FRESHWATER MOLLUSKS AT DESIGNATED AREAS IN ELEVEN PROVINCES OF THAILAND ACCORDING TO THE WATER RESOURCE DEVELOPMENT PROJECTS

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Abstract. The study was conducted at 75 collecting loci in 15 districts of 11 provinces in Thailand during 1999-2004. A total of 12,079 live mollusks were collected, 11,874 were snails and 205 were clams. The snails were comprised of 39 species and classified into 9 families: Ampullariidae, Bithyniidae, Buccinidae, Potamiopsidae, Stenothyridae, Thiaridae, Viviparidae, Planorbidae and Lymnaeidae. The clams were comprised of 14 species classified into 2 families: Amblemidae and Corbiculidae. Fifteen species were medically important snails: *Pomacea canaliculata, Pila ampullacea*, *P. pesmei*, *P. polita*, *Bithynia* (*Digoniostoma*) *funiculata*, *B*. (*D*.) *siamensis goniomphalos*, *B*. (*D*.) *s. siamensis*, *Filopaludina* (*Siamopaludina*) *martensi martensi*, *F*. (*Filopaludina*) *sumatrensis polygramma*, *Melanoides tuberculata*, *Tarebia granifera*, *Helicorbis umbilicalis*, *Gyraulus convexiusculus*, *Indoplanorbis exustus* and *Radix rubiginosa*. Of these 3 snail species harbored trematode cercariae. *I. exustus* harbored *Echinostoma malayanum*, Xiphidio and *Schistosoma spindale*, and *R. rubiginosa* and *B*. (*D*.) *siamensis goniomphalos* harbored Xiphidio and intestinal flukes, respectively.

INTRODUCTION

Thailand has launched many water resource development projects in order to supply more water for agriculture, hydro-power production, and flood control. However, water development projects both small scale and large dams have not only benefited the population, they have also had adverse effects on human health. Hydropower and irrigation projects increase the risk of snail vector-borne disease in humans. These diseases are caused by two main types of parasitic helminths: (1) flukes, such as schistosomiasis, opisthorchiasis, paragonimiasis; and (2) roundworms, such as *Angiostrongylus cantonensis*. These helminths usually have specific hosts and intermediate hosts. For example, *Neotricula* spp and *Tricula* sp serve as snail intermediate host for *Schistosoma mekongi*, *Bithynia* spp serve as snail intermediate host for *Opisthorchis viverrini* and *Pila* spp serve as snail intermediate host for *Angiostrongylus cantonensis* (Burch and Lohachit, 1983).

Construction of irrigation systems creates changes in the ecology of the environment that causes alternations in the distribution of water-borne diseases. The construction of Lake Volta Dam in West Africa resulted in an increase in schistosomiasis. In Thailand after the construction of the Ubolratana (Nam Pong) Dam in the Northeast, opisthorchiasis out-

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breaks increased (Seddon, 2000).

Since Brandt (1974) did large scale surveys in all the provinces of Thailand there have only been specific mollusk investigations undertaken (Temcharoen *et al*, 1987; Temcharoen, 1992a,b). These surveys did not cover the areas of this study. This study conducted the vector surveys to provide baseline information on freshwater mollusks of medical importance in designated areas of irrigation projects in 15 districts of 11 provinces: 1 province in eastern Thailand, 2 provinces in central Thailand, 2 provinces in northern Thailand, and 6 provinces in northeastern Thailand.

MATERIALS AND METHODS

Study area

The study areas were 15 districts in 11 provinces, where irrigation system projects were to be undertaken (Fig 1). These areas had been previously studied in many aspects, such as engineering, environment, geology, agriculture, and suitability for the irrigation projects. In each district, 4-18 loci were sampled based on areas of public health impact around the areas of the projects. These collecting loci were comprised of purposed boundaries of reservoirs and resettlement areas. Number of loci depended on the areas the project covered. The studies were made during 1999-2004; each station area had one visit (Fig 1).

