

MALACOLOGICAL SURVEY IN PHANG-NGA PROVINCE, SOUTHERN THAILAND, PRE- AND POST-INDIAN OCEAN TSUNAMI

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Abstract. Three malacological surveys were conducted in the Takua Pa District of Phang-Nga Province, southern Thailand, before and after the Indian Ocean Tsunami disaster. Twenty-nine species of fresh- and brackish-water snails were found, in which 10 species of freshwater snails were present, including live *Pila polita*; 8 species were of medical importance. Two brackish-water snails, *Nerita articulata* and *Littorinopsis scabra*, were absent after the tsunami disaster, while brackish-water *Cerithidea cingulata* and *C. djadjariensis* harbored 9 types of trematode cercariae.

INTRODUCTION

Phang-Nga Province is located 788 km south of Bangkok and covers an area of 4,170 km². The area is bordered to the west by the Andaman Sea and the Indian Ocean. Phang-Nga used to be a land of tin mines, and numerous mangrove and evergreen forests. In the past decade, the mangrove forests have been reduced continuously by intensive shrimp farming and overexploitation. From 1961 to 1996, the mangrove forests in Phang-Nga decreased from 358,750 Rai to 190,265 Rai (Aksornkoae *et al*, 2004). As mangrove forests are the primary features of coastal ecosystems, mollusk fauna, other invertebrates, some vertebrates, or even macroorganisms, are found in mangrove ecosystems.

Studies of the brackish-water mollusks in mangrove forests and estuaries of Thailand are sparse. Since Brandt (1974) studied the mollusks of Thailand between April 1963 and February 1971, there have been scarcely any investigations of brackish-water mollusks in Thailand. The Applied Malacology Center, at the Department of Social and Environmental Medicine, Faculty of Tropical Medicine, Mahidol University, Thailand, and the Department of International Medical Zoology, Kagawa University, Japan conducted a study of brackish-water snails and their parasitic trematodes in mangrove forests, tidal flats, and estuaries in Thailand, in 2003-2005. The study aimed to fill the knowledge gap regarding the medical and veterinary

importance, and distribution, of brackish-water snails in Thailand.

On 26 December 2004, the Indian Ocean Tsunami hit 5 districts in Phang-Nga Province and another 5 provinces on the west coast of southern Thailand. Takua Pa District of Phang-Nga suffered the worst destruction. The giant waves killed over one thousand people and damaged the coastal ecosystem.

The main aim of this study was to identify and compare pre- and post-tsunami species and populations of fresh- and brackish-water snails in Takua Pa District, Phang-Nga Province, which was heavily impacted by the tsunami; the second aim was to determine natural trematode infections of host snails pre- and post-tsunami.

MATERIALS AND METHODS

Area of study

Three malacological surveys were conducted in Takua Pa District, Phang-Nga Province. The first was on 13 February 2004 (pre-tsunami), while the second and third were on 25 January, and 17-20 February 2005 (post-tsunami). The study sites covered 27 stations in tsunami- and non-tsunami-affected areas (Fig 1, Table 1), in which the first, second and third snail collections were done only at station No. 4. Station selections were based upon available water reservoirs, mangrove forests and estuaries along the coast of Takua Pa District.

Snail collection method

The snail collection methods were 15-minute search, and ¼ m² sampling of each station area. All likely habitats, including water plants, leaf-filled surface depressions, log-mud interfaces, log and stone

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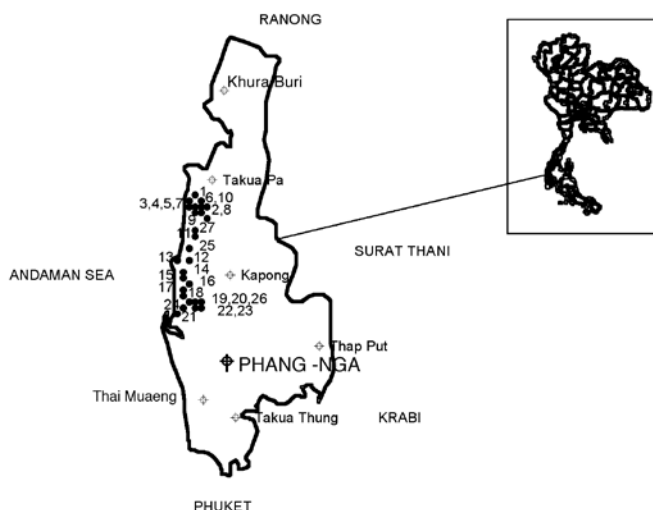


Fig 1- Location of 27 collection sites in Takua Pa District, Phang-Nga Province.

