INTERNATIONAL WORKSHOP ON ECOLOGY AND MANAGEMENT OF THE GOLDEN APPLE SNAIL IN RICE PRODUCTION IN ASIA, 16-19 JUNE 1997, PHITSANULOK, THAILAND

Participation Report

Submitted to USAID, Washington, DC

by

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Summary

An international workshop on the ecology and management of the “Golden Apple Snail” in rice production in Asia was held in Phitsanulok, Thailand, 16-19 June 1997. The purpose of the workshop was to bring together international scientists, local researchers and crop protection managers, and representatives of interested international agencies, in order to open communication among them and to develop a concerted, internationally agreed agenda of research to address the extremely serious and increasing impact of these snails on paddy rice in Asia.

There were 34 participants from 11 countries. These included internationally recognized snail biologists and biological control experts, local researchers and crop protection specialists, and representatives of IRRI and FAO.

USAID, via the FAS of the USDA, funded the travel costs associated with the participation in the workshop of Dr. Robert H. Cowie, malacologist at the Bishop Museum (Honolulu) and an experienced “apple snail” researcher. Dr. Cowie contributed a formal presentation on the taxonomy and identification of the pest species, as well as contributing more generally on the basic biology and ecology of apple snails.

A series of formal presentations allowed participants to become familiar with the problems experienced in each of the countries represented, the management strategies being used, and research in progress, to learn more about apple snails, and to understand the lack of knowledge that prevents an immediate solution to the pest problem.

Following the formal presentations, round-table discussion led to identification of the most important immediate research needs. The most generally perceived priority is to resolve the taxonomy of the species involved (one or more) and clarify its/their geographic origins. This is seen as the necessary underpinning of any rigorous attempt to understand relevant aspects of the biology of the pest species and to develop control measures (especially biological control) within this context.

Increased knowledge of relevant aspects of the biology of apple snails and means by which they might be controlled are of significance to the USA. These snails are agricultural pests in Hawaii and potentially in US territories in the Pacific. They have been introduced to the US mainland and although not currently considered agricultural pests, they do cause environmental damage and any increase in understanding of them will be of benefit. More generally, serious loss of Asian rice inevitably has impacts globally that may affect the US.

Contents

1. Introduction and Background

Freshwater snails that have come to be known commonly as “Golden Apple Snails” were first introduced to South-east Asia from their native South America between 1979 and 1981. The primary reason for their introduction was to develop aquaculture projects directed at the western restaurant “escargot” market; the snails were also to be developed for local consumption. Neither market developed, for a number of reasons, and the snails escaped or were released, quickly becoming widespread, especially in rice paddies.

The initial introduction is thought to have been from Argentina to Taiwan. By 1982 the snails had been introduced from Taiwan to the Philippines, and introductions to the Philippines continued from various sources (and possibly including more than one species) as snail-farming was heavily promoted by both governmental and non-governmental organizations. Later the snails were taken to China (1985), Korea (probably 1986), parts of Malaysia (Sarawak and Peninsular Malaysia, 1987), Indonesia (Java and Sumatra, 1989), Thailand (1989), Vietnam (1988 or 1989) and Laos (1992). They have also been reported in Hong Kong (1991), Cambodia (1995), Singapore (1993), Guam (1992), Papua New Guinea (1991), and Hawaii (1989).

Many of these introductions have been between countries or territories within South-east Asia and the Pacific, but there may have been multiple introductions from South America (perhaps from geographically widely separate localities), and perhaps introductions from unknown intermediary locations via the aquarium trade (these snails are popular aquarium snails). The ultimate origins of the various pest populations now widespread in South-east Asia are therefore essentially unknown.

