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Spread of Freshwater *Pomacea* Snails (Pilidae, Mollusca) from Argentina to Asia

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Abstract—*Pomacea canaliculata* (Lamarck) was introduced as a human food from Argentina into Taiwan (China) in 1979–80. It was introduced from Taiwan to Japan in 1981, the Philippines in 1982, China (Guangdong, Fuzhou, & Hangzhou) in March 1985, Korea (Suwon) in 1987 or earlier, Malaysia (Sarawak) in 1987 or earlier, and Indonesia and Thailand by 1989. The snail has escaped from aquaculture and established in open fields affecting aquatic plants. Estimation of areas infested by this snail was 171,425 ha in Taiwan in 1986, 16,195 ha in Japan in 1989, and ca. 400,000 ha in the Philippines in 1989. In Japan ethylthimetone + thiocyclam G, cartap G, bensultap G, and IBP G are registered as snail repellents, and IBP G shows some toxicity. Calcium cyanamide is registered as a fertilizer with toxicity to snails. Metaldehyde, triphenyl-tin acetate, and niclosamide are not registered for control purposes because of high toxicity to fish. In Taiwan, however, metaldehyde and triphenyl-tin acetate are registered. In addition, the predatory black carp (*Mylopharyngodon piceus* (Richardson)) and common carp (*Cyprinus carpio* L.) are recommended as control agents. In the Philippines, 5 chemicals including triphenyl tin-acetate, niclosamide, and endosulfan are in the market. Hand-picking, ducks, setting of metal screens, etc. are also recommended. More effective methods of control have yet to be developed.

Introduction

Pomacea canaliculata (Lamarck) commonly known as golden snail, golden apple snail, apple snail, jumbo snail, and golden miracle snail, is indigenous to South America and was introduced to Taiwan from Argentina in 1979–1980 and into Kyuusyuu and Wakayama, Japan, from Taiwan in 1981. The snail was cultured in ponds and sold as fresh, canned or bottled human food. However, currently it has little commercial value in either Taiwan or Japan.

There are at least three species of *Pomacea* that occur in the Philippines: *P. canaliculata* was introduced from Taiwan into the Rafael Atayde Hatchery, Lemary, Batangas, Luzon in 1982. *P. gigas* (Spix) was imported by the Bio-Research Institute, Metro Manila from Florida, USA in 1983. *P. cuprina* (Reeve) was also introduced to Manila around 1983. *P. canaliculata* was introduced from Luzon around 1983 and directly from Argentina or Taiwan into the Asturias Farm in Cebu in 1984 for commercial production (Mochida 1987, 1988a, b). *Pomacea* culture was recommended to farmers through a livelihood project of the Philippine Government up to 1988.

Pomacea snails were brought to Fuzhou from Guangzhou, China in March 1985. They were also found in aquaculture at Suwon, Korea in 1986, in Sarawak, East Malaysia in 1987, and Bangkok, Thailand in 1990. The spread of the snails in East Asia is shown in Fig. 1.

Taxonomy

The scientific name of the freshwater snails introduced from Argentina to Japan via Taiwan around 1981 was frequently confused. According to Habe (1986), the valid and invalid names are as follows:

Phylum	Mollusca
Class	Gastropoda
Order	Mesogastropoda
Family	Pilidae (Synonym; Ampullariidae)
Species	*Pomacea canaliculata* (Lamarck) (Plate I A–E)
	Ampullaria canaliculata Lamarck
	A. canaliculata Lamarck
	A. insularum Hamada & Matsumoto 1985 (nec d'Obigny 1839)
	A. insularus Chang 1985 (nec d'Orbigny 1839)
	A. insularus Miyazaki 1985 (nec d'Orbigny 1839)
	A. insularus Hirai et al. 1986 (nec d'Orbigny 1839)
	A. insularus Kaneshima et al. 1986 (nec d'Orbigny 1839)
	A. insularus Miyahara et al. 1986a, b (nec d'Orbigny 1839)
	A. insularus Ōya et al. 1986 (nec d'Orbigny 1839)

Pest status of *Pomacea canaliculata*

Aquatic plants affected by this snail are: young rice seedlings (*Oryza sativa* L.), taro (*Colocasia esculenta* (L.) Schott), swamp cabbage (*Ipomoea aquatica* Forskål), lotus (*Nelumbo nucifera* Gaertner), mat rush (*Juncus decipiens* Buchenau), Chinese mat grass (*Cyperus monophyllus* Vahl), wild rice (*Zizania latifolia* Turczaninov), Japanese parsley/dropwort (*Oenanthe stolonifera* Wall), water chestnuts (*Trapa bicornis* Osbeck), and azolla (*Azolla* spp.). Also, the snail fed on the terrestrial plants such as cabbage placed in their culture ponds.

