STATUS OF THE APPLESNAIL *Pomacea canaliculata* IN THE UNITED STATES

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Abstract

The South American applesnail *Pomacea canaliculata* (Family Ampullariidae) has been introduced and established within the United States in central Florida, three sites in southern California, and in at least 12 places in southeastern and northern Texas. Most of these populations are not in agricultural areas, though some ecological impact has been observed in Florida. One California introduction discovered in 2001 may be near cultivated lands, but not plant species subject to *Pomacea* depredation. In Texas, however, populations found in 2000 and 2001 are centrally-located in the rice-producing region. The species is now present in rice irrigation canals, natural streams and bayous adjacent to fields, and rice fields themselves. Although egg masses, vast numbers of juveniles, and some adults have been found in rice fields in 2002, no crop damage has been reported to date (August 2002). It is hoped that draining irrigation canals over winter, dewatering fields when not in production, and perhaps use of selected pesticides may be able to restrict population size to tolerable levels. Present *P. canaliculata* populations also are not in locations where extensive ecological damage would be expected.

Introduction

The South American applesnail *Pomacea canaliculata*, and possibly related species, attained international attention in the 1980s and 1990s when populations became established in Southeast Asia, the Indo-Pacific islands, and outside native ranges in Latin America. This species and other applesnails had been handled in aquarium culture in the United States and elsewhere in the world since about the 1950s, but without particular ecological or economic significance. In 1979, *P. canaliculata* was taken to Taiwan, then to the Philippines in 1982, and subsequently to numerous other locations in Southeast Asia and the Indo-Pacific region (Acosta and Pullin 1991; Mochida 1991), including Hawaii (Lach and Cowie 1999). This snail was originally imported under the name “golden snail” or “golden apple snail” for human consumption (Halwart 1994). However, the Asian escargot market never materialized. Applesnails, that escaped or were released, ultimately came to cause extensive damage to *Oryza sativa* (rice), *Colocasia esculenta* (taro), and other important agricultural crops (Cowie 1998).

Prior to July 2000, *P. canaliculata* shells had been found at a number of locations and populations were documented in several sites in the southern United States (Fullington 1978; Thompson 1984; Neck 1984, 1986; Neck and Schultz 1992), but, no established populations occurred in major agricultural areas. However, in July 2000, reproducing *P. canaliculata* were found by Texas Parks and Wildlife Department (TPWD) personnel in a rice irrigation canal near Houston, Texas, centrally located in the state rice-production region (Howells 2001a, b). Subsequent surveys in late 2000 and early 2001 documented the species in a three-county area in southeastern Texas (Howells 2001b), as well as an additional population found near Fort Worth in northern Texas (Howells 2001c). In late 2001, the species was also located in a canal feeding into the Salton Sea in southern California (A.R. Hardy, California Department of Food and Agriculture, CDFA, Sacramento; pers. comm.).

The discovery of this snail in a rice-growing area in Texas prompted concerns and actions at both the state and national level. This paper summarizes records of *P. canaliculata* in the continental United States, with comments on Hawaii, and documents the most-recent reports of the status of known populations. Also included are comments addressing association with agricultural crops and preliminary control efforts.

Classification and Terminology

Approximately 50 species have been reported in the genus *Pomacea* (Cowie, In Press), but identification is confused and the genus is in need of revision, particularly with biochemical genetic techniques. Proposals to carry out the necessary genetic research have been forwarded to both U.S. Department of Agriculture (USDA), Animal and Plant Health Protection Service (APHIS) – Plant Protection and Quarantine (PPQ) and U.S. Fish and Wildlife Service (USFWS),

and are currently under review. About 15 of these species, including *P. canaliculata*, have channeled shells (Cowie, In Press). Although introductions in the United States and Indo-Pacific region are generally attributed to *P. canaliculata*, it is possible more than one species may actually be involved. Feeding differences among populations in Hawaii and Texas, for example, may reflect different species or strains (Howells 2002). Because of variation in conchological features, this issue will likely remain unresolved until DNA studies, or other genetic analyses, are employed. The populations in the United States are referred to as *P. canaliculata* in this paper.

