NEMOURIA

Occasional Papers of the Delaware Museum of Natural History

ANNOTATED BIBLIOGRAPHY OF THE FLORIDA APPLESNAIL, *POMACEA PALUDOSA* (SAY) (GASTROPODA: AMPULLARIIDAE), FROM 1824 TO 1999

by

Richard L. Turner

and

Paula M. Mikkelsen

NUMBER 48

DECEMBER 1, 2004

Published by the

DELAWARE MUSEUM OF NATURAL HISTORY
4840 Kennett Pike, P.O. Box 3937
Wilmington, Delaware 19807-0937 U.S.A.
www.delmnh.org

Nemouria 48:1-188

NEMOURIA

Occasional Papers of the Delaware Museum of Natural History

NUMBER 48 DECEMBER 1, 2004

ANNOTATED BIBLIOGRAPHY OF THE FLORIDA APPLESNAIL, *POMACEA PALUDOSA* (SAY) (GASTROPODA: AMPULLARIIDAE), FROM 1824 TO 1999

Richard L. Turner[1] and Paula M. Mikkelsen[2]

ABSTRACT. The Florida applesnail, *Pomacea paludosa* (Say, 1829), inhabits freshwater rivers, lakes, and wetlands of the southeastern United States and Cuba, where it is prey to several species of birds, reptiles, and fish, particularly the snail kite, limpkin, American alligator, and redear sunfish. It has additionally been a staple in the diet of several native human populations. Introduction of exotic aquatic vegetation and the management practices of the 1900s have impacted the availability of *P. paludosa* to its predators, some of which are listed on federal and state registries of species that are endangered, threatened, or of special concern. Its association with the snail kite, limpkin, and Everglades has marked it by federal and state biologists as a species in great need of study. The present work is a bibliography of 673 annotated works on the Florida applesnail through 1999, 175 yr since its original description in 1824 by Thomas Say. The works are mostly primary and secondary literature, but some are fiction, videotapes, stamps, and commercial artwork, including one sculpture. Newspaper articles and websites are excluded. Early publications dealt with taxonomy, distribution, and the observations of naturalists. More recent documents, including many unpublished agency reports, have focused on ecological studies, particularly with regard to the management and restoration of wetlands and to the population biology of the snail kite. An early impediment to our knowledge of applesnail biology was the tendency of naturalists of the 1700s and 1800s to visit Florida during winter, a

[1] Department of Biological Sciences, Florida Institute of Technology, 150 W University Boulevard, Melbourne, Florida 32901-6975, U.S.A.; rturner@fit.edu

Serial Publication
ISSN 0085-3887

[2] Division of Invertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024-5192, U.S.A.; mikkel@amnh.org

season when both mosquitoes and applesnails are less active. A more recent impediment has been the use of specimens of uncertain or incorrect identity from the aquarium trade for descriptive and experimental studies in laboratories around the world.

Key words: apple snail, *Aramus*, freshwater, limpkin, Pilidae, *Rostrhamus*, snail kite.

INTRODUCTION

Pomacea paludosa (Say, 1829) has inhabited lakes, rivers, and swamps of Florida and Cuba for one to two million years (Tucker & Wilson, 1932; Taylor, 1966; Karrow *et al.*, 1996), its range undoubtedly changing with shorelines and climate. Its large size, abundance, and ubiquity in Florida wetlands and its occurrence in large numbers in American Indian middens (Moore, 1892-1893; Cumbaa, 1976) assure us that the Florida applesnail has been known to human civilization since American Indians first invaded the region about 12,000 YBP (**Milanich, 1995**). But it was not until 1824, when Thomas Say described this snail as "*Ampularia depressa*", that it was recorded in written history. In the years since its initial description, *P. paludosa* has become recognized as a staple in the diets of several endangered, threatened, or otherwise officially listed animal species and as an indicator of the health of many freshwater ecosystems in the state. State and federal agencies recognize its critical ecological role. Nevertheless, *P. paludosa* remains poorly studied; interest in it remains indirect, overshadowed by a focus on its most famous predator, the snail kite, *Rostrhamus sociabilis plumbeus* Ridgway, 1874. Even **Marjorie Stoneman Douglas (1947)** failed to mention this common Everglades inhabitant in her popular *River of Grass*, an oversight only recently corrected (Loftis & Douglas, 1988).

In recognition of the importance of *P. paludosa* in Florida—particularly in view of the priority given by the United States Fish and Wildlife Service (USDI, 1986) to studies on the snail—the Florida Game and Fresh Water Fish Commission (presently, Florida Fish and Wildlife Conservation Commission) contracted a project in 1989 to search for and to review literature on the Florida applesnail and to make recommendations for management and further studies. Publication of the final report, submitted in December 1993, was greatly delayed (**Turner *et al.*, 2001**). The annotated bibliography of the report included 400 citations, of which only four had publication dates of 1992, zero of 1993, and one (a forthcoming title) of 1994. Less than 75% of the citations were annotated. The purpose of the present document is to cull, complete, and expand the annotated bibliography through 1999, covering 175 years of works that have appeared since Say's (1824) original description of *Pomacea paludosa*.

SCOPE AND METHODS

The emphasis of this bibliography is on primary sources of information on the Florida applesnail. The core of the bibliography is based on a search in *Zoological Record* volumes 1-138 (1864-2002), but a large proportion of citations—particularly the grey literature of reports to and by government agencies—came from the literature cited in documents in hand (*e.g.*, **Baird, 1970**) and from colleagues who kindly alerted us to other sources. The search in *Zoological Record* was supplemented over the years by searches in the print databases *Biological Abstracts*, *Current Contents (Life Sciences)*, *Current Contents (Agriculture, Biology and Environmental Sciences)*, and *General Science Index* and by searches in the electronic databases DIALOG, Wilson OmniFile, UnCover/Reveal, and Ingenta. In the latter two sources, the following search strings were used that others might find helpful:

(applesnail* or apple snail* or pilid* or pomacea) and not ampullari*
ampullari* and not ampullaris

A single source that provided many documents was the library at Arthur R. Marshall Loxahatchee National Wildlife Refuge, Palm Beach County, Florida. At the time of our two trips to examine its holdings in the early 1990s, many files were boxed in anticipation of a court case to settle a lawsuit filed in 1988 (WNET, 1989; **Light, 1998**). The holdings were incompletely searched and might include additional unpublished reports, research notes, and correspondence, especially research done at the refuge when Thomas W. Martin was there. We have been unable to locate any issues of the *Pomacea Newsletter* by the late Earl R. Rich; several individuals and facilities on Rich's distribution list (E. R. Rich, 20 August 1990, *in litt.*) never received issues or no longer have them.

We read several reports of exploring expeditions, though few from early French and Spanish explorers, without finding reference to applesnails: Hernando d'Escalante Fontaneda's memoir of his 17 years of captivity following his shipwreck in Florida in the mid-1500s (**True, 1945**); René Laudonnière's expeditions and establishment of a fort on the St. Johns River in 1562-1565 (**Laudonnière, 1975**); Jonathan Dickinson's journal of his journey in 1696-1697 (**Andrews & Andrews, 1985**); the travels of William Bartram 1773-1777 (**Bartram, 1791**); George Henry Preble's 1842 canoe trip across the Everglades (**Preble, 1883**); travels in Florida commissioned by publishers of *Forest and Stream* in 1873-1875 (**Hallock, 1876**); the Ingraham Everglades Exploring Expedition of 1892 (**Marchman, 1947**); Hugh L. Willoughby's canoe trip across the Everglades in January 1897 (**Willoughby, 1898**); and the travels (probably early 1900s) of Winthrop Packard (**Packard, 1910**). D'Escalante Fontaneda traveled the region around Lake Okeechobee and described the food that American Indians derived from the lake, but no invertebrates are mentioned in his memoir (**True, 1945**).

Although Laudonnière had a "scientific interest in things observed in the New World" [C. E. Bennett, in: **Laudonnière (1975)**], he focused on large animals, plants, food, geography, precious metals, and military matters; he avoided swamps, although of necessity he once found himself overnight up to his shoulders in water. The Dickinson party rarely traveled west of the Indian River Lagoon into habitats that might have held *Pomacea paludosa* **(Andrews & Andrews, 1985)**. **Bartram (1791)** described the shelly banks along the St. Johns River; although Harper (1958) notes that the banks include *P. paludosa*, the shells are likely to have been predominantly those of the banded mysterysnail *Viviparus georgianus* (Lea, 1834) and other smaller and more common species. Wallace R. Moses (in **Marchman, 1947**) described the discomfort of "periwinkle shells" that lodged in shoes of members of the Ingraham Expedition, but such small shells are unlikely to have been those of *P. paludosa*. Although Willoughby shot and ate limpkins [*Aramus guarauna* (Linnaeus, 1766)], mentioned the snail kite, and stumbled through solution holes that often hold *P. paludosa* in south Florida (Loftus *et al.*, 1992; Gunderson & Loftus, 1993), he offered no observations of the snail **(Willoughby, 1898)**. The oversight of the applesnail by Preble, the writers in *Forest and Stream*, the Ingraham Expedition, Willoughby, and Packard might have been due partly to their focus on plant communities, game and fish, and conditions for human survival, and partly to their predominantly winter travel, a time when the activity of adult snails is low and production of egg clutches has not begun. As for earlier accounts of the biota of Florida, Purdy (1991) expressed surprise at the lack of reference by early French and Spanish explorers to the use of freshwater mollusks by Florida Indians.

In addition to primary literature, we consulted the standard scholarly treatises, symposia, and edited series on mollusks as secondary sources. Other secondary sources included nature guides, general books on wildlife, and videotapes but only as we found them to be representative of the type of source or for their historical importance, illustrations, or special observations or statements pertinent to the Florida applesnail; no attempt was made to be exhaustive. Many primary and secondary sources on the snail kite that merely note that applesnails are the kite's sole food were excluded. Because of their temporary and tertiary nature, newspaper articles and internet websites were excluded. Most newspaper articles on the Florida applesnail have appeared in *Miami Herald*, *St. Petersburg Times*, and *Florida Today*. One website of excellent quality that has been actively developed for several years is that of Stijn Ghesquiere of Belgium, launched in March 1998 (http://www.applesnail.net).

The bibliography includes 673 annotated references to print literature of a variety of formats, videotaped productions, a postcard, stamps, and a sculpture. Additional references such as abstracts and editions of print literature are listed (usually embedded within an annotation) but are not annotated unless they offer significantly different information from full articles or first editions. Publication data for editions that were unavailable were checked in Online Computer Library Center's (OCLC) First Search database. A number of references claiming to deal with the Florida applesnail are not about or are unlikely to be about *P. paludosa* because of suspected errors in identification; they are included, and the annotations explain the basis for our uncertainty.

NOMENCLATURE AND OTHER CONVENTIONS

The Florida applesnail has been assigned to the family-group names Ampullariidae, Pilidae, and Trochidae and the genus-group names *Ampullaria*, *Ampullarius*, *Pomacea*, and *Pomus*. The currently accepted assignment is *Pomacea paludosa* in family Ampullariidae. The most frequently encountered synonyms of *P. paludosa* are *Ampullaria depressa* and *A. caliginosa* Reeve, 1856; others are given in the annotations. Nomenclatural details of authorship and synonymy are explained in **Pain (1972)**, **Cowie (1997)**; **[International Commission on Zoological Nomenclature] (1999)**, **Turner *et al.* (2001)**, **Cazzaniga (2002)**, and **Cowie & Thiengo (2003)**.

Taxonomic authorities are given for scientific names in the annotations generally at their first appearance. Our use of the common names "Florida applesnail" and "snail kite" follows the conventions of Turgeon *et al.* (1998) and the American Ornithological Union, respectively. Unless qualified, "*Ampullaria depressa*" and "*Pomacea depressa*" refer to *Ampularia depressa* Say, 1824, not *Ampullaria depressa* Lamarck, 1804; "snail kite" refers to the Florida subspecies *Rostrhamus sociabilis plumbeus* Ridgway, 1874.

Bibliographic entries occur in the annotated bibliography and in the section of literature cited that follows it. Citations in the text are in plain font for the former and in bold font for the latter. Bracketed information in the bibliographic citations represents additional data from sources other than the document. For example, if the publication date differs from that printed on the document, the correct date is given in brackets.

THE BIBLIOGRAPHY

Abbot[t], R. T. 1966. Shells. Nelson Doubleday, Garden City, New York. 63 pp.

In this popular book on shells, "pomacea snails" are figured with an excellent black-and-white photograph of a female snail depositing an egg clutch on cattails (*Typha* sp.). The caption includes the emotionally charged statement, "If the snails are destroyed, the birds [snail kites] will die out completely."

Abbott, R. T. 1984. Collectible Florida shells. American Malacologists, Melbourne, Florida. 64 pp.

The shell of *Pomacea paludosa*, as "Swamp Apple Snail" from the Everglades, is figured in color. The snail is noted as "food of birds" in this popular work.

Abbott, R. T. 1989. Compendium of landshells. American Malacologists, Melbourne, Florida. vii + 240 pp.

Pomacea paludosa (in Pilidae) is listed in a one-page summary of common freshwater snails in this book of otherwise terrestrial coverage. The caption ("Several New World tropical species and some Asia and African genera, all operculate," p. 194) describes the familial composition rather than the species.

Abreu, V. 1976. Snails of wilderness waters. Of Sea and Shore, 7(3): 161-162.

This popular article describes the general biology of Florida applesnails and predation by the limpkin and snail kite in the Florida Everglades. Much of the description seems to be based on the author's personal observations and includes references to predators of adult snails and snail eggs not recorded elsewhere in the literature. Two human uses of snails are cited: consumption by native Seminole Indians as well as by "urban residents" (including a recipe); as indicators of water purity through the survival of "planted" snails in local waters by early settlers in Florida and Georgia. Crude illustrations by the author are included.

Agarwal, R. A., P. J. B. Ligon & M. J. Greenberg. 1972. The distribution of cardioactive agents among molluscan species and tissues. Comparative and General Pharmacology, 3(11): 249-260.

This survey of cardioactive agents in one species from each of four molluscan classes includes field-collected *Pomacea paludosa* as the representative gastropod. Pooled samples of cerebral, pedal, pleural, buccal, and abdominal ganglia gave cardioactive peaks for acetylcholine, 5-hydroxytryptamine, three of four previously discovered but unidentified substances, and high concentrations of one novel substance (agent B°). Heart extracts gave only acetylcholine activity. Agent B° was subsequently found in ganglia of the other three mollusks studied, and it was partly characterized as resembling a catecholamine.

Aguayo, C. G. 1944. Los moluscos comestibles de Cuba. Revista de la Sociedad Malacologica, 2(1): 17-20.

This paper addresses concern for the scarcity of protein worldwide and alternative sources. The author lists preferred mollusks that are marketed or consumed locally in Cuba. A second list gives mollusks eaten elsewhere and suggests Cuban equivalents for consideration. The equivalents given for *Pomacea* sp. used in Guadelupe are *P. paludosa* and *P. poeyana* [= *P. poeyana*

Pilsbry, 1927], but both are considered difficult to collect or potentially objectionable to Cubans.

Aguayo, C. G. & M. L. Jaume. 1939. Moluscos semifosiles del "Bosque de la Habana." Memorias de la Sociedad Cubana de Historia Natural, 13(4): 229-245.

Subfossil mollusks from a region of the Almendares River near Havana, Cuba, are compared with living mollusks of the area. Numerous specimens (subfossils) of *Pomacea paludosa* are recorded from "station C," but the species is not included in the table comparing subfossil and Recent faunas.

Aguayo, C. G. & M. L. Jaume. 1947. Gasteropoda—Ampulariidae. Catálogo Moluscos de Cuba, no. 24, 1 p.

Pomacea paludosa is listed from Florida (type locality) and Cuba. In the latter, it is "very abundant in all rivers and lakes" [our translation]. Four forms of *P. paludosa* are given: *dilatata* (Orbigny, 1842) from Cuba; *elongata* (Orbigny, 1842) from Cuba; *flava* (Pilsbry, 1937) [should read "(Smith, 1937)"; see annotation for Smith (1937)] from the Florida Everglades (type locality) and Cuba; and *garciae* Richards, 1933, from Cuba. The catalogue was revised in 1954 (A. Gutiérrez, personal communication, 2000; cited by Gutiérrez, *et al.*, 1993-1994 [1995]), but we have been unsuccessful in locating a copy.

Aguiar Prieto, P. H., J. Pascual Gispert, B. Dumenigo, G. Perera de Puga & M. D. Galvez Oviedo. 1981. *Angiostrongylus cantonensis*. Hospederos intermediarios en las dos provincias habaneras. Revista Cubana de Medicina Tropical, 33(3): 173-177.

The authors mistakenly claim this to be the first report of *Pomacea paludosa* as host of the rat lungworm *Angiostrongylus cantonensis* (Chen, 1935) stage III larvae (see Wallace & Rosen, 1969). This nematode infects 40% of specimens from the provinces of Havana and Havana City, Cuba. Eight of eleven gastropod species studied were infected, and *P. paludosa* was the only one infected of three aquatic species.

Alden, P., R. B. Cech, R. Keen, A. Leventer, G. Nelson & W. B. Zomlefer. 1998. National Audubon Society field guide to Florida. Alfred A. Knopf, New York. 447 pp.

This richly illustrated field guide to flora, fauna, and habitats of Florida includes information in several places on the Florida applesnail and its predators and a photograph (printed twice) of a living snail. The text clearly implies (erroneously) that the snail eats sawgrass (*Cladium jamaicense* Crantz, 1766) and that limpkins eat the snail's eggs, described to be the size of BB-shot (4.5 mm), which is at the low end of the usually reported range of 4-6 mm for *Pomacea paludosa* eggs (but see Ferrer [López] *et al.*, 1992).

Alden, R. W. 1971. Trophic relationships of two invertebrates of the water hyacinth community. Quarterly Journal of the Florida Academy of Sciences, 34(suppl. 1): 5. [abstract]

In this three-sentence abstract of a meeting presentation, the author concludes that *Pomacea paludosa* feeds on water hyacinths *Eichhornia crassipes* (Mart.) Solms, 1883, based on analyses of radionuclide tracers and stomach contents.

Alderson, E. G. 1925. Studies in *Ampullaria*. W. Heffer & Sons, Cambridge, England. xx + 102 pp., 19 pls.

Ampullaria paludosa is reported from Georgia, Florida, Cuba [Pilsbry (1927) [1928] states this as the only recognition of Cuban *P. paludosa* at that time], and possibly the West Indies. Variations in color and shape of the shell are described and figured (pl. IX, fig. 4; pl. X, figs. 7-10). Although not included in the synonymy, Pfeiffer's (1854-1860) specimens of *A. reflexa* Swainson, 1823, from southwestern Cuba are suggested as belonging to *A. paludosa*. [See Blok and Pain (1948) for discussion of Alderson's collection.]

Aldrich, J. W. 1966. Before it is too late. Pp. 488-505, in: A. Stefferud & A. L. Nelson (eds.), Birds in our lives. United States Department of the Interior, Bureau of Sport Fisheries & Wildlife, Fish & Wildlife Service, Washington, D. C. xiii + 561 pp.

In this one of several chapters on management and conservation of birds, the population size of the Florida applesnail is claimed to decline in drought and under water-management practices that lower water levels. Aldrich's contribution to a later edition of this book (1970, Arco Publishing Company, Inc., New York, xiii + 447 pp.) is identical, but his chapter is found on pp. 376-393.

Aldridge, D. W. 1983. Physiological ecology of freshwater prosobranchs. Pp. 329-358, in: W. D. Russell-Hunter (ed.), The Mollusca. Vol. 6. Ecology. Academic Press, Orlando, Florida. xx + 695 pp.

For *Pomacea paludosa*, this review includes only information on ciliary feeding and distance chemoreception. Although the selection of literature often reflects the biases of a reviewer, scant mention of *P. paludosa* here also demonstrates the low impact that research on this species has made on our understanding of functional biology of prosobranchs.

Alper, J. 1992. Everglades rebound from Andrew. Science (Washington, D. C.), 257(5078): 1852-1854.

This commentary suggests that the management strategy imposed by the Endangered Species Act might have more damaging and longer lasting effects on the Everglades than will Hurricane Andrew. The article uses the snail kite as an example of single-species management that places an ecosystem in jeopardy, based on a then-forthcoming report by Orians *et al.* (1992).

Photographs show a snail kite with a shelled applesnail in its beak and a midden of spent applesnail shells on the ground. Most of the few statements about applesnails are explicitly or implicitly inaccurate: the snail is the kite's sole food; the presence of water "forces" the snails to climb plant stems; snails climb to the tops of sawgrass blades [ca. 1-2 m high].

Alper, J. 1993. How to save a species AND its ecosystem. Audubon, 95(1): 104-105.

The author reports that an Everglades restoration plan initiated in 1989 was halted in 1990 out of concern for the snail kite. The plan involved drainage of feeding grounds of the kite. A subsequent dispute among agencies and conservation organizations led to formation of a panel that released a report (Orians *et al.*, 1992) that favored a multi-species approach to Everglades management. The panel and other biologists noted that the kite migrates around south Florida in search of populations of applesnails that become available to the kite under conditions of high water.

Alpha, C. 1993. Alien snails threaten Hawaiian wetland ecosystems. Hawaiian Shell News, 41(12): 1, 3-5.

Four introduced species of Ampullariidae and one of Viviparidae are documented to occur in the Hawaiian Islands, and the potential impact on native stream ecosystems is discussed. *Pomacea paludosa* is considered one of the most recent arrivals through the aquarium trade, based on Bishop Museum material from one location on Maui in 1990.

Anderson, J. F., H. Rahn & H. D. Prange. 1979. Scaling of supportive tissue mass. The Quarterly Review of Biology, 54(2): 139-148.

Original data are given on shell weight vs. fresh weight of *Pomacea paludosa* in this review, which otherwise draws mostly from other published sources. The data for *P. paludosa* fit closely the scaling relationship for mollusks ($Y = 0.231X^{1.096}$), based also on the authors' data for two other snails and a clam. Although the mollusks have a proportionately larger skeleton than spiders, bird eggs, adult birds, snakes, and mammals, all groups have the same scaling factor ($b = 1.12$).

Andrews, E. A. 1933. Eggs of *Ampullaria* in Jamaica. The Nautilus, 46(3): 93-97, pl. 8.

The egg masses of the Florida applesnail (as "*Ampullaria depressa*") [as figured by Brooks & McGlone (1908: pl. 1, fig. 8)] are compared to those of *A. gossei* Reeve, 1856 from Jamaica.

Anonymous. 1868. Antiquity of man. The American Naturalist, 2(8): 443.

This note, probably authored by the four editors of the journal (A. S. Packard, Jr., E. S. Morse, A. Hyatt & F. W. Putnam), attempts to settle a misunderstanding over the origin of bones found by L. F. Pourtalés. Pourtalés is quoted here to explain that the bones came from Lake Monroe, Florida, in association with shells of freshwater mollusks ("*Ampullaria*" among them) that presently inhabited the lake. Pourtalés' quotation is reprinted in Wyman (1875).

Anonymous. 1942. Florida birds of prey. The Florida Naturalist, 15(2): 21-27.

This article was written to counter the persecution of "hawks". Out of 29 species of bird of prey in Florida, the snail kite is listed as 1 of 2 that are harmless. Its sole prey consists of "an everglades snail" that can survive only in undrained habitats. An editorial note encourages members of the Audubon Society to disseminate the article among schools in Florida.

Anonymous. 1954. Florida's vanishing snailhawk. Florida Wildlife, 8(6): 31, 39.

Restricted distribution of the Florida applesnail (as "*Pomacea caliginosa*") has driven the snail kite to marshes where migratory waterfowl attract duck hunters and where bass fishermen might interfere with nesting of the kite. Decline of the applesnail populations is attributed to drainage, saltwater intrusion, and drought. Periodic drying of marshes kills "the 'seed' stock of snails." One passage suggests that kites feed on snails only when snails emerge from the water: "During daylight hours, the freshwater snail is usually up out of the water only during the early morning and late afternoon, the very times when duck hunters are on the grounds." Mention is made of the film "Phantom of the Marshes" by B. W. Read (Read, 1954; **Baird, 1970**). Similarities of text with Naggiar (1954) indicate that this article might have been authored by M. H. Naggiar.

Anonymous. 1964a. Protection for Everglade kite. National Parks Magazine, 38(202): 18.

Parts of the Loxahatchee National Wildlife Refuge were closed to protect the nine resident snail kites, whose numbers have diminished because of a decline in the applesnail population in central and south Florida due to drainage. Proper wetlands management for both snail and kite is seen as the only recourse for restoring the kite population.

Anonymous. 1964b. Florida's rarest bird. Young Naturalists Afield in Florida, supplement to The Florida Naturalist, 37(4): 1.

Specializations of the snail kite for feeding on the Florida applesnail are described. Decline in the kite population is attributed to loss of snail habitat from drainage and to hunting. The article is illustrated with a National Wildlife Federation [ca. 1956] conservation stamp without crediting the source.

Anonymous. 1965. Everglade kite. Science News Letter, 88(9): 142.

This article informs the popular science readership of the plight of the snail kite, nearing extinction due to drainage of marshes, which causes mortality of its prey, the Florida applesnail. Course hunting (a foraging style) for the snail by the kite and extraction of the snail from the shell are briefly described.

Anonymous. 1968a. Kites in the Everglades. Nature, 218(5145): 1006-1007.

In this review of Stieglitz & Thompson (1967), the prey of the snail kite is given as *Pomacea paludis* [*sic*]. Sykes & Robertson (1968) later corrected the name to *P. paludosa*.

Anonymous. 1968b. Everglade kite tour. Massachusetts Audubon Newsletter, 7(7): 2.

The "*Pomacea* snail" is mentioned as the sole prey of the snail kite, which is claimed to be "among the world's rarest birds."

Anonymous. 1975. Two endangered birds. Florida Wildlife, 29(5): 8-9.

In this popular article, a decline in the snail kite population in Florida is partly attributed to a decline in populations of *Pomacea paludosa* as a result of drought, fire, and diversion of water for agricultural and residential use. The author mentions federal research efforts to re-establish applesnail populations.

Anonymous. 1977. Snail-raising planned. New York Shell Club Notes, no. 239: 4.

This note includes an excerpt from a newspaper article about the intent of the federal government to raise the Florida applesnail on a large tract of land in south Florida.

Anonymous. 1978. Apple snails in Florida. Chicago Shell Club Newsletter, 13(6): 3.

Referring to an article by Jeff Klinkenberg in the March 5, 1978, issue of St. Petersburg Times, this account describes an award-winning shell show display by Mrs. Edith Dodd on the Florida applesnail. Mrs. Dodd collected eggs at Ocala's Silver Springs and successfully hatched and reared the snails in bowls in her home. They were provided lettuce and oatmeal as food and reproduced to a population of "several hundred snails." Mrs. Dodd was said to be cooperating with biologists at Loxahatchee National Wildlife Refuge who are culturing applesnails as food for snail kites. The dependence of the kite on applesnails is discussed.

Anonymous. 1982. Everglade kite count. Florida Wildlife, 35(5): 47.

This brief popular article mentions the reduction of applesnail habitat by drought in south Florida.

Anonymous. 1986a. A picky eater. Audubon Adventures, 2(6): [1 p.].

This brief popular article describes the method by which the snail kite finds, captures, extracts, and consumes an applesnail.

Anonymous. 1986b. An endangered hawk and the apple snail. Audubon Adventures, 2(6): [1 p.].

This brief popular article reports on a labor-intensive method for providing applesnails to nesting snail kites during droughts.

Anonymous. 1992. Apple snails. [Unpublished note. State of Hawaii, Department of Agriculture, Honolulu.] 4 pp.

Pomacea paludosa is listed as collected in 1990 from taro [*Colocasia esculenta* (L.) Schott, 1832] patches in Keanae, Maui, Hawaii. Line art of shells and a dichotomous key are given to distinguish exotic viviparid and ampullariid snails, including *P. paludosa*, in Hawaii; both keys and artwork are attributed to R. H. Cowie. Bracketed publication data are from Cowie (1997).

Arango [y Molina], R. 1865-1866. Continuacion al catálogo de los moluscos [terrestres y fluviales de la isla de Cuba]. Repertorio Fisico-Natural de la Isla de Cuba, 1: 123-149.

Ampullaria conica Wood, 1828, *A. teres* Philippi, 1849, and *A. reflexa* are listed from various locations in Cuba. An index was subsequently published by Arango y Molina in volume 2 of this work [1866-1868. Conspectus familiarum et index molluscorum terrestrium et aquarum dulcium insulae Cubae. Pp. 73-90].

Arango y Molina, R. 1878-1880. Contribución a la fauna malacológica Cubana. R. Arango y Molina, Havana. 280 + 35 [index] pp. [issued in six parts]

In an expanded version of data presented by Arango [y Molina] (1865-1866), *Ampullaria conica*, *A. teres*, and *A. reflexa* are listed from Cuba with additional synonymies. The last species, from Güines (southeast of Havana), was listed by Pilsbry (1927) [1928] as misidentified *Pomacea paludosa*.

Asch, F. & T. Levin. 1996. Sawgrass poems: a view of the Everglades. Harcourt Brace & Co., San Diego. Approx. 50 pp., unpaginated.

The authors combine children's poetry, wildlife photography, and informative text to communicate their views of the Everglades. The poem "Two baby snail kites" includes the chorus: "Apple snails for dinner. Apple snails for lunch. And every Sunday morning, apple snails for brunch." The photograph on the title page captures a male snail kite in flight, presumably transferring a snail from its talons to its beak. Text notes give additional information on applesnails.

Audubon, J. J. 1838. Ornithological biography, or an account of the habits of the birds of the United States of America, accompanied by descriptions of the objects represented in the work entitled *Birds of America*, together with an account of the digestive organs of many of the species, illustrated by engravings on wood. Vol. IV. Adam & Charles Black, Edinburgh. xxviii + 618 pp.

In his description of the limpkin (the "scolopaceous courlan"), Audubon mentions that this bird feeds mainly on a large greenish snail, the empty shells of which accumulate on the ground around the bird's nest.

Audubon, J. J. 1842. The birds of America, from drawings made in the United States and their territories. Vol. V. J. J. Audubon, New York, & J. B. Chevalier, Philadelphia. viii + 346 pp., pls. 281-350.

See Audubon (1838), which contains the identical text.

Bailey, H. H. 1925. The birds of Florida: a popular and scientific account of the 425 species and subspecies of birds that are now, and that have been found within the state and its adjacent waters; with special reference to their relation to agriculture. The Williams & Wilkins Company, Baltimore. xxi + 146 pp., 1 map, 76 color pls., 1 black-and-white drawing.

The snail kite prefers adults and eggs of the Florida applesnail (as "*Ampullaria depressa*") to lesser dietary items (lizards, frogs, snakes). Its hooked beak is used to extract the meats from the snail shells, which accumulate in large numbers beneath perches. Kite distribution is governed by snail abundance. No substantiation is given for the claim that snail eggs are consumed.

Baird, S. F., T. M. Brewer & R. Ridgway. 1875. A history of North American birds. Land birds. Vol. III. Little, Brown, and Company, Boston. [iii] + 560 + xxviii pp., color pls. LVII-LXIV.

In the section on the snail kite (pp. 209-212), the authors report the discovery by Maynard of remains of the Florida applesnail (as "*Pomus depressa* of Say") in stomachs of dissected kites. Greater detail is given in Maynard (1879) of observations from his trips into the Everglades. The trips occurred in winter of 1870 according to the present authors, but Maynard's (1879: iii) preface suggests that the year might have been 1871.

Baker, F. C. 1889a. Contents of the stomachs of certain birds collected in Brevard Co., Florida, between Jan. 5, and April 15, 1889. Ornithologist and Oologist, 14(9): 139-140.

In this listing of gut contents of many birds, the author reports finding soft parts of applesnails (as "*Pomus depressus*") in the stomachs of four snail kites from Brevard County.

Baker, F. C. 1889b [1890]. Notes on the food of birds. Proceedings of the Academy of Natural Sciences of Philadelphia, 1889, [41]: 266-270.

Although this would seem to be a repeat of Baker (1889a), the list of bird species from material collected near Micco, Brevard County, Florida, is slightly different, and the enumeration and identity of stomach contents differ, sometimes greatly. For the snail kite (as "*Rostramus* [sic] *sociabilis*"), the author's conclusion is similar to Baker (1889a): "The food of this bird consists entirely of the animal of *Pomus depressus* Say."

Baker, F. C. 1903. Shells of land and water: a familiar introduction to the study of the mollusks. A. W. Mumford, Chicago. xvii + 175 pp., [8] color pls.

This is a narrative of a supposed "Professor Parker" addressing his students. The shell and crawling animal of *Pomacea paludosa* (as "*Ampullaria depressa*") are illustrated. Predation by snail kites and external appearance of the living snail are summarized. "Ampullarias" (also called apple-shells, idol-shells, pond snails) are considered "truly amphibious" in their ability to exist "for several years away from the water." One of the plates includes a photograph of an empty shell. A line drawing (p. 21) of the living animal is reproduced from **Tryon (1883: pl. 74, fig. 16)**. The figure caption of the latter reads "*Ampullaria* (*Pomus*) *canaliculata*, Lam. [1822] Florida," although the text indicates "American". Baker apparently assumed that the name applied to this figure was wrong by virtue of the locality, and he understandably, although incorrectly, "corrected" it to *A. depressa*. Although not stated by **Tryon (1883)**, his figure was in fact a reproduction from **Orbigny (1835-1847: vol. 9, pl. 50, fig. 5)**, labeled as *A. canaliculata* from "..." [*i.e.*, locality unknown]. The same figure appeared in **Woodward (1851-1856: text-fig. 85)** as "*Ampullaria canaliculata* ... South America." **Woodward's (1851-1856)** figure was the basis for the logo of the Malacological Society of London from 1893 until just recently, when the logo was redrawn **(Bebbington, 1990)**.

Baker, G. 1980. Copper herbicides vs. snails? Aquatics, 2(1): 6, 11.

This paper gives a chronology of events surrounding a controversy over the use of copper herbicides to control submerged plants in south Florida's Water Conservation Area No. 1. Based on research contracted as a result of the controversy and based on some arm-chair calculations of copper concentrations, the author concludes that copper is unlikely to affect Florida applesnail populations. Several future lines of research are suggested, but the author overlooks the possibility that copper, if accumulated in snail tissue, could affect the snail kite.

Baker, H. B. 1930. The Mollusca collected by the University of Michigan-Williamson Expedition in Venezuela. Part VI. Occasional Papers of the Museum of Zoology, University of Michigan, no. 210: 1-95.

This is part VI of a series of papers on the terrestrial and aquatic mollusks of Venezuela, covering freshwater species in the families Ampullariidae and Melaniidae. *Pomacea paludosa* is not included, but *P. chemnitzii* (Philippi, 1852) is considered as a member of the "*reflexa-flagellata-paludosa* group, as suggested by Sowerby" (1909). [Sowerby (1909) named no species "group" but rather treated *A. reflexa*, *A. flagellata* Say, 1829, and *A. porphyrostoma* Reeve, 1856 (= *chemnitzii*) as varieties of *A. hopetonensis* Lea, 1834. *Ampullaria depressa* (= *paludosa*) was listed in synonymy with *A. hopetonensis*.]

Baker, H. B. 1964. Type land snails in the Academy of Natural Sciences of Philadelphia. Part III. Limnophile and thalassophile Pulmonata. Part IV. Land and fresh-water Prosobranchia. Proceedings of the Academy of Natural Sciences of Philadelphia, 116(4): 149-193.

Type material for 18 species of Ampullariidae is documented, listing literature citations, Academy (ANSP) catalog numbers, and (in some cases) shell dimensions. The species *Ampullaria paludosa*, *Pomacea flava*, *P. garciae*, *A. miamiensis* Pilsbry, 1899, and *A. rotundata* Say, 1829 are included.

Baker, T. & N. Glover. 1993. Taro Action Resource Organization (TARO) meeting, July 2, 1993 minutes. Taro Action Resource Organization, [Hawaii]. 7 pp.

Two reports listed only by title deal with problems with applesnails on Kaua'i and Maui, with an indication of ongoing studies on Maui of the use of American black ducks (*Anas rubipes* Brewster, 1902) to control snails. In a discussion about growing taro, *Pomacea paludosa*, "native to Florida", is listed as an exotic from the aquarium trade. Methods of applesnail control include mechanical eradication of egg clutches and collection of adult snails by prison inmates and taro growers, trapping, use of ducks as a natural control agent, application of copper sulfate (5 ppm; 100% mortality after 24-48 h exposure), ammonia, and chlorine, restriction by copper fencing, and search for other biological control agents in countries of origin. Participants recommend several courses of action: public media campaign; establishment of regulations; research on damage by applesnails and on their biological, rather than chemical, control; expansion of the mechanical eradication program of the Hawaii Department of Agriculture. Although some of the content refers to applesnails in general, it is likely to be based more on experience with *P. canaliculata* rather than with *P. paludosa*.

Baldo, B. A. & G. Uhlenbruck. 1974. Studies on the agglutinin specificities and blood group O(H)-like activities in extracts from the molluscs *Pomacea paludosa* and *Pomacea urceus*. Vox Sanguinis, 27(1): 67-80.

This is a continuation of earlier work (see Baldo *et al.*, 1973) on serological and immunochemical properties of saline extracts of *Pomacea paludosa* eggs. Extracts agglutinated erythrocytes of groups O, A, AB, and B. Agglutination activity was inhibited by pneumococcus type XIV polysaccharide and by several sugars containing D-galactose or its derivatives. The extracts contained two agglutinins with high polysaccharide specificity. The authors suggested that their findings support the hypothesis that agglutinins protect eggs from microbial infection.

Baldo, B. A., G. Uhlenbruck & G. Steinhausen. 1973. Blood group O(H)-like activity in extracts from some invertebrates. A study with catfish and eel sera and three anti-H lectins. Vox Sanguinis, 25(5): 398-410.

The authors surveyed 22 species of invertebrates for substances that are immunologically similar to human blood group H-substance. Saline extracts of *Pomacea paludosa* eggs gave H-like activity, reacting with anti-H sera from fish; but they also agglutinated human group O erythrocytes, prompting further study (see Baldo & Uhlenbruck, 1974).

Banner, A. & C. Sultzman. [No date.] HSI model for the snail kite. [United States Department of the Interior], United States Fish & Wildlife Service, [city, state unknown]. [10] pp., figs. [draft copy]

The authors develop Habitat Suitability Indices (HSI) for the snail kite in Water Conservation Area 3A. The HSI model is not based on known availability of Florida applesnails in the area, but it is based on factors that affect habitat suitability to the snail and foraging by the snail kite. All information on the applesnail is extracted from literature, most recently published in 1988. The document seems not to have been published. The date and origin of our incomplete copy are unknown.

Barr, B. R. 1994. Dietary studies on the American alligator, *Alligator mississippiensis*, in southern Florida. M. S. thesis, University of Miami, Coral Gables, Florida. vi + 73 pp.

This three-part study was preliminary to Barr (1997). In an examination of diet of 80 juvenile alligators [*Alligator mississippiensis* (Daudin, 1801)] from Lake Okeechobee in 1993, the author found gastropods to occur in 87.5% of pumped stomachs, followed in frequency by insects, crustaceans, and vertebrates. Diet did not vary by season or by size or sex of alligator. Most of the gastropods were *Pomacea paludosa*, primarily opercula (up to 109 per stomach) with no flesh attached. A personal communication of unpublished data from J. A. Kushlan states that *P. paludosa* predominated in > 2000 alligator stomachs from the Everglades; but Kushlan was concerned about interpretation of the data because of possible differences in digestion rates among prey. Barr's study of force-feeding penned alligators with *P. paludosa*, crayfish (*Procambarus* sp.), or fish indicated that the snail was slowest to be digested, 12% dry mass predicted to remain after 144 h. The opercula remained undigested when the study was concluded at 200 d, although some opercula were regurgitated earlier; no opercula were found in the feces. Opercula were clean of attached soft tissue by 48 h. The author recommends that opercula with attached tissue be used to indicate recent ingestion, on which basis *P. paludosa* occurred in only 7.5% of stomachs and ranked fifth in the diet. A regression equation was used for wet-to-dry mass conversion of *P. paludosa*: dry mass = 0.485 + 0.298·wet mass. In an attempt to evaluate the substitution of snail opercula for gastroliths to facilitate digestion, penned alligators were force-fed fish and granitic stones, fish and opercula, or fish alone. Results indicated that gastroliths had no effect on digestion and that opercula slowed digestion, perhaps "by blanketing the prey or lining the stomach wall" or by obstructing evacuation through the pyloric sphincter.

Barr, B. [R.] 1997. Food habits of the American alligator, *Alligator mississippiensis*, in the southern Everglades. Ph. D. dissertation, University of Miami, Coral Gables, Florida. xiv + 243 pp. [1998. Dissertation Abstracts International, 58B(8): 4013.]

This dissertation contains extensive data on *Pomacea paludosa* as prey of the American alligator. The study consisted of four parts: stomach contents of alligators, gastric residence times of selected prey species, a re-evaluation of diet based on gastric residence times, seasonal variation in body condition of alligators and its relationship to dietary insufficiency hypothesized by earlier authors for alligators of south Florida. The dietary study used 635 alligators in five size classes (adult, subadult, larger juveniles, smaller juveniles, and hatchlings and first-of-the-year alligators) collected from Shark River Slough, Everglades National Park, in the wet season (October 1994, 1995) and dry season (March 1995, 1996). The Florida applesnail (7147 individuals; but in a later section the author claims to have found only 5715) comprised 95% of gastropods and 77% of all animals found in stomachs. They were found in 58% of stomachs (a frequency greater than any other of the 53 animal taxa recorded) and weighed 18% of "total food mass" (wet or dry not specified). Consumption by male and female alligators did not differ. A greater mass of applesnails was found in stomachs in the dry season than in the wet season, but seasonal variation was believed to reflect changes in availability of applesnails and in foraging patterns of alligators rather than in water level. Alligators of the two smallest size classes rarely contained applesnails. In the laboratory, smaller juveniles were unable to swallow applesnails and probably could not crush them. Applesnails occurred in great frequency (up to 100%) and mass (up to 78% of food mass) in stomachs of the other three size classes and particularly made a substantial contribution to the diet of larger juveniles. The latter were found to swim along the bottom in the field, sweeping their heads side-to-side with mouth open, a behavior used by captive larger juveniles for capturing applesnails. Although data used here on gastric residence times for applesnails are from Barr (1994), they are compared with data for other prey force-fed to penned subadult alligators. Time to 50% loss of mass of applesnails (56 h) was much longer than for cockroaches, crayfish (*Procambarus* sp.), fish, amphibians, reptiles, birds, and mammals, and time to 90% loss (138 h) was second only to crayfish. In addition, the inability of alligators to digest chitin resulted in the retention of snail opercula for at least 200 d in the stomach (no occurrence in feces), whereas parts of reptiles, birds, and mammals remained at least 10 d. Applesnails had, therefore, the potential of being greatly overrepresented in stomach contents. The author recommends using only opercula with attached soft tissue to indicate recent consumption (< 36 h) of applesnails. Reanalysis of his present data using this residency criterion resulted in both the frequency of occurrence and percentage contribution to food mass by applesnails to decline about 50%. Application of similar criteria for other prey based on 48-h gastric residence times and resistant body parts resulted in adjusted overall values of 47% frequency of occurrence and 8% of food mass, still a major contribution by applesnails to diets of Everglades alligators. Based on larger taxonomic groups after adjustment of data, alligator diets were dominated by snakes and aquatic salamanders rather than by gastropods.

Bartsch, P. 1937. An ecological cross-section of the lower part of Florida based largely upon its molluscan fauna. Pp. 11-25, in: W. H. Twenhofel (ed.), Report of the Committee on Paleoecology, 1936-1937; presented at the annual meeting of the Division of Geology and Geography, National Research Council, May 1, 1937. National Research Council, Division of Geology and Geography, Washington, D. C. 63 pp.

Largely narrative species lists of dominant mollusks in the terrestrial, freshwater, estuarine, and marine habitats of the Florida Everglades and Keys are provided as keys to understanding local ecology. *Pomacea depressa* is listed as a member of the freshwater molluscan community in streams and channels in the Everglades. The author mentions that deeper water at edges between shallow sawgrass marsh and deep sloughs is favorable habitat for this snail. Its importance as a food item for snail kites and limpkins is noted.

Bauer, E. A. 1967. The sunset of the snail kite. Field & Stream, 72(4): 58-60.

This popular article discusses some factors that have contributed to the decline of the snail kite population in Florida. Some original anecdotal observations are given on foraging by the kite. The adult size and geographic range of the applesnail (as "*Pomacea caliginosa*") are underestimated here. The article includes a reproduction of a painting by Richard Evans Younger of a pair of snail kites; it shows three clutches of *P. paludosa* eggs on emergent vegetation and a snail held by the toe of a perching kite (Younger [1960s]).

Beard, D. B., F. C. Lincoln, V. H. Cahalane, H. H. T. Jackson & B. H. Thompson. 1942. Fading trails: the story of endangered American wildlife. The MacMillan Company, New York. xvii + 279 pp., 12 text-figs., 6 black-and-white pls., 4 color pls.

As a conservation book for the lay community, this book has an unusually long chapter on the snail kite ("The Snail Bird"), although much of the text only sets the stage for the reader by describing the natural history and human alteration of the Everglades ecosystem. The decline of kite populations is attributed to a decline in its food source, "Pomacea snails", used also by the limpkin, whose populations seem less affected statewide. Capture and extraction of snails by kites are briefly described. The author implies that kites feed only at dawn and dusk, when the snails come "out of the water" to crawl on emergent vegetation. A black-and-white plate was intended to illustrate this chapter; but it and nine others are missing from our copy, their absence perhaps explained partly by a footnote (p. xiii) to the list of illustrations that not all figures are "reproduced in entirety."

Beissinger, S. R. 1981. Nest failure and demography of the Everglade kite. 1981 End-of-the-year report to United States Fish & Wildlife Service, Endangered Species Research Division. University of Michigan, Ann Arbor, Michigan. 21 pp.

This document is an agency report that presents field observations on the effects of a drought in 1981 on snail kites in south Florida. The author attributes changes in diet, foraging range, and nesting habits to a subjectively estimated decline in availability of applesnails. Correlative data are given on kite and snail populations in several bodies of water, but census methods are unspecified. Kites were observed feeding on four species of turtles and a viviparid snail. Attempts to use snails as bait to trap kites were unsuccessful. Three laboratory experiments are briefly described from which the author concludes that applesnails increase the frequency of surfacing and inspiration of air at low oxygen tension and decrease this activity at low temperature.

Beissinger, S. R. 1982. Nest failure and demography of the Everglade kite. 1982 End-of-the-year report to United States Fish & Wildlife Service, Endangered Species Research Division. University of Michigan, Ann Arbor, Michigan. 19 pp.

This agency report on demography, nesting, and feeding of the snail kite in south Florida in late 1981 through late 1982 is largely a summary of Beissinger & Takekawa (1983). The author attributes altered behavior and reduced numbers of kites to a decline in population of applesnails, inferred from scarcity of snail egg clutches, abundance of floating empty snail shells, and increased snail-capture time by kites. He predicts a lag in re-establishment of snail populations upon reflooding of the habitat. It is quantitatively determined that kites occurred in areas with higher indices of snail egg clutches. Numerous incidents of consumption of two species of turtle by snail kites were observed.

Beissinger, S. R. 1983. Nest failure and demography of the snail kite: effects of Everglades water management. 1983 End-of-the-year report to United States Fish & Wildlife Service, Endangered Species Research Division. University of Michigan, Ann Arbor, Michigan. 22 pp.

This is an agency report of continuing studies on snail kite populations in south Florida. Despite claims early in this document of evidence for the direct effect of water-level management on density of applesnails, no evidence is given. The author speculates that in 1983 snail density in the Everglades National Park was higher than it was in Water Conservation Area 3A and then expresses puzzlement over the much greater use of WCA3A for nesting. He urges future research of environmental effects on the population biology of applesnails.

Beissinger, S. R. 1984. Mate desertion and reproductive effort in the snail kite. Ph. D. dissertation, University of Michigan, Ann Arbor, Michigan. xviii + 181 pp. [1985. Dissertation Abstracts International, 45B(7): 2023.]

This dissertation documents ambisexual mate desertion in the snail kite based on population studies in south Florida during 1979-1983. Findings are discussed in relation to mating systems theory. All conclusions regarding the impact of applesnail populations on the snail kite depend on the untested assumption that snail abundance can be estimated as an inverse of foraging range of the snail kite. (The author recognizes several errors in this assumption.) The author concludes that variation in snail abundance does not affect nesting success or clutch size, but the rate of mate desertion varies directly with snail abundance. Range of snail sizes in this study was 19-71 mm shell length and 0.82-1.29 g dry weight of soft parts. Composition of soft parts on a dry-weight basis was found to include 2.5% calcium, 10% ash, 62% protein, 3% lipid and 4.5 kcal/g. Estimated daily intake of protein and lipid by snail kites was sufficient to account for egg production by female kites. Many quantitative data are given on foraging by kites and on provisioning to mates and young.

Beissinger, S. R. 1986. Demography, environmental uncertainty, and the evolution of mate desertion in the snail kite. Ecology, 67(6): 1445-1459.

In this field study (1979-1983), ambisexual mate desertion and nesting success were both related to water levels of south Florida wetlands. Using previously published data on applesnail abundance or availability, the author makes several suggestions: snail abundance does not affect mean or modal clutch size or year-to-year distribution of clutch sizes; the timing and location of reproduction in snail kites is probably determined by use of snail density and other factors as proximate cues; high snail abundance contributes to mate desertion. The validity of these hypotheses is untested.

Beissinger, S. R. 1987a. Anisogamy overcome: female strategies in snail kites. The American Naturalist, 129(4): 486-500.

This study compares energy budgets of male and female snail kites in an effort to explain how ambisexual mate desertion could be adaptive. Foraging times, feeding rates, and rates of provisioning a mate are given for each sex. Original data on proximate analysis of soft parts of six *Pomacea paludosa* are modified by taking ingestion rates into consideration, making it unwise or impossible to back-calculate the original proximate analysis of ash, protein, lipid, and calories. Protein content of snail bodies is 20 times the lipid content, but ingestion rates allow sufficient lipid for egg production by female kites.

Beissinger, S. R. 1987b. Mate desertion and reproductive effort in the snail kite. Animal Behaviour, 35(5): 1504-1519.

Delivery of applesnails to nestlings was used as one measure of reproductive effort in the snail kite, and foraging for snails was a category used in time budgets of kites. For nests that eventually suffered desertion by one mate, the deserter provided only 34-45% of the snails to feed nestlings between hatching and mate desertion.

Beissinger, S. R. 1988a. A faithful, fickle hawk: the fluctuating Everglades influences the nesting behavior of an endangered bird. Natural History, 97(1): 42-51, cover.

This is a well-written popular article that describes ambisexual mate desertion in snail kites and that includes descriptions of feeding on applesnails. The article is well illustrated with photographs of snail kites capturing and eating snails and of an applesnail crawling on submerged plants. The cover photo of this issue shows an adult kite feeding an extracted snail to nestlings.

Beissinger, S. R. 1988b. Snail kite. Pp. 148-165, in: R. S. Palmer (ed.), Handbook of North American birds. Vol. 4. Yale University Press, New Haven, Connecticut. vii + 433 pp.

In this detailed summary of many aspects of the biology of the snail kite, no new information on the applesnail is given; but data from many sources are summarized concisely and in an excellent format. Sections on feeding by the snail kite should especially be consulted. Much inferential matter on applesnails is, however, stated dogmatically. A line drawing of empty shells in a kite midden is included.

Beissinger, S. R. 1990. Alternative foods of a diet specialist, the snail kite. The Auk, 107(2): 327-333.

This paper does much to correct the misconception that the Florida applesnail is the sole food of the snail kite. Data show that small turtles are eaten during droughts, in winter, and after the passage of meteorological cold fronts. The author also observed consumption of viviparid snails during droughts. He argues that kites are limited in diet by their morphological specializations for eating applesnails and that their behavior in consuming turtles is explained by their mechanism for extracting snails and by the 40-fold greater handling time for chelonian over gastropod prey.

Beissinger, S. R. 1995. Modeling extinction in periodic environments: Everglades water levels and snail kite population viability. Ecological Applications, 5(3): 618-631.

A model presented here relies on "census" data for the snail kite, water levels in snail kite habitat, and rainfall data. Reference to the Florida applesnail is peripheral, but the prediction is made that applesnail populations will decline in the absence of long-hydroperiod marshes. Plate 1 is a photograph of a snail kite taking flight with an applesnail in its talons.

Beissinger, S. R. & N. F. R. Snyder. 1987. Mate desertion in the snail kite. Animal Behaviour, 35(2): 477-487.

The authors attribute an increase in ambisexual mate desertion to increased applesnail abundance during periods of ample water supply to Florida wetlands. Snail density was not measured directly because it was low; the authors assumed that snail density was inversely proportional to foraging range of adult snail kites. The impact of mate desertion on delivery rates of snails to nestlings varied inconsistently with brood size, but single parents generally maintained the rate previously achieved by both parents. Mean rates for all brood sizes and categories of parenting were 0.8-4.7 snails/h.

Beissinger, S. R., A. Sprunt, IV & R. Chandler. 1983. Notes on the snail (Everglade) kite in Cuba. American Birds, 37(3): 262-265.

Although not referred to by species, *Pomacea* [probably *P. paludosa*; see González Alonso *et al.* (1986)] was found to be abundant in marshes of Zapata Swamp, Matanzas Province, Cuba, in the autumn of 1982. The snails produced clutches with more eggs of smaller diameter than reported for snails in Florida by Hanning (1979; cited as “1978”).

Beissinger, S. R. & J. E. Takekawa. 1983. Habitat use by and dispersal of snail kites in Florida during drought conditions. Florida Field Naturalist, 11(4): 89-106.

During a severe drought in Florida in 1981-1982, snail kites abandoned their three primary areas of distribution and dispersed throughout the state. This movement is attributed to the birds' search for "foraging habitats with apple snails." The lakes of central Florida were popular destinations and were said to be important refuges for kites because they are "permanent bodies of water capable of supporting snail populations even during low water conditions."

Belleville, B. 1997. Another roadside attraction: beyond the billboards, glimpses of eternity. Sierra, 82(5): 18-19.

Coming upon oases of wildlife in urbanized areas, the author wonders if wood storks (*Mycteria americana* Linnaeus, 1758), mosquitofish, and applesnails are just biding time, waiting for humans to leave the scene, and anticipating Florida's return to its natural setting.

Belleville, B. 1999. River out of time: the Wekiva River provides a peek into Florida's past. Sierra, 84(4): 26, 28.

Limpkins and applesnails are mentioned as inhabitants of the Wekiva River in this spotlight on the river as a place for recreation.

Bennetts, R. E., M. W. Collopy & S. R. Beissinger. 1988. Nesting ecology of snail kites in Water Conservation Area 3A. Department of Wildlife & Range Sciences, University of Florida, Gainesville, Florida. Florida Cooperative Fish & Wildlife Research Unit, Technical Report, no. 31: i-xiii, 1-174.

The purpose of this study was to assess the influence of several hydrologically related factors on reproduction of the snail kite in a managed area of the Everglades. The density of applesnails in the region was estimated by the time required for kites to capture snails, by counts of snail egg clutches and development of an "egg-cluster index," and by use of a portable suction dredge. The authors found that the density of kite nests was higher in areas of higher clutch density and index; but the relationship did not hold for the other two measures of snail density (despite the authors' claims in the discussion). The authors suspect that a biological relationship between kite nest density and snail abundance exists but that their sampling techniques were inadequate. They also make the point that snail availability to the foraging kites might be more important than snail density. The authors make the claim that the snails need a dry-down interval of > 1.7 yr for stable populations, but the claim is based on kite data rather than snail data. They point to the need for more information on the effects of hydrology, water quality, and fires on applesnail populations. Density of snail clutches declined from the edge to the interior of sawgrass stands. The line drawing that illustrates the cover of this document represents a perched kite extracting a snail from its shell.

Bennetts, R. E., M. W. Collopy & J. A. Rodgers, Jr. 1994. The snail kite in the Florida Everglades: a food specialist in a changing environment. Pp. 507-532, in: S. M. Davis & J. C. Ogden (eds.), Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida. xv + 826 pp.

Evidence additional to the observations of Beissinger (1990) is offered that the snail kite switches to alternative food when applesnails are less accessible, adding crayfish (*Procambarus* spp.) and speckled perch [*Pomoxis nigromaculatus* (LeSueur, 1829)] to the list. The authors review the literature on factors that affect accessibility of the snails for the kite. Reduction in snail populations is one of several factors hypothesized to produce short-term changes in size and distribution of kite populations. The authors repeatedly associate high densities of applesnails with long hydroperiods, and they caution that there is little understanding of the effects of drought on applesnails.

Bennetts, R. E. & V. J. Dreitz. 1997. Possible use of wading birds as beaters by snail kites, boat-tailed grackles, and limpkins. The Wilson Bulletin, 109(1): 169-173.

Limpkins were observed in single-species flocks; but snail kites and boat-tailed grackles (*Quiscalus major* Vieillot, 1819), both of which feed heavily on Florida applesnails, occurred in temporary (4-5-wk) mixed-species flocks with white ibises [*Eudocimus albus* (Linnaeus, 1758)] or great egrets (*Ardea alba* Linnaeus, 1758). Predation on snails in mixed-species flocks seemed to be high, and capture time by kites was greatly reduced. Based on anecdotal observations on the effect of airboat passage on applesnail behavior, the authors believe that wading ibises and egrets cause snails to release their hold on plant stems and float briefly at the surface of the water, increasing their availability to foraging kites and grackles.

Bennetts, R. E. & W. M. Kitchens. 1993. Estimation and environmental correlates of survival and dispersal of snail kites in Florida: 1993 annual progress report. Report to United States Department of the Interior, Fish & Wildlife Service, Jacksonville, Florida, & United States Department of the Interior, National Park Service, Everglades National Park, Homestead, Florida. University of Florida, Florida Cooperative Fish & Wildlife Research Unit, Gainesville, Florida. 43 pp.