Mollusk collection

The mollusks were collected using 15-mimute search sampling at each study site by five persons. Each person took 30 minutes (2 search samplings) for collecting mollusks which were collected by hand and/or using a standard wire-mesh scoop, and placed in separate labeled plastic bags. All likely habitats, including rice fields, shorelines of rivers, canals, and ponds, emergent and submerged vegetation, logs and stone crevices, were examined and the snails collected.

All mollusks were brought to the laboratory in Bangkok, identified for species using morphological characteristics with the aid of the identification keys of Upatham *et al* (1983) and Brandt (1974) and compared with the snail collection in the Mollusk Museum of the Faculty of Tropical Medicine, Mahidol University. Only the doubtful specimens were checked anatomically. The voucher specimens were also deposited in this museum. Medically important snails were examined for natural trematode infection by shedding method as described by Sri-aroon *et al* (2005).

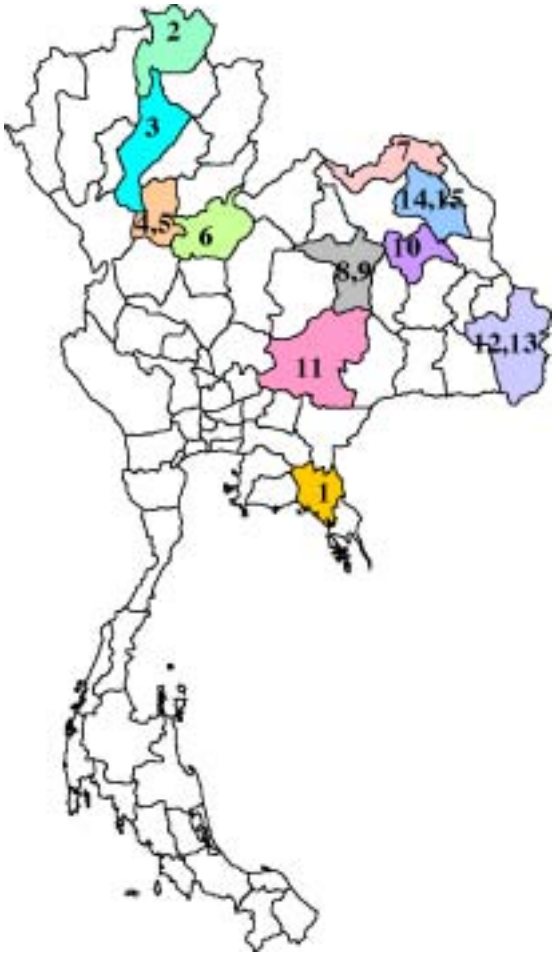
RESULTS

A total of 75 collecting loci in 15 stations (districts) of 11 provinces were visited during 1999-2004 (Fig 1). Each station had one visit for mollusk investigations. The study areas were rice fields, mountain creeks, irrigation canals, river banks, and ponds. The surveys caught a total of 12,079 live mollusks, of which 11,874 were snails belonging to 9 families 39 species (Table 1), and 205 were clams in 2 families and 14 species (Table 2).

Of the snails collected, only 15 species were medically important snails (Tables 1 and 4), and only 3 species, *Indoplanorbis exustus*, *Bithynia goniomphalos* and *Radix rubiginosa,* were found with cercariae of trematodes. *I. exustus* hosted several types of cercariae: *Echinostoma malayanum*, found at station 2 in Chiang Rai and station 11 in Nakhon Ratchasima Province; and *Schistosoma spindale,* found at station 15 in Sakon Nakhon Province. *B. goniomphalos* and *R. rubiginosa* shed one type of cercariae, Xiphidio, and an intestinal fluke, respectively (Fig 1 and Table 3).

The snail intermediate host of *Schistosoma mekongi*, *Neotricula aperta* and the other related species, *Neotricula burchi* and *Tricula bollingi*, were not found.

