GLOBAL ADVANCES IN ECOLOGY AND MANAGEMENT OF GOLDEN APPLE SNAILS

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Apple Snail Invasions and the Slow Road to Control: Ecological, Economic, Agricultural, and Cultural Perspectives in Hawaii

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Abstract

Four species of apple snails (Ampullariidae) have been reported from Hawaii. These have been provisionally identified as *Pomacea canaliculata*, *P. bridgesii*, *P. paludosa,* and *Pila conica*. Of these, *Pomacea paludosa* may not have become established; *P. bridgesii* is highly localized; *Pila conica* is a pest of taro (*Colocasia esculenta*) on the island of Molokai; but the most widespread and serious pest is *Pomacea canaliculata*, present on five of the main Hawaiian Islands. It was introduced, probably from the Philippines, in 1989 or perhaps earlier. Taro is a minor crop in terms of planted area in Hawaii but is the most important crop culturally, as it is the traditional staple of the native Hawaiian people and of great cultural significance to them. Farmer surveys indicate that crop losses of 18–25 % are typically sustained, despite a range of control measures, including primarily hand picking, water level management, herding ducks, cleaning and inspecting taro propagules ("*huli*") before planting, and use of screens on irrigation canals and pipes. This study, using a participatory action research approach, is the first attempt to obtain detailed information regarding apple snail impacts on taro in Hawaii.

Key words: apple snail, invasive species, economics, Hawaii

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Introduction

Apple snails (family Ampullariidae) are listed in the Global Invasive Species Database (http://www.issg.org/database/welcome/) among "100 of the world's worst invasive alien species" (Lowe et al. 2000). Four species of apple snails have been recorded in the Hawaiian Islands (Fig. 1), none of them native there. Based on data associated with specimens in the mollusk collections of the Bishop Museum (Honolulu), *Pomacea bridgesii* was present by 1962, *P. canaliculata* by 1989, *P. paludosa* by 1990 (although it had previously been reported by Wallace and Rosen [1969] but perhaps misidentified), and *Pila conica* by 1966 (Cowie 1995). *Pomacea paludosa* was recorded from only one locality on the island of Maui (Cowie 1995). *Pomacea bridgesii* has been recorded in small numbers from only three localities, one each on the islands of Kauai, Oahu, and Hawaii (Cowie 1995). Ongoing research (Cowie et al. 2006) may demonstrate that this species should correctly be identified as *P. diffusa*. *Pila conica* is the only species of ampullariid recorded from the island of Molokai, where it is present in a number of localities, primarily in areas of wetland taro (*Colocasia esculenta*); it has also been recorded from the islands of Oahu and Maui (Cowie 1995). *Pomacea canaliculata* is present on the islands of Kauai, Oahu, Lana'i, Maui, and Hawaii in large numbers and at numerous locations (Cowie 1995, 1996; Lach and Cowie 1999).

Apple snails were introduced to the Hawaiian Islands for two reasons. *Pomacea bridgesii* and *P. paludosa* (assuming correct identification) were most likely introduced as domestic aquarium snails. *Pomacea bridgesii*, native to South America, is popular in the aquarium trade (Perera and Walls 1996) and has become widely distributed in many parts of the world as a result. Various colorful forms, especially bright orange-yellow or "golden" forms, are particularly popular. *Pomacea paludosa* is the only ampullariid native to North America, where it occurs in the southeastern United States (US). *Pila conica*, a species native to Southeast Asia, including the Philippines, was almost certainly introduced from the Philippines by members of the