The use of two estimates of applesnail availability to snail kites was initiated in this the second year of their study: suction dredge for direct collection of Florida applesnails; a time-energy budget of the snail kite with a focus on search, capture, and handling of snails. The dredge technique was modified from Owre & Rich (1987) by incorporation of a 1-m^2 quadrat frame, use of a larger-diameter hose, and application of a single-blind mark-recapture technique to estimate efficiency of capture. Although not included in the final report (Bennetts & Kitchens, 1997a), the data and the evaluation of the technique are not much different from Darby *et al.* (1999), who expanded the study and reduced the size of the intake hose per recommendation herein. Results of the time-energy budget are not included here but appear in the final report (Bennetts & Kitchens, 1997a). The authors summarize unpublished data in stating that "snails smaller than 1 cm are not typically used by kites in Florida."

Bennetts, R. E. & W. M. Kitchens. 1997a. The demography and movements of snail kites in Florida. United States Geological Survey, Biological Resources Division, Florida Cooperative Fish & Wildlife Research Unit, Gainesville, Florida, Technical Report, no. 56: i-viii, 1-169.

Snail kites conducted course hunting for applesnails in open wetlands and perch hunting in cypress prairie habitat. Capture times were less than 3 min during times of high snail abundance and exceeded 30 min during the drought of 1992. Capture times were lowest in summer. The authors imply that capture time is directly correlated to snail availability. The factors that were presumed to reduce snail availability most were low water level (reduced abundance), cold fronts (reduced surfacing frequency), high wind speed (reduced kite maneuverability), and floating plants (obscured visibility of prey). Contrary to suppositions of earlier authors, kites tended to migrate more during times of high snail abundance and high water levels rather than in times of lower water levels and reduced snail abundance, although the authors caution that their data are mostly from times of generally high levels of water. Use of non-breeding (peripheral) habitat is believed to serve two purposes: to reduce the impact of foraging on snail supply in breeding areas; to allow kites to investigate areas that might serve as refuges during times of drought. The greater tendency to migrate during non-drought periods is proposed to improve the ability of kites to accomplish the latter purpose at times of low risk. Wandering of kites (especially juveniles) into areas of low snail abundance is predicted to cause emaciation and subsequent mortality. The authors call for studies on post-drought recovery of applesnails and on the effect on applesnails of changes in composition of the aquatic plant community. In regard to the latter, the authors err (p. 124) in stating that **Davis (1994)** mentioned *Pomacea paludosa* in discussing data and ideas on nutrient-related sawgrass-to-cattail conversion in the Everglades; data tabulated in **Davis (1994)** were for four other genera of snail.

Bennetts, R. E. & W. M. Kitchens. 1997b. Population dynamics and conservation of snail kites in Florida: the importance of spatial and temporal scale. Colonial Waterbirds, 20(2): 324-329.

Some of the ideas in this paper repeat those of Bennetts and Kitchens (1997a). Here the authors emphasize that the effect of natural and altered hydrology in snail kite habitat is not so much a direct one on applesnail populations by the drought intolerance of the snails. There is instead an indirect effect on the plant community subjected to naturally variable and localized drought or to long-term inundation under water-management practices.

Bennetts, R. E. & W. M. Kitchens. 1999. Within-year survival patterns of snail kites in Florida. Journal of Field Ornithology, 70(2): 268-275.

Although no data on comparative foraging success on applesnails are given, the authors interpret their data on timing of snail kite mortality in terms of foraging as well as other factors. Periods of high risk of mortality are in late spring and summer for fledgling snail kites and in winter and early spring for adults. In the first 4 mo after fledging, juvenile kites are learning how to forage for applesnails. In the dry season (winter), adults experience reduced availability of applesnails, in part because of reduced frequency of surfacing by snails at low temperatures.

Bennetts, R. E., W. M. Kitchens & D. L. DeAngelis. 1998. Recovery of the snail kite in Florida: beyond a reductionist paradigm. Pp. 486-501, in: K. G. Wadsworth (ed.), Transactions of the sixty-third North American wildlife and natural resources conference: conference theme, changing resource values in challenging times. Wildlife Management Institute, Washington, D. C. 648 pp.

The history of observations and explanations of changes in population size and distribution of the snail kite is reviewed. The prevailing hypothesis, based on water levels in snail kite habitat, is named the "Reductionist Paradigm," which views the minimization of droughts or their effects as the appropriate management approach in snail kite habitat. The authors propose an alternative "Dynamic Landscape Hypothesis" to govern management practices for snail kites. This hypothesis incorporates water depth, duration between droughts, and long-term hydroperiod. The authors favor the maintenance of a network of hydrologically diverse and geographically extensive habitat for snail kites. The impact of the proposed management approach is more directly on applesnail populations (through snail behavior, aestivational and respiratory physiology, and population dynamics) and plant communities (through effects of disturbance) than on snail kites. A graphical model (fig. 2) of relative habitat quality for snail kites depicts the outcome of duration between droughts in terms of applesnail population recovery (frequent droughts) and degradation of the plant community (infrequent droughts).

Bennetts, R. E. & B. R. Toland. 1993. The snail kite. Florida Power & Light Company [Miami, Florida], Solid Waste Authority of Palm Beach County [West Palm Beach, Florida] & St. Johns River Water Management District [Palatka, Florida]. [unpaginated four-fold brochure]

This illustrated flier summarizes several aspects of the biology of the snail kite and its relationship to behavior and availability of the Florida applesnail.

Bent, A. C. 1926. Life histories of North American marsh birds. United States National Museum Bulletin, no. 135: xii + 392 pp., 98 pls.

In a section on limpkins, the author includes excerpts from Audubon (1842; cited as "1840") and Bryant (1859) on applesnails as prey. Bent advises that the accumulated empty shells at favored locations are clues to the presence of limpkins. It is unclear if a later excerpt from a paper by William Brewster refers to applesnails or to a smaller snail that is swallowed without extraction from the shell. This document was reprinted in 1963 by Dover Publications, Inc., New York.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. United States National Museum Bulletin, no. 167: i-x, 1-409.

A review of observations on plumage, vocalization, behavior, and reproduction of the snail kite (as "Everglade kite") is provided. A section on feeding lists the Florida applesnail (as "*Ampullaria depressa*") as its exclusive prey. **Lang's (1924)** description of the kite's feeding method (based on South American observations) is quoted. Reduction in numbers of kites in the Florida Everglades is attributed to drainage or drought, causing reduction in populations of the applesnail. This document was reprinted in 1961 by Dover Publications, Inc., New York.

Benyus, J. M. 1989. The field guide to wildlife habitats of the eastern United States. Simon & Schuster, New York. 336 pp.

This children's natural history book is organized by habitat and includes mostly vascular plants and vertebrate animals. In an introductory section that explains how animals "choose" habitats, the snail kite is given as an example of an animal dependent on other organisms in such a "choice": "Snail kites wouldn't survive a month in a marsh that didn't have a good population of apple snails, their favorite food." The frontispiece for the chapter on the Everglades is a line drawing of a section of marsh with representative plants and animals, including a high-spired shell labeled "apple snail" and a snail kite with a bill similar to that of a mockingbird. One of the three Everglades animals featured in the text is the snail kite. The population success of the kite is linked to the snail and to altered hydrology of the Everglades. Brief notes are included on the biology of the applesnail (described as "tiny") and on foraging by kites.

Berthold, T. 1991. Vergleichende Anatomie, Phylogenie, und historische Biogeographie der Ampullariidae (Mollusca, Gastropoda). Abhandlungen des naturwissenschaftlichen Vereins in Hamburg (neue Folge), 29: 1-256.

This is the published version of a German (University of Hamburg) doctoral dissertation concerning anatomy and biogeography of an assortment of 36 worldwide ampullariid species (not including *Pomacea paludosa*) in 6 genera. The author, citing González Alonso *et al.* (1986), states that *P. paludosa* might be passively distributed when its eggs adhere to the feathers of the Cuban Zapata sparrow (*Torreornis inexpectata* Barbour & Peters, 1927) as it feeds on the sticky mass. Given the non-sticky nature of the Florida applesnail's calcareous eggs at advanced stages (when the sparrow was observed feeding), this seems unlikely. The paper was critically reviewed by **Bieler (1993)**.

Binney, W. G. 1865. Land and fresh-water shells of North America. Part III. Ampullariidae, Valvatidae, Viviparidae, fresh-water Rissoidae, Cyclophoridae, Truncatellidae, fresh-water Neritidae, Helicinidae. Smithsonian Miscellaneous Collections, 144: viii + 120 pp.

Characters of the family Ampullariidae and its seven genera are summarized. The Florida applesnail (as "*Pomus depressa*") is listed from Georgia and Florida; the living animal, shell, operculum, jaws (in Appendix), and radula are illustrated. Say's original description (1824) and name replacement (1829) are reprinted. *Ampullaria paludosa* is listed in synonymy because Lamarck's homonym had since been removed from *Ampullaria* Lamarck, 1799. *A. hopetonensis* is also listed in synonymy; Lea's (1834) original description is reprinted. *A. disseminata* 'Say' De Kay, 1843 and *A. penesima* 'Say' Binney, 1865 (error for *penesma* 'Say' De Kay, 1843) are mentioned. Say's (1829) original description of *A. rotundata* is reprinted; it is considered "not ... well established" and is surmised to have been introduced from Calcutta.

Blackwelder, P. L. & N. Watabe. 1977. Studies on shell regeneration. II. The fine structure of normal and regenerated shell of the freshwater snail *Pomacea paludosa*. Biomineralisation, 9: 1-10.

Although the snails are described as "obtained from Florida" and no evidence in the paper places doubt on the identity of specimens, this study is one in a series with identical funding that includes two papers (Meenakshi *et al.*, 1974; Meenakshi & Watabe, 1977) based on clearly misidentified specimens.

Blatchley, W. S. 1932. In days agone: notes on the fauna and flora of subtropical Florida in the days when most of its area was a primeval wilderness. Nature Publishing Company, Indianapolis. 338 pp.

This travelogue reports applesnails (as "idol snails") and clutches from three locations in Florida. Shells were found in Indian mounds at one site. Fish crows (*Corvus ossifragus* Wilson, 1812) were observed eating the eggs of applesnails, and the author claims that other aquatic birds also prey on the eggs.

Blok, A. & T. Pain. 1948. Shell collection of the late Revd. E. G. Alderson, with special reference to the genus *Pila* Röding. Journal of Conchology, 22(12): 299-302.

Alderson's shell collection, important chiefly as the source for "Studies in *Ampullaria*" (Alderson, 1925), is traced to the private home of "Lady Iliffe" of Yattenden Court, near Newbury, Berks [United Kingdom]. An estimated 80% of the shells used for the published figures were still in the collection at the time of this publication. *Ampullaria paludosa* is listed as among those represented by "a remarkable range" of specimens. Shells in the collection were marked for future reference by the authors, and a catalog was prepared and left with the owner.

Bolen, E. G. & D. Flores. 1993. The Mississippi kite: portrait of a southern hawk. University of Texas Press, Austin, Texas. xi + 115 pp.

In comparing the several species of kite in the United States, the authors particularly note the dietary specialization of the snail kite and the morphological adaptation of its bill for extracting applesnails from their shells.

Boss, K. J. 1974. Oblomovism in the Mollusca. Transactions of the American Microscopical Society, 93(4): 460-481.

In this review of aestivational physiology and behavior, the author summarizes the work of Little (1968); but he attributes Little's findings to *Pomacea depressa* (= *P. paludosa*) as well as to *P. lineata* (Spix, 1827). See the annotation for Little (1968).

Branson, B. A. 1961. Recent Gastropoda of Oklahoma. Part II. Distribution, ecology and taxonomy of fresh-water species, with description of *Helisoma travertina* sp. nov. Oklahoma State University Publication, 58(17): 1-72.

Wallen & Dunlap's (1953) record of *Pomacea* sp. from the Bell Water Gardens is here referred to *P. paludosa*, but the high spire and flared apertural lip of the specimen shown in pl. IV (fig. 27) reveal that the specimens were not *P. paludosa*. Characters are given for the Oklahoma species. It is said to be a favorite exotic in aquaria, "apparently incapable" of living in the wild as evidenced by the demise of released specimens. Hundreds of individuals have been raised by Dr. W. H. Irwin (Oklahoma State University); ciliary feeding in these aquarium specimens is confirmed as not due to underfeeding.

Branson, B. A. 1969. Snail records from various southern, eastern and middle states. Sterkiana, no. 35: 1-4.

Pomacea paludosa is listed from Ichtucknee [*sic*] Springs, Columbia County, Florida.

Brönmark, C. 1989. Interactions between epiphytes, macrophytes and freshwater snails: a review. Journal of Molluscan Studies, 55(2): 299-311.

This review cites McClary's (1964; erroneously given as "1965") paper on ciliary feeding in *Pomacea* (?*paludosa*) and considers ciliary feeding on surface films a minor contributor to diet.

Brooks, H. K. 1974. Lake Okeechobee. Pp. 256-286, in: P. J. Gleason (ed.), Environments of south Florida: present and past. Memoir 2. Miami Geological Society, Miami, Florida. vi + 452 pp.

This paper describes the current features of Lake Okeechobee and its geologic history. Deposits in the beach ridges at the margins of the lake contain shells of *Pomacea paludosa* and other freshwater mollusks. Associated material has been dated to 1685 YBP using carbon-14. The ridges possibly developed during the Neo-Atlantic episode, 900-1200 AD. Deposits of freshwater gastropods are mentioned earlier in the paper without specific mention of applesnails. This paper was reprinted unmodified in the second edition (**Gleason, 1984: 38-68**).

Brooks, W. K. 1906. The origin of the lung in *Ampullaria*. Carnegie Institution Year Book, no. 5: 109-110.

This abstract was later used with little modification as the introduction to the full paper (Brooks & McGlone, 1908).

Brooks, W. K. & B. McGlone. 1908. The origin of the lung of *Ampullaria*. Carnegie Institution of Washington, Publication 102: 95-104, pls. 1-7.

The left gill and osphradium of the Florida applesnail (as "*Ampullaria depressa*") develop from a pair of parallel ridges of epithelium along the inner surface of the mantle. Based on histological evidence, the lung forms as an invagination between the gill and osphradium. All three organs are in close association with the pulmonary sinus. At hatching, the lung is an extensive pouch within the mantle and opens into the mantle cavity via a valved aperture. The region of the mantle cavity into which the lung opens is separable by a ridge from the part of the mantle cavity that is occupied by the gill. The gill has at least nine filaments at hatching. No mention is made of rudiments of gill, lung, and osphradium on the right side, but they presumably do not appear during embryogenesis. Anecdotal observations on drowning of forcibly submerged juveniles and on long-term submersion of adults lead the authors to conclude that the lung is functional before the gill.

Browder, J. A., P. J. Gleason & D. R. Swift. 1994. Periphyton in the Everglades: spatial variation, environmental correlates, and ecological implications. Pp. 379-418, in: S. M. Davis & J. C. Ogden (eds.), Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida. xv + 826 pp.

An Everglades food web (fig. 16.4) includes applesnails as grazers of periphyton and dead organic matter.

Brown, K. M. 1991. Mollusca: Gastropoda. Pp. 285-314, in: J. H. Thorp & A. P. Covich (eds.), Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego. 911 pp.

A table on the distribution of North American families of freshwater gastropods shows that ampullariids have a low diversity, and both genera (*Pomacea* and *Marisa*) are restricted to the southeastern part of the continent. Size range of members of the genera is given as 50-60 mm. The genera are included under family Pilidae in an illustrated key based largely on Burch (1982). A line drawing of the shell with operculum of *P. paludosa* is derived from Burch (1982: figs. 72-73). For an updated version, see **Thorp & Covich (2001)**.

Bryan, D. [C.] 1981a. The curious limpkin. Florida Wildlife, 35(2): 24-28.

This popular article includes color photographs, one of a limpkin clasping an applesnail in its beak. The brief text summarizing the author's research stresses the limpkin's dependence on the applesnail as its primary food item. Conservation of Floridan waterways is the final word: "as the apple snail goes, so goes the limpkin."

Bryan, D. C. 1981b. Territoriality and pair bonding in the limpkin (*Aramus guarauna*). M. S. thesis, Florida State University, Tallahassee, Florida. ix + 62 pp.

Territoriality, fledging, dispersal, vocalizations, pair bonding and breeding in limpkins are documented at Wakulla Springs and Alexander Springs, Florida. Males defended linear territories along the rivers. Partial migration and alteration in territories might be related to habitat quality, which the author defines subjectively by vegetation and prey. Distribution of limpkins throughout their range is related to, but not entirely restricted to, distribution of *Pomacea* spp., for the birds feed on other large gastropods and bivalves. *Pomacea paludosa* comprised 76% of shells in limpkin middens at one analyzed site at Alexander Springs. Live applesnails were densest (32-75/m^2) under 100% cover of *Vallisneria americana* Michaux, 1803 (tapegrass) and sparsest (< 4/m^2) on bare mud with no cover. The author's hand-collecting technique was time consuming (1.3-1.5 h/m^2 quadrat). The data on snail densities were later published in an abstract (Bryan, 1990). In 1981, *Pomacea* and limpkins were absent from Ingalls's (1972) Alexander Springs site but were present farther downstream.

Bryan, D. C. 1990. Apple snail densities at Alexander Springs, Lake County, and observations on snail ecology. Florida Scientist, 53(suppl. 1): 13. [abstract]

Applesnails were censused by hand-searching river bottom quadrats. Densities were highest in tapegrass beds, decreased under mats of water hyacinth and water lettuce (*Pistia stratiotes* Linnaeus, 1753), and were lowest in unvegetated areas. Herbicide management of floating vegetation is a potential ecological problem for maintenance of applesnail populations. A fuller presentation is given in Bryan (1981b).

Bryan, D. C. 1996. Limpkin (*Aramus guarauna*). Pp. 485-496, in: J. A. Rodgers, Jr., H. W. Kale, II & H. T. Smith (eds.), Rare and endangered biota of Florida. Vol. V. Birds. University Press of Florida, Gainesville, Florida. 688 pp.

The author describes the relationship between acquired bill morphology of limpkins and the method of extraction of applesnail meat from the shell. Vulnerability of limpkin populations is viewed to be tied mainly to threats to the snail: modifications in hydrology of the habitat; pollutants; competition by exotic aquatic plants with native aquatic plants on which *Pomacea paludosa* is claimed by the author to feed. In addition to the control of exotic plants, a conservation measure recommended here is to examine applesnail populations "for their value in measuring and monitoring the health of Florida's freshwater wetlands."

Bryant, H. 1859. [On some of the birds observed by him in East Florida, south of St. Augustine.] Proceedings of the Boston Society of Natural History, 7[1-2]: 5-21.

Limpkins (as "*Aramus scolopaceus*") on the St. Johns River were found to take snails of the genus *Natica* [see Harper (1941)], which were far more abundant on the river than the "large green snail, so common in the everglade." The author's obvious misidentification in reference to a marine snail genus might reflect a belief that the St. Johns River snail was not the same one Audubon (1838) called "a large greenish snail" commonly eaten by limpkins in the Everglades. Bryant writes that the limpkin extracts the meat "with a few blows" of the bill while grasping the shell with one foot.

Bull, J. & J. Farrand, Jr. 1977. The Audubon Society field guide to North American birds: eastern region. Alfred A. Knopf, New York. 775 pp. (incl. color pls.).

Applesnails are mentioned as prey items in this popular bird guide. The Everglade kite feeds exclusively on *Pomacea* sp., "found in shallow ponds and swampy places," using a sharply hooked bill. The limpkin feeds on *Pomacea* sp., as well as other aquatic fauna.

Bullen, R. P. & W. J. Bryant. 1965. Three Archaic sites in the Ocala National Forest, Florida. The William L. Bryant Foundation, Orlando, Florida. American Studies, Report no. 6: i-vi, 1-30, pls. I-VI.

The age, composition, and formation of freshwater snail middens are described from part of the St. Johns River drainage system. The sites are dominated by shells of *Viviparus georgianus*, and they differ in archaeological composition from other St. Johns River middens in containing only very small (~0.1% total volume) amounts of *Pomacea paludosa* and mussels. The same (preceramic) zones of middens elsewhere along the St. Johns River are reported to consist of alternating layers that vary in percentage composition of snail species. Early layers of the Ocala Forest middens date to about 3000 B. C. and were abandoned within 1000 yr.

Burch, J. B. 1978. An outline of classification of the freshwater gastropods of North America (north of Mexico). Journal de Conchyliologie, 115(1/2): 3-9.

This outline classification was produced in anticipation of subsequent treatments (Burch, 1979, 1982a, b, 1988 [1989], 1989; Burch & Tottenham, 1980). "*Pomacea* Perry 1810" is listed as the only genus of ampullariid prosobranch gastropod native to North America exclusive of Mexico. "*Pomacea maculata* Perry 1810" is listed as the type species. The only other ampullariid genus in the region, "*Marisa* Gray 1824," was introduced.

Burch, J. B. 1979. Genera and subgenera of Recent freshwater gastropods of North America (north of Mexico). Malacological Review, 12(1/2): 97-100.

Although modified from Burch (1978), information on *Pomacea* is unchanged.

Burch, J. B. 1982a. North American freshwater snails: identification keys, generic synonymy, supplemental notes, glossary, references, index. Walkerana, 1(4): 217-365.

The family Ampullariidae is characterized and includes three species: *Marisa cornuarietis* (Linnaeus, 1758), *Pomacea paludosa*, and "*Pomacea bridgesi* (Reeve)" [error for *bridgesii*] (introduced from Brazil). A key and ranges, with references, are provided for the three species; the key includes a line drawing of the shell of *P. paludosa*. *P. miamiensis* is given as a "population" of *P. paludosa* from Miami. Identical text appears in Burch (1982b), and both text and figure appear in Burch (1989).

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

Text and illustrations for *Pomacea paludosa* in this document are from Burch & Tottenham (1980) and Burch (1982a).

Burch, J. B. 1988 [1989]. North American freshwater snails: introduction, systematics, nomenclature, identification, morphology, habitats, distribution. Walkerana, 2(6): 1-80.

The inside front cover states, "This number contains the introductory sections of a larger work," presumably Burch (1989). The systematic treatment is similar to that appearing in Burch (1978, 1982b), with mention of the occurrence of two North American species of *Pomacea* and placement of the family Ampullariidae within the superfamily Ampullarioidea. The cover (1988) and copyright (1989) dates of this document differ.

Burch, J. B. 1989. North American freshwater snails. Malacological Publications, Hamburg, Michigan. xiii + 365 pp.

Text and illustrations for *Pomacea paludosa* in this book are from Burch & Tottenham (1980) and Burch (1982a).

Burch, J. B. & J. L. Tottenham. 1980. North American freshwater snails: species list, ranges and illustrations. Walkerana, 1(3): 81-215.

The range of *Pomacea paludosa* includes five river systems in Florida and Georgia and one locality in Alabama. The shell and operculum are illustrated by excellent line drawings. Identical text and figures appear in Burch (1982b, 1989).

Call, D. J. 1993. Validation study of a protocol for testing the acute toxicity of pesticides to invertebrates using the apple snail (*Pomacea paludosa*). Final report to United States Environmental Protection Agency, Cooperative

Agreement no. CR 819612-01. Lake Superior Research Institute, University of Wisconsin-Superior, Superior, Wisconsin. 59 pp.

This study applied a draft protocol for pesticide testing on 1- or 7-d-old Florida applesnails using the following pesticides: diazinon [O,O-diethyl O-2-isopropyl-6-methyl(pyrimidine-4-yl)phosphorothioate], an organophosphate used as an insecticide; esfenvalerate [(S)-alpha-cyano-3-phenoxybenzyl(S)-2-(-4-chlorophenyl)-3-methylbutyrate], a pyrethroid used as an insecticide; folpet [N-[(trichloromethyl)thio]phthalimide], a carboximide used as a foliage fungicide; *Bacillus thuringiensis* Berliner, 1915, a bacterium used as an insecticide; copper sulfate, used as a fungicide, algicide, herbicide, and molluscicide. Hatchling snails were grown in hardened water at about 27°C and fed a formulated diet (recipe given) based on fish pellets. Some snails not used for assays were raised until they oviposited their first clutches at an age of about 5 mo. Significant mortality of snails occurred at diazinon concentrations > 3.45 mg/L but at none of the tested levels of esfenvalerate. Rapid hydrolysis of folpet made bioassay difficult, but mortality at 0.23-0.28 mg/L was rapid and high. The few mortalities of snails exposed to *B. thuringiensis* were attributed to hypoxia in the culture water. Copper sulfate concentrations of 10.6 µg/L of Cu^{+2} resulted in high mortality or morbidity, whereas no mortality or other effects were observed at concentrations of 5.2 µg/L Cu^{+2} or below. Juvenile applesnails are among the least sensitive aquatic animals under exposure to diazinon but are highly sensitive to copper sulfate. The author recommends using only 7-d-old juveniles for testing acute toxicity. The study did not validate the protocol for adult applesnails. The protocol has not yet been published by United States Environmental Protection Agency (N. Vyas, 2002, personal communication).

Campbell, M. L. (editor). 1976. Shell of the month. The Shell-O-Gram [Jacksonville Shell Club, Jacksonville, Florida], p. 1 [April].

The editor writes that J. Lott presented "Ampullarius (Pomacea) paludosa" as Shell-Of-The-Month at the club's March meeting. The brief note gives some information on the applesnail's biology and distribution (Texas to Florida) and makes the claim that it can aestivate for up to 2 yr. This note was incorrectly dated "1977" by Lee (1978).

Cant, G. 1964. Lonely gourmet of the swamps fights for his life. Sports Illustrated, 21(6): 53-55.

The author describes the history behind formation of the Emergency Committee for the Everglades Kite and closure of part of the Loxahatchee National Wildlife Refuge in mid-1964 in response to declining numbers of the kite population, attributed to mortality of the Florida applesnail from drainage of marshes. The description of snail kite foraging contains a number of misconceptions: the kite impales the brain of the snail to paralyze it, swallows the operculum, and will eat the snail piecemeal. The author claims that applesnails burrow in response to drought and that "it takes the slow-motion snails many years to recolonize an area." The critical water level for the kite and snail is reported to be 14 ft above sea level in the Everglades; based on other data in the article, our calculations estimate this critical level to give a water depth of only 3 in. A painting illustrates a kite "patiently holding a snail" on a perch over a midden of empty shells, with a clutch of snail eggs nearby on an emergent stem.

Cantwell, I. E. (compiler). 1973. Birds of Florida. Midland Naturalists, Inc., [Midland, Texas]. i + 171 pp.

This book notes the migratory habit of the snail kite to search for applesnails ("its favorite food") during times of drought and fires.

Caras, R. A. 1966. Last chance on earth: a requiem for wildlife. Chilton Company, Philadelphia. xiii + 207 pp.

This book about 40 species of endangered animal includes a chapter on the snail kite. Decline of the population of the kite is attributed in part to reduction in snail populations due to water-management practices and to the unsupported claim that snails forced into marginal habitats (drainage ditches) became intermediate hosts for lung flukes that fatally parasitized the kites. The lung flukes mentioned here might be the cyclocoelid trematode reported by Cole *et al.* (1995) from snail kites. The author predicts that a similar fate awaits snails and kites in Cuba. A drawing depicts a male snail kite perched on a rock in a sawgrass marsh with a large (61-67 mm spire height, our estimate) snail shell nearby. This book was republished in 1972 by Schocken Books, New York.

Carr, A. 1973. The Everglades. Time, Inc., New York. 184 pp.

In his introduction to this natural history of the Everglades, the author begins an imaginary journey by a mosquitofish (*Gambusia*) at Turkey Lake, considered by the author as the origin of the Everglades drainage system; clutches of applesnail eggs attached to cattails are found in the lake. The applesnail is claimed to survive drought by aestivation in mud, but drought (as well as human mismanagement) is held responsible for a purported decline in the snail population, linked to a similar decline in numbers of snail kites. Brief descriptions are given of the general biology of the snail, of foraging techniques of its avian predators (snail kite, limpkin, boat-tailed grackle), and of extraction of snails from the shell by the kite. Applesnails are a major component in the diet of grackles in the Everglades, and grackles fight kites and limpkins to steal snails from them. A number of these and other observations are attributed to N. Snyder and H. Snyder but do not appear in their published work (see elsewhere in this bibliography). Unique to this narrative is the author's first-hand account of a North American river otter [*Lontra canadensis* (Schreber, 1777)] and a limpkin fighting over a live applesnail. The book includes a photograph of a perched snail kite holding an applesnail in its beak.

Cary, D. M. [1983.] Climatological and environmental factors effecting [*sic*] the foraging behavior and ecology of Everglade kites. [Unpublished report to United States Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland.] University of Miami, Department of Biology, Coral Gables, Florida. 92 pp.

The author found that the mean size of "pond apple snail" shells found in middens under perches of snail kites varied significantly by locality. He found correlations between mean prey size and the depths (units of measure unspecified) of water and sediment nearby. But his attempts to explain the correlations are confounded by the absence of data on size distribution of live snails and on selectivity by and availability to snail kites. The author emphasizes that the key to proper management of snail kite habitat is in understanding the biology of its prey. The author describes damage done to applesnail shells during extraction of the meat by limpkins. This report appeared later (Cary, 1985) in slightly revised and corrected form as a graduate thesis that, however, excluded sections on snail size, recommendations for management of and future research on snail kites, and a lengthy summary of the study.

Cary, D. M. 1985. Climatological factors affecting the foraging behavior and ecology of snail kites (*Rostrhamus sociabilis plumbeus* Ridgway) in Florida. M. S. thesis, University of Miami, Coral Gables, Florida. viii + 58 pp.

This study is an analysis of the time budget of the snail kite during wet summer and dry winter seasons in the Everglades. The budget includes time spent searching, capturing, transporting, extracting, and consuming the Florida applesnail. Success of foraging attempts is calculated. The author correlates parts of the time budget with climatic factors on the suspicion that the factors would affect frequency of surfacing by snails, their detectability by the kites, and maneuverability of the kites. Kites captured 2.78 snails/h between sunrise and sunset at a success rate of 91% of foraging bouts. Rates of capture and success were lower in winter than in summer. Rainfall and wind had short-term effects on foraging. Increasing intensity of rainfall reduced the number of foraging bouts initiated, the rate of capture, and time spent foraging; the author erroneously states that foraging time per capture increased. Gusts of wind, however, increased foraging time per capture and were the main cause of failed attempts to capture sighted snails. Temperature had long-term effects on foraging. The number of foraging bouts initiated and the number of captures per hour increased with air and water temperature. The author provides data that challenge the claim that the population of snail kites has declined from substantial numbers during the 1900s and argues that Florida has always been a marginal environment because of the effect of cold dry years on kite energetics and accessibility of applesnails.

Catlow, A. (assisted by L. Reeve). 1845. The conchologist's nomenclator. A catalogue of all the Recent species of shells, included under the subkingdom 'Mollusca,' with their authorities, synonymes, and references to works where figured or described. Reeve, Brothers, London. vii + 326 pp. + frontispiece.

Ampullaria hopetonensis is listed among 53 species in the genus, placed in the family "Peristomata" with *Valvata* Müller, 1774 and *Paludina* Lamarck, 1816.

Caulfield, P. 1970. Everglades. Sierra Club, San Francisco, & Ballantine Books, New York. 143 pp.

This book of the author's photographs taken in south Florida is supplemented by extracts from and contributions by several writers. One outcome of completion of Levee 29 in 1962 is implied to be the elimination of snails for the diet of limpkins. Notes on a photograph of a limpkin mention that *Pomacea paludosa* is the principal food of the limpkin and the sole food of the snail kite. A photograph of a kite on a wooden post shows an applesnail clutched in its talons.

Chable, A. C. 1947. A study of the food habits and ecological relationships of the sunfishes of northern Florida. M. S. thesis, University of Florida, Gainesville, Florida. 98 pp.

Of the 12 species of sunfish in northern Florida, only redear sunfish [as “shellcrackers”; *Lepomis microlophus* (Günther, 1859)] consumed *Pomacea paludosa* (in 13% of fish collected from streams). Mollusks, primarily *Goniobasis*, dominated the diet. The behavior of redear sunfish feeding on snails is described.

Chandler, R. & J. M. Anderson. 1974. Notes on Everglade kite reproduction. American Birds, 28(4): 856, 858.

This short report summarizes kite nesting data from 1966 to 1973, adding new data on nest building, incubation and fledging times, and causes of mortality. As marshes dried up, kites were noted to congregate in areas with enough water to support *Pomacea paludosa* populations. Data for 1973 showed tremendously increased reproductive success compared to the previous 7 yr, e.g., with 22 young fledged versus a previous maximum of 4. The reason behind this is unknown but is presumed to be related to applesnail populations. In the admitted absence of quantitative data, 1973 also had "the highest snail population in the memory of the senior author." The United States Bureau of Sport Fisheries and Wildlife is mentioned as "currently doing research and developing management plans for the snail" toward understanding their role in limiting kite populations.

Chapman, F. M. 1895. Handbook of birds of eastern North America[,] with keys to the species and descriptions of their plumages, nests, and eggs[,] their distribution and migrations[,] and a brief account of their haunts and habits, with introductory chapters on the study of ornithology, how to identify birds[,] and how to collect and preserve birds[,] their nests, and eggs. D. Appleton and Company, New York, xiv + 421 pp., 19 pls., frontispiece.

The limpkin is said to feed on "land shells (*Ampullaria*)," and the bill becomes distorted from "forcing it into the spiral opening of the shell to extract the animal." Information on the Florida applesnail in the section on the snail kite ("snail-hawk") is included in a long quotation from Scott (1881). By 1896, this book was already in its third edition, followed by various printings and editions, some with a shorter subtitle. Dover Publications (New York) in 1966 reprinted the 1939 printing of the second revised edition (D. Appleton and Company) with further modifications, but all editions and printings seem to have the same comments and sources on the Florida applesnail.

Cheng, T. C. 1980. Final report on the possible effects of commercial herbicides on the apple snail, *Pomacea paludosa*, in Florida. Unpublished report, Sandoz Inc., San Diego, & Chevron Chemical Company, Orlando, Florida. 12 + [1] pp., 2 tables, 21 figs.

Based on inspection of graphs of the time-course of respiration, oxygen uptake by *Pomacea paludosa* was depressed during 3 h of exposure to 5 ppm Cu as copper II sulfate, to recommended high field concentrations of the herbicide Komeen, and to a higher-than-recommended combination of Komeen and Diquat. Respiration was not depressed at lower concentrations, at recommended concentrations of Diquat alone, or at any of the chosen concentrations in the presence of mud and/or the aquatic plant *Hydrilla* sp. The author concludes from these short-term studies that the purported declines in populations of *Pomacea paludosa* and the snail kite are not due to application of the two commercial herbicides.

Clench, W. J. 1954. *Mesodon thyroidus* (Say) in Florida. The Nautilus, 68(1): 23-24.

Spring Creek, southeast of Marianna, Florida, is described as a "remarkable" locality for freshwater mollusks in terms of species abundance. *Mesodon*, *Goniobasis floridensis* (Reeve, 1860), and *Elliptio strigosa* (Lea, 1841) are discussed, as is *Pomacea paludosa*, which has "plastered" the sides of boats in the creek with its egg masses, "in places over one inch thick."

Clench, W. J. 1955. Notes and news: *Melania cancellata* Say. The Nautilus, 68(3): 107.

Ampullaria rotundata and two other species, obtained by Say from Captain LeConte and described from the St. Johns River, are actually from India. The first species should not, therefore, be considered a synonym of *P. paludosa*, as suggested by Sowerby (1909; as a form of *A. hopetonensis*).

Clench, W. J. 1959. Mollusca. Pp. 1117-1160, in: W. T. Edmondson (ed.), Freshwater biology, 2nd edition. John Wiley & Sons, New York. xx + 1248 pp.

The author has greatly abbreviated and rewritten the text and reorganized the taxonomic key of Walker's (1918b) original chapter but has retained the line drawings of the radula and shell of *Pomacea paludosa* [*Ampullaria paludosa* in Walker (1918b)]. The family name is changed from Ampullariidae to Pilidae, and *Marisa* is added as a second but introduced genus. The shell of *Pomacea* is described as "greenish". Characters of the radula and operculum are not used in the key. Some information on reproduction is added, and the claim is made that the role of ovipositing terrestrial eggs is predator avoidance. This book was reprinted in 1992 by International Books & Periodicals Supply Service, New Delhi.

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

A diagnosis of *Pomacea*, in Pilidae, and a description and figure (pl. 1, fig. 6, from Wakulla Springs, Florida) of the shell and egg masses of *P. paludosa* are presented. A lectotype is selected. A wide range of shell variability is noted, although uniformity appears within single populations. It is recorded from the Choctawhatchee, Apalachicola, Econfina, St. Marks, and Suwannee river systems, as well as the "Orange Island" area in central Florida, and is indicated as extending beyond this range. Early records from the Altamaha River in southeastern Georgia were not reconfirmed; one Georgia locality in Seminole County is noted. It is said to occur in rivers, lakes, ponds, and roadside ditches but is restricted (by temperature) to springs and spring-fed creeks in Georgia and northern Florida. Listed synonyms are: *Ampullaria depressa* Say (non Lamarck, 1804, nec Risso, 1826); *A. hopetonensis*; *A. penesma* 'Say' De Kay, 1843; *A. disseminata* 'Say' De Kay, 1843; *A. penesima* (error for *penesma* 'Say' De Kay) 'Say' Binney, 1865; *A. pinei* Dall, 1898; *P. paludosa flava* 'Pilsbry' M. Smith, 1937; and *P. paludosa lutea* Pérez Farfante, 1942 (*nomen nudum*). *Ampullaria miamiensis* is reduced to the status of a small, reddish-brown, local population; paratypes were located. The form *flava* 'Pilsbry' Smith is a uniform pale yellow "partial albino" that occurs sporadically throughout the range of the species.

Cohn, J. P. 1994. Restoring the Everglades: proposed changes in Florida's water management plans could deliver more flow to wetlands. BioScience, 44(9): 579-583.

The return of nesting snail kites to Loxahatchee National Wildlife Refuge after a 20-yr hiatus is attributed to the restoration of a long hydroperiod and a resultant increase in applesnail production.

Cole, R. A., N. J. Thomas & C. L. Roderick. 1995. *Bothrigaster variolaris* (Trematoda: Cyclocoelidae) infection in two Florida snail kites (*Rostrhamus sociabilis plumbeus*). Journal of Wildlife Diseases, 31(4): 576-578.

The lung fluke *Bothrigaster variolaris* (Fuhrmann, 1904) is reported for the first time in the Florida population of the snail kite, the fluke's definitive host. Although the life cycle of this fluke is unknown, the authors suspect the Florida applesnail as the intermediate host.

Colt, G. H. 1995. The frail future of an alligator hole. Life, 18(11): 60-66.

This popular article explains the ecological role of alligator holes during the dry season in the Florida Everglades. The drying marsh around the holes is described to be "littered with ... desiccated apple snails."

Conti, J. A., D. J. Forrester & S. A. Nesbitt. 1985. Parasites of limpkins, *Aramus guarauna*, in Florida. Proceedings of the Helminthological Society of Washington, 52(1): 140-142.

The echinostome trematode *Prionosoma serratum* (Diesing, 1850) is recorded from the intestine of one of nine limpkins from the Oklawaha River, Florida, and immature echinostome stages were found in three others. The authors implicate *Pomacea paludosa* as the intermediate host for this fluke. See also Pérez Vigueras (1944).

Cottam, C. 1936. Food of the limpkin. The Wilson Bulletin, 48(1, pt.1): 11-13 [vol. 43 (new series), whole no. 174].

The restricted distribution of the limpkin (as "*Aramus pictus pictus*") to southern Georgia and Florida is attributed to the likewise restricted distribution of the Florida applesnail (as "*Ampullaria depressa*"), its primary food. Unionid bivalves and other freshwater snails are also given as prey from literature evidence and field observations. Gut analyses (n = 30) indicated that approximately 70% of the total food of the bird consisted of applesnails, with most of the remaining (26.66%) as "unidentifiable mollusk flesh, probably most of which was *Ampullaria*."

Cottam, C. 1942. Supplementary notes on the food of the limpkin. The Nautilus, 55(4): 125-128.

The author increases slightly his earlier (1936) estimate of volumetric frequency of applesnails in the stomachs of limpkins. This revision was based on examination of opercula (which are frequently consumed) and radulae. Stomach analysis for another limpkin is added. *Pomacea paludosa* is reported from Mill Creek, Camden County, Georgia, explaining the occurrence of limpkins there (see Harper, 1941). The unpublished field notes of A. Wetmore are quoted, describing feeding by limpkins at Paradise Key, Florida, on applesnails buried in the mud of a wet prairie.

Cottam, C. & P. Knappen. 1939. Food of some uncommon North American birds. The Auk, 56(2): 138-169.

The results of gut analyses of 47 species of bird are presented, as issued by the Section of Food Habits of the United States Biological Survey. Stomachs of four specimens of snail kite (as "Everglade kite") are included and confirmed that the Florida applesnail (as "*Pomacea depressa*") is the bird's exclusive prey. Three of the four stomachs contained 100% snail flesh; the fourth contained 97% snail flesh and 3% plant debris (probably incidentally consumed). Reduction in numbers of kites is attributed to drainage of the Florida Everglades, causing a decline in populations of the applesnail.

Cowie, R. H. 1992a. Introduced ampullariid and viviparid snails in Hawaii. Pacific Science, 46(3): 397-398. [abstract]

As evidenced by specimens from the collections of the Bishop Museum, four species of ampullariid and one viviparid have been introduced to and established in the Hawaiian Islands principally during the 1980s. *Pomacea paludosa* was recorded from Keanae, Maui, and is the only one of the four not involved in aquaculture projects that raise snails for human consumption and the aquarium trade on three islands. Concern is expressed for the threat to native freshwater ecosystems, the Hawaiian taro crop, and human health through a potential for disease transmission.

Cowie, R. [H.]. 1992b. Rams-horn snail is an ampulariid. Hawaiian Shell News, 40(10): 6.

This note comments on a previous article about *Marisa cornuarietis* in this newsletter. *Pomacea paludosa* is stated to be the only native United States ampullariid and to be from "the south-eastern states, especially Florida." Reference is made to three *Pomacea* and one *Pila* species introduced to Hawaii (citing Cowie, 1992a).

Cowie, R. H. 1993 [1995]. Identity, distribution and impacts of introduced Ampulariidae and Viviparidae in the Hawaiian Islands. Journal of Medical and Applied Malacology, 5: 61-67.

Pomacea paludosa is one of four applesnails in the genera *Pomacea* and *Pila*, in addition to one species of viviparid, collected from field locations in the Hawaiian Islands. All species were introduced for the aquarium trade or for human consumption and subsequently escaped or were released into fields of taro plants. The species with the smallest distribution is *P. paludosa*, for which only juveniles were collected twice in 1990 from a taro-growing area in Keanae, Maui. This article includes a photograph [also found in Eldredge (1994)] of one museum specimen.

Cowie, R. H. 1997. Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands. Bishop Museum Occasional Papers, no. 50: 1-66.

The genus *Pomacea* is characterized as "centered in Central and South America," with introductions to Hawaii and other locations as escapees from aquaculture and aquarium industries. *Pomacea bridgesii*, *P. canaliculata*, and *P. paludosa* are listed, the first two as "established," and the last as status "unknown". *P. paludosa* was recorded once from Oahu by Wallace & Rosen (1969), perhaps as "a misidentification," and from Maui. The author attributes its introduction to the aquarium trade. Although the information on *P. paludosa* in this paper is similar to that in Cowie (1993 [1995]), the bibliography includes several obscure references. We have obtained and annotated these references (Anonymous, 1992; Baker & Glover, 1993; Glover & Campbell, 1994) except for an unpublished class report. See also Nishimura *et al.* (1996).

Cox, J. 1988. Delicate balance. Species: snail kite (*Rostrhamus sociabilis*). Florida and Federal status: endangered. Florida Wildlife, 42(2): 30.

This popular article attributes the fluctuation in snail kite populations to the availability of applesnails, *e. g.*, during droughts. A brief description of capture and handling of prey is included.

Cox, J. 1991. Delicate balance. Species: limpkin (*Aramus guarauna*). Florida status: species of special concern. Florida Wildlife, 45(1): 35.

This popular article briefly describes the limpkin's adaptations to feeding on *Pomacea paludosa*: curved bill for snail extraction; general morphology/coloration for foraging in shallow marshes. Population decline is attributed to reduction in snail populations due to pollution and commercial development.

Crisman, T. L. 1992. Part III. Lentic systems. 12. Natural lakes of the southeastern United States: origin, structure, and function. Pp. 475-538, in: C. T. Hackney, S. M. Adams & W. H. Martin (eds.), Biodiversity of the southeastern United States: aquatic communities. John Wiley & Sons, New York. xiii + 779 pp.

In a section on the introduction of exotic plants and animals into lakes, the author writes that competition by *Marisa cornuarietis* "is feared with the apple snail (*Pomacea paludosa*), the principal food of the endangered Everglades kite" without further explanation of the basis of the concern.

Cruickshank, H. [G.] 1977. Everglade kites in baskets. The Florida Naturalist, 50(4): 21-23.

Reduction in numbers of the Florida applesnail is given as one of three reasons for the decline in geographic distribution of the snail kite in Florida during the 1920s. Low temperatures in March 1975 are said to have "kept the *Pomacea* snails deep in the mud" until April, when snails are reported to have emerged under warmer temperatures.

Cruickshank, H. G. (editor). 1986. William Bartram in Florida, 1774: the adventures of the great American naturalist, explorer, artist. Florida Federation of Garden Clubs, Inc. [Winter Park, Florida]. x + 162 pp.

The editor corrects **Bartram's (1791: 148)** claim that the limpkin feeds "chiefly on crayfish" by noting that "the fresh water apple snail, *Pomacea*", is its main prey.

Cumbaa, S. L. 1976. A reconsideration of freshwater shellfish exploitation in the Florida Archaic. Florida Anthropologist, 29(2, pt. 1): 49-59.

The author cites the observations of Bullen & Bryant (1965) that shell middens from the hunter-gatherer Archaic period (following the Pleistocene) in the St. Johns River valley include *Pomacea paludosa* in low numbers.

Cushing, J. E., Jr. 1944. The relation of non-heritable food habits to evolution. The Condor, 46(6): 265-271.

Despite the existence of genetically based morphological specialization to support feeding habits, the author concludes that the feeding habits of raptorial birds are learned through parent-offspring interaction. The snail kite is given as an example in which foraging behavior is especially distinctive. The kite is offered as a good species to study the effects of learning because of its exclusive diet of applesnails (as "*Pomacea caliginosa*"). A personal communication by A. Sprunt, Jr., states that "the young associate with their parents through the fall and probably also the winter and apparently are 'taught' to hunt by their parents." The restricted diet of kites on applesnails is viewed as "aberrant".

Dahm, C. N., K. W. Cummins, H. M. Valett & R. L. Coleman. 1995. An ecosystem view of the restoration of the Kissimmee River. Restoration Ecology, 3(3): 225-238.

Restoration of fluctuating water levels in the Kissimmee River basin is expected to improve habitat (particularly in aquatic plants) for the Florida applesnail within a few years of project completion. The applesnail is considered among the important components of food webs in the basin and is noted to be the prey of limpkins, snail kites, white ibises, grackles, alligators, and common snapping turtles [*Chelydra serpentina* (Linnaeus, 1758)]. The former two predators, although rare in the basin, are given as examples of species that would be important to monitor because of their dietary dependence on the applesnail. An incorrect attribution to Brown

(1991) states that the Florida applesnail feeds on periphyton and senescent plants.

Dall, W. H. 1885. Notes on some Floridian land and fresh-water shells with a revision of the Auriculacea of the eastern United States. Proceedings of the United States National Museum, 8(519): 255-289, pls. 17-18.

Pomacea paludosa [as "*Ampullaria* (*Pomus*) *depressa*"] is listed, with synonymy and line drawings of shell and operculum, from shell mounds in several Florida locations. *Ampullaria* (*Pomus*) *caliginosa* [also a synonym of *P. paludosa*] from Cedar Keys (and Central America) is distinguished from the former on the basis of shell characters. *Pomus* 'Humphrey' H. & A. Adams, 1854, is used for *Ampullaria* species with purely horny opercula.

Dall, W. H. 1889. A preliminary catalogue of the shell-bearing marine mollusks and brachiopods of the southeastern coast of the United States, with illustrations of many of the species. Bulletin of the United States National Museum, no. 37: 1-221, pls. 1-74.

Ampullaria depressa is listed from Georgia through Florida, Texas, the West Indies [including here all of the Antilles], and to Mexico; "P. [Post?] Pliocene" is given as its geologic range. *Ampullaria caliginosa* is listed from western Florida, Texas, the West Indies, and to Central America; no geologic range is provided. Both species names are synonyms of *Pomacea paludosa*. This work was reprinted in 1903, with the addition of 21 plates (75-95, mostly of bivalves).

Dall, W. H. 1892. Contributions to the Tertiary fauna of Florida, with especial reference to the Miocene Silex-beds of Tampa and the Pliocene beds of the Caloosahatchie River. Part II. Streptodont and other gastropods, concluded. Transactions of the Wagner Free Institute of Science of Philadelphia, 3(2): 201-473, pls. 13-22, 1 map.

Pomacea paludosa [as "*Ampullaria* (*Pomus*) *hopetonensis* Lea"] is listed from the Pliocene of the Caloosahatchee beds [Florida], the Post-Pliocene of Georgia, Florida and Alabama, and the Recent of Darien, Georgia. Specimens agree with Lea's type, which the author describes as having a higher spire and more sloping shoulder than *Pomacea paludosa* (as "*A. depressa*"). **Taylor (1975)** doubts the age of Dall's specimens.

Dall, W. H. 1898. Description of a new *Ampullaria* from Florida. The Nautilus, 12(7): 75-76.

Ampullaria pinei (now a synonym of *Pomacea paludosa*) is described (shell and operculum only) from Homosassa River, Florida. It is distinguished from *A. depressa* by its deep red apertural border, wider shell, and very depressed spire.

Dalrymple, G. H. 1977. Intraspecific variation in the cranial feeding mechanism of turtles of the genus *Trionyx* (Reptilia, Testudines, Trionychidae). Journal of Herpetology, 11(3): 255-285.

Florida soft-shelled turtles, *Trionyx ferox* (Schneider, 1783), from Lake Okeechobee and neighboring areas to the northwest consume *Pomacea paludosa* with opercular lengths of 13-30 mm. As size of the turtle increases, the number of turtles that consume applesnails increases, and the diet shifts from dominance by the smaller *Viviparus georgianus* to dominance by the larger *P. paludosa*. Snails are positioned at the back of the jaws and cracked by a slow increase of pressure. Applesnail shells stuffed with chicken were included in the diets offered to turtles maintained in the laboratory.

Darby, P. C. 1998. Florida apple snail (*Pomacea paludosa* Say) life history in the context of a hydrologically fluctuating environment. Ph. D. dissertation, University of Florida, Gainesville, Florida. vi + 154 pp. [1999. Dissertation Abstracts International, 60B(2): 424.]

Although large sections of this dissertation have been published elsewhere (Darby *et al.*, 1997 [1998], 1998), one chapter (chapter 5) gives yet unpublished data; and the introduction and synthesis give a fresh perspective on and excellent overview of the relationship between the physiological and reproductive ecology of the Florida applesnail and the natural and artificial changes in hydrology to which the snail has been subjected in evolutionary time and with the recent application of water-management practices. In the unpublished study, over-wintering pre-reproductive snails were exposed to dry-down conditions and monitored for survival and size. Control and exposed snails had high survival (> 75%) for about 12 wk before survival dropped steeply in both groups. Shell width remained constant in the control group but increased in the exposed group, perhaps by size-dependent mortality. The author interprets the results to demonstrate the limited lifespan (1-1.5 yr) of the applesnail that is independent of hydrology. A second experiment using post-reproductive snails demonstrated the same trend; but shell width decreased in the exposed group, probably reflecting survival of young-of-the-year snails. The second experiment was partly disrupted by an infestation of red imported fire ants (*Solenopsis invicta* Buren, 1972) (see Stevens *et al.*, 1999). The author proposes that *P. paludosa* is an annual uniseasonally iteroparous species that has a reproductive season controlled by photoperiod and a pre-reproductive stage with the capacity for aerobic aestivation.

Darby, P. C., R. E. Bennetts, J. D. Croop, P. L. Valentine-Darby & W. M. Kitchens. 1999. A comparison of sampling techniques for quantifying abundance of the Florida apple snail (*Pomacea paludosa* Say). Journal of Molluscan Studies, 65(2): 195-208.

This study evaluates and compares the use of several methods for estimating the relative or absolute density of the Florida applesnail: counts of egg clutches at the edge (ecotone) of sawgrass stands; collection efficiency from a 1-m^2 throw trap using dip net, bar seine, and suction dredge in wet prairie/slough and sawgrass habitat. Vegetation was uprooted from the trap before sampling. Efficiency was checked against the number of marked snails planted in and retrieved from the trap. The bar seine was least efficient in recovering marked snails and was not, therefore, used for all parts of the study. Extraction efficiency was slightly greater using the suction dredge and for sampling in wet prairie/slough habitat than using the dip net and for dense sawgrass habitat. Most throw traps contained no unmarked snails; many contained one unmarked snail; and the greatest number collected from a single trap was four. Densities of egg clutches increased sharply from March to April and declined slowly over the subsequent 4 mo. Clutch densities at the ecotone bore no relationship to the densities of applesnails from throw traps in neighboring wet prairie/slough habitat. Clutch densities within stands of sawgrass 7.5 m and 15 m from the ecotone were about half the densities estimated at the ecotone. The authors conclude that the suction dredge operates more efficiently than the bar seine and dip net over the irregular substratum created by first uprooting vegetation in the trap. But the suction dredge has logistic and operational limitations, the most serious probably being its poor performance in water depths less than 0.15 m. All techniques using the throw traps were labor intensive. The authors attribute the lack of correlation between clutch density and snail density to high temporal and spatial variability in clutch production. Although dense stands of sawgrass had lower densities of applesnails, sawgrass is an important habitat for the Florida applesnail, contrary to earlier findings.

Darby, P. C., P. L. Valentine-Darby, R. E. Bennetts, J. D. Croop, H. F. Percival & W. M. Kitchens. 1997 [1998]. Ecological studies of apple snails (*Pomacea paludosa*, Say). South Florida Water Management District, West Palm Beach, Florida, & St. Johns River Water Management District, Palatka, Florida. Special Publication SJ98-SP6: i-x, 1-152.

This study compares methods for sampling applesnails, estimates abundance of applesnails in different habitats, and describes the effects of dry downs (declining water levels) on behavior and survival of snails. The authors' evaluation of the effectiveness of egg clutch indices and throw trap methods for measuring the abundance of applesnails was published, with somewhat modified data and conclusions for figs. 2 and 22, by Darby *et al.* (1999; see figs. 4 and 6). In addition, unbaited crayfish traps and drift fence-funnel trap arrays were used to capture applesnails. (Bait was found not to improve the rate of snail capture.) Both types of trap were greatly labor-saving devices

compared to the use of throw traps. Results from crayfish traps were poorly related to densities estimated from throw traps, but the drift fence-funnel trap arrays gave a strong relationship to throw-trap data. Crayfish traps had low escape rates and required minimal disturbance when used in a variety of habitats. A mark-recapture technique combined with use of crayfish traps revealed that applesnails were patchily distributed and varied in density by habitat and site; densities ranged from 0.129 to 0.428 m^{-2}. Movements, survival, and reproductive activity were studied during natural (drought) and artificial (lake restoration) dry downs by radio-telemetry of 89 snails tagged with transmitters, by trapping, and by egg clutch indices. Most snails moved less than 10 m per week but continued to move rather than remain in one location or habitat, with no detectable diurnal differences in movement patterns; movement patterns of males seemed to be more linear than those of females. Snail movement was not related to water depth, dissolved oxygen, or temperature, except that movement was considerably reduced in water depths < 10 cm. Snails did not seek deep-water refuges during dry downs. During periods of high clutch production, males appeared preferentially to enter a trap that a female snail had entered. Male and female snails had similar survival curves; mortality rate was steady as water depth decreased and water temperature increased. Stranded snails did not burrow and on average survived about 4 wk of exposure on sediments that were 4.6°C cooler than adjacent standing water. Many stranded snails in one dry down survived hard freezes. Laboratory studies of the effects of desiccation on applesnails during a simulated dry down showed that survival of control and experimental snails over 7 wk of exposure was similar, regardless of substratum and presence of vegetation. The same trend of survival continued during recovery upon return to water until only the young-of-the-year remained alive. In an insufficiently replicated laboratory study of the effects of elevated water temperature, applesnail mortality increased precipitously at temperatures between 32°C and 38°C. Based on field and laboratory studies and anecdotal observations, the authors conclude that *Pomacea paludosa* lives about 1-1.5 yr and senesces and dies rapidly after the peak of clutch production early in the breeding season; desiccation and elevated temperatures might hasten death, but young snails are tolerant of dry downs and probably are tolerant of the normal range of water temperatures in snail habitat. Discussion of their results is based on water levels in a managed marsh in a drought year rather than under natural conditions of the typical Florida dry (November-March) and wet (April-October) seasons. Despite the cover date, this report was issued in 1998 (E. F. Lowe, 1999, personal communication).

Darby, P. C., P. L. Valentine-Darby & H. F. Percival. 1998. Assessing the impact of the Lake Kissimmee restoration on apple snails. Final report to Florida

Game and Fresh Water Fish Commission, Bureau of Nongame Wildlife, Tallahassee, Florida. [United States Department of the Interior], United States Geological Survey, Biological Research Division, Florida Cooperative Fish and Wildlife Research Unit & University of Florida, Department of Wildlife Ecology and Conservation, Gainesville, Florida. v + 54 pp.

