

# SNAILS AND TREMATODE INFECTION AFTER INDIAN OCEAN TSUNAMI IN PHANG-NGA PROVINCE, SOUTHERN THAILAND

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**Abstract.** The tsunami and non-tsunami affected areas of Takua Pa District, Phang-Nga Province were investigated for fresh- and brackish-water snails that transmit human parasitic diseases during 2006 and 2007. Among 46 snail species found, 17 species of 8 families were freshwater snails, 28 species of another 7 families were brackish-water snails, and 1 species was a land snail. Of these species, 11 freshwater snails, 4 brackish-water snails and 1 land snail were of medical importance. The fresh-water snails were *Pomacea canaliculata*, *Pila angelica*, *P. gracilis*, *P. polita*, *Filopaludina (S.) martensi*, *F. (F.) s. polygramma*, *Melanoides tuberculata*, *Indoplanorbis exultus*, *Radix rubiginosa*, *Helicorbis umbilicalis*, *Gyraulus convexiusculus*. Four brackish-water snails were *Cerithidea cingulata*, *C. djadjarensis*, *C. alata*, *Sermyla riqueti* and *Achatina fulica* was the land snail. *I. exultus*, *M. tuberculata* and *F. (F.) s. polygramma* harbored Xiphidio, Microcercus, Furocercus, Echinostome cercariae, and cercaria without eyespots or tail with hair. Three species of brackish-water snails, *Cerithidia cingulata*, *C. djadjariensis*, and *C. alata* presented with 6 types of trematode cercariae and rediae. Knowledge of medically important snails and their parasitic diseases, and prevention were given to Takua Pa people by poster, pamphlets and broadcasting through community radio.

**Key words:** tsunami, snails, trematode infection

## INTRODUCTION

The Indian Ocean tsunami caused damage to 6 provinces in southern Thailand on 26 December 2004. Takua Pa District of Phang-Nga Province suffered the worst destruction. The tsunami killed

people and caused enormous damage to property, and the coastal ecosystem. The affected areas were contaminated with debris of buildings, trees, garbage and seawater. These had effects on the ecosystems of the land, water and mangrove forests, impacting the vector-borne environment by increasing habitats for mosquitoes and snail intermediate hosts.

Eight weeks after the tsunami, the Faculty of Tropical Medicine, Mahidol University launched a preliminary survey of water quality, human parasitic diseases and vector-borne diseases. The preliminary

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results revealed the freshwater was contaminated with seawater since conductivity and salinity were greatly increased (Tharnpoophasiam *et al*, 2006) and there was wide spread presence of *Anopheles sandaicus* (Apiwathnasorn *et al*, 2005) and trematodes in snails (Sri-aroon *et al*, 2006).

Two surveys of snails and their parasitic trematodes were carried out in February and September 2005 at Takua Pa District, Phang-Nga Province. The survey revealed that where freshwater resources were seriously affected by the tsunami, there were no living freshwater snails but only the shells of *Pila angelica*, *P. polita*, *Indoplanorbis exustus*, *Melanoides tuberculata*, *Filopaludina (S.) martensi* and *F. (F.) s. polygramma* (Sri-aroon *et al*, 2006). In the tsunami-affected areas and mangrove forests, many species of brackish-water snails were present, including numerous *Faunus ater* at site 38 of the Khuk Khak Subdistrict. The environment also changed, since the area was covered with debris, neither grasses nor small trees emerged in February 2005.

Examinations of snail samples for natural parasitic infection showed 5% positive or rediae and cercariae of trematodes (Sri-aroon *et al*, 2006). The recovery of trematodes in snail hosts and changes in snail diversity and abundance may cause direct or indirect effects on human health in tsunami affected communities. Investigation of fresh- and brackish-water snails that can transmit human parasitic diseases, including schistosomiasis, opisthorchiasis, paragonimiasis, meningoencephalitis, angiostrongyliasis and echinostomiasis, had the following objectives; 1) to monitor fresh- and brackish-water snails that transmit human parasitic diseases, 2) to evaluate trematode infection through snails mediated diseases, and 3) to provide knowledge about prevention of snail-borne diseases to health authorities

and local people in Takua Pa District, Phang-Nga Province.