In Taiwan, *Pomacea* snails infested 17,000 ha in 1982 and 171,425 ha in 1986. In 1986, the area treated with molluscicides was 103,350 ha, and the estimated loss in rice fields alone was US $30.9 million. Over half a million fingerlings of black carp (*Mylopharyngodon piceus* (Richardson)) and even more of common carp (*Cyprinus carpio* Linné) were released to control the snails (Table 1).

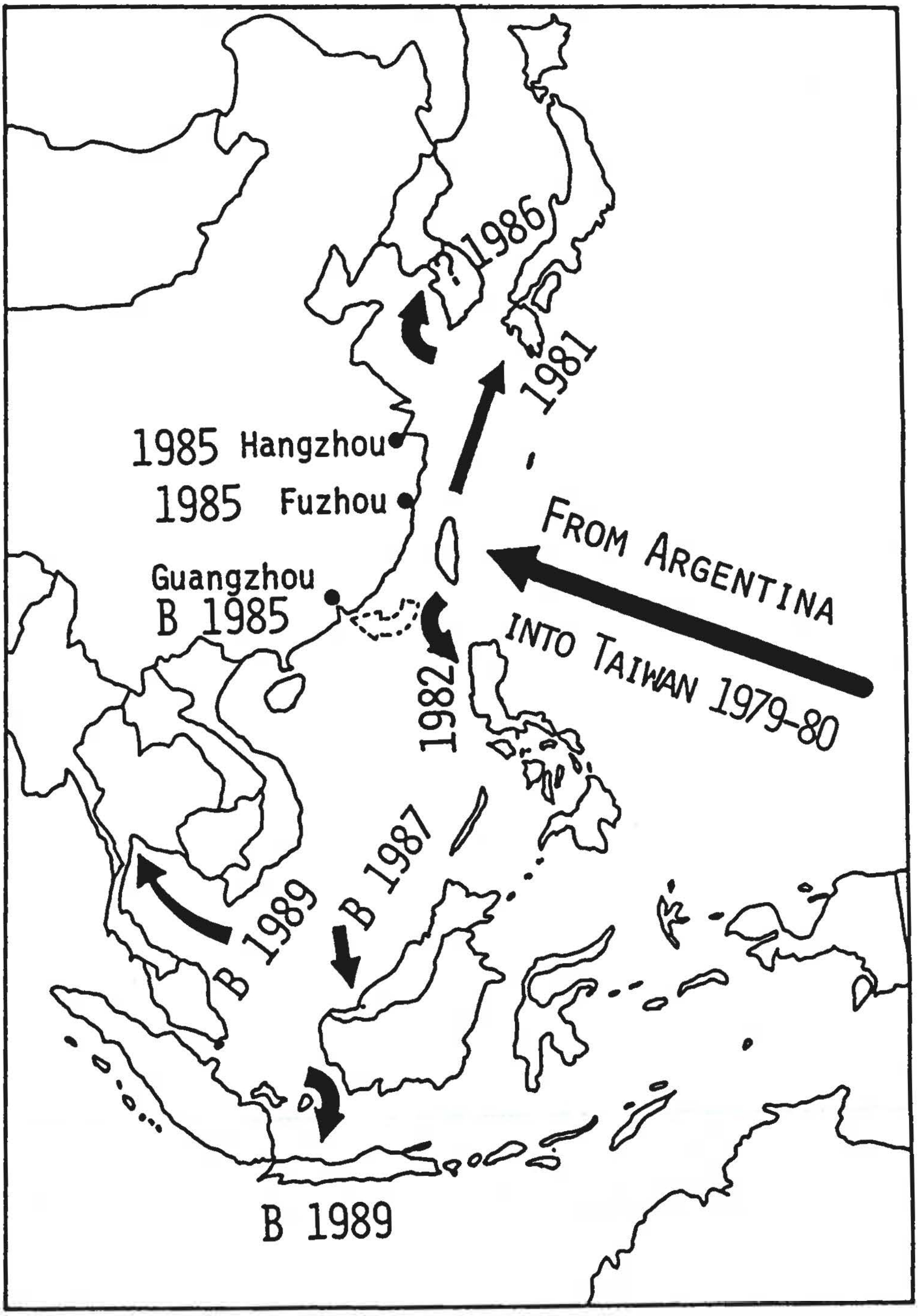


Figure 1. Spread of *Pomacea* snails in East Asia.