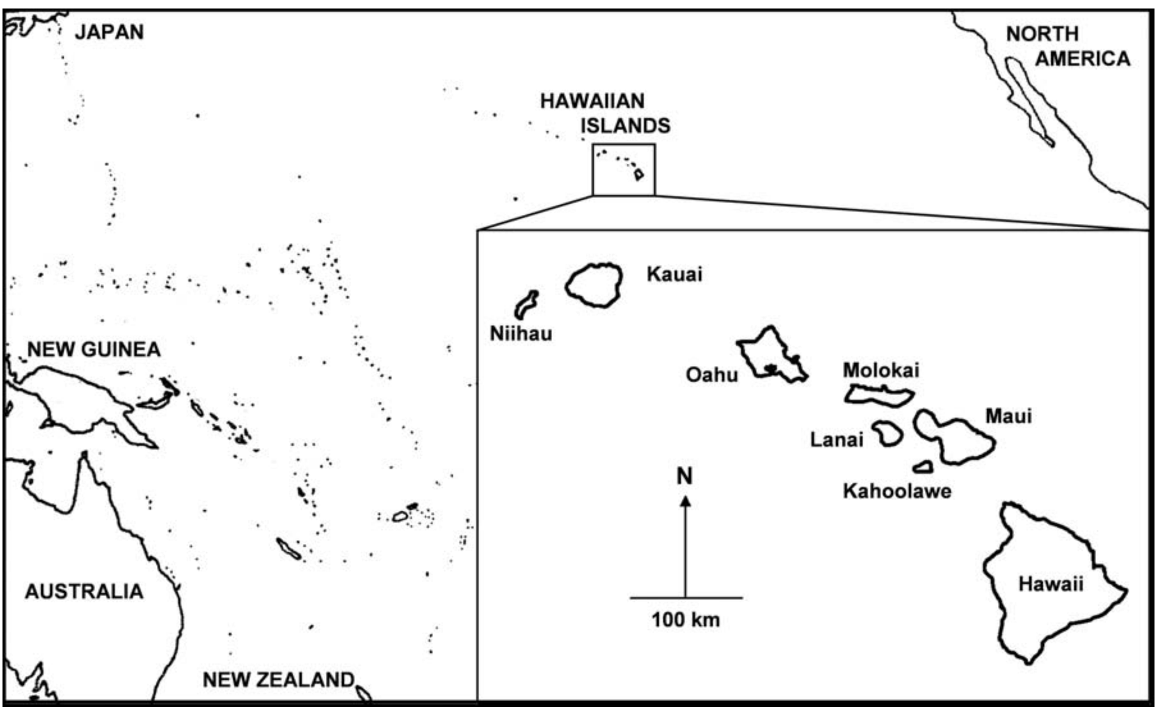

Fig. 1. The Hawaiian Islands and their location in the Pacific Ocean.

Filipino community in Hawaii as a human food resource. *Pomacea canaliculata* was probably also introduced via this route, subsequent to its introduction to Southeast Asia from its native South America. These introductions, initially to Asia and subsequently to Hawaii, were intended not only as a local source of food but also as a potentially lucrative source of money through sale of the snails as exotic "escargot" to gourmet restaurants both locally and overseas (Lai et al. 2005). In Asia, the overseas "escargot" market never developed, and the local market was only partly successful in certain countries, as the introduced snails were not preferred over native snails. In Hawaii, the local market is confined to certain ethnic communities (see below), the gourmet market is tiny, and overseas export has not been possible. *Pomacea canaliculata* has also been present in the aquarium trade in Hawaii, but molecular genetics evidence suggests that this has not been a pathway of introduction to the wild (T. Chuong, K.A. Hayes, and R.H. Cowie, unpublished).

Neither *P. bridgesii* nor *P. paludosa* has become an agricultural pest in Hawaii. However, the two species introduced as food, *Pila conica* and *Pomacea canaliculata*, initially maintained in aquaculture facilities, very soon were released and/or escaped into taro fields. *Pila conica* is a pest in wetland taro fields on Molokai, the only island where it is common, although the levels of damage are not severe, and the farmers are able to adequately manage or tolerate the snails. *Pomacea canaliculata*, however, has become a major wetland taro pest on Kauai, Oahu, Maui, and Hawaii. It is *P. canaliculata* that is the main subject of this article.

Pomacea canaliculata was officially allowed into Hawaii as the basis for an enterprise opportunity around 1989, although unconfirmed reports suggest it was introduced several years earlier. Despite long-standing efforts to dissuade further apple snail enterprise initiatives in Hawaii and repeated requests by wetland taro farmers for assistance once the snails became established, very few government resources were directed towards the growing problem. A grassroots movement among the taro farming community, at a time when Hawaii's awareness of invasive species has increased dramatically, has finally brought multi-agency attention to *P. canaliculata*. This article presents preliminary findings of a participatory action research (PAR) study on the economic impacts of apple snails on taro culture in Hawaii, initiated in 2004. The project was developed and supported by a statewide organization of taro farmers, who provided most of the information presented here. The study is not yet complete. However, this article presents an overview of our observations so far, as they have implications for prevention and control efforts specific to island ecosystems and the unique issue of cultural survival and family welfare. We also comment briefly on the use of PAR to expand the relevance of research and decision-making for control of invasive species.