This study examines the effect of a 6-mo dry down of a Florida lake on density, behavior, and survival of the applesnail. Much of the methodology and results of a section on use of drift fence-funnel trap arrays to capture snails and to estimate their abundance is given in Darby *et al.* (1997 [1998]); but more data are given here in the appendices. A muck substratum seems not to support populations of applesnails. Post-dry-down densities were difficult to analyze because of the impact of management decisions on the authors' sampling design. In general, snail densities remained low even in the second year after restoration of the water level. The greatest impact was on juveniles in the first year, but the proportion of juveniles increased substantially in the second year. The strong impact on abundance of juveniles was probably due to occurrence of the dry down during the snail oviposition season. Removal of accumulated organic matter (primarily from decay of water lilies) by the dry down-substratum scraping method of restoration seemed to improve habitat for applesnails. The authors point out that the muck in Lake Kissimmee is quite different from the fibrous sawgrass peat in the Everglades, where applesnails can be found abundantly. The authors stop short of making a specific recommendation that lake dry downs be avoided during periods of clutch production by the Florida applesnail. Data on movement of snails tagged with radio-transmitters and on survival during the dry down are more complete here than in Darby *et al.* (1997 [1998]), but the conclusions are similar.

Davis, F. 1996. Flying kites in Florida. The Florida Naturalist, 69(3): 12-13.

In comparing the four species of kite occurring in Florida, the author notes that the snail kite has the most restricted diet and range, the latter dependent on the former. Its mode of finding, capturing, and eating applesnails is briefly described.

Davis, S. M. & J. C. Ogden. 1994. Toward ecosystem restoration. Pp. 769-796, in: S. M. Davis & J. C. Ogden (eds.), Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida. xv + 826 pp.

Findings of Bennetts *et al.* (1994) on applesnails are briefly summarized in this concluding chapter in a section on the relationship between hydroperiod and populations of prey and predators. Applesnails are included as one of the "abundant and presumably important organisms of intermediate trophic levels" on which there is little ecological information.

Dawson, F. E. 1929. Lamping the limpkin: "shooting" America's most romantic bird. Nature Magazine, 14(4): 211-213.

This article is an illustrated narrative from field notes of W. L. Dawson, who attempted to photograph limpkins at an unreported location. The author attributes the co-occurrence of limpkins and snail kites to their use of applesnails as food but wrongly identifies snails as the sole food of both species of bird. He believes the limpkin to have a better method of locating snails and the snail kite to have a better method for extracting the meat from the shell.

Dean, H. 1997. Giving nature a second chance on the mighty St. Johns. The Florida Naturalist, 70(1): 14-15.

The history of mismanagement of the St. Johns River in the first 75 yr of the 1900s is briefly reviewed in this article, much of which deals with more recent efforts at restoration in the Upper St. Johns River Basin Project. A major concern of the project is to control water levels in favor of the applesnail as a food source for snail kites.

Declerck, C. H. 1995. The evolution of suspension feeding in gastropods. Biological Reviews, 70(4): 549-569.

In this review, the author points out the rarity of suspension feeding among gastropods and stresses convergence in the repeated development of suspension feeding mechanisms in the group. Citing McClary's (1964) work on *Pomacea paludosa*, ampullariids are described as mucus net feeders in two tables and as ciliary feeders in the text, where the formation of a pedal ciliary funnel is described.

De Kay, J. E. 1839. Catalogue of the animals belonging to the state of New-York, as far as they have been figured and described. [The Legislature], Albany, New York, Document no. 50: 7-36.

Ampullaria paludosa is included among the gastropods of New York State. An asterisk preceding the name indicates "those species which have been figured for this Report," although no illustrations appear in the copy at hand [American Museum of Natural History Research Library]. Binney (1865: 5) referred to this document, stating that "*A. paludosa* is included erroneously"; De Kay's (1843) full report changed the status of this species to "extra-limital".

De Kay, J. E. 1843. Zoology of New-York, or the New-York fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New-York; with brief notices of those occasionally found near its borders: and accompanied by appropriate illustrations. Part V. Mollusca. Carroll and Cook, Albany, New York. [xiv] + 271 pp., 40 pls.

Three "extra-limital" species, *i. e.*, not from New York, are listed and their shells described in the genus *Ampullaria* in the family Trochidae: A.

hopetonensis, from Georgia; *A. rotundata*, from Florida; *A. "paludosa* et *depressa"* Say, from Florida. Two manuscript names attributed to Say, *A. penesma* and *A. disseminata*, are introduced in synonymy with *A. paludosa* without comment or description. De Kay corrects herein his previous inclusion of *A. paludosa* among the gastropods of New York State (De Kay, 1839).

Delany, M. F. 1987. What do alligators eat? Florida Wildlife, 41(6): 7-8.

Stomach contents of 715 alligators were examined from individuals in north-central Florida. Fish were determined to be the "most important" food item, and amphibians, birds, snakes, and an interesting array of man-made items were also recorded. Applesnails constituted the "most numerous food item, occurring equally in alligator size classes from four to 13 feet in length." The author attributes the presence of stones (gastroliths) in alligator stomachs to their being mistaken for snails and turtles.

Delany, M. F. 1990. Late summer diet of juvenile American alligators. Journal of Herpetology, 24(4): 418-421.

This study supplements that of Delany & Abercrombie (1986) by examination of stomach contents of juvenile (< 122 cm total length [TL]) alligators in north-central Florida. Consumption of Florida applesnails increased with size class of alligators from hatchling (< 41 cm TL) to the fourth and largest size class (92-122 cm TL) both in the volumetric contribution by snails to the diet and in the percentage of stomachs that contained snails. Little attention is given to applesnails in the text because of the author's focus on higher taxonomic groups in the diet. Tabulated data of 29 food taxa from 80 alligator stomachs show that applesnails ranked first in their contribution to diet by the total number of individuals present in the stomachs and by volume; and they were second only to water bugs (*Belastoma* spp.) in the percentage of stomachs containing them. The contribution of other freshwater snails was minor.

Delany, M. F. & C. L. Abercrombie. 1986. American alligator food habits in northcentral Florida. Journal of Wildlife Management, 50(2): 348-353.

Applesnails (n = 861) were the most numerous prey item found in 194 of 350 hunted alligators harvested in late summer at three lakes in north-central Florida over a 3-year period. Applesnails volumetrically comprised only 0.4% of the food but 50% of the invertebrate prey. Applesnails were eaten at the same frequency by alligators of all sizes (1.3-3.9 m). Only the operculum was usually found in the alligator stomachs. Over 98% of the volume of applesnails fed to alligators was digested within 5 d; opercula remained undigested.

Delany, M. F., A. R. Woodward & I. H. Kochel. 1988. Nuisance alligator food habits in Florida. Florida Field Naturalist, 16: 90-96.

Applesnails (*n* = 753) were the most numerous item in 46 stomachs of 113 nuisance alligators collected in north and central Florida. The snails comprised 1% of the food by weight and 2.1% by volume. In comparison with an earlier study (Delany & Abercrombie, 1986) on hunter-harvested alligators, this study included animals from urban areas and from a greater part of the calendar year.

Demian, E. S. 1965. The respiratory system and the mechanism of respiration in *Marisa cornuarietis* (L.). Arkiv för Zoologi, ser. 2, 17(8): 539-560.

Although this major study of respiratory anatomy and behavior of an ampullariid snail does not include new data on *Pomacea paludosa*, it discusses former studies on *P. paludosa* in light of what is generally known about ampullariid respiration and its comparison with pulmonate respiration.

Demian, E. S. & F. Yousif. 1973. Embryonic development and organogenesis in the snail *Marisa cornuarietis* (Mesogastropoda: Ampullariidae). IV. Development of the shell gland, mantle and respiratory organs. Malacologia, 12(2): 195-211.

Embryogenesis of the mantle, ctenidium, lung, and osphradium in *Marisa cornuarietis* is compared to that from previous studies on ampullariids, especially *Pomacea paludosa* (as "*Ampullaria depressa*"). The authors challenge Brooks & McGlone's (1908) suggestion that the lung evolved from gill lamellae and that it is homologous to the ctenidium and osphradium.

Dineen, J. W. 1974. The fishes of the Everglades. Pp. 375-385, in: P. J. Gleason (ed.), Environments of south Florida: present and past. Miami Geological Society Memoir 2. Miami Geological Society, Miami, Florida. vi + 452 pp.

In contrast to other centrarchid fishes of the Everglades, the abundant redear sunfish feeds largely on *Pomacea* and *Physa* by crushing these snails with its pharyngeal plates. This work was reprinted unmodified in **Gleason (1984: 258-268).**

Dodrill, J. 1989. Miscellaneous natural history observations. Memorandum to J. Stevenson. Florida Department of Natural Resources, Wakulla Springs State Park, [Wakulla Springs, Florida]. 2 pp. [11 July]

The author records his observations made at Wakulla Springs State Park. While foraging for prey to feed five chicks, the male of a pair of limpkins caught 25 applesnails in 1 hour. The author interprets the low success rate of probing by several limpkins for prey (mostly applesnails) to indicate that the birds use touch, not vision, while foraging among dense aquatic plants. One limpkin took 4 minutes to extract the meat of "an unusually large" snail from its shell. Water currents temporarily caused the accumulation of an estimated 300 applesnail opercula in a shallow depression of sand measuring 16 ft^2.

Donnay, T. J. & S. R. Beissinger. 1993. Apple snail (*Pomacea doliodes* [*sic*]) and freshwater crab (*Dilocarcinus dentatus*) population fluctuations in the llanos of Venezuela. Biotropica, 25(2): 206-214.

The greater shell length and higher density of *Pomacea dolioides* (Reeve, 1856) in rice fields than in natural wetlands are explained by drawing on published data for the Florida applesnail, which reaches larger size and density under conditions of prolonged flooding.

Dundee, D. S. 1974. Catalog of introduced molluscs of eastern North America (north of Mexico). Sterkiana, no. 55: 1-37.

Pomacea paludosa is listed as introduced from its original distribution in Hispaniola (but see Thompson, 1984). A literature record (Branson, 1961) for Oklahoma is also given [but see annotation for Branson (1961)]. Museum and collection records for Florida and Georgia are provided. A population from New Orleans, Louisiana, present "through ... 1965," is "no longer there."

Edwards, C. E. 1975-1976. Alligator Alley. Of Sea and Shore, 6(4): 251, 216.

This brief popular article describes the search by a group of collectors for fossil shells during the construction of Alligator Alley, a roadway across south Florida. No fossils were encountered, but *Pomacea paludosa* shells were collected from the canals. The general biology of applesnails is discussed, including their importance as food items for the snail kite and limpkin. Collection of empty shells rather than live snails as curios is advocated because of the dependence of these birds on the snails.

Eisemann, J. D., W. N. Beyer, R. E. Bennetts & A. Morton. 1997. Mercury residues in south Florida apple snails (*Pomacea paludosa*). Bulletin of Environmental Contamination and Toxicology, 58(5): 739-743.

Mercury concentrations were measured in soft tissues of adult applesnails and in clutches of eggs from three sites in the Everglades, from the Panther National Wildlife Refuge, and from two sites in the upper St. Johns River basin. Eggs did not have quantifiable amounts of mercury. Concentrations in adults were found to differ geographically and were unrelated to three measures of snail size. Average concentration was highest in snails from the Loxahatchee National Wildlife Refuge and was at the lower detectable limit in those from the immediately adjacent Water Conservation Area 2A. The authors' claim that mercury levels are higher in snails south of Lake Okeechobee than in those north of the lake is not strongly supported by their statistical analyses. The lack of measurements from sediments and the water column makes arguable the authors' conclusion that *Pomacea paludosa* is a bioindicator of mercury contamination. Because mercury levels in applesnails are lower than those reported previously for largemouth bass in the region, the authors speculate that snail predators would be less at risk of mercury toxicity than would fish predators. See Rattner (1993) for an earlier summary of this study.

Eldredge, L. G. 1994. Perspectives in aquatic exotic species management in the Pacific Islands. Vol. I. Introductions of commercially significant aquatic organisms to the Pacific Islands. South Pacific Commission, Noumea, New Caledonia. v + 127 pp.

Pomacea paludosa is listed among other ampullariids (called "apple" or "golden" snails) introduced to islands in the Pacific Ocean. Ampullariids in general are viewed to be of agricultural, ecological, and medical concern. A photograph of a juvenile *P. paludosa* is also found in Cowie (1993 [1995]). Humphries (1995) is a companion to this volume.

Emerson, W. K. & M. K. Jacobson. 1976. The American Museum of Natural History guide to shells: land, freshwater, and marine, from Nova Scotia to Florida. Alfred A. Knopf, New York. [viii] + 482 + xviii pp., 16 color + 31 black-and-white pls.

Pomacea paludosa and *P. miamiensis* are described in general, noting respiratory adaptations for breathing in water and air and dependence of the limpkin and snail kite on the former species as food. The latter species is surmised to be an ecological form of *P. paludosa* that is "probably extinct." A black-and-white photograph of the shell of *P. paludosa* is given.

Emery, D. L. 1924. Collecting in southern Florida, the Bahamas and Cuba. The Nautilus, 38(2): 56-62.

The narration describes a summer 1924 trip by the author and a collector, Mr. C. C. Allen, to Miami, Nassau, Key West, and the vicinity of Havana, Cuba. The Florida applesnail (as "*Ampullaria miamiensis*") is given in the species list from "Florida".

Emery, D. L. 1943. Sinistral *Pomacea*. The Nautilus, 57(2): 66.

This brief field note reports the discovery of a live *Pomacea paludosa* in St. Petersburg, Florida, with a sinistrally coiled shell.

Ernst, J. P. & V. Brown. 1989. Conserving endangered species on southern forested wetlands. Pp. 135-145, in: D. D. Hook & R. Lea (eds.), Proceedings of the symposium: the forested wetlands of the southern United States. General Technical Report SE-50. United States Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina. 168 pp.

This position paper on the Endangered Species Act is one of the few to warn that the potential accumulation of toxins by *Pomacea paludosa* might further adversely affect the snail kite because the kite is a dietary specialist.

Everglade Kite Recovery Team. 1978. Recovery plan: Everglade kite (*Rostrhamus sociabilis plumbeus* Ridgway). Everglade Kite Recovery Team, Boynton Beach, Delray Beach, Gainesville, and Tavernier, Florida. [47] pp. [six parts variously paginated] [draft]

This unofficial draft was followed by three approved versions (USDI, 1983, 1986, 1999). The cover of the document includes a drawing of a perched snail kite clutching a Florida applesnail in its talons; the illustration also appears on the covers of USDI (1983, 1986). Later versions give more attention to the applesnail than this draft. A section on snail predation by the kite includes the misstatement that the kite's bill is adapted "for grasping the shell from below the water surface" (p. I-4).

Ferrer [López], J. [R.] 1997. Crecimiento, reproducción y mortalidad de *Pomacea paludosa* en condiciones naturales. Sociedad Internacional de Malacología Médica y Aplicada, Boletín, no. 8: 1-2. [October] [not seen]

Ferrer [López], J. R., G. Perera [de Puga] & M. Yong [Cong]. 1990. Life tables of *Pomacea paludosa* in natural conditions. Florida Scientist, 53(suppl. 1): 15. [abstract]

This oral presentation was later published in full under a different title by Ferrer [López] *et al.* (1992).

Ferrer [López], J. R., G. Perera [de Puga] & M. Yong [Cong]. 1992. Growth, mortality and reproduction of *Pomacea paludosa* (Say) in natural conditions. Pp. 379-382, in: C. Meier-Brook (ed.), Proceedings of the Tenth International Malacological Congress, Tübingen, 27 August-2 September 1989. 2 vols. Unitas Malacologica, Tübingen, Germany. vi/ix + 636 pp.

Life-history studies were conducted in the field in Cuba with snails confined to half-submerged, specially designed, plastic boxes of unspecified construction. The authors found that *Pomacea paludosa* is a slow-growing species with a long life-span, with an age of first reproduction at 5 mo, and with a reproductive peak at 6-7 mo. Female snails averaged 50-60 eggs per clutch, and eggs averaged 3.8 mm diameter, 21 d incubation, and 94% hatching success. Mortality rates were low (10-15%) in the first few months, intermediate (25-35%) up to 11 mo, and highest (50%) through 17 mo of age. The length of a normal life-span was not given. The authors conclude that *P. paludosa* is a *k*-strategist that might be effective in biological control, specifically for intermediate molluscan hosts of human parasites. The year of publication is misprinted "1991" on the first page of the article. An abstract was not included in the 1989 abstract volume for the poster presentation at the congress.

Fisher, A. K. 1893. The hawks and owls of the United States in their relation to agriculture. United States Department of Agriculture, Division of Ornithology and Mammalogy, Bulletin, no. 3: 1-210, pls. 1-26.

Because the Florida applesnail (as "*Ampullaria depressa*") "does not seem to be in any way injurious," no economic value is placed on its predator the snail kite, viewed here as harmless and not to be "wantonly destroyed." Shell diameter of the snail is given as 2-3 inches, and the snail is considered abundant in central and south Florida. The kite extracts the meat without damage to the shell and holds several in its "gullet" before returning to the nest to feed offspring. This document was reprinted in 1974 by Arno Press, New York.

Fisher, J., N. Simon & J. Vincent. 1969. Wildlife in danger. The Viking Press, New York. 368 pp.

Decline of the population of the snail kite is attributed to drainage of the Everglades and other marshes in Florida, but the Florida applesnail is considered to be widespread in the state. Recolonization of the applesnail in the Everglades is presumed to occur from Lake Okeechobee and is critical to survival of the kite. The authors repeat the misinformation that kites paralyze snails by piercing them with the sharp beak.

Fleming, D. M., D. L. DeAngelis, L. J. Gross, R. E. Ulanowicz, W. F. Wolff, W. F. Loftus & M. A. Huston. 1994. ATLSS: across-trophic-level system simulation for the freshwater wetlands of the Everglades and Big Cypress Swamp: draft report. [United States Department of the Interior, United States Geological Survey, National Biological Survey, South Florida/Caribbean Field Laboratory], Homestead, Florida. [3] + 76 pp.

This project is an attempt at ecosystem modeling using three (and eventually four) types of model to improve restoration and management of wetlands in south Florida. The Florida applesnail is specifically excluded as a macroinvertebrate grazer of plants and periphyton in the lower trophic-level model and is included in an age/size-structural model (called "intermediate trophic-level model"). The focus of the model is to predict the effects of hydrological regime on productivity of fish communities and selected macroinvertebrates using 5-d age classes (from which sizes are to be calculated) and estimates of age-dependent mortality. The data are to be used also for the prey-base sub-model of the higher consumer models. The authors recognize that gaps exist in the knowledge required to develop the models, and they outline areas for future research. Plans include the further development of an age- and size-structural model for the Florida applesnail and the addition of a higher consumer model for the snail kite. The snail kite model is included in later versions of ATLSS (USDI, 1997; United States Army Corps of Engineers & South Florida Water Management District, 1999).

Florida Audubon Society. 1964. Florida's rarest bird fighting for survival in marshy refuge. The Florida Naturalist, 37(3-B): 1.

This news release, based on Cant (1964), contains the claim that "fluctuating water levels in the lakes and marshes nearly wiped out the species of large snail upon which the [snail] kites depend for food."

[Florida Department of Agriculture.] 1951. Birds in Florida. Florida Grower Press, Tampa, Florida. [xvii] + 208 pp., 32 color pls., 1 black-and-white pl.

This edition of **[Florida] Department of Game and Fresh Water Fish (1931)** includes the identical sections on the snail kite and boat-tailed grackle—including statements about the Florida applesnail—that were added to the second edition (Writer's Program, Work Projects Administration in the State of Florida, 1942).

Florida Department of Environmental Regulation. 1986. Lake Okeechobee algal bloom toxicity bioassays. Florida Department of Environmental Regulation, Biology Section, Bureau of Laboratories and Special Programs, [Tallahassee, Florida]. [ii] + 9 pp.

Inconclusive results were obtained in an attempt to explain a massive mortality of applesnails and other animals in Lake Okeechobee, concurrent with a severe bloom of the cyanobacterium *Anabaena*. Most *Pomacea paludosa* survived a static acute toxicity bioassay of a water sample that the author concludes was unrepresentative of the lake under bloom conditions.

Florida Game and Fresh Water Fish Commission. 1988. A strategic plan for the comprehensive management of Florida's wildlife and freshwater fish, third edition, 1988-1993. Florida Game and Fresh Water Fish Commission, [Tallahassee, Florida]. iv + 80 pp.

Wide annual fluctuations in numbers of snail kites are claimed to be due to similar annual fluctuations in water levels and in population size of the Florida applesnail. Although a 5-yr goal is set for population size of the snail kite, objectives for the Everglades region cover only satellite imaging of the habitat and monitoring of the kite population, with no mention of management of the habitat or the snail.

Florida Power and Light Company. 1988. Seasons in the swamp. Florida Power and Light Co., Video Services, Juno Beach, Florida. [videotape, 28 min]

This narrated montage of fauna and flora of the Barley Barber Swamp east of Lake Okeechobee is vaguely organized around the theme of seasons. The snail kite and limpkin (briefly illustrated) are mentioned as predators of applesnails. A short segment shows a shell and a clutch of eggs on a blade of cattail. The shot seems posed because the shell is above the clutch and oriented up the stem during the daytime, no foot, tentacles or operculum is visible, and the clutch is dried.

Flowers, R. W. 1972. Shelling in southern freshwaters. Of Sea and Shore, 3(3): 117-118, 126.

In this travelogue by a shell collector, *Pomacea* sp. from roadside ditches in south Florida is described as "ugly, black, rubbery, almost shapeless." A photograph includes two views of the shell, which is described to be "not unpleasing to behold."

Fogarty, M. J. 1974. The ecology of the Everglades alligator. Pp. 367-374, in: P. J. Gleason (ed.), Environments of south Florida: present and past. Miami Geological Society Memoir 2. Miami Geological Society, Miami, Florida. vi + 452 pp.

This paper summarizes Fogarty & Albury (1968) and adds no new data on predation by American alligators on applesnails. It was published apparently unmodified in **Gleason (1984: 211-218)**, including the first sentence, which refers to the basis for this report in an "on-going" research program.

Fogarty, M. J. & J. D. Albury. 1968. Late summer foods of young alligators in Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners, 21: 220-222.

Stomachs of 24 of 36 immature American alligators from an Everglades canal contained 119 *Pomacea paludosa* (65.8% of diet by volume). No difference in diet was found between sexes of alligators.

Folger, F. A. (photographer). 1971. Apple snails—escargots for the rare Everglade kite. Audubon, 73(5): 24-25, 5 pls.

A short text is illustrated with several photographs of a snail kite handling its applesnail prey. The author claims the snail to be the sole prey of the snail kite. Oviposition by the snail and snail capture by the kite are briefly described. The writer attributes to the Florida subspecies of snail kite the extraction method described by **Lang (1924**; see Murphy, 1955) for snail kites in British Guiana, and he claims other descriptions of snail extraction to be incorrect. Authorship of the text is unspecified for this photoessay, which is cited by Perry (1971, 1973 [1974]) as "Anon. (1971)."

Fox, R. S. 1997. Manual of invertebrate zoology, 10th edition. Lander University [Greenwood, South Carolina]. 263 pp.

One of two exercises on Mollusca in this laboratory manual is on *Pomacea paludosa*, although in this edition the section is headed only "*Pomacea*" (R. S. Fox, 2002, personal communication). The descriptions of gross external and internal anatomy and function are based largely on the author's own observations and are supplemented by five original pencil sketches. [Improved drawings are available in the most recent (2003) web-based version: www.lander.edu/rsfox/310PomaceaLab.html.] In addition to general external features, systems covered are digestive, circulatory, excretory, nervous, and male and female reproductive systems. A mite of the genus *Atax* is reported as a symbiont in the mantle cavity of *P. paludosa*. Aside from a

1994 version found at the author's website, earlier editions—print or electronic—have not been consulted by us. A copy of the 10th edition is deposited in the library at Lander University.

Freiburg, M. W. 1971. A comparison of the structure of the respiratory systems and the oxygen consumption of two amphibious snails, *Pomacea paludosa* Say and *Marisa cornuarietis* Linné (Prosobranchia, Mesogastropoda, Pilidae) in aquatic and terrestrial environments. Ph. D. dissertation, University of Missouri-Columbia, [Columbia, Missouri]. [xiv] + 104 pp. [1971. Dissertation Abstracts International, 32B(5): 3076.]

Based on the author's description of the clutch of eggs, this work was not done on *Pomacea paludosa*. The source of material is not given; but, here and in Freiburg & Hazelwood (1977), reference is made to the availability of *P. paludosa* in pet shops. Clutches measuring 25 x 10 mm contained 200 eggs, each 3 mm in diameter and nonspherical because "the capsules are pressed tightly against one another."

Freiburg, M. W. & D. H. Hazelwood. 1977. Oxygen consumption of two amphibious snails: *Pomacea paludosa* and *Marisa cornuarietis* (Prosobranchia: Ampullariidae). Malacologia, 16(2): 541-548.

This work is not on *P. paludosa*. See Freiburg (1971).

Fullington, R. W. 1978. The Recent and fossil freshwater gastropod fauna of Texas. Ph. D. dissertation, North Texas State University, Denton, Texas. vi + 279 pp. [1979. Dissertation Abstracts International, 39B(11): 5273.]

"All current knowledge of Texas fossil and recent freshwater gastropod fauna," including 70 species in 38 genera, is presented. *Pomacea paludosa* is given as an introduced element of Neotropical origin. The author's claim that **Taylor (1975)** listed this species incorrectly as "*Ligumia (Unio) calignosa*" [*sic*], citing Singley (1893) as the basis for his conclusion, is incorrect for two reasons: **Taylor (1975)** includes no such listing, and Singley (1893) includes "*Unio caliginosus*" as well as "*Ampullaria caliginosa*."

Gambel, W. 1848. Contributions to American ornithology. Proceedings of the Academy of Natural Sciences of Philadelphia, 4(6): 126-129.

A communication to the author from A. L. Heerman reports observations on four snail kites shot on 6 May 1848 near the head of Miami River. Heerman's notes include, "On dissecting them, I found their stomachs filled with a species of snail, which lives on the rank grasses of the everglades." This might be the first report of the kite as predator of *Pomacea paludosa* in Florida.

Gantz, C. O. 1971. A naturalist in southern Florida. University of Miami Press, Coral Gables, Florida. xiv + 256 pp.

In this narrative of travels and observations in several habitats of south Florida, applesnails (named "bullseye snails") are noted as the favored prey of limpkins in Corkscrew Swamp Sanctuary and of snail kites in the Everglades, where the author describes empty shells littering the ground. A photograph is included of an adult limpkin and a chick standing among a collection of empty applesnail shells.

Gaudion, M. 1879. Liste alphabétique des espèces du genre *Ampullaria* de Lamarck. Bulletin de la Société d'Etude des Sciences naturelles de Béziers, 4: 20-43.

The species "PALUDOSA Say. Philip." is included among 224 species of the genus *Ampullaria*. Listed synonyms are "Amp depressa. Say" and "Amp. hopetonensis ? Lea." Florida and Georgia in North America are given as the geographic range.

George, J. C. 1972. Everglades wildguide. Natural History Series, United States Department of the Interior, Office of Publications, National Park Service, [city, state unknown]. 106 pp.

Applesnails are mentioned as the sole prey of the snail kite in this illustrated booklet on the habitats and biota of the Florida Everglades. Figures include colored drawings of an applesnail shell and of a clutch of five eggs arranged in linear series on the stem of an emergent plant.

Giovanetto, L. A. 1992. Population ecology and relative abundance of sympatric freshwater turtles in the headwaters of two spring-fed rivers in western peninsular Florida. Ph. D. dissertation, Florida Institute of Technology, Melbourne, Florida. 96 pp. [1992. Dissertation Abstracts International, 53B(2): 659-660.]

The work includes the only recorded direct observation of a Florida soft-shelled turtle consuming a Florida applesnail in the wild. The single observation was made in the Rainbow River.

Gleason, P. J. 1972. The origin, sedimentation and stratigraphy of a calcitic mud located in the southern fresh-water Everglades. Ph. D. dissertation, Pennsylvania State University, University Park, Pennsylvania. [1] + 3 + xiii + 355 + [1] pp. [1973. Dissertation Abstracts International, 33B(12): 5913.]

Holocene calcitic mud (marl), covering about 1 million acres, was formed in the Everglades by precipitation of calcite crystals within an overlying blue-green algal mat. Trace amounts of aragonite in the mud are attributed to erosion of shells of the Florida applesnail and two other gastropods, shells of which were found to depths of 38 inches in cores from Taylor Slough. X-ray analysis showed that whole shells had not completely inverted to calcite.

Gleason, P. J. 1974. Preface. Pp. i-iii, in: P. J. Gleason (ed.), Environments of south Florida: present and past. Miami Geological Society Memoir 2. Miami Geological Society, Miami, Florida. vi + 452 pp.

The author suggests culturing applesnails to augment their supply to snail kites and alligators in the Everglades. This suggestion is absent from the completely revised and abbreviated preface of the second edition **(Gleason, 1984)**.

Gleason, P. J., A. D. Cohen, H. K. Brooks, P. Stone, R. Goodrick, W. G. Smith & W. Spackman, Jr. 1974. The environmental significance of Holocene sediments from the Everglades and saline tidal plain. Pp. 287-341, in: P. J. Gleason (ed.), Environments of south Florida: present and past. Miami Geological Society Memoir 2. Miami Geological Society, Miami, Florida. vi + 452 pp.

Calcitic mud (*Helisoma* marl) in the freshwater part of the Everglades includes shells of the Florida applesnail. This paper was reprinted apparently unmodified in **Gleason (1984: 297-351)** except for a change in the sequence of authors.

Gleason, P. J. & P. A. Stone. 1975. Prehistoric trophic level status and possible cultural influences on the enrichment of Lake Okeechobee. [Central and South Florida Flood Control District, West Palm Beach, Florida.] v + 133 pp. [unpublished]

Shells of *Pomacea paludosa* were found in *Helisoma* marl in a quarried rock pit near Pahokee, southeast of Lake Okeechobee. The applesnail shell was radiocarbon dated to 3830 YBP.

Gleason, P. J., P. A. Stone, P. Rhoads, S. M. Davis, M. Zaffke & L. Harris. 1975. The impact of agricultural runoff on the Everglades marsh located in the conservation areas of the Central and Southern Florida Flood Control District. [South Florida Water Management District], Resource Planning Department, [West Palm Beach, Florida]. v + 119 pp. and irregularly numbered appendices.

Based on published studies of other freshwater snails and a few on the Florida applesnail as well as their own preliminary observations, the authors examined the relationship between density of egg clutches and several hydrographic and water-quality measures. They found positive correlations between clutch density and specific conductance, calcium concentration, and alkalinity of the water, inverse correlations with inundation index and sedge biomass, and no relationship with water depth or hydroperiod. Minimal needs of the applesnail for shell growth and clutch production are offered to explain the positive correlations.

Glover, N. & C. Campbell. 1994. Apple snails in wetland taro. Agricultural Development in the American Pacific, Pacific Land Grant Programs, Integrated Farm Development Project, CTAHR, University of Hawaii, Honolulu. Pacific Islands Farm Manual, Taro Pest & Disease Leaflet, no. 5: 1-4.

This leaflet includes information on methods of controlling exotic applesnails, prevention of their introduction and spread, and a recipe to encourage consumption rather than destruction of collected snails. The leaflet focuses on *Pomacea canaliculata* but includes text and line art to distinguish it from other species of *Pomacea* (*P. bridgesii*, *P. paludosa*) and *Pila conica* in the Pacific region.

Gochfeld, M. 1964. The current status of the Everglade kite. The Linnaean News-Letter, 18(7): 1-3.

Loxahatchee National Wildlife Refuge is not viewed as an ideal location for management of snail kites. Because the refuge was intended to serve primarily for flood control and irrigation and secondarily for conservation, drainage would restrict the available population of applesnails to canals, which the author regards to be suboptimal habitat for foraging by kites.

González Alonso, H., F. González Bermúdez & M. Quesada. 1986. Distribución y alimentación del cabrerito de la ciénaga (*Torreornis inexpectata*) (Aves: Fringillidae). Poeyana, no. 310: 1-24.

The Cuban Zapata sparrow is vegetarian during the dry season (November to early May) and switches to embryonic *Pomacea paludosa* during the rainy season (May-October). The authors observed the sparrow to spend 54% of its major period of daily activity (0600-1000) in the rainy season consuming eggs from *Pomacea* clutches. Stomachs of six mist-netted sparrows contained 40 opercula of embryonic size. It is not known if the bird consumes eggs of earlier developmental stages, but **Raffaele *et al.* (1998)** suggest that post-hatching stages of *Pomacea* sp. are eaten.

Graham, F., Jr. 1987a. A warden's story. Audubon, 89(2): 105-121.

In this account of the experiences of a warden for the National Audubon Society in south Florida, one of the focus species is the snail kite. Decline of kite populations is linked to drought and habitat destruction because of the dependence of the kite on the Florida applesnail. A description of snail capture and processing by the kite suggests that the snails climb toward the surface of the water to feed. The warden prepared feeding stations for the kites in winter by placing boxes containing applesnails, gathered by dip net, near nests of the kites. Dietary supplementation in winter was deemed necessary because "snails remained out of reach in deep water." Two photographs illustrate clutches of eggs on the stem of a water lily (*Nymphaea* sp.) and a snail kite returning to its nest with an extracted applesnail in its bill.

G[raham], F., [Jr.] 1987b. The "sewer ditch" undone. Audubon, 89(2): 114-115.

Death of "most of the [Florida apple]snails" in Lake Okeechobee during the summer of 1986 is attributed to extensive and repeated blooms of cyanobacteria that were induced by nutrient input from the channelized

Kissimmee River ("sewer ditch"). Other accounts of this applesnail mortality and algal bloom are given in Florida Department of Environmental Regulation (1986) and Rudolph & Strom (1990).

Graham, F., Jr. 1990. Kite *vs.* stork. Audubon, 92(3): 104-110.

This popular article describes the differences between management goals of the United States Fish and Wildlife Service and the United States National Park Service in the Everglades. An historical account of the Everglades under human regulation and a reasonable hypothetical scenario of its development on a geological/evolutionary time scale are given. It is suggested that the Florida applesnail is not drought resistant. The snail is illustrated in three photographs, one of which shows a female in oviposition.

[Gray, J. E.] 1854. List of the shells of Cuba in the collection of the British Museum, collected by M. Ramon de la Sagra. Described by Prof. Alcide d'Orbigny, in the "Histoire de l'Ile de Cuba." British Museum, London. [iii] + 48 pp.

Ampullaria fasciata Lamarck, 1816 listed here is reported by Pilsbry (1927) [1928] to be a misidentified *Pomacea paludosa*. See Orbigny (1845).

Great Outdoors Publishing Company. 1995. Birds of prey. 2nd edition. Great Outdoors Publishing Company, Inc., St. Petersburg, Florida. 64 pp.

The specialized morphology and behavior of the snail kite for feeding on the Florida applesnail are briefly described. This edition retains the line drawings of the first **(Ovington, 1975)**, which omits direct reference to the applesnail.

Green, D. 1999. Watching wildlife in the Wekiva River basin. Sabal Press, Longwood, Florida. xiii + 124 pp.

This is a well-illustrated guide to wildlife and habitats of the Wekiva River and associated wetlands in parks and preserves of the river basin. The applesnail and the feeding habits of its avian predator the limpkin are described. Decline of applesnail populations is attributed to drainage of wetlands, to replacement of tapegrass (purportedly the natural food of applesnails) by *Hydrilla verticillata* (Linnaeus f.) Royle, 1839 (hydrilla), and possibly to application of herbicides to control hydrilla. According to checklists that suggest keenness of observation among park visitors, "city slickers" are not expected to spy applesnails, but "budding naturalists" are.

Green, I. 1960. Wildlife in danger. Coward, McCann & Geoghegan, New York. 128 pp.

This children's book on endangered animals includes a chapter on the snail kite. Information on the Florida applesnail ("the Pomacea") includes its habitat, effect of altered marsh management, and methods of predation by the kite. The book was reprinted in 1964 by E. M. Hale and Company, Eau Claire, Wisconsin.

Greenberg, M. J., R. A. Agarwal, L. A. Wilkens & P. J. B. Ligon. 1973. Chemical regulation of rhythmical activity in molluscan muscle. Pp. 123-142, in: J. Salánki (ed.), Neurobiology of invertebrates: mechanisms of rhythm regulation. Akadémiai Kiadó, Budapest, Hungary. 494 pp.

In bioassays on bivalve (*Mercenaria*) hearts, a substance (Peak C-ase) extracted from the circumesophageal and abdominal ganglia of *Pomacea paludosa* inactivates the cardioexcitatory agent Peak C, also isolated from ganglia of *P. paludosa*.

Grossman, M. L. & J. Hamlet. 1964. Birds of prey of the world. Bonanza Books, New York. 496 pp., 53 pls.

Almost none of the information about the Florida applesnail in this document is supported by the primary literature. The Florida applesnail is claimed to be the intermediate host for a lung fluke (see Cole *et al.*, 1995) that one author (J. Hamlet) found in high numbers in dead snail kites. The low number (reported here to stand at seven or eight) of snail kites in Florida is attributed to mortality from flukes acquired from consumption of snails. The applesnails are stated to suffer a higher rate of infection by flukes because of the confinement of snail populations to drainage ditches in areas of land reclamation for agriculture. Kites are claimed to forage only on snails that leave the water and climb on emergent vegetation near dawn and dusk. The authors' description of extraction of the snail from its shell by the kite seems to follow in part May's (1935) modification of the erroneous notes of **Lang (1924)**.

Guimarães, C. T. 1978. Observações bio-ecológicas sobre *Pomacea haustrum* (Reeve, 1856). Sua utilização no controle biológico da esquistossomose mansoni. Tese de Mestrado [master's thesis], Departamento de Parasitologia, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Minas Gerais, Brazil. [vii] + 114 pp.

The mechanism of pedal ciliary feeding by *Pomacea haustrum* at the surface of the water is described and stated to be similar to that described by McClary (1964) for *P. paludosa*.

Gunderson, L. H. & W. F. Loftus. 1993. The Everglades. Pp. 199-255, in: W. H. Martin, S. G. Boyce & A. C. Echternacht (eds.), Biodiversity of the southeastern United States: lowland terrestrial communities. John Wiley & Sons, Inc., New York. 502 pp.

Aquatic invertebrates are among the least-known groups in the depauperate fauna of the Everglades. The Florida applesnail is the only ampullariid (listed as "pilid") species among 21 species of aquatic snail, and the studies of Kushlan (1975) and Hanning (1978) on applesnails are among the four major studies listed for aquatic invertebrates. Applesnails are reported to occur in the sawgrass-prairie ecotone, wet peat prairies and sloughs, solution holes of wet marl prairies, and along the edges of ponds and creeks. The snails are figured as part of the detrital-periphyton food web as prey (along with other snails in some cases) of redear sunfish, limpkins, and snail kites. Loftus has observed limpkins to use the floating feeding platforms of muskrats [probably *Neofiber alleni* True, 1884] as a place for extracting snails from their shells. Several factors that the authors discuss to explain the low endemism and low contribution of Neotropical animals to the Everglades community are pertinent to applesnail distribution: some elements of the peninsular fauna have probably moved there only since the present Everglades plant communities formed about 5000 YBP; few aquatic animals can tolerate the wide variations in water depth, temperature, and oxygen; the Atlantic Ocean, Straits of Florida, and Gulf of Mexico form a barrier to potential Neotropical colonizers.

Gutiérrez, A., G. Perera [de Puga], M. Yong [Cong] & J. A. Fernandez. 1997 [1998]. Relationships of the prosobranch snails *Pomacea paludosa, Tarebia granifera* and *Melanoides tuberculata* with the abiotic environment and freshwater snail diversity in the central region of Cuba. Malacological Review, 30: 39-44.

Sixteen species of mollusk were collected by sieving in 6 creeks, 6 rivers, and 11 lakes in and near Santa Clara Province, Cuba. Abundance was expressed based on a time of 15 min per sample and was correlated with abiotic factors and three statistical measures of diversity. *Pomacea paludosa* was most abundant in creeks and rarely collected in rivers and lakes. Its abundance was related inversely to molluscan diversity and positively to salinity and nitrate concentration.

Gutiérrez, A., G. Perera [de Puga], M. Yong [Cong] & J. Sánchez. 1993-1994 [1995]. Estudio morfométrico en dos poblaciones del género *Pomacea* (Prosobranchia: Ampullariidae) de Cuba. Walkerana, 7(17/18): 15-22.

Two populations of applesnails, suspected to be *Pomacea paludosa* and *P. poeyana*, differ significantly in shell shape, aperture shape, operculum shape, relative diameter of the nucleus, and relative length of the body whorl. The population from an artificial lake in El Rubio was sexually dimorphic in aperture shape; the relatively greater width of the aperture in males is explained to accommodate the penial complex. The population from rice fields in Valle Grande was sexually dimorphic also in shell shape and operculum shape. The authors do not indicate which population is suspected to be *P. paludosa*, but the locations of voucher specimens are named.

Haldeman, S. S. 1845. A monograph of the freshwater univalve Mollusca of the United States, including notices of species in other parts of North America. No. 8. E. G. Dorsey, Philadelphia. 11 pp., 2 colored pls.

The exterior anatomy, eggs, and shell of *Pomacea paludosa* (as "*Ampullaria depressa*") are described and figured. Sexual dimorphism is noted in head color. The habitat and process of oviposition are described from "letters" of J. Hamilton Couper, who supplied the author with shells and living specimens. The species name was resurrected because the earlier *A. depressa* (of Lamarck), a fossil, was thought to be a *Natica* by Deshayes, thereby removing the homonymy according to Haldeman's thinking. Say's replacement name (*A. paludosa*) and *A. hopetonensis* are listed as synonyms. *Ampullaria rotundata* is treated as a synonym of *A. globosa* Swainson, 1822 from India; Say's Florida distribution is suspected to be an accidental introduction. This series was published also by J. Dobson (Philadelphia) and later as a two-volume set by the Academy of Natural Sciences of Philadelphia and other publishers with dates ranging from 1840 to 1871; parts 1-5 of the Dobson edition bear the title "A monograph of the Limniades and other freshwater univalve shells of North America."

Hale, H. S. 1984. Prehistoric environmental exploitation around Lake Okeechobee. Southeastern Archaeology, 3(2): 173-187.

Faunal remains are described from excavations of anthropological sites at Fort Center, west of Lake Okeechobee, and at Big Circle (Tony's) Mound Group, south of the lake. No invertebrates are reported from Fort Center, but shell fragments of *Pomacea paludosa* were found in a 1-m^2 test pit at Big Circle. The author notes that the snail presently lives in nearby marshes.

Hale, H. S. 1989. Prehistoric subsistence strategies and settlement patterns in the Lake Okeechobee basin of the south Florida peninsula. Ph. D. dissertation, University of Florida, Gainesville, Florida. x + 239 pp. [1990. Dissertation Abstracts International, 51A(5): 1668-1669.]

Shells of *Pomacea paludosa* and bivalves were found in the midden-bearing stratum of the Pahokee Ridge rock pit site, east of Lake Okeechobee. Based on radiocarbon dating of shells, including those of *P. paludosa*, by Gleason & Stone (1975), the author concludes that the area was occupied by humans during the Late Archaic and Transitional periods.

Hale, M. C. 1964. The ecology and distribution of the introduced snail, *Marisa cornuarietis* (Ampulariidae [*sic*]) in south Florida. M. S. thesis, University of Miami, Coral Gables. vii + 115 pp.

Hale published this thesis later (Robins, 1971) with little modification of the text. The thesis includes much more tabulated data on *Marisa* than does the published paper, but the author's comparisons of *Marisa* and *Pomacea* are nearly identical.

Hall, H. M. 1950. Wakulla limpkins. Audubon Magazine, 52(5): 308-314.

This article on the form, behavior, and distribution of limpkins in the southeastern United States includes observations on their feeding on the

Florida applesnail, called "the green snail" in reference to its shell color. Middens of empty shells accumulate beneath limpkin nests and perches. Disappearance of limpkins from the northern Everglades is attributed partly to a decline in the applesnail population. The breeding season of the snail, clutch parameters, and mode of oviposition are described. The author briefly notes the "Florida grackle" as a predator of *Pomacea paludosa* at Wakulla Springs.

Hamilton, P. V. 1991. Variation in sense organ design and associated sensory capabilities among closely related molluscs. American Malacological Bulletin, 9(1): 89-98.

This review of sensory system design in mollusks illustrates the great variety encountered throughout the phylum, especially regarding eye and rhinophore structure and function in Gastropoda. In a comparison of 32 gastropods, the eye structure of *Pomacea paludosa* is presented, including previously unpublished observations for eye diameter, retinal area, lens diameter, and receptor distance, number, and density. Among those gastropods in its size range (40-60 mm adult length), the eye of *P. paludosa* is relatively large, with high receptor abundance and density.

Hanley, S. C. T. 1854-1858. The conchological miscellany of Sylvanus Hanley ... illustrative of *Pandora*, *Amphidesma*, *Ostrea*, *Melo*, the Melaniadae, *Ampullaria* and *Cyclostoma*. Williams and Norgate, London. 12 pp., 40 pls.

According to two short concluding paragraphs to this work, most of the 40 black-and-white plates in this rather odd assemblage of illustrated species were originally intended for publication in Sowerby's "Species Conchyliorum" [probably Thesaurus Conchyliorum, vol. I, by G. B. Sowerby I, 1843-1846 **(Palmer, 1966)**]. After Sowerby's death in 1854, Hanley published his plates separately. The four plates covering 15 species of *Ampullaria* were published in November 1854 with those on *Ostrea* and 5 plates of *Melania*, as parts 1-3. *Ampullaria depressa* appears on pl. III, fig. 9 (actually two figures, in dorsal and apertural view).

Hanning, G. W. 1978. Oviposition of *Pomacea paludosa* (Say) in Lake Okeechobee, Florida. Bulletin of the American Malacological Union for 1977: 90-91. [abstract]

This is an abstract of a preliminary oral report of part of the author's master's thesis (Hanning, 1979).

Hanning, G. W. 1979. Aspects of reproduction in *Pomacea paludosa* (Mesogastropoda: Pilidae). M. S. thesis, Florida State University, Tallahassee, Florida. x + 138 pp.

This is a highly cited and mostly unpublished thesis that covers many aspects of the reproductive biology of *Pomacea paludosa*: gross anatomy and some histology; field studies in Lake Okeechobee on clutch parameters,

population biology, reproductive period, and parasitism; and laboratory and field studies on rates of clutch production. Male and female reproductive systems are described and illustrated with line art; the systems are essentially the same as reported for other species of *Pomacea*. Males are distinguishable from females by the presence of a penis, the less swollen body whorl of the shell, a wider aperture, and the flaring outer lip of the shell. In populations from northern Florida, males have a larger penial sheath, and differences in shell characters of males and females are greater. Mean adult shell length is 39 mm, with females slightly larger than males. Distributions of shell sizes were bimodal in summer, and overwintering adults died by the following October. Life span was estimated at 1-1.5 yr. In the field, hatchlings grew at 13 mm/mo, but growth slowed during summer and halted during winter. Growth in the laboratory was slower. Sex ratio was 1:0.75 (female to male). Histological examination of gonads revealed gonadal cycles that corresponded to periods of oviposition. Snails reached reproductive maturity at a shell length of 35 mm (age of 4-5 mo). High proportions (up to 80%) of both sexes were parasitically castrated by trematode larvae. Copulation is described and can last for hours, be repeated several times daily, and involve a succession of partners. Oviposition is nocturnal on stems of emergent plants at a mean of 0.15 m above the water. Eggs are laid one every 2-4 min in ordered rows and columns in an adhesive mucus that later dries. Eggs change color during 16-22 d of incubation and hatch at night at a success rate of 77-87% of eggs per clutch. Clutch production was unimodal from March through October and peaked at 2.5 clutches/m^2 mean standing clutch density in June. Densities were highest in stands of southern cattail (*Typha domingensis* Persoon, 1807) and *Pontederia*. Mean clutch size was 28 eggs/clutch and decreased from beginning to end of the season. Mean egg diameter was 4.4 mm. Females of caged isolated pairs of snails in the laboratory and field laid 0.56 (laboratory) and 0.97 (field) clutches of 13.4 and 20.3 eggs, respectively, per week. Using these data, field data for clutch density, and an equation devised by the author, he estimated adult snail density to be 2.8 snails/m^2 at the study site in Lake Okeechobee. Damage to eggs was attributed to abrasion from adjacent stems and by incidental crushing by ovipositing female snails and by perching boat-tailed grackles. A section on management practices makes several recommendations but is based disproportionately on literature and speculation rather than on the author's data.

Hanning, G. W. & W. S. Leedom. 1978. Schistosome dermatitis from *Pomacea paludosa* (Say) (Prosobranchia: Pilidae). The Nautilus, 92(3): 105-106.

Contraction of dermatitis by the senior author while conducting field work in Lake Okeechobee led to a search for cercarial infection in the local

population of *Pomacea paludosa*. Three percent (n = 326) of the population was found to be infected with schistosome trematodes, which the authors suspect to use a species of local or migratory waterfowl as the definitive host. This is the first report of schistosomes in *P. paludosa* and the second report for the genus. Despite the title, almost no evidence is given that the parasite from the applesnails was responsible for the original chronic dermatitis in this one clinical case. Other species of aquatic snails were not examined. The cercaria is described by Leedom & Short (1981).

Hansen, K. L., E. G. Ruby & R. L. Thompson. 1971. Trophic relationships in the water hyacinth community. Quarterly Journal of the Florida Academy of Sciences, 34(2): 107-113.

This attempt to construct a food web based on uptake of phosphorus-32 and on stomach analyses focuses on an herbivorous amphipod, but it includes some data on *Pomacea paludosa*. Radioisotope uptake was detected in *P. paludosa* in the presence of labeled whole plants in an aquarium and caged in the field. The numbers of experimental and control animals are not given. In the absence of data on stomach analyses and direct observation of feeding, the authors conclude twice in the paper that *P. paludosa* consumes roots of water hyacinths but elsewhere caution that they might only graze on epiphyton. Studies by Talbot (1970) and Alden (1971) appear to be from the same laboratory as this paper.

Harper, F. 1936a. The distribution of the limpkin and its staple food. The Oriole, 1(3): 21-23.

Based on literature and museum specimens, the author derives a good correlation between the distributions of limpkins and applesnails in the southeastern United States. Assuming the snails' requirement for calcium, the author explains its westernmost presence in Spring Creek by the proximity of a calcareous hammock and its absence from the Okefenokee Swamp by the acidity of the swamp waters. A line drawing of an adult *Pomacea paludosa* [reprinted from Heine (1935)] and a distribution map of *Pomacea* spp. in the United States are given. Distributions of *P. p. miamiensis* and *P. pinei* are mentioned. The author speculates that limpkins might feed on applesnails at night. This article was reprinted with modifications as Harper (1936b).

Harper, F. 1936b. The distribution of the limpkin and its staple food, *Pomacea*. The Nautilus, 50(2): 37-40.

With only a few minor changes, this is a reprint of Harper (1936a). Further notes on the co-occurrence of the limpkin and *Pomacea* in Central America, South America, and the Greater Antilles are appended. A footnote reports nocturnal oviposition by *Pomacea* held in aquaria. A second footnote explains the type locality and etymology of the synonym *Ampullaria hopetonensis*.

Harper, F. 1941. Further notes on the food of the limpkin. The Nautilus, 55(1): 3-4.

The author reports limpkins from Mill Creek, Camden County, Georgia, in the apparent absence of applesnails [but see Cottam (1942)]. The absence of applesnails and the presence of *Viviparus georgianus* are used to refute Bryant's (1859) claim that limpkins on the St. Johns River eat *Natica* sp.

Harper, F. (editor). 1958. The travels of William Bartram: naturalist's edition. Yale University Press, New Haven, Connecticut. lxi + 727 + [1] pp., 29 + [1] illustrations, [5] maps, frontispiece.

On a trip in 1940 to the area on the St. Johns River called "Charlotia" by **Bartram (1791)**, the author found the shelly bluff described by Bartram to consist mainly of the gastropod *Viviparus georgianus* and of lesser numbers of *Pomacea paludosa*. Harper suspects that Bartram's "Coch[lea] voluta" is *P. paludosa*.

Harris, S. C., T. H. Martin & K. W. Cummins. 1995. A model for aquatic invertebrate response to Kissimmee River restoration. Restoration Ecology, 3(3): 181-194.

The authors stress that invertebrates must be among the indicators used to evaluate the success of attempts to restore the original route and drainage of the Kissimmee River in Florida. Among the expected outcomes of restoration is the return of the snail kite after increases in population density and distribution of the Florida applesnail when the community of aquatic plants becomes reestablished.

Heard, W. H. 1968. Mollusca. Pp. G 1-G 26, in: F. K. Parrish (ed.), Keys to water quality indicative organisms (southeastern United States). United States Department of the Interior, Federal Water Pollution Control Administration, [Washington, D. C.]. v + separately paginated sections A 1-Y 15.

In addition to a section on bivalves, a key is given to 38 gastropod genera of the southeastern United States. *Pomacea* and *Marisa* are listed under family Pilidae, and a line drawing of the shell of *P. paludosa* is included. An errata sheet enclosed with the volume includes a correction only to the key on bivalves. Incorporation of the errata was the sole basis for publication of the second edition in 1975 [F. K. Parrish (ed.), Keys to water quality indicative organisms of the southeastern United States (second edition). United States Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio. vii + 195 pp.].

Heard, W. H. 1970. American Malacological Union symposium: Rare and endangered mollusks. 3. Eastern freshwater mollusks (II). The south Atlantic and Gulf drainages. (With "Discussion of Dr. Heard's paper" by H. D. Athearn.) Malacologia, 10(1): 23-31.

Pomacea paludosa is offered as an example of a species of decreased abundance due to drainage of the Everglades by the United States Army Corps of Engineers. The snail kite's dependence on the snail as prey and the kite's concurrent decrease are noted without reference to its endangered status.

Heard, W. H. 1976. Reproduction and ecology of the apple snail, *Pomacea paludosa* (Say), sole food of the endangered Everglade kite. Interim report of progress to United States Department of the Interior, United States Fish & Wildlife Service, Office of Endangered Species. Florida State University, Department of Biological Science, Tallahassee, Florida. 3 + [8] pp.

This report apparently uses some data of Hanning (1979) on clutch parameters, oviposition, population biology, and parasitism of the Florida applesnail.

Heard, W. H. 1977. Freshwater Mollusca of the Apalachicola drainage. Pp. 20-21, in: R. J. Livingston & E. A. Joyce, Jr. (eds.), Proceedings of the conference on the Apalachicola drainage system, 23-24 April 1976, Gainesville, Florida. Florida Marine Research Publications, no. 26: 1-177.

Pomacea paludosa is recorded from the Apalachicola River drainage system, where it is the only prosobranch of 16 species that has biphasic gas exchange and the only snail of 20 species that lays terrestrial eggs.

Heard, W. H. [& G. W. Hanning]. 1978. Reproduction and ecology of the apple snail, *Pomacea paludosa* (Say), sole food of the Everglade kite. Final report of progress to United States Department of the Interior, United States Fish & Wildlife Service, Office of Endangered Species. Florida State University, Department of Biological Science, Tallahassee, Florida. 149 pp.

This is a preliminary draft of Hanning's (1979) thesis.

Heilprin, A. 1882 [1883]. On the occurrence of nummulitic deposits in Florida, and the association of *Nummulites* with a fresh-water fauna. Proceedings of the Academy of Natural Sciences of Philadelphia, 1882: 189-193.

Deposits of the new foraminiferan *Nummulites willcoxi* Heilprin, 1883 were found 2 ft above the tide line near the mouth of the Chassahowitzka (as "Cheeshowiska") River on the Gulf coast of Florida. This Eocene or Oligocene formation was intermixed with fossil freshwater and terrestrial gastropods, including the Florida applesnail (as "*Ampullaria depressa*", identified for the author by [G. W.] Tryon [Jr.]). Rather than "a co-mingling of contemporaneous marine and fresh-water organisms" near the mouth of a river, the author interprets the formation to represent the mixture of fossil foraminiferal rock fragmented in the subtidal and of geologically younger molluscan shell washed downstream. This report was reprinted in Heilprin (1884), and the description of the formation was extensively quoted in Heilprin (1886-1887).

Heilprin, A. 1884. Contributions to the Tertiary geology and paleontology of the United States. Angelo Heilprin, Philadelphia. [v] + 117 pp., 1 map.

This report includes the full text of Heilprin (1882 [1883]) on nummulitic rock that includes fossil Florida applesnails. An addendum mentions the discovery of more of this formation 15 mi inland at 150 ft above sea level along the Chassahowitzka (as "Cheeshowiska") River, but the presence of the applesnail in the upstream site is not specifically mentioned in the addendum.

Heilprin, A. 1886-1887. Explorations on the west coast of Florida and in the Okeechobee wilderness. With special reference to the geology and zoology of the Floridian peninsula. A narrative of researches undertaken under the auspices of the Wagner Free Institute of Science of Philadelphia. Wagner Free Institute of Science, Philadelphia. vii + 136 pp. + 21 pls.

During explorations in west and south Florida, *Pomacea paludosa* (as "*Ampullaria depressa*") was found alive and in fossil beds. At the mouth of the Chassahowitzka (as "Cheeshowiska") River, *P. paludosa* was found "beautifully preserved" as part of a freshwater limestone enclosing an intertidal marine limestone. The same outcrop of mixed marine and freshwater limestone was found 1 mi upstream, and there is a possible reference to the same type of rock farther upstream at "Loenecker's". This mix of older (Eocene or Oligocene) marine limestone and post-Pliocene freshwater limestone led the author to conclude that the area has experienced "considerable changes in the topography." In the excursion along the Caloosahatchee River from Fort Myers to Lake Okeechobee, live *P. paludosa*, described as "large", were taken as part of the depauperate fauna of the river between Fort Myers and Fort Thompson, in "the everglade tract above Fort Thompson," and by dredge at the west and central parts of a manmade canal that connected Lake Hicpochee (as "Hikpochee") and Lake Okeechobee. It is unfortunate that the author is not more explicit than "etc." in describing the Fort Thompson limestone beyond its holding the freshwater "Planorbis, Limnea, etc.," for he later writes obscurely that it was these same organisms—fossil and live—that were netted in the canal between Lake Flirt (now drained) and Lake Hicpochee. No mention is made of *P. paludosa* among the fauna of Lake Okeechobee. The fossil rock containing *P. paludosa* is described both in the narrative and in the section on geology. Bibliographic records of this document might err in reporting pagination and plates because of the inclusion of pp. 64A and 64B and of plates 16a and 16b; the origin of this peculiarity is explained along with a discussion of the publication date of Heilprin's work by **Petit & Wilson (1986)**. Our copy is a 1964 reprinted edition by Paleontological Research Institution, Ithaca, New York.