Table 1

Station and locality of malacological surveys in Takua Pa District, Phang-Nga Province, southern Thailand.

Station	Locality
^a 1	Ban Pruteaw Temporary Residence, Bang Mueang Subdistrict
^a 2	Ban Bang Mueang Temporary Residence, Bang Mueang Subdistrict
3	Soi Taksin, Ban Nam Khem, Bang Mueang Subdistrict
4	Soi Nakhon Sri Thammarat, Ban Nam Khem, Bang Mueang Subdistrict
5	Nam Khem Road, Moo 2, Ban Nam Khem, Bang Mueang Subdistrict
6	The estuary of Khlong Bang Muang, Ban Nam Khem, Bang Mueang Subdistrict
7	Soi Suphan, Ban Nam Khem, Bang Mueang Subdistrict
^a 8	Beside a health center in Ban Nam Khem, Bang Mueang Subdistrict
^a 9	Khlong Bang Mueang Bridge on Petchkasaem Road, Bang Mueang Subdistrict
^a 10	Petchkasaem Road km 79 Khlong Bang Lued Bridge, Bang Mueang Subdistrict
^a 11	Petchkasaem Road km 71 Khlong Pak Weep Bridge, Bang Mueang Subdistrict
12	Ban Bang Khaya, Soi Lam Pakarang, Khuek Khak Subdistrict
13	Similana Resort, Hat Lam Pakarang, Khuek Khak Subdistrict
14	Lam Pakarang Resort, Hat Lam Pakarang, Khuek Khak Subdistrict
15	The bridge near Hat Khuek Khak, Khuek Khak Subdistrict
16	Ore mine water wells beside the road, Ban Khuek Khak, Khuek Khak Subdistrict
17	Estuary near La Flora Resort, Ban Bang Niang, Khuek Khak Subdistrict
18	Bang Niang Emerald Arcade, Ban Bang Niang, Khuek Khak Subdistrict
19	Khlong Bang Niang Bridge near Bang Niang Temple, Ban Bang Niang, Khuek Khak Subdistrict
^a 20	Tonchongfa Waterfall, Ban Bang Niang, Khuek Khak Subdistrict
^a 21	Khao Lak-Lam Ru National Park, Khuek Khak Subdistrict
22	Khlong Bang Niang, 1 km from Bang Niang Temple, Moo 6, Khuek Khak Subdistrict
23	Ore mine water wells at Ban Bang Niang School, Moo 6, Khuek Khak Subdistrict
24	Ore mine water wells beside Petchkasaem Road km 61, Ban Bang Niang, Khuek Khak Subdistrict
25	Ore mine water wells near the permanent house building, Ban Bang Khaya, Khuek Khak Subdistrict
26	Ore mine water wells beside Petchkasaem Road, opposite Bang Niang Temple, Khuek Khak Subdistrict
27	Hat Bang Sak, Bang Mueang Subdistrict

^a = non-tsunami-affected areas

crevices, soil, sand or mud around roots and on leaves, stones and trunks of mangrove trees, were examined and snails collected.

At each station, 6 experienced persons searched for and collected snails by hand and/or standard wire-mesh scoops, and placed each sample in an individual labeled plastic bag. All snails collected were packed in iceboxes for transport to Bangkok, as described by Sri-aroon *et al* (2004).

Snail identification

Snails were identified for family, genus and species with the aid of the identification keys of Upatham *et al* (1983), Brandt (1974) and Van Benthem Jutting (1956), and compared with the snail collection in the Mollusk Museum, Faculty of Tropical Medicine,

Mahidol University. The voucher specimens were also deposited in this museum.

Snail examination for parasite

The snails collected were examined for natural trematode infections. Two methods were used to detect cercariae in snail samples, the natural emerging or shedding method, and the crushing method (Ito, 1980). Trematode cercariae recovered were measured and their morphology recorded for identification.

RESULTS

Sixteen species of live brackish-water snails were recovered at 9 of 27 stations. These species belonged to 7 families - Neritidae, Littorinidae, Stenothyridae,

Table 2

Brackish-water snails of Takua Pa District, Phang-Nga Province, southern Thailand, 17-20 February 2005.