Methods

An extensive field survey using geographical information system technology mapped the presence of *P. canaliculata* and *Pila conica* on six of the eight main Hawaiian Islands (Kauai, Oahu, Molokai [*Pila conica* only], Lanai, Maui, and Hawaii) during 2004-2005 and compared this current distribution with the previously known distribution (Cowie 1995, 1996, 1997; Lach and Cowie 1999). Written questionnaires and in-depth interviews are being used to investigate the economic impacts on taro farmers; their families; and, to a small degree, the larger community (crop production, apple snail control costs, food resources, educational resources, health and wellbeing, culture). The visual beauty of *lo'i kalo* (wetland taro fields) in the lowlands of the islands is of significant value to the tourist and advertising industries in Hawaii; however, this study does not assess the impacts of apple snails on those industries were the snails to eliminate these viewplanes.

Results and Discussion

Apple Snail Distribution

The detailed results of the geographic survey will be presented elsewhere. We summarize the results here.

We did not find *Pomacea paludosa*, which had previously been reported from a single locality on Maui. It may not have become established there, but it is also possible that it was never there and that these records were based on misidentifications of *P. canaliculata*. We confirmed the continued presence of *Pila conica* as the only species of apple snail on Molokai, but did not find it on Maui or Oahu, where it had been recorded previously; it may have failed to become established there (perhaps outcompeted by *Pomacea canaliculata*). *P. bridgesii*, previously recorded from Kauai, Oahu, and Hawaii, may be declining also, as it was not seen during the survey, nor in other recent surveys of the known localities (Cowie and Hayes, unpublished). *P. canaliculata*, however, has become more widespread since previous surveys, notably in a number of new localities on Maui, and in particular in the Hanalei National Wildlife Refuge on Kauai. Its distribution on the island of Hawaii has not expanded from its main locality, Waipio Valley, most likely because there is little additional suitable habitat (bodies of still or slow-flowing water, usually with a muddy bottom substrate) on that island. On Oahu, it continues to spread. In 1992, it was present at five locations (Cowie 1995); by 1998, it was present in 19 of 98 bodies of water surveyed by Lach and Cowie (1999); it is now present in at least three additional locations.

Culture and Agriculture

Polynesians were the first people to arrive, by canoe, in the Hawaiian Islands, around 300–700 AD (Kirch 1985, Athens and Ward 1993), or perhaps later (Tuggle and Spriggs 2001). With them came a handful of plants essential to survival in unknown lands. Taro, or *kalo* in Hawaiian, was one of these plants. It was grown in both wet and dry cultivation, but it is the wetland taro that became the staple food of the Hawaiians. *Kalo* is sacred in Hawaiian culture; it is the elder brother to the Hawaiian people and plays an important role in their cultural identity and spiritual well-being. Today, many farmers continue to grow taro for these cultural and spiritual reasons as much as for food or monetary reasons.

Prior to the 19th century, wet and dry taro cultivation in Hawaii covered thousands of hectares (Kelly 1983; Kirch 1985, 1994; Handy and Handy 1991) and fed perhaps as many as a million people (estimates of the maximum human population in Hawaii prior to European colonization range from 200,000–250,000 [Schmidt 1971, Kirch 1985] to around a million [Stannard 1989]). Today, less than 200 ha of *lo'i kalo* remains in production. Taro is the most culturally important crop in Hawaii, yet in comparison with other crops its monetary value and total area planted are small. In 2004, Hawaii Agricultural Statistics (HAS; http://www.nass.usda.gov/hi/) reported the farm value of taro at US$2.7 million. HAS data for 2004-2005 indicate an estimated 19,162 ha of vegetable crops in Hawaii, with taro representing just over 1% of this land. By comparison, in 2004, HAS reported ~ 245,000 ha planted to sugar and pineapple. This distribution has influenced the level of agency resources directed at developing solutions for control of apple snails.