The snails have become pests of paddy rice (and other crops) in many countries including Thailand, Vietnam, parts of Malaysia and Indonesia, China, Taiwan, Japan, but probably most seriously in the Philippines. In Taiwan, 17,000 ha of rice and other crops had been infested by 1982, increasing rapidly to 171,425 ha by 1986. In the Philippines the snails’ spread has been even more rapid, from 9,500 ha of rice in 1986 to over 400,000 ha in late 1988, and 800,000 ha by 1995. They have now become probably the most important pest of rice in the Philippines: in 1990, costs associated with apple snail damage were estimated as $28-45 million; by now, annual costs far exceed this figure. In Japan, introduced in 1981, they had spread to 35 out of 47 prefectures by 1989 and by 1995 occurred in over 50,000 ha of paddy fields. Few data are available from other countries, but the damage is clearly sufficiently serious to warrant major concern.

This concern has been manifested notably by the establishment of a FAO Technical Cooperation Project with Vietnam on “Integrated snail management in rice”, and by the convening of the recent workshop in Thailand by IRRI (the subject of this report).

The snails continue to be introduced to as yet uninfested countries by uninformed people believing they will be able to make money by farming them, not understanding the devastating impact the snails will have on human food security.

2. The Problem

A diversity of management practices has been developed, including chemical, biological, physical, and cultural methods. None has proven adequately safe and effective. Chemicals are still used extensively and inappropriately.

Scientists in both the western world and in the impacted countries in Asia have begun to develop research programs on apple snails. However, as yet, these have been uncoordinated efforts that have borne little fruit. Studies are rarely directly comparable because of the different methodologies used; different species may even be involved in these studies making the results even less comparable; communication of results has been poor; frequently the work is done by entomologists and agronomists with little experience in or understanding of snail biology; overall, little real progress has been made.

A prerequisite of any pest management program, particularly when dealing with such intractable pests as apple snails, is adequate understanding of the basic biology of the pest. Unfortunately this is seriously lacking for the “Golden Apple Snail”. The pest snails belong to the genus *Pomacea* of the family Ampullariidae, but we do not know the identity of the snails in South-east Asia, indeed whether there is more than one species (quite possible); and we do not know their geographic origin(s), other than that they are from South America. The loose group of species to which the unidentified pest belongs is extremely widespread from temperate Argentina to tropical Brazil and equatorial Venezuela, Surinam, etc. The taxonomy of this group of species is a mess. A recent comprehensive review of the biology, pest status, and management of these snails, written by me and to be published as a chapter in a forthcoming book (see below), illustrates the scanty and scattered nature of our knowledge of the family.

Thus, any attempts at snail management that depend on a clear understanding of ecology and behavior rest on extremely shaky ground. And in particular, identification of biocontrol agents cannot be reliable because the identity of the snail species and its/their geographic origin(s) are uncertain.

3. Purpose of the Workshop

The workshop was convened by Dr. K.L. Heong of IRRI, with support from the Director General of IRRI, to bring together the world experts in the areas of apple snail biology and snail pest management (particularly biological control), agricultural pest managers and researchers in countries impacted by the snails, as well as representatives of interested international agencies (FAO, IRRI). There were 34 participants in the workshop, listed in Appendix 1.

The primary goal of the workshop was to develop a concerted research agenda, agreed upon by the workshop participants, that would identify the main areas of immediate research need, and thereby foster cooperation among scientists, managers and funding agencies, allowing the apple snail problem to be addressed efficiently and effectively. A concomitant goal was to identify the individuals and/or organizations best placed to undertake these research activities and/or to facilitate communication among the various players.

4. The Workshop

4.1. Program

The workshop began with presentations from the participants over the first day and a half. This allowed all participants to become familiar with the problems experienced in each of the countries represented, to hear about the management strategies being used and about research in progress, and, especially for non snail specialists, to learn more about apple snails and to understand the real gaps in current knowledge that prevent an immediate solution to the pest problem. The list of presentations is given in Appendix 2.

Following the formal presentations, the discussion phase of the workshop began, the primary goals being to identify and prioritize research needs, and to identify the organizations, institutions and individuals best placed to undertake and/or facilitate these activities. In addition, potential contributions of each of the workshop participants and their organizations/institutions were discussed.

This second phase of the workshop (days 2 and 4) was coordinated and facilitated by Dr. K.L. Heong (IRRI). Dr. Heong was successfully able to involve all the workshop participants in the discussion, so that the final outcome was a true consensus.