Heine, F. E. 1935. "Infusoria snails". The Aquarium, Philadelphia, 4(8): 175-177 + text-figs.

The author describes techniques for raising applesnails to produce cultures of infusorians as microscopic food for aquarium fish. Although the article deals mainly with *Pomacea canaliculata*, the text is written as if the techniques were generally applicable to applesnails. Some etymologies of scientific and common names are described. A photograph of a hatched egg clutch and a line drawing of a crawling adult of *P. paludosa* (as "*Ampullaria paludosa* Spix" [*sic*]) are included; it is said to be known also as "nursemaid snail" and for years was erroneously referred to *A. gigas* (Spix, 1827) (a South American species) in the aquarium trade.

Henderson, J[ohn]. B. 1916. A list of the land and fresh-water shells of the Isle of Pines. Annals of the Carnegie Museum, 10(3/4): 315-324.

Ampullaria reflexa is recorded from the swamp in the central part of the island. These animals are *Pomacea paludosa* according to Yong [Cong] & Perera [de Puga] (1984).

Henderson, J[unius]. 1927. The practical value of birds. The MacMillan Company, New York. xii + 342 pp.

This book deals with "the food habits of [North American] birds and their relation to the material welfare of the human race," or "economic ornithology." On 35 pages that include snails as prey of birds, the applesnail (as "*Ampullaria*") is listed on 3 only as prey of the snail kite (= Everglade kite, snail hawk); the limpkin is not mentioned in the book. The author notes adaptations of the kite's upper mandible and the talons for grasping and extracting the snail.

Henderson, J[unius]. 1935. Fossil non-marine Mollusca of North America. Geological Society of America, Special Papers, no. 3: 313 pp.

The Florida applesnail (as "*Ampullaria hopetonensis*") is listed along with other freshwater and terrestrial mollusks from the Caloosahatchee Pliocene of Florida [citing Dall (1892)].

Hepler, N. M. 1974. Report on *Pomacea paludosa*. N. M. Hepler, Deerfield Beach, Florida. 17 pp. [unpublished]

This report was produced during preparation of a shell-show exhibit on *P. paludosa*. Descriptions of the shell, predators, and feeding methods of the snail kite are summarized. Original observations (mainly from animals in home aquaria) on behavior, respiration, feeding, copulation, oviposition, and development are included. Drawings are provided detailing external morphology (including sexual dimorphism), shell, radula, and buccal anatomy. The frontispiece includes a photograph of a specimen depositing an egg mass.

Hinsch, G. W. & P. E. Vermeire. 1990a. Histochemistry and ultrastructure of the capsule gland duct of the prosobranch gastropod *Pomacea paludosa*. Invertebrate Reproduction and Development, 17(3): 203-211.

The duct of the capsule gland in female *Pomacea paludosa* coils through the albumen gland from the anterior of the gland, posteriorly to the bursa copulatrix complex, where it joins the oviduct and the duct of the albumen gland. Based on Vermeire (1980) and Vermeire & Hinsch (1984), the duct of the capsule gland is the distal part of the oviduct. The columnar epithelium of the duct consists of ciliated and secretory cells in two layers: a luminal layer of ciliated cells and the necks of secretory cells, and a basal layer of cell bodies of secretory cells. The authors describe the two layers to be separated by a basal lamina but do not elaborate on the histological organization of the layers. The opposing (anterior and posterior) faces of the duct differ in the ultrastructure and cytochemistry of the secretory cells, the secretions differing in proportions of protein and polysaccharide. The secretions presumably are among the several concentric layers that coat the zygote in the fully formed egg. Release is probably apocrine or merocrine. Figures 2-7, attributed to the capsule gland duct, are identical to figures 2a-f of the albumen gland duct in Vermeire (1980). Reference to cells with a diameter of 1600 µm (p. 204) apparently is an error from Vermeire's (1980: 10) reference to secretory vesicles with a diameter of 1600 nm. This paper represents the citations by Vermiere & Hinsch (1984) of "Vermeire and Hinsch (1982a, in part)" and "Vermeire and Hinsch (1982c)", titles that seem not to have been published as such. It was published as an abstract in 1990 with slightly different title in Florida Scientist, 53(suppl. 1): 14.

Hinsch, G. W. & P. E. Vermeire. 1990b. Histochemistry and ultrastructure of the albumen gland duct of the prosobranch gastropod *Pomacea paludosa*. Invertebrate Reproduction and Development, 17(3): 213-219.

The albumen gland duct is a blind tubule that joins other ducts of the female reproductive system near the bursa copulatrix complex. Its simple columnar epithelium consists of three cell types: a non-secretory ciliated cell that probably moves secretions along the duct, an unciliated receptosecretory or neurosecretory cell, and an unciliated secretory cell that stains cytochemically for mucopolysaccharides and glycoproteins that might provide a nutritive or protective role in the fully formed egg. Secretions appear to be released by exocytosis. Figures 2-7, attributed to the albumen gland duct, are identical to figures 12a-f of the anterior face of the capsule gland duct in Vermeire (1980) [see annotation for Hinsch & Vermeire (1990a)]. This paper represents a combination of citations by Vermeire & Hinsch (1984) of

"Vermeire and Hinsch (1982a, in part)" and "Vermeire and Hinsch (1982b)", titles that seem not to have been published as such.

Hobbs, H. H., III. 1992. Part II. Lotic systems. 3. Caves and springs. Pp. 59-131, in: C. T. Hackney, S. M. Adams & W. H. Martin (eds.), Biodiversity of the southeastern United States: aquatic communities. John Wiley & Sons, New York. xiii + 779 pp.

Pomacea is given as one of four snail genera that occur in high density in the clear alkaline waters of Florida runs (spring-fed streams). Prime habitat for these snails is watercress, which grows near the outlet of the spring.

Hoerle, S. E. 1970. Mollusca of the "Glades" unit of southern Florida: Part II. List of molluscan species from the Belle Glade Rock Pit, Palm Beach County, Florida. Tulane Studies in Geology and Paleontology, 8(2): 56-68.

A species list of lower Pleistocene mollusks from this rock pit includes 85% still living in Florida and the Caribbean. *Pomacea paludosa* is listed as "abundant", indicating that more than 100 specimens had been collected.

Horne, F. & V. Boonkoom. 1970. The distribution of the ornithine cycle enzymes in twelve gastropods. Comparative Biochemistry and Physiology, 32(1): 141-153.

The digestive gland (as "hepatopancreas") of aquatic and terrestrial snails was analyzed for enzymes of the ornithine cycle to elucidate the role of the cycle in urea biosynthesis. For six enzymes assayed, *Pomacea paludosa* (as "*Pomacea depressa*") had weak activity of ornithine transcarbamylase, arginosuccinate lyase, and arginase. All four species of aquatic prosobranch and one species of aquatic pulmonate had much lower activities than seven terrestrial pulmonates. The authors conclude that urea biosynthesis is probably not important in the nitrogen metabolism of the prosobranchs in this study, and it is likely that the snails accumulate uric acid instead, especially during aestivation.

Howell, A. H. 1932. Florida bird life. Coward-McCann, New York. xxiv + 579 pp.

Reports of limpkins and snail kites in Florida are summarized in sections on early faunal surveys, including the works of Peale, Maynard, Brewster, Field, and the author. The description of the snail kite (pp. 168-171) states that population fluctuations in freshwater marshes of Palm Beach County were due to changing densities of "their favorite food, the large everglade snails, which in turn are dependent for their existence on a permanent body of shallow water." Feeding methods are discussed, noting that after extraction, the snail (as "*Ampullaria caliginosa*") was "swallowed in pieces about a half or three-quarters of an inch in length," sometimes eaten in flight, and that occasionally the shell received a puncture in one side. The limpkin also was claimed to feed "exclusively" on snails of the genus *Ampullaria*, thus also restricting its range through habitat requirements. The manuscript notes of

Dr. Alexander Wetmore are quoted, describing the feeding habits of the limpkin: following removal of the operculum, snails (as "*Ampullaria depressa*") were extracted whole and swallowed, nearly always leaving the intact shell with its operculum lying nearby. In yet another species description, boat-tailed grackles are reported to feed on large freshwater snails (as "*Ampullaria*") in the Everglades, extracted without damage to the shells (again citing Wetmore notes); applesnails are not, however, listed as part of the typical diet of this bird. A clutch of snail eggs is illustrated (pl. 17, fig. 2). This book was revised by Sprunt (1954).

Hubricht, L. 1962. *Pomacea paludosa* in Alabama. The Nautilus, 75(3): 123.

The Florida applesnail was artificially transported from Gainesville to Jacksonville, Florida, in 1943 and from there to Gantt, Alabama, in 1953.

Hull, H. C., L. F. Bartos & R. A. Martz. 1980. Occurrence of *Urnatella gracilis* Leidy in the Tampa Bypass Canal, Florida. Florida Scientist, 43(1): 12-14.

In this first report of a freshwater entoproct in Florida, shells of live *Pomacea paludosa* were among the substrata listed from a flood-control system in Tampa.

Humphries, J. D. 1995. Perspectives in aquatic exotic species management in the Pacific Islands. Vol. II. Introductions of aquatic animals to the Pacific Islands: disease threats and guidelines for quarantine. South Pacific Commission, Noumea, New Caledonia. x + 53 pp.

Pomacea paludosa is listed among other ampullariids introduced to islands in the Pacific Ocean, but no disease is associated with it. Eldredge (1994) is a companion volume.

Hurdle, M. T. 1973. Habitat requirements of the apple snail (*Pomacea paludosa*) at Lake Woodruff National Wildlife Refuge. Report of refuge management study, progress report no. 2. [United States Department of the Interior, United States Fish and Wildlife Service, Lake Woodruff National Wildlife Refuge, DeLeon Springs, Florida.] 20 pp.

In addition to information published in Hurdle (1974a), this report describes initiation of studies on growth of applesnails and on the effects of changes in water level on vegetation. Few results are given. A third study on submergence (flooding) of egg clutches revealed (1) that submergence reduces the structural integrity of the dried extracapsular jelly and after 1 wk can result in disaggregation of the clutch and (2) that submergence for as long as 2 wk has little effect on viability or the timing of hatching. See Perry (1971) for progress report no. 1.

Hurdle, M. T. 1974a. Life history studies and habitat requirements of the apple snail at Lake Woodruff National Wildlife Refuge. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners, 27: 215-224.

This paper is based on a series of studies summarized in part by Perry (1971, 1974) and Hurdle (1973, 1974b) but includes previously unpublished information. Egg clutches along transects at the head, mid-region, and mouth of Spring Garden Creek declined from a high density at the head to only a few clutches at the mouth; pH, clarity, and concentrations of calcium carbonate and oxygen also decreased. Adjacent areas in the refuge that harbored abundant snails had water quality similar to the head of the creek; but a site in the Okefenokee Swamp with no observed snails had conditions similar to the mouth of the creek. Blue Springs Run, with water of apparently favorable quality but few snails, lacked submerged plants. The author concludes that alkaline waters with moderate oxygen levels and aquatic plants are favorable habitat for *Pomacea paludosa*. Egg clutches appeared in the refuge in late February or early March and took longer (21-25 d) to hatch in the cooler dimmer laboratory than in the field (16-18 d). Based on these observations, oviposition and incubation are suggested to be sensitive to temperature and light. A pair of snails in the laboratory readily ate muskgrass (*Chara* sp.) and spiny naiad (*Najas marina* Linnaeus, 1753), which are locally abundant; and the pair mated frequently. Two females held in the laboratory—one paired with a male snail—laid clutches 3-4 d apart from March to middle or late summer, producing 21 and 25 clutches. Clutches of the paired female were all fertile; but the isolated female produced 10 fertile clutches followed by several infertile clutches until she was mated with a male, whereupon she began to produce fertile clutches again.

Hurdle, M. T. 1974b. Habitat requirements of the apple snail (*Pomacea paludosa*) at Lake Woodruff National Wildlife Refuge. Report of refuge management study, progress report no. 3. [United States Department of the Interior, United States Fish and Wildlife Service, Lake Woodruff National Wildlife Refuge, DeLeon Springs, Florida.] 11 + [4] pp.

This report continues the series of Perry (1971) and Hurdle (1973). Applesnails began to lay eggs when water temperature at several locations exceeded 70°F. Production of egg clutches peaked in mid-May and in late August; the author believes that the first peak represents production by females over 1 yr of age and the second peak represents maturing snails that hatched in the previous year. Egg clutches hatched in 16-18 d. An attempt to evaluate the effect of submergence (flooding) of clutches for 1 wk was confounded by the author's use of clutches of unknown ages, but he claims that submergence reduced the adhesion of the clutch to stems and did not affect the success of hatching. Spraying of clutches with standard concentrations of the herbicide 2, 4-D had no detectable effect on hatching success. Adult snails did not survive several months either in the laboratory or while caged in the field. Mortality of caged hatchlings was high, but some survived 1 yr, at which time a few had reached minimal size for maturity and several clutches had been laid. Clutch densities at two locations in August 1974 were 227/acre and 740/acre. The author estimates that adult density is 40% of clutch density based on clutch production by confined females and sex ratio (1:1.17, male to female) in the field. The most favorable habitat in the refuge seemed to be alkaline, weakly brackish (1‰) waters with abundant muskgrass. The author makes recommendations for management of the refuge for applesnails and snail kites by construction of impoundments, seasonal variation of water level, and drainage of impoundments every 4-5 yr.

Imlay, M. J. 1983. Relation of gizzard stones to toxicity of copper. American Malacological Bulletin, 1: 97. [abstract]

Copper was less toxic to *Pomacea paludosa* in the presence of sediment, which removes copper from solution. Toxicity increased when snails were fed lettuce, perhaps because the snails might ingest sediment-bound copper in search of "gizzard stones" for trituration.

Imlay, M. J. & P. V. Winger. 1980. Application of molluscicidal data to a water quality problem with the apple snail. Bulletin of the American Malacological Union, 1979: 68. [abstract]

The authors hope that data on the action of molluscicides will help protect the Florida applesnail.

Imlay, M. J. & P. V. Winger. 1983. Toxicity of copper to Gastropoda with notes on the relation to the apple snail: a review. Malacological Review, 16: 11-15.

The cause for a decline in numbers of applesnails in the Loxahatchee National Wildlife Refuge is suspected to be the application of herbicides for eradication of aquatic weeds. This literature review summarizes the effects of copper-based molluscicides on other gastropods. The authors caution that the concentrations of copper used at the refuge under conditions that prevail there are toxic to other species. The work of Cheng (1980) is not cited.

Ingalls, E. A. 1972. Aspects of the ethology of limpkins (*Aramus guarauna*). M. A. thesis, University of South Florida, Tampa, Florida. viii + 131 pp.

This study of behavior of the non-migratory territorial limpkin at Wakulla Springs and Alexander Springs Creek, Florida, has major sections that include information on the Florida applesnail: diet, foraging, extraction and consumption of snails, territory, courtship feeding, and feeding of young. A photograph (fig. 10a) of *Pomacea paludosa* in oviposition is printed upside down; applesnails are included in many other figures. Limpkin diet is varied but largely dependent on *P. paludosa*; the ratio of snails to mussels captured was 168:21. Limpkins are visual and tactile predators, probing with the decurved bill while wading or swimming, and they are able to distinguish between empty shells and live snails. Maximal depth of foraging is limited by the tendency of animals to immerse up to half of the body, though usually only part of the bill or the whole head is immersed. Birds concentrate foraging in patchy vegetation or on submerged material on otherwise bare areas. Based on daytime observations of a male over 3 d, 20-25% of time is spent foraging, with snails caught every 2-3 min when foraging intently. A snail is carried a short distance between the mandibles at or near the tip, usually to a favored location with a shell midden, usually on a solid substratum. Extraction is described in detail but, contrary to reports by other authors, does not involve use of the bird's feet. Extraction takes 1-2 min and rarely results in shell breakage. Viscera are not eaten (especially the albumen gland), but the remaining parts are swallowed whole. Snails as small as 1.3-cm shell size are eaten. Each juvenile bird is fed about nine snails per 8.5-h daylight period by its parents. An immature bird pecked at a clutch of snail eggs on two occasions, but the author could not confirm the consumption of eggs. At 5 wk of age, juvenile birds begin catching and extracting snails, and they are weaned beginning at 7 wk. The author gives several lines of evidence that snail and limpkin densities decline with distance downstream of the spring and with use of herbicides.

Ingersoll, E. 1879. In a snailery. Scribner's Monthly, 17(6): 796-803. [April]

Although the author restricts use of the term "snail" to terrestrial lung-bearing gastropods, various aquatic and non-pulmonate species are described and figured. One black-and-white drawing by R. Riordan depicts an adult applesnail crawling over the stump of a tree, just above the water. The siphon is extended. A clutch of about 40 eggs is attached to a nearby branch. A few individuals of other species of freshwater snail are shown submerged. No mention of the applesnail is made in the text, but the caption of the figure reads, "The home of the pond-snail; eggs of the apple-snail." The applesnail is likely to be *Pomacea paludosa* because of the article's focus on North American snails and because of the morphology of the clutch. This is the earliest illustration of the Florida applesnail and its egg clutch in popular literature. Authorship of this article and its nine figures is credited only in the cumulative table of contents in the bound volume available to us.

Innes, W. T. 1936. Giant scavenger snail (*Ampullaria cuprina* Reeve). The Aquarium, Philadelphia, 4(10): 221-223.

The shell of the Florida applesnail (as "*Ampullaria paludosa*") is illustrated and distinguished from three congeners used in the aquarium trade by its combination of low spire and unchanneled suture. A guide to the etymology and pronunciation of its scientific name is provided.

Innes, W. T. 1938. Spawning of *Ampullaria* snails. The Aquarium, Philadelphia, 7(8): 132-134.

There is little information on *Pomacea paludosa* ("the giant watersnail") in this article about spawning by ampullariids held in aquaria. In addition to comparative shell morphology, some history behind the use of *P. paludosa* in the aquarium trade is given, and the origin of the terms "nursemaid" and "infusoria" snail is explained.

Innes, W. T. 1941. Snails and other scavengers. The Aquarium, Philadelphia, 9(12): 201-210.

This popular article describes the selection and care of aquarium snails, including the "Florida infusoria snail," *Pomacea* (as "*Ampullaria*") *paludosa*. Nomenclature and comparative morphology of ampullariids used by aquarists are discussed. *P. paludosa* is described as a "gluttonous" herbivore, and the terms "infusoria" and "nursemaid" snails are explained in terms of feeding habits. Anecdotal information is given on oviposition and respiratory physiology.

Jacobson, M. K. 1949. In Pinar del Rio, a collecting trip. The Nautilus, 62(3): 78-86.

Presumed *Pomacea paludosa* forma *garciae* was collected from a creek near Mendoza (Paso Real), Cuba, in January 1948.

Jahn, O. L. & R. P. Bullen [A. K. Bullen & J. T. Milanich (editors)]. 1978. The Tick Island site, St. Johns River, Florida. Florida Anthropological Society Publications, no. 10: i-iv, 1-25, 57 pls. [The Florida Anthropologist, 31(4, part 2)]

This document, edited for publication after the death of O. L. Jahn, contains no text on the Florida applesnail except in the authors' introduction, in which the area around Tick Island (St. Johns River) is described to be "ideal" for *Pomacea paludosa*. No reference other than editorial comments is made to the 57 plates (figs. 4-60); but one (fig. 45h) includes a specimen that resembles *P. paludosa*. Unfortunately, the caption is brief: "Worked shell and shell food remains."

Jewell, S. D. 1993. Exploring wild South Florida: a guide to finding the natural areas and wildlife of the Everglades and Florida Keys. Pineapple Press, Sarasota, Florida. 224 pp., 38 color figs.

This guide includes a color photograph (no. 6) of a snail kite holding a Florida applesnail in its beak. A confusing segment of text (pp. 75-76) mentions "white shells" of applesnails along a boardwalk in Everglades National Park, referring ambiguously either to egg clutches 1.5 inches long or to old bleached body shells of dead adults. The ambiguity is corrected in Jewell (1997).

Jewell, S. D. 1995. Exploring wild central Florida: a guide to finding the natural areas and wildlife of the central peninsula. Pineapple Press, Sarasota, Florida. xii + 314 pp., 21 color figs.

A section on raptors includes statements that populations of the Florida applesnail require several years to recover from the effects of drought to reach levels that "attract the [snail] kites again." In addition to drought, foraging on the snail by the kite is visually impeded by floating exotic plants. A color photograph captures a snail kite holding an empty snail shell with its talons and dangling an extracted snail from its beak.

Jewell, S. D. 1997. Exploring wild south Florida: a guide to finding the natural areas and wildlife of the southern peninsula and the Florida Keys, 2nd edition. Pineapple Press, Sarasota, Florida. xx + 338 pp., 38 color figs.

This second edition corrects the confusing text of Jewell (1993) by distinguishing between the 1.5-inch adult shells and the "pearl-like" egg clutches. The section on raptors from Jewell (1995), which includes information on the Florida applesnail and snail kite, is repeated almost verbatim. In a new section on Arthur R. Marshall Loxahatchee National Wildlife Refuge, the attention of canoeists is drawn to snail egg clutches on the leaves and stems of emergent plants.

Johnson, B. M. 1952. Ciliary feeding in *Pomacea paludosa* (Say). The Nautilus, 66(1): 3-5.

This is the first report of pedal ciliary funnel feeding at the surface of water in an aquarium by specimens purported to be *Pomacea paludosa*. Particulate fish food on the surface was taken in by ciliary action of the anterior half of the foot, which was formed into a funnel and tube. The food, enveloped by pedal mucus, was subsequently engulfed through action of the radula. The posterior half of the foot was used to grasp the substratum. Ciliary feeding was observed only in underfed snails. The author's reference to "mystery snail," apparent aquarist orientation of the author, and location (Michigan) make the species identity of the snails uncertain.

Jordan, C. F., Jr. 1996. Spatial ecology of decapods and fishes in a northern Everglades wetland mosaic. Ph. D. dissertation, University of Florida, Gainesville, Florida. xi + 155 pp. [1998. Dissertation Abstracts International, 58B(7): 3429.]

Although this work studies interactions among crayfish, shrimp, small fishes, and dragonfly naiads, the author recognizes that applesnails are an important component of the aquatic macrofauna in the Everglades and that they comprise a common part of a consistent macrofaunal community resident in marshes of south Florida. Applesnails are not included in the lists of fauna from samples taken in Loxahatchee National Wildlife Refuge, but the lists seem to include only a selection of taxa captured.

Kale, H. W., II. 1977. Endangered species: Everglade kite. The Florida Naturalist, 50(4): 14-20.

This summary of the biology of the snail kite chronicles the reduction in wetlands available to the kite and the Florida applesnail in the 40 yr since Bent's (1937) description of habitat loss for these species. Among the reasons for decline of kite populations are: the inability of the snail to survive seasonal drying of a marsh; the need for a dried marsh to be "seeded" by snail populations from adjacent bodies of water; the complete dependence of the kite on the snail as food; the preference of snails for areas of open marsh, from which kites are prevented from nesting because of seasonally high air-boat traffic; increased difficulty in locating snails in areas with high coverage by floating water hyacinths. Fledgling kites might require a long apprenticeship with parents to learn how to capture and extract snails. The author's description of snail extraction includes the now-discredited view—advanced by Murphy & Amadon (1953) and Murphy (1955)—that the bird facilitates extraction by impaling a nerve, which causes the snail to relax.

Kale, H. W., II (editor). 1978. Rare and endangered biota of Florida. Vol. 2. Birds. University Presses of Florida, Gainesville, Florida. 121 pp.

The introduction to this volume uses the snail kite's dietary restriction to *Pomacea paludosa* as an example of how specialization can put a population of bird at risk. It is implied that kite populations decline with snail populations when drainage projects make hydrological conditions unfavorable. A somewhat different view is given in the second edition (Rodgers *et al.*, 1996). Additional information on *P. paludosa* is given in sections on the snail kite (Sykes, 1978) and limpkin (Nesbitt, 1978). For updates on these sections, see Rodgers (1996) and Bryan (1996), respectively.

Kale, H. W., II. & D. S. Maehr. 1990. Florida's birds: a handbook and reference. Pineapple Press, Sarasota, Florida. 288 pp.

This field guide includes standard material on the snail kite and limpkin. The authors link the distribution, abundance, migration, and aggregation of snail kites to the maintenance of natural water levels in marshes that support an abundance of applesnails. Capture and extraction of snails by kites are briefly described, and applesnails are stated to be the sole food of the kite. The limpkin's diet is less restricted but strongly dependent on applesnails as food.

Karrow, P. F., G. S. Morgan, R. W. Portell, E. Simons & K. Auffenberg. 1996. Middle Pleistocene (early Rancholabrean) vertebrates and associated marine and non-marine invertebrates from Oldsmar, Pinellas County, Florida. Pp. 97-133, in: K. M. Stewart & K. L. Seymour (eds.), Palaeoecology and palaeoenvironments of late Cenozoic mammals, tributes to the career of C. S. (Rufus) Churcher. University of Toronto Press, Toronto, Canada. 675 pp.

Pomacea paludosa is listed and illustrated from non-marine deposits of the Oldsmar 1 site, which has a high diversity of terrestrial and freshwater mollusks. Based on the faunal composition, the site is interpreted to be riverine or palustrine, with a variety of aquatic plants and a silty substratum.

Katz, C. 1996. The nature of Florida's waterways, including dragonflies, cattails and mangrove snapper. Atlantic Press, Melbourne Beach, Florida. 64 pp.

Profusely illustrated with the author's line drawings, this guide gives synopses of about 100 animals and plants associated with fresh- and saltwater habitats in Florida. A section on the limpkin briefly describes its preference for applesnails, extraction of the meat, and formation of shell middens.

Kern, R. 1987. Hidden worlds of the Big Cypress Swamp (Everglades). International Video Projects, Coral Gables, Florida. [videotape, 45 min]

This videotape about natural history of a swamp in south Florida includes footage on applesnail egg clusters attached to cattails, adult applesnails crawling, and a snail kite capturing a snail and bringing the extracted meat to nestlings. The narration states erroneously that applesnails are the only food of snail kites. Video segments from this tape and from Kern (1988a, b) also appear in three other video titles by Kern (Wild Florida; Wild Florida for children—the Everglades; Birds of the Everglades), but the latter include no new material on applesnails (R. Kern, 16 August 1995, personal communication).

Kern, R. 1988a. Down upon the Suwannee. International Video Projects, Coral Gables, Florida. [videotape, 45 min]

In this videotape on the natural history of wetlands and springs of the Suwannee River and its tributaries, three segments show Florida applesnails clinging to ("feeding on") submerged aquatic vegetation, dead shells tumbling in the flow of a spring like popcorn in a popper, and a limpkin capturing a snail.

Kern, R. 1988b. Wildlife adventure at Fisheating Creek. International Video Projects, Coral Gables, Florida. [videotape, 40 min]

A short segment of nocturnal oviposition by a Florida applesnail on a cypress knee (*Taxodium* sp.) is included in this videotape on the natural history of wetlands and woodlands along a south Florida creek that flows into Lake Okeechobee. The time-lapse segment shows the release of two eggs into a clutch.

King, R. L. (photographer). 1991. Apple snail laying eggs. Florida Wildlife, 45(6): 24.

This photograph of a Florida applesnail depositing a clutch of eggs on emergent vegetation (*Typha?*) won an honorable mention in the "Reptiles, amphibians, insects" category of the 1991 photographic contest held by the Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Kinkade, M. L. M. 1974. Behavior of cadmium in a simulated aquatic ecosystem. Ph. D. dissertation, Texas Woman's University, Denton, Texas. vi + 50 pp. [1976. Dissertation Abstracts International, 36B(9): 4331.]

The author attempts to simulate an aquatic ecosystem for four toxicological studies by combining several *Pomacea* (as "*Ampullaria*") *paludosa*, catfish [*Corydoras punctatus* (Bloch, 1794)], and guppies (*Poecilia reticulata* Peters, 1859) in 1- and 2-liter beakers, sometimes with two species of aquatic plant. Snails were obtained from an aquarium shop. In an attempt to establish minimal toxic levels, concentrations of cadmium-115 of 0.2 ppm had no noticeable effect on applesnails over 2 wk. Survival over 2 wk at 0.4, 0.6, and 0.8 ppm was 67, 27, and 13%, respectively. Snails did not survive 4 d exposure to 1.0 ppm ^{115}Cd. In a second study conducted over a 7-d period at 0.6 ppm ^{115}Cd, snails accumulated Cd steadily. The rate of uptake was high for kidney and the shell (perhaps by adsorption). Uptake by the gut seemed to occur rapidly for 2 d and to decline rapidly by 7 d, but the gut and its contents were not separated. Elimination of ^{115}Cd over 35 d was measured in a third study after a loading period of 1 wk at 0.1 ppm. Cadmium levels in the snail declined 37% within the first week, probably from loss by defecation. The slow loss of Cd over the remaining time gave a biological half-life of 115 d. A fourth study on the effect of water hardness on uptake of ^{115}Cd by applesnails is reported almost verbatim by Kinkade & Erdman (1975).

Kinkade, M. L. [M.] & H. E. Erdman. 1975. The influence of hardness components (Ca^{2+} and Mg^{2+}) in water on the uptake and concentration of cadmium in a simulated freshwater ecosystem. Environmental Research, 10(2): 308-313.

This study is part of Kinkade's (1974) doctoral dissertation. Florida applesnails (as "*Ampullaria paludosa*" and referred to as "infusoria snails") were exposed in combination with aquatic plants and fish to 0.1 ppm ^{115}Cd in hard and soft water for periods from 1 h to 21 d. Uptake of ^{115}Cd by snails was greater from hard water than from soft water in the first 12 h; total accumulation plateaued after several days at a higher level from soft than from hard water, although the means for the two treatments did not differ statistically on most days.

Klinkenberg, M. & E. Leach. 1993. Natural wonders of Florida: a guide to parks, preserves and wild places. Country Roads Press, Castine, Maine. 189 pp.

Not simply a guide, this book includes travelogs and observations of natural history made by the authors, although the frequent lapse into first-person singular probably indicates the experiences of Klinkenberg. Many sites described in this guide hold populations of applesnails, but references to the snails (as sole food of the snail kite) are made only in two sections about the Everglades. This book was released also under the title "The green guide, Florida: a travel guide to natural wonders" with the same date and publisher.

Kloor, K. 1999. Vanishing act: is the law that protects endangered species itself endangered? The Sciences, 39(5): 14-17.

This article discusses the shift from a single-species approach in conservation to a holistic approach. Cyclical hydrological management for snail kites and applesnails on the one hand and for wood storks on the other is given as an example of a multi-species or ecosystem approach to habitat management.

Knorr, G. W. 1771. Vergnügen der Augen und des Gemüths: in Vorstellung einer allgemeinen Sammlung von Schnecken und Muscheln, welche im Meer gefunden werden. Vol. 5. G. W. Knorr, Nuremberg, Germany. 46 pp. + 30 pls.

Color plate 5, figure 2 is of the shell of a species called Ochsenaugen (= "bulls-eyes"). According to Swainson (1820-1823), this is a specimen of *Ampullaria reflexa* with the periostracum removed. The shell appears with very dark early whorls, followed by an axially striped body whorl with four close spiral threads (or stripes) just above the periphery, and an unchanneled suture; but the figure is so artistically stylized that it is impossible to argue or agree with Swainson's judgment. The nomenclatural relationship between *A. reflexa* and *Pomacea paludosa* is presently unclear (**Turner *et al.*, 2001; Cowie & Thiengo, 2003**).

Kobelt, W. 1915 [1911-1914]. Die Gattung Ampullaria. Neue Folge. In Abbildungen nach der Natur mit Beschreibungen. Pp. 1-236, color pls. 22-79, in: H. C. Küster & W. Kobelt, Systematisches Conchylien-Cabinet von Martini und Chemnitz. Neue Folge. Vol. 1, pt. 20. Bauer & Raspe (Emil Küster), Nuremberg.

Ampullaria paludosa is treated and figured. *A. reflexa*, *A. livescens* Reeve, 1856, *A. venetus* Reeve, 1856, and *A. hopetonensis* are also treated, all as subspecies of *A. paludosa*. *A. yucatanensis* Crosse and Fischer, 1890, which was considered a variety of *A. hopetonensis* by Sowerby (1909), is given full species rank. Although the cover page is dated 1915, **Johnson (1968)** gives 1911-1915 as the proper citation for this part; and **Cowie & Thiengo (2003)** give 1911-1914 and list the dates of publication for each of the 30 signatures that comprise the final document.

Kolipinski, M. C. & A. L. Higer. 1969. Effects of mineralized artesian water on the fresh-water biota of Taylor Slough, Everglades National Park, Florida. Open-file report. United States Department of the Interior, United States Geological Survey, Water Resources Division, Tallahassee, Florida. 39 pp.

This study examined the short-term effects of artesian water from the Floridan aquifer on selected plants and animals near the Royal Palm Visitor Center to evaluate the potential of using well water to flood wetlands during seasonal droughts. Chlorinity of the well water was about 200 times that of surface water of Taylor Slough, and salinity was about 15% that of sea water. Freshly drawn well water was anoxic; dissolved oxygen under experimental conditions was 4.0-8.5 mg/L; the concentration of hydrogen sulfide was 2-3 times that of surface water, based on our estimation from fig. 4. All *Pomacea paludosa* survived 48 h exposure to artesian water in laboratory aquaria; but it is not clear whether there were four applesnails in the experimental group alone or four total in the experimental and control groups.

Kourí, P. 1946. El hallazgo de furcocercarias en "*Drepanotrema lucidum*": nota previa. Revista de la Sociedad Malacológica "Carlos de la Torre", 4(3): 93-94.

During an expedition to the city of Pinar del Río, Cuba, surveying the occurrence of trematode infection in five species of aquatic and terrestrial snails, only one specimen of *Pomacea paludosa* was collected; and it was uninfected.

Kurtz, E. M. 1974. An ultrastructural study of the albumen gland in the freshwater snail, *Pomacea paludosa*, with special attention to the development of calcium spherules. M. S. thesis, University of South Carolina, Columbia, South Carolina. vi + 98 pp.

As in other studies from the laboratory of N. Watabe (*e. g.*, Meenakshi *et al.*, 1974; Meenakshi & Watabe, 1977), snails referred to in this thesis as *Pomacea paludosa* were purchased from an aquarium shop in Columbia, South Carolina. The only internal evidence for the identity of the species is the hatching of 225 juveniles from one clutch of eggs (p. 14). The large clutch size is strong evidence that the animals were not *P. paludosa*.

Kushlan, J. A. 1974. The ecology of the white ibis in southern Florida, a regional study. Ph. D. dissertation, University of Miami, Coral Gables, Florida. xii + 129 pp. [1975. Dissertation Abstracts International, 35B(12): 5854.]

This study deals primarily with population biology, sexual dimorphism, breeding, feeding, and energetics. Florida applesnails, 1 of 60 species of prey, are consumed whole and might, therefore, have a size refuge from predation by ibises. Caloric value of applesnails is 1.17 kcal/g dry weight, but it is not clear if the shell is included. Ibises forage in water 5-10 cm deep (maximally 25 cm) and require falling water levels to concentrate aquatic food during the nesting season.

Kushlan, J. A. 1975. Population changes of the apple snail, *Pomacea paludosa*, in the southern Everglades. The Nautilus, 89(1): 21-23.

Pomacea paludosa was sampled at undefined locations in Everglades National Park monthly for 6 yr using pull-up traps in sawgrass marsh and mixed-marsh prairie. Snail density and biomass were directly related to constancy of water level, and individual fresh weight was inversely related. Without the support of experimental evidence, the author attributes high density and biomass during years of constantly high water to improved success in juvenile recruitment; increased individual size in years of fluctuating water level is attributed to greater drought resistance of large snails.

Kushlan, J. A. 1978. Predation on apple snail eggs (*Pomacea*). The Nautilus, 92(1): 57-58.

Observations on consumption of the eggs of *Pomacea paludosa* by one individual of the coneheaded grasshopper [*Neoconocephalus triops* (Linnaeus, 1758), Tettigoniidae] are presented. Consumption occurred during the early stages of egg development, which are known to be distasteful to vertebrates. The method of gaining entry to the eggs by the grasshopper was not observed. The author suggests that although the conspicuousness of *Pomacea* eggs may serve an aposematic function in vertebrates (citing observations on the bluegill, *Lepomis macrochirus* Rafinesque, 1819, and previous studies), this might not be true for invertebrates. Size of the eggs might be the most important protective factor against invertebrates in the snail's marsh habitat.

Kushlan, J. A. 1983. Everglades kite recovery plan. Florida Field Naturalist, 11(4): 117-119.

This strongly critical review of USDI (1983) [cited here as Martin *et al.* (1983)] notes that too little research has been done on the snail kite's main prey, *Pomacea paludosa*.

Kushlan, J. A. 1990a. The Everglades. Pp. 121-142, in: R. J. Livingston (ed.), The rivers of Florida. Springer-Verlag, New York. 289 pp.

This commentary and review of literature on the Everglades attributes drought resistance of the Florida applesnail to its survival in pools of deeper water.

Kushlan, J. A. 1990b. Freshwater marshes. Pp. 324-363, in: R. L. Myers & J. J. Ewel (eds.), Ecosystems of Florida. University of Central Florida Press, Orlando, Florida. 765 pp.

This review of ecology of Florida freshwater marshes mentions *Pomacea paludosa* as one of a few important invertebrates in the food chains. Its requirement of high water levels for survival indirectly impacts the snail kite, one of its predators.

Kushlan, J. A. & M. S. Kushlan. 1975. Food of the white ibis in southern Florida. Florida Field Naturalist, 3(2): 31-38.

This study of dietary items in regurgitation samples from white ibis nestlings includes some stomach samples from adults. *Pomacea paludosa* comprised 5.28% of the diet by dry weight and was found in 8% of samples from inland locations. Occurrence in coastal samples was negligible. At inland sites, ibises fed mostly in open vegetated areas, in shallow waters, and along edges of habitats, frequently probing for animals that live among aquatic plants.

Kushlan, J. A., S. A. Voorhees, W. F. Loftus & P. C. Frohring. 1986. Length, mass, and calorific relationships of Everglades animals. Florida Scientist, 49(2): 65-79 & 49(4): 268.

This paper fits linear and gravimetric measurements of 52 species of Everglades fish and invertebrates to a parabolic curve for potential use in estimating standing stock and energy flow. Calorific values are tabulated. Specimens were collected by many techniques, but few, if any, would take a representative sample of *Pomacea paludosa*. Longest opercular axis was measured in 39 formaldehyde-fixed, alcohol-preserved applesnails, as were wet and oven-dried weights of soft parts. Opercular lengths ranged from 13 mm to 32 mm and wet weights from 0.83 g to 12 g. No data are given for dry weights. The authors fail to define terms of the equation used for one table, but it appears that wet weight increased as a power of 2.864 of the opercular length. Calorific value was 1.17 kcal/g dry weight, which included the shell despite earlier reference to measurement of soft parts. This paper should not be used without reference to errata published on p. 268 of the journal.

Lachner, E. A., C. R. Robins & W. R. Courtenay, Jr. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smithsonian Contributions to Zoology, no. 59: 1-29.

Although not discussed under the subheading "The Florida travesty," *Marisa cornuarietis* is given as an example of an exotic introduction in North America. This South American snail is expected to compete for food with *Pomacea paludosa* in southern Florida. Because of its planorbiform shell, the authors suspect that it would be unsuitable as a substitute for applesnails in the diet of the snail kite.

Lahart, D. 1973. Florida's endangered dozen. Florida Wildlife, 26(9): 15-22.

Restriction of the diet of snail kites to applesnails is viewed as "overspecialization", whereby "evolution may have condemned [the snail kite] to extinction." The author states that habitat loss and reduced water quality decrease the availability of the snail for the kite. The caption of a photograph includes the prediction, "When snails go, so does this bird."

Lamont, T. & W. Reichel. 1970. Organochlorine pesticide residues in whooping cranes and Everglade kites. The Auk, 87(1): 158-159.

Soft parts of 30 specimens of *Pomacea paludosa* from Loxahatchee National Wildlife Refuge were analyzed by gas chromatography for residues of the pesticides DDE, DDD, DDT, and dieldrin. Three whooping cranes (two adults, one embryo) [*Grus americana* (Linnaeus, 1758)], two snail kites (one adult, one nestling) (brain, liver, breast muscle for both bird species), and one kite egg were also analyzed. All values were low and corresponded to the background contamination of the habitat. The levels in the snail kites corresponded to those in the applesnails.

Lantz, P. S. & W. A. Hale. 1994. The young naturalist's guide to Florida. Pineapple Press, Sarasota, Florida. 183 pp.

This children's book covers wildlife, plants, and habitats in Florida. In a line drawing of a wetlands food web, two applesnails crawl along a fallen branch out of water in daytime. Accompanying text explains that applesnails eat aquatic plants and are prey to the snail kite. An illustration in a chapter on raptors depicts a perched snail kite preparing to extract an applesnail from its shell, and the specialization of its bill for this purpose is described.

Larson, R. 1995. Swamp song: a natural history of Florida's swamps. University Press of Florida, Gainesville, Florida. 214 pp.

Light reading, non-technical but informative, this book describes the types of Florida wetlands—with travelog-style descriptions of examples—and their fauna and flora. Excellent but sparse illustrations are provided in several media. A brief review of the biology of *Pomacea paludosa* is given in three paragraphs and records their use as food by Calusa Indians in south Florida. The author writes his own observations of "a male limpkin feeding its mate a seemingly endless supply of golf-ball-sized apple snails."

Lauber, P. 1973. Everglades country: a question of life or death. Viking Press, New York. 125 pp.

Limpkins and snail kites are avian predators of the Florida applesnail. The snail is listed among several animal species that burrow into the sediment to avoid desiccation during drought; but hatchling snails are claimed not to survive. Drought affects foraging by the kite because buried snails are inaccessible and because the success of snail reproduction declines. Capture and extraction of the snail by the kite are described. A photograph illustrates a juvenile kite with the shell of an applesnail in its beak.

Laycock, G. 1969. America's endangered wildlife. Grosset & Dunlap, Inc., New York. 226 pp.

The author attributes decline of the snail kite to drainage, drought, and fire in the territory of *Pomacea paludosa*, the "large, dark-shelled pomacea snails" on which the kite "monotonously" feeds. The kite is given as an example of an animal "too specialized for its own good." A photograph shows four live snails and a clutch of snail eggs.

Lea, I. 1834a. Observations on the Naiades; and descriptions of new species of that, and other families. [Third supplement. Read before the American Philosophical Society, April 18th, 1834.] Transactions of the American Philosophical Society, New Series, 5: 114-119, pl. 19.

Clench & Turner (1956) record this work as the first dealing with southeastern United States freshwater mollusks. It includes the original description of *Ampullaria hopetonensis*, with a figure (pl. 19, fig. 84), from Hopeton, near Darien, Georgia. This species is described as less globose and flatter at the sides and shoulder of the whorls than *Pomacea* (as "*Ampullaria*") *paludosa*, of which it is now considered a synonym.

Lea, I. 1834b. Observations on the genus *Unio*, together with descriptions of new genera and species in the families Naiades, Conchae, Colimacea, Lymnaeana, Melaniana and Peristomiana: consisting of four memoirs read before the American Philosophical Society from 1827 to 1834, and originally published in their transactions. I. Lea, Philadelphia. 231 pp., 19 pls.

This work includes reprints of Lea (1834a) and related articles. The description of *Ampullaria hopetonensis* appears on pp. 227-228 and in plate 19, figure 84.

Lee, H. G. 1978. Mollusks and the media. Shell-O-Gram [Jacksonville Shell Club, Jacksonville, Florida], 19: 3-4. [January]

This popular article summarizes a report from the Florida Times-Union [not seen] telling of plans for *Pomacea*-breeding impoundments in Loxahatchee National Wildlife Refuge. The snails would be raised to feed the dwindling population of snail kites, especially during periods of drought. This note was reprinted slightly modified in 1981 in Hawaiian Shell News, 29(6): 6.

Lee, H. G. 1998. Checklist of northeast Florida aquatic mollusks. Shell-O-Gram [Jacksonville Shell Club, Jacksonville, Florida], 39(1): 4-5.

Pomacea paludosa is listed and figured among freshwater snails collected from Nassau, Duval, Clay, and St. Johns counties by the author from 1975 to "present".

Leedom, W. S. 1979. A new dermatitis-producing schistosome cercaria from the Florida apple snail, *Pomacea paludosa*, with a list of described freshwater schistosome cercariae of the world. M. S. thesis, Florida State University, Tallahassee, Florida. vii + 59 pp.

Most of the data in this study were published by Leedom & Short (1981), but the thesis describes the methodology in greater detail. In describing experimental exposure of humans and laboratory animals to cultures of newly emerged cercariae, the author does not give the degree to which cultures contained non-schistosome cercariae, which infected the snail population at three times the frequency of schistosomes. Photographs of cercariae are included. The list documents the rarity of freshwater prosobranchs as intermediate hosts; *Pomacea glauca* (Linné, 1758) is the only other member of the genus listed.

Leedom, W. S. & R. B. Short. 1981. *Cercaria pomaceae* sp. n., a dermatitis-producing schistosome cercaria from *Pomacea paludosa*, the Florida apple snail. Journal of Parasitology, 67(2): 257-261.

This paper describes as a new species one of several trematode cercariae from *Pomacea paludosa*. The new species infected 2.6% (n = 1434) of the applesnail population in a part of Lake Okeechobee. Infection rate with other non-schistosome cercariae was 9.2%. An unspecified number of human volunteers developed dermatitis from clinical exposure to cercariae shed by *P. paludosa*. The authors were unable to harvest adult worms from several laboratory mammals and birds exposed to cercariae, nor did they find worms or eggs in organs and feces of seven species of field-collected bird. Snail kites were not examined. Based on the presence of eyespots and furcal finfolds, the authors suspect the cercaria to belong to an avian schistosome. For additional details on methodology and photographs of cercariae, see Leedom (1979).

Levin, T. 1994. Cuba's sea of grass. Audubon, 96(2): 18, 20.

This travelog is a description of plants and animals encountered on a day's journey through the Zapata Swamp, Cuba, an ecosystem similar to the Florida Everglades. Among the sights that reminded the author of the Everglades was the presence of applesnail eggs on stems of emergent plants.

Levin, T. 1996. Immersed in the Everglades. Sierra, 81(3): 56-63, 86-87.

In this popular article about the biological effects of natural variation in hydroperiod, disruption of hydroperiod by water-management techniques, and recent and planned attempts to restore the Everglades, the author poetically states that snail kites "troll for snails" during wet periods.

Levin, T. 1998. Listening to wildlife in the Everglades: what five species are telling scientists about habitat damage and repair in south Florida. National Wildlife, 36(4): 20-31.

Shark River Slough is one area of the Everglades severely impacted by water-management practices of the 1900s. The author believes that, if anticipated changes in these practices are made in the current restoration effort, flooding of the slough should increase the density of applesnails, food for the snail kite and American alligator.

Lewin, T. 1976. World within a world—Everglades. Dodd, Mead & Co., New York. 64 pp., 27 illus.

This book is a popular fictitious account of a day's trip through the Everglades based on the author's years of natural-history study and laced with a few anecdotes. The author describes an area of soggy ground within which applesnails find refuge from drought. Limpkins are mentioned as predators. A drawing of an applesnail shell from apical view could be mistaken as the planospiral shell of the cohabiting exotic snail *Marisa cornuarietis*.

Little, C. 1968. Aestivation and ionic regulation in two species of *Pomacea* (Gastropoda, Prosobranchia). Journal of Experimental Biology, 48(3): 569-585.

The author studied reno-vascular physiology during aestivation and recovery in *Pomacea lineata* and conducted a few analyses on *P. paludosa* (as "*P. depressa*"). Normal (unstressed) values are given for haemolymph concentrations of Na^+, K^+, Ca^{2+}, HCO_3^-, Cl^-, and uric acid, haemolymph osmotic pressure, and total weights and concentrations of uric acid in the posterior and anterior chambers of the kidney and in the lung. Haemolymph osmotic pressure was higher in *P. paludosa* than in *P. lineata*, primarily because of higher chloride concentration. Although no data are provided, the mortality rate of *P. paludosa* during aestivation was higher than that of *P. lineata*, and the author attributes the difference to a poorer fit of the operculum to the aperture of *P. paludosa*. Normal values for uric acid in *P. paludosa* are inappropriately used (table 8) as controls for comparison with experimental data from *P. lineata*. None of the author's major conclusions are derived from data on *P. paludosa*.

Little, J. A., R. F. Schneider & B. J. Carroll. 1970. A synoptic survey of limnological characteristics of the Big Cypress Swamp, Florida. United States Department of the Interior, Federal Water Quality Administration, Southeast Region, Southeast Water Laboratory, Technical Services Program. 94 pp., appendices A-D.

The results are reported of a month-long study at 34 stations sampled for physical, chemical, and biological parameters in Big Cypress Swamp during the dry season. Applesnails (as "*Pomacea* sp." and "*P. caliginosa*") were collected at two stations: a deep vertical-sided drainage canal (84 snails/m^2) and a nearby sawgrass marsh. Clutches of eggs were found at many stations, and body shells were found at all stations. The authors express concern about the anticipated effects of increasing chloride concentration and drainage on the applesnail population.

Lodge, T. E. 1994. The Everglades handbook: understanding the ecosystem. St. Lucie Press, Delray Beach, Florida. 228 pp.

This comprehensive book about the geological history, habitats, wildlife, and management issues of the Florida Everglades is short and very readable. Two sections provide brief descriptions of the Florida applesnail and of the foraging habits of the snail kite. The applesnail is recognized as an important link in the Everglades food web. It is claimed to feed on periphyton, and predation on juvenile snails by redear sunfish is mentioned. A personal communication from Earl Rich states that applesnails can aestivate up to 4 mo in sediments, thereby surviving drought in marl prairies of short hydroperiod as well as habitats of longer hydroperiod. High densities of snails on the windward side of shores and of dense stands of emergent vegetation are attributed to the wind-drift of neustonic juveniles clinging to the surface of the water. Two photographs illustrate the adult snail shell with an egg clutch and a limpkin grasping an adult snail.

Loftis, R. L. & M. S. Douglas. 1988. Forty more years of crisis. Pp. 391-427, in: M. S. Douglas, The Everglades: river of grass, revised edition. Pineapple Press, Sarasota, Florida. 448 pp.

Chapter 16 is an afterword that is new in this special edition and appears also in the fiftieth anniversary edition (1997, Pineapple Press). It has the only mention of the Florida applesnail, an important Everglades animal neglected in earlier editions (**Douglas, 1947**). The snail is erroneously compared in maximal size to a United States quarter dollar coin (24.4 mm diameter). See annotations of Beissinger (1984) for size ranges in middens of snail kites and Moore (1892-1893) for sizes in Indian mounds and museum holdings.

Loftus, W. F., J. D. Chapman & R. Conrow. 1990. Hydroperiod effects on Everglades marsh food webs, with relation to marsh restoration efforts. Pp. 1-22, in: G. Larson & M. Soukup (eds.), Conference on science in the national parks 1986, proceedings volume 6, fisheries and coastal wetlands research. The fourth conference on research in the national parks and equivalent reserves, July 13-18, 1986, Colorado State University, Fort Collins, Colorado. The George Wright Society, Hancock, Michigan, & United States National Park Service, Washington, D. C. iii + 184 pp.

Although no collection data are given for the Florida applesnail and conclusions of the paper cannot be applied to this species, the authors mention that applesnails are more accurately and easily sampled by use of throw traps than by a multiple-coring device, by a multiple-funnel trap, or by volumetric sampling of the periphyton-*Utricularia* mat complex. This study has been cited incorrectly as "1986" by some authors.

Loftus, W. F., R. A. Johnson & G. H. Anderson. 1992. Ecological impacts of the reduction of groundwater levels in short-hydroperiod marshes of the Everglades. Pp. 199-208, in: J. A. Stanford & J. J. Simons (eds.), Proceedings of the first international conference on ground water ecology. American Water Resources Association, Bethesda, Maryland. 419 pp.

Florida applesnails were among several macroinvertebrates caught in minnow traps placed in deep solution cavities during the dry season in the Rockland marshes of the eastern Everglades. The authors suggest that the karst topography of the Miami oolitic limestone bedrock serves as a link between use of the surface water and ground water during wet and dry seasons, respectively, by aquatic fauna of the short-hydroperiod marsh. Use of solution cavities as refuges during the dry season is dependent on proper water-management practices that maintain groundwater levels.

Loftus, W. F., J. C. Trexler & R. D. Jones. 1998. Mercury transfer through an Everglades aquatic food web. Final report, contract SP-329, to Florida

Department of Environmental Protection [Tallahassee, Florida]. xiv + 276 pp. [irregularly paginated]

Snails often were found in the stomachs of fish sampled in Shark Slough, Everglades National Park, but none was identifiable as *Pomacea paludosa*, which "normally exceeded the gape of the redear [sunfish]." Maximal standard length of redear sunfish taken in this study was 164 mm. Florida applesnails were, however, included among the fauna collected from the slough for mercury analysis. Mean concentration of mercury in applesnails was 19.26 ng/g wet weight. The authors consider this value low and within an expected range for a grazer or detritivore.

Longstreet, R. J. 1965. Birds in Florida. Trend House, Tampa, Florida. 176 pp., 32 color pls.

Material on the Florida applesnail in the section on the boat-tailed grackle is identical to that in earlier editions (Writer's Program, Work Projects Administration in the State of Florida, 1942; [Florida Department of Agriculture], 1951), but the section on the snail kite was omitted because it "is a bird rare indeed here." This fourth edition was republished with minor changes in 1969.

Lowenstam, H. A. 1981. Minerals formed by organisms. Science (Washington, D. C.), 211(4487): 1126-1131.

This review article summarizes much information on calcium carbonate in snail shell, eggshell, and soft parts of purported *Pomacea paludosa* based on studies of Watabe *et al.* (1976; dated erroneously by Lowenstam as "1974").

Malek, E. A. & T. C. Cheng. 1974. Medical and economic malacology. Academic Press, New York. x + 398 pp.

In a chapter on gastropod systematics (including the role of various species as hosts for human parasites), characteristics of the family Ampullariidae (as "Pilidae") and its included genera are described in general terms. Host capacities are listed in this family only for species of *Pila* and *Marisa*. *Pomacea paludosa* is mentioned as occurring in Georgia and Florida; shells from Louisiana and Florida are figured in a black-and-white photograph.

Martens, E. v. 1857. Die Ampullarien des Berliner Museums. Malakozoologische Blätter, 4: 181-213.

This list of ampullariid species in holdings of the Berlin Museum mentions that *Ampullaria hopetonensis* is the northernmost species of *Ampullaria*. The species *A. depressa* and *A. paludosa* are listed as synonyms of *A. hopetonensis*, disregarding the priority of Say's names [see Binney (1865)]. The species *A. caliginosa* and *A. notabilis* Reeve, 1856 are listed separately as valid. The species *A. rotundata* is listed as a synonym of *A. globosa*, "introduced?" to Florida. The introductory paragraph includes a rather strong critique of Reeve (1856), which is called merely a "picture-book" ("Bilderwerk") for use by collectors.

Martin, T. W. 1973 [1974]. Management for the Everglade kite (*Rostrhamus sociabilis plumbeus*). Report of refuge management study, progress report no. 2, [United States Department of the Interior, United States Fish and Wildlife Service, Loxahatchee National Wildlife Refuge, Delray Beach, Florida]. 27 pp., 28 exhibits.

Although dated "1973" in its heading, this report includes data from a study conducted in 1974 (Martin [1975]) and contains internal reference to another 1974 study. Despite its title, the report contains much data on *Pomacea paludosa*. From one study conducted in large tanks, the author concludes that bladderwort (*Utricularia* sp.) grown with fertilizer results in higher growth rates of hatchling applesnails than does unfertilized bladderwort; that fertilized cultures of phytoplankton give a poor growth rate; and that aeration of the tanks has no effect on growth rate. After 11 wk of eating fertilized bladderwort, hatchling snails attained average shell dimensions of 43.8 mm and 39.4 mm (along axes that are unclearly described in the text) and began laying eggs. The author states that snails prefer bladderwort and suspects that they graze heavily on plant detritus. In a second study of clutch production along transects in the refuge [extending results reported by Martin & Doebel (1974)], oviposition was often found to be bimodal, with a higher peak in March-April and a lower peak in August-September. Low clutch production along canals is attributed to application of herbicides and insecticides nearby. In a third study, snails captured in Lake Pansoffkee were released in the refuge or held in cages. Values for clutch production and mortality among animals caged for 1 mo were used to estimate mortality of released snails from clutch data for the refuge. Having calculated that 100% of released snails died, the author proposes studies of predation by turtles, alligators, fish, and crayfish and recommends immediate initiation of a program to control potential predators of applesnails by removal and exclusion of predators and by stocking the refuge with snails. A bibliography on applesnails, included as attachment 2 of Martin [1975], is missing from our copy of the report.

Martin, T. W. [1975.] South Florida National Wildlife Refuges, Loxahatchee National Wildlife Refuge, narrative report, FY 1974. United States Department of the Interior, United States Fish and Wildlife Service, Loxahatchee National Wildlife Refuge, Delray Beach, Florida. [iii] + 17 pp., attachments.