Taro is harvested for both its corms and leaves. The corm takes on average 9–12 months to reach harvestable size, depending on the variety and other factors, including climatic and environmental conditions. Farmers receive an average of US$1,075–$1,250 per US ton (907 kg) (data from farmer interviews; August 2005 prices). Farmers report that apple snails can consume the labor of an entire year in a single week, when snail densities outpace the farmers' ability to limit population impacts. In 2002, one large farm in Hanalei, Kauai (~12 ha in production) was estimated to contain between 1.7 million and 6.8 million snails greater than 0.5 g, with an additional 128 million smaller snails present. Missing more than a single day of snail control under such conditions would result in significant crop loss (Tamaru et al. 2005; R. Haraguchi personal communication, 2005). Preliminary project survey results, along with data from HAS (2004), recorded an average 18–25% loss in crop production attributed to apple snails for 2003-2004, despite constant control efforts.

Taro is propagated by saving the tops of the parent corm and its side shoots, known as *huli*. Farmers reported that limited availability of *huli* was already a factor affecting the survival and expansion of cultivation of traditional taro varieties. The impact of apple snails exacerbated the situation, with some farmers reporting a 50% loss of newly planted *huli*.

About 300 printed questionnaires were initially given to the taro-farming community for distribution to farmers, but only an estimated 150 actually reached the farmers themselves, of which 32 (21.3%) were returned. Not all respondents answered all questions, and some questions were designed to have multiple responses as well as multiple degrees of response; therefore the number of responses (*n*) and the percentages will vary across questions. The 32 farmers worked a combined total of 89 ha, which is 45% of the estimated taro land in the state.

Preliminary results indicate that if taro can no longer be grown because of apple snails, people in Hawaii would have much more at stake than a cash crop or food source. Of those responding to the question "Why do you grow *kalo*?" 86% agreed or strongly agreed that they grow *kalo* for cultural learning and practice ($n = 29$). Personal and family health was also an important reason to be a taro farmer (100% and 87%, respectively; $n = 31$). Having extra food to share or trade ranked equally high at 91% ($n = 32$). Only 40% grew taro as their primary source of income ($n = 30$), while 68% grew taro as a secondary source of income ($n = 27$). Almost all (94%; $n = 31$) grew taro "because [it] is *ono* [delicious]." When asked "What would you lose, if you lost your crop to apple snails?" farmers responded by strongly agreeing that they would lose an important food source (88%; $n = 25$) and a preferred lifestyle (96%; $n = 26$). Crop loss would result in job losses for taro farmers and local *poi* (pounded taro) mill employees; the mills would be forced to close in the absence of a steady supply. Most respondents noted that they would lose "something important to me culturally" (96%; $n = 25$) and "spiritually" (100%; $n = 26$); and many indicated that they would "lose part of my identity" (92%; $n = 26$). In a recent taro farmers' gathering, one individual described such an event as "the loss of the source of the genealogy of every Hawaiian; the very root of who we are as a People."

Poi is a keystone food in the traditional Hawaiian diet. Native Hawaiians have the highest rate of heart disease (Aluli 1991) and the second highest rate of type 2 diabetes (Mau et al. 2001) in the US, in part resulting from major changes in diet and lifestyle patterns that occurred in conjunction with the Westernization of agriculture and food, beginning roughly around the mid-1800s, at about the same time as the loss of taro-producing lands began (Else 2004). A return to a traditional Hawaiian diet, which includes taro products, has proven effective in improving native Hawaiian health (Shintani et al. 1991, Hughes 1998), but reduced availability of *kalo* or *poi* in both formal and informal markets would limit the opportunity to maintain such a diet. These limitations would potentially impact many people beyond the taro-growing community. Interviews (September 2005) with small and mid-sized *poi* producers who are also taro growers revealed that they supply from 200 to 1,000 pounds (lb) (91–454 kg) of *poi* per week to local families either directly or through local markets, depending on the size of the mill. Based on millers' consumption estimates of 1 lb (0.454 kg) of *poi* being sufficient to accompany one meal for four people, this is enough *poi* for at least one meal per week for 800–4,000 individuals per mill. Five million lb (~2.3 million kg) of taro was milled for *poi* throughout Hawaii in 2004 (HAS 2005), producing ~3.75 million lb (1.7 million kg) of *poi* at a 1:0.75 conversion rate of taro to *poi*.