Some snail species which had limited



Station 1 Kaeng Hang Maeo District, Chanthaburi Province. Dec, 1999.
Station 2 Wiang Pa Pao District, Chiang Rai Province. Nov, 2000
Station 3 Ngao District, Lumpang Province. Oct, 2000.
Station 4 Ban Dan Lan Hoi District, Sukhothai Province. Oct, 2000.
Station 5 Si Satchanalai District, Sukhothai Province. Oct, 2000.
Station 6 Nakhon Thai District, Phitsanulok Province. Sept, 2003.
Station 7 Mueang District, Nong Khai Province. Jul, 2001
Station 8 Ubon Ratana District, Khon Khean Province. Jul, 2001
Station 9 Chonnabot District, Khon Khean Province. Jul, 2001
Station 10 Kamalasai District, Kalasin Province. Jul, 2001
Station 11 Non Sung District, Nakhon Ratchasima Province. Jul, 2001
Station 12 Warin Chamrap District, Ubon Ratchathani Province. Sept, 2001
Station 13 Khong Chiam District, Ubon Ratchathani Province. Sept, 2001
Station 14 Nikhom Nam Un District, Sakon Nakhon Province. Oct, 2001
Station 15 Nong Han District, Sakon Nakhon Province. Jan, 2004

Fig 1–Map of Thailand showing 15 mollusk collecting stations, months and years collections made.

geographical localities were also found, such as *Cipangopaludina annandalei* (Family Viviparidae) and *Brotia binodosa binodosa* and *B. binodosa spiralis* (Family Thiaridae) (Table 1).

DISCUSSION

Mollusks have habitat requirements. Some mollusks can be found in all sizes of water bodies and in all types of water conditions, some mollusks are special species requiring permanent water with specialized microhabitats and/or specific conditions, while some species are spring specialists fed by underground aquifers (Seddon, 2000). Our surveys showed that some mollusks had been found in all areas, while some mollusks had limited geographical localities.

The present surveys recovered 39 species of snails and 14 species of clams. The most common snail species found in nearly all the stations visited were *P. canaliculata*, *F.* (*S.*) *martensi* and *I. exustus* (Table 1). These 3 species were all medically important snails. Moreover, *P. canaliculata* is also an important pest in the rice field. This species is not a native species, it was imported from South America in 1988 (Chanyapeth and Achawakhom, 1998), and is now widely distributed in almost all the provinces of Thailand.

Table 1
Number of snail species found in 15 districts of 11 provinces during 1999-2004.