Our copy of this report from refuge files is undated, but internal evidence indicates that it must have been issued in 1975. Three attachments, dated as early as September 1974 in their headings, bear signature dates of 15

January 1975. The attachments propose studies of growth of and predation on the Florida applesnail at the refuge. The cover of the document has an excellent photograph of a female snail depositing a clutch of eggs. The author expresses concern that much information needed for proper management of the applesnail is unknown. The snail is believed to be eliminated from waters that become infested with water lettuce and water hyacinth. Based on an earlier study by the author, the pesticide 2, 4-D is claimed to be "innocuous" to applesnails. Further data from the feeding study by Martin (1973 [1974]) are given here: snails fed fertilized bladderwort laid eggs 2 wk sooner and laid eight times the number of eggs in 7 wk than did snails fed unfertilized bladderwort. The author cautions that airboat use results in mechanical damage to clutches of applesnail eggs. Sections of the report are critical of the United States Fish and Wildlife Service, duck hunters, Florida Power and Light Company, and the practice of deer hunting by airboat.

Martin, T. W. & J. H. Doebel. 1974. Management techniques for the Everglade kite: preliminary report. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners, 27: 225-236.

This paper describes the approaches to managing Loxahatchee National Wildlife Refuge for the snail kite and studies conducted or planned on the Florida applesnail. A cutting machine was used to control the density of emergent plants to levels presumed to be favorable for foraging by snail kites, for oviposition by applesnails, and for maintenance of submerged plants, presumably as food for snails. Results of surveys for egg clutches along transects in the refuge are tabulated but unanalyzed [but see Martin (1973) [1974]]. Transplantation of 4800 snails from Lake Pansoffkee is stated to have had no effect on clutch densities (data not provided). Only 2 applesnails were found in 20 quadrats sampled by emplacement of an open-ended 55-gallon drum, whereas 98 were caught from 1 such quadrat at a site in Lake Okeechobee with clutch densities 25 times those found on the refuge. Methods for other laboratory and field studies are described, but results are not given.

Mason, W. T., Jr. 1991. A survey of benthic invertebrates in the Suwannee River, Florida. Environmental Monitoring and Assessment, 16(2): 163-187.

This quantitative study was undertaken to assess potential prey of the Gulf sturgeon, to provide a basis for estimating human and natural disturbances, and to test and improve methods of benthic sampling in the middle and lower parts of the Suwannee River. Egg clutches of *Pomacea paludosa* were found on emergent structures at four locations in the lower part of the river. Available data indicate that the river waters are less acidic here than farther upstream. The Florida applesnail is given a "quality value" of 4 out of 10, with tolerance to organic pollution ranging from 0 (least tolerant) to 10 (most tolerant). Origin of the quality value is not given.

Mason, W. T., Jr., R. A. Mattson & J. H. Epler. 1994. Benthic invertebrates and allied macrofauna in the Suwannee River and estuary ecosystem, Florida. Florida Scientist, 57(4): 141-160.

Pomacea paludosa is included among 707 invertebrate taxa from the Suwannee River, Florida.

Matthiessen, P. 1959. Wildlife in America. The Viking Press, New York. 304 pp.

The snail kite is referred to as "sadly over-specialized" because of its dietary restriction to the Florida applesnail, called the "freshwater moon snail, *Pomacea caliginosus*." This popular book has subsequently been reprinted by a number of publishers but retains its original title.

May, J. B. 1935. The hawks of North America: their field identification and feeding habits. The National Association of Audubon Societies, New York. xxxiv + 140 pp., 37 figs., 4 pls., maps.

The snail kite is listed among several hawks in danger of extirpation from the United States and Canada, and its status is attributed to its specialized diet of feeding on applesnails (as "*Ampullaria*") and to the drainage of marshes. The author gives the following as part of his rationale for recommending "complete protection" of the kite: "As the snails upon which it feeds have no known value to man, the Everglade Kite has no economic claim for consideration ..." The description of predation of the kite on the snail draws almost entirely from the erroneous observations of **Lang (1924)** for kites in British Guiana, with the added presumption that the snail muscularly detaches itself from the shell in response to impalement by the kite's bill. An accompanying painting shows a pair of kites and a juvenile with empty snail shells on the ground; the juvenile is standing on the ground and examining an empty shell held in its talons.

Maynard, C. J. 1873. Blue kite—Everglade kite. The American Sportsman, 3(12): 181.

This account of travel by the author in the winter of 1870 (Baird, 1875) or 1871 (Maynard, 1879) is largely repetitious of Maynard (1879) (including observations of applesnails), but it might be more readily available than the rare volumes that the author published on Florida and eastern North American birds. Although it includes an otherwise unpublished account of a day's (3 March) successful journey with his wife to shoot a snail kite, it contains no new information on the Florida applesnail.

Maynard, C. J. 1879. The birds of eastern North America: with original descriptions of all the species which occur east of the Mississippi River between the Arctic Circle and the Gulf of Mexico, with full notes upon their habits, etc. C. J. Maynard & Co., Newtonville, Massachusetts. 532 pp., 32 pls. [issued in 16 parts]

Maynard's first sighting of a snail kite was of one carrying a Florida applesnail ("*Pomus depressa* of Say") in its talons. During his trip to the Everglades in the early 1870s, Maynard observed kites capturing snails, found middens of snail shells and other shells floating on the water, and found the snails in the stomachs of all captured kites. He describes the applesnail as "only a few years ago, considered quite rare" and its shell as "about two inches in diameter, and dark, glossy green." Maynard recognized that the talons and bill of the kite are adapted for capture and extraction of the snail. He notes that some snail shells were punctured by the bill. Maynard never saw a live snail during his visits but found freshly killed snails on a dry marsh after a fire. The eggs of the snail were "about the size of those of the Humming Bird" and began appearing in "bunches" on sawgrass soon after 18 February, eventually occurring in the "millions". Maynard reports the Seminole name for applesnails as "Shal-ly-bung-kar" and that of its eggs as "Shal-ly-bung-kar sos-ta-kar." In the preface of the present version, Maynard describes the early checkered publication history of this work, beginning with issue of parts 1 (1872) and 2 (1873) by the Naturalists' Agency, Salem, Massachusetts, under the title "The birds of Florida: containing original descriptions of upwards of two hundred and fifty species, with notes upon their habits, etc." We consulted incomplete holdings of parts and editions issued in 1872-1874, 1879, and 1886 at American Museum of Natural History and Rollins College; intermediate and later editions exist. Based on those available to us and on Maynard (1873), information on the Florida applesnail does not differ.

McAtee, W. L. 1918. Food habits of the mallard ducks of the United States. U. S. Department of Agriculture Bulletin, no. 720: 1-35, frontispiece.

Of three anatine duck species studied, the mallard (*Anas platyrhynchos* Linnaeus, 1758)(1725 stomachs examined) consumed the highest proportion (91% of diet) of plant matter and the smallest proportion (6% of diet) of mollusks. *Pomacea* sp. was found in three stomachs. Florida ranked fifth among states in the number of mallards examined in this study. The American black duck (622 stomachs examined; unknown contribution from its limited range in Florida) consumed less plant matter (76% of diet), a larger proportion of mollusks (12%), and no *Pomacea*. Florida specimens were well represented in the 51 samples of mottled ducks (*Anas fulvigula* Ridgway, 1874, as "southern black duck"); although much less vegetarian (59% of diet) and more predominately molluskivorous (27%), no *Pomacea* were found in its diet.

McC[abe], T. T. 1939. Food of some uncommon American birds. Bird-Banding, 10(3): 140.

This review of Cottam & Knappen (1939) refers to dietary specialization of the snail kite as a "paradox" and lauds the authors for substantiating that the kite is a specialist predator of applesnails.

McClary, A. 1962. Surface behavior of the gastropod, *Pomacea* (*Ampullaria*) *paludosa*. American Zoologist, 2(4): 539. [abstract]

This presentation at the 1962 annual meeting of the American Society of Zoologists was published in full in McClary (1964).

McClary, A. 1963. Statolith formation in *Pomacea paludosa* (Say). The American Malacological Union, Annual Reports for 1963, Bulletin, no. 30: 20-21. [abstract]

Statocysts are associated with the pedal ganglia and lie within connective tissue that contains calcium-rich spherules. High amounts of calcium were also found in the walls and statoliths of statocysts. Information on morphology, number, and size of statoliths was published in full in McClary (1968b).

McClary, A. 1964. Surface inspiration and ciliary feeding in *Pomacea paludosa* (Prosobranchia: Mesogastropoda: Ampullariidae). Malacologia, 2(1): 87-104.

This is a behavioral study of aerial gas exchange and ciliary feeding by applesnails and of factors stimulating and repressing these activities. Factors studied in surface inspiration included lung volume, tactile stimulation of the tentacles and siphon, dissolved nutrients and irritants, water temperature, suspended particles, starvation, food in the surface film, lack of access to the surface, and dissolved and atmospheric oxygen concentration. Surface inspiration was accomplished by repeated contraction of the body. Several of the factors listed above were also used to study ciliary feeding at the surface. By far, the presence of food particles at the surface was the major stimulus to initiate this behavior, which the author otherwise observed to occur infrequently in aquaria. Although purportedly *Pomacea paludosa*, the specimens were purchased from a Wisconsin aquarium shop, thereby making the identification questionable.

McClary, A. 1966. Statocyst function in *Pomacea paludosa* (Mesogastropoda: Ampullariidae). Malacologia, 3(3): 419-431.

Unilateral and bilateral removal of statocysts had no interpretable effects on behavior of applesnails. The author studied the pattern of behavior leading to, during, and following surface inspiration, ciliary feeding at the surface of the water, activity level, occurrence on horizontal and vertical surfaces, rate and direction of locomotion, and righting response. Effects of surgery were determined by use of sham-operated controls. The author attributes some differences between this study and prior work on other gastropods to surgical damage in prior works and other differences to insufficient recovery in the present study. The author discusses several mechanisms for vertical movement of applesnails in the absence of statocysts and dismisses all but the buoyant effect of gas in the lung. Refer to the cautionary statement about species identification in the annotation for McClary (1964).

McClary, A. 1967. Statocyst function in *Pomacea paludosa* (Say). Advance Abstracts of Contributions on Fisheries and Aquatic Sciences in India, 1(4): 65. [abstract]

This abstract is a verbatim preprint of the abstract that accompanied McClary (1968a).

McClary, A. 1968a. Statocyst function in *Pomacea paludosa* (Say). Pp. 379-385, in: [editor unknown], Proceedings of the symposium on Mollusca held at Cochin from January 12 to 16, 1968. Symposium series 3, part I. Marine Biological Association of India, Mandapam Camp, India. xxxv + 385 pp.

This extension of experiments reported in McClary (1966) used animals with bilateral removal of statocysts, usually along with sham-operated and unoperated controls. The author was interested in the ability of animals to orient and move vertically and to maintain foothold after statocystectomy. Longer post-operative recovery time was allowed than in McClary (1966). Direction of light and downward pull of the shell were not used as orientational cues, but curvature of the cylindrical aquarium wall strongly aided vertical orientation. Poor success in orienting on a flat aquarium wall was only partly overcome by covering the glass with roughened plastic sheet to improve the foothold of operated snails. Vertically climbing operated snails that were prodded to a horizontal position reoriented vertically by gradual whole-body turning during forward locomotion rather than by abrupt vertical twisting of the head and forefoot by unoperated controls. Refer to the cautionary statement about species identification in the annotation for McClary (1964).

McClary, A. 1968b. Statoliths of the gastropod *Pomacea paludosa*. Transactions of the American Microscopical Society, 87(3): 322-328.

The morphology, number, and size of statoliths in statocysts of applesnails were compared to age and body weight of snails to evaluate the usefulness of statolith analysis in estimating snails' ages between 0 and 450 d. Lamellate rectangular statoliths 20-100 µm long predominated, and non-lamellate rectangular statoliths of similar size were less frequently found; the study was not designed to compare morphology and age. The number of statoliths per statocyst was highly variable but increased with age (size?) to an apparent maximum at 120 d. Statolith length increased with both snail age and body weight. Comparison of cohorts of crowded and uncrowded (densities unspecified) hatchlings revealed that statolith size corresponded better to body weight than to age. Based on these and other observations, the author hypothesizes that statolith formation is highly sensitive to calcium physiology of the snail. Refer to the cautionary statement about species identification in the annotation for McClary (1964).

McClung, R. M. 1969. Lost wild America: the story of our extinct and vanishing wildlife. William Morrow and Company, New York. 240 pp.

In the brief and general account of the snail kite, predation on its "exclusive" prey, "big, freshwater snails", is described. Decline of kite populations is linked to decline in snails due to water-management practices. A drawing depicts two kites course hunting for snails. In the "revised, expanded, and updated version" published in 1993 by Linnet Books/The Shoe String Press, Hamden, Connecticut, the kite is reported to feed almost exclusively on applesnails.

McCormick, P., S. Newman, S. Miao, R. Reddy, D. Gawlik, C. Fitz, T. Fontaine & D. Marley. 1999. Ecological needs of the Everglades. Pp. 3-1 through 3-66, in: G. Redfield (ed.), Everglades interim report. South Florida Water Management District, West Palm Beach, Florida. xxv + 25 pp. + 12 chapters separately paginated.

A section on the role of invertebrates as links between marsh periphyton and vertebrate predators states that much of the research has been done on “a few conspicuous species ... of special importance,” including the Florida applesnail.

McElaney, B. L. 1997. Freshwater shells—the excitement of discovery. American Conchologist, 25(1): 3-5.

Pomacea paludosa from Tamiami Canal, Collier County, Florida, is figured but not discussed in this popular article about freshwater shell collecting.

McGinty, T. L. 1970. Mollusca of the "Glades" unit of southern Florida: part I. Introduction and observations. Tulane Studies in Geology and Paleontology, 8(2): 53-56.

A distinct late Tertiary fossil deposit in southern Florida, termed the "Glades" unit, includes one locality at the Belle Glade Rock Pit that is especially rich in species of marine mollusks. An overlying freshwater facies, approximately 3 ft in depth, includes "fine large *Pomacea*."

McGlone, B. 1907. Notes on the development of the lung in *Ampullaria depressa*. Johns Hopkins University Circular, no. 195 (1907, no. 3): 4-7, pls. I-II.

This “abstract” is a summary of findings reported by Brooks & McGlone (1908) on the gross morphology and histology of the developing gill, osphradium, and lung of embryonic *Ampullaria depressa*. The author concludes that the lung is a secondary organ for respiration and that A.

depressa is, therefore, a prosobranch, not a pulmonate. Two plates are given and are similar to those published in Brooks & McGlone (1908).

McLane, W. A. 1939. *Pomacea paludosa* a predator on the brown darter. The Nautilus, 52(4): 141-142.

This note documents the capture and partial consumption of a fish (*Villora* [now *Etheostoma*] *edwini* Hubbs & Cannon, 1935) by a Florida applesnail in a small aquarium.

McLane, W. M. 1955. The fishes of the St. Johns River system. Ph. D. dissertation, University of Florida, [Gainesville, Florida]. v + 361 + [1] pp.

Pomacea is recorded among the "large quantities of snails" found in stomachs of adult channel catfish [*Ictalurus punctatus* (Rafinesque, 1818)] from the St. Johns River. No applesnails were found in stomachs of 153 redear sunfish (as "shellcrackers"), reported by others (Chable, 1947; Wilbur, 1969; Dineen, 1974) as a predator of *P. paludosa* elsewhere in Florida.

Meenakshi, V. R., P. L. Blackwelder, P. E. Hare, K. M. Wilbur & N. Watabe. 1975. Studies on shell regeneration—I. Matrix and mineral composition of the normal and regenerated shell of *Pomacea paludosa.* Comparative Biochemistry and Physiology, 50A(2): 347-351.

Although animals were purchased "from Florida through a commercial supplier" and no evidence within the paper can be used to question their identity, the reader is cautioned against attributing these data to *Pomacea paludosa*. The funding and taxonomic authority are the same as those acknowledged by Meenakshi *et al.* (1974).

Meenakshi, V. R., P. L. Blackwelder & N. Watabe. 1974. Studies on the formation of calcified egg-capsules of ampullarid snails. Part I. Vaterite crystals in the reproductive system and the egg capsules of *Pomacea paludosa.* Calcified Tissue Research, 16(4): 283-291.

The presence of the vaterite polymorph of calcium carbonate was demonstrated in the albumen gland-capsule gland complex and egg capsules of specimens purportedly belonging to *Pomacea paludosa*. Specimens were purchased from pet shops in or near Columbia, South Carolina. Several lines of evidence indicate that the animals were not *P. paludosa*: small eggs (2.2-2.8 mm diameter, estimated from fig. 8), large clutch size (200-300 eggs), and simple ultrastructure of the capsule [see Norlund & Turner (1988b)]. The authors acknowledge the taxonomic assistance of the late Joseph Rosewater, but there are no voucher specimens at the Smithsonian Institution (Robert Hershler, 25 July 1989, *in litt.*). See also Meenakshi & Watabe (1977).

Meenakshi, V. R. & N. Watabe. 1977. Studies on the formation of calcified egg capsules of ampullarid snails. II. Calcium in reproductive physiology with special reference to structural changes in egg capsules and embryonic shell. Biomineralisation, 9: 48-58.

Several lines of evidence indicate that the specimens used in this study were not *Pomacea paludosa*: clutch morphology (close adherence of eggs), small size of hatchling (1.3 mm, estimated from pl. 4, fig. 3), embryonic requirement for calcium resorption from the capsule [see Turner & McCabe (1990)], and simplicity of capsular ultrastructure [Norlund & Turner (1988b)]. See also Meenakshi *et al.* (1974).

Merritt, R. W., M. J. Higgins, K. W. Cummins & B. Vandeneeden. 1999. The Kissimmee River-riparian marsh ecosystem, Florida: seasonal differences in invertebrate functional feeding group relationships. Pp. 55-79, in: D. P. Batzer, R. B. Rader & S. A. Wissinger (eds.), Invertebrates in freshwater wetlands of North America: ecology and management. John Wiley & Sons, New York. 1100 pp.

Continuing the work of Merritt *et al.* (1996), applesnails were again found to occur in beds of the water lily *Nuphar lutea* (L.) Smith, 1809.

Merritt, R. W., J. R. Wallace, M. J. Higgins, M. K. Alexander, M. B. Berg, W. T. Morgan, K. W. Cummins & B. Vandeneeden. 1996. Procedures for the functional analysis of invertebrate communities of the Kissimmee River-floodplain ecosystem. Florida Scientist, 59(4): 216-274.

Pomacea paludosa, listed incorrectly under Planorbidae, was collected in sweep-net samples from beds of the floating plant *Nuphar* [*lutea*?] in the Kissimmee River basin. Without citing the source, *P. paludosa* is characterized as a scraper and a clinger with more than three generations per year.

Michael, A. 1995. Studying the Florida applesnail: an interview with Dr. Richard Turner. Animalwatch, 1(6): 50-53.

This article in a children's magazine describes several ongoing research projects: use of various emergent plants for egg clutch deposition, effects of submersion of eggs prior to hatching, eggshell structure using scanning electron microscopy, and resistance of applesnails to drought. Other data (taxonomic, cultural use, effects of chemical pesticides), including a one-page natural history narrative, are apparently summarized from a preprint of **Turner *et al.* (2001).**

Michelson, E. H. 1955. Studies on the biology of the genus *Ceratodes* (Mollusca: Pilidae). Ph. D. dissertation, Harvard University, Cambridge, Massachusetts. 171 pp., 22 pls.

This study details the anatomy and histology of the pilid (= ampullariid) snail *Ceratodes* (= *Marisa*) *cornuarietis*, along with notes on its natural history. It includes an excellent review of literature on the family Ampullariidae (as "Pilidae"), discussions on nomenclature and evolutionary relationships, and comparisons of the present work with former studies of other genera. The author presents a tabulated comparison of characters of the nine genera and concludes that they cannot be distinguished by their radulae but can by the nature of their egg masses. The author includes original observations on *Pomacea paludosa*: snail shell microstructure is similar to that described for *C. cornuarietis*, but the pigment that contributes to shell color of the former occurs in the inner (hypostracum) as well as the outer (ostracum) calcareous layer; copulation occurred between a female *P. paludosa* and several male *C. cornuarietis* in an aquarium, but the female did not subsequently lay an egg clutch.

Michelson, E. H. 1961. On the generic limits in the family Pilidae (Prosobranchia: Mollusca). Breviora, no. 133: 1-10.

Seven genera of the family Ampullariidae (as "Pilidae") are summarized, and diagnostic characteristics of shell, operculum, behavior, and the respiratory, excretory, and reproductive systems are tabulated. Morphology of the kidney of *Pomacea paludosa* is described and figured. An internal sperm canal is also reported; a histological cross-section through the penial sheath and penis of this species is provided. The genera *Pila* and *Pomacea*, with calcareous eggshells, represent evolutionary advances toward terrestriality.

Middleton, N. 1996. Swamp politics. The Geographical Magazine, 68(6): 32-34.

Among other species whose population declines in the Everglades are chronicled in this article, the Florida applesnail is claimed to have been "killed off" by drainage of wetlands for flood control, agriculture, and development.

Mihalik, M. B. [1994.] North County Resource Recovery Facility wildlife conservation management & bird monitoring program, 1987-1993 final report. Solid Waste Authority of Palm Beach County, West Palm Beach, Florida. [6] + iv + 92 pp., 7 appendices [separately paginated].

During site development of a municipal solid waste combustor, ponds were dredged with shallow margins as habitat for aquatic plants and applesnails that were intentionally introduced. Use of the littoral habitat by snail kites is taken as an indication of successful mitigation. Snail kites, roosting in a nearby water conservation area, were observed carrying snails to the roost during courtship and nest preparation. The appendices include copies of Rumbold (1992, 1995). The 1994 publication date of this undated document, listed as "1995" in OCLC, is from the author (M. B. Mihalik, 2002, personal communication).

Miller, S. J., A. K. Borah, M. A. Lee, E. F. Lowe & D. V. Rao. 1996. Environmental water management plan for the Upper St. Johns River Basin Project. Draft report, St. Johns River Water Management District, Palatka, Florida. vii + 54 pp.

Hydrologic criteria are given for several conservation and management areas within the Upper St. Johns River Basin Project. Only those for the Blue Cypress Water Management Area have appeared in final form (Miller, Lee, Lowe & Borah, 1996) and include consideration of the biology of the Florida applesnail in development of the criteria.

Miller, S. J., M. A. Lee, E. F. Lowe & A. K. Borah. 1996. Environmental water management plan for the Blue Cypress Water Management Area; Upper St. Johns River Basin Project. St. Johns River Water Management District, Department of Water Resources, Palatka, Florida. Technical memorandum, no. 13: i-vi, 1-21.

Hydrologic criteria for management of the Blue Cypress Water Management Area are delineated, including minimal and maximal water levels, frequency of inundation, range of drydowns, timing of fluctuations, and recession rates. These criteria are based on requirements for maintaining a heterogeneous community of aquatic plants, nesting by the snail kite, maintaining a population of the Florida applesnail suitably accessible to foraging kites, and foraging and nesting by wood storks. Attention is given to the needs of applesnails for minimal water depths, suitable emergent plants, prolonged hydroperiods, and infrequent extreme drydowns.

Mohlenbrock, R. H. 1992. Alexander Springs, Florida. Natural History, 101(11): 66-68.

The flora and fauna of Alexander Springs, in Ocala National Forest, north central Florida, are described as an ecotourism attraction. Among the virtues noted for the abundant, introduced water hyacinth is providing "a perfect home" for applesnails among the rhizomes. The applesnail is incorrectly described as the "only source of food" for the limpkin. The article includes an excellent color photo of a limpkin holding an applesnail in its beak.

Moore, C. B. 1892-1893. Certain shell heaps of the St. John's River, Florida, hitherto unexplored. The American Naturalist, 26(311): 912-922, pls. XXIII-XXIV; 27(313): 8-13; 27(314): 113-117; 27(319): 605-624, pl. XVI; 27(320): 708-723.

This five-part account of freshwater shell middens "of the aborigines" (American Indians) supplements the earlier work of Wyman (1875) and was made possible by the advent of "steam motive power." Forty-three localities are listed, covering a 300-mile stretch of the St. Johns River in eastern Florida; 11 are discussed in detail. No mention is made of the presumed age of the excavations. The middens are interpreted as refuse heaps, reflecting dietary use of freshwater mollusks, deer, alligator, and turtle. Possible methods of culinary preparation are discussed but remain uncertain. Pottery and weapons occurred in only some of the mounds; human remains suggestive of cannibalism were recovered in others. *Pomacea paludosa* (as "*Ampullaria depressa*"; or most often as "ampullariae") formed a major component of the heaps, sometimes entire layers. The applesnail is listed specifically in descriptions of localities at Mt. Taylor, near Econlockhatchee Creek, and at Orange Mound. Approximately 10% of the applesnail shells were perforated by artificial means; the author was unable to interpret this, but we suggest that this was a method of extraction by releasing the snail's columellar muscle. A table of dimensions of applesnails (provided to the author by H. A. Pilsbry) lists the largest excavated specimen as 80 mm in height versus the largest Recent specimen in the Academy of Natural Sciences, Philadelphia, at 55 mm; these data agree with earlier observations of Wyman (1875) that many of the recovered specimens were significantly larger than those living in the area at the time of excavation.

Mott, P. R. 1982. Florida birds. The Florida Naturalist, 55(3): 15.

A series of three essays includes one on the snail kite. The essay records the cycling of kite population size and distribution with periods of drought (1971, 1981) and periods of water levels "required for a healthy population of Apple Snails and Everglade Kites."

Moyer, E. J., M. W. Hulon, R. S. Butler, R. W. Hujik & J. Buntz. [1992.] 1986-91 completion report for Kissimmee Chain of Lakes studies, study III. Boggy Creek/East Lake Tohopekaliga investigations. Florida Game and Fresh Water Fish Commission, Division of Fisheries, Bureau of Fisheries Management, Tallahassee, Florida. v + 72 pp.

The appearance of nesting snail kites on East Lake Tohopekaliga in early 1990 during an artificial drawdown for lake restoration probably was the reason for the authors to recommend monitoring of the applesnail population for long-term effects of the restoration effort. Our date for this document is based on dates entered with signatures on the approval page.

Murphy, R. C. 1955. Feeding habits of the Everglade kite (*Rostrhamus sociabilis*). The Auk, 72(2): 204-205.

Despite the author's use of the common name "Everglade kite", observations of feeding on "Ampullarias" by kites were made in Argentina on a different subspecies of snail kite than occurs in the Florida Everglades. A reference to similar observations by **Lang (1924)** notes that Lang's work was done in British Guiana. Although this author attempts to correct Howell's (1932) description of how snail kites in Florida extract the meat of *Pomacea paludosa*, he nevertheless uses the behavior of birds from South America feeding on other species of *Pomacea* as the basis for correction.

Murphy, R. C. & D. Amadon. 1953. Land birds of America. McGraw-Hill Book Company, New York. 240 pp.

A brief non-scientific description of "kites" includes the snail kite in Florida, which "feeds exclusively on certain fresh-water snails of the genus *Ampullaria*." A one-sentence description of snail extraction is probably attributable to observations by the senior author (Murphy, 1955) on kites feeding in South America, not in Florida. The authors claim that the neurally stunned prey, impaled on the kite's beak, "falls out of its shell."

Murray, G. 1989. First year. [scratchboard artwork]

This illustration of two young alligators shows small scattered clusters of applesnail eggs above and below the waterline on stems of emergent plants. The image is available from the Florida Wildlife Federation, Tallahassee, Florida, as prints, posters, and postcards and was once available on T-shirts. Our copy is on a postcard.

Nabergall-Luis, L. A. 1990. Faunal studies from an Early Archaic wetsite: the Windover archaeological site, Brevard County, Florida. M. S. thesis, Florida State University, Tallahassee, Florida. vii + 126 pp.

Windover is a wet archaeological site in the St. Johns River drainage basin. Preservation is exceptional because of the saturated sediment and peat. *Pomacea paludosa*, one of eight species of freshwater gastropod collected from the site, comprised only about 0.006% of excavated shells. The author interprets the occurrence of these gastropods as natural rather than as part of a human midden and, in addition to other taxa, as an indication that the site had been a freshwater pond. The pond might have formed as a marsh as early as 9,500 YBP, before its use as a human cemetery. In a brief ecological summary extracted from Thompson (1984), the common name is given as "Florida pondapple snail."

Naggiar, M. H. 1954. The kite and the snail. Florida Wildlife, 7(9): 27, 38.

The author gives a firsthand account of the capture, extraction, and consumption of a Florida applesnail (as "*Ampullaria*") by a snail kite at Big Cypress Swamp. Snail mortality in Florida is attributed to drainage, drought, and saltwater intrusion from a lowered water table. The occurrence of applesnail shells in American Indian middens is mentioned to emphasize the former abundance and wider distribution of the snail. The kite is used as an example of a bird whose population has declined because of dietary specialization rather than hunting, although hunters are urged to become familiar with field identification characters of the kite to avoid the inclination to shoot any hawk-like bird. Similarities of text indicate that M. H. Naggiar might have been the author of Anonymous (1954).

Naggiar, M. [H.] 1975. The limpkin. Florida Wildlife, 28(12): 22-23.

In this note on the biology of limpkins, applesnails (as "*Ampullaria*") are stated to be the "mainstay" of their diet. Three photographs illustrate the limpkin carrying and extracting its gastropod prey.

Nasir, P. & M. T. Díaz. 1972. Avian flukes of Venezuela. Rivista di Parassitologia, 33(4): 245-276.

The authors synonymize the echinostome trematode *Prionosoma malacophilum* Pérez Vigueras, 1944 from the snail kite with *P. pricei* Pérez

Vigueras, 1944 from the northern jacana, *Jacana spinosa violacea* (Cory, 1881). They recount the discovery by Pérez Vigueras (1944) of metacercarial cysts of *P. malacophilum* in *Pomacea paludosa* from Cuba but erroneously attribute the description to an earlier work (**Pérez Vigueras, 1940**).

National Audubon Society, Inc. 1987. Wood stork: barometer of the Everglades. Coproduction of National Audubon Society, Turner Broadcasting System & WETA, Washington, D. C.; C. N. Palmer, Executive Producer; produced by Wolfgang & Sharon Obst, Obst Productions, Inc. [videotape, 60 min]

Although this videotaped production concentrates on the wood stork and contains little information on the Florida applesnail, it describes well the biotic and climatic conditions in the Everglades and several problems in management of the Everglades, particularly natural and unnatural changes in hydrology. One brief segment shows dead snail shells on the ground during the winter dry season. In another segment on food availability for birds, two scientists seining mention that applesnails and other food are too dispersed for effective capture by wood storks at times of elevated water levels.

National Geographic Society. 1997. Everglades: secrets of the swamp. National Geographic Television, National Geographic Video, National Geographic Society, Washington, D. C. [videotape, 53 min]

This videotaped production, prepared as a National Geographic Explorer television program, follows the post-hatching escapades of an American alligator ("Ally") and American crocodile [*Crocodylus acutus* (Cuvier, 1807)] ("Cleo") over their first 3 yr of life. One brief segment shows a young-of-the-year alligator capturing an applesnail that is lying above water among emergent vegetation. Having grasped plant stems as well, the alligator uses a whole-body twisting technique in an attempt to free its prey from the tangle of plants. The narrator states that the young alligator was unable to crush the applesnail. In a second sequence, a snail kite catches an applesnail, perches in a tree, and eats the extracted snail in pieces. The restricted diet of the kite is compared to the catholic diet of the alligator. Applesnails are said to scavenge dead fish in an alligator hole during the dry season while a snail is shown crawling over the submerged carcass of a fish. During an encounter between a rat snake [*Elaphe obsoleta* (Say, 1823)] and the costarring alligator, a brief segment of videotape shows what appears to be the large shell of an applesnail lying on the drying surface of the Everglades marsh.

National Geographic Society. 1998. Everglades. National Geographic Society, Washington, D. C. [videotape, 120 min]

This special edition of National Geographic Explorer, aired on 12 July 1998 on Turner Broadcasting System, includes three parts, two of which have footage on the Florida applesnail. "Lords of the Everglades" (44 min) is a shorter version of National Geographic Society (1997) but with a different title; the only footage of Florida applesnail retained are the segments on a young alligator attempting to eat an applesnail and on the encounter between a rat snake and an alligator. "Gator doc" (18 min) features the research of Brady Barr, University of Miami, on diet of Everglades alligators. Applesnail opercula, some with flesh attached, were found in the contents aspirated from stomachs of two alligators caught on a relatively unproductive night. This film is not available for retail distribution but is archived in the National Geographic Film Library, Washington, D. C.

National Wildlife Federation. [Ca. 1956.] [The Everglade kite.] Wildlife Conservation Stamp Series, National Wildlife Federation, Washington, D. C.

This wildlife stamp, signed by "R. Carson," depicts a pair of snail kites, the female in flight and the male perched on sawgrass. The male is grasping in its talons a large shell that must represent the Florida applesnail despite its high spire. We have not seen an original of the stamp, but its image is printed in Sprunt (1956) and Anonymous (1964b), although the latter does not credit the source.

National Wildlife Federation. 1984. Florida apple snail. Wildlife Conservation Stamp Series. National Wildlife Federation, Washington, D. C.

This conservation stamp depicts a Florida applesnail crawling down the petiole of an emergent plant (*Sagittaria* or *Typha?*). The petiole also bears a clutch of snail eggs.

Neck, R. W. 1986. A second record of an introduced apple snail, *Pomacea canaliculata*, from the lower Rio Grande Valley of Texas. Texas Conchologist, 22(3): 54-57.

Literature and museum records of *Pomacea paludosa* in Texas are reviewed. Specimens from Harris and Matagorda counties are referred to *P. paludosa*. "Fresh dead" shells of *P. canaliculata*, native to South America, are recorded from two locations and differ from *P. paludosa* in larger size, more prominent apex, and channeled suture. Aquarium release is proposed as the probable origin of the *P. canaliculata* specimens. *Pomacea paludosa* is considered as "introduced" to Texas, although probably not by oceanic rafting from the southeastern United States.

Neck, R. W. & J. G. Schultz. 1992. First record of a living channeled applesnail, *Pomacea canaliculata* (Pilidae), from Texas. Texas Journal of Science, 44(1): 115-116.

An established population of introduced *Pomacea canaliculata* is reported from Harris County, Texas. The authors indicate that the status of *P. paludosa* in Texas is uncertain, but they do not comment on Neck's (1986) conclusion that museum material from Harris County is referable to *P. paludosa*.

Nesbitt, S. A. 1978. Species of special concern: limpkin. Pp. 86-88, in: H. W. Kale, II (ed.), Rare and endangered biota of Florida. Vol. two. Birds. University Presses of Florida, Gainesville, Florida. 121 pp.

The limpkin is listed in part because of its dependence on aquatic mollusks, primarily *Pomacea paludosa*. The updated chapter by Bryan (1996) contains more information on the relationship between the limpkin and the applesnail.

Nesbitt, S. A., W. M. Hetrick & L. E. Williams, Jr. 1975. Foods of white ibis from seven collection sites in Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners, 28: 517-532.

Of 125 white ibis shot at four freshwater sites, 27.2% had snails in their stomachs. Most snail remains were not identifiable to species. Of six identified species, *Pomacea paludosa* occurred in only one stomach.

Nichols, J. D., G. L. Hensler & P. W. Sykes, Jr. 1980. Demography of the Everglade kite: implications for population management. Ecological Modelling, 9(3): 215-232.

The authors develop mathematical population models for the snail kite. They give no new data on applesnails, but they cite information in Kushlan (1975) on applesnails to strengthen their recommendation of maintaining proper water levels in marshes that are managed as snail-kite habitat.

Nicholson, D. J. 1926. Nesting habits of the Everglade kite in Florida. The Auk, 43(1): 62-67, pls. III-IV.

Field notes are included on nesting and feeding by snail kites near Melbourne and Malabar, Florida. The author recognizes the specialized diet of the snail kite and the need for proper wetlands management to maintain its food supply. Only applesnails were found in stomachs of five adult and young kites. Kites were observed capturing snails by diving to the surface after sighting from a perch or by waiting at the water's edge for a snail to surface. Snails were carried in talons or beak and extracted and eaten in flight or on a perch. Shells were carried from occupied nests for disposal but were accumulated in large numbers in and beneath unoccupied nests.

Nicholson, D. J. 1928. Habits of the limpkin in Florida. The Auk, 45(3): 305-309, pl. XI.

The Florida applesnail (by implication) is the principal prey of the limpkin. This diet is shared with the snail kite and results in both birds nesting in the same wetlands. Empty snail shells are reported to occur in piles on the marsh but not in limpkin nests with unhatched eggs and only rarely when nestlings are present. Survival of the limpkin is tied to survival of the snail. The author expresses hope for the bird and snail in the vastness of

Florida wetlands and alarm at the inevitability of drainage projects that would remove habitat.

Nishimura, T. A., H. Ako, R. Paguirigan, J. Tanaka & C. Tamaru. 1996. Feed lot for the Hawaiian escargot, *Pomacea canaliculata*. Appendix 4 (pp. 1-24), in: C. S. Tamaru, Control of the apple snail (*Pomacea canaliculata*), planning project. Six month report: contract 40785. Unpublished Sea Grant Miscellaneous Report. University of Hawaii Sea Grant College Program, Honolulu. 18 + [5] + 24 pp.

The effect of five feeds on growth, reproduction, nutritive value, and marketability of applesnails was studied in an attempt to improve snail culture as a method of turning an exotic agricultural pest into an industry. The field-collected snails are reported to consist of *Pomacea canaliculata* (gold color), *P. paludosa* (black color), and a hybrid (color unspecified) of the two species. Because the studies seem to have used pooled samples, the applicability of the data to an understanding of the biology of the Florida applesnail remains uncertain to us.

Nordlie, F. G. 1990. Rivers and springs. Pp. 392-425, in: R. L. Myers & J. J. Ewel (eds.), Ecosystems of Florida. University of Central Florida Press, Orlando, Florida. 765 pp.

Pomacea paludosa is mentioned as one of several mollusks with high population densities in alkaline waters of Florida's calcareous streams.

Norlund, C. M. 1989. The role of extracapsular mucus in eggshell formation of the Florida apple snail. Bios, 59(3-4): 116. [abstract]

Eggshells of *Pomacea paludosa* contained 1.03 mg calcium (37% of eggshell dry weight) per egg, the embryo 1.07 mg (18%), and extracapsular mucus 0.03 mg (9%). Before drying, mucus was 97% water and 18% protein. The dried outer mucous layer was undetectable on the bilayered eggshell by scanning electron microscopy. The author concludes that extracapsular mucus probably contributes insignificantly to calcification of the eggshell.

Norlund, C. M. & R. L. Turner. 1988a. The role of extracapsular mucus in eggshell formation of the Florida apple snail. Florida Scientist, 51(suppl. 1): 17. [abstract]

Although similar to Norlund (1989), the authors err in confusing the outer mucous layer with the outer layer of the eggshell. See also Norlund & Turner (1988b).

Norlund, C. M. & R. L. Turner. 1988b. Role of extracapsular jelly in eggshell formation of the Florida apple snail. American Zoologist, 28(4): 34A. [abstract]

In this meeting presentation, similar to Norlund (1989), the authors describe the eggshell as a three-layered structure. The dried mucus forms a thin amorphous layer over dispersed spherules. Beneath the mucous layer, the eggshell consists of a middle region of multiple thin laminae and an inner region of large crystals.

Norlund, C. M. & R. L. Turner. 1989. Calcium source for protoconch formation in the Florida apple snail: more evidence for physiological plasticity in the evolution of terrestrial eggs. Florida Scientist, 52(suppl. 1): 18. [abstract]

This work was published in full as Turner & McCabe (1990).

Odum, H. T. 1957. Trophic structure and productivity of Silver Springs, Florida. Ecological Monographs, 27(1): 55-112.

The author reports that *Pomacea paludosa* occurs at Silver Springs, Florida, and other springs "without the development of races," referring to the tendency of relict species to form in springs at high latitudes. Annual turnover rate (net production x 100%/standing crop) of *P. paludosa*, caged and provided with duckweed, was estimated to be 324% based on wet volume increase of individual snails during 1 mo. Juvenile applesnails are claimed to create an undescribed problem by crawling through the mesh (size unreported) of cages of hardware cloth during the spring and by growing "to important size in a couple of weeks." The author aborted two cage-enclosure studies on growth and production by *Sagittaria subulata* (L.) Buchenau, 1871 (as "*S. lorata*") upon discovering large applesnails within the cages after 1-2 mo. The reproductive cycle of *P. paludosa* at Silver Springs is thought to be governed by photoperiod.

O'Hara, J. J. 1961. The invertebrate fauna associated with water hyacinths in south Florida. M. S. thesis, University of Miami, Coral Gables, Florida. vii + 66 pp.

Data on applesnails (as "*Pomacea miamiensis*") are published in O'Hara (1967 [1968]), but that publication omits information in this thesis on physico-chemical conditions and vertebrate fauna.

O'Hara, J. [J.]. 1967 [1968]. Invertebrates found in water hyacinth mats. Quarterly Journal of the Florida Academy of Sciences, 30(1): 73-80.

Relative abundances of more than 55 species from root mats are tabulated, including Turbellaria, Oligochaeta, Hirudinea, Mollusca, Arachnida, Crustacea, and Insecta. Gastropods were the most numerous, represented by six species comprising an average of 28% of the animals collected. *Pomacea miamiensis* [= *P. paludosa*] is listed as "occasionally" encountered. Exceptionally high invertebrate densities relative to those of other plant associations and comparable bottom communities are attributed to the physical complexity of the root-mat habitat. Data on applesnails do not differ from those given by O'Hara (1961).

O'Meara, T. E., W. R. Marion, O. B. Myers & W. M. Hetrick. 1982. Food habits of three bird species on phosphate-mine settling ponds and natural wetlands.

Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 36: 515-526.

Gut contents of mottled ducks were compared from two phosphate-mine settling ponds and one wetland (Lake Kissimmee) in central Florida. *Pomacea paludosa* were found in 2 of the 16 ducks from Lake Kissimmee; applesnails comprised 9.3% of the total food volume of the 16 ducks. No applesnails were found in the 20 ducks from settling ponds nor in the other two bird species [common moorhen, *Gallinula chloropus* (Linnaeus, 1758), double-crested cormorant, *Phalacrocorax auritus* (Gmelin, 1789)].

Orbigny, A. d'. 1845. Moluscos. Vol. V, in: R. de la Sagra, Historia física política y natural de la isla de Cuba. Segunda parte. Historia natural. A. Bertrand, Paris. 376 pp.

Ampullaria fasciata varieties *dilatata* and *elongata* are described from Cuba. Both varieties were regarded as "misidentified" *Pomacea paludosa* by Pilsbry (1927) [1928], citing both this and the French edition (1853. Mollusques. Vol. 5, in R. de la Sagra, Histoire physique, politique et naturelle de l'île de Cuba. A. Bertrand, Paris. 380 pp.). See **Cowie & Thiengo (2003)** for additional bibliographic data on the French edition, parts of which containing the original descriptions of the two varieties might predate the Spanish edition (R. Cowie, 2003, personal communication).

O'Reilly, J. 1940. South Florida's amazing Everglades. The National Geographic Magazine, 77(1): 115-142.

This pictorial on the Florida Everglades includes a brief description of the snail kite, which is noted to feed "mainly" on *Pomacea*. Drainage and agriculture are blamed for reduction in the snail population, with corresponding reduction in numbers of the kite to an approximated 30 individuals at time of publication.

Orians, G. H., M. Bean, R. Lande, K. Loftin, S. Pimm, R. E. Turner & M. Weller. 1992. Report of the advisory panel on the Everglades and endangered species. National Audubon Society, New York. Audubon Conservation Report, no. 8: 1-43.

This report summarizes the history of physical and institutional compartmentalization of the Everglades, pertinent legislation, and attempts to reduce or reverse negative effects on Everglades biota. Much attention is given to the snail kite and a little to its prey, the Florida applesnail. The panel offers long- and short-term recommendations for restoration of the Everglades ecosystem. The panel recognizes that there is “disappointingly little information” on the applesnail, for which they give “a high priority for study.” Although the panel views removal of levees as a long-term goal for Everglades restoration, it recommends the use of one region circumscribed by levees as an experimental area for studies on the effects of hydrology on the biology and ecology of the snail.

Orians, G. H. & D. H. Janzen. 1974. Why are embryos so tasty? The American Naturalist, 108(963): 581-592.

Citing the work of Snyder & Snyder (1971) on palatability of *Pomacea paludosa* eggs, the authors make the case that the eggs of few animals are toxic or unpalatable.

Owre, O. T. & E. R. Rich. 1987. Development and evaluation of field census methodologies for the apple snail. Final report to United States Department of the Interior, United States Fish and Wildlife Service. Department of Biology, University of Miami, Coral Gables, Florida. 53 pp.

This document evaluates methods for censusing Florida applesnails in the field. The authors considered net scoop, trapping, epibenthic sled, and suction pump to census adults and visual inspection along transects to census egg masses on emergent vegetation in the Everglades. Suction pump was the only method judged suitable to census adults in stands of emergent vegetation. The authors found a relationship between the densities of adults and egg masses and the types of plant community: densities were highest in stands of sawgrass. Whereas egg masses were abundant and reliably counted, adult snails were rarely caught, and the reliability of estimates using the suction pump was difficult to determine. Seasonal differences in abundance of egg masses were probably due to temperature, hydrology, and suitability of emergent plants.

Pain, T. 1956. Notes on the generic names *Pomacea* and *Ampullarius*. Journal of Conchology, 24(3): 79.

Pomacea Perry, 1810, has priority over *Ampullarius* Montfort, 1810 [not *Ampullaria* Lamarck, 1799], and applies to all "American" Ampullariidae. For a more detailed analysis, see **Cowie (1997)** and **[International Commission on Zoological Nomenclature] (1999)**. *Ampullaria rotundata* is a synonym of *A. globosa* [citing Pilsbry (1927) [1928]].

Painter, P. E. 1966. The ecology and nutrition of the snail kite: a literature review. United States Department of the Interior, United States Bureau of Sport Fisheries and Wildlife, Patuxent Wildlife Research Center, Laurel, Maryland. 61 pp. [unpublished]

Information on the snail kite and Florida applesnail (as "*Ampullaria depressa*") and other aquatic snails was reviewed to develop a plan for the captive propagation of kites and snails. The general biology of the applesnail is summarized. In a map of the southeastern United States, the geographic range of the applesnail includes Florida, the southern parts of Georgia, Alabama, and Mississippi, and southeastern Louisiana, but the text states that *A. depressa* is found also in Mexico, Central America, and in South America

to Argentina. In comparing the species to *Marisa cornuarietis*, the author erroneously states that the former "leaves the water to feed," thereby becoming exposed to predation by the kite. It is noted that applesnails are provided by male kites to females during courtship, and the author observed this once in a caged pair of kites. A protocol for culture of applesnails (appendices 1, 2) is adapted from another source for the snail *Australorbis glabratus* (Say, 1818), but it is not tested for its applicability to the Florida applesnail. Although data on biochemical composition of freshwater snails is reviewed with the intent of developing an artificial diet for the kite, the author cautions that a substitute for the Florida applesnail might not be suitable and recommends raising applesnails in culture as the best method, preferably along with captive kites in Florida. Shells of adult snails, hatchlings, and embryos, a crawling adult, and a clutch of snail eggs on a plant stem are illustrated.

Partington, W. M. 1968. Aquatic plants and wildlife. The Florida Naturalist, 41(4): 141-143, 166-167.

This article is a cautionary note about [over]management of water depth, quality, and vegetation in Florida's marshes, rivers, canals, and lakes. The author favors the maintenance of floating plants and shoreline trees and warns that the exotic snail *Marisa cornuarietis* might compete with and exclude *Pomacea paludosa*. He communicates the suggestion by R. L. Thompson that aquatic plants might impede attempts by *P. paludosa* to elude capture by the snail kite.

Pennak, R. W. 1953. Fresh-water invertebrates of the United States. The Ronald Press Company, New York. ix + 769 pp.

Pomacea (family Ampullariidae) is included in a key to families and genera of Gastropoda as "the largest American fresh-water snails ... usually on muddy substrates; several species in Fla. and Ga.", mentioning the common name and its respiratory and tentacular morphology. The second edition (1978. John Wiley & Sons, New York. 803 pp.) of this popular book reads similarly, but the third edition [1989 (subtitled "Protozoa to Mollusca." John Wiley & Sons, New York. xvi + 628 pp.] is less descriptive and modifies the distribution to "2 species in FL, GA, AL." The same black-and-white photograph is in all three editions; it is a rather high-spired shell, with operculum, described as *Pomacea calignosa* [*sic*] in the first edition and changed to simply *Pomacea* in the second and third. In the fourth edition **(Smith, 2001)**, a drawing possibly of *Pomacea haustrum* is substituted for the *Pomacea* of previous editions and is labeled "*Pomacea canaliculata*"; the dichotomous key only states for *Pomacea* "Shell low conical ... 2 introduced, 1 native species, AL, FL, GA, TX."

Perera [de Puga], G. & J. P. Pointier. 1995. Ampullarid snails: forgotten creatures of the freshwater world. Tropical Fish Hobbyist, 43(10): 234-242.

The authors describe the usefulness of applesnails as human food (two recipes included), for handicrafts, in the aquarium trade, and especially as biological control agents of other snails that serve as intermediate hosts of tropical parasites. The general biology of applesnails is reviewed. Several photographs illustrate newly oviposited and hatched egg clutches, habitat landscape views, and empty snail shells (including an "albino" form) of *Pomacea paludosa*. Mating by *P. paludosa* is reported to occur during winter low temperatures. The effectiveness of applesnails as control agents is thought to derive from their voracious consumption of aquatic macrophytes that serve as food and refuge for aquatic pulmonate host snails and from their damage to and consumption of egg masses and juveniles of host snails.

Perera de Puga, G., J. P. Pointier, M. Yong Cong & J. R. Ferrer López. 1991. Comparación del crecimiento de 2 especies de *Pomacea* del área antillana, útiles como agente de control de enfermedades tropicales. Revista Cubana de Medicina Tropical, 43(1): 36-38.

With a view toward the use of *Pomacea paludosa* and *P. glauca* as competitive control agents of pulmonate snails that carry trematode parasites, growth of the snail shell was measured to calculate parameters using the von Bertalanffy equation. The authors conclude that *Pomacea* spp., in contrast to medically important pulmonates, can form stable populations in permanent bodies of water because of their slow growth rates and long life spans. *Pomacea paludosa* is predicted to grow to 50 mm in 2 yr and to live for about 30 mo. It is the largest freshwater snail in the Caribbean region and is very common in Cuba, where it often inhabits waters that lack pulmonates.

Perera [de Puga], G. & J. G. Walls. 1996. Apple snails in the aquarium. Ampullariids: their identification, care, and breeding. T. F. H. Publications, Neptune City, New Jersey. 121 pp.

The many high-gloss color photographs in this book could make it easily mistaken as a coffee-table item. But this authoritative volume accurately describes the general biology of applesnails and other gastropods for the aquarium, their use and care in the aquarium trade, and a review of selected species of *Pomacea*, *Marisa*, *Asolene*, *Pila*, *Lanistes*, *Afropomus*, *Saulea*, and non-ampullariids of several other families. Two recipes using applesnails are included. Information or photographs are given for the presence of the Florida applesnail in Cuba (Lake Hanabanilla, El Rubio Lake, Canasi), Georgia (Ocmulgee and Flint rivers), and Hawaii (introduced). In addition to many aspects of its biology that agree with existing literature, the Florida applesnail is reported here not to be sexually dimorphic externally. The authors offer their perspective on the rise and fall in popularity of *Pomacea paludosa* among aquarists. This book was reviewed by **Lindsay (1996)**.

Perera [de Puga], G. & M. Yong [Cong]. 1984. The influence of some abiotic factors on the distribution of freshwater mollusks on the Isle of Youth (Isle of Pines), Cuba. Walkerana, 2(7): 131-139.

Pomacea paludosa was recorded from 11 of the 12 "dams" [waters impounded by artificial damming] surveyed. It was the only freshwater mollusk found in acid waters (pH 6.0-7.0) and was found, unlike pulmonate snails, to be resistant to high chloride concentration.

Perera [de Puga], G. & M. Yong [Cong]. 1990a. Factors regulating the presence of *Pomacea paludosa* in Cuban freshwater habitats. Florida Scientist, 53(suppl. 1): 15. [abstract]

Twenty-five freshwater habitats in Cuba were investigated for the occurrence of populations of *Pomacea paludosa*. The main factors affecting its presence were water hardness, chloride concentration, salinity, and temperature. Substrate type, water pH, and the presence of floating vegetation did not act as limiting factors.

Perera [de Puga], G. & M. Yong [Cong]. 1990b. Seasonal studies on *Pomacea paludosa* in Cuba. Florida Scientist, 53(suppl. 1): 15. [abstract]

Studies in one Cuban lake determined that applesnail abundance varied mainly according to food availability. Water temperature, hardness, and other factors (unspecified, but excluding pH) also exerted some effect. Reproductive peaks were noted between November and January, with a high of 84 egg masses/m^2 of emergent vegetation. Data and conclusions differ from those in the full paper (Perera [de Puga] & Yong [Cong], 1991 [1992]), which includes two more years of study.

Perera [de Puga], G. & M. Yong [Cong]. 1991 [1992]. Seasonal studies on *Pomacea paludosa* in Cuba. Walkerana, 5(13): 19-23.

Pomacea paludosa, the commonest and largest freshwater snail in Cuba, is found in El Rubio Lake, where it feeds mostly on Brazilian waterweed (*Egeria densa* Planchon, 1849). Densities of the snail varied seasonally and annually over 32 mo of study, and size-class distribution seemed to be inconsistent. In general, however, applesnails were most abundant in winter and rare in summer, when large numbers of empty shells were found along the shore. Changes in snail density were not related to pH, total hardness, oxygen saturation, or salinity. Salinities of 0-4‰ are considered to be within the range of tolerance of *P. paludosa*. Mean density of egg clutches was 84/m^2 at times of high production. The authors recommend harvest of live snails as food during warm months and shore-collection of empty shells to make handicrafts. Unpublished data of Perera de Puga are cited on the effectiveness of *P. paludosa* for controlling populations of pulmonate snails of medical concern.

Perera de Puga, G., M. Yong Cong & J. R. Ferrer López. 1989. Influencia de la vegetatión acuática en la distribución de los moluscos fluviales de la Isla de la Juventud. Revista Cubana de Medicina Tropical, 41(2): 182-191.

Pomacea paludosa was found to be the most abundant mollusk on Juventud Island, Cuba, occurring in 17 of 25 bodies of fresh water. The distribution of this prosobranch snail was less restricted than that of pulmonate snails because *P. paludosa* was the sole snail species found in waters of pH < 6, because its diet was broader, and because its use of emergent southern cattail for oviposition allowed it to inhabit deeper water. The only habitat from which *P. paludosa* was excluded was seasonal ponds.

Perera [de Puga], G., M. Yong [Cong], J. [R.] Ferrer [López], A. Gutiérrez & J. Sánchez. 1995. Ecological structure and factors regulating the population dynamics of the freshwater snail populations in Hanabanilla Lake, Cuba. Malacological Review, 28(1-2): 63-69.

This article reports results of a 6-yr study of the correlation between several physical and chemical factors measured in the lake and the densities of 10 species of freshwater snail. The period of time included passage of a tropical storm, which altered conditions in the lake and composition of the molluscan fauna. Although included in the discussion, *Pomacea paludosa* was excluded from the analysis because the sampling design could not accommodate its large size and its habitation of deeper water.

Perera [de Puga], G., M. Yong [Cong], J. R. Ferrer [López] & R. Velo. 1990. Anatomy and morphometry of *Pomacea paludosa*: a medically and economically interesting snail. Florida Scientist, 53(suppl. 1): 14. [abstract]

Anatomical and morphometric data are summarized for *Pomacea paludosa*. The penis is flagella-shaped and is rolled within the penis sac. The species is unlike other members of *Pomacea* in possessing only one male gland and in details of the osphradium. Populational differences exist in spire height, surmised to be due to differing physical parameters or food sources.

Perera [de Puga], G., M. Yong [Cong], J. R. Ferrer [López] & R. Velo. 1991. Anatomia y morfometria de *Pomacea paludosa*. Iberus, in press.

This paper, cited as "in press" by Perera [de Puga] & Yong [Cong] (1991 [1992]) and Gutiérrez *et al.* (1993-1994 [1995]), was not published (G. Perera, 2 December 1999, personal communication).

Perera [de Puga], G., M. Yong [Cong] & R. Sánchez. 1987. First record of and ecological studies on *Melanoides tuberculata* in Cuba. Walkerana, 2(8): 165-171.

Pomacea paludosa is listed among snails present in the Hanabanilla dam reservoir, central Cuba.

Pérez Farfante, I. 1942. Moluscos de la region de Camoa y Somorrostro y sus condiciones de vida. Memorias de la Sociedad Cubana de Historia Natural, 16(1): 45-56.

Pomacea paludosa is listed as abundant, living on the shores of lagoons in mud and vegetation. The variety *Poomacea* [error for *Pomacea*] *paludosa lutea* is named from the same habitat, but no distinguishing characters are provided. The latter was considered a *nomen nudum* by Clench & Turner (1956).

Pérez Vigueras, I. 1944. Trematodes de la super-familia Echinostomatoidea, con descripcion de siete especies nuevas de Cuba. Revista, Universidad de la Habana, no. 55-57: 221-234, 9 figs.

Pomacea paludosa is claimed to be the intermediate host of the new echinostome trematode *Prionosoma malacophilum* Pérez Vigueras, 1944. Metacercarial cysts, found in the digestive caecum of the applesnail, were fed to two captive snail kites that had been raised on beef since hatching. Adult *P. malacophilum* were found in the captive kites upon autopsy as well as in intestines of free-ranging kites captured from the same lagoon from which the infected applesnails were taken. Although the author planned to publish more details of this study, we have not found a subsequent publication.

Pérez Vigueras, I. 1956. Contribución al conocimiento de la fauna helmintologica cubana (continuación). Memorias de la Sociedad Cubana de Historia Natural, 23(1): 1-36.

The description of the biology of *Prionosoma malacophilum* gives no more information about *Pomacea paludosa* as its intermediate host than was given by Pérez Vigueras (1944), in which plans were mentioned to publish more details of this relationship.