On the third day of the workshop, participants visited a “snail management campaign” in a rice-growing area south of the workshop venue. This allowed participants to gain some experience of the problem and current management activities in Thailand at first hand.

4.2. Outcome and Products of the Workshop

Priority research needs were identified, and a statement of these needs, the primary product of the workshop, was developed and is available in Appendix 3. This statement is a consensus view and will be of great significance in focusing international efforts to address the problem.

Needs were broken down into three major areas: 1) ecology, 2) social aspects, and 3) management.

The first, ecology, is of underlying importance. The main areas of ecological research identified as of immediate need are: 1) snail taxonomy and geographic origins, perceived by all participants as of crucial and primary importance; 2) snail population ecology, including modeling of population dynamics and mortality factors, feeding biology, and developing standardized sampling protocols; 3) search for natural enemies, which is dependent on correct identification of the pest species and its/their geographic origins.

The second, social aspects, is less clearcut as a research effort, but is important if management practices are to be implemented appropriately within the different social contexts of the various countries affected. Although not exactly a research need, particular note was made of the need for heightened levels of publicity and education, as well as more rigorous quarantine procedures to prevent the further spread of the snails.

The third area, management, crucially includes yield loss assessment. At present there are few adequate yield loss studies, and without them, the development of new pest management strategies and evaluation and modification of existing strategies (also included among the recommendations) will proceed in a vacuum.

In addition to identifying research needs, potential contributions of workshop participants and their institutions were discussed in a preliminary way. Dr. Heong agreed that IRRI would act as an information coordinator and disseminator. Dr. Baker agreed to also participate in coordination. The workshop supported Dr. Symondson’s proposal (to the European Union) to undertake research to identify snail predators (in collaboration with Drs. Coupland, De Lara and Halwart). [I have recently been informed by Dr. Heong that Dr. Symondson has decided not to submit his proposal at this time.] Dr. Heong invited me to submit a short concept note to him outlining research on the taxonomy and geographic origins of the pest snails, to be undertaken under my supervision at Bishop Musuem (Honolulu), and which would probably involve collaboration with molecular biologists, using facilities at the University of Hawaii.

5. Robert H. Cowie's Expertise and Contribution to the Workshop

5.1. Expertise

I have worked on "apple snails" (family Ampullariidae) since 1990, when they first began to be a problem in Hawaiian taro cultivation. Through extensive study of museum specimens (over 7,000 lots, probably over 30,000 specimens, in major museums in the USA, UK, and Australia), in part funded by FAO, I became familiar with the immense intraspecific morphological variability exhibited by these snails as well as the horrendous taxonomic confusion that surrounds them. I was nevertheless able to identify the species in Hawaii (there are four) and map their distributions (published in 1995). As well as continuing to monitor the snails' spread in Hawaii, I currently contribute my expertise locally to the Hawaii Department of Agriculture and to the Taro Action Resource Organization.

My main publications and reports dealing with ampullariids are listed in Appendix 4. In particular, I have recently completed the manuscript of an invited book chapter entitled "Apple snails as agricultural pests: their biology, impacts, and management". This is a comprehensive review of the biology of the snails as it is relevant to pest management, a review of their agricultural impacts not only in South-east Asia but throughout the world, evaluation of the various management strategies currently in use (none adequate), and suggestions for future research and management actions. It includes a large bibliography. The manuscript has been sent to Dr. Heong at IRRI for distribution to interested workshop participants, as well as directly to a number of the participants. I also maintain a more extensive bibliography on ampullariid biology as a research resource, and which I have also distributed to a number of the participants. I am acknowledged as one of only a tiny handful of snail biologists worldwide with a research interest in ampullariids.

I am currently employed at a major US museum, so my research focus in relation to apple snails is their taxonomy, systematics and biogeography. In a previous situation, however, I worked extensively in pest management in developing countries. Thus, as well as having a broad understanding of ampullariid biology, I am able to set this in the context of the agricultural needs.