Family/species	Station number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Family Ampullariidae															
**Pila ampullacea* (Linnaeus)	0	0	0	0	6	5	0	0	0	0	0	0	0	0	2
**P. pesmei* (Morlet)	38	10	3	0	9	1	11	0	2	0	10	0	0	0	5
**P. polita* (Deshayes)	2	0	0	0	0	0	9	0	4	6	0	2	9	0	1
**Pomacea canaliculata* Lamarck	0	24	13	1	39	1	35	51	0	18	0	1	0	102	602
Family Bithyniidae															
**Bithynia(D.) funiculata* Walker	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0
**B. (D.) s. goniomphalos* Morelet	0	0	0	0	0	0	63	1,921	223	1,380	319	7	0	953	1,468
**B. (D.) s. siamensis* Lea	0	0	0	48	40	121	0	0	0	0	0	0	0	0	0
B. (Gabbia) wykoffi Brandt	0	0	0	47	106	82	2	20	0	0	0	0	0	0	0
Wattebledia crosseana (Wattebled)	0	0	0	0	0	0	260	0	14	0	3	0	0	84	0
W. siamensis Moellendorff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Hydrobiodes nassa (Theobald)	0	4	175	0	0	0	0	0	0	0	0	0	0	0	0
Family Buccinidae															
Clea helana (Philippi)	136	0	0	0	60	0	0	1	38	3	10	19	2	0	0
Family Potamiopsidae															
Pachydrobia zichi Brandt	0	0	0	0	0	0	0	0	0	6	0	2	0	0	0
Family Stenothyridae															
Stenothyra sp	0	0	0	0	0	0	0	0	0	0	17	0	59	0	0
Family Viviparidae															
**F.* (*Siamopaludina*) *m. martensi* (Frauenfeld)	131	39	18	56	46	14	47	37	7	27	27	5	0	267	82
F. (*S.*) *m. cambodiensis* (Mabille & Mesle)	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. (Filopaludina) filosa (Reeve)	0	0	0	43	35	0	0	0	0	0	0	0	0	0	0
**F.*(*F.*) *s. polygramma* (Martens)	2	0	0	0	2	10	123	16	0	0	0	0	0	1	0
F.(*F.*) *s. speciosa* (Deshayes)	108	0	0	0	0	2	0	0	77	0	0	2	0	1	5
Cipangopaludina annandalei Brandt	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0
Idiopoma dissimilis (O. F. Muller)	0	51	67	0	0	0	0	0	0	0	0	0	9	0	0
I. umbilicata (Lea)	0	35	0	0	0	2	8	1	0	0	0	0	4	0	16
I. ingallsiana (Lea)	0	12	0	0	0	0	5	0	0	0	0	0	0	0	0
Anulotaia forcarti Brandt	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Trochaotaia trochoides (Martens)	0	0	0	1	6	0	0	9	0	0	0	0	0	14	0
Mekongia sphaericula (Deshayes)	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Family Thiaridae															
Brotia citrina (Brot)	2	0	91	0	0	0	0	0	0	0	0	0	0	0	0
B. costula costula (Rafinesque)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B. binodosa binodosa (Blanford)	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
B. bindosa spiralis Brandt	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0
**Melanoides tuberculata* O.F. Muller	3	5	17	184	0	15	11	2	1	0	5	0	0	0	0

Table 1 (Continued).

Family/species	Station number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
**Tarebia granifera* (Lamarck)	0	0	75	109	0	11	0	0	0	0	0	0	0	0	0
Thiara scabra (O.F. Muller)	0	2	1	0	0	19	0	0	0	0	0	0	0	0	0
Adamietta housei (Lea)	0	0	0	0	0	0	0	0	0	12	0	16	0	0	0
Family Planorbidae															
**Indoplanorbis exustus* (Deshayes)	45	105	19	7	96	1	62	3	0	0	2	0	0	407	28
**Helicorbis umbilicalis* (Benson)	0	0	0	0	5	0	0	0	2	0	0	0	0	0	0
**Gyraulus convexiusculus* (Hutton)	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Camptoceras sp	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0
Family Lymnaeidae															
**Radix rubiginosa* (Michelin)	0	0	47	0	4	0	2	0	3	1	44	0	2	6	0
Total	569	320	526	496	454	316	651	2,061	371	1,453	442	61	85	1,835	2,234
Grand Total	11,874														

* Medically important snail

Table 2
Number of clam species found in 15 districts of 11 provinces during 1999- 2004.

Family/species	Station number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bivalvia															
Family Amblemidae															
Pseudodon inoscularis harmandi Crosse and Fischer	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudodon inoscularis callifer (Martens)	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Pseudodon sp	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Pilsbryoconcha exilis exilis Lea	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0
Pilsbryoconcha sp	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0
Physunio cambodiensis Lea	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Physunio eximius (Lea)	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Physunio sp	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Hyriopsis bialatus Simpson	0	0	0	0	0	0	0	10	0	0	5	0	0	0	0
Ensidens sp	0	0	0	0	0	0	0	6	0	1	0	0	0	0	0
Scabies sp	0	0	0	0	0	0	0	59	0	4	7	0	0	0	0
Chamberlainia sp	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Uniandra sp	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Family Corbiculidae															
Corbicula sp	1	24	0	0	2	0	0	7	11	20	1	2	0	0	0
Total	18	25	6	3	9	0	0	86	13	28	14	2	1	0	0
Grand Total	205														

Table 3
Snail hosts and type of cercariae at station areas.