Perry, M. C. 1971. Habitat requirements of the apple snail (*Pomacea paludosa*) at Lake Woodruff National Wildlife Refuge. Report of refuge management study, progress report no. 1. [United States Department of the Interior, United States Fish and Wildlife Service], Lake Woodruff National Wildlife Refuge, [DeLeon Springs, Florida]. 12 pp.

This frequently cited report was published by Perry (1973 [1974]), which does not, however, include the list of substrata on which clutches of eggs were found at the refuge. In addition to using a variety of emergent plants, snails deposited clutches on wooden pilings, aluminum posts, and concrete bulkheads.

Perry, M. C. 1973 [1974]. Ecological studies of the apple snail at Lake Woodruff National Wildlife Refuge. Florida Scientist, 36(1): 22-30.

This limited descriptive study reports clutch parameters of the Florida applesnail (clutch density, vegetative substratum, eggs per clutch) along a creek. Parameters were correlated with data on water chemistry and temperature, but the accuracy of the observed trends is uncertain because of the sampling design. Several interesting anecdotal observations and unsupported speculations are included. Good descriptions of nocturnal emergence of the adult and oviposition are provided. The article is illustrated with photographs of applesnail habitat, clutches, and an ovipositing snail. The author feels that studies on the applesnail are prerequisite for improvement and management of snail-kite habitat.

Peterson, R. T. 1980. A field guide to the birds: a completely new guide to all the birds of eastern and central North America, 4th edition. Houghton Mifflin Company, Boston. 384 pp.

In this most popular of bird guides, applesnails are listed as necessary components of the habitats of two birds: the limpkin, requiring "marshes with large snails," and the snail kite in "marshes and canals with Pomacea Snails." Interestingly, neither description notes the snails as prey items, although the implication is there. The restricted distributions of both birds are graphically represented in the map section of the book.

Peterson, R. T. & J. Fisher. 1955. Wild America. Houghton Mifflin Company, Boston. 434 pp.

This travelog includes observations on the capture of and feeding on applesnails (as "*P. caliginosa*") by limpkins at Wakulla Springs and by snail kites near Lake Okeechobee. The authors note that young limpkins eat snails with the shell. The authors attribute the elimination of snail kites from the St. Johns River and the Everglades to marsh drainage, which kills the snails.

Pettingill, O. S., Jr. 1966. Masters of the air. Pp. 12–23, in: A. Stefferud & A. L. Nelson (eds.), Birds in our lives. United States Department of the Interior, United States Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Washington, D. C. xiii + 561 pp.

In this one of several introductory chapters to the edited volume, the snail kite is offered as an example of a highly specialized bird that is almost totally dependent on one aspect of its niche (*viz.*, its prey, the Florida applesnail). The author predicts that elimination of the snail would cause disappearance of the kite. Pettingill's contribution to a later edition of this book (1970. Arco Publishing Company, Inc., New York. xiii + 447 pp.) is identical.

Petuch, E. J. 1992. The edge of the fossil sea: life along the shores of prehistoric Florida. Bailey-Matthews Shell Museum, Sanibel Island, Florida. Publication no. 2: 1-80.

This book is a popular, partly fictionalized account of the geology and fauna of southern Florida during the mid-Pleistocene. Fossilized shells of *Pomacea paludosa* are visible in a photograph of strata from the Kansan (glacial) Stage of the Bermont Formation, illustrating the change from

Petuch's Okeechobean Sea to his Lake Okeelanta. The common name of *P. paludosa* is given as "Everglades Apple Snail".

Pfeiffer, L. 1854-1860. Novitates conchologicae. Series prima. Mollusca extramarina. Beschreibung und Abbildung neuer oder kritischer Land- und Süsswasser-Mollusken. (Mit Einschluss der Auriculaceen.) Theodor Fischer, Cassel, Germany. 138 pp., 36 pls.

Ampullaria reflexa and *A. conica* are described and figured from Cuba. Alderson (1925) stated that Pfeiffer's specimens of *A. reflexa* "accord pretty well with *paludosa*." Both descriptions were listed as "misidentified" *P. paludosa* by Pilsbry (1927 [1928]). The section on *Ampullaria* (pp. 49-56, pls. XIII-XV) was published on 5 March 1856.

Philippi, R. A. 1851-1852. Die Gattung Ampullaria. In Abbildungen nach der Natur mit Beschreibungen. Pp. 1-74, pls. A + 1-21, in: Vol. 1, pt. 21, in: H. C. Küster, Systematisches Conchylien-Cabinet von Martini und Chemnitz. Bauer und Raspe (Julius Merz), Nuremberg.

The shells of *Ampullaria hopetonensis*, *A. paludosa*, and *A. rotundata* are described, and the first two figured in color (pl. 16). *A. hopetonensis* is redescribed from specimens from the type locality. *A. paludosa* is compared with the very similar *A. hopetonensis* and is said to range from Florida to Georgia. *A. rotundata* is thought to be a variety of *A. globosa* that arrived in Florida from India via the rice industry. Although our copy of Küster's title page indicates "ersten Bandes einundzwanzigste Abtheilung," **Johnson (1968)** and **Cowie & Thiengo (2003)** refer this to volume 1, part 20.

Pilsbry, H. A. 1899. A new *Ampullaria*. Proceedings of the Academy of Natural Sciences of Philadelphia, 1899[23]: 365.

Ampullaria miamiensis is described (unfigured) from a creek flowing from the Everglades near Miami, Florida. The species differs from *Pomacea paludosa* in having a heavier darker shell.

Pilsbry, H. A. 1927 [1928]. Revision of the Ampullariidae of Jamaica and Cuba. Proceedings of the Academy of Natural Sciences of Philadelphia, 1927, 79: 247-253, pls. 21-22.

Ampullaria paludosa is widely distributed in Cuba. The Cuban form (pl. 22, figs. 1-4) is inseparable from the Florida/Georgia form; both are extremely variable. Cuban specimens often have basal part of outer lip expanded—these may be called var. *dilatata* (pl. 22, fig. 3). The synonymy includes *A. depressa*, *A. hopetonensis*, and ?*A. caliginosa*. Many "misidentifications" are also listed: *A. reflexa* (Pfeiffer, 1854-1860; Arango y Molina, 1878, from Güines), *A. conica* (Pfeiffer, 1854-1860, from Havana; Poey, 1857a), *A. fasciata*, with varieties *dilatata* and *elongata* (Orbigny, 1845, from Cuba). Reeve's (1856) *A. notabilis* (not listed in synonymy), without locality, might be the small Cuban form of *paludosa* called *A. conica* by Pfeiffer

(1854-1860). An expanded description and figure (pl. 22, figs. 5-7; holotype, two paratypes) of *A. miamiensis* (considered valid but "may turn out to be an ecologic form") are appended; it differs from *A. paludosa* by a much heavier shell, thick lip, and smaller aperture.

Pilsbry, H. A. 1953. The case of *Paludina multilineata* Say. The Nautilus, 67(2): 58-61.

Ampullaria rotundata, from "St. Johns river in Florida" and with calcareous operculum, is a synonym of *Pila globosa* from India. A mixture of specimens by Captain LeConte (source of Say's original material) is evident.

Pinney, R. 1963. Vanishing wildlife. Dodd, Mead & Company, New York. xi + 193 pp.

The Florida population of the snail kite, claimed by the author to be fewer than 12 birds, has been jeopardized by its specialist diet on the snail *Pomacea califinosa* [*sic*], once abundant but in decline because of drainage of marshes. The method of search, capture, extraction, and consumption of the snail by the kite is briefly described.

Pinney, R. 1966. Wildlife in danger. Duell, Sloan and Pearce, New York. ix + 113 pp.

The text that describes the snail kite, or “snail hawk”, has content similar to Pinney (1963), but he gives the name for the Florida applesnail correctly as *Pomacea paludosa*, and the writing is in a style suitable for younger readers.

Poey, F. 1857a. Memorias sobre la historia natural de la isla de Cuba, acompañadas de sumarios latinos y extractos en frances. Vol. 2. XXXIX. Index molluscorum terrestrium et aquarum dulcium insulae cubae. Imprenta de la Viuda de Barcina, Havana, Cuba. Pp. 3-13.

Ampullaria conica, *A. teres*, and *A. reflexa* are listed. See comments under Poey (1857b).

Poey, F. 1857b. Memorias sobre la historia natural de la isla de Cuba, acompañadas de sumarios latinos y extractos en frances. Vol. 2. XLII. Observations diverses au sujet des mollusques terrestres et fluviatiles de l'île de Cuba. Imprenta de la Viuda de Barcina, Havana, Cuba. Pp. 40-68, pls. 5-8.

The living animal of *Ampullaria conica* is figured in a line drawing. This reference was listed as "misidentified" *P. paludosa* by Pilsbry (1927) [1928]. Wood's *A. conica* is from the Orient. The work that includes Poey (1857a, b) was issued in eight parts in 1851-1858 and as a two-volume set in 1861. The work was reprinted in 1975 by Antiquariaat Junk, Lochem, Netherlands, and was issued in microform in 1958 by Microcard Editions, Washington, D. C., and in 1992 by SOLINET, Atlanta.

Pointier, J. P., J. R. Ferrer [López], M. Yong [Cong] & G. Perera [de Puga]. 1990. Growth studies of some freshwater prosobranchs from the West Indies. Florida Scientist, 53(suppl. 1): 14. [abstract]

This study was published in full by Pointier *et al.* (1992).

Pointier, J. P. & G. Perera [de Puga]. 1995. Les Ampullariidae de la région Caraïbe. Xenophora, no. 72: 14-20.

This article focuses on ampullariid snails as competitors of other species of freshwater snail that serve as intermediate hosts of medically important trematodes. It briefly describes the anatomy, morphology, physiology, reproduction, and diet of ampullariids and an example of their use in successful eradication of schistosomiasis. Several photographs illustrate *Pomacea paludosa*, its eggs, and habitat. This French article is accompanied by an English translation.

Pointier, J. P., G. Perera [de Puga], M. Yong [Cong] & J. R. Ferrer [López]. 1989. Growth studies of some freshwater prosobranchs from West Indies. P. 187, in: C. Meier-Brook (ed.), Abstracts of the Tenth International Malacological Congress, Tübingen, West Germany, 27 August-2 September 1989. Unitas Malacologica, Tübingen, West Germany. ii + 287 pp. [abstract]

This study was published in full by Pointier et al. (1992).

Pointier, J. P., G. Perera [de Puga], M. Yong [Cong] & J. R. Ferrer [López]. 1992. Growth studies of some freshwater prosobranchs from West Indies. Pp. 233-237, in: C. Meier-Brook (ed.), Proceedings of the Tenth International Malacological Congress, Tübingen, 27 August-2 September 1989. 2 vols. Unitas Malacologica, Tübingen, Germany. vi/ix + 636 pp.

Four prosobranch species, including *Ampullaria paludosa* from Cuba, were examined under natural and laboratory conditions. Growth parameters and curves showed that all are slowly growing species with long life spans, providing stable populations that compete successfully or potentially compete with pulmonate intermediate host snails of tropical parasites. Growth rate of *A. paludosa* was faster than that of *A. glauca*, but the former was held at higher temperatures and with a greater diversity of macrophytic food.

Post, W., J. P. Poston & G. T. Bancroft. 1996. Boat-tailed grackle (*Quiscalus major*). No. 207, in: A. Poole & F. Gill (eds.), The birds of North America. The Academy of Natural Sciences, Philadelphia, & The American Ornithologists' Union, Washington, D. C. 28 pp.

In this extensive summary from literature, the authors describe methods of foraging by boat-tailed grackles on gastropods, including *Pomacea paludosa*. Piracy of applesnails by grackles from limpkins is not known to occur and from snail kites is not known to be successful.

Pough, R. H. 1939. Florida's hawks need friends. The Florida Naturalist, 12(3): 55-58.

The author points out that birds of prey had, unlike other birds, not recovered from decimation inflicted on bird populations "in the early days" in Florida. Recovery of raptor populations could be expected largely through establishment of legal protection from hunting. Such regulations would not, however, help the snail kite, which requires instead the maintenance of habitat for its food, "*Ampullaria* snails." The author calls for "a complete survey of the state [of Florida], to determine the size and location of all areas that still afford conditions suitable for these snails" and for protection of those areas where the snail and snail kite are found together.

Pough, R. H. 1940. Hawks aloft. Natural History, 46(3): 146-151.

In an attempt to counter "hawk persecution," the author explains the misapplication of the name "hawk", referring in England to a bird-eating bird, to many North American birds by colonists. He illustrates his point about the generalist diet of hawks by a contrast with the extreme specialist diet of the snail kite, feeding on applesnails ("genus *Ampullaria*") to the point "that it is no longer capable of sustaining itself on any other food." Drainage of applesnail habitat is blamed for the migration of kites around south Florida.

Pough, R. H. 1951-1952. Bird protection in the United States. Conservation in the Americas, no. 11: 19-24. [October 1951-January 1952 issue]

The author hails the time since his earlier publication (Pough, 1940) as a period with an encouraging shift from "simple" protection of birds to wildlife management and with a growing public sentiment toward conservation. But birds of marshes are among those species that remain in jeopardy. Interestingly, the author attributes the near extinction of the snail kite to duck hunters rather than to destruction of the habitat of "our race of [a] ... tropical snail-eating species" despite his earlier (Pough 1939, 1940) focus on ecology of the Florida applesnail. This article was reprinted in 1952 in Passenger Pigeon, 14(4): 141-148.

Pratt, H. S. 1916. A manual of the common invertebrate animals exclusive of insects. A. C. McClurg & Co., Chicago. 737 pp.

Shell morphology and color are described for *Ampullaria depressa* ("*A. paludosa*" in later editions) from rivers and lakes in Florida and Georgia. This first edition was followed by numerous revisions and printings (1923, 1925, 1927, 1929, 1935, 1948, 1951) by several publishers (A. C. McClurg & Co., Chicago; P. Blakiston's Son & Company, Inc., Philadelphia; McGraw-Hill, New York).

Price, D. 1997. Dawn. David Price, Lake Wales, Florida. [bronze sculpture, 48 in x 48 in x 21 in]

This bronze sculpture of two sandhill cranes (*Grus canadensis* Linnaeus, 1758) is supported by a 21-in by 31-in base depicting an unvegetated shoreline with the empty shells of several Florida applesnails. The intent is to show habitat, not food, of the cranes. As of 2003, four castings in a limited edition of ten had been made, of which three were sold to individuals and one has been on public display in several Florida galleries.

Price, D. A. 1986. Evolution of a molluscan cardioregulatory neuropeptide. American Zoologist, 26(4): 1007-1015.

By fractionation of peak C cardioregulatory neuropeptides, the author found a new molluscan tetrapeptide (phenylalanyl-leucyl-arginyl-phenylalanine amide, or FLRFamide) among four immunoreactive peaks from *Pomacea paludosa*. FLRFamide accounted for 10-20% of FMRFamide-like activity, the remainder contributed almost entirely by FMRFamide. In discussing the evolution of FMRFamide-like neuropeptides in their roles as transmitters and hormones, the author suggests that FLRFamide is less prone to oxidative degradation and "helps to stabilize the blood levels without unduly prolonging the transmitter action."

Price, D. A. 1987. The distribution of some FMRFamide- and SCP-related peptides in the Mollusca. Pp. 208-214, in: H. H. Boer, W. P. M. Geraerts & J. Joosse (eds.), Neurobiology: molluscan models. North Holland Publishing Company, Amsterdam. 376 pp.

Pomacea paludosa does not contain neuroregulatory heptapeptides of the FMRFamide family of compounds found in pulmonates. Immunoreactivity was, however, detected for a second family of neuropeptides, called "small cardioactive peptide" (SCP), as a SCP_B-like compound, in addition to the previously reported (Price, 1986) tetrapeptides FMRFamide and FLRFamide.

Price, D. A., N. W. Davies, K. E. Doble & M. J. Greenberg. 1987. The variety and distribution of the FMRFamide-related peptides in molluscs. Zoological Science, 4(3): 395-410.

In this review of an intraphyletic family of peptides, FLRFamide—first discovered in *Pomacea paludosa*—is reported to occur in other mollusks. A cartoon of *P. paludosa* is included in a drawing (fig. 1) that illustrates the distribution of FMRFamide-like peptides among the major molluscan groups.

Purdy, B. A. 1991. The art and archaeology of Florida's wetlands. CRC Press, Boca Raton, Florida. xii + 317 pp.

This book includes lists of animal remains for many wetland archaeological sites. *Pomacea paludasa* [*sic*] is included, with a number of marine mollusks and freshwater vertebrates, in a previously unpublished list for Bay West, a cypress pond in southwest Florida. The author interprets Wyman's (1875) "Ampullarias" from an Indian mound on Hontoon Island in the St. Johns River as *P. paludosa*. For other sites, mention is made only of more common smaller freshwater snails reported in the literature.

Rader, R. B. 1994. Macroinvertebrates of the northern Everglades: species composition and trophic structure. Florida Scientist, 57(1-2): 22-33.

Pomacea paludosa is listed as "rare" (fewer than 20 individuals collected in sweep samples) in the northern Florida Everglades, dominated by fluctuating water conditions in temporary sloughs. No snails were found in samples from dense sawgrass. It is characterized as a grazer, the most frequent trophic category among macroinvertebrates. *P. paludosa* is erroneously given as one of three species that occur in Central and South America [citing Thompson (1984), who gave only Cuba as a locality outside the United States]. In spite of the focus of this paper on trophic structure, no mention is made of the applesnail's importance as a food source for the limpkin and endangered snail kite.

Rader, R. B. 1999. The Florida Everglades: natural variability, invertebrate diversity, and foodweb stability. Pp. 25-54, in: D. P. Batzer, R. B. Rader & S. A. Wissinger (eds.), Invertebrates in freshwater wetlands of North America: ecology and management. John Wiley & Sons, New York. 1100 pp.

Pomacea paludosa is depicted as a scraper within the Everglades foodweb. The trophic relationship between this snail and the snail kite is used as an example of how important it is to consider invertebrates in habitat management for endangered species. Based on results in literature, applesnails are considered to be sensitive to changes in hydrology as embryos, hatchlings, and adults.

Rader, R. B. & C. J. Richardson. 1992. The effects of nutrient enrichment on algae and macroinvertebrates in the Everglades: a review. Wetlands, 12(2): 121-135.

By literature review and from the authors' "preliminary results," this work compares areas of the Everglades that are oligotrophic and those that have been subjected to nutrient enrichment. Comparisons are made concerning species composition and primary production by algae, carbon dioxide and oxygen concentrations, pH, and abundance and diversity of macroinvertebrates. The authors indicate that applesnails, crayfish, and shrimp have received significantly more attention than other macroinvertebrates by biologists working in the Everglades.

Rader, R. B. & C. J. Richardson. 1994. Response of macroinvertebrates and small fish to nutrient enrichment in the northern Everglades. Wetlands, 14(2): 134-146.

D-frame sweep-net samples contained an average density of applesnails of 0.89 m^{-3} from eight slough sites along a nutrient gradient within Water Conservation Area 3A in the Everglades. Gastropods comprised almost one-fourth of the animals at enriched and unenriched sites, but *Pomacea paludosa*—listed as a grazer—was uncommon.

Rattner, B. A. 1993. Data analysis. Unpublished memorandum to C. Facemire, Regional Environmental Coordinator, Region 4. United States Department of the Interior, Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland. [3 pp.] [5 May 1993]

Data are summarized from a study by J. Eisemann and N. Beyer on mercury concentrations in the Florida applesnail from south Florida. The data and statistical analysis differ slightly from those published later (Eisemann & Beyer, 1997). This memorandum is probably the one listed in the bibliography of the Science Subgroup (1996: 265) titled "Mercury and pesticides in the Everglades snail kite"; it was prepared in response to a *Freedom of Information Act* request and was the only one so prepared on the subject by Rattner (B. A. Rattner, 28 January 2003, personal communication).

Read, B. W. 1954. Florida's snailhawk. Atlantic Naturalist, 9(5): 224-232.

This popular article attributes the decline of the snail kite population in Florida to drainage of marshes (killing applesnails, purportedly its sole food) and to interference from duck hunters and fishermen. It outlines an "all-out protective program," enlisting the assistance of federal and state authorities, sport clubs, civic groups, conservation groups, and businesses in sparing the kite. The author points out that the limpkin has a broader diet and, therefore, is less impacted by altered habitat. But he erroneously claims that kites feed only at dawn and dusk because only at these times are snails "usually up and out of the water," as if kites captured only emergent snails. A 20-min film "Phantom of the marshes" (National Audubon Society & Florida State Division of Game and Fresh Water Fish, Tallahassee, Florida) was mentioned, but a copy has not been located; **Baird (1970)** indicated that no known copies exist. Our request in January 2002 to the Florida Fish and Wildlife Conservation Commission went unfilled. If a copy is found, it is likely to contain information on applesnails. The title of the film might have been inspired by Sprunt (1945a, b).

Reader's Digest Association. 1982. North American wildlife. Reader's Digest Association, Pleasantville, New York. 559 + [17] pp.

This illustrated field guide includes colored drawings of a shell and an ovipositing individual of the Florida applesnail. Identifying characteristics, habitat, and reproductive biology are briefly described. An "updated edition" with the subtitle "an illustrated guide to 2,000 plants and animals" appearing only on its cover is dated 1982 internally but dated 1998 in OCLC; the material on applesnails is unchanged.

Reader's Digest Association. 1991. Nature in America. Reader's Digest Association, Pleasantville, New York. 456 pp.

A color photograph of a Florida applesnail laying a clutch of eggs accompanies a short paragraph that serves to describe "snail" as a category of wildlife in the United States.

Reark, J. B. 1961. Ecological investigations in the Everglades: second annual report, June 1961. Report to Superintendent, Everglades National Park. [Zoology Department], University of Miami, [Coral Gables, Florida]. [i] + 19 pp.

This is a summary of a 2-yr study on the vegetation and aquatic fauna of Shark River Valley and Taylor Slough in the Florida Everglades. Applesnails occurred at densities up to 1000/acre in communities of grasses and rushes and in open water, densities of 1000-2000/acre in mats of *Bacopa* sp., and 4000-8000/acre in mats of *Utricularia* sp. Daily changes in physical and chemical data in several aquatic plant communities are graphically presented. Passage of hurricanes Donna and Florence (1960) during the study resulted in destruction of *Utricularia* mats. This work seems to summarize information that was included on applesnails in the first annual report (Reark, J. B. & H. F. Strohecker. 1960. Ecological investigations in the Everglades: first annual report, June 1960. Report to Superintendent, Everglades National Park. Zoology Department, University of Miami, Coral Gables, Florida. 15 pp.), which we have not seen. Although this research is said to comprise the author's doctoral dissertation (anticipated to have appeared in 1962), we find no record of the dissertation at University of Miami under "Reark" in OCLC or in Dissertation Abstracts International.

Redfield, G., G. Goforth & K. Rizzardi. 1999. Major findings and preliminary implications of the Everglades Interim Report. Pp. 1-25, in: G. Redfield (ed.), Everglades interim report. South Florida Water Management District, West Palm Beach, Florida. xxv + 25 pp. + 12 chapters separately paginated.

The Florida applesnail is called a critical species in the Everglades because of the restricted diet of the snail kite. Reproduction by the snail is noted to be dependent on hydrology.

Redfield, G., J. VanArman, K. Rizzardi & M. Chimney. 1999. Introduction to the Everglades Interim Report. Pp. 1-1 through 1-26, in: G. Redfield (ed.), Everglades interim report. South Florida Water Management District, West Palm Beach, Florida. xxv + 25 pp. + 12 chapters separately paginated.

The term "apple snails" is included in the glossary, which notes the common occurrence of the Florida applesnail in wetlands of south Florida and the dependence of the snail kite on it as food.

Reeve, L. [A.] 1856. Monograph of the genus *Ampullaria*. Color pls. 1-28, in: L. [A.] Reeve, Conchologia Iconica: or, illustrations of the shells of molluscous animals. Vol. 10. Lovell Reeve, London.

The shells of 130 *Ampullaria* species are illustrated, 75 of which are described as new (4 as validated manuscript names). *Ampullaria depressa* Say, from unknown locality, differs from Say's *S.* [*sic*] *paludosa* [which was not reviewed by Reeve] in being thinner shelled, more inflated, and rather narrowed at the base [this is an astonishing statement in that *A. paludosa* is a replacement name for *A. depressa*]. *A. hopetonensis*, from Darien, Georgia, and *A. reflexa*, from unknown locality, are also illustrated. The latter [from Cuba] was listed among the varieties of *A. hopetonensis* by Sowerby (1909). Among the new species is *A. caliginosa* (from unknown locality, with flatly sloping shoulders and bulging whorls), which was listed as a possible synonym of *P. paludosa* by Pilsbry (1927) [1928]. Pilsbry (1927) [1928] also notes that another new species, *A. notabilis*, from unknown locality [also figured by Alderson (1925)], could be a small Cuban form of *P. paludosa* called *A. conica* by Pfeiffer (1856). Two other new species of Reeve, *A. livescens* and *A. venetus*, were treated as subspecies of *A. paludosa* by Kobelt (1915 [1911-1914]) but are not now considered as such (Clench & Turner, 1956).

Rhoads, S. N. 1899. Annotated list of land and fresh-water shells recently collected in the vicinity of Miami, Florida. The Nautilus, 13(4): 43-48.

The Florida applesnail (as "*Ampullaria depressa*") is reported from the Miami River and the Everglades in abundance, based on a collection made in January.

Rich, E. R. 1990. Observations on feeding by <u>Pomacea</u> <u>paludosa</u>. Florida Scientist, 53(suppl. 1): 13. [abstract]

Methods for studying feeding by *Pomacea paludosa* included gut content analysis, stable isotope ratio measurements, gut passage rates, and feeding rates related to size and temperature. Periphyton was found to be a major food component, but stable isotope data indicated that vascular plant material was more important. Periphyton was of low preference in laboratory-reared snails.

Rich, E. R. & O. T. Owre. 1990. Adaptation of a portable dredge technique to field census of *Pomacea paludosa*. Florida Scientist, 53(suppl. 1): 13. [abstract]

Assessment of applesnail populations is regarded as difficult because of the complexity of the snail's normal habitat. Seasonality of reproduction makes the presence of egg masses an inadequate indicator of population size. A suction device developed for marine benthic sampling was tested and analyzed for a *P. paludosa* population in the conservation areas of the Everglades.

Richards, H. G. 1933. A conchological expedition to Cuba. Proceedings of the Pennsylvania Academy of Science, 7: 167-172.

Pomacea paludosa garciae is described and figured (text-fig. 21) from Guane, Pinar del Rio, as a new subspecies, distinguished from *P. paludosa paludosa* on the basis of its lower spire and purple-bordered inner lip.

Richardson, C. J., C. B. Craft, R. G. Qualls, R. B. Rader & R. R. Johnson. 1991. Effects of nutrient loadings and hydroperiod alterations on control of cattail expansion, community structure and nutrient retention in the water conservation areas of south Florida. Annual report to Agricultural Area Environmental Protection District, Belle Glade, Florida. Duke Wetland Center, Duke University, Durham, North Carolina. 318 pp.

The authors propose to study the effect of phosphorus enrichment on growth of several caged invertebrates, including *Pomacea paludosa*. To our knowledge, the results of this study, if carried out, have not been published. The authors cite an unpublished report (Terczak, 1980) as a case in which *P. paludosa* occurred at a lower density at an enriched site than at unenriched sites.

Ripple, J. 1990. The Everglades: a threatened wilderness. Ross/Ripple Productions, Boca Raton, Florida. [videotape, 30 min] [available through St. Lucie Press, Delray Beach, Florida]

This narrated sequence of still photographs gives an overview of the history, ecology, biota, and present environmental problems of the Everglades and the adjacent Kissimmee River, Lake Okeechobee, Big Cypress Swamp, Ten Thousand Islands, and Florida Bay. The 144 photographs of landscapes, plants, and animals (supplemented with 4 maps) include only one about the Florida applesnail: a clutch of eggs on a plant stem.

Robbins, C. S., B. Bruun & H. S. Zim. 1966. Birds of North America: a guide to field identification. Golden Press, New York. 340 pp.

This field guide states that *Pomacea paludosa* is the sole food of the snail kite and illustrates a perched female kite extracting a snail from its shell.

Robins, C. H. 1971. Ecology of the introduced snail, *Marisa cornuarietis* (Ampullariidae) in Dade County, Florida. The Biologist, 53(3): 136-152.

In this published version of Hale's (1964) master's thesis, Robins compares *Pomacea paludosa* and *Marisa cornuarietis* in body form, oviposition, general habitat, and diet. Similarities might lead to predators switching to *M. cornuarietis*, but the author states that sufficient differences exist between the snails to minimize interspecific competition. She implies that the applesnail is less macrophytophagous than *M. cornuarietis* and calls for more studies on the diet of *P. paludosa*. Aerial oviposition and the large size of juvenile applesnails probably preclude control by *M. cornuarietis* through accidental ingestion.

Rodgers, J. A., Jr. 1983. Diary of an Everglade kite survey: how Mother Nature and Murphy's Law interact to give biologists fits. The Florida Naturalist, 56(3): 6-10.

In this humorous account of the problems of doing fieldwork, the author writes that the Florida drought of 1981 caused snail kites to seek populations of applesnails that occupied habitats suboptimal for the kite. He attributes the return of snail kites in 1982 to Conservation Area 3A to the natural restoration of the applesnail population. By contrast, the absence of kites in Lake Okeechobee in 1982 is believed to be due to the lack of recovery of snails from drought and fires, as evidenced by the paucity of clutches of applesnail eggs. The many sites mentioned where kites were found in this survey probably held snail populations, but the capture of applesnails by kites was recorded only at Conservation Area 3A. A photograph shows an adult kite feeding a snail to its nestling.

Rodgers, J. A., Jr. 1996a. Florida snail kite (*Rostrhamus sociabilis plumbeus*). Pp. 42-51, in: J. A. Rodgers, Jr., H. W. Kale, II & H. T. Smith (eds.), Rare and endangered biota of Florida. Vol. V. Birds. University Press of Florida, Gainesville, Florida. 688 pp.

Three factors seem to be most important limitations to the maintenance of and recolonization by populations of the snail kite: habitat modifications that reduce the ability of the kite to see the applesnail; frequent dry-downs, which cause death of snails; and slow post-drought recovery of snail populations to densities that support the return of kites.

Rodgers, J. A., Jr. 1996b. Measurements of snail kite eggs from central Florida. The Wilson Bulletin, 108(4): 804-807.

Variable provisioning of applesnails to nestlings by parent snail kites is suggested as one of two factors that explain differences in competition among sibling kites.

Rodgers, J. A., Jr., H. W. Kale, II & H. T. Smith (editors). 1996. Rare and endangered biota of Florida. Vol. V. Birds. University Press of Florida, Gainesville, Florida. 688 pp.

In their introduction to this volume, the editors point out that successful foraging on the Florida applesnail by the snail kite requires a habitat that allows the bird to see the snail. Additional information on *Pomacea paludosa* is given in chapters on the snail kite (Rodgers, 1996a) and limpkin (Bryan, 1996).

Rodgers, J. A., Jr., S. T. Schwikert & A. S. Wenner. 1988. Status of the snail kite in Florida: 1981-1985. American Birds, 42(1): 30-35.

The authors cautiously interpret historical changes in the distribution and population estimates of the snail kite and their own data on indices of habitat use by kites in the early 1980s. Increased use at times of declining water levels is suspected to be due to greater population size or availability of applesnails after a period of high water level. Kites, which are visual foragers on applesnails, generally use "open marsh-slough wetlands" and are believed to abandon sites that become overgrown with emergent plants and, therefore, suboptimal for feeding on snails.

Rodgers, J. A., Jr. & P. W. Stangel. 1996. Genetic variation and population structure of the endangered snail kite in south Florida. Journal of Raptor Research, 30(3): 111-117.

Recolonization of the more northern part of the historical range of the snail kite is partly attributed to limited availability of applesnails. Caution is urged about interpreting the return of snail kites to Lake Kissimmee as a positive post-drawdown effect on the applesnail population.

Roessler, M. A., G. L. Beardsley & D. C. Tabb. 1977. New records of the introduced snail, *Melanoides tuberculata* (Mollusca: Thiaridae) in south Florida. Florida Scientist, 40(1): 87-94.

This paper cites Hale (1964) and, incorrectly, **Hunt (1958)** in the impact of the exotic species *Marisa cornuarietis* on *Pomacea paludosa* populations.

Rogers, J. E. 1908. The shell book: a popular guide to a knowledge of the families of living mollusks, and an aid to the identification of shells native and foreign. Doubleday, Page & Company, New York. xxi + 485 pp., 8 color pls., 96 black-and-white pls.

A two-page chapter on applesnails in this popular work discusses familial characteristics (gross anatomy, habitat, respiratory adaptations, egg masses) and describes several Brazilian *Ampullaria* species. The shell of *Pomacea paludosa* (as "*P.* [= *Pomus*] *depressa*" and the "Flattened Apple Snail") is described from "tributaries of St. John's River, Eastern Florida." "*Pomus*, Humphrey" is said to differ from "*Ampullaria*, Lam." in lacking a "shelly coat" on the horny operculum. A black-and-white photograph of the shell of "*Ampullaria depressa*" is provided.

Romer, A. J., Jr. 1972. The aposomatic [*sic*] eggs of *Pomacea paludosa* (Say). M. S. thesis, University of South Florida, Tampa, Florida. vi + 44 pp.

A diverse approach tests the ideas of Snyder & Snyder (1971) on the aposematic and automimetic properties of applesnail eggs. Newly oviposited (new-stage) eggs were clearly distasteful to captive wild and domestic birds, to captive cotton rats, and to humans under controlled conditions. Distastefulness declined for eggs that were close to hatching (old-stage). Based on human thresholds for taste, new-stage eggs contained twice the amount of offensive substance of old-stage eggs. Birds were able to distinguish new- and old-stage eggs visually. The high level of consumption of old-stage eggs was depressed significantly by an intermediate period during which birds were offered new-stage eggs; the author interprets the results to demonstrate automimicry. Clutches in the field suffered high damage—taken to represent predation by unknown animals—during the first week of oviposition; rate of damage of new clutches dropped precipitously in the second week as predators might have learned to avoid the eggs. Chemical fractionation, electrophoresis, and proteolysis of egg albumen components gave a single band of a possible glycoprotein with a molecular weight of 800,000, the flavor of which was destroyed by boiling but not by proteases.

Roosevelt, R. B. 1884. Florida and the game water-birds of the Atlantic coast and the lakes of the United States, with a full account of the sporting along our sea-shores and inland waters, and remarks on breech-loaders and hammerless guns. Orange Judd Company, New York. 443 pp.

No direct mention is made of the Florida applesnail in the two chapters on Florida, a travelogue of the author's journey primarily up the St. Johns River, on the Halifax River, and within the Indian River Lagoon System and its associated creeks in winter and spring 1882. Two indirect references to *Pomacea paludosa* might be inferred. The author writes (pp. 9-10) of the mysteries that await the Northerner visiting Florida, "where at first nothing is believed to be real and where finally everything is considered to be possible. When the visitor first arrives he cannot be convinced that the cows feed under water [perhaps a reference to manatees, but not clarified by the author's later description on pp. 66-67]; before he leaves he is willing to concede that alligators may live on chestnuts." The latter comment is not explained but might refer to the discovery of the large brown shells of applesnails in the stomachs of alligators, the hunting of which he calls "excessive." The second probable indirect mention of the applesnail is in his sighting of "A bank of snail shells, which must have been cast up by the waves" (p. 84) at a place that marked the outlet of a "silver" sulfur spring into Lake George. "Many of them are in good preservation, and quite pretty" (pp. 84, 87). Judging by the frequency of the author's reference to limpkins along the St. Johns River (pp. 10-11, 24, 80-82, 87), the bank of snails might have been the midden of a limpkin feeding on applesnails [see annotation of Say (1824)].

Ross, L. T. & D. A. Jones (editors). 1979. Biological aspects of water quality in Florida. Florida Department of Environmental Regulation, Technical Series, 4(3): 516 pp. (pt. 1) + 402 pp. (pt. 2) + 597 pp. (pt. 3) + 248 pp. (pt. 4).

This document is a compilation of monitoring efforts over the period 1973-1978 to survey bacteria, algae, and macroinvertebrates in Florida waters, primarily riverine drainage basins. A background and a summary of methods are given in part 1. *Pomacea paludosa* (sometimes as "*Pomacea* sp.") is listed from 41 of about 250 monitoring sites. It was found in many rivers throughout the state, from as far west as the Escambia River (near Pensacola) to the Peace and Kissimmee river basins and the Caloosahatchee River in southwestern Florida; from the lower St. Johns River drainage basin in northeastern Florida to several canals that drain Lake Okeechobee and the Everglades in southern Florida.

Rudolph, H. D. & D. G. Strom. 1990. Macroinvertebrates associated with macrophytes in Lake Okeechobee, Florida. Biological Basin Assessment

Survey, 1986-1987. Florida Department of Environmental Protection, Southeast District Branch Office, Port St. Lucie, Florida. xxiv + 301 pp.

Whereas earlier work reviewed in this study examined the community of profundal invertebrates in Lake Okeechobee, the present study sampled the littoral macroinvertebrates associated with submergent and emergent plants by season at 12 stations mainly using a variety of techniques for harvesting the plants, from which invertebrates were collected. Authors made limited use also of baited minnow traps and a benthic trawl. *Pomacea paludosa* was one of the 93 dominant (> 15 individuals per sample) or abundant (10-15 per sample) animal taxa collected out of 294 taxa. It was not collected by trap or trawl, but it was present in 1-4 seasons at 8 stations and was a dominant or abundant species at stations 32 and 33 in spring and summer. Oddly, in the descriptions of faunal communities by station, the authors mention *P. paludosa* only for station 34 as a significant component. The applesnail is described as a "lunged snail" that uses emergent and floating plants to reach the surface of the water to breathe. It is reported from alligator flag (*Thalia geniculata* Linnaeus, 1753), an emergent of the arrowroot family. Among the 50 most abundant taxa, *P. paludosa* did not consistently share plant substrata with other invertebrates, based on three similarity-index matrices. In an account of an algal bloom in the lake that reached public attention because of the death of the applesnail and the potential impact of the event on the snail kite, one author (Rudolph) is quoted for his own observation: the odor "could be smelled in the air over a mile away. The dead apple snails, crayfish, and dragonfly nymphs in uncountable numbers lay rotting on the surface." Data on *P. paludosa* might be included in some of 10 appendices listed that are not bound with the volume but are available from the authors or the agency. The literature cited includes many unpublished agency reports, memoranda, lists, and presentations on faunal communities of the lake and south Florida.

Rumbold, D. G. 1992. Ecotoxicological surveillance of chemical residues in wildlife near the North County Resource Recovery Facility: a baseline study. Final report to Solid Waste Authority of Palm Beach County, West Palm Beach, Florida. D. G. Rumbold, Boca Raton, Florida. 57 pp.

The Florida applesnail was chosen as one of several sentinel species to monitor the presence of organic toxicants, heavy metals, chlorinated hydrocarbon insecticides, and chlorophenoxy herbicides on wildlife near a newly established municipal solid waste combustor. The rationale for choosing applesnails was "to document chemicals that do not exhibit biomagnification" and to monitor the prey of the snail kite, a colony of which was roosting in the nearby West Palm Beach Water Catchment Area. Sizes of snails and dates of collection (except year) are not reported. Snails were pooled for analysis, and no replication of samples nor sampling of snails prior to start-up of the combustor (except in the catchment area) was done. Snails were taken from the catchment area and from the storm-water retention area of the combustor facility. Results of the analyses for chlorinated hydrocarbon insecticides were later published by Rumbold *et al.* (1996). Furans and dioxins were detected in snail tissue at levels similar to or less than those found in bird eggs and nestlings. Of the heavy metals (arsenic, beryllium, cadmium, lead, mercury, nickel, selenium), all were detected in some pooled snail samples, but the author expresses greatest concern over the levels and trends for cadmium and lead. Low levels of chlorophenoxy herbicides (dalapon, dichloroprop, 24-D, 24-DB, 245-T, 245-TP) were detected in only one pooled snail sample in one year and only at the storm-water retention area. Continued sampling of applesnails is recommended for monitoring of dioxins, furans, and metals; and the author targets the body burden of arsenic in the snail kite as an area of future study.

Rumbold, D. G. 1995. Biomonitoring environmental contaminants from Palm Beach County's Resource Recovery Facility: the first five years. Final report to Solid Waste Authority of Palm Beach County, West Palm Beach, Florida. D. G. Rumbold, Boca Raton, Florida. vi + 53 pp.

Data for sampling and analyses in 1994 were added to those reported by Rumbold (1992) in a continuation of a monitoring project on and near a municipal solid waste combustor. Body water in snails was 82.7%, and lipid was 0.6%. Analyses for organochlorine pesticides were not done. The data on metals in applesnails are reviewed in Rumbold (1996). Levels of dioxin and furan residues, which peaked in 1990 in snails from the West Palm Beach Water Catchment Area, were low in 1994. Dioxin residues increased and furans remained low in snails from the storm-water retention area of the combustor facility in 1994. All levels over the 5-yr period were, however, relatively low. See Rumbold (1996) and the annotation for Rumbold (1992) for cautions about replication and interpretation of trends in the data. A 10-yr overview is given in **Rumbold (2000)**.

Rumbold, D. G. 1996. Metal residues in apple snails and sediments collected at the North County Resource Recovery Facility in 1996. Final report to Solid Waste Authority of Palm Beach County, West Palm Beach, Florida. D. G. Rumbold, Boca Raton, Florida. ii + 23 pp.

Applesnail tissue was analyzed for levels of arsenic, beryllium, cadmium, lead, mercury, nickel, and selenium in pooled samples from four sites at a municipal solid waste combustor and landfill facility and at one site at the West Palm Beach Water Catchment Area (WCA). Sediments from the five sites also were analyzed. Snail tissue consisted of 82% water. Beryllium was not detected. Average values for lead and mercury barely exceeded detection

limits. Mean levels of arsenic, cadmium, mercury, nickel, and selenium were very high in snails from the Class III landfill storm-water catch basin compared to the other four sites and to sediments, but sites differed statistically only in arsenic and nickel. Concentrations of lead in snail tissue were very low despite high levels in sediments of some sites. In comparison to values for WCA in previous years, concentrations of arsenic, cadmium, lead, and selenium appeared to decrease, and lead and nickel showed no trend. No identifiable long-term trends were detected at the landfill catch basin except for elevated levels of nickel and extremely elevated levels of arsenic. The author notes statistical problems with studies of earlier years (Rumbold, 1992, 1995) because of lack of replication and suggests that apparent trends might not have been real. The attempt in the present study to increase the statistical value of the data by replication (n = 2) at a greater number of sites falls short, however, because of pooling of snails; moreover, pooled samples consisted of a variable number of snails. The author recommends that the sampling be repeated in 1999 as part of the long-term monitoring program [see **Rumbold (2000)**]. Because the Florida applesnail has a short life span, the concentrations of metals reflect only recent exposure and not long-term bioaccumulation. The implications of the body burden of metals in snails for the snail kite are uncertain, but the author does not view the high concentration of arsenic in snails to be a threat to the kite.

Rumbold, D. G., M. C. Bruner, M. B. Mihalik, E. A. Marti & L. L. White. 1996. Organochlorine pesticides in anhingas, white ibises, and apple snails collected in Florida, 1989-1991. Archives of Environmental Contamination and Toxicology, 30(3): 379-383.

No organochlorine pesticides (aldrin, Aroclor 1016, chlordane, DDD, DDE, DDT, dieldrin, endosulfan I and II, endrin, HCH, heptachlor, heptachlor-epoxide, methoxychlor, toxaphene) were detected in pooled samples of applesnails from the West Palm Beach Water Catchment Area or from the storm-water retention area of a municipal solid waste combustor, possibly because of the low level of lipid (0.71%; probably based on wet weight) in applesnail tissues. Water comprised 81.7% of the wet weight of the snails; but there is no indication if the value includes or excludes the shell, and size of the snails and dates of collection are not given. Several of the pesticides were detected in bird eggs and nestlings.

Rumbold, D. G. & M. B. Mihalik. 1994. Snail kite use of a drought-related habitat and communal roost in West Palm Beach, Florida: 1987-1991. Florida Field Naturalist, 22(2): 29-38.

Applesnail shells were found in an old nest at the West Palm Beach Water Catchment Area (WCA), and snail kites were observed using applesnails in courtship rituals in a nearby roost. Kites foraged for applesnails

up to 27 km from the roost at borrow pits, marshes, a variety of canals, ponds, and pools. The authors link the choice of the roost near the WCA to applesnail abundance, which they also relate to hydroperiod. A personal communication from S. Beissinger is included that postulates that low numbers of nestling kites per nest observed by the authors were due to low availability of applesnails.

Russo, M., B. A. Purdy, L. A. Newsom & R. M. McGee. 1992. A reinterpretation of Late Archaic adaptations in central-east Florida: Groves' Orange Midden (8-Vo-2601). Southeastern Archaeology, 11(2): 95-108.

The Florida applesnail was fourth in frequency of faunal occurrence in Groves' Orange Midden, Lake Monroe, Volusia County, Florida, composed of shells of freshwater mollusks. It was considered among the edible species. Using weight-to-weight ratios of shell to meat, the authors estimate that the applesnail (ratio of 2.32; 1 g shell = 2.32 g meat) was third in the abundance of meat represented in the faunal remains, contributing 11% of the total. The authors use their data to argue for the presence of Late Archaic human populations in Florida that were non-migratory cultures that used aquatic resources for subsistence rather than for dietary supplementation. See Wheeler & McGee (1994) for additional data on the Florida applesnail at this site. The shell-to-meat ratio is claimed to be from **Wing & Brown (1979)**, who report no such value.

Ryder, J. A. 1889. Notes on the development of *Ampullaria depressa*, Say. The American Naturalist, 23(272): 735-737.

This report consists of scattered notes on oviposition, clutch parameters, internal organization of the egg, yolk utilization, embryonic organs, and embryonic behavior. The author reports that submerged eggs will die. The egg consists of the calcareous shell, air space, outer fluid albumen, inner viscous albumen, and the ovum. The color of the egg is imparted by albumen, not the eggshell. The embryo rotates within the eggshell using its ciliated foot.

Safford, W. E. 1919. Natural history of Paradise Key and the near-by Everglades of Florida. Annual report for 1917, Smithsonian Institution, Washington, D. C., publication no. 2508: 377-434, frontispiece, 1 map, 64 pls.

Ampullaria depressa is called "the great marsh snail" and "the principal food staple" of the snail kite. Eggs and the clutch are described and illustrated (fig. 13). Plate 35 is a colored drawing of a live snail, although the skin is not dark, and plate 36 is a photograph of the empty shell. Crayfish are regarded to be "of greater economical [ecological] importance" than the applesnail in Everglades food webs.

Sand, G. X. 1971. The Everglades today: endangered wilderness. Four Winds Press, New York. 191 pp.

Chapter 1 focuses on the foraging activity of a snail kite in May after several years of drought, which has brought "both the snail and kite populations to the point of extinction." The text suggests that kites use egg clutches of the Florida applesnail (as "*Pomacea paludis*") as cues to the presence of the "gray-green" snails, which must be caught in daytime before snails bury themselves in the mud after laying the clutches at night. Capture and extraction from the shell are described. An accompanying photograph illustrates a snail crawling down a plant stem or leaf; four clutches are visible. The caption erroneously states that "eggs of the apple snail ... are the only known food" of the kite.

Santos, C. A. Z., C. H. S. Penteado & E. G. Mendes. 1987. The respiratory responses of an amphibious snail *Pomacea lineata* (Spix, 1827), to temperature and oxygen tension variations. Comparative Biochemistry and Physiology, 86A(3): 409-415.

Discussion in this paper repeatedly references the work of Freiburg & Hazelwood (1977), who erroneously assigned their material to *P. paludosa* [see also Freiburg (1971)].

Sarasúa, H. 1943. Vocabulario malacologico de voces cubanas. Revista de la Sociedad Malacologica "Carlos de la Torre", 1(2): 62-68.

A list of vernacular names of Cuban mollusks includes "ampularias" and "babosa de río" (= river slug) as applied to various freshwater snails, but especially for *Pomacea paludosa* and *P. poeyana*.

Sarasúa, H. 1944. Las neritinas en acuarios de agua dulce. Revista de la Sociedad Malacologica "Carlos de la Torre", 2(1): 15-16.

Among snails used in freshwater aquaria, *Pomacea paludosa* is called "la destructora No. 1" of aquatic plants from its insatiable appetite and the physical damage caused by its size and weight.

Say, T. 1824. Appendix. Part I. Natural History. 1. Zoology. Pp. 253-378, pls. 14-15, in: W. H. Keating, Narrative of an expedition to the source of St. Peter's River, Lake Winnepeek, Lake of the Woods, &c. &c. performed in the year 1823, by order of the Hon. J. C. Calhoun, Secretary of War. Under the command of Stephen H. Long, Major U. S. T. E., compiled from the notes of Major Long, Messrs. Say, Keating, and Colhoun. Volume II. H. C. Carey & I. Lea, Philadelphia. 459 pp., pls. 7-15.

Ampularia [*sic*] *depressa* is described and figured (shell, dorsal view) from eastern Florida, specifically the St. Johns River and tributaries and Lake George. Say collected the first specimen, which was dead and broken; J. E. Le Conte later provided Say with a "perfect specimen." Say's trip to Florida was not part of the midwestern expedition described in Keating's two-volume narrative. The species is distinguished by the spire being "very much depressed." Le Conte reported to Say that piles of empty applesnail shells occurred along the shoreline of Lake George and that the snails were preyed upon by *Numenius longirostra* [= *N. americanus* Bechstein, 1812, the long-billed curlew], which probably was a misidentified limpkin. A lectotype was selected by Clench & Turner (1956). This paper was reprinted by **Binney (1858)**.

Say, T. 1829. Descriptions of some new terrestrial and fluviatile shells of North America. The New Harmony Disseminator of Useful Knowledge, New Harmony, Indiana, [part issued 26 August 1829]: 259-261.

Ampullaria paludosa is proposed as a replacement name for *A. depressa* Say, 1824 (non Lamarck, 1804, a fossil species). Also, *Ampullaria* (as "*Ampluria*") *rotundata* is described as a new species from the St. Johns River, Florida, and is distinguished by being "remarkably globose," by the body whorl being "undulated", and by a calcareous operculum. Say considered it to be similar to (and perhaps a variety of) *A. globosa* from India. This document was reprinted in pamphlet form by Mrs. Say in 1840 (not seen) and by **Binney (1858)**.

Schomer, N. S. & R. D. Drew. 1982. An ecological characterization of the lower Everglades, Florida Bay and the Florida Keys. United States Department of the Interior, United States Fish and Wildlife Service, Office of Biological Services, Washington, D. C. FWS/OBS-82/58.1: 1-246.

Pomacea paludosa is mentioned as a key species and as one of the few "crustaceans" from the lower Everglades for which ecological data are available. Its diet is reported to include periphyton and detritus. The authors imply that the dietary dependence of snail kites on applesnails is responsible for the high concentration of DDT measured in snail kite eggshells by **Kolipinski & Higer (1969)**, who reported data for kite eggs, not eggshells.

Schroder, H. H. 1948. Snail hawks. Nature Magazine, 41(3): 129-131.

Despite the title, the author points out the negative attitude of duck hunters toward hawk-like birds regardless of the birds' feeding habits. A pamphlet (not seen by us) prepared by the National Audubon Society to educate hunters about the feeding habits of the snail kite was distributed in communities around Lake Okeechobee with the intention of reducing mortality of the kites. At the time of this article, the kite population is described as "making their last stand on Lake Okeechobee" (where the snail occurs in "countless numbers") because of death of applesnails (as "*Pomacea caliginosa*") from drainage of marshes elsewhere in Florida. The author briefly describes the snail egg clutches on emergent stems, the prior occurrence of kites and snails in marshes of the St. Johns River basin, and personal observations of the feeding habits of the kite on the snail in marshes west of Vero Beach, Florida.

Schroder, H. H. 1953. The vanishing Everglade kite. Frontiers, 17(4): 116-118.

Decline of availability of applesnails (as "*Pomacea caliginosa*") to the snail kite is attributed to drying of marshes because of prolonged drought and drainage by humans for agriculture, cattle rangeland, and real estate. Parts of this article repeat Schroder (1948), but a photograph is included that shows at least seven clutches of applesnail eggs on stems of emergent plants. The figure caption, though perhaps just poorly written, suggests that snail kites take female snails from the stems after they have oviposited.

Science Subgroup. 1996. South Florida ecosystem restoration: scientific information needs. Report to the Working Group, South Florida Ecosystem Restoration Task Force, [city unknown], Florida. xxix + 487 pp.

This report defines restoration goals, restoration objectives, science objectives, and information needs for an ecosystem approach to restoration of the Florida Everglades and neighboring wetlands, uplands, and marine regions. The Florida applesnail is identified as a key species and a potential ecological indicator in part because of its use as prey by many animals in the Everglades; but the poor state of knowledge about the species is viewed as a hindrance to restoration. Accumulation of useful information about the applesnail has been slow because of problems in assessing population parameters. Autecological studies of the snail are recommended to provide information needed for restoration and modeling. In particular, the report calls for a study of "what conditions make them available to snail kites."

Scott, W. E. D. 1881. On birds observed in Sumpter, Levy, and Hillsboro' counties, Florida. Bulletin of the Nuttall Ornithological Club, 6(1): 14-21.

In January through March 1876, the author observed snail kites and limpkins preying on "a kind of large fresh-water snail" abundant at Panasofkee Lake. The local name for the kite was "snail hawk." The kite's gull-like searching flight, capture, and extraction of the snail "from the shell without injury to the latter" are described. The snail was present in nearby marshes and the river, but the kite was observed foraging only on the lake. The author describes kite middens "heaped with the empty shells of these unfortunate snails."

Seaman, D. E. & W. A. Porterfield. 1962. Feasibility of controlling aquatic weeds with snails. Proceedings of the Southern Weed Conference, 15: 256-257. [abstract]

This paper was published in full as Seaman & Porterfield (1964).

Seaman, D. E. & W. A. Porterfield. 1964. Control of aquatic weeds by the snail *Marisa cornuarietis*. Weeds, 12(2): 87-92.

This paper deals with the use of the snail *Marisa cornuarietis* to control aquatic weeds in Florida. The authors report that boat-tailed grackles prey on *M. cornuarietis* and *Pomacea paludosa*, and they speculate that limpkins and other known predators of *P. paludosa* might consume *M. cornuarietis*. Among predators of *P. paludosa*, the authors include raccoon, [*Procyon lotor* (Linnaeus, 1758)], American alligator, and common snapping turtle, with attribution to a personal communication from F. J. Ligas in 1961; this citation, although unsubstantiated, represents the first reference to non-human mammalian and to reptilian predators of the Florida applesnail.

Simkiss, K. & A. Z. Mason. 1983. Metal ions: metabolic and toxic effects. Pp. 101-164, in: P. W. Hochachka (ed.), The Mollusca. Vol. 2. Environmental biochemistry and physiology. Academic Press, New York. xviii + 362 pp.

Data (table V) on inorganic and organic composition of connective tissue in *Pomacea paludosa* are attributed to Watabe *et al.* (1976), the identity of whose snails we doubt.

Simkiss, K. & K. M. Wilbur. 1989. Biomineralization: cell biology and mineral deposition. Academic Press, San Diego. 337 pp.

Data (table 14.4) on the mobilization of calcium reserves for shell repair in *Pomacea paludosa* are derived from Watabe *et al.* (1976). Attribution of the data to *P. paludosa* should, therefore, be questioned.

Simpson, C. T. 1887-1889. Contributions to the Mollusca of Florida. Proceedings Davenport Academy of Natural Sciences, 5: 45-72, 63*-72*.

Ampullaria depressa is listed from Sumpter, Volusia, and Orange counties, Florida. *Ampullaria caliginosa* is listed from Manatee County, Royal Palm Hammock, Miami, and Cedar Keys. Both "species" [synonyms of *Pomacea paludosa*] are characterized as zoogeographically tropical, *A. depressa* from Cuba and *A. caliginosa* [incorrectly] from Mexico and Nicaragua. The great similarity of the two "species" is noted, but the latter is generally said to be heavier and more globose. This work was issued in four parts. The pagination of the fourth part overlaps earlier parts, and the page numbers are printed in our copy with asterisks.

Simpson, C. T. 1894. Distribution of the land and fresh-water mollusks of the West Indian region, and their evidence with regard to past changes of land and sea. Proceedings of the United States National Museum, 17(1011): 423-450, pl. 16.

Ampullaria depressa, which extends its range into Georgia, is considered a form of *A. caliginosa* [incorrectly stated to be from Mexico] in a general discussion of relationships of the south Floridan fauna with that of the Antilles and of Central and South America. Species of south Florida are surmised to be results of recent migration from southern locations.

Simpson, C. T. 1920. In lower Florida wilds: a naturalist's observations on the life, physical geography, and geology of the more tropical part of the state. G. P. Putnam's Sons, New York. xv + 402 pp., 64 figs., 2 maps.

Although not mentioned in the chapter on the Everglades, including a paragraph on the limpkin and snail kite, the applesnail ("Ampullaria", "apple snail", "idol snail") is described in the chapter on streams. The brief notes on general biology of the snail are generally pertinent to *Pomacea paludosa*, but information on burrowing and aestivation must derive from the author's knowledge of South American species of *Pomacea*.

Singley, J. A. 1893. Texas Mollusca: a preliminary list of the land, fresh water, and marine Mollusca of Texas. Annual report, Geological Survey of Texas, 4: 299-343.

Ampullaria depressa and *A. caliginosa* are listed from Texas following Dall (1889).

Sklar, F., C. McVoy, R. Van Zee, D. Gawlik, D. Swift, W. Park, C. Fitz, Y. Wu, D. Rudnick, T. Fontaine, S. Miao, A. Ferriter, S. Krupa, T. Armentano, K. Tarboton, K. Rutchey, Q. Dong & S. Newman. 1999. Hydrologic needs: the effects of altered hydrology on the Everglades. Pp. 2-1 through 2-70, in: G. Redfield (ed.), Everglades interim report. South Florida Water Management District, West Palm Beach, Florida. xxv + 25 pp. + 12 chapters separately paginated.