Family/ Species	Station number								
	3	4	6	7	13	21	25	26	27
Family Neritidae									
<i>Clithon (Clithon) faba</i> (Sowerby 1836)	0 ^a	0	0	38	0	0	0	0	0
<i>Dostia violacea</i> (Gmelin 1790)	4	0	0	0	0	0	0	0	0
<i>Neritina polita</i> (Linnaeus 1758)	0	0	0	0	0	5	0	0	0
<i>Clithon</i> sp	0	0	0	10	0	0	0	0	0
Family Littorinidae									
<i>Littorinopsis undulata</i> (Gray 1839)	1	0	0	0	0	0	0	0	0
Family Stenothyridae									
<i>Stenothyra</i> sp	0	0	0	0	2	0	0	0	0
Family Assimineidae									
<i>Assiminea (Sphaerassiminea) brevicula</i> Pfeiffer 1854	25	1	0	2	0	0	0	0	0
Family Thiaridae									
<i>Sermyla riqueti</i> (Grateloup 1840)	0	0	0	1	0	0	0	0	0
Family Potamididae									
<i>Cerithidea (Cerithidea) obtusa</i> (Lamarck 1822)	1	0	0	0	0	0	0	0	0
<i>Cerithidea (Cerithidea) quadrata</i> (Sowerby 1866)	0	0	0	2	0	0	0	0	0
<i>Cerithidea (Cerithideopsilla) alata</i> (Phillippi 1849)	5	3	0	0	0	0	0	0	0
<i>Cerithidea (Cerithideopsilla) cingulata</i> (Gmelin 1790)	256	864	210	13	0	0	0	0	0
<i>Cerithidea (Cerithideopsilla) djadjariensis</i> (Martin 1899)	10	40	114	10	0	0	0	0	0
<i>Telescopium telescopium</i> (Linnaeus 1758)	20	1	1	5	0	0	0	0	0
<i>Faunus ater</i> (Linnaeus 1758)	3	0	0	4	92	0	147	51	30
Family Ellobiidae									
<i>Cassidula mustelina</i> (Deshayes 1830)	0	0	0	10	0	0	0	0	0

^a = Number of individuals

Table 3
Freshwater snails of Takua Pa District, Phang-nga Province, southern Thailand, 17-20 February 2005.

Family/ Species	Station number								
	1	9	12	16	17	18	19	22	24
Family Ampullariidae									
<i>Pila angelica</i> (Annandale 1920) ^a	0 ^b	0	0	0	0	2 ^c ✓	0	0	11
<i>Pila polita</i> (Deshayes 1830) ^a	0	0	0	0	0	4 ^c ✓	14 ^c ✓	1 ^c ✓	2
<i>Pomacea canaliculata</i> (Lamarck 1819) ^a	20	1	0	0	0	0	0	0	1
Family Viviparidae									
<i>Filopaludina</i> (<i>F.</i>) <i>s. polygramma</i> (Marten 1860) ^a	36	0	0	0	7 ^c ✓	1 ^c ✓	0	0	1
<i>Filopaludina</i> (<i>F.</i>) <i>s. speciosa</i> (Deshayes 1876)	26	0	0	0	0	0	0	0	21
<i>Filopaludina</i> (<i>S.</i>) <i>m. martensi</i> (Frauenfeld 1865) ^a	69	0	0	0	0	1 ^c ✓	0	0	2
Family Thiaridae									
<i>Melanoides tuberculata</i> (OF Muller 1774) ^a	52	0	39	13	3 ^c ✓	18 ^c ✓	0	2 ^c ✓	1
Family Planorbidae									
<i>Indoplanorbis exustus</i> (Deshayes 1834) ^a	38	0	0	0	0	1 ^c ✓	0	0	17
<i>Camptoceras jiraponi</i> (Hubendicki 1967)	0	0	0	0	1 ^c	0	0	0	0
Family Lymnaeidae									
<i>Radix auricularia rubiginosa</i> (Michelin 1831) ^a	2	0	0	0	0	0	0	0	0

^a = snail of medical importance ^b = number of individuals ^c = only shell found ✓ = live snails found upstream

Table 4
Brackish-water snails of station No.4, Ban Nam Khem, in Takua Pa District, Phang-Nga Province, southern Thailand, pre- and post-tsunami.