Table 1. Area infested by *Pomacea* snails, area treated with molluscides, and fingerlings released for controlling the snails in Taiwan, China (MAF, Taiwan, 1985b, 1986).

	Year				
	1982	1983	1984	1985	1986
Area Infested (ha)					
Rice fields	13,000	40,574	72,780	147,311	151,444
Others	4,000	11,071	16,500	19,382	19,980
(Total)	(17,000)	(51,645)	(89,280)	(166,693)	(171,425)
Area Treated with Molluscides (ha)					
Rice fields	—	32,000	15,000	35,560	90,000
Others	—	14,000	5,000	12,135	13,350
(Total)		(46,000)	(20,000)	(47,695)	(103,350)
Estimated Loss in Rice Fields					
US $ (× million)	2.7	8.3	14.9	30.1	30.9
No. Fingerlings Released					
Black Carp*	—	—	85,000	—	592,000
Common Carp**	—	—	500,000	—	650,000

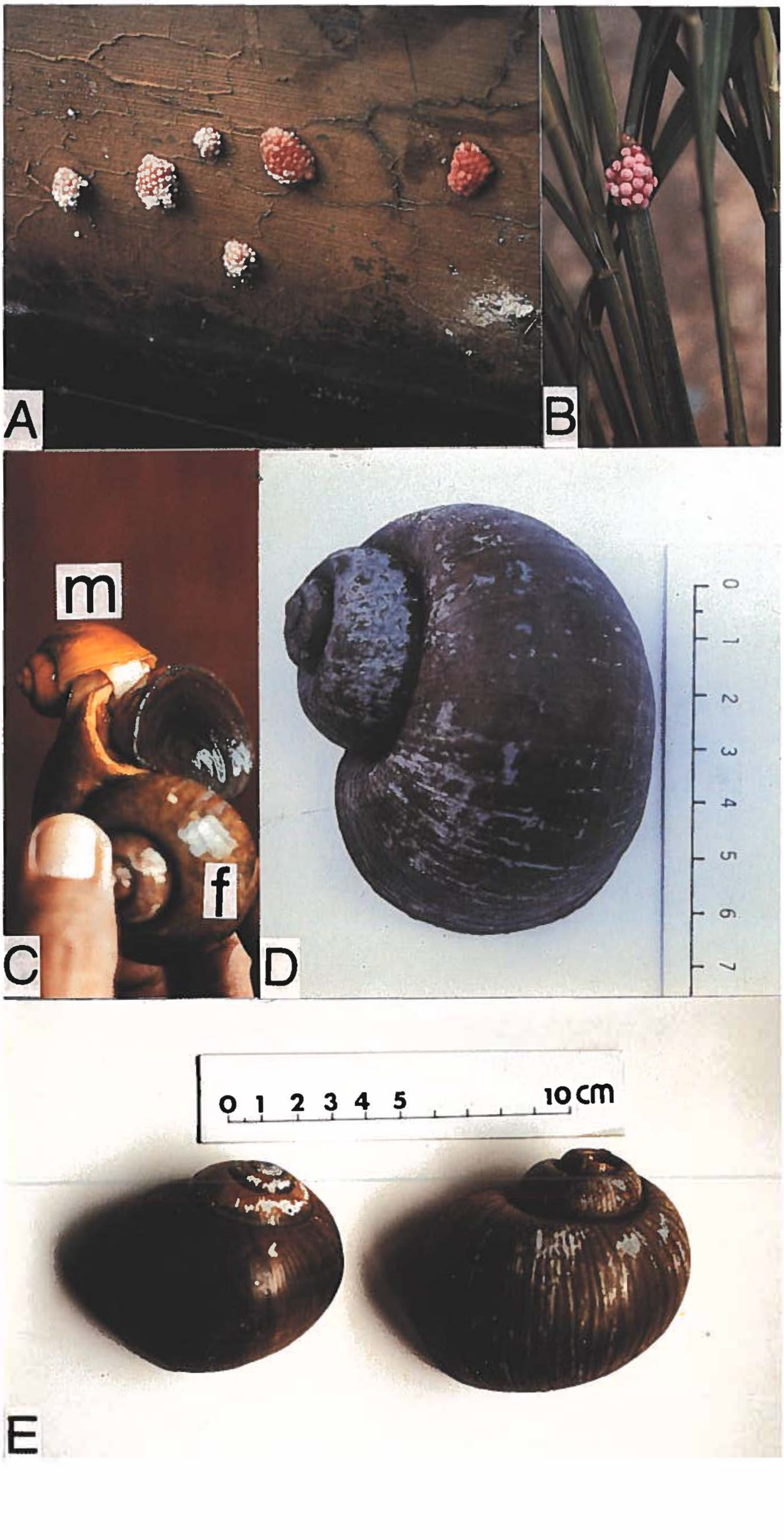
**Mylopharyngodon piceus.*
***Cyperinus carpio.*