## MATERIALS AND METHODS

### Area of study

Three visits to tsunami and non-tsunami affected areas were arranged per year during and after the rainy season: in June 2006, October 2006 and February 2007. The study sites were 3 subdistricts of Takua Pa District, Phang-Nga Province: Ban Bang Nai Si, Bang Muang, and Khuk Khak (Fig 1). Snail samples were obtained from 47 snail collection sites (Table 1): in water reservoirs, mangrove forests and/or estuaries of rivers or canals existing in tsunami and non-tsunami study areas. Of the 47 sites, 4 were in Ban Bang Nai Si Subdistrict, 24 in Bang Muang, of which 5 study sites had been affected by the tsunami, and 19 were in Khuk Khak, of which 12 study sites had been affected by the tsunami. These included 23 sites previously explored in February and September 2005 by Sri-aroon *et al* (2006).

### Snail collection method

The method of snail collection was a 15-minute search, as described by Lohachit (2001) and Sri-aroon *et al* (2004). All likely habitats, including water plants, leave-filled surface depressions, log-mud interfaces, log and stone crevices, soil, sand or mud around roots and on leaves, stones and trunks of mangrove trees were examined and all snails were collected. At each station, all snails found were collected by hand and/or standard wire-mesh scoops, and placed in a separate labeled plastic bag.

### Snail identification and examination for parasites

The freshwater snails of medical importance were identified per Burch and Lohachit (1983) and examined for natural

trematode infection at the field station by the shedding method described by Sri-aroon *et al* (2005). All freshwater snails were then kept in fresh water and brought to the Malacological Laboratory, Department of Social and Environmental Medicine, Faculty of Tropical Medicine, Mahidol University in Bangkok for further investigation. All brackish-water snails kept in their plastic bags and packed in ice boxes for transport back to the laboratory, as describe by Sri-aroon *et al* (2004).

In the laboratory, all collected fresh- and brackish-water snails were enumerated, identified for family, genus and species using the identification keys of Upatham *et al* (1983), Brandt (1974), and Van Benthem Jutting (1956). Brackish-water snails were examined for infection by crushing. More examination for infection in the fresh-water snails was carried out by shedding and crushing methods.

#### **Environmental observation**

General observations of the environment around the snail habitat in each study station was also employed. Comparison of the environmental changes were made using a previous study by Sri-aroon *et al* (2006), during the 3 collection periods.

#### **Implementation of health promotions, preventive and control measures of snail-borne diseases**

Information regarding snails of medical importance and snail-borne diseases were given to the local people in the study areas through posters, pamphlets, and community radio broadcasting. Confirmation of local fresh- and brackish-water snails, and land snails of medical importance were made in a previous snail survey in 2005 by Sri-aroon *et al* (2006), during the first snail collection in June 2006. Distribution of posters and pamphlets,

and health education regarding local snail mediated diseases and their prevention were given to primary and secondary school teachers, librarians, and health officers in the study areas during the second and third snail collections. Community radio programs about local snails of medical importance, diseases and prevention were made during the last visit to Ban Nam Khem, Bang Muang Subdistrict (Sites 21-26) (Table 1) where the village was nearly destroyed by the tsunami.

## **RESULTS**

A total of 13,335 live snails were collected from Bang Nai Si, Bang Muang, and Khuk Khak Subdistricts of Takua Pa District, Pang-Nga Province. Of these snails, 7,991 were freshwater snails (Table 2) and 5,344 were brackish-water snails (Table 3). The numbers and proportions of those snails collected during the 3 periods are shown in Tables 2 and 3. However, these numbers did not include 12 land snails, *Achatina fulica*, family Achatinidae, found in Site 2 (Table 4) during snail collection in October 2006, where the area was flooded by heavy rain. During these 3 surveys, excluding unidentified snails, 46 species of snails were found, of which 17 species from 8 families were fresh-water snails (Table 2), 28 species from 7 families were brackish-water snails (Tables 3), and 1 species was a land snail (Table 4).

In the snail habitat areas many permanent houses were built by various government and non-government organizations (Sites 4, 22, 24, and 37). The areas not rehabilitated were covered with high grass, brushes and trees (Site 38). In Ban Nam Khem, reconstruction of houses around ore mine water wells (Site 24) have been carried out. Site 37 in Khuk Khak Subdistrict was rehabilitated for construction of

Table 1

Forty-seven snail collection sites in 3 subdistricts of Takua Pa District, Phang-Nga Province.