Family/ Species	Date and year of investigation		
	13 Feb 2004	25 Jan 2005	17 Feb 2005
Family Nertidae			
<i>Clithon</i> (<i>Pictoneritina</i>) <i>oualaniensis</i> (Lesson 1831)	32 ^a	4	0
<i>Nerita</i> (<i>Nerita</i>) <i>articulata</i> (Gould 1847)	1	0	0
Family Littorinidae			
<i>Littorinopsis scabra</i> (Linnaeus 1758)	3	0	0
Family Assimineidae			
<i>Assiminea</i> (<i>Sphaerassiminea</i>) <i>brevicula</i> (Pfeiffer 1854)	89	141	1
Family Thiaridae			
<i>Sermyla riqueti</i> (Grateloup 1840)	0	1	0
Family Potamididae			
<i>Cerithidea</i> (<i>Cerithidea</i>) <i>obtusa</i> (Lamarck 1822)	2	0	0
<i>Cerithidea</i> (<i>Cerithideopsilla</i>) <i>alata</i> (Phillippi 1849)	6	11	3
<i>Cerithidea</i> (<i>Cerithideopsilla</i>) <i>cingulata</i> (Gmelin 1790)	191	720	864
<i>Cerithidea</i> (<i>Cerithideopsilla</i>) <i>djadjariensis</i> (Martin 1899)	100	42	40
<i>Telescopium telescopium</i> (Linnaeus 1758)	0	1	1

^a = Number of individuals

Table 5
Natural infection of snails in Takua Pa District, Phang-nga Province, pre- and post-tsunami.

Family/ Species	13 Feb 2004		25 Jan 2005		17 Feb 2005	
	% infection	Cercariae type	% infection	Cercariae type	% infection	Cercariae type
Family Planorbidae						
<i>Indoplanorbis exustus</i> (Deshayes 1834)	-	-	-	-	0 (0/10)	-
Family Potamididae						
<i>Cerithidea (Cerithideopsilla) cingulata</i> (Gmelin 1790)	0 ^a (0/13) ^b	-	6.4 (7/109)	A ^c (4) ^d B (2) C (1) D (1)	1.3 (5/381)	B (1) E (1) F (1) G (1) I (1)
<i>Cerithidea (Cerithideopsilla) djadjariensis</i> (Martin 1899)	-	-	0 (0/12)	-	25.6 (23/90)	B (9) E (1) F (7) H (4) I (2)
<i>Cerithidea (Cerithidea) obtusa</i> (Lamarck 1822)	0 (0/2)	-	-	-	0 (0/1)	-
<i>Cerithidea (Cerithideopsilla) alata</i> (Phillippi 1849)	0 (0/6)	-	0 (0/19)	-	0 (0/1)	-
<i>Cerithidae (Cerithidea) quadrata</i> (Sowerby 1866)	-	-	-	-	0 (0/1)	-
<i>Faunus ater</i> (Linnaeus 1758)	-	-	-	-	0 (0/65)	-
Family Assimineidae						
<i>Assimineia (Sphaerassimineia) brevicula</i> (Pfeiffer 1854)	0 (0/19)	-	-	-	-	-
Family Ellobiidae						
<i>Cassidula mustelina</i> (Deshayes 1830)	-	-	-	-	0 (0/5)	-

a = percentage of infection, b = number of positive snails found / total snails examined

c = type of cercariae, d = number of positive snails found

A = furcocercus type, ogatai like, B = cystogenous type without eye spot and collar spines,

C = huge tail cercariae, D = large excretory bladder, ventral sucker, E = cercariae with granules in branched excretory system, F = redia only, G = furcocercous type, H = cystogenous gland with eyespots, I = small stylet type

Assimineidae, Thiaridae, Potamididae, and Ellobiidae (Table 2). All snails were found living on the described habitats, as well as on mud-sand and in mangrove forest.

Five families of freshwater snails were found at another 9 stations (Table 3): Ampullariidae, Viviparidae, Thiaridae, Planorbidae, and Lymnaeidae. At station nos. 17, 18, 19, and 22 (Table 3): in Ban Bang Niang, Khuek Khak Subdistrict, most freshwater reservoirs had been destroyed by the tsunami, and only the shells of freshwater snails were found, *ie Pila angelica*, *P. polita*, *Filopaludina (F.) s. polygramma*, *F. (S.) m. martensi*, *Melanooides tuberculata*, and *Indoplanorbis*

exustus. However, when the investigation team sampled upstream of station No.18, at station No. 24, which was less impacted by the tsunami, all of these snail species were found alive.