5.2. Contribution

In the specific context of the workshop, I was thus able to offer expertise on taxonomy and identification of the species, essentially educating participants about the uncertain identification(s) and origin(s) of the snails. Most of the participants from Asia are not snail specialists. Not unreasonably, they then often use inappropriate characters such as shell and body color and shell size for identification. These characters are highly variable in this group and using them for identification purposes is virtually meaningless. In some instances, for example, snails in a single population, differing only in shell color, had been named as two species. Not only was differentiating them into two species incorrect, but their actual identifications as named species were based on little more than hearsay. I was able to explain to the participants the inadequacy of these characters for identification, showing them appropriate illustrations, and to explain the reasons for our current inability adequately to identify the pest species. Nonetheless, there remained dissatisfaction that the snail specialist (myself) was unable to offer definitive identifications in most cases. Unfortunately this is a reflection of current knowledge.

I also brought to the workshop a broad background of knowledge of ampullariid biology, based on a thorough familiarity with the literature (more so than any other participant). This allowed me to act as something of an information resource when particular issues of ecology and biology were

addressed. Having worked on snails for over 20 years (also more than any of the other participants), I was also able to bring a more general comparative molluscan perspective to bear on the issues being addressed.

My formal presentation was entitled “What are apple snails? Taxonomy and identification of the pest species”. The abstract is available in Appendix 5. I explained what kind of snails apple snails are, their worldwide distribution, distribution of the genera *Pomacea* (including the pest species) and *Pila* (which includes the native species of Asia, which are of concern because they may be being replaced by *Pomacea* and might also be vulnerable to biocontrol agents introduced in the future against *Pomacea*). I outlined the climatic/ecological limits to ampullariid distribution, indicating their threat to northern Australia and islands of the Pacific (which are climatically and ecologically suitable, but do not naturally support ampullariids, for reasons of historical biogeography). I then summarized the confusion surrounding the identification of the pest species, and reasons for this confusion, ending by indicating the need for better taxonomic understanding in order to set management strategies on a firm base.

6. The Future

Frequently there is a conflict between potential environmental harm and economic benefit when species are considered for introduction. In the case of apple snails, the potential for short-term economic gain (which has not materialised) has been foremost in people’s minds, while they have been blind (and in some cases continue to be so) to the potential (and realised) long-term environmental and agricultural destruction.

There is a rapidly increasing literature on invasive species: factors causing their success or failure, the dynamics of establishment, the ecological and agricultural problems they cause, and what can be done about them. In many cases, new invaders exhibit a lag phase before their populations expand rapidly, when they become pests. In the case of *Pomacea* introduced to South-east Asia and other areas, the lag phase seems virtually non-existent, giving authorities minimal time to make a decision to act.

For regions as yet not infested, prevention of the introduction of apple snails must then be the primary strategy. Awareness must therefore be raised so that officials know the potential problems that will overcome them should the snails be introduced, rather than only becoming aware of the problems when it is too late. Officials must also be prepared to act quickly if an introduction is detected. Eradication at this early stage might still be possible, but there will be only a very narrow window of opportunity.

For areas already infested and with little hope of eradicating the snails, integrated management strategies involving both existing control measures and measures developed in the future, must be implemented. These strategies will differ from region to region, depending on the levels of infestation, potential environmental consequences, the specific needs of the local farmers and the options open to them, and local economics. Development of widely implemented and successful strategies has to be based on a thorough understanding of relevant aspect of the snails’ biology. Implementing the research identified at the workshop is the crucial first step.

7. Relevance to the United States

Apple snails are already serious agricultural pests in Hawaii. Yet we remain as ineffective in their management as do the countries of South-east Asia. The most serious pest species in Hawaii is almost certainly the same species as that in the Philippines; in fact the Philippines are probably the

immediate geographic origin of the Hawaiian populations (even though they are of ultimate South American origin). Any increased understanding of apple snails in Asia and their geographic origins in South America will be of great value in management of these pests in Hawaii. Apple snails are also a threat in other US-affiliated territories in the Pacific: they are present in Guam; they have been reported in Palau; and American Samoa is highly vulnerable.