Hydrologic needs of the snail kite and Cape Sable seaside sparrow *Ammodramus maritimus mirabilis* (Howell, 1919) conflict because water levels need to be greater than 10 cm for springtime reproduction by the Florida applesnail (the kite's prey) and less than 10 cm for springtime foraging by the sparrow on insects and seeds. A section of this chapter summarizes the findings from a prepublication version of Darby *et al.* (1998).

Slaugenhaupt, B. 1981. Hiking the Florida Trail. Florida Wildlife, 35(2): 32-36.

A color photograph in this travelogue shows a man standing in water among cypress and sedges and holding a globose brown snail shell. The caption describes the occurrence of many floating empty shells of the "tree snail" and speculates that the shells are leftovers from predation by snail kites. Based on size, color, shape, and habitat, the shell is more likely to be that of *Pomacea paludosa* than a species of tree snail (*Liguus*).

Sloan, D., T. Lothrop, A. Oyler & R. Pelletier. 1998. Reuse, reclaim, and recharge: Orlando, Fla., makes the most of the three R's of wastewater treatment. Water Environment & Technology, 10(9): 56-59.

Orlando Easterly Wetlands Park is used as an example of a successful water-reclamation project. Northward extension of the nesting range of the snail kite to this area is attributed to the implied presence of the Florida applesnail, which "only resides in high-quality waters."

Sloan, W. C. 1958. A comparative study of nitrogen excretion in *Ceratodes cornuarietis* (Linnaeus) and *Pomacea paludosa* (Say) (Pilidae, Gastropoda). Ph.

D. dissertation, University of Florida, Gainesville, Florida. 46 pp. [1959. Dissertation Abstracts, 19(7): 1805.]

During embryogenesis, eggs of *Pomacea paludosa* do not release ammonia to the atmosphere, but ammonia and uric acid accumulate in the egg. By hatching, uric acid nitrogen is four times the concentration of ammonia nitrogen. In contrast to the terrestrial uricotelic embryos of *P. paludosa*, the aquatic embryos of *Marisa* (as "*Ceratodes*") *cornuarietis* are suspected to be ammonotelic. Adult *P. paludosa* slowly accumulate uric acid in renal tissue to a concentration four times that of M. *cornuarietis*; and they excrete uric acid at ten times the rate of M. *cornuarietis*. Adults of both snails are, however, predominately ammonotelic and have similar rates of ammonia excretion. The author concludes that embryonic uricotely is an adaptation in *P. paludosa* for a cleidoic egg and that adults retain some uricotely as a vestige of embryonic physiology. Urea production is negligible or undetectable in both species. The author was unable to account for most (> 99%) of the non-protein nitrogen in analyses for ammonia, urea, and uric acid. Much of the data here on embryonic physiology were published by Sloan (1964). *Pomacea paludosa* hatchlings matured to adulthood on a diet of lettuce, and adults fed lettuce oviposited.

Sloan, W. C. 1964. The accumulation of nitrogenous compounds in terrestrial and aquatic eggs of prosobranch snails. The Biological Bulletin, 126(2): 302-306.

This paper represents the part of Sloan's (1958) dissertation that compares the embryonic physiology of *Pomacea paludosa* and *Marisa cornuarietis*. See Sloan (1958) for a full annotation.

Smith, D. G. 1987. Keys to the freshwater macroinvertebrates of Massachusetts (no. 2): Mollusca Mesogastropoda (operculate snails). Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control, [city unknown], Massachusetts, publication no. 14812-39-300-4-87-C.R.: i-iii + 1-35.

An unbanded *Pomacea* sp., with operculum in place, is figured in a simple line-drawing. The tropical family Ampullariidae is included in the key because specimens are occasionally released by pet owners. Florida [referencing Thompson (1984)] is cited inaccurately as the only native occurrence in North America. Permanent establishment in Massachusetts is "doubtful." This same information is presented in a subsequent version (1991. Keys to the freshwater macroinvertebrates of Massachusetts. Version 1.0. D. G. Smith [Publ.], Amherst, Massachusetts. iv + 236 pp.); and a line drawing of a banded form of *Pomacea* is added to the second edition (1995. [same main title], 2nd edition. Including the Porifera, Cnidaria, Entoprocta, Ectoprocta, Platyhelminthes, Nematomorpha, Nemertea, Mollusca

(Prosobranchia and Pelecypoda), and Crustacea (Branchiopoda and Malacostraca). D. G. Smith [Publ.], Sunderland, Massachusetts. iii + 243 pp.).

Smith, M. 1937. East coast marine shells: descriptions of shore mollusks together with many living below tide mark, from Maine to Texas inclusive, especially Florida. Edwards Brothers, Ann Arbor, Michigan. vii + 308 pp.

The family Piliidae [*sic*] and genus *Pomacea* are diagnosed. *Pomacea paludosa* is cited from "every Florida county." Juveniles are noted under water hyacinths in the St. Johns River, as are fossil deposits in shell-gravel pits in Volusia County. The range is given as South Carolina to Louisiana. A photograph of a shell from Lantana, Florida, and a line drawing of the eggs are provided. The variety "*flava* Pilsbry" is described, with a pale yellow unbanded shell, from the central Everglades and near Miami, Florida. Because the species was never described by Pilsbry, Smith is the original author of the name. It was included in the synonymy of *P. paludosa* by Clench & Turner (1956) as a "partial albino" that sporadically occurs throughout its range. The text and illustrations remained unchanged through the second printing (1941), third edition (1945), and fourth edition (1951).

Snyder, N. F. R. 1967. An alarm reaction of aquatic gastropods to intraspecific extract. Cornell University Agricultural Experiment Station, Memoir 403: 1-122.

In this predominately laboratory study, the author assayed the alarm reactions of 30 species of snail (mostly freshwater) to intraspecific and interspecific snail extracts and to "aquarium water" of known and potential predators. *Pomacea paludosa*, collected in south Florida, responded by burial into the substratum, preceded by "commotion" and by release from the glass sides of the aquaria. Positive responses were different between field-collected adult snails and juveniles hatched in the laboratory. Adults responded only to intraspecific extract and to extracts of the snails *Helisoma duryi* (Weatherby, 1879) (but irregularly in a second study), "*Pomacea* cf. *lymnaeformis*" [error for *Pomacea lymnaeaeformis* (Reeve, 1856)], and *Lymnaea columella* Say, 1817. Snail extracts retained potency after filtration at a pore size of 0.45 μm and after boiling. Juveniles responded only to water taken from aquaria that had held *Sternotherus minor* (Agassiz, 1857) (loggerhead musk turtle) or common snapping turtle but not crayfish [*Orconectes obscurus* (Hagen, 1870)], sunfish, catfish [*Ictalurus nebulosus* (LeSueur, 1819)], or painted turtle [*Chrysemys picta* (Schneider, 1783)]. Despite his statement to the contrary, one other species of snail (*Goniobasis virginica* Say, 1817) gave a significantly different response to intraspecific extract with and without predator water; but the difference was not indicated to be related to size, and the outcome was not repeatable in a second series of experiments. The author classified the shell of *P. paludosa* as weak because it could be crushed by foraging painted turtle in an aquarium. This species and common snapping turtle extracted *P. paludosa* from the shell also by grasping the operculum and pulling as well as by crushing the shell. Applesnails were crushed by *S. minor*, common snapping turtle, *Kinosternon bauri* (Garman, 1891) (striped mud turtle), and *Lepomis gibbosus* (Linnaeus, 1758) (pumpkinseed [sunfish]), and they were pierced by the beak of *Belostoma flumineum* Say, 1832 (giant water bug). In the predator-exposure study, *P. paludosa* gave a fright reaction to the presence of pumpkinseed and of all species of turtle except common snapping turtle. *Pomacea paludosa* individuals were found to harbor nematodes and oligochaetes upon dissection. This document is a verbatim copy of Snyder's doctoral dissertation of the same title (1966. Cornell University, [Ithaca, New York]. x + 235 pp. [Dissertation Abstracts, 28B(1): 390.]), except that his dissertation includes three additional figures and lacks the summary.

Snyder, N. F. R. 1969. Defenses of the Florida apple snail. American Zoologist, 9(4): 1061. [abstract]

This is an abstract mostly of Snyder (1967). Mention that embryos respond to turtle odors is explained in Snyder & Snyder (1971), as are notes on the ability of turtle species to crush applesnails of given sizes.

Snyder, N. F. R., S. R. Beissinger & R. E. Chandler. 1989. Reproduction and demography of the Florida Everglade (snail) kite. The Condor, 91(2): 300-316.

This re-analysis of nesting and other life-history parameters based on old and new data for the snail kite in Florida refutes conclusions drawn in three earlier papers, including one that presents a demographic model. Several parameters were statistically correlated with water level, and the authors offer a few intriguing untested hypotheses causally relating life-history characteristics to applesnail populations; but no evidence is given that the applesnail is drought sensitive or that its populations fluctuate directly with water level. Some new observations are recorded on foraging by snail kites on applesnails: effect of cold weather, development of foraging skills by fledglings, in-flight extraction of the snail from its shell.

Snyder, N. F. R. & H. W. Kale, II. 1983. Mollusk predation by snail kites in Colombia. The Auk, 100(1): 93-97.

Although this paper is primarily about predation on *Pomacea chemnitzi* [= *P. chemnitzii*] and *Marisa cornuarietis* by snail kites in Colombia, the authors compare feeding by the kites with those in Florida, which feed almost exclusively on *P. paludosa*. Both species of *Pomacea* are low spired, but *P. chemnitzi* reaches a much larger size. Kites in Colombia are less effective in extracting snail meat than Florida kites are; the difference is partly related to the larger size that *P. chemnitzi* reaches. Young snail kites in Florida often fail to extract snails, and the authors attribute their failure in part to "clumsiness" of the fledglings while holding and manipulating snails during extraction. Because the Colombian subspecies of kite avoids consumption of the yolk gland of female snails, the authors suspect that the gland contains a distasteful substance, as do the eggs of the Florida applesnail. In Colombia, *M. cornuarietis* forms a major proportion of the diet of kites; but this introduced snail is not an alternative to *P. paludosa* as prey for the snail kite in Florida.

Snyder, N. F. R. & H. A. Snyder. 1969. A comparative study of mollusc predation by limpkins, Everglade kites, and boat-tailed grackles. The Living Bird, 8: 177-223.

This paper is a well-illustrated, thorough, comparative review on how these three species of bird find, capture, and extract applesnails and freshwater mussels. Many original observations by the authors are given, and observations and hypotheses in the literature are critically evaluated.

Snyder, N. F. R. & H. A. Snyder. 1970. Feeding territories in the Everglade kite. The Condor, 72(4): 492-493.

Defended feeding areas of four snail kites measured about 30 m by 75 m each along a canal that had an unusually high density of applesnails. The authors attribute territoriality to the occurrence of highly localized patches of prey in great abundance. Data are given on frequency of snail capture and on search time.

Snyder, N. F. R. & H. A. Snyder. 1971. Defenses of the Florida apple snail *Pomacea paludosa*. Behaviour, 40: 175-215, pls. VII-X.

This paper extends the study by Snyder (1967) on the responses of *Pomacea paludosa* to intraspecific extracts and to metabolites of potential and known predators. Defenses that are reviewed include the alarm response (dropping through the water column in response to intraspecific extracts and subsequently burrowing into the substratum), burrowing response of juvenile applesnails to metabolites of predators, aposematism and automimicry of eggs, and dropping response to mechanical disturbance. Oviposition and the color changes of eggs during embryogenesis are described. One of several photographs illustrates an ovipositing snail. Laboratory observations indicate that crayfish, several kinds of aquatic insect, and various fish and tetrapods are potential predators of *P. paludosa*. A field observation of predation on applesnails by a belostomid beetle is mentioned but not described. New data demonstrate that force-hatched and juvenile applesnails respond to metabolites of all species of turtle tested (including non-native species) and respond weakly to metabolites of other reptiles, fish, crustaceans, and insects. Reaction of snails to metabolites of loggerhead musk turtle declines with age and size of the snail, especially after 8 wk of age and a fresh weight of 3 g. Response does not decline to metabolites of the common snapping turtle, from which *P. paludosa* has no size refuge from predation. The responses are inhibited in darkness. In contrast, alarm response to intraspecific extracts does not develop until several days after hatching, does not diminish with age or size, and is not inhibited by darkness. The authors attempt preliminary characterizations of turtle metabolites and intraspecific extract.

Solem, A. 1974. The shell makers: introducing mollusks. John Wiley & Sons, New York. xii + 289 pp.

Pomacea paludosa (shell with operculum in place) is illustrated with a black-and-white photograph as one of two species of freshwater snail sold for aquarium use.

Sowerby, G. B. 1909. Notes on the family Ampullariidae, with a list of species, varieties, and synonyms, also descriptions of four new species. Proceedings of the Malacological Society of London, 8(6): 345-362.

Species nos. 1-106 are listed (with synonymies, localities, and notes) in *Ampullaria s. s.* and in the subgenera *Ceratodes* Guilding, 1828 and *Pomella* Gray, 1847. *Ampullaria depressa* is given in the synonymy of *A. hopetonensis*, from Florida and Georgia. [Sowerby was not aware of the replacement name, *paludosa*, by Say (1829).] Fifteen varieties of *A. hopetonensis* are listed, mainly from Central and South America. *A. reflexa*, from Cuba, is one of these. *A. paludosa* Say, "1840" [the reprint of Say (1829)] is given in the synonymy of var. *dysoni* Hanley, 1854, from Honduras. *A. miamensis* [*sic*], *A. pinei*, and *A. rotundata* ["unknown" to Sowerby, but "most likely a form of *Hopetonensis*"; but see Clench (1955)] are listed as valid species from Florida.

Sowerby, G. B. 1910. Notes on the family Ampullariidae. Proceedings of the Malacological Society of London, 9(1): 56-64.

This article is a continuation of Sowerby (1909). Species nos. 107-153 are listed (with synonymies, localities, and notes) in the subgenera *Pila* Röding, 1798 (as "*Pila* Bolten") and *Saulea* Gray, 1867 of *Ampullaria*. An "errata" resulting from the discovery of Say's (1829) description adds *A. paludosa* as a valid species, with *A. hopetonensis* moved into its synonymy. In addition, *A. paludosa* is removed from the synonymy of *A. hopetonensis* var. *dysoni*.

Sowerby, G. B. 1916. Notes on the family Ampullariidae. Proceedings of the Malacological Society of London, 12(2-3): 65-73.

This last of the three "Notes on the family Ampullariidae" provides additions and an index. *Ampullaria caliginosa* is added to the synonymy of *A. paludosa* without citation or further comment.

Sprunt, A., Jr. 1945a. The phantom of the marshes. Audubon Magazine, 47(1): 15-22.

This popular article warns of the decline in population size and distribution of the snail kite over the preceding 15 yr due to drainage of marshes and hunting. The author notes its disappearance from St. Johns River marshes, its failure to establish at marshes farther south, and its present [1945] restriction to the Lake Okeechobee region, where "the snail crop is tremendous." The author refers to the birds' exclusive feeding on the applesnail (as "*Pomacea caliginosa*", formerly "*P. depressa*") and attributes the demise of the snail kite directly to the snail's intolerance of drainage. The author reports that snail kites take snails "considerably smaller" than those of maximal size, and he briefly describes extraction of meat from the shell. A photograph (printed upside down?) shows a shell and several clutches of eggs on a tree. "Natives" (unspecified) are noted to apply the name "snail hawk" to the bird in reference to its diet and its morphological similarity to buteos.

Sprunt, A., Jr. 1945b. "The phantom of the marshes." The Florida Naturalist, 18(4): 57-63.

This article is a reprint of Sprunt (1945a) without the photographs. An editorial note indicates that the situation of the snail kite and the Florida applesnail is so important to the Florida readership that Sprunt's article is the first to be reprinted in the journal.

Sprunt, A., Jr. 1947. Snail hawks of the saw grass. Fauna, 9(3): 77-79.

The snail kite is used as an example of a bird that does not respond well to protection because of its specialized diet. Sprunt attributes the rapid decline of the snail kite to drainage (reducing the supply of its food, as "*Pomacea caliginosa*"), unscrupulous duck hunters, and collectors of skins and eggs. Size, color, and eggs of the snail and the method of predation by the kite are briefly described. The dietary specialization of the kite has given rise to the common name "snail hawk" among Florida residents.

Sprunt, A., Jr. 1948. Voice in the wilderness. Fauna, 10(2): 39-42.

This popular article describes the habits of the limpkin, especially its piercing vocalizations. The bird's habitat and range are dependent on that of its primary prey, "a species of large greenish snail that possesses no generally-recognized common name and labors under the formidable scientific cognomen of *Pomacea paludosa*." A very brief account of its extraction method is given. Field photographs of snail egg clutches and apparently empty shells are included.

Sprunt, A., Jr. 1950. Vanishing wings over the sawgrass. Audubon Magazine, 52(6): 380-386.

This article is a revision of Sprunt (1945a), describing the plight of the snail kite, but more explicitly attributing its decline to the effect of marsh drainage on the Florida applesnail. The author describes the "reeking odor of dead *Pomacea* snails" detected during drainage of a marsh, but it is not clear if the author is implying that snails die quickly or if he is only dramatizing a scenario.

Sprunt, A., Jr. 1954. Florida bird life, based upon and supplementary to *Florida Bird Life* by Arthur H. Howell, published in 1932. Coward-McCann, New York. xlii + 527 pp., 56 color pls.

Howell (1932) is quoted extensively in this work, including all references to *Pomacea paludosa* as prey of snail kites and limpkins. But the author substitutes "[largely]" for Howell's "exclusively" in describing the reliance of limpkins on applesnails as prey. Sprunt later explains that limpkins consume freshwater mussels as a secondary item in their diet.

Sprunt, A., Jr. 1956. The Everglade kite. Pp. 15-16, in: [No editor], Our endangered wildlife. National Wildlife Federation, Washington, D. C. 31 pp.

In addition to repeating the essence of Sprunt (1947) regarding factors contributing to the decline of the snail kite, the author cautions against projects that change water levels in Florida marshes and potentially reduce applesnail populations. One figure illustrates a National Wildlife Federation [ca. 1956] conservation stamp with a high-spired *Pomacea* in the talons of a perched male kite. Mention is made of the film "Phantom of the marshes" by B. W. Read (Read, 1954; **Baird, 1970**).

[Sprunt, A., IV.] 1957a. Report on Everglade kite survey, May 1957. [7] pp. [unpublished]

This report surveys *Pomacea paludosa* egg clutches in Lake Okeechobee because of the lack of snail kites at the time of the study and because of the difficulty in sampling live snails. The density of clutches was directly related to water depth, a relationship that the author attributes to the 1956 drought. Clutch densities ranged from 48 per acre in Moonshine Bay (which was almost dry in the drought) to 592 per acre in Turners Cove (where there was deep water near the marsh). During the drought of 1956, exposed flats of Kramer and Torrey islands held "thousands of dead snails." Clutches were found on stems of arrowhead and pickerelweed (*Pontederia cordata* Linnaeus, 1753). The number of eggs per clutch ranged from 15 to 78. In each clutch, 1-3 eggs were small or infertile and did not hatch. This report is on file at Arthur R. Marshall Loxahatchee National Wildlife Refuge. Authorship is attributed by a handwritten entry on the first page.

[Sprunt, A., IV.] 1957b. Report on Everglade kite situation, October 1957. [4] pp. [unpublished]

This is a follow-up study to Sprunt (1957a). The author reports that a 5-yr drought had ended and that the water level in Lake Okeechobee had risen about 1 ft since May and had returned to its pre-drought value. Snail kites had not returned to the lake. *Pomacea paludosa* clutch densities increased 2-4 times since May at four of five sites, but the author includes hatched clutches in his counts; based on tabulated data in both reports, we estimate increases of 0.3-1.7 times. He interprets the clutch data as a rapid increase in the applesnail population and emphasizes a need for much research on life history of the snail. Clutch sizes ranged from 2 to 62 eggs. This report is on file at Arthur R. Marshall Loxahatchee National Wildlife Refuge. Authorship is attributed by a handwritten entry on the first page.

Sprunt, D. N. 1960. Studies in *Pomacea caliginosa*, July, 1960, Tavernier, Florida. [31] pp. [unpublished]

The author measured 1-3 dimensions of the snail shell over several weeks post-hatching for 11 cohorts of applesnails from clutches collected in the Everglades and held in the laboratory. Some interesting anecdotal observations are included. Data are tabulated and graphed with little explanation. Hatchlings doubled or tripled the linear dimensions of shells in 5-6 wk. This report is on file at Arthur R. Marshall Loxahatchee National Wildlife Refuge.

Stahlschmidt, V. & H. G. Wolff. 1972. The fine structure of the statocyst of the prosobranch mollusc *Pomacea paludosa*. Zeitschrift für Zellforschung und mikroskopische Anatomie, 133(4): 529-537.

This is the second ultrastructural study on prosobranch statocysts and the first to analyze polarity of the sensory cilia. Statocysts have far more hair cells than are found in pulmonates and opisthobranchs. In contrast to the latter two groups, sensory cilia of *Pomacea paludosa* are morphologically polarized, as in vertebrates, suggesting directional sensitivity. The source of *P. paludosa* is not given.

Stevens, A. J., N. M. Stevens, P. C. Darby & H. F. Percival. 1999. Observations of fire ants (*Solenopsis invicta* Buren) attacking apple snails (*Pomacea paludosa* Say) exposed during dry down conditions. Journal of Molluscan Studies, 65(4): 507-510.

The authors' attempt to study the effect of dry-down conditions on survival of post-reproductive adult applesnails in June in an outdoor laboratory became an "unplanned laboratory experiment" when their six sand-filled tanks were invaded by fire ants within a day of dry down. Ants bypassed the loosely closed opercula. Their attack caused snails to writhe and to secrete mucus. Snail mortality was higher than in control tanks (with standing water). Based on unpublished data [probably a reference to Darby *et al.* (1997 [1998])], mortality was not expected to differ between dry-down and control tanks of post-reproductive adults. The authors do not comment specifically on the potential effect of fire ants on pre-reproductive snails during the natural dry season, approximately November through March.

Stevenson, H. M. & B. H. Anderson. 1994. The birdlife of Florida. University Press of Florida, Gainesville, Florida. 892 pp.

The cover and title page of this book include original artwork of a limpkin carrying an applesnail in its bill. Applesnails are listed as prey of snail kites, limpkins, and boat-tailed grackles (in the latter case referring to the snails as "*Ampullaria* sp."). A brief description is given for the methods of locating, capturing, and extracting snails by the snail kite. The authors suggest that the ability of the snail kite to find snails, the migratory habits of the bird, and its tendency to switch from predation on snails are related to water depth.

Stieglitz, W. O. 1965. The Everglade kite (*Rostrhamus sociabilis plumbeus*). United States Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Division of Refuges, [city, state unknown]. 32 pp.

This report was published as Stieglitz & Thompson (1967) with a similar organization and updated text. In addition to different photographs of kite nests and habitat, the report includes a photograph of only a clutch of applesnail eggs on a plant stem rather than the photograph of a clutch and snail shell that appears in the later publication.

Stieglitz, W. O. & R. L. Thompson. 1967. Status and life history of the Everglade kite in the United States. [United States Department of the Interior], Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Special Scientific Report—Wildlife, no. 109: 1-21.

Based on Stieglitz (1965), this review of the general biology of the snail kite includes sections on population biology, habitat, reproduction, feeding, and limiting factors. The authors depend heavily on personal observations made mostly at the Loxahatchee National Wildlife Refuge. Sections on feeding, snail life history, and pesticides include new information on *Pomacea paludosa*. The authors emphasize the importance of maintaining water levels to preserve kite habitat through control of snail populations and the plant community. A photograph (figure 12) of a seemingly staged situation appears to be an empty adult shell in daytime positioned below a clutch of eggs and oriented as if the snail were crawling down the plant stem.

Stouffer, M. 1995. Marty Stouffer's wild America: animal oddities, family edition. Marty Stouffer Productions, Ltd., [Aspen, Colorado], & King World Direct, Inc., [Los Angeles]. [videotape, 82 min]

The second episode of three is titled "A multitude of mollusks" and runs for 28 min. The episode deals with the diversity of mollusks (mostly gastropods), their specialized predators, and their defenses against generalist predators. Brief segments show a crawling Florida applesnail and a clutch of eggs on the stem of an emergent plant. The narrative by Marty Stouffer explains that Florida populations of two major applesnail predators, the limpkin and snail kite, are in peril because of a decline in the applesnail population from habitat loss. This episode originally aired on Public Broadcasting System stations in the 1980s.

Stouffer, M. 1997. Marty Stouffer's wild America: the predators. Marty Stouffer Productions, Ltd., [Aspen, Colorado], and Dastar Corporation, [location unknown]. [videotape, 51 min]

About 1 min of this episode deals with the snail kite and describes it as a specialized feeder. Its prey, the Florida applesnail, is disappearing because of drainage of the Everglades. A brief segment shows an adult kite feeding pieces of snail to its two chicks. This episode was originally released in 1994, and some versions carry a copyright date of 1999.

Stouffer, M. 1999. Marty Stouffer's wild America: the bill makes the bird. Marty Stouffer Productions, Inc., [Aspen, Colorado], & MG Perrin, Inc., [location unknown]. [videotape, 28 min]

This videotaped production describes the adaptations of bills of birds for various functions. Film footage of a snail kite feeding on an applesnail is accompanied by an explanation that applesnail populations are declining due to habitat loss from water-management practices and drought. The limpkin is said to remove an applesnail from the shell by grabbing the body after it "waits for the snail to emerge." This film was seen by us when it was aired on WFTV, Orlando, in 2003. The videotape has not yet been commercially released, but the text is accessible at www.wildamerica.com.

Strebel, H. 1873 [1874]. Ein Beitrag zur Fauna mexikanischer Land- und Süsswasser Conchylien. Abhandlungen aus dem Gebiete der Naturwissenschaften herausgegeben von dem naturwissenschaftlichen Verein in Hamburg, 6(1): 1-69, pls. 1-9.

Ampullaria flagellata is described from Mexico in great detail but by shell characters only. Three species names (*malleata* Jonas, 1844, *reflexa*, *violacea* Valenciennes, 1833) are listed following the name *A. flagellata* in the heading as synonyms. Four "Monstrositäten" are also described, dealing with shell malformations. Pfeiffer's (1854-1860) accounts of *A. reflexa* and *A. conica* are discussed as corresponding very well within the author's concept of *A. flagellata*. These descriptions by Pfeiffer were listed as misidentified *Pomacea paludosa* by Alderson (1925) and Pilsbry (1927) [1928]. Our corrected date of publication for Strebel's work comes from the last sentence of a review by **Martens (1874: 362)**: "Das Werk führt auf dem Titel die Jahrzahl 1873, ist aber thatsächlich in der ersten Hälfte des Monats Mai 1874 erschienen."

Summers, W. C. 1966. Quantitative measurements of snail feeding at the water surface. Ph. D. dissertation, University of Minnesota, Minneapolis, Minnesota. [8] + 72 pp. [1967. Dissertation Abstracts, 28B(1): 391.]

Pedal ciliary feeding was studied in laboratory specimens of three pulmonate snails and of a prosobranch identified as *Pomacea paludosa*. Feeding rates were measured as the weight per hour of particulate fish food consumed and as the area per hour of water surface cleared. Purchase of applesnails from a pet shop in the midwestern United States makes identity of these specimens doubtful.

Swainson, W. 1820-1823. Zoological Illustrations, or original figures and descriptions of new, rare, or interesting animals, selected chiefly from the classes of ornithology, entomology, and conchology, and arranged on the principles of Cuvier and other modern zoologists. Conchology, Part I. Baldwin, Cradock, and Joy, and W. Wood, London. 182 pls.

Plate 172 (dated 1823) is of *Ampullaria reflexa* (called the "purple apple snail"), from an unknown locality. A diagnosis is provided. A figure by Knorr (1771) is cited as a specimen without periostracum ("uncoated"). The nomenclatural relationship between *A. reflexa* and *Pomacea paludosa* is presently unclear (**Turner *et al.*, 2001; Cowie & Thiengo, 2003**). A second edition ("series") of this work is given dates ranging from 1829 to 1833 by various sources.

Sykes, P. W., Jr. 1971a. Connoisseur of snails. In-sight [United States Department of the Interior, Bureau of Sport Fisheries and Wildlife], October: 6.

Hunting, capture, and extraction of applesnails by the snail kite are described. Decline of the kite population in Florida is attributed to many factors, including habitat destruction and increase in floating aquatic plants, both presumably related to the kite's diet of applesnails.

Sykes, P. W., Jr. 1971b. The Everglade kite. Florida Wildlife Federation, annual meeting, 24-26 September, Governor's award banquet, Winter Park, Florida, p. 26. [brochure]

In addition to material similar to Sykes (1971a), this article in the annual banquet program brochure briefly describes the seasonal activity cycle of the Florida applesnail and claims that the snail burrows during droughts. Clutches of eggs are described, and the cover illustration of the brochure depicts a clutch on an emergent plant stem near a perched kite.

Sykes, P. W., Jr. 1978. Endangered: Florida Everglade kite. Pp. 4-7, in: H. W. Kale, II (ed.), Rare and endangered biota of Florida. Vol. 2. Birds. University Presses of Florida, Gainesville, Florida. 121 pp.

The author states that the snail kite "has the most specialized feeding habit of all the raptorial birds in the world." The methods kites use to locate, capture, and extract snails are briefly described. The endangered status of the kite is attributed largely to the Florida applesnail's requirement for continuous flooding of marsh habitat and the kite's need for waters free of floating aquatic plants. Sykes strongly recommends that ecological studies be done on the Florida applesnail. Consult Rodgers (1996) for an updated version of this section.

Sykes, P. W., Jr. 1979. Status of the Everglade kite in Florida—1968-1978. The Wilson Bulletin, 91(4): 495-511, frontispiece.

The author claims that the Florida applesnail requires several years of flooded marsh to reach population sizes that are adequate for foraging by snail kites. Invasion by water hyacinth reduces the ability of the kite to find snails. Kites are nomadic because natural hydrological changes affect the availability of applesnails. This nomadic behavior has increased probably because of water-management practices. The author attributes some mortality of young kites to chronic damage to their plumage from their failure to learn how to find and capture applesnails properly.

Sykes, P. W., Jr. 1982. Everglade kite. Pp. 43-44, in: D. E. Davis (ed.), CRC handbook of census methods for terrestrial vertebrates. CRC Press, Boca Raton, Florida. 397 pp.

The Florida applesnail, primary prey of the snail kite, is available to the kite in shallow open-water marshes.

Sykes, P. W., Jr. 1983a. Snail kite use of the freshwater marshes of south Florida. Florida Field Naturalist, 11(4): 73-88.

In this summary of census data taken of snail kites in 1967-1980, several correlative observations are given to support a relationship among kite population size, Florida applesnail population density, and hydrological conditions. The author recommends studies on snail ecology, including the effects of pesticides. Specifications given here for management of kite habitat are presumably in part a formula for maintenance of snail populations. The claim that Martin & Doebel (1974; listed as "1973") found seeding of habitat with applesnails to be feasible is not supported by their data.

Sykes, P. W., Jr. 1983b. Recent population trend of the snail kite in Florida and its relationship to water levels. Journal of Field Ornithology, 54(3): 237-246.

This article is an update to a continuing census of snail kites in south Florida. Kite census data are positively correlated with water depth. Although briefly alluded to in the discussion, concurrent changes in populations of Florida applesnails are not documented, and no causal relationship is established among kite populations, snail populations, and water depth.

Sykes, P. W., Jr. 1984. The range of the snail kite and its history in Florida. Bulletin of the Florida State Museum, Biological Sciences, 29(6): 211-264.

This is a detailed record of the historic range of the snail kite based on literature, personal communications, museum holdings of skins, mounts, and eggs, and the author's field observations. Many locations are listed as possible breeding sites for kites in the past, probably based on the author's assessment of applesnail abundance. He writes, "Prior to about 1900, the Snail Kite was probably found, at least in years when water levels were high, in nearly all freshwater marshes containing an apple snail (*Pomacea paludosa*) population from about 29° 15' north latitude south ..."

Sykes, P. W., Jr. 1985a. Evening roosts of the snail kite in Florida. The Wilson Bulletin, 97(1): 57-70.

This study on snail kite roosting sites and roosting habits includes notation of whether or not an arriving bird had a Florida applesnail in its bill or had recently eaten as evidenced by a distended crop. From observations on 450 individuals, 2-26% arrived at roosts carrying snails, which were usually still in the shells. Grey birds (adult and subadult males) brought snails to the roost 14% of the time, and brown birds (all females and immature males) only 3%; but brown birds arrived with distended crops 46% of the time. All roosts were located in flooded freshwater marshes.

Sykes, P. W., Jr. 1985b. Pesticide concentrations in snail kite eggs and nestlings in Florida. The Condor, 87(3): 438.

Supplemental to data presented by Lamont & Reichel (1970), tissues of unhatched snail kite eggs and dead nestlings were analyzed by gas chromatography for DDE, DDD, DDT, dieldrin, and PCB. Most samples showed pesticide concentrations below measurable limits and were considered to reflect baseline environmental levels. [DDT and dieldrin were banned for use in the United States *ca.* 1975.] Continued monitoring of kite populations as well as of Florida applesnail populations was recommended, especially because, at the time, none of the large variety of agricultural pesticides used in south Florida (which run off untreated into surrounding wetlands) had been tested for their effect on applesnails. No cause was suggested for the observed mortality of eggs and nestlings.

Sykes, P. W., Jr. 1987a. The feeding habits of the snail kite in Florida, USA. Colonial Waterbirds, 10(1): 84-92.

In this strongly quantitative study based on 14 yr of observations in south Florida, the author describes course-hunting and still-hunting by the snail kite. Habitat use in hunting the Florida applesnail, time budgets of hunting, estimated maximal depth of capture, capture success, capture rate, handling time, attempts at extraction and processing of soft parts, and feeding of nestlings are quantified. Data on male and female kites are compared. Food is characterized by shell dimensions, weight of soft parts, organic and inorganic composition of snail body, and energy content; a graph is presented for shell dimensions versus fresh weight of soft parts. The first report of regurgitated pellets and new reports of kites feeding on prey other than *Pomacea paludosa* are included. The author cites an unpublished document by **Holgerson (1967)**, a copy of which we have been unable to examine.

Sykes, P. W., Jr. 1987b. Some aspects of the breeding biology of the snail kite in Florida. Journal of Field Ornithology, 58(2): 171-189.

Gifts of extracted Florida applesnails by male snail kites to females are part of pre-copulatory behavior and of changeover of duties during incubation on the nest. Although the activity and abundance of applesnails are considered by the author to be important to the survival of nestlings and to the development of hunting skills in fledglings, low availability of applesnails is not among the 22 factors listed as responsible for nesting failure.

Sykes, P. W., Jr. & D. J. Forrester. 1983. Parasites of the snail kite in Florida and summary of those reported for the species. Florida Field Naturalist, 11(4): 111-116.

The Florida applesnail is suspected to be an intermediate host for endoparasites of the snail kite. Ectoparasites of the kite might be obtained by contact with boat-tailed grackles, which "often attempt to steal apple snails ... from kites while the kites perch to feed ..."

Sykes, P. W., Jr. & H. W. Kale, II. 1974. Everglade kites feed on nonsnail prey. The Auk, 91(4): 818-820.

This article reports two incidents of snail kites consuming flesh of a turtle and a rodent in the field. Consumption of the turtle meat was attributed tentatively to a decline in the Florida applesnail population due to local drought; but consumption of the rodent occurred in an area abundant with applesnails, which were being actively preyed upon by other snail kites.

Sykes, P. W., Jr. & W. B. Robertson, Jr. 1968. Kites in the Everglades. Nature, 220(5170): 939-940.

In this letter, the authors give corrections and additions to Anonymous (1968), including a correction of the name of the Florida applesnail from *Pomacea paludis* to *P. paludosa.*

Sykes, P. W., Jr., J. A. Rodgers, Jr. & R. W. Bennetts. 1995. Snail kite (*Rostrhamus sociabilis*). No. 171, in: A. Poole & F. Gill (eds.), The birds of North America. The Academy of Natural Sciences, Philadelphia, & The American Ornithologists' Union, Washington, D. C. 32 pp.

This pamphlet is a recent and thorough summary of the biology of the snail kite, including the snail kite in Florida. Detailed descriptions from the literature are given of kite foraging for snails, handling of prey, extraction of snail meat from the shell, feeding rates; of food value of the Florida applesnail; of factors influencing the availability of snails to the kite and prey switching; and of proposals for conservation. The authors conclude that more information is needed about applesnail biology. A line drawing illustrates a perched kite extracting applesnail meat from the shell.

Tabb, D. C. 1963. A summary of existing information on the fresh-water brackish-water and marine ecology of the Florida Everglades region in relation to fresh-water needs of Everglades National Park. Unpublished report ML

#63609 to The Office of the Superintendent, Everglades National Park & Fort Jefferson National Monument. Institute of Marine Science, University of Miami, [Miami], Florida. 152 pp.

This report is primarily the result of literature research, including a few references on applesnails. The author refers to eyewitness accounts of applesnails and other animals "burrowing into the soft muds at the bottoms of deeper holes" during droughts. The author recommends a field study on the effects of declining water level on marsh animals and a laboratory study on tolerance to desiccation and high CO_2 concentration and on the ability to burrow. The author remarks that applesnails are weak burrowers in soft substrates.

Takekawa, J. E. & S. R. Beissinger. 1983. First evidence of snail kites feeding on introduced snail, *Pomacea bridgesi*, in Florida. Florida Field Naturalist, 11(4): 107-108.

The authors provide circumstantial evidence for consumption of *Pomacea bridgesii* (as "*Pomacea bridgesi*") by snail kites in disturbed habitats unoccupied by *P. paludosa*. Shell morphology, shell color, and clutch parameters of the two species are compared. The authors suggest that the smaller hatchling size of *P. bridgesii* might permit its more rapid dispersal to and colonization of disturbed habitats.

Takekawa, J. E. & S. R. Beissinger. 1989. Cyclic drought, dispersal, and the conservation of the snail kite in Florida: lessons in critical habitat. Conservation Biology, 3(3): 302-311.

This work documents snail kite distribution during periods of drought in Florida, emphasizing emergency habitats as limiting factors in population maintenance and the Florida applesnail as the food source sought by the dispersing kites. The kite is characterized as a "wandering species," hardest to protect through conservation efforts because of their frequent but irregular use of disjunct patches of habitat. From data gathered through the "Snail Kite Sighting Hotline" at Loxahatchee National Wildlife Refuge, the authors document dispersal during a 1985 drought from the Florida Everglades to sites mostly in Palm Beach County (but as far north as Duval County). "Drought-related" habitats included not only lakes and seasonal marshes but also man-made canals, borrow pits, and agricultural fields—areas that have received little attention from conservationists in the past. The influence of snail abundance on emergency habitat use by snail kites is illustrated by one example, a canal and flooded farm field that supported extensive use in 1981-1982 but received little use in 1985 after dredging and draining activities eliminated the snail populations. Designation of emergency habitats as "critical habitat" is urged to assure maintenance flooding and snail survival during times of low water.

Talbot, S. 1970. A study of *Pomacea paludosa* and *Lepomis macrochirus* as a possible strand of the food web of the *Eichhornia crassipes* community. Unpublished report, Stetson University, Deland, Florida. [not seen]

Perry (1973 [1974]: 23) cites this document: "Talbot (1970) found with the aid of radioisotopes that apple snails in aquaria preferred eating the leafy portions of [water] hyacinths to the roots and detritus." This report also was cited by Perry (1971).

Taylor, D. W. 1966. Summary of North American Blancan nonmarine mollusks. Malacologia, 4(1): 1-172.

A list from the North American Blancan age (late Pliocene and early Pleistocene) includes *Pomacea paludosa* from "unit A" localities in central Florida [all other Blancan localities are west of the Mississippi River]. A specimen from St. Lucie County is figured as a black-and-white photograph. The author surmises that, because *P. paludosa* had not been found in collections from the Pliocene Caloosahatchee Formation (indicating that Dall's [1892] records were probably from higher strata), the species probably more recently extended its range into central Florida. The author considers *Ampullaria hopetonensis* of Tucker & Wilson (1932) to be *P. flagellata innexa* (Crosse & Fischer, 1888) (a synonym of *P. flagellata*; **Cowie & Thiengo, 2003**) that co-occurred with *P. paludosa* in "unit A" but is now extirpated from Florida. [There is no other evidence that *P. flagellata* occurred in Florida.]

Taylor, M. G. & K. Simkiss. 1989. Structural and analytical studies on metal ion-containing granules. Pp. 427-460, in: S. Mann, J. Webb & R. J. P. Williams (eds.), Biomineralization: chemical and biochemical perspectives. VCH Publishers, New York. 541 pp.

In a section on carbonates, the authors summarize the findings of Watabe *et al.* (1976) on vaterite granules in *Pomacea paludosa* and their role in shell repair. See the annotation for Watabe *et al.* (1976) for cautions about the identity of their snails.

T[ennis], H. 1954. Everglade kite *Rostrhamus sociabilis plumbeus*. The Florida Naturalist, 27(3): 89-90.

The journal's editor summarizes information from Read (1954), including predation on and habitat requirements of *Pomacea caliginosa*.

Terczak, E. F. [1980.] Aquatic macrofauna of the Water Conservation Areas, September 1979-1980. South Florida Water Management District, Environmental Sciences Division, Resource Planning Department, [West Palm Beach, Florida]. [38 or 39 pp.] [unpublished]

Pomacea paludosa were collected with other fauna from Water Conservation Areas 1, 2, and 3 in the Everglades using a small tub sampler of 850 cm^2 area. Bottomless tubs were driven into the substratum at water depths less than 0.9 m, and animals were removed from the tubs by dip net. The Florida applesnail was the third most abundant of four species of snail. An unlabelled drawing of *P. paludosa* in apertural view is included. The only existing copy of this document that we have found is in the library of the South Florida Water Management District. It seems to be missing one page in the methods section, and the pages in the bound volume are out of order. Page numbers, where they appear, and the date are entered by hand.

Thompson, F. G. 1984. The freshwater snails of Florida: a manual for identification. University Presses of Florida, Gainesville, Florida. x + 94 pp.

The family Pilidae (= Ampullariidae, based on *Ampullaria* Lamarck, a junior objective synonym of *Pila* Röding) and its three Floridan species are discussed. Key characteristics are provided for *Marissa cornuaurietus* [*sic*], *Pomacea bridgesi* [*sic*] (these last two introduced), and naturally occurring *P. paludosa*. *Pomacea paludosa* is native to Florida, Cuba, and Georgia and has been introduced into Alabama in artificially heated water. Fossil records exist since the Florida Pliocene. The taxonomic status of *Pomacea miamiensis* is uncertain. Photographs of the shells of all four species are provided.

Thorp, J. H. & A. P. Covich (editors). 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego. 911 pp.

In their introduction, the editors use a line drawing (fig. 1.8) of *Pomacea paludosa* to illustrate spiral morphology of a snail shell. For more information on *P. paludosa* in this volume, see Brown (1991). This book has recently been revised (**Thorp & Covich, 2001**).

Toland, B. R. [1993.] Snail kite ecology and status reports of other species of regional concern in the upper St. Johns marshes. 1990-1993 final report to St. Johns River Water Management District, Palatka, Florida. Florida Game and Fresh Water Fish Commission, Office of Environmental Services, Vero Beach, Florida. [35] pp.

In this 4-yr study in marshes at the headwaters of the St. Johns River, foraging by snail kites on Florida applesnails (as "*Pomacea palidosa*" [*sic*]) was studied. Applesnails seemed to be inaccessible to kites in areas dominated by sawgrass, hydrilla, water hyacinth, water lettuce, and cattail. Kites in the marsh foraged in water of 0.5-1.3 m depth by course hunting (89% of foraging bouts, 92% success rate, over prairie and slough) and still hunting (11% of bouts, 58% success, along edges of sawgrass and tree islands). Adult kites were more successful (94%) than immature kites (58%) in capturing snails. The average duration of a foraging bout was shorter for male (65 sec) than female (170 sec) kites, and immature kites took even longer (6.5 min). Adults delivered snails at an average rate of 5/h to nestlings, which had a characteristic food-begging call. Nesting kites captured snails with larger shell dimensions (40.6 mm length by 43.5 mm width) than did non-nesting kites

(25.6 mm by 28.4 mm), although the author attributes the difference in part to the selection of smaller snails by immature kites. The size of snails captured was not different between kites that nested successfully and those that were unsuccessful. Starvation of nestlings accounted for 3-12% of nest failures in 1991-1993 and was attributed to patchiness in the availability of snails, as was abandonment of nests. Statements about density, patchiness, and size of applesnail populations are not supported by the presence of data. Although this document is undated, S. J. Miller (2002, personal communication) of the St. Johns River Water Management District reports that it was received in 1993.

Tompa, A. S. & N. Watabe. 1976. Ultrastructural investigation of the mechanism of muscle attachment to the gastropod shell. Journal of Morphology, 149(3): 339-351.

The authors report that the ultrastructural relationship among the columellar muscle, its tendon, and the shell is uniform among two terrestrial pulmonate snails, a freshwater pulmonate, and alleged *Pomacea paludosa*. Although no source of *P. paludosa* is mentioned and no internal evidence in the paper can be used to evaluate the validity of the identity of the applesnails, this study was supported by the same grant as those of Meenakshi *et al.* (1974) and Meenakshi & Watabe (1977), to which the reader is referred for cautionary details.

Toner, M. 1984. The kite hangs by a thread. National Wildlife, 22(5): 38-43.

Decline of the snail kite in Florida is attributed to habitat loss and the effect of such loss on populations of the Florida applesnail, which "requires year-round flooded marshes." The method and rate of extraction of the snail by the kite are briefly described, and a photograph records an adult kite offering an extracted snail to a nestling.

Toops, C. 1998. The Florida Everglades, revised edition. Voyageur Press, Stillwater, Minnesota. 112 pp.

Florida applesnail diet, locomotion, predation, respiration, aestivation, and oviposition are briefly described. Hatchling snails are claimed to live among periphyton. A photograph shows a clutch of eggs on a pickerelweed stem. The first edition (**Toops, 1989**) includes no information or illustrations about applesnails.

Toth, L. A., S. L. Melvin, D. A. Arrington & J. Chamberlain. 1998. Hydrologic manipulations of the channelized Kissimmee River: implications for restoration. BioScience, 48(9): 757-764.

The reliance on long hydroperiods by the snail kite for nesting and for foraging on *Pomacea paludosa* is used as an example of the impact on wildlife by channelization of the Kissimmee River in Florida.

Truslow, F. K. 1958. Limpkin, the "crying bird" that haunts Florida swamps. The National Geographic Magazine, 113(1): 114-121.

This naturalist describes his field observations of limpkins and their feeding on Florida applesnails at Wakulla Springs, Florida, and illustrates the article with photographs. Capture and handling of prey are described. In a figure caption, the author claims that a limpkin waits for the snail to relax and to open its operculum before the bird strikes with its bill to attempt extraction of the meat.

Truslow, F. K. & F. G. Vosburgh. 1967. Threatened glories of Everglades National Park. The National Geographic Magazine, 132(4): 508-553.

This pictorial on the Florida Everglades mainly documents the activities of various bird species but also traces the history of south Florida development and water use and their impact on the national park. A series of three photographs shows a limpkin extracting a Florida applesnail from its shell.

Tucker, H. I. & D. Wilson. 1932. A list of Caloosahatchie Pliocene species. Proceedings of the Indiana Academy of Science, 1931, 41: 355-356.

The Florida applesnail (as "*Ampullaria depressa*" and, perhaps, "*A. hopetonensis*" [but see Taylor (1966)]) was collected from the Caloosahatchee Formation (Pliocene) at Port Mayaca, Florida, near the eastern shore of Lake Okeechobee.

Tüllner, H.-U. 1973. Die Bedeutung der Statocysten von *Lymnaea stagnalis* und *Pomacea paludosa* für die Raumorientierung. Diplomarbeit, Universität zu Köln, Cologne, West Germany. 66 pp.

Much of this work is published in Tüllner & Wolff (1979), but this original work includes more details of methodology, more illustrations and tabulated data, results of sham-operated animals, and some speculation on how compensation for loss of statocysts occurs. Some values are different and were presumably recalculated for publication. In addition, the author studied movement of normal and unilaterally statocystectomized applesnails along a vertical surface placed along the diameter of a rotating aquarium. The angle of orientation of animals subjected to this treatment was determined by the resultant vector of centrifugal and gravitational forces. As in studies on horizontal surfaces (see Tüllner & Wolff [1979]), the direction of operated snails deviated to the intact side of the body. The source of specimens of *Pomacea paludosa* for this study was not given.

Tüllner, H.-U. & H. G. Wolff. 1979. Statocyst controlled orientation in the prosobranch gastropod *Pomacea paludosa*. Zoologische Jahrbucher, Abteilung für allgemeine Zoologie und Physiologie der Tiere, 83(1): 13-20.

Centrotactic orientation in normal, uni- and bilaterally statocystectomized, and sham-operated applesnails was studied in rotating aquaria and darkness with the aid of flash photography within 3 d after operation. Orientation was measured as the angle between the direction of locomotion and the tangent (instantaneous direction of rotation). Normal snails moved at an angle of 88°; right statocystectomized snails, 103° (to the left of normal snails); left statocystectomized snails, 70° (to the right). These snails moved toward the center of the aquarium and remained there. Bilaterally statocystectomized snails moved randomly and did not remain in the center if they reached it. Sham-operated snails were used, and the authors implied that their behavior was normal; but no data were given and no statistical comparisons made. Deviation of the angle of orientation from normal was compensated within about 4 d after operation in unilaterally statocystectomized snails although a subsequent temporary period of overcompensation sometimes ensued. Bilaterally extirpated snails compensated fully (82°) in 30-40 d, by which time the statocysts were not regenerated. Angle of orientation did not appear to vary with centrifugal force. These results challenge those of McClary (1966, 1968a [erroneously cited as "1967"]), who tested negative geotaxis in snails with a longer post-operative recovery time. The source of specimens of *Pomacea paludosa* is not given.

Turgeon, D. D., A. E. Bogan, E. V. Coan, W. K. Emerson, W. G. Lyons, W. L. Pratt, C. F. E. Roper, A. Scheltema, F. G. Thompson & J. D. Williams. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. American Fisheries Society, Bethesda, Maryland, Special Publication, no. 16: 1-277, [12] color pls.

The common name "Florida applesnail" is established for *P. paludosa*. This remains unchanged in the second edition (Turgeon *et al.*, 1998).

Turgeon, D. D., J. F. Quinn, Jr., A. E. Bogan, E. V. Coan, F. G. Hochberg, W. G. Lyons, P. M. Mikkelsen, R. J. Neves, C. F. E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F. G. Thompson, M. Vecchione & J. D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks, 2nd edition. American Fisheries Society, Bethesda, Maryland, Special Publication, no. 26: 1-526. [available in CD-ROM]

See Turgeon *et al.* (1988).

Turner, R. L. 1994. The effects of hydrology on the population dynamics of the Florida applesnail (*Pomacea paludosa*). St. Johns River Water Management District, Palatka, Florida, Special Publication, no. SJ94-SP3: i-vi, 1-31.

Laboratory and field experiments investigated the Florida applesnail's preference of vegetation for oviposition, the survivability of adults in air, the survivability of developing embryos under water, and the impact of predators on submerged egg masses. Most parts except adult survival were published separately (Turner 1996b, 1998). To test the tolerance of adults to aerial exposure, adults were placed in partitioned containers either with apertures up (to facilitate retention of mantle fluid) or with apertures down on saturated sand from the habitat. Four trials varied in presence or absence of air-conditioning, length of trial, subjectiveness of examiner, and "freshness" of adults (*i.e.*, length of time between specimen collection and beginning of a trial). Each snail was observed daily for viability and evidence of locomotion for periods of 7-29 d. Aestivation did not occur, and mortality was highest during the first week of testing; the availability of moist sand did not substantially improve the results for these shallow burrowers. In this respect, *Pomacea paludosa* was judged to be much more susceptible to exposure than some of its congeners that can reportedly survive several months out of water. An abstract of this work appeared as Turner & McCaffree (1994). Recommendations for management include maintaining a heterogeneous community of broad-stemmed vegetation, restricting water-level drawdowns to naturally dry winter seasons (never more than one year in a row), and considering clutch height in determining the rate and level of intentional flooding.

Turner, R. L. 1995. Use of emergent plant stems for oviposition by the Florida applesnail: implications for marsh management. Florida Scientist, 58(suppl. 1): 11. [abstract]

This work was published in full as Turner (1996b).

Turner, R. L. 1996a. Effects of submersion on eggs of the Florida applesnail and implications for predation by aquatic predators. Florida Scientist, 59(suppl. 1): 12. [abstract]

This work was published in full as Turner (1998).

Turner, R. L. 1996b. Use of stems of emergent plants for oviposition by the Florida applesnail, *Pomacea paludosa*, and implications for marsh management. Florida Scientist, 59(1): 34-49.

A 1992-1993 field study is described examining the density and distribution of applesnail egg clutches among emergent plants in sawgrass, maidencane, mixed shallow, and deep-water marshes at Blue Cypress Water Management Area, east central Florida. Densities were highest in sawgrass marsh, intermediate in maidencane and mixed shallow marshes (at *ca.* one-third of sawgrass density), and zero in deep marsh. Sixteen taxa of emergent plant were encountered; those most used for oviposition were sawgrass, string lily (*Crinum americanum* Linnaeus, 1753), pickerelweed, and lance-leaved sagittaria (water plantain) (*Sagittaria lancifolia* Linnaeus, 1759). Preference in all marsh types was for broad stems exceeding 6 mm diameter at water level, a factor clearly related to stability of the broad foot of the applesnail. Clutch elevation on stems above water was not significantly different among plants. Clutches were generally rare in dense stands of vegetation. Advice for management of applesnail habitat stresses a heterogeneous community of broad-stemmed emergent plants at moderate density. This work was initially published as Turner (1994) and as an abstract (Turner, 1995).

Turner, R. L. 1998. Effects of submergence on embryonic survival and developmental rate of the Florida applesnail, *Pomacea paludosa*: implications for egg predation and marsh management. Florida Scientist, 61(2): 118-129.

Laboratory and field experiments tested the survivability of applesnail embryos to submergence as well as the hypothesis that aerial oviposition evolved in response to predation. Fresh egg masses ("0-d-old," based on the presence of extracapsular "jelly", which dries within the first day) were collected from two freshwater ponds in eastern Florida. Selected masses were submerged in beakers in native pond water at starting points ranging from 1 to 12 d. At 14 or 21 d after collection, embryos were measured and observed to determine stage and viability. Results showed that submergence slowed the rate of embryonic development and resulted in increased mortality in all cases; longer and earlier submergence were positively correlated with retarded development and increased incidence of embryonic death. Field studies addressing the impact of submerged predators involved attachment of paired clutches to polyvinylchloride poles (one aerial clutch and one submerged clutch per pole) and harvest of clutches after 3 or 7 d to assess the degree of damage. Mortality was greater in the field than in the laboratory experiments; but losses were attributed to loss of adhesion or entanglement in floating debris, suggesting that predators are not a significant influence on applesnail survivability in these two locations, despite the presence of two known predators (redear sunfish, Florida soft-shelled turtle). Given the normal elevation of egg-mass deposition above the water line (150-200 mm) and the fact that highest susceptibility exists for the youngest embryos, normal rates of water rise present few problems for applesnail populations. Nevertheless, unnaturally rapid water rise, such as that precipitated by wetlands management, can pose a serious threat during spawning season (March through October). This work was initially published as Turner (1994) and as an abstract (Turner, 1996a), but the present article adds the results of another trial of embryonic susceptibility to submergence.

Turner, R. L., T. C. DiNoto & C. M. McCabe. 1990. Hydric relations of terrestrial eggs of the Florida apple snail, *Pomacea paludosa*. Florida Scientist, 53(suppl. 1): 14. [abstract]

Clutches of eggs lose 40% of their wet weight during drying of the extracapsular jelly in the first day after oviposition. Desiccation thereafter is slow and is inversely related to humidity.

Turner, R. L. & C. M. McCabe. 1990. Calcium source for protoconch formation in the Florida apple snail, *Pomacea paludosa* (Prosobranchia: Pilidae): more evidence for physiologic plasticity in the evolution of terrestrial eggs. The Veliger, 33(2): 185-189.

The calcified eggs of *Pomacea paludosa* were analyzed to determine the source of calcium for developing embryos. Freshly laid and late-stage clutches from the field provided egg capsules, intracapsular material (including the embryo), and hatchlings for analysis. The initial amount of calcium was 1.03 mg, or 18.3% of intracapsular dry weight, per egg; comparable values for the hatchling were 0.967 mg or 20.7% dry weight, of which 97% was found in the shell and operculum. Scanning electron microscopy revealed little change in thickness or physical appearance of the capsule during development, but the integrity of the innermost crystalline layer appeared altered, probably providing some structural weakness prerequisite for hatching. Cited studies on presumed *P. paludosa* (*e.g.*, Meenakshi *et al.*, 1974, 1975; Watabe *et al.*, 1976; Meenakshi & Watabe, 1977) are attributed to *P. bridgesii* on the basis of clutch parameters, rendering this study as the first of its kind on verified specimens of *P. paludosa*. The initial high concentration (745 mM) of intracapsular calcium in these eggs is more than 300% greater than that reported so far for other gastropods. Contrary to conclusions drawn from data on other gastropods with terrestrial eggs, *P. paludosa* embryos derive calcium entirely from intracapsular contents, not from the capsule or external sources. Structural properties of the capsule probably are largely maintained for protection and support of the embryo during intracapsular development.

Turner, R. L. & S. E. McCaffree. 1994. Desiccation tolerance of adult and hatchling Florida applesnails. Florida Scientist, 57(suppl. 1): 18-19. [abstract]

Hatchlings 1-2 d old did not survive 1 d of full exposure to air, but placement on water-saturated sand increased survival slightly to 1.5 d. Data on adult Florida applesnails were published in full as part of Turner (1994).