At station No. 4, Ban Nam Khem, three visits for snail collections were made (Table 4). The first visit was pre-tsunami (13 February 2004), and the other two were post-tsunami (25 January and 17 February 2005). Ten species of brackish-water snails in 5 families presented: Neritidae, Littorinidae, Assimineidae, Thiaridae, and Potamididae.

Table 5 presents the 9 species of snails examined for trematode infection. The first species was

Indoplanorbis exustus, a freshwater snail, while the rest were all brackish-water species. Among the brackish-water snails, only 2 species, *Cerithidea cingulata* and *C. djadjariensis*, harbored 9 types of trematode cercariae.

DISCUSSION

Generally, these three malacological surveys revealed 29 fresh- and brackish-water snail species in Takua Pa District, Phang-Nga Province in southern Thailand (Tables 2, 3, and 4). The brackish-water snails obtained from all three snail collections are recorded as common in mudflats, mangrove forests, tidal flats and estuaries of Thailand (Brandt, 1974). It was clearly observed that the brackish-water snails inhabiting mud-sand and mangrove forest could survive even in high-impact areas of tsunami in Takua Pa District (Tables 2, 4).

Among 10 freshwater snail species collected (Table 3), 8 are considered of medical importance (Burch and Lohachit, 1983). Kaewjam (1986) reported that *Pila polita* was never found in southern Thailand, while Thaewnon-ngiw *et al* (2003) reported the discovery of *P. polita* in Phang-Nga Province. In this investigation (Table 3), we discovered *P. polita* at station Nos. 18, 19, and 22 (only shells) and station No. 24 (live snails). It is, therefore, noteworthy to conclude that Takua Pa District, Phang-Nga Province, is a habitat for *P. polita* in southern Thailand.

At station No. 4, Ban Nam Khem, 3 snail species, *Nerita articulata*, *Littorinopsis scabra*, and *Cerithidea obtusa*, were not found after the tsunami, in the second and third snail collections on 25 January and 17 February 2005, respectively (Table 4). However, *Cerithidea obtusa* was present at station No. 3, (Table 2); therefore, only 2 species, *N. articulata* and *L. scabra*, were missing. On the other hand, 2 snail species, *Sermyla riqueti* and *Telescopium telescopium*, were not found pre-tsunami but were recovered afterwards. Further snail investigations are thus recommended prior to making any firm conclusions on the distribution, abundance, diversity, and species extinction by the tsunami.

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REFERENCES

- Aksornkoae S, Paphanasit N. Research background on integrated management of mangrove plantations for development of coastal resources and environments of Thailand. In: Aksornkoae S *et al*, eds. Handbook on integrated management of mangrove plantations for development of coastal resources and environments of Thailand. 2003:1-9.
- Brandt RAM. The non-marine aquatic Mollusca of Thailand. *Arch Molluskenkund* 1974;105:1-423.
- Burch JB, Lohachit C. Snails of medical importance in Thailand. *Walkerana* 1983;1:395-8.
- Ito J. Studies on cercariae in Japan. Reprint of papers compiled in commemoration of the 25th anniversary as a professor of Shizuoka University, Shizuoka, Japan, 1980: 376 pp.
- Kaewjam R. The apple snails of Thailand: distribution, habitats and shell morphology. *Malacol Rev* 1986;19:61-81.
- Sri-aroon P, Lohachit C, Harada M. Survey of brackish-water snails in eastern Thailand. Proceedings of 4th Seminar on Food and Water-Borne Parasitic Zoonoses and 2nd International Meeting on Gnathostomiasis. *Southeast Asian J Trop Med Public Health* 2004;35(suppl 1):150-55.
- Thaewnon-ngiw B, Lauhachinda N, Sri-aroon P, Lohachit C. Distribution of *Pila polita* in a southern province Thailand. Proceedings of the Joint International Tropical Medicine Meeting 2002. *Southeast Asian J Trop Med Public Health* 2003;34(suppl 2):128-30.
- Uphatham ES, Sornmani S, Kittikoon V, Lohachit C, Burch JB. Identification key for fresh- and brackish-water snails of Thailand. *Malacol Rev* 1983;16:107-32.
- Van Benthem Jutting WS. Systematic studies on the non-marine Mollusca of the Indo-Australian Archipelago. *Treubia* 1956;23:259-477.