More generally, and I am neither politician nor economist, it seems that the serious destruction of rice in Asia may have a global impact from which the US would not be immune.

A number of nonindigenous (i.e., alien, exotic, non-native, introduced) ampullariids are now established on the US mainland. They are not as yet serious agricultural pests, but they have been implicated in significant environmental damage. Increased knowledge of their biology and development of control measures will clearly be important should these snails ever become a more serious and widespread problem.

8. Itinerary

12 June 1997 Travel from Honolulu to Bangkok, arriving late on 13 June having crossed the International Date Line
14 June Bangkok (personal time)
15 June Travel to Phitsanulok
16-19 June Participate in workshop
20 June Travel from Phitsanulok to Honolulu, arriving on 20 June having crossed the International Date Line

Appendix 1 - List of Participants

Mr. Fouzi Ali, Muda Agricultural Development Authority, Alor Setar Kedah, Malaysia
Dr. Jambari Haji Ali, University Putra Malaysia, Selangor, Malaysia
Dr. Geoff H. Baker, CSIRO, Australia
Mr. A.T. Barrion, IRRI, Los Baños, Philippines
Ms. Chompoonut Chanytapate, Department of Agriculture, Bangkok, Thailand
Dr. James Coupland, Montpellier, France
Dr. Robert H. Cowie, Bishop Museum, Honolulu, Hawaii, USA
Mr. Le Duc Dong, Plant Protection Department, Hanoi, Vietnam
Mr. Somraul Dokmaihom, Department of Agricultural Extension, Bangkok, Thailand
Dr. Matthias Halwart, FAO, Rome, Italy
Dr. K.L. Heong, IRRI, Los Baños, Philippines
Mr. Sermsakdi Hongnark, Department of Agriculture, Bangkok, Thailand
Dr. Melanda Hoque, National Crop Protection Center, Los Baños, Philippines
Mr. Nguyen Huu Huan, Department of Plant Protection, Ho Chi Minh City, Vietnam
Mr. Ly Ngoc Hung, Department of Plant Protection, Ho Chi Minh City, Vietnam
Dr. Gary Jahn, Cambodia-IRRI-Australia Project, Phnom Penh, Cambodia
Mr. Ho Nai Kin, Muda Agricultural Development Authority, Alor Setar Kedah, Malaysia
Dr. Ayolani de Lara, University of the Philippines at Los Baños, Philippines
Dr. Nitaya Lauhachinda, Kasetsart University Chatuchak, Bangkok, Thailand
Mr. Pham Ngoc Man, Department of Plant Protection, Ho Chi Minh City, Vietnam
Mr. Lakchai Meenakanit, Department of Agricultural Extension, Bangkok, Thailand
Ms. Patcharee Meenakanit, Department of Agricultural Extension, Bangkok, Thailand
Dr. Seiichi Moriya, JIRCAS, Japan
Ms. Piyanee Nookarn, Department of Agriculture, Bangkok, Thailand
Mr. Aroonpol Payakaphanta, Department of Agricultural Extension, Bangkok, Thailand
Dr. Narinchai Phatanaphongsa, Chiang Mai University, Chiang Mai, Thailand
Mr. Prasatlong Promkerd, Department of Agriculture, Bangkok, Thailand
Mr. Zulkifli Romli, Muda Agricultural Development Authority, Alor Setar Kedah, Malaysia
Dr. K.G. Schoenly, IRRI, Los Baños, Philippines
Dr. Teo Su Sin, Agriculture Research Center, Sabah, Malaysia
Dr. Lim Guan Soon, IIBC, Selangor, Malaysia
Dr. W. Symondson, University of Wales, Cardiff, UK
Dr. Yoichi Yusa, Kyushu National Agricultural Experiment Station, Japan
Ms. Ngizailah Haji Zakaria, Department of Agriculture, Kuala Lumpur, Malaysia

Appendix 2 - List of Presentations

K.L. Heong
The Rice IPM Network. Objectives of the Workshop.