Since 1981 the snails were introduced for aquaculture from Taiwan into some locations like Nagasaki (Kyuusyuu), and Wakayama (Honsyuu) in Japan. Eventually snails escaped from the culture ponds into open fields, streams, ponds, and rice fields. In 1986 the Federal government spent 9 million yen (US $64,385) to control them in 176 ha of rice fields. As of the end of 1989 the snails have been observed in 35 out of 47 prefectures (Fig. 2). The areas of different crops attacked by the snails are given in Table 2.

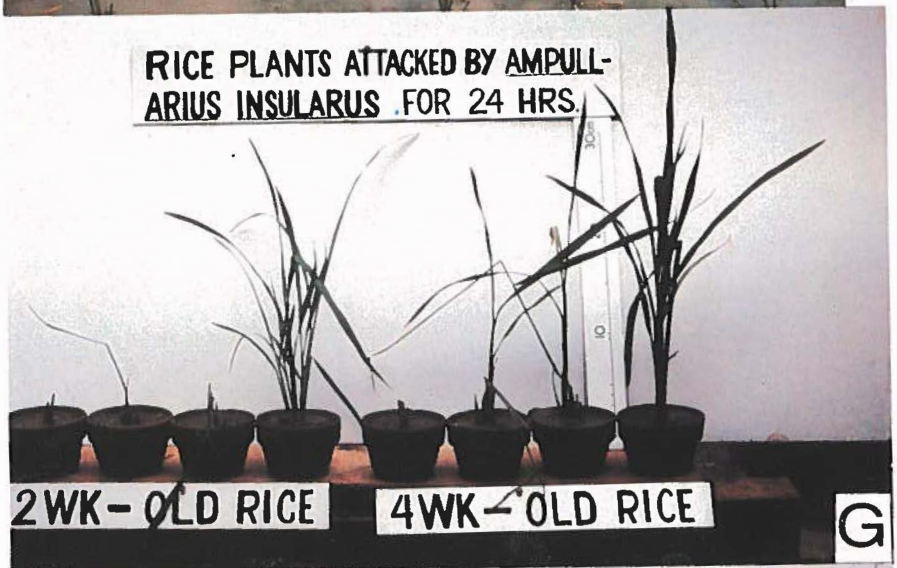
In the Philippines, the infestation of rice fields by the snails was estimated 13,945 ha in February 1988 (Rejesus et al. 1989) and about 400,000 ha in 1989 (FAO 1989). Further FAO (1989) also estimated 1 to 40% yield loss of rice due to this snail.

P. canaliculata was confirmed as an intermediate host of the rat lungworm, *Angiostrongylus cantonensis* Chen (Namatoda, Metastrongylidae), causing the disease eosinophilic meningoencephalitis in humans in Taiwan (Chen 1985) and in Japan (Nishimura et al. 1986, Nishimura & Sato 1986).

Plates I, II. *Pomacea* snails and damage to rice plants in the Philippines. A, Egg masses on a concrete wall of water path. B, An egg-mass on rice plants. C, Copulation, f = female; m = male. D, A big female. E, 2 snails. F, Rice field attacked by *Pomacea* snails. G, Potted 2- and 4-wk old rice seedlings damaged under experimental condition by *Pomacea*. H, Transplanted 2- and 4-wk old rice seedlings damaged under experimental condition by *Pomacea*.