The wide and often misleading array of common names used for *P. canaliculata* has also created confusion. The American Fisheries Society has recommended the use of channeled applesnail (not apple snail) for *P. canaliculata*, with others being spiketop applesnail (*P. bridgesii*), Florida applesnail (*P. paludosa*), and titan applesnail (*P. haustrum*). Within the pet and aquarium trade, *Pomacea* are generally sold as mystery snails, but some dealers use mystery snail for *P. bridgesii* and apple snail (sometimes Peruvian apple snail) for *P. canaliculata* or other larger *Pomacea*. The name golden apple snail given to *P. canaliculata* when first introduced in the Indo-Pacific region continues to be used, both in that area and among agriculture concerns generally. Gold-colored and albino forms of both *P. canaliculata* and *P. bridgesii* (and occasionally other species) are commonly sold by the pet trade around the world as golden mystery snails and golden apple snails. Specimens of *P. bridgesii* of any color do not threaten macrophytes (Howells 2002), but golden-colored specimens of *P. canaliculata* do. Thus, some "golden" applesnails are harmful and others are not. This confusion has confounded enforcing regulations intended to stop trade in *P. canaliculata* in the United States. We therefore recommend the term "golden apple snail" be replaced by "channeled applesnail" for *P. canaliculata.*

Records of *Pomacea canaliculata* in the United States

Florida

Collection data on specimens in the Florida Museum of Natural History (FMNH) collection indicate *P. canaliculata* was present in Palm Beach County in 1978. By the late 1990s, other populations were found in Collier, Hillsborough, and Pinellas counties as well (FMNH collection data). None of these populations threaten major agricultural areas (F.G. Thompson, FMNH, Gainesville; pers. comm.). Additionally, *P. bridgesii* is established in Florida (Thompson 1984) and *P. haustrum* has also been reported there, though it may be synonymous with *P. canaliculata* (Turgeon et al. 1998).

North Carolina

In 1992, *P. canaliculata* was collected in a reservoir in Stoneville, Rockingham County, North Carolina and specimens submitted to the FMNH in 1993 (FMNH collection data) and others retained by North Carolina Department of Agriculture. This introduction apparently did not become established.

California

A population of *P. canaliculata* was found established in Lake Miramar, San Diego County, in 1997 and another was reported in a small pond at the Norton Simon Museum, Pasadena, San Diego County, about that same time (Hardy 2001). The Lake Miramar site is surrounded by relatively arid, non-agricultural lands and the Pasadena population is in an urban setting. In October 2001, living *P. canaliculata*, their shells, and egg masses were found in a canal near the Salton Sea in Riverside County (A.R. Hardy, CDFA; pers. comm.). Whether this population can or will impact agricultural crops remains to be determined. However, plant species cultivated in this region are terrestrial forms not generally subject to *Pomacea* damage. Additionally, an infestation reported in Fremont, Alameda County in 1998 was eradicated by county personnel (A.R. Hardy, CDFA; pers. comm.).

Texas

Specimens of *P. canaliculata* were reported from a canal in Cameron County in the lower Rio Grande Valley earlier in this century (Fullington 1978) and again in the 1980s (Neck 1986), as well as a dry creek bed in Travis County in central Texas (Neck and Schultz 1992). However, all were probably aquarium releases that failed to survive and there was no confirmation of any established populations (Howells 2001a, b). A population was documented by Neck and Schultz (1992) in a pond in the Hedwig Village area of Houston, Harris County, in 1989 and was observed to have successfully overwintered into 1990. The Hedwig Village population was in an urban area where it posed no agricultural threat; it was not reexamined again until 2001.

In July 2000, a reproducing population of *P. canaliculata* was found in the American Canal, Brazoria and Galveston counties. Field survey efforts from December 2000 through 2001 ultimately documented the species at the following locations in the Houston area of southeastern Texas: (1) the American Canal (6-7 km), Brazoria and Galveston counties; (2) Mustang Bayou (37-38 km), Brazoria and Galveston counties; (3) Briscoe Canal, Brazoria County; (4) Halls Bayou, Brazoria County; (5) Chocolate Bayou, Brazoria County; (6) Hedwig Village pond, Harris County; (7) borrow pit at Barker Reservoir, Harris County; (8) Armand Bayou, Galveston County; (9) a private pond in northern Harris County; and (10) a private pond in southeastern Texas (Howells 2001a, b, c). An additional population was reported in a small pond in Bedford near Fort Worth, Tarrant County, in 2001 in northern Texas (Howells 2001b, c) and another

located in a small, backyard pond in Wichita Falls, Wichita County, in 2001, was identified and destroyed. Most of the Houston-area sites were either irrigation canals that supply local rice fields or were natural bayous adjacent to agricultural areas. The Bedford population is in an urban, non-agricultural area, but is now known to have survived two winters in northern Texas. State law precludes revealing the location of two of the *P. canaliculata* populations in southeastern Texas without landowner permission; thus, details cannot be release on two of these sites.