Site no.	Locality	North latitude	East longitude
<b>Subdistrict 1: Bang Nai Si (4 Sites)</b>			
1	Grass field	8°51'42.05"	98°20'52.75"
2	Bang Nam Sai Canal	8°51'41.21"	98°20'51.87"
3	Ore mine reservoir, Ban Bang Tao	8°51'38.64"	98°20'00.67"
4 <sup>a</sup>	Ore mine reservoir, Ban Prutteo Moo7	8°52'12.33"	98°19'38.34"
<b>Subdistrict 2: Bang Muang (24 Sites)</b>			
5 <sup>b</sup>	Bang Muang Canal	8°50'30.11"	98°17'58.91"
6	Ore mine reservoir, Ban Bang Muang No4	8°50'32.92"	98°17'29.38"
7 <sup>b</sup>	Bang Pu Te Canal, Ban Bang Pu Te, No5	8°49'54.91"	98°18'50.50"
8 <sup>b</sup>	Grass field and ore mine reservoir, Ban Nai Pi	8°49'49.86"	98°20'36.91"
9 <sup>b</sup>	Irrigation canal, Ban Hua Ruae	8°50'40.67"	98°18'22.14"
10 <sup>b</sup>	Ore mine reservoir, Ban Hua Ruae	8°50'29.45"	98°18'32.04"
11 <sup>b</sup>	Dok Daeng Canal, Ban Bang Pu Te, No5	8°50'08.96"	98°18'43.44"
12 <sup>b</sup>	Ore mine reservoir1, Ban Bang Now	8°48'16.39"	98°17'12.65"
13 <sup>b</sup>	Ore mine reservoir 2, Ban Bang Now	8°48'18.78"	98°17'16.38"
14	Ore mine reservoir 3, Ban Bang Now	8°48'36.72"	98°17'18.01"
15	Irrigation canal, Ban Bang Now	8°48'50.09"	98°17'13.01"
16	Ore mine reservoir 4, Ban Bang Now	8°48'58.90"	98°17'05.37"
17 <sup>a</sup>	Klong Bang Lued Bridge, Phet Kasem Road	8°48'59.45"	98°17'01.50"
<b>Subdistrict 2: Bang Muang (Continued)</b>			
18	Irrigation canal, Soi Ban Bon Rai	8°47'20.20"	98°16'22.29"
19	Ditch, Ban Bon Rai	8°47'45.63"	98°16'08.29"
20 <sup>b</sup>	Bo Hin Waterfall	8°46'30.65"	98°16'45.88"
21 <sup>a,c</sup>	Soi Tak Sin, Ban Nam Khem	8°51'36.06"	98°16'41.30"
22 <sup>a,c,e</sup>	Soi Nakhon Si Thammarat, Ban Nam Khem	8°51'47.05"	98°16'34.76"
23 <sup>a,c,d</sup>	The estuary of Klong Bang Muang, Ban Nam Khem	8°51'57.10"	98°16'30.09"
24 <sup>a,c,e</sup>	Ore mine reservoir 2 sides of the road in Ban Nam Khem	8°51'43.05"	98°16'19.32"
25 <sup>a,c,d</sup>	Mangrove forest, Ban Nam Khem	8°51'35.48"	98°16'43.79"
26 <sup>a</sup>	Pond beside health center, Ban Nam Khem	8°51'23.82"	98°16'24.95"
27 <sup>a,d</sup>	Bang Muang Bridge, Phet Kasem Road	8°50'47.55"	98°17'17.70"
28 <sup>a</sup>	Ponds at, Phet Kasem Road	8°50'47.55"	98°17'17.70"
<b>Subdistrict 3: Khuk Khak (19 Sites)</b>			
29	Pak Weep Waterfall	8°44'27.86"	98°16'44.55"
30	Pak Weep Waterfall	8°44'36.67"	98°16'36.48"
31	Ore mine reservoir to Pak Weep Waterfall	8°44'36.81"	98°16'24.47"
32 <sup>a</sup>	Pak Weep Bridge, Phetkaseam Road	8°44'50.15"	98°15'45.46"
33 <sup>b</sup>	Klong Kao Ba Bridge, Phetkasem Road	8°44'02.17"	98°15'18.53"
34 <sup>a,c</sup>	Ore mine reservoir, Ban Bang Khaya	8°43'23.96"	98°14'53.63"
35 <sup>a,c</sup>	Ore mine reservoir to Similana Resort	8°43'52.83"	98°14'31.42"
36 <sup>a,c,d</sup>	Canal at Similana Resort	8°44'24.34"	98°14'44.22"
37 <sup>a,c,d</sup>	Laem Pakarang	8°43'19.77"	98°14'08.55"
38 <sup>a,c</sup>	Ore mine reservoir, Ban Bang Khaya	8°43'02.12"	98°14'57.87"
39 <sup>b</sup>	Khuk Khak Bridge, Phetkasem Road	8°42'09.08"	98°15'30.33"
40 <sup>a,c</sup>	Ore mine reservoir to Khuk Khak Beach	8°41'49.66"	98°14'51.24"
41 <sup>a,c,d</sup>	Bridge closed to Khuk Khak Beach,	8°41'35.20"	98°14'30.32"