A
B
m
f
C
0 1 2 3 4 5 6 7
D
0 1 2 3 4 5 10cm
E


F


RICE PLANTS ATTACKED BY AMPULL-
ARIUS INSULARUS FOR 24 HRS.
2WK-OLD RICE
4WK-OLD RICE
G

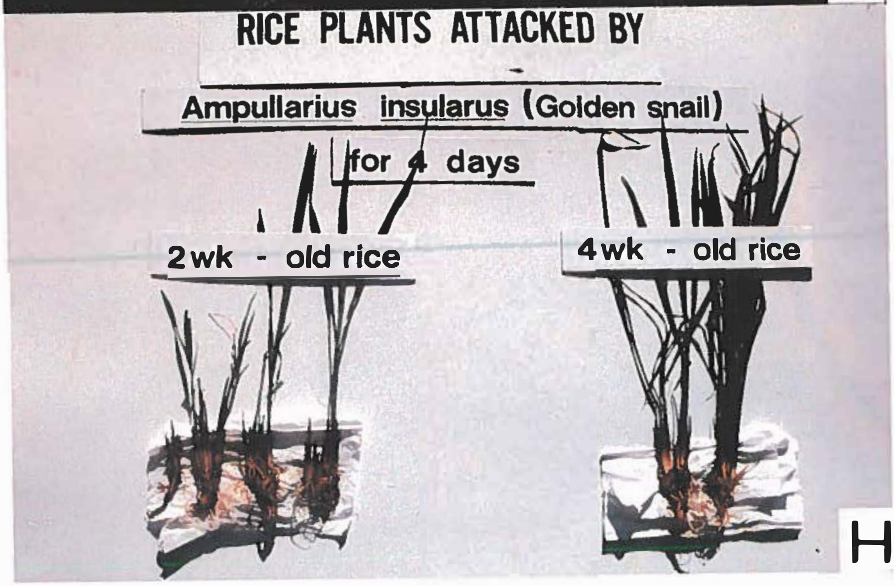

RICE PLANTS ATTACKED BY
Ampullarius insularus (Golden snail)
for 4 days
2wk - old rice
4wk - old rice
H

Table 2. Occurrence and crops attacked by *Pomacea* snails in Japan (ha).

	Rice	Lotus	Taro	Matrush	Wild Rice	Jpn Parsley	Others	Occurrence
1985	51	0	1	1	0	0	0	3,774
1986	172	3	*	0	0	0	0	6,168
1987	9,786	68	7	5	*	0	30	9,896
1988	10,212	56	10	5	*	0	*	10,283
1989	16,122	59	10	4	*	*	0	16,195

*Damaged but less than one ha.

Biology

Observations on the biology of the snails and crop damage by them were reported in Taiwan by K. M. Chang (1985), W. C. Chang (1985), MAF (1985a b, 1986); in Japan by Nishiuchi (1984), Hamada & Matsumoto (1985), Hirai et al. (1986), Kaneshima et al. (1986), Miyahara et al. (1986a, b), Ōya et al. (1986); and in the Philippines by IRRI (1987), Mochida (1987), Saxena et al. (1987), Adalla & Morallo-Rejesus (1989). Guidelines for culture of *Pomacea* spp. in the Philippines were given by Manacop (1986), whereas general information on the snail and crop damage were shown by Miyahara (1987) and Mochida (1988a, b).

Eggs hatch in about 3 weeks after oviposition depending on temperature. Young snails fall into water from the egg clusters deposited above the water surface. Hatchability is 7–90%. Snails reach maturity in 2 months and are about 3 cm in height. Copulation (Plate IC) takes place in water and females oviposit an average of 321 eggs/eggmass on plants, concrete walls or stones above the water surface at night (Plate I A, B). A female deposits an average of 4,375 (range 2,410–8,680) eggs per year. The snails are estimated to survive for 2–3 years in Japan (Miyahara et al. 1986a) and 3–5 years in Taiwan (K. M. Chang 1985). Mortality is high at water temperatures above 32°C. The snails can survive for 15–20 days at 0°C, 2 days at −3°C, but only 6 hours at −6°C. In Okinawa, Japan, it has been confirmed that the snails can survive 234 days without water.

Snails less than 1.3 cm in height are not capable of damaging rice seedlings, whereas those more than 1.5 cm can feed on seedlings in water. At water depths less than 1 cm, rice seedlings are hardly damaged (Miyahara 1987). It was confirmed at IRRI that two-week-old TN1 rice seedlings were eaten out by 20 snails of 3.8–4.3 cm in height whereas four week old plants were less damaged, and six week old plants were hardly damaged at all (Plate II G, H).