Snail hosts	Type of cercariae			
	Echinostoma malayanum	Xiphidio	Intestinal fluke	*Schistosoma spindale*
Indoplanorbis exustus	+ [a]	+ [a]	-	+ [c]
Radix rubiginosa	+ [b]	-	-	-
Bithynia s. goniomphalos	-	-	+ [c]	-

a = Station area at Wiang Pa Pao District, Chiang Rai Province.
b = Station area at Non Sung District, Nakhon Ratchasima Province.
c = Station area at Nong Han District, Sakon Nakhon Province

Table 4
Medically important mollusks potentially transmitting disease.

Species	Potential disease
1. *Pomacea canaliculata*	Angiostrongyliasis
2. *Pila ampullacea*	Angiostrongyliasis
3. *P. pesmei*	Angiostrongyliasis
4. *P. polita*	Angiostrongyliasis
5. *F.*(*Siamopaludina*) *m. martensi*	Angiostrongyliasis
	Echinostomiasis
6. *F.*(*Filopaludina*) s. *polygramma*	Angiostrongyliasis
	Echinostomiasis
7. *Bithynia funiculata*	Opisthorchiasis
	Echinostomiasis
8. *Bithynia goniomphalos*	Opisthorchiasis
	Echinostomiasis
9. *Bithynia siamensis*	Opisthorchiasis
	Echinostomiasis
10. *Melanoides tuberculata*	Paragonimiasis
	Echinostomiasis
11. *Tarebia granifera*	Paragonimiasis
12. *Indoplanorbis exustus*	Echinostomiasis
	Cercarial dermatitis
13. *Radix rubiginosa*	Echinostomiasis
	Cercarial dermatitis
14. *Helicorbis umbilicalis*	Echinostomiasis
15. *Gyraulus convexiusculus*	Echinostomiasis

Of the 39 snails species recovered, they were located in various geographic areas in Thailand. Some species, such as *Brotia* (*Brotia*) *binodosa binodosa* and *B.* (*B.*) *b. spiralis* (Family Thiaridae) (Table 1) were found in only specific locations, being found in only the Kaek River and the Kwai Noi River in Nakhon Thai District in Phitsanulok Province (Brandt, 1974).

Brandt (1974) reported that *Cipango-*

paludina annandalei (Family Viviparidae) was found in only the Mae Khok River near Chiang Rai Province and the On River at Ban Pong near Ngao District, Lampang Province. During the present survey this species was recovered at Station 2, Mae Chedi River, Mae Chedi subdistrict, Wiang Pa Pao District, Chiang Rai Province (Table 1).

Bithynia (*D.*) *funiculata* (Family Bithyniidae) was found only in the northern province (Brandt, 1974). The present survey also recovered *B.* (*D.*) *funiculata* at station 2 in Chiang Rai Province, northern Thailand. For the other 2 species, *B.* (*D.*) *s. goniomphalos* and B. (*D.*) *s. siamensis*, the first species was found in northeast Thailand, while the second species was widely distributed in central, northern and southern Thailand.

Though the surveys found all 3 species of *Bithynia* spp (Table 1) that are snail intermediate hosts of *Opisthorchis viverrini* in Thailand, no cercariae of *O. viverrini* were found, only the cercariae of an undetermined intestinal fluke was found in *B.* (*D.*) *s. goniomphalos* at station 15 in Sakon Nakhon Province (Table 3).