In June 2001, Tropical Storm Allison flooded much of Harris, Brazoria, and Galveston counties. It is likely this event, and two additional minor floods since, have helped to distribute *P. canaliculata* to even more sites in southeastern Texas.

Hawaii

The species was first reported on Maui in 1989 (Lach and Cowie 1999) and later appeared elsewhere on Maui, Kauai, Oahu, and Hawaii (Cowie 1995), and then on Lanai (Cowie 1996). Documented agricultural impacts were discussed by Cowie (1995, 1997, 1998, In Press).

Specimens in Commercial Trade

Historically, possession and sale of *Pomacea* has not been legally restricted in most states. However, in states like Texas and California where *P. canaliculata* is legally prohibited, numerous specimens have been found by biologists and game wardens in pet, aquarium, and water garden stores at many locations. Further, USDA inspectors have also found numerous shipments at entry ports around the country. According to David Robinson (USDA, APHIS-PPQ, Philadelphia; pers. comm.), *P. canaliculata* have been intercepted in virtually all of the 48 contiguous states. Examples are too numerous to list herein.

Responses to *Pomacea* Introductions in the Continental United States

In November 2000 following the discovery of *P. canaliculata* populations in southeastern Texas, the USDA organized a teleconference to bring together biological and agricultural experts from both federal and state agencies to better define and assess the significance of these introductions. TPWD initiated field surveys in southeastern Texas in late 2000 and throughout 2001 to determine the location of Texas populations and in April 2001, added *P. canaliculata* to its list of prohibited harmful and potentially-harmful exotic mollusks. In June 2001, USDA and CDFA held a meeting in California focusing on *P. canaliculata* and

other invasive, exotic mollusks. Also, in 2001, Mississippi moved to prohibit all species in the family Ampullariidae and impose a quarantine on agricultural products imported from states with known *P. canaliculata* populations.

Because *P. bridgesii* was popular in the pet trade, but its food habits were only assumed, feeding trials were initiated to compare it to *P. canaliculata* (Howells 2002). This in turn provides some estimation as to whether it too posed an ecological or agricultural risk in terms of damage to macrophytes. Test results indicated *P. bridgesii* was not found to consume any of the macrophyte taxa examined (Howells 2002).

In 2002, USDA initiated action to prohibit importation and transport across state lines of all species in the family Ampullariidae, except *P. bridgesii*. By allowing continued trade in *P. bridgesii*, not known to be an agricultural pest, potential conflict with pet trade interests was avoided and the regulation made more palatable to most parties. Regulatory changes require a Pest Risk Assessment (PRA), so one was initiated by APHIS-PPQ that specifically focuses on the potential impact on rice. At present, USDA is finalizing a Risk Analysis of *P. canaliculata.* It will begin more aggressive enforcement or restrictions on the family when this document is completed. USDA has also initiated an Internet Surveillance Team to identify trade in *Pomacea* and other prohibited species that fall under their jurisdiction that are now being traded through Internet sources.

Current Status and Impacts

Florida

Applesnail populations in Florida have been in non-agricultural areas. No new information has been released recently to suggest any change in this status. Ecologically non-native *Pomacea* may be displacing native *P. paludosa* and endangered Everglades kite (*Rostramus sociabilis*), that eats only *P. paludosa*, may not be able to consume introduced *Pomacea* (Hale 1964; McCann et al. 1996). Additionally, *P. canaliculata* may also be introgressing and hybridizing with *P. paludosa* (T. Collins, Florida International University, Miami; pers. comm.) and Collins and R.H. Cowie (University of Hawaii, Honolulu) have submitted proposals to USDA and USFWS to fund research on this problem.

California

The California population in Riverside County was recognized less than one year ago. Agricultural production in the area utilized plant species that would not be expected to experience major damage from *P. canaliculata*. Similarly, lands outside agricultural fields are often rather arid and downstream waters extremely

saline. Thus, little ecological impact is expected. Other populations are not in or near agricultural areas or have been eliminated.

