail by Paraense & Deslandes (1956) [as *Australorbis janeirensis*] and by Paraense (1964). In Cuba, *B. schrammi* can be distinguished readily from *B. havanensis* by characteristics of its shell, but less easily from *B. helophila* and *B. obstructa*. The shells of both of the latter species sometimes have the deflection of the aperture and terminal part of the body whorl which characterizes *B. schrammi*. However, *B. schrammi* can be differentiated from *B. helophila* and *B. obstructa* by characters of the genitalia (see Barbosa et al., 1968). In *B. schrammi*, the penial sac is long (Fig. 4), whereas it is short in *B. helophila* and of intermediate length in *B. obstructa*. The spermathecal sac is intermediate in length in *B. schrammi* (Fig. 4), but short in both *B. helophila* and *B. obstructa*. (Our dissections of *B. schrammi* from the Isle of Youth were on specimens relaxed with menthol in a 0.1% aqueous alcohol solution for 24 hrs.)

There are many permanent and seasonal ponds throughout the southern part of the Isle of Youth, each with its own particular characteristics, due mainly to the salinity and hardness of the water. This area is routinely surveyed for freshwater snails every two months, and since *Biomphalaria schrammi* was not found during the two years previous to its discovery, we believe its sudden appearance in our samples was due to its recent introduction to the Isle. The Isle of Youth serves as a transit point for birds in their migrations from north to south in winter and

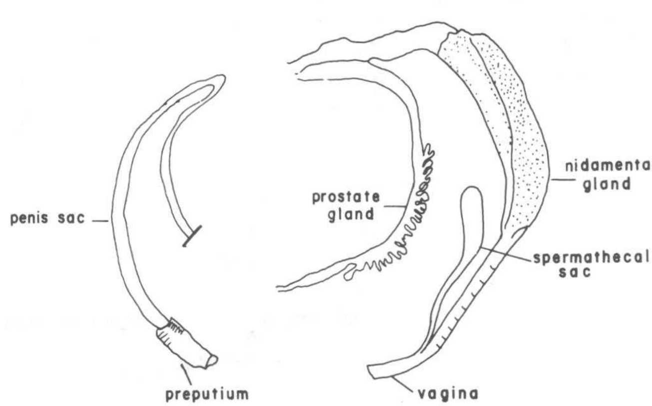

FIG. 4. Portions of the reproductive system of *Biomphalaria schrammi*, showing diagnostic characters: a long penis sac and a spermathecal duct of intermediate length.

when returning later to their places of origin (Todd, 1916; Lincoln, 1950; Bellrose, 1981). We strongly suspect that birds flying back north brought the snails or their egg masses to the ponds, where in favorable conditions the population developed.

Voucher specimens of *Biomphalaria schrammi* have been deposited in the Instituto de Zoologia, Academia de Ciencias de Cuba, and in the Museum of Zoology, The University of Michigan, Ann Arbor, Michigan, U.S.A.

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