The snail intermediate host for *Schistosoma mekongi*, *Neotricula aperta*, has been reported in the Mun and the Mekong River in Ubon Ratchathani Province (Brandt, 1974). Our surveys in the Mun and the Mekong River at stations 12 and 13, Warin Chamrap and Khong Chiam District, Ubon Ratchathani Province, respectively (Fig 1), did not find *N. aperta.* The surveys were made in September 2001, while the waters' level of the Mun and the Mekong River were high. According to Upatham (1980), Attwood (1996) and Marrat *et al* (1996), this snail species can be found during dry season, March through May. *N. aperta* is not found during high water periods (June-February). Upatham (1980) explained that the rising water may kill snails which could not move vertically in order to stay in their preferred niche. On the other hand, their studies in the laboratory showed annual snail egg laying and die-off may be associated phenomena.

N. burchi has been found at Ban Tham, near Chieng Dao Cave, Chiang Mai Province and in Dan Sai District, Loei Province. *T. bollingi* has been found in some areas of Fang District, Chiang Mai (Brandt, 1974). These 2 species were not reported elsewhere.

In conclusion, it is strongly recommended to assess the health status of the population in areas before water resource development projects are approved for construction. The impact of water-borne diseases is one aspect in decision making in the development of a water resource project.

ACKNOWLEDGEMENTS

We would like to thank the Department of Social and Environmental Medicine, Faculty of Tropical Medicine for providing facilities for these surveys.

REFERENCES

Attwood S. Change in *Neotricula* β- *aperta* population density following construction of the Pak Mun Dam in northeast Thailand, with implications for the transmission of schistosomiasis. Special report. *Southeast Asian J Trop Med Public Health* 1996; 27: 24-8.

Brandt RAM. The non marine aquatic Mollusca of Thailand. *Archive Mollusk* 1974; 105: 1-423.

Burch JB, Lohachit C. Snails of medical importance in Thailand. *Walkerana Trans POETS Soc* 1983; 1: 395-8.

Chanyapeth CH, Achawakhom T. Golden Apple snails. Proceedings of a seminar on the golden apple snail. Bangkok 1998: 3.1-3.15.

Maratt T, Kitikoon V, Jongsuksuntigul P. The study on surveillance and prevention of schistomiasis in the areas of Pakmoon Dam Project, Ubon-Ratchathani Province: Snail Intermediate Host. *Com Dis J* 1996; 22: 78-87.

Seddon M. Contributing paper: Molluscan biodiversity and the Impact of Large Dams.

Prepared for Thematic Review 11.1: Dams, ecosystem functions and environmental restoration. 2000: 42 pp. [Cited 2006 Nov 22]. Available from: URL: http://www.dams.org/kbase/thematic/tr21.htm

Sri-aroon P, Butraporn P, Limsomboon J, Kerdpuech Y, Kaewpoolsri M, Kiatsiri S. Freshwater mollusks of medical importance in Kalasin Province, northeast Thailand. *Southeast Asian J Trop Med Public Health* 2005; 36: 653-7.

Temcharoen P, Rojanapremsuk J, Viboolyavatana J . Malacological survey at Nam Khek River, Phitsanulok Province, north of Thailand. *J Parasit Trop Med Assoc Thai* 1987; 10: 39-42.

Temcharoen P. Malacological survey in the Bhumibol Reservoir, the first dam constructed in Thailand. *Southeast Asian J Trop Med Public Health* 1992a; 23: 103-10.

Temcharoen P. Malacological survey in the Sirikit Reservoir, the largest earthfilled dam in Thailand. *Southeast Asian J Trop Med Public Health* 1992b; 23: 332-5.

Upatham ES. Field studies on the bionomics of alpha and gamma races of *Tricula aperta* in the Mekong River at Khemmarat, Ubol Ratchathani Province, Thaiand. The Mekong Schistosome. *Malacol Rev* 1980; 2: 239-61.

Upatham ES, Sornmani S, Kitikoon V, Lohachit C, Bruch JB. Identification key foy fresh-brackish water snails of Thailand. *Malacol Rev* 1983; 16: 107-32.