Turner, R. L. & S. L. Williams. 1997. Role of the egg capsule in protection of embryonic applesnails from ultraviolet light. Florida Scientist, 60(suppl. 1): 11. [abstract]

The extracapsular jelly of applesnail eggs does not contain biological sunscreens (mycosporine-like amino acids) against penetration of UV-B radiation. The thin (40-µm) calcareous eggshell, on the other hand, blocks 99.98% of UV-B light by reflectance and/or absorbance.

United States Army Corps of Engineers & South Florida Water Management District. 1999. Central and Southern Florida Project comprehensive review study: final integrated feasibility report and programmatic environmental impact statement. United States Army Corps of Engineers, Jacksonville District, Jacksonville, Florida & South Florida Water Management District, [West Palm Beach, Florida]. [CD-ROM, 2 discs]

This document compiles a variety of final and draft reports and a web page. The 4033-page final report makes only one reference to the Florida applesnail in the body but several in the annexes and appendices. *Pomacea paludosa* is recognized as an important component of the food web in wetlands of south Florida, particularly as prey of the snail kite. The exotic *P. bridgesii* is regarded to be a potential threat to *P. paludosa* populations. An ATLSS snail kite model, described by its authors as "crude" and still "under development", fills a gap in Fleming *et al.* (1994) and expands the model of USDI (1997). Based largely on the effect of water level and dry-downs on applesnail behavior, physiology, life history, and availability to the kite, the model uses 20-cm to 1-m water depth and 2-5 yr after dry-down as acceptable ranges for successful nesting by the kites.

United States Department of the Interior [USDI]. 1965. Survival Or Surrender for endangered wildlife. USDI, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Circular, no. 223: 1-15.

Both drainage and fire in Florida applesnail habitat are blamed for the demise of snail kite populations.

USDI. 1966. Rare and endangered fish and wildlife of the United States. USDI, Bureau of Sport Fisheries and Wildlife, Resource Publication, no. 34. [irregular pagination]

This document, including the section on the snail kite (sheet B-13), was revised as USDI (1968, 1973).

USDI. 1967. Biological report. Pre-impoundment studies of the waters of the Cross-Florida Barge Canal (Oklawaha and Withlacoochee r.). USDI, Federal Water Pollution Control Administration, Southeast Water Laboratory, Athens, Georgia & Technical Advisory and Investigations Branch, Cincinnati, Ohio. 37 pp.

This report is often erroneously cited as the appendix of a second report **(United States Department of the Interior, 1967)**, with which it is bound. Although its focus is on water quality of rivers impacted by construction of the Barge Canal, benthic animals were inventoried as indicators of water quality. *Pomacea* sp. is listed as intermediate in its sensitivity to pollution without explanation of the basis for this designation. Applesnails were present at several stations along the Withlacoochee and Oklawaha rivers.

USDI. 1968. Rare and endangered fish and wildlife of the United States, revised edition. USDI, Bureau of Sport Fisheries and Wildlife, Resource Publication, no. 34. [irregular pagination]

This document, including the section on the snail kite (sheet B-12), was revised as USDI (1973).

USDI. 1973. Threatened wildlife of the United States. USDI, Bureau of Sport Fisheries and Wildlife, Resource Publication, no. 114: 1-289.

In a species profile on the snail kite, the decline in numbers of kites is attributed to effects of drought, fire, and drainage on populations of Florida applesnails. Attempts to restore snail populations by control of water hyacinths are reported. Studies on the effects of hydrology on applesnails are recommended, and excavation of deep holes is suggested "to assure survival of nucleus populations of snails" [during drought?].

USDI. 1980. Selected vertebrate endangered species of the seacoast of the United States—the Florida everglade kite. USDI, [United States] Fish and Wildlife Service, Biological Services Program, FWS/OBS-80/01.32: i-iii, 1-5.

This report is a summary of information extracted from other sources on the biology of the snail kite. Emphasis is on management of snail kite habitat. Need is mentioned of more knowledge on the biology of the Florida applesnail.

USDI. 1983. Everglade kite recovery plan. USDI, United States Fish and Wildlife Service, Region 4, Atlanta, Georgia. [i-viii] + 51 pp.

In this earlier version of USDI (1986, 1999) and first approved version of Everglade Kite Recovery Team (1978), the biology of the snail kite is reviewed, and procedures are recommended for recovery of its populations in Florida. Although it is known that Florida applesnail population size is generally linked to water quality and hydroperiod and that snail kites need open water to hunt snails, the plan recommends further study of these factors related to applesnail ecology as well as study of snail predators and methods for increasing snail populations and their availability to kites. These aspects of the recovery plan are assigned the lowest priority. The document was reviewed by Kushlan (1983).

USDI. 1984. Southeast regional resource plan. USDI, United States Fish and Wildlife Service, Atlanta, Georgia. Pp. ES49-53. [not seen]

This report was cited in USDI (1986) to support a statement that applesnails require up to 3 yr to recover from drought; but the document does not seem to be generally available.

USDI. 1986. Florida snail kite (*Rostrhamus sociabilis plumbeus* Ridgway) revised recovery plan. USDI, United States Fish and Wildlife Service, Atlanta, Georgia. [i-v] + 48 + [5] pp.

This revision of the snail kite recovery plan (USDI, 1983) was superceded by USDI (1999). But its version of the outline for the recovery plan includes greater detail about the involvement of research on Florida applesnails for management of snail-kite habitat. Research on applesnails is declared to be "the first priority for Florida snail kite recovery."

USDI. 1997. ATLSS: across-trophic-level system simulation: an approach to analysis of south Florida ecosystems, progress report, January 1997, draft. USDI, United States Geological Survey, Biological Resources Division, South

Florida/Caribbean Ecosystem Research Group, Miami, Florida. [iii] + 64 pp., 27 figs., 3 tables.

This draft of ATLSS adds an initial model for the snail kite to the earlier work of Fleming *et al.* (1994). The authors anticipate inclusion of applesnails in the model by the sixth and final phase of model development. The full model is given in United States Army Corps of Engineers & South Florida Water Management District (1999).

USDI. 1999. South Florida multi-species recovery plan: a species plan ... an ecosystem approach. USDI, United States Fish and Wildlife Service, Southeast Region, Atlanta, Georgia. [2172 pp., paginated separately by sections] [also available as CD-ROM, version 4.0]

In the introduction to this document, the competition presumed to occur between *Pomacea paludosa* and the exotic *P. bridgesii* is mentioned as an example of problems created by an introduced pest; see the annotation for Warren (1997) for cautions. Some information on *P. paludosa* also is given in sections that describe freshwater marshes, wet prairies, and seepage swamps. The report turns Bryan's (1966) speculations and recommendations into statements of fact regarding the diet of the Florida applesnail, predation on it by raccoons and river otters, and the utility of applesnails as indicators of ecosystem health. The section on the snail kite is a second revision of the original recovery plan (USDI, 1983, 1986). [See also Everglade Kite Recovery Team (1978).] It constitutes a major recent summary of the relationship between the kite and the snail, especially in its coverage of foraging by the kite and effects of hydrology in their shared habitat. The report recommends the monitoring of pesticides in the Florida applesnail; the prevention of eutrophication that might lead either to reduction of applesnail populations or to reduced visibility of the snail to the kite; inclusion of snail abundance and distribution in predictive models of kite populations; and further research on applesnail ecology.

Valdés-González, A. 1989. Culture of the apple snail, *Pomacea paludosa*. Journal of Medical and Applied Malacology, 1(suppl.): 59-60. [abstract]

This oral presentation before the First International Congress on Medical and Applied Malacology gives general information on the color, morphology, size, growth, and reproductive behavior of the Florida applesnail. Average shell length is reported to be 60 mm. Oviposition follows 10-20 d after mating, and embryogenesis takes 15 d to hatching at 23-26°C, at which point the snail weighs 4-9 mg. A weight of 500 mg is attained by 60 d, and 50 g at 1 yr, with first oviposition occurring at weights of 10-25 g. Food conversion ratios exceeding 1:1 are obtained using pelletized fish food. The author suggests that *P. paludosa* is a good candidate for aquaculture. It is claimed to be used by humans "in soups, broth, chowder, fried, cocktails and in 'ceviche'."

Valentine-Darby, P. L., R. E. Bennetts & W. M. Kitchens. 1998. Seasonal patterns of habitat use by snail kites in Florida. Journal of Raptor Research, 32(2): 98-103.

During 343 h of observations on snail kites, 814 *Pomacea paludosa* were captured, 82% by aerial (course) hunting and 18% by perch (still) hunting. Perch hunting was the preferred hunting style in cypress prairie, where kites hunted mainly in the non-breeding season, perhaps because it is a more energy-efficient style. Perches for sighting snails are less abundant in other habitats (graminoid marshes, lakes) that are more suitable for use during the breeding season. Data in this paper duplicate those of Bennetts & Kitchens (1997a).

Van Arman, J. & R. Goodrick. 1979. Effects of fire on a Kissimmee River marsh. Florida Scientist, 42(4): 183-195.

Densities and species richness of animals and biomass of plants were compared in a burned and an unburned plot within a maidencane-pickerelweed marsh along the Kissimmee River, Florida, on several dates after the marsh was reflooded. Although *Pomacea paludosa* was collected, it was too rare to have contributed to the authors' conclusion that burning increases secondary productivity in the marsh.

[Vannote, R.] 1971. Biological evaluation of Kissemmee [*sic*] River, project. Pp. 25-27, in: T. E. Haeussner, L. Shanks, W. Hegenbuck, E. T. Heinen, N. V. Storch, J. M. Wilkinson, C. M. Mohr, F. Besley & R. Vannote, Field evaluation no. 15: Kissimmee River (Central and Southern Florida Project). United States Army Corps of Engineers, Jacksonville, Florida & Arthur D. Little, Inc., [Cambridge, Massachusetts]. 27 pp. + appendix.

As part of its flood-control project, the United States Army Corps of Engineers channelized and straightened the course of the Kissimmee River in central Florida in 1968-1971. This report recounts 1-d post-project surveys at one site in the river, in a nearby oxbow, and at one control site in Fisheating Creek. Part of the channelization design included a 6-10-ft wide sandy littoral zone, which at the survey site was dominated by "Pomacea snails" and other mollusks. The identity of "snails" collected from the oxbow and of "gilled snails" from Fisheating Creek cannot be confirmed because our copy lacks an appendix that originally accompanied the document (J. W. Koebel, Jr., 2002, personal communication). Authorship of this section, attributed to "Limnology Department, Academy of Natural Sciences [Philadelphia]," of the larger report was confirmed by R. Vannote (2002, personal communication).

Vermeire, P. E. 1980. Ultrastructure and histochemistry of the ducts in the albumen gland of the apple snail, *Pomacea paludosa*. M. A. thesis, University of South Florida, Tampa, Florida. x + 92 pp.

Most of this thesis has been published (Hinsch & Vermeire, 1990a, b, c; Vermeire & Hinsch, 1979, 1984). A section on origin of layers of the fully formed egg has not been published, but it is rather speculative, although plausible. See cautions noted in annotations of the published papers.

Vermeire, P.E. & G. W. Hinsch. 1979. Electron microscopy and histochemistry of ducts in the albumen gland of the apple snail, *Pomacea paludosa*. American Zoologist, 19(3): 1000. [abstract]

This work was published in full as Hinsch & Vermeire (1990c).

Vermeire, P.E. & G. W. Hinsch 1984. Structure of the female reproductive tract of the apple snail. II. Scanning electron microscopy. Tissue & Cell, 16(1): 107-114.

This paper describes the gross anatomy and limited cytology of ducts and accessory glands of the female reproductive system of the Florida applesnail: oviduct (including its distal specialized region called the capsule gland duct), which coils through the albumen gland; collecting tubules and duct of the albumen gland; seminal receptacle; bursa copulatrix; capsule gland; gonopore. Ciliation and secretory activity vary widely. Opposing faces of the capsule gland duct differ in degree of folding (see Hinsch & Vermeire [1990b] for ultrastructural and cytochemical differences). The abstract contains additional information absent from the text about the two-layered epithelium of the capsule gland duct. The paper includes an erroneous statement that oviposition occurs during the daytime. Papers cited as Vermeire & Hinsch (1982a, b, c; "submitted") were published as Hinsch & Vermeire (1990b, c). It appears that no part I exists.

Vyas, N. B. & D. J. Call. 1997 [1998]. A method for long-distance transport of eggs of the apple snail (*Pomacea paludosa*). Malacological Review, 30(1): 87-89.

The authors describe the applesnail equivalent of an egg crate and test its success for shipment. Pieces of clutch-bearing plant stems were attached to wooden dowels that were suspended within an insulated box by insertion of the dowels into perforated end-walls of polystyrene foam. Although damage was high (25% of eggs), all was attributable to an easily corrected problem; and hatching success of remaining eggs equaled that of an independent study (Hanning, 1978).

Wachenfeld, A. W. 1956. Present status of Everglade kite. Linnaean News-letter, 10(3): 1.

During a tour of Lake Okeechobee on 8 April 1956, the author and others found abundant clutches of Florida applesnail eggs on emergent vegetation and "hundreds of large snails all about;" as many as 500 (perhaps empty shells?) were collected along the bank of a canal. Limpkins were common in the area, but snail kites were few. Low numbers of kites was not attributed to food supply. The presence of fresh snails and empty shells near a collapsed kite nest was taken as evidence that the parents continued to feed the nestling kites.

Walker, B. 1918a. A synopsis of the classification of the freshwater Mollusca of North America, north of Mexico, and a catalogue of the more recently described species, with notes. University of Michigan, Museum of Zoology, Miscellaneous Publications, no. 6: 1-213.

Part I (Synopsis) includes a diagnosis of the family Ampullariidae and genus *Ampullaria*. Examples of the shell (of *A. paludosa*), living animal, and radula for the genus are figured. Part II (Catalogue) includes *A. borealis* Valenciennes, 1832 [not an ampullariid], *A. caliginosa*, *A. miamiensis*, *A. paludosa*, *A. pinei*, and *A. rotundata*. A letter from Sowerby (presumably to Walker) is cited as claiming that the last species "is a small specimen of the Indian *A. globosa* Sw[ainson];" and Walker errs in claiming that Sowerby (1909) assigned *A. rotundata* to *A. paludosa* (see Sowerby [1909]).

Walker, B. 1918b. Chapter XXIX. The Mollusca. Pp. 957-1020, in: H. B. Ward & G. C. Whipple (eds.), Fresh-water biology. John Wiley & Sons, New York. ix + 1111 pp.

In addition to extensive preliminary notes on the North American freshwater molluscan fauna, their habitats, anatomy, and methods of collection and curation, a taxonomic key is given that includes the genus *Ampullaria* (sole genus in the family Ampullariidae), of which *A. paludosa* is mentioned as one of "two or three species" from Georgia and Florida. Line drawings of the shell and radula are provided. Based on the key, ampullariids are gill- and lung-bearing gastropods with seven rows of radular teeth, with a "large, globose-turbinate ... umbilicate" shell, and with a corneous operculum that has concentric growth lines. They are also considered to be the largest North American freshwater snails. This chapter was updated in its second edition by Clench (1959).

Wallace, G. D. & L. Rosen. 1969a. Experimental infection of Pacific island mollusks with *Angiostrongylus cantonensis*. The American Journal of Tropical Medicine and Hygiene, 18(1): 13-19.

Adult (37-42-mm shell length) *Pomacea paludosa* from a Hawaiian pet store were used as one of the aquatic mollusks assayed for their potential as intermediate hosts of the rat lungworm. Snails were maintained in aquaria and fed watercress and a commercially prepared fish food. All 10 experimental *P. paludosa* became infected when exposed to rat feces bearing first-stage larval nematodes, and controls remained uninfected. Third-stage larvae from one applesnail reached adulthood in a rat exposed to them. The authors consider the level of infection low in *P. paludosa* and rank the snail as having low potential as an intermediate host. See the annotation for Wallace & Rosen (1969b) for a caution about this snail's identity.

Wallace, G. D. & L. Rosen. 1969b. Studies on eosinophilic meningitis. V. Molluscan hosts of *Angiostrongylus cantonensis* on Pacific islands. The American Journal of Tropical Medicine and Hygiene, 18(2): 206-216.

In this survey of intermediate hosts of the rat lungworm on Oahu, Tahiti, Rarotonga, and Majuro, *Pomacea paludosa* was the only aquatic snail of five species in five families on Oahu that carried the nematode larvae, with an infection rate of 27% (*n* = 128). Imported *P. paludosa* held in irrigation ditches are raised on Oahu for the aquarium trade and as human food. Cowie (1997) considered this a possible misidentification, although *P. paludosa* has been subsequently recorded from Maui (Cowie, 1993 [1995]).

Wallace, H. E., C. M. Loveless, F. J. Ligas & J. A. Powell. 1956. Wildlife investigation of the Central and Southern Florida Flood Control Project. Annual progress report for Investigations Project, 1 July 1956. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. 36 pp.

Absence of the snail kite from the study area prompted a preliminary investigation of applesnails (as "*Pomacea caliginosa*") in April and May. Clutches were reported to occur more frequently on broad-stemmed plants than on narrow-stemmed plants and also were found on artificial substrata. Data are given on clutch elevation (6 in), egg number (mean 28.8, range 5-69), egg size (4-6 mm), and color change (pink to white from oviposition to hatching). Despite an explicit intent to continue applesnail studies, no data are given in the authors' next quarterly progress report (**Wallace *et al.,* 1956**). Hatchlings and adults in captivity consumed lettuce, but only adults survived a few weeks on this diet. The authors assumed that the adult population had already declined in the study area and that drought and fire were responsible. They give anecdotal evidence to support a general belief that clutch production and population density are favored by a long hydroperiod.

Wallace, H. E., C. M. Loveless, J. A. Powell & F. J. Ligas. 1956. Wildlife investigation of the Central and Southern Florida Flood Control Project. Quarterly progress report for Investigations Project, 1 April 1956. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. 21 pp.

A flock of 70 limpkins was reported feeding on Florida applesnails in Conservation Area 3 in January.

Warren, G. L. 1997. Nonindigenous freshwater invertebrates. Pp. 101-108, in: D. Simberloff, D. C. Schmitz & T. C. Brown (eds.), Strangers in paradise: impact and management of nonindigenous species in Florida. Island Press, Washington, D. C. 467 pp.

The shell morphology of the exotic *Pomacea bridgesii* and of native *P. paludosa* is compared. Citing only "[r]esearchers working in the Everglades", the author makes two claims: the former species is capable of outcompeting the latter in southern Florida; the snail kite "apparently" cannot use *P. bridgesii* as prey. The author views the potential outcome of interspecific competition between the two snail species not to bode well for the endangered kite.

Watabe, N. 1974. Crystal growth of calcium carbonate in biological systems. Journal of Crystal Growth, 24/25: 116-122.

This paper includes scanning electron micrographs of vaterite crystals in soft tissue and of normal and regenerated shells of supposed *Pomacea paludosa* that are not included in Meenakshi *et al.* (1974) and Blackwelder & Watabe (1977). These studies were based on clearly misidentified material.

Watabe, N. 1988. Shell structure. Pp. 69-104, in: E. R. Trueman & M. R. Clarke (eds.), The Mollusca. Vol. 11. Form and function. Academic Press, New York. 504 pp.

This paper is a review of the structure of adult shell and eggshell of mollusks. Information incorrectly or questionably attributed to *Pomacea paludosa* is summarized, and it includes more than half of the section on eggshells. See also Meenakshi *et al.* (1974) and Meenakshi & Watabe (1977).

Watabe, N. & P. L. Blackwelder. 1976. Studies on shell regeneration in molluscs III. Effects of inorganic ions on shell mineralogy; ultrastructural changes of mantle epithelium. American Zoologist, 16(2): 249. [abstract]

This abstract of a paper presentation at the 1976 annual meeting of the American Society of Zoologists claims to be about *Pomacea paludosa*. See Meenakshi *et al.* (1974) and Meenakshi & Watabe (1977) for cautions about the identity of specimens.

Watabe, N. & P. L. Blackwelder. 1980. Ultrastructure and calcium localization in the mantle epithelium of the freshwater gastropod *Pomacea paludosa* during shell regeneration. Pp. 131-144, in: M. Omori & N. Watabe (eds.), The mechanisms of biomineralization in animals and plants. Tokai University Press, Tokyo. 310 pp.

Although the snails were "obtained from Florida" and no internal evidence places doubt on the identity of specimens, this is one in a series of studies with identical funding that includes two papers (Meenakshi *et al.*, 1974; Meenakshi & Watabe, 1977) based on clearly misidentified specimens.

Watabe, N., V. R. Meenakshi, P. L. Blackwelder & D. G. Dunkelberger. 1973. Distribution of vaterite crystals in the reproductive system of Ampullarid snails. American Zoologist, 13(4): 1334. [abstract]

This abstract of a paper presented at the 1973 annual meeting of the American Society of Zoologists was published in full as Meenakshi *et al.*

(1974), to which the reader is referred regarding misidentification of specimens attributed to *Pomacea paludosa.*

Watabe, N., V. R. Meenakshi, P. L. Blackwelder, E. M. Kurtz & D. G. Dunkelberger. 1976. Calcareous spherules in the gastropod, *Pomacea paludosa.* Pp. 283-308, in: N. Watabe & K. M. Wilbur (eds.), The mechanisms of mineralization in the invertebrates and plants. University of South Carolina Press, Columbia, South Carolina. xii + 461 pp.

Despite the lack of internal evidence, the authors' acknowledgment of identical sources that funded Meenakshi *et al.* (1974) and Meenakshi & Watabe (1977) creates doubt that the specimens examined in this study were *Pomacea paludosa.*

Watts, B. M. 1975. The watery wilderness of Apalach, Florida. Apalach Books, Tallahassee, Florida. 139 pp.

In this natural history of rivers and wetlands of northwestern Florida, the author mentions nocturnal oviposition by the Florida applesnail and dependence on the snail as prey of limpkins along the spring-fed Wacissa River. Two photographs show clutches of eggs "in delicate pastel shades" on stems, petioles, and leaves of emergent plants. In one photograph, a female snail is caught in the act of laying eggs over a dried older clutch.

Webb, W. F. 1937. Shells and other invertebrates of the United States. W. F. Webb, Rochester, New York. xiv + 80 pp., 25 pls.

In this popular work, "ampullaria" are noted as common to Florida and other parts of the world. "They can be happy in almost any situation and many of the wading birds like to eat them." This same paragraph, revised only by the addition of "*Pila*" as a parenthetical alternative name, appeared in the first (Webb, 1942) and many revised editions of Webb's "United States Mollusca."

Webb, W. F. 1942. United States Mollusca: a descriptive manual of many of the marine, land and fresh water shells of North America, north of Mexico. W. F. Webb, Rochester, New York. 220 pp., 63 pls.

See annotation for Webb (1937). Webb adds a note (p. 139) on the "enormous *Pila* ... from Florida and other southern states" and explains that the many species of this genus reproduce "enormously fast" and are prey of "Limpkins and other wading birds." This first edition was reprinted, often with additional plates, privately (1951, St. Petersburg, Florida), by Ideal Printing Co., St. Petersburg, Florida (1942; with 13 new plates), and by Lee Publishing, Wellesley, Massachusetts (1942, 1960 or 1969, 1971). We have not checked the content of all editions and reprintings for material on applesnails or for accuracy of publication data in OCLC.

Wegener, W., V. Williams & T. D. McCall. 1975. Aquatic macroinvertebrate responses to an extreme drawdown. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners, 28: 126-144.

The authors monitored populations of benthic invertebrates over a 42-mo period in Lake Tohopekaliga, Florida. The period included 1 yr during which water level in the lake was drawn down 7 ft (to the transition between the littoral and limnetic zones) and allowed slowly to refill. No Florida applesnails were collected in the limnetic zone by Ekman grab. None was collected in the littoral zone before or within 1.5 yr after drawdown by either Ekman grab or sweep net; thereafter, applesnails were found at moderate to high densities (0.1-$1.7/ft^2$) (*cf.*, Bryan, 1981b; Darby *et al.*, 1999).

Wheeler, R. J. & R. M. McGee. 1994. Report of preliminary zooarchaeological analysis: Groves' Orange Midden. The Florida Anthropologist, 47(4): 393-403.

The authors add to the data of Russo *et al.* (1992) with further excavations at the Groves' Orange Midden, Lake Monroe, Volusia County, Florida. The Florida applesnail was found in several samples but in lower frequency and with lower estimates of "meat weight" than in the earlier paper. Although the present work confirms the hypothesis of Russo *et al.* (1992) regarding subsistence of Late Archaic humans on freshwater animals, the dietary contribution by aquatic shellfish (including *Pomacea paludosa*) is less and by fish more.

White, J. J. 1899. Shells of Lake Worth, Florida. The Nautilus, 12(12): 142-143.

Seemingly to spite his wife, who complained about the numbers of terrestrial and marine mollusks that the author collected near Miami and Lake Worth, this account of collecting on the east coast of Florida includes a note about taking "at least a half a bushel of the large *Ampullaria*" *caliginosa* in freshwater ponds of Rockledge [Brevard County?]. This article was extracted from an entry in Transactions of the Isaac Lea Conchological Chapter of the Agassiz Association for 1898, a manuscript serial that was never published and seems not to be available **(Bieler & Kabat, 1991)**.

White, P. S., S. P. Wilds, G. A. Thunhorst, J. M. Alderman, M. Barnett-Lawrence, J. W. Gibbons, T. C. Gibson, D. S. Lee, M. R. Pelton, D. Penrose & J. D. Williams. 1998. Southeast. Pp. 255-314, in: M. J. Mac, P. A. Opler, C. E. Puckett Haecker & P. D. Doran (eds.), Status and trends of the nation's biological resources. Vol. 1. United States Department of the Interior, United States Geological Survey, Reston, Virginia. xi + 436 pp.

In reviewing the ecological problems of the Everglades, the snail kite is mentioned to be "particularly vulnerable" partly because of its specialist diet of Florida applesnails.

Wilbur, R. L. 1969. The redear sunfish in Florida. Florida Game & Fresh Water Fish Commission, Fishery Bulletin, no. 5: i-vii + 8-64.

Pomacea paludosa was found to be common to abundant on muck and sand bottoms and among aquatic vegetation in Lakes Griffin and Weir in Florida, but it occurred in stomachs of only 3% of redear sunfish from Lake Griffin and 0% from Lake Weir. Another common name of the redear sunfish, "shellcracker", derives from its feeding on snails. The author describes the pharyngeal adaptations of this fish for durophagy. Based on this and cited studies, however, the author notes that snails are neither the exclusive nor always the major component of the fish's diet.

Wing, E. S. & L. McKean. 1987. Preliminary study of the animal remains excavated from the Hontoon Island site. The Florida Anthropologist, 40(1): 40-46.

Pomacea paludosa was rare in the shell matrix of the "*Viviparus* or prehistoric levels" (Zones 4 and 5; 90+ cm depth) of the excavations on Hontoon Island in the St. Johns River, Florida. These zones consisted of a mixture of freshwater and marine gastropods and bivalves accumulated by humans since 0 A. D.

Winger, P. V. [*ca.* 1980.] Review of "Final report on the possible effects of commercial herbicides on the apple snail, Pomacea paludosa, in Florida" by T. C. Cheng. [United States Department of the Interior, United States Fish and Wildlife Service], C[olumbia] N[ational] F[isheries] R[esearch] L[aboratory], Field Research Station, Athens, [Georgia]. 3 pp.

This undated, apparently internal, government document is highly critical of Cheng (1980) for "inaccurate statements, misinterpretation of data" and because Cheng "contradicts his earlier work on molluscicidal action of copper." But most of the criticism seems to be on Cheng's methodology, including his use of the "Lehigh Molluscicide Test." Results of testing in Winger's laboratory found that 2-4-wk-old *Pomacea paludosa* have 96-h LC50s of 0.034 ppm Cutrine copper and 0.042 ppm Komeen copper. The 96-h LC50 for adult applesnails was 0.1 ppm Cutrine copper.

Winger, P. V., M. J. Imlay, W. E. McMillan, T. W. Martin, J. Takekawa & W. W. Johnson. 1984. Field and laboratory evaluation of the influence of copper-diquat on apple snails in southern Florida. Environmental Toxicology and Chemistry, 3(3): 409-424.

Loxahatchee National Wildlife Refuge provides habitat and feeding areas for snail kites in southern Florida. A recorded decline in abundance of Florida applesnails in canals of the refuge in the 1960s and 1970s paralleled the use of copper-diquat-containing herbicides against nuisance aquatic vegetation (*Hydrilla verticillata*). Laboratory and field studies by the authors did not, however, conclusively show that copper was responsible for this decline. Snails acquire the copper through ingestion of detritus or directly from the water. Feeding cessation was noted as a behavioral indication of toxic response to sublethal copper concentrations. Herbicides in solution in water-only aquaria were extremely toxic to immature snails (1-2 d post-hatching) at 24-27 µg/L, while adults were less sensitive (57 µg/L). Both adults and immature snails in aquaria containing sediment and food plants were not affected by copper concentrations up 150 µg/g in the sediment. Similarly, survival of adult snails caged in copper-contaminated areas was unaffected. Rapid adsorption of copper by sediment and organic material in the habitat provides protection from toxic effects for the applesnails. It is concluded that copper-containing herbicides at recommended doses pose no threat to applesnail populations in southern Florida.

Winner, B. E. 1989. A comparison of three species of *Pomacea* and their spawn. American Conchologist, 17(3): 15-16.

The shells, external morphology, egg masses, and hatchlings of *Pomacea paludosa*, *P. bridgesi* [*sic*], and *P. haustrum* are compared and illustrated. *P. paludosa* eggs are pink, attached individually to the substrate vegetation, and "less fragile." The shell is low spired, and the animal is black. The animals are nocturnally active.

Winner, B. E. 1990. A comparison of Pomacea Paludosa eggs to other species of Pomacea. Florida Scientist, 53(suppl. 1): 13. [abstract]

The eggs of *Pomacea paludosa* are easily distinguished from those of *P. bridgesi* [*sic*] and *P. haustrum*. Newly hatched snails are also distinct.

Winner, B. E. 1991. A field guide to molluscan spawn. Vol. II. B. E. Winner [North Palm Beach, Florida]. vi + 94 pp.

The shell and egg mass of *Pomacea paludosa* and the shell and animal (depositing eggs) of *P. miamiensis* are figured and described. Conchological differences between the two are mentioned. *Pomacea bridgesi* [*sic*], *P. canaliculata*, and *P. haustrum* are described as introduced to Florida, and characters distinguishing these species from *P. paludosa* (*e. g.*, egg color, egg shape, shell shape, animal color) are given or illustrated.

Winner, B. E. 1996. A comparison of four species of *Pomacea* and their spawn. Hawaiian Shell News, 44(7-8): 5-7.

Shells of adults, egg masses, and hatchlings are illustrated for *Pomacea paludosa, P. bridgesii, P. canaliculata*, and *P. haustrum*, all of which are found in Florida, although only *P. paludosa* is native. General information on distribution, ecology, trematode parasites, sexuality, reproductive behavior, and clutch parameters for *P. paludosa* is given. Without reference to one of the four species, the author mentions instances of applesnails eating fish in aquaria and fish farms; and she lists the snail kite, snapping turtle, limpkin, and juvenile alligator as applesnail predators.

WNET. 1989. Nature: the Everglades rain machine. WNET, New York. [videotape, 55 min] [available from Public Broadcasting Service through PBS Video]

This film, produced for a television series, documents the natural history, management, and mismanagement of the Florida Everglades. A few sequences include *Pomacea paludosa*. In one sequence, snails under water are shown mating and crawling, and a snail kite is shown capturing a snail and extracting it from the shell. A "flotilla" of empty shells is shown floating beneath the kite's perch. The narrator states that the snail cannot survive drought and that the kite cannot survive without the snail. While reporting on droughts in the 1960s, another scene shows empty bleached applesnail shells lying on dry Everglades marsh. A limpkin passes by with an applesnail in its bill in a sequence about feeding by wood storks. A long (134-sec) but interrupted sequence records a female snail ascending an emergent plant stem, depositing a clutch of eggs, and subsequently falling from the stem into the water. The narrator claims, probably incorrectly, that oviposition takes 5 h. A 90-sec sequence shows hatchlings emerging from a clutch, falling into the water, and crawling on the shell of an adult snail. The narrator states that embryogenesis takes 3 wk and that embryos might die if the clutch is submerged by flooding the marsh.

WNET. 1991. Land of the eagle. Part 3. Conquering the swamps. WNET, New York. [videotape, 60 min] [available from Public Broadcasting Service through PBS Video]

This is the third video in a series of eight on the impact of European settlers on the natural history and native human cultures of North America. A segment on the Everglades and the Seminole Indians states that Florida applesnails were one of the most important animals in the diet of the Seminoles as a supplement to their agricultural crops. Video sequences show a snail crawling and breathing. Two captures by snail kites also are illustrated. Information on the applesnail is excluded from the companion text by **Peck (1990)**.

Wolfe, J. L., D. K. Bradshaw & R. H. Chabreck. 1987. Alligator feeding habits: new data and a review. Northeast Gulf Science, 9(1): 1-8.

Although *Pomacea paludosa* is important in the diet of young alligators in south Florida, fish and crustaceans are the major prey elsewhere in the geographic range of the alligator. Mammals dominate the diet of adult alligators.

Wolff, H. G. 1975. Statocysts and geotactic behaviour in gastropod molluscs. Pp. 63-84, in: H. Schöne (ed.), Mechanisms of spatial perception and orientation as related to gravity: international symposium on spatial orientation, Köln, September 18th-20th, 1973. Gustav Fischer Verlag, Stuttgart. xii + 296 pp. [Fortschritte der Zoologie, 23(1): 63-84]

This review paper discusses ultrastructural, electrophysiological, and behavioral data on statocysts of gastropods. Greater attention to comparative ultrastructure of applesnails and the pulmonate and opisthobranch snails is given here than in Stahlschmidt & Wolff (1972). There appear to be no electrophysiological data for statocysts of *Pomacea paludosa*. The author challenges McClary's (1966) claim that statocysts of P. *paludosa* play a minor role in geotactic behavior. The forthcoming data of Tüllner & Wolff (1979) are not included, but some data of Tüllner's (1973) thesis are published here. The author hypothesizes that statocysts with larger numbers of hair cells (as in *Pomacea*) allow increased orientational discrimination. Refer to annotations of McClary (1964), Stahlschmidt & Wolff (1972), Tüllner (1973), and Tüllner & Wolff (1979) for cautions about species identity.

Wood, F. & D. Wood. 1968. Animals in danger: the story of vanishing American wildlife. Dodd, Mead & Company, New York. x + 181 pp.

Both limpkins and snail kites feed on the "green snail," the authors' common name for the Florida applesnail. The habitat of the snail and its predation by the kite are described briefly along with the need for conservation of kite habitat.

Woodin, M. C. & C. D. Woodin. 1981. Everglade kite predation on a soft-shelled turtle. Florida Field Naturalist, 9(4): 64.

The observation of a snail kite feeding on a soft-shelled turtle is offered as evidence that *Pomacea paludosa* is not the only prey of the kite.

Writer's [*sic*] Program, Work Projects Administration in the State of Florida. [1942.] Birds in Florida. State of Florida, Department of Agriculture, Tallahassee, Florida. [x] + 213 pp., 30 color pls., 2 color frontispieces.

This report links the decline of snail kite populations to extensive marsh drainage through the presumed effects on its food, "a single type of large fresh-water snail now becoming scarce." The authors briefly describe capture and extraction of snails and the accumulation of shells "in and around old nests." Boat-tailed grackles in the Everglades are reported to "feed on large fresh-water snails which are extracted deftly from the shell." The document is undated, but OCLC gives the date as 1942, the latest date internally mentioned (p. 192). University of Jacksonville, Jacksonville, Florida, apparently holds a typescript of this document. The first edition (**[Florida] Department of Game and Fresh Water Fish, 1931**) does not include sections on the snail kite or the boat-tailed grackle. See also annotations for later editions ([Florida Department of Agriculture], 1951; Longstreet, 1965).

[Wyman, J.] 1868a. [St. John's River, Florida, shell mounds.] Proceedings of the Boston Society of Natural History, 11(1866-1868): 158-159.

Shells in 28 excavated mounds along the St. Johns River in 1867 included those of the Florida applesnail (as "*Ampullaria*"). Wyman's report, entered in the minutes of the society's meeting of 17 April 1867, represents the first published indication of the use of the snail by Native American Indians.

Wyman, J. 1868b. Report of the Curator. IV. Explorations. Pp. 11-18, in: S. Salisbury, A. Gray, J. Wyman & G. P. Russell, First annual report of the Trustees of the Peabody Museum of American Archaeology and Ethnology, presented to the President and Fellows of Harvard College, Feb. 15, 1868. Press of John Wilson and Son, Cambridge, [Massachusetts]. 28 pp.

The form and contents are described for 20 shell mounds excavated in 1867 along a 150-mile region of the St. Johns River from Palatka, Florida, south. Shells of the Florida applesnail (as "Ampullaria") were among the three kinds of mollusk found. Several reasons are given, based on excavations, for the author's conclusion that the mounds were produced by Native American Indians, probably a tribe that predated the Seminole Indians. Wyman hypothesizes that the mollusks were cooked on site. Without local knowledge of applesnails having been consumed by humans, Wyman points out the lack of evidence "that they are unsuitable as food."

Wyman, J. 1868c. On the fresh-water shell-heaps of the St. Johns River, East Florida. The American Naturalist, 2(8): 393-403 + pl. 10; 2(9): 449-463.

Shells of the Florida applesnail, called simply *Ampullaria* in previous articles (Wyman, 1868a, b), are here assigned to *Ampullaria depressa*. Because the shells of *A. depressa* and two other molluscan species were far more abundant than bones of vertebrates, Wyman concludes that mollusks predominated in the diet of the natives that built the mounds.

Wyman, J. 1875. Fresh-water shell mounds of the St. John's River, Florida. Memoirs of the Peabody Academy of Science, 1(4): i-viii + 1-94, frontispiece, 9 pls., map.

Shell mounds along the St. Johns River were found to consist of three species of freshwater mollusks: two gastropods and one bivalve. The second most abundant was *Ampullaria depressa*, found at many of the 48 mounds studied by the author. Elsewhere in the United States, dwelling shell mounds consist almost entirely of unionid bivalves. The author argues that the shells represent use of the mollusks as food rather than use of geologic deposits to elevate dwellings. Accumulation of shell is attributable to long periods of habitation or to greater former abundance of animals. Some of the mounds are identified as sites visited by **Bartram (1791)**. Comparison of maximal shell size indicates that the Florida applesnail grew larger in the past. Oviposition is reported to occur in February on stems of emergent plants at heights up to 2 ft above the water. This volume was reprinted in 1973 by AMS Press, New York.

Yong [Cong], M. 1991. ¿Se atrevería Vd. a comer *Pomacea*? Noticiario de la Sociedad Española de Malacologia, no. 12: 32-34.

As the title suggests, the author views *Pomacea paludosa* as a culinary adventure for those unfamiliar with this Western Hemisphere snail. In addition to its use as human food, this snail is eaten by predatory birds; and it can be used by humans in the biological control of human parasites and in artisan trades for earrings and baby rattles. Its abundance in Cuban wetlands makes the snail easy to collect, and it can be found at densities up to 60 m^{-2}. The living snail is described, as are methods of collection and preparation as food. It is recommended that only the foot be used in recipes, two of which are given after having been tested for acceptance in a single-blind study on the author's colleagues at the Instituto de Medicina Tropical "Pedro Kouri." A photograph of an empty snail shell is included.

Yong [Cong], M. & G. Perera [de Puga]. 1984. A preliminary study of the freshwater mollusks of the Isle of Youth (Isle of Pines), Cuba. Walkerana, 2(7): 121-123.

Pomacea paludosa was found to be the most common species in rivers and "dams" (waters impounded by artificial means). General low abundance is attributed to lack of calcium and vegetation.

Younger, R. E. [1960s.] The snail kite (female and male). Vanishing species of birds [folio]. Caribbean Gardens, Naples, Florida. [painting]

This painting illustrates a pair of snail kites perched on emergent vegetation. Three clutches of the Florida applesnail are shown attached to blades of the plants, and a snail shell is held by a talon of the male kite. According to the author (R. E. Younger, 2003, personal communication), this painting is one of eight in a folio commissioned, perhaps as early as 1959, by Julius Fleischmann. All 800 folios were sold, and the original paintings are held by the Fleischmann family. The painting of the snail kite might have been printed by Van Leer, Amsterdam, The Netherlands, one of two printers for the series. The only publicly available image of this painting to our knowledge is in Bauer (1967).

Zaitseva, O. V. 1998a. Structure of sensory organs and skin innervation in the mollusc *Pomacea paludosa* (Prosobranchia). Journal of Evolutionary Biochemistry and Physiology, 34(3): 233–242. [originally published in Russian in: 1998. Zhurnal Evolyutsionnoi Biokhimii i Fiziologii, 34(3): 352–363]

Several types of chemoreceptor cells, two types of photoreceptors, mechanoreceptors, and proprioreceptors are described from cephalic structures, osphradium, statocysts, and siphon of *Pomacea paludosa*. Most sensory receptors are intraepithelial. One type of subepithelial chemoreceptor, especially abundant on the cephalic tentacles, does not occur in other freshwater prosobranchs and is abundant in pulmonates; its presence in the applesnail might be related to amphibious respiration, which might also explain the unique neurological organization of the siphon of *P. paludosa*. The author's report of carotenoid-like pigments in the skin and retina and of the absence of melanin causes us to question the identity of the snails in this study as *P. paludosa*, which is known for its black or dark brown skin. Furthermore, the animals are stated to inhabit "the Caribbean basin."

Zaitseva, O. V. 1998b. The structural organization of the peripheral segment of the olfactory analyzer in the amphibious mollusk *Pomacea paludosa*. Sensory Systems, 12(2): 137-144. [originally published in Russian in: 1998. Sensornye Sistemy, 12(2): 182-194]

Each cephalic tentacle of *Pomacea paludosa* is supplied with a tentacular nerve and an optic nerve, both types arising from the cerebral ganglia. The tentacular nerve receives bundled mixed axons from clusters of primary receptor cells of four types, three of which are both intra- and subepithelial and one of which ("second type") is only subepithelial. Other neural elements seem to be mechanoreceptors (perhaps proprioreceptors), associative neurons, and motor neurons, the latter innervating tentacular muscles and mucosecretory glands for a "peripheral protective-defensive skin reflex." The presence of numerous and diverse receptor cells, secretory glands, and epithelial cells with long cilia suggests a chemoreceptive role for the cephalic tentacles. Neurological organization of the cephalic tentacles of most primary aquatic prosobranch gastropods differs little from that of the skin of the head. But the organization in *P. paludosa* is more complex, particularly in the presence of the second type of primary receptor cell, and similar to the more advanced neurological organization of terrestrial and aquatic pulmonate gastropods; the organization suggests a parallelism associated with an amphibious lifestyle. Cephalic tentacles of *P. paludosa* do, however, lack the olfactory glomeruli and tentacular ganglia of terrestrial gastropods. See the annotation for Zaitseva (1998a) for cautions regarding the snails' identity.

Zaitseva, O. V. 1999. The structural organization of the statocyst sensory system of prosobranch mollusks. Sensory Systems, 13(2): 91-100. [originally published in Russian in: 1999. Sensornye Sistemy, 13(2): 99-109.]

Although the author claims to provide new data on statocysts of *Pomacea paludosa*, the information is probably only confirmatory of the general knowledge of prosobranch statocysts reviewed in this paper. Specific information given here for *P. paludosa* is from Zaitseva (1998a) and the work of others. New for applesnail biology are two line drawings of the statocyst wall with otoconia and one modular unit of receptor cells and a scanning

electron micrograph of the sensory surface of a statocyst. The emphasis in the review is on the similarities among prosobranch gastropods in the organization of statocysts, particularly in their modular construction in contrast to the simpler organization of statocysts of opisthobranchs and pulmonates. See Zaitseva (1998a) for cautions regarding the snails' identity.

DEDICATION

We dedicate this work to the memory of Gloria Perera, a Cuban malacologist who died in February 2000. Dr. Perera was affiliated with Laboratorio de Malacologia of the Instituto Pedro Kourí in Havana. The present bibliography includes 22 entries from her work on the molluscan fauna of Cuba, a substantial contribution to the biology of *Pomacea paludosa.*

ACKNOWLEDGMENTS

We greatly appreciate the assistance of many colleagues and students who have helped us with this project since it began in 1989. Organizations given below are those with which individuals were affiliated at the time they provided assistance. Many gave us access to their valuable research libraries or to collections in their care: Rüdiger Bieler and Gene K. Hess (Delaware Museum of Natural History); Fred G. Thompson (Florida Museum of Natural History); Mark Maffei, Laura A. Brandt, and Camille W. Sewell (Arthur R. Marshall Loxahatchee National Wildlife Refuge); Wenxian Zhang and Gertrude F. Laframboise (Rollins College, Department of Archives & Special Collections); Cynthia Plockelman (South Florida Water Management District). The following also assisted in the procurement of literature, some of it rare: the late R. Tucker Abbott (American Malacologists, Inc.); Thomas M. Baugh (United States Fish and Wildlife Service); Robert E. Bennetts (University of Florida, Florida Caribbean Science Center); Robert H. Cowie (Bernice P. Bishop Museum); Lynda J. Garrett (Patuxent Wildlife Research Center); the late Richard S. Houbrick (National Museum of Natural History); Ron Larson (Harbor Branch Oceanographic Institution); Harry G. Lee (Jacksonville Shell Club); Mary Beth Mihalik (Solid Waste Authority of Palm Beach County); Cynthia M. Moon (Everglades National Park); Roger W. Portell (Florida Museum of Natural History); Anja N. Ruchatz (Florida Institute of Technology); Sammantha Ruiz (Everglades National Park); Nimish B. Vyas (United States Environmental Protection Agency, Patuxent Wildlife Research Center); as well as numerous respondents to our questionnaire distributed in 1989 and authors who sent reprints of their own work. Faculty and staff of Evans Library, Florida Institute of Technology, provided literature searches, interlibrary loan, and other library services: Celine Lang, Thomas A. McFarland, Victoria L.

Smith, Jeanette C. Sparks, and Kathy A. Turner. Additional library services were provided by Kristen L. Metzger of Harbor Branch Oceanographic Institution and by many staff members at the American Museum of Natural History Research Library. The following staff and students at Florida Institute of Technology translated several articles into English: Carmen R. Carvalho, Fleur M. Lacharmoise, Paola C. López-Duarte, Silvano E. Reynoso, Anja N. Ruchatz, Carla M. Lema Tomé, and María C. Torres. We received additional technical assistance from the following students at Florida Institute of Technology: Amy R. Baco, Kerry A. Fallon Green, Robyn M. Heyman MacBeth, Matthew L. Kinter, Cathleen M. Norlund McCabe, and Robin L. Tallon. We thank Robert H. Cowie and Philip C. Darby (University of West Florida) for their review of and helpful suggestions on the manuscript. This project was partly funded by contract NG88-105 from the Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program. This is Contribution no. 1531 of Harbor Branch Oceanographic Institution.

LITERATURE CITED

Andrews, E. W. & C. M. Andrews (editors) [with L. W. Labaree]. 1985. Jonathan Dickinson's journal[,] or, God's protecting providence. Being the narrative of a journey from Port Royal in Jamaica to Philadelphia between August 23, 1696 and April 1, 1697. Florida Classics Library, Port Salerno, Florida. [48] + 109 pp., illus.

Baird, G. (compiler). 1970. Everglade kite (*Rostrhamus s. plumbeus*): a bibliography. United States Department of the Interior, Office of Library Services, Washington D. C., Bibliography Series, no. 18: i-iii, 1-21. [content of cover page and title page differs]

Bartram, W. 1791. Travels through North & South Carolina, Georgia, East & West Florida, the Cherokee country, the extensive territories of the Muscogulges, or Creek Confederacy, and the country of the Chactaws; containing an account of the soil and natural productions of those regions, together with observations on the manners of the Indians. William Bartram, Philadelphia. xxxiv + 522 pp., [8] pls., map.

Bebbington, A. 1990. Award winning logo. Bulletin of the Malacological Society of London, no. 14: [8].

Bieler, R. 1993. Ampullariid phylogeny—book review and cladistic re-analysis. The Veliger, 36(3): 291-297.

Bieler, R. & A. R. Kabat. 1991. Malacological journals and newsletters, 1773-1990. The Nautilus, 105(2): 39-61.

Binney, W. G. (editor). 1858. The complete writings of Thomas Say, on the conchology of the United States. H. Baillière, New York. vi + 252 pp., 75 color pls.

Cazzaniga, N. J. 2002. Old species and new concepts in the taxonomy of *Pomacea* (Gastropoda: Ampullariidae). Biocell, 26(1): 71-81.

Cowie, R. H. 1997. *Pila* Röding, 1798 and *Pomacea* Perry, 1810 (Mollusca, Gastropoda): proposed placement on the Official List, and AMPULLARIIDAE Gray, 1824: proposed confirmation as the nomenclaturally valid synonym of PILIDAE Preston, 1915. Bulletin of Zoological Nomenclature, 54(2): 83-88.

Cowie, R. H. & S. C. Thiengo. 2003. The apple snails of the Americas (Mollusca: Gastropoda: Ampullariidae: *Asolene*, *Felipponea*, *Marisa*, *Pomacea*, *Pomella*): a nomenclatural and type catalog. Malacologia, 45(1): 41-100.

Davis, S. M. 1994. Phosphorus inputs and vegetation sensitivity in the Everglades. Pages 357-378, in: S. M. Davis & J. C. Ogden (eds.), Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida. xv + 826 pp.

Douglas, M. S. 1947. The Everglades: river of grass. Rinehart, New York. 406 pp., illus., maps.

[Florida] Department of Game and Fresh Water Fish. 1931. Florida birds: biographies of selected species of birds and compiled list of all species occurring in Florida. Quarterly Bulletin of the [Florida] Department of Agriculture, 41(3): 1-189, A1-A9, 32 color pls.

Gleason, P. J. (editor). 1984. Environments of south Florida: present and past II [2nd edition]. Miami Geological Society, Coral Gables, Florida. xxv + 552 pp.

Hallock, C. (compiler). 1876. Camp life in Florida; a handbook for sportsmen and settlers. Forest and Stream Publishing Company, [New York]. 348 pp. [i-vi + 7-348].

Holgerson, N. E. 1967. Life history, ecology and management of the Florida Everglade kite (*Rostrhamus sociabilis plumbeus*). United States Department of the Interior, Bureau of Sport Fisheries and Wildlife, Washington, D. C. [unpublished] [not seen]

Hunt, B. P. 1958. Introduction of *Marisa* into Florida. The Nautilus, 72(2): 53-55.

[International Commission on Zoological Nomenclature.] 1999. Opinion 1913: *Pila* Röding, 1798 and *Pomacea* Perry, 1810 (Mollusca, Gastropoda): placed on the Official List, and AMPULLARIIDAE Gray, 1824: confirmed as the nomenclaturally valid synonym of PILIDAE Preston, 1915. Bulletin of Zoological Nomenclature, 56(1): 74-76.

Johnson, R. I. 1968. Martini and Chemnitz (Kuester's edition) *Systematisches Conchylien-Cabinet*, 1837-1920, a complete collation. Journal of the Society for the Bibliography of Natural History, 4(7): 363-367.

Kolipinski, M. C. & A. L. Higer. 1969. Some aspects of the effects of the quantity and quality of water on biological communities in Everglades National Park. Open File Report. United States Department of the Interior, United States Geological Survey, Water Resources Division, Tallahassee, Florida. 97 pp.

Lang, H. 1924. *Ampullarius* and *Rostrhamus* at Georgetown, British Guiana. The Nautilus, 37(3): 73-77, pl. 4.

Laudonnière, R. [C. E. Bennett, translator and editor]. 1975. Three voyages. The University Presses of Florida, Gainesville, Florida. xxii + 232 pp., 2 maps [end leaves], frontispiece.

Light, A. R. 1998. The myth of Everglades settlement. St. Thomas Law Review, 11(1): 55-76.

Lindsay, S. 1996. *Apple snails in the aquarium*, by Gloria Perera and Jerry G. Walls. Malacological Review, 29(1-2): 135. [book review]

Marchman, W. P. (editor). 1947. The Ingraham Everglades Exploring Expedition, 1892. Tequesta, 1(7): 3-43.

Martens, E. v. 1874. Hermann Strebel, Ein Beitrag zur Fauna mexikanischer Land- und Süsswasser-Conchylien. (Abhandlungen aus dem Gebiete der Naturwissenschaften, herausgegeben von dem naturwissenschaftlichen Verein in Hamburg. VI. Band, I. Abtheilung, 69 Seiten in 4° mit 9 Tafeln Hamburg 1873 gr.4°.) Jahrbücher der deutschen malakozoologischen Gesellschaft, 1: 353-362. [review]

Milanich, J. T. 1995. Florida Indians and the invasion from Europe. University Press of Florida, Gainesville, Florida. xix + 290 pp.

Orbigny, A. d'. 1834-1847. Voyage dans l'Amérique méridionale: (le Brésil, la République orientale de l'Uruguay, la République Argentine, la Patagonie, la République du Chili, la République de Bolivia, la République du Pérou), exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1831, 1832, et 1833. Pitois-Levrault, Paris, & Ve. Levrault, Strasbourg. [9 volumes]

Ovington, R. 1975. Birds of prey. Great Outdoors Publishing Company, St. Petersburg, Florida. 64 pp.

Packard, W. 1910. Florida trails as seen from Jacksonville to Key West and from November to April inclusive. Small, Maynard and Company, Boston. [xiii] + 300 pp. [1983 reprint by Pineapple Press, Inc., Englewood, Florida]

Pain, T. 1972. The Ampullariidae, an historical survey. Journal of Conchology, 27(7): 453-462.

Palmer, K. V. W. 1966. Who were the Sowerbys? Sterkiana, no. 23: 1-6, frontispiece.

Peck, R. M. 1990. Land of the eagle: a natural history of North America. Summit Books, New York. 288 pp.

Pérez Vigueras, I. 1940. Notas sobre algunas especies nuevas de trematodes y sobre otras poco conocidas. Revista, Universidad de la Habana, no. 28-29: 217-242, 15 pls.

Petit, R. E. & D. Wilson. 1986. Publication dates of Heilprin's *Explorations on the west coast of Florida*. Tulane Studies in Geology and Paleontology, 19(1-2): 95-96.

Preble, G. H. 1883. The diary of a canoe expedition into the Everglades and interior of southern Florida in 1842. The United Service, 8(4): 358-376. [reprinted: 1946. Tequesta, 1: 30-51]

Raffaele, H., J. Wiley, O. Garrido, A. Keith & J. Raffaele. 1998. A guide to the birds of the West Indies. Princeton University Press, Princeton, New Jersey. 511 pp., 86 color pls.

Rumbold, D. G. 2000. Contaminants in wildlife inhabiting the area around Palm Beach County's North County Resource Recovery Facility: 1989-1999. Final report to Solid Waste Authority of Palm Beach County, West Palm Beach, Florida. D. G. Rumbold, Boca Raton, Florida. vi + 68 pp.

Smith, D. G. 2001. Pennak's freshwater invertebrates of the United States, fourth edition, Porifera to Crustacea. John Wiley & Sons, Inc., New York. x + 638 pp.

Taylor, D. W. 1975. Freshwater molluscs from the Nueces River drainage, Texas. D. W. Taylor, San Diego. 42 pp. [unpublished]

Thorp, J. H. & A. P. Covich. 2001. Ecology and classification of North American freshwater invertebrates, 2nd edition. Academic Press, San Diego. xvi + 1056 pp.

Toops, C. 1989. The Everglades. Voyageur Press, Stillwater, Minnesota. 96 pp.

True, D. O. (editor). 1945. Memoir of Do. d'Escalante Fontaneda respecting Florida, written in Spain, about the year 1575, translated from the Spanish with notes by Buckingham Smith, Washington: 1854. Glade House, Coral Gables, Florida. 77 pp., map [frontispiece].

Tryon, G. W., Jr. 1883. Structural and systematic conchology: an introduction to the study of the Mollusca. Vol. II. G. W. Tryon, Jr., Philadelphia. 430 pp., pls. 23-91.

Turner, R. L., M. C. Hartman & P. M. Mikkelsen. 2001. Biology and management of the Florida applesnail: final report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida. v + 150 pp.

United States Department of the Interior. 1967. Cross Florida Barge Canal pre-impoundment studies. United States Department of the Interior, Federal Water Pollution Control Administration, Southeast Water Laboratory, Athens, Georgia. [iii] + 25 pp.

Wallace, H. E., C. M. Loveless, F. J. Ligas & J. A. Powell. 1956. Wildlife investigation of the Central and Southern Florida Flood Control Project.

Quarterly progress report for Investigations Project, 1 October 1956. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. 21 pp.

Wallen, I. E. & P. Dunlap. 1953. Further additions to the snail fauna of Oklahoma. Proceedings of the Oklahoma Academy of Science, 34: 76-80.

Willoughby, H. L. 1898. Across the Everglades: a canoe journey of exploration. J. B. Lippincott Company, Philadelphia. 192 pp., plates, map.

Wing, E. S. & A. B. Brown. 1979. Paleonutrition: method and theory in prehistoric foodways. Academic Press, New York. xiv + 202 pp.

Woodward, S. P. 1851-1856. A manual of the Mollusca; or, rudimentary treatise of Recent and fossil shells. John Weale, London. xvi + [3] + 486 + 24 pp., 24 pls., 1 map. [issued in three parts]

Published by the

DELAWARE MUSEUM OF NATURAL HISTORY
4840 Kennett Pike, P.O. Box 3937
Wilmington, Delaware 19807-0937 U.S.A.
www.delmnh.org

Published by the

DELAWARE MUSEUM OF NATURAL HISTORY
4840 Kennett Pike, P.O. Box 3937
Wilmington, Delaware 19807-0937 U.S.A.
www.delmnh.org