A pound (0.454 kg) of *poi* in the market can cost between US$3.00 and US$6.00 and provides food for up to four adults for one meal. For those families that eat *poi*, cooked taro, or *lu'au* (taro leaf) consistently, replacement values can range as high as US$150–200 per month (September 2005 prices; excluding cost of fuel and travel time to market), almost doubling their food budget. Addressing the same question "Why do you grow *kalo*?" 88% of farmers (n = 25) agreed or strongly agreed that they grow it as food for their family. Of these, 23% (n = 26) stated that if they could not grow taro, they would be financially unable to replace this family food source. The possible health impacts and potential loss of resources to low-income sectors of the community are some of the less obvious and difficult-to-measure results of the introduction of apple snails to Hawaii.

In addition, *lo'i kalo* served educational purposes, according to 96% of the survey respondents (n = 23). Students, teachers, and community groups use irrigated taro systems to explore topics in the study of art, science, mathematics, health, capacity-building, and Hawaiian culture, including one school, *Kanu o ka 'Aina*, that uses *lo'i kalo* and the streams that support them as the central theme for all subjects taught to students from 5th through 12th grade (approximately ages 11-18).

Hawaii's Melting Pot of Cultural Dilemmas

Apple snail dispersal among valleys, districts, and islands is strongly linked to human dispersal. According to the questionnaire results, 44% of apple snail introductions to particular locations were intentional (n = 9). In addition to the so-called "economic enterprise" project that brought the snails to Hawaii, farmer observations of how apple snails were introduced to many taro-growing areas indicate that Hawaii's multiethnic population has influenced the spread of the snails. Some people intentionally established snails in taro fields as a familiar food from their home country; *Pila* spp. are native to Asia and are eaten in some parts of the region, but *Pomacea* spp. are native to South America, and, although introduced widely in Asia and eaten to some extent (Lai et al. 2005), they are not part of the natural biota. These introductions, associated with cultural practices in parts of Asia, have had negative impacts on the host (Hawaiian) culture's traditional source of food. A small number of introductions have been malicious attempts to damage a farmer's crop or infest a watershed (e.g., Dixon-Stong 1995). An important proportion of introductions (33%; n = 9) occurred through infested *huli*, probably involving small, newly hatched snails, which may be less than 2 mm in size.

Every culture, as it travels around the globe, desires to bring with it the customs, cultural practices, and foods of its home. In the case of *P. canaliculata* in Hawaii, the socially complex cause of the present situation may involve the confluence of a number of factors. These include a large immigrant Filipino population and their desire for a familiar food; a South American species that partly supplanted Asian apple snail species in local cuisine in the Philippines; an already failed idea for escargot looking for yet another new market (there is only one small permitted snail raising and processing enterprise in Hawaii); and, on the part of state agencies a lack of knowledge of the devastating effects of invasive apple snails globally and of the potential for damage to taro cultivation.

Ecological and Landscape Level Issues

Six of the main Hawaiian islands (Kauai, Oahu, Molokai, Maui, Lana'i, and Hawaii) have climatically dry and wet sides. The traditional Hawaiian practice of cultivating irrigated taro is still undertaken in most wet districts where water is available. The pattern of spread of *P. canaliculata* is readily visible along wet and dry taro-growing district lines. Apple snails are now present in most wet locations where taro farming occurs, as well as in irrigation ditches, ponds, streams, springs, and wetlands.

Lo'i kalo are intricate farming systems uniquely designed to fit the environmental, physical, and climatic conditions of each valley where they were built, normally around the middle and lower reaches of streams, using natural water flows. Individual patches are typically connected, one to another, from uphill to downhill, by water intakes, outlets and irrigation ditches, similar to irrigated rice systems. Water moves from a stream into the system and back out to the stream as it exits from the lowest elevation patches. Within valleys (watersheds) or individual wetland systems, snail dispersal also tends to follow these natural waterflows downhill, although other means of dispersal, including the snails' own mobility, may lead to some dispersal in other directions. Survey respondents reported that 22% of infestations occurred from "uphill" sources ($n = 9$) and 11% from adjacent sites ($n = 9$). Others noted that the snails arrived before they began farming, and they were not aware of the source of the original infestations. Farmers reported that, on rare occasions, the snail could also be transported by predatory birds, including the indigenous *'auku'u* or black-crowned night heron (*Nyctocorax nycticoraxu*), which is a legally protected species, and the non-native cattle egret (*Bubulcus ibis*).