Current Control Methods and Further Directions

The aquaculture of *Pomacea* for commercial food purposes eventually resulted in snails escaping into the surrounding environment and establishing in rice and other crop fields, ponds and streams. At present, large scale control of *Pomacea* is too expensive although their temporary eradication from small fields

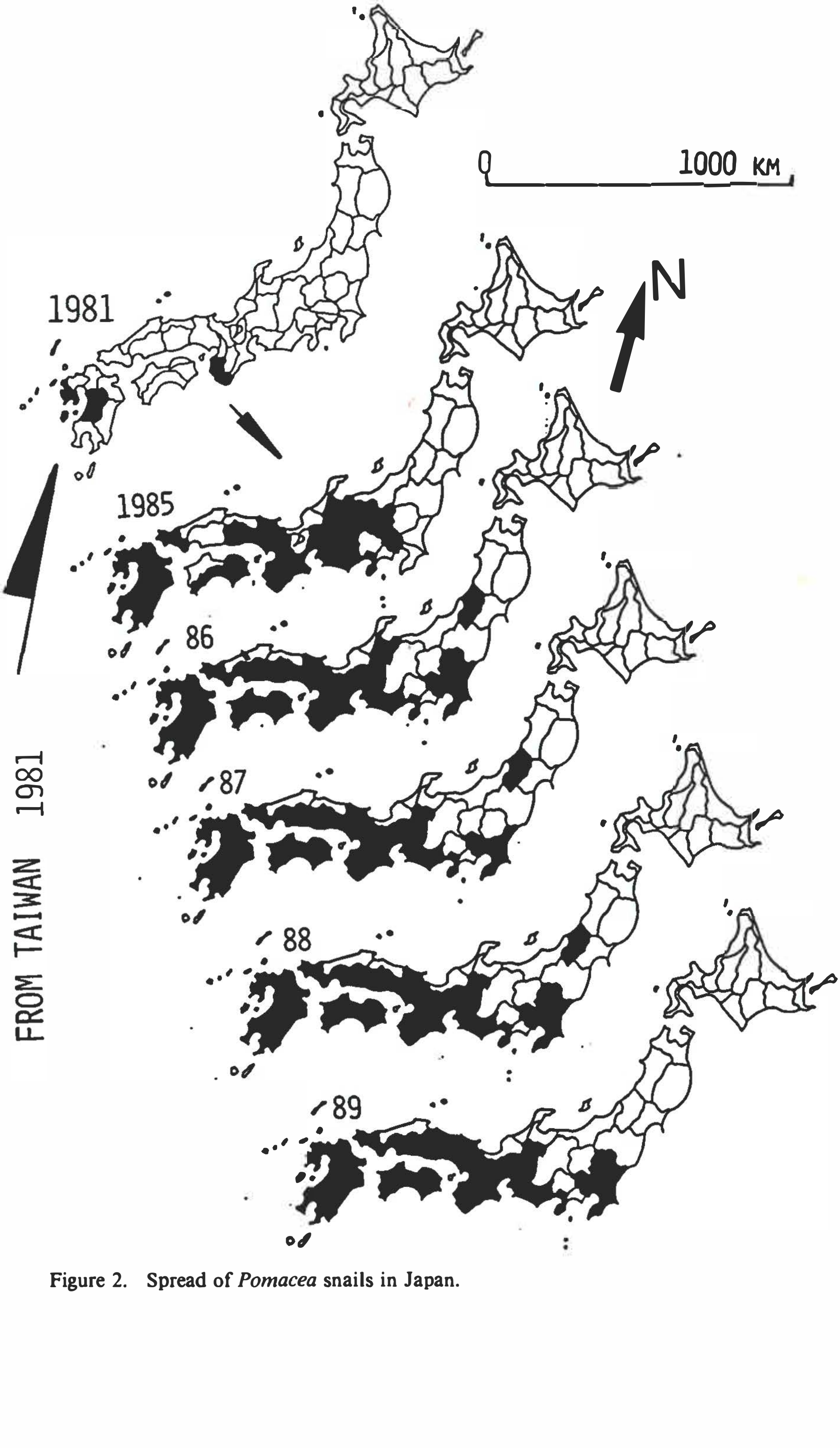


Figure 2. Spread of *Pomacea* snails in Japan.

of rice, lotus, swamp cabbage and fish ponds may be achieved with chemicals. However, specimens get reintroduced from adjacent areas in irrigation waters the following season. In Japan and Taiwan many trials were conducted involving hand picking, chemicals, and sand pumps without much success. Plant quarantine regulation seems to be the best method to prevent introduction of *Pomacea* snails into rice growing countries.