Aroonpol Payakaphanta
The golden apple snail problem in Thailand.

Melanda M. Hoque
The golden apple snail problem and farmers' management practices in the Philippines.

Gary Jahn
The golden apple snail invades Cambodia.

Le Duc Dong
Golden apple snails in Vietnam.

Nitaya Lauhachida
Heavy metals and pesticide residues in the golden apple snail *Pomacea canaliculata* Lamarck.

Seiichi Moriya
Apple snail problems and the national research project of the apple snail in Japan.

Matthias Halwart
Integrated management of golden apple snails in Asia.

Ngizailah Haji Zakaria
Management of golden apple snail (*siput gondang emas*) in rice production in Malaysia.

Teo Su Sin
The golden apple snail in Sabah, E. Malaysia.

Robert H. Cowie
What are apple snails? Taxonomy and identification of the pest species.

A. de Lara
Snail biology and its significance in management.

W. Symondson
Identification of the predators of pest molluscs using monoclonal antibodies and the use of such techniques as part of an integrated apple snail control program.

Chompoonut Chanyapate
The golden apple snail, *Pomacea canaliculata*. Research and management in Thailand.

Yoichi Yusa
Ecological studies on the golden apple snail in Kyushu, Japan.

Jambari Haji Ali
Some biological and ecological aspects of *Pomacea* in Malaysia.

James Coupland
Apple snails in South America: a different perspective.

A.T. Barrion
Biology and laboratory predation of *Dindymus pulcher* Stal (Hemiptera: Pyrrhocoridae) on golden apple snails in the Philippines.

Appendix 3 - Statement of Research Needs

International Workshop on
Ecology & Management of the Golden Apple Snail
in Rice Production in Asia
16-19 June 1997 Nanchao Hotel
Phitsanulok Thailand

Outputs from brain storming sessions:

Problem: **The Golden Apple Snail causes serious economic loss to rice production in Asia. Many conventional control measures currently used have negative impacts on environmental and human health. The distribution of the snail is increasing.**

Objective: **To reduce economic loss in Asian rice production caused by the Golden Apple Snail through the use of measures that are sustainable, economically viable, environmentally-friendly, and with minimal hazards to human health, while preventing further spread of the snail in the region.**

What are the research needs necessary for the management of the Golden Apple Snail?

Ecology

Taxonomy
- Resolve the taxonomy and clarify the geographic origins and distributions of the *Pomacea canaliculata* group of species in South America and Asia.
- Develop biochemical and molecular methods for taxonomic studies.

Population Ecology
- Quantify factors influencing population ecology/dynamics and feeding behavior.
- Identify and quantify natural mortality factors.
- Develop and validate sampling and population models of the Golden Apple Snail for testing management strategies.

Natural Enemy Search and Biological Control
- Exploration for natural enemies in place of origin of the Golden Apple Snail.
- Develop monoclonal antibodies to identify snail natural enemies in Asia and South America.
- Evaluation of exotic natural enemies for introduction.

Social Aspects

Farmers' Knowledge, Attitude and Practice
- Conduct studies on farmers' perceptions of the Golden Apple Snail and its control methods and their decision making.
- Evaluation of farmers' practices for inclusion into the management of the snail.

Farmer Training
- Develop extension strategies and training curriculum for extension workers and farmers.

Awareness campaigns
- Evaluate various campaign strategies and materials.

Quarantine
- Develop quarantine procedures to control spread.

Management

Loss Assessments
- Quantify yield losses due to the Golden Apple Snail.
- Determine the economic threshold.

Alternatives to chemical molluscicides
- Evaluate cultural control methods that farmers are using.
- Evaluate water management and physical methods.

Integrated Approaches
- Develop integrated management approaches from existing information and evaluate them scientifically and with farmers' participation.

Monitoring
- Monitor and predict spread of the Golden Apple Snail and related taxa in Asia, Pacific and Australia.
- Monitor pesticide residues and heavy metal accumulations in snails.

Rice cultivars tolerant to snail damage
- Develop rice cultivars resistant or tolerant to snail damage.
- Understand crop compensation in different cultivars from snail damages.