Coastal wetlands (at the bottom of these watershed systems) are the most difficult habitats in which to manage apple snails. Year-round availability of shallow water supports continual snail reproduction, with dense non-native vegetation harboring egg clusters. The protected status of the wetlands, and the threatened and endangered waterbird and insect species that reside there, limit the use of chemical controls. Wetlands in Hawaii are also typically located in Special Management Area zones or are federally recognized navigable water bodies that carry additional layers of regulations for chemical use, and often include the need for environmental assessments or approved mitigation plans for such strategies as large-scale brush clearance. To date, no apple snail control efforts have been attempted in non-agricultural wetlands under government jurisdiction. Apple snails thrive best in those areas that are naturally flooded year round. These are also the largest taro-producing areas in Hawaii and thus are where the greatest crop losses are occurring.

According to farmers, apple snail populations appeared to increase markedly sometime around 1998, and there may currently (2005) be a second population expansion occurring, although there are no quantitative data to support these observations. If boom-bust cycles do occur in invasive apple snail populations, understanding the triggers may helping with control efforts.

Apple Snail Control in Hawaii

Taro farmers prefer to use organic methods of snail control, because the water in their fields goes directly back into streams and thence to the ocean. To date, chemical control methods, such as use of copper sulfate, and pest-to-profit programs that encourage the collection of snails as an alternative crop in order to reduce their populations, have had limited success. There are strict controls on the use of chemicals in freshwater resources that preclude the use of molluscicides; and of particular concern is the lack of data on copper sulfate impacts on soils and on native freshwater and coastal reef biota. Farmers have clearly stated that they do not want to be "snail farmers."

Growers use a combination of techniques to reduce snail impacts (no one technique is enough). Some have learned through trial and error, others from the experience of apple snail control measures in other countries. Among 18 respondents, the most frequently used control methods included hand picking of snails (94%) and eggs (89%); water regulation, including repeatedly drying out patches during the growing season to drive snails underground, and lowering water levels to limit snail consumption of the crop (50%) (the latter, in combination with shallow trenches around the inside edges of a patch, has the effect of concentrating snails in the trenches, where they can be more easily removed); and cleaning and inspecting taro *huli* before planting (44%). Farmers also used mesh bags or screens to capture snails coming through irrigation canals and pipes (39%) and ducks as biological control agents (39%). Fewer farmers inspected tools and boots to prevent snail transfer (17%); used chemical controls (17%) or traps (11%); or dipped their *huli* in bleach, soap, or other solution to disinfect them (6%).

Early in-depth interviews (the second phase of this research) indicate that, where farmers are employing water level regulation but without the use of ducks, weeding time and labor may increase by as much as 50%, because frequent dry-downs lead to greater proliferation of weeds. *Lo'i kalo* with cool, steady water flows; relatively few dry-downs; and ducks appear to have limited weed problems and lower crop losses. Farmers consider this minimum group of strategies most cost-effective and efficient. The use of ducks, however, raises other concerns.

Regular use of domestic ducks (primarily derived from the mallard, *Anas platyrhynchos*) becomes a challenge in areas where the endangered *koloa* or Hawaiian duck, *Anas wyvilliana*, is present because of the potential for hybridization and the threat of extinction of pure *koloa* (Rhymer and Simberloff 1996, Engilis et al. 2002). Where dogs are allowed to run loose, they often kill farm ducks. An additional obstacle is the limited sources of ducklings for taro farmers, especially with recent increased restriction on importing birds to Hawaii because of the potential introduction of West Nile virus.

Farmers made two key observations about the use of ducks for apple snail control: (a) Pekin, a large, easy to manage variety, is a dependable snail consumer that does not damage mud banks to the degree other varieties do; and (b) starting with ducklings instead of adults results in more manageable birds that become trained to the call of the farmer.