The methods recommended in Taiwan are:

1. Pick up and crush egg masses and snails. If possible use them as feed for ducks, chickens, and fish.
2. Burn the straw after harvest in the rice fields where snails are a serious problem.
3. Place 5-mm mesh metal screens at the irrigation water inlets of rice and other fields with aquatic plants.
4. Application of Molluscicides:
   a. in rice fields:
      i) triphenyl-tin acetate 45% WP at 0.6 kg/ha at water temperatures higher than 20°C and at 1.2 kg/ha at lower temperatures; do not drain water for 3 days and keep water at 1 to 3-cm depth for 7 days; do not use this chemical close to fish ponds and streams; protect skin from the chemical to avoid rubefaction.
      ii) metaldehyde 80% WP at 1.2 kg/ha at water temperatures higher than 20°C.
   b. in waterways, streams, and ponds:
      i) metaldehyde 80% WP at 2.4 kg/ha.
5. Release fingerlings of black carp *M. piceus* and common carp *C. carpio* in ponds, rivers, and streams.
6. Place 2 kinds of metal screens (6-10 and 16-32 mm mesh) at each water inlet and outlet of *Pomacea* infested fish ponds, aquatic field crops like swamp cabbage and taro.

In Japan, triphenyl-tin acetate/chloride/hydroxide, niclosamide (Bayluscide®), and other chemicals with high fish toxicity are prohibited for use in rice fields. Of the 32 chemicals tested in 1986 (MAFF, 1987), as of June 30, 1990, only ethylthiometone + thiocyclam (Ekamat® 5G), cartap (Padan® G), bensultap (Ruban® 4G), and IBP (Kitazin P ® 17G) were registered as repellants. IBP G was toxic. Calcium cyanamide is registered as a fertilizer with toxicity. Even though application of 200–400 kg/ha is recommended 3 days after the first plowing, calcium cyanamide 200 kg/ha is preferred in practice as 400 kg/ha provides too much N. A metal screen (5 mm mesh) should be placed over water inlets to prevent snail introduction. Picking snails by hand during land preparation and 5–7 days after mechanical transplanting, and destroying pink eggmasses are also recommended. The mortality in winter was 81% in fields plowed by rototiller from January to February and 57% in fields unplowed in Miyazaki prefecture (MAFF 1987). Metaldehyde 6% is effective when broadcasted at 40–50 kg/ha (= 2.4 − 3.0 kg ai/ha) or baited at 10 kg (=0.6 kg ai/ha) by mixing at 2:2:1 by weight with Irish potato and wheatflour. Keeping 1 cm water in the field is effective in protecting rice seedlings from snail damage but this method has problems in practice under monsoon conditions in Asia.

Table 3. LC50/95 values (ppm, ai) of 4 chemicals for golden snail (*P. canaliculata*) and nile telapia (*Oreochromis niloticus*), IRRI, 1986–1987 (Mochida, unpublished).

		Snail								Telapia[1]			
		Male[2] LC50		Female[3] LC50		Male LC95		Female LC95		LC50			
Chemical		48	72	48	72	48	72	48	72	24	48	72	96 hrs
Lab[4]													
ethoprop	10% G	—	—	17.9	15.2	—	—	75.8	43.8	—	—	—	—
metaldehyde	6% G	0.5	0.4	0.3	0.4	0.6	0.5	1.3	0.9	1.2–1.5	0.6–0.8	0.6–0.8	0.6–0.8
niclosamide	70% WP	0.6	0.3	0.3	0.2	1.0	0.6	0.6	0.6>	0.8	0.7	0.5	0.4
triphenyl-tin acetate	60% WP	0.1	0.1>	0.1	0.1>	0.2	0.2>	0.5	0.5>	0.1>	0.06	0.007	0.002
Field[5]													
ethoprop	10% G	—	—	—	—	—	—	—	—	—	—	—	—
metaldehyde	6% G	—	—	0.8	0.8	—	—	1.8	1.5	>0.8	>0.8	>0.8	>0.8
niclosamide	70% WP	—	—	0.2	0.2	—	—	0.7	0.7>	0.4>	0.4>	0.4>	0.4>
triphenyl-tin acetate	60% WP	—	—	0.2	0.1	—	—	0.3	0.2	0.6	0.5	0.1	0.1