Texas

The northern Texas *P. canaliculata* population is confined to a small, urban pond. In southeastern Texas, *P. canaliculata* occurs both in rice irrigation canals and in natural waters adjacent to rice fields. When first discovered in July 2000, rice plants in southeastern Texas were too advanced to suffer extensive snail depredation and most *P. canaliculata* populations were not in or near most growing areas at the time. Snails probably did not enter rice-growing sites in 2001 until Tropical Storm Allison flushed them into these areas in June. Again, however, by late June and early July, rice plants were nearly mature and not especially susceptible to depredation. Likewise, snail densities were probably relatively limited at that time.

As awareness of the potential *Pomacea* threat to crops became more widely recognized, canal operators moved to drain irrigation canals over the winter of 2001-2002 to promote snail kills due to cold temperatures or desiccation. Although large numbers of *P. canaliculata* were observed dead in dewatered canals in Galveston and Brazoria counties, many survived by burrowing in the mud substrates of the canals or seeking out pools of water that could not be completely drained. In spring 2002, these snails emerged and immediately began to lay eggs. Growers and agricultural experts hoped that winter canal draining, drying fields when not in production, and perhaps the use of pesticides would be able to limit snail damage to rice crops.

In spring 2002, fields were prepared, rice seeds typically drill planted, then fields flooded. Few, if any, growers reported crop damage associated with *P. canaliculata* throughout the growing season in 2002. However, when fields were drained prior to harvest, reports reached agricultural extension agents about snails and egg masses in rice fields in Brazoria County. Upon examination in early August 2002, these agents reported egg masses on rice stems, numerous egg masses that had fallen off the rice plants as they dried, vast numbers of tiny juveniles, and limited numbers of large adults, both shells and living specimens (M. Way, Texas Cooperative Extension, TCE, Texas A&M University, TAMU, Beaumont and W.H. Thompson, TCE, TAMU, Angleton; pers. comm.), but they did not observe actual crop damage associated with these snails. One grower reportedly applied the pesticide Karate (cyhalothrin) to control *Oebalus pugnax* (rice stink bugs) and believed it may have contributed to massive mortality of young *P. canaliculata* as well.

Some growers in southeastern Texas plant rice seeds in early spring, drain fields in July to allow them to dry, and harvest in late July or August. Fields are reflooded in August to produce a ratoon or second crop the same year (M. Way,

TCE, TAMU, Beaumont and W.H. Thompson, TCE, TAMU, Angleton; pers. comm.). Whether the surviving adult and juvenile snails will be able to inflict damage on this second growth is unknown, but may become evident in fall 2002.

Harris, Galveston, and Brazoria counties are situated in a coastal plain environment of marshes and small streams and bayous, punctuated with irrigation canals and agricultural fields. The most ecologically sensitive areas are salt marsh habitats and saline waters that would naturally preclude *Pomacea* invasion and subsequent habitat damage. Even the freshwater reaches of streams and bayous are short and flow toward coastal brackish waters. Any natural range expansion by these snails is confounded by salt waters or short-stream systems flowing directly to the coast that make accessing other larger drainage basins difficult at best (at least without human assistance). Therefore, no particular ecological harm from these introductions has been reported or expected thus far. Urban expansion of the Houston metroplex has already approached the American Canal site where *P. canaliculata* was found in 2000 and may displace both agriculture and natural environments in the area in the near future.

Hawaii

Status of *P. canaliculata* as a major crop pest in Hawaii was discussed by Lach et al. (2000) and Cowie (In Press) and more-recent data were unavailable as this manuscript was prepared.

Summary

Populations of *P. canaliculata* are present in central Florida, three sites in southern California, and southeastern and northern Texas. In Florida, this species has been implicated in ecological problems including displacing a native applesnail and compromising the food supply of an endangered bird. The introductions in southeastern Texas may become ecologically problematic in the future, but have not been so to date. Other populations are not expected to become environmental issues. The potential threat this snail poses to American agriculture is relatively new. Most American *P. canaliculata* populations are not situated geographically as to represent major agricultural problems. One southern California introduction may be adjacent to cultivated lands, but not to crops it would likely damage. However, populations in southeastern Texas are in rice irrigation canals, natural water adjacent to rice fields, and in rice fields themselves. Agricultural interests in Texas are hopeful that mid-winter draining of irrigation canals, dewatering rice fields when not in production, and even application of some pesticides may prevent these snails from reaching problematic densities. But, the introduction of *P. canaliculata* into Texas rice-

production areas was only detected just over two years ago. Snail distribution, potential impact, and control efforts remain newly evolving issues at this time.

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