Develop Improved Chemical Control Strategies

Evaluate new formulations of molluscicides

Evaluate the use of repellents and attractants

Appendix 4 - Main Publications of Robert H. Cowie dealing with Ampullariids

Cowie, R.H. 1992. Report on a visit to the mainland United States to study museum collections of ampullariid snail and to discuss research on these snails. *Bishop Museum Report to the Food and Agriculture Organization of the United Nations*. 27 pp.

Cowie, R.H. 1994. Freshwater snail surveys in relation to eradication of apple snails with copper sulphate on Kauai. *Bishop Museum Technical Report* 5. 26 pp.

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

Cowie, R.H. 1995. Report on a visit to Cambodia to advise on apple snails as potential rice pests. *Bishop Museum Report to Cambodia–IRRI–Australia Project, Phnom Penh*. 8 + [2] pp.

Cowie, R.H. 1996. New records of introduced land and freshwater snails in the Hawaiian Islands. *Bishop Museum Occasional Papers* 46: 25-27.

Cowie, R.H. 1997. Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands. *Bishop Museum Occasional Papers* 50: 1-66.

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. in press. Apple snails as agricultural pests: their biology, impacts and management. [invited book chapter].

Appendix 5 - Abstract of Robert H. Cowie's Presentation

What are apple snails? Taxonomy and identification of the pest species

Apple snails are caenogastropod (formerly "prosobranch") operculate snails. There are nine or ten genera, distributed almost throughout the humid tropics and subtropics.

Nomenclature.

- The preferred family name is Ampullariidae. Pilidae is also used, but is a junior synonym.
- The pest species in Asia is/are in the genus *Pomacea*.
- The native species in Asia are in the genus *Pila*.
- The names *Ampullaria* and *Ampullarius* are junior synonyms of *Pila*. Their use is incorrect.
- Common names include "golden snail", mystery snail", "miracle snail". Correspondence between these names and the correct scientific names is vague and causes much misunderstanding.

Identification.

- The pest species (possibly more than one) in Asia has been identified in the literature as *Pomacea canaliculata*, *P. lineata*, *P. gigas*, *Pomacea* cf. *canaliculata*, *Pomacea* sp., *Pila* sp., a "hybrid [of] *Ampullaria canaliculata* and *Ampullaria cuprina*", "*Ampularius* sp. a hybrid of undetermined origin". In Thailand, three species have been distinguished: *Pomacea canaliculata*, *P. insularum* and an unidentified *Pomacea* sp. In addition to *P. canaliculata*, two other species have been identified as introduced to the Philippines: *Pomacea gigas*, *P. cuprina*.
- The correct name(s) for the pest species is/are uncertain. Wide morphological variability, sexual dimorphism in size, and huge variation in shell color/pattern, confound rigorous identification.
- The pest species (possibly more than one) belongs to a relatively well defined group of about 15 nominal species, most of them widely distributed in South America. The most frequently used name is *Pomacea canaliculata*.
- The taxonomy of these species has not been adequately reviewed for almost a century and not in the light of a modern species concept. Modern revision, using shell characters, internal anatomy, and molecular characters, would reduce the "*canaliculata* group" to perhaps as few as three species.

Problems.

- We do not know which species has been introduced to Asia.
- We do not know whether only one species or more than one species has been introduced.
- We do not know how many valid species there are in South America.
- We do not know the distributions of the species in South America because we do not know what those species really are.
- Therefore, studies of snail biology, search for control agents, etc., cannot be undertaken with a secure foundation. Comparability among studies is unreliable.

Needs.

- Taxonomic study of the "*canaliculata* group" in South America to define species and document their distributions.
- With this sound taxonomy, identify the species (one or more) in Asia.

Future.

- Pest management can only be successful against a background of clear understanding of the biology of the pest. Correct identification of the pest will allow research in South America to be targeted at the correct species in the correct localities, and is one of the first steps in developing a management strategy.
- With the pest species identified, development of ecological and behavioral understanding will permit control measures to be more reliably developed.