In the past, control efforts have focused on single farms. Observations about the pattern of natural spread of *P. canaliculata* suggest that ecologically based, landscape-level control practices may be a newly emerging focus. Since all taro farmers around a given stream receive water from the same source, farms above or adjacent to a farm where control is practiced that do not participate in snail control efforts remain a perpetual source of reinfestation. Unmanaged, infested wetlands also back up into taro-growing areas during heavy flood events in low-lying areas. Clearing snails in a pattern that follows natural water flows through the *lo'i* system (from first patch to last; from highest elevation to lowest) may have a better chance of reducing the population of apple snails in the whole system.

At two sites on Maui, when water was removed and *lo'i kalo* remained dry for over a year (a 2-year loss of production), apple snails were completely eliminated. This method is viable only in areas that do not accumulate standing water during the rainy season and where irrigation can be temporarily halted. More attention needs to be given to mitigation in wetlands at the bottom of valley systems, where standing water is present year round and cannot be drained.

A Role for Participatory Action Research in Invasive Species Control

PAR strongly supports decision-making and policy recommendations that are more closely aligned to the real needs of farmers through collective research; a critical recovery of historical memory, accounts, and observations; valuing and applying farmer knowledge and indigenous cultural practices; and the sharing of new knowledge (the results of inquiry) (Fals-Borda and Rahman 1991). PAR methodology can at times be an uncomfortable experience for formally trained scientists, yet the PAR approach is often a key element in effective community-researcher collaborative efforts, particularly where trust-building is necessary; it requires researchers to allow farmers to lead before they can walk together (Horton and Freire 1990). The economic impact study was developed and defined by taro farmers as a means to educate, leverage resources, and create positive change at both the policy and action levels. They reviewed and approved grant proposals and written survey documents, and proposed questions for interviews in collaboration with researchers. Farmers readily articulate the daily, weekly, and monthly impacts of apple snails on their farms, if not in dollars, certainly in time, production, and changes to their routine. However, printed surveys were not the best instrument for inquiry. As is true in many rural communities, farmers prefer to speak face-to-face with someone they trust. This has been confirmed as we enter the second phase (one-on-one interviews) of the study.

This is the first grassroots-led effort to investigate the economic impacts of an invasive species in Hawaii, a rare occurrence in invasive species control efforts in the US. *P. canaliculata* is considered a well-established pest in Hawaii, beyond the ability of state agencies and invasive species field crews to manage. Community collaboration increases the relevance of information gathered and of future recommendations. Taro farmers remind us that the most immediately impacted stakeholders make decisions about when to give up on control efforts based on different criteria than those used by state agencies. Apple snails are doing far more than changing landscapes; they are putting at risk a whole way of life. Communities can and should be key players in the study and mitigation of invasive species in Hawaii's watersheds.

Conclusion

Taro farmers in Hawaii have been petitioning state agencies for assistance in apple snail eradication or control since at least 1990, with limited response. In 2003, a severe and costly infestation of the alien aquatic plant, *Salvinia molesta,* on a popular public lake brought invasive species issues to the front of the political arena. Increased awareness has finally led to greater agency and legislative support for invasive species control.

In May 2005, even though our study was not yet complete, the Hawaii Department of Aquatic Resources provided funding for development of a statewide strategic control plan for apple snails (expected completion date 31 March 2006). The plan is guided by taro growers and will make recommendations about new directions for farm-based and watershed-level control efforts, snail control research, and specifically what legislation and agency action can best support farmers in collaborative efforts to reduce snail populations.

Increased education regarding invasive species is needed among all sectors of the community. For many residents and cultures in Hawaii, even the concept of an invasive species is unfamiliar. Taro farmers are finding that they need to educate not just each other, but everyone who might potentially contribute to the spread of the snail and, equally importantly, to its control. This includes taro farmers who do not yet have snails, entire communities where snails are present, snail consumers, pet stores, students, teachers, agencies, legislators, and the general public. Multicultural and multilingual approaches are necessary. Farmers also recognize that the next generation will need to be aware of the full meaning and costs associated with any invasive species, not only apple snails, if native ecosystems, traditional cultural and agricultural practices, and traditional food sources are going to survive. For Hawaiians, it could mean the difference between continued survival and the collapse of the root of their identity.

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