[1] Avg size was 5.2 cm in body length and 3.0 g in fresh weight. 10 fish × 3 repl.
[2] Avg size was 4.2 cm in altitude and 13.4 g in fresh weight. 20 snails × 3 repl.
[3] Avg size was 4.1 cm in altitude and 13.0 g in fresh weight. 20 snails × 3 repl.
[4] Tested in plastic container with clean water and air pump at 10 fish/10 lit and 20 snails/20 lit water.
[5] Tested in 1 m × 1 m iron-framed plots with 21-day-old TN1 seedlings with irrigated water of 5 cm depth.

Table 4. Chemicals sold for snail control in the Philippines (FAO, 1989)

Common Name	Brand Name	kg ai/ha	
TPTA*	Brestan C	0.2	Immediately after transp. or seeding or needed
TPTC*	Aquatin	0.2	
TPTH*	Telustan	0.18	
niclosamide	Bayluscide	0.2	
endosulfan	Thiodan	0.75	
	Endox		
	Endosulfan		

*Banned in Jan. 1990.

Table 5. Laboratory test of pyridaphenthion (Ofunack®) for *Pomacea* snail control in clean water (Mitsui Toatsu Co., unpublished)

Formul. (%, g)	Dosage (kg/ha)	No. snails tested	Mortality 7 DT (%)
0.5	30	15	0.0
1.0	30	15	26.7
2.0	30	15	100
4.0	30	15	100
6.0	30	15	100
control or untreated	—	—	0.0

Table 6. Fish toxicity of LC50 (ppm, 48 hrs) of 6 chemicals with killing effect on *Pomacea canaliculata.*

	Common carp *C. carpio*	Killifish *Oryzias latipes* (Temminch et Schlegel)	Goldfish *Carassius auratus* (Linné)
pyridaphenthion (Ofunack)	12.0	10.0	10.0
endosulfan (Thiodan, etc.)	0.0072		
niclosamide* (Bayluscide)	0.235		0.279
TPTA (fentin acetate) (Brestan)	0.064		
TPTC (fentin chloride) (Aquatin)	0.055	0.056	
TPTH (fentin hydroxide) (Telustan)	0.050		

*Formerly known as clonitralid.

In the Philippines 4 chemicals other than 32 tested in Japan were tested at IRRI in 1986 (IRRI 1987). LC50 (48 hrs) for females was 0.1, 0.3, and 0.3 ppm in the laboratory tests and 0.2, 0.2, and 0.8 ppm in the field tests for triphenyltin acetate (Brestan®), niclosamide (Bayluscide®), and metaldehyde (Namekill®), respectively. LC50 (24 hrs) for *nile* tilapia (*Saratherodon niloticus* (Linné)) was 0.1, 0.8, and 1.2–1.5 ppm in the laboratory tests and 0.6, 0.4, and 0.8 ppm in the field tests, respectively. Ethoprop (Mocap®) was not effective on snails (Table 3). Tetraphenyl-tin acetate/chloride/hydroxide, niclosamide, and endosulfan were the 5 chemicals sold for *Pomacea* snail control in the Philippines (Table 4). However, chemicals containing tin have been banned since 1990.

Pyridaphenthion (Ofunack®) showed promising results (Table 5). The toxicity of pyridaphenthion to fish was lower than the 5 other chemicals sold in the Philippines (Table 6).

Morallo-Rejesus et al. (1989) conducted cultural, environmental, chemical and biological (using ducks) control methods for the control of *Pomacea* snails in the Philippines, but did not find any definitively effective control method. Van Dinther (1973), Van Dinther & Stubbs (1963) reported that 2 kinds of snails, *Pomacea dolioides* (Reeve) and *P. glauca* (Linné), are pests of rice, especially in seedbeds and direct-sown fields in Surinam, South America. They mentioned that copper sulphate, BHC, niclasamide, sodium pentachlorophenate (Na-PCP), triphenyl-tin acetate, and N-trityl morpholine (Frescon®), were effective on the snails but all of them were not practically used for several reasons including their high toxicity to fish and other fauna. Na-PCP is recommended in rice fields where *Pomacea* snails are serious pests along the Sâo Francisco in Brazil (de Freidas-Machado 1953). Effective pesticides, either oil-based or botanical, or both with less toxicity to non-target organisms should be evaluated.

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