Table 1 (Continued).

Site no.	Locality	North latitude	East longitude
42 <sup>a</sup>	Tonchongfa Waterfall, Ban Bang Niang	8°39'37.97"	98°16'55.12"
43 <sup>a,c,e</sup>	Klong Bang Niang, Ban Bang Niang	8°40'08.23"	98°15'19.15"
44 <sup>a,c</sup>	Irrigation of Klong Bang Niang	8°40'01.91"	98°15'33.24"
45 <sup>a,c,d</sup>	Estuary near Laflora Resort, Ban Bang Niang	8°39'39.80"	98°14'59.38"
46 <sup>a,c</sup>	Irrigation canal and pond, Ban Bang Niang	8°40'05.52"	98°14'59.46"
47 <sup>a,c</sup>	Ore mine reservoir, Phetkasem Road km 61	8°39'26.15"	98°15'12.63"

<sup>a</sup>Sites previously explored in February and September 2005; <sup>b</sup>sites where snails absent; <sup>c</sup>sites affected by the tsunami; <sup>d</sup>sites with only brackish-water snails present; <sup>e</sup>sites with both fresh- and brackish-water snails present.

Table 2

Number and percent composition of fresh-water snails collected by 15-minute search in 2006 and 2007 at Takua Pa District, Phang-Nga Province, Thailand.

Family/species	Number of fresh-water snails				
	Jun 06	Oct 06	Feb 07	Total	%
<b>Neritidae</b>					
<i>Neritina (Neritina) pulligera</i> (Linnaeus 1767)	66	4	138	208	2.6
<b>Ampullariidae</b>					
<i>Pila angelica</i> Annandale 1920	1	1	0	2	0.03
<i>Pomacea canaliculata</i> Lamarck 1819	128	470	240	838	10.49
<i>Pila gracilis</i> (Lea 1856)	15	74	44	133	1.66
<i>Pila polita</i> (Deshayes 1830)	4	12	6	22	0.28
<b>Hydrobiidae</b>					
<i>Clenciella microscopica</i> (Nevill 1877)	3	0	1	4	0.05
<b>Lymnaeidae</b>					
<i>Radix rubiginosa</i>	3	1	7	11	0.14
<b>Planorbidae</b>					
<i>Gyraulus convexiusculus</i> (Hutton 1849)	8	414	11	433	5.42
<i>Helicorbis umbilicalis</i> (Benson 1836)	5	33	1	39	0.49
<i>Indoplanorbis exustus</i> (Deshayes 1834)	220	735	415	1,370	17.14
<i>Segmentina (Trochorbis) trochoideus</i> (Benson)	89	0	0	89	1.11
<b>Stenothyridae</b>					
<i>Stenothyra</i> sp	148	285	438	871	10.90
<b>Thiaridae</b>					
<i>Melanooides tuberculata</i> (OF Muller 1774)	1,100	549	1,028	2,677	33.50
<i>Thiara scabra</i> (OF Muller 1774)	6	0	0	6	0.08
<b>Viviparidae</b>					
<i>Filopaludina (S.) martensi</i> (Frauenfeld 1865)	68	115	117	300	3.75
<i>Filopaludina (F.) s. polygramma</i> (Marten )	29	309	314	652	8.16
<i>Filopaludina (F.) s. speciosa</i> (Deshayes 1876)	118	52	149	319	3.99
Unidentified	0	7	10	17	0.21
<b>Total</b>	2,011	3,061	2,919	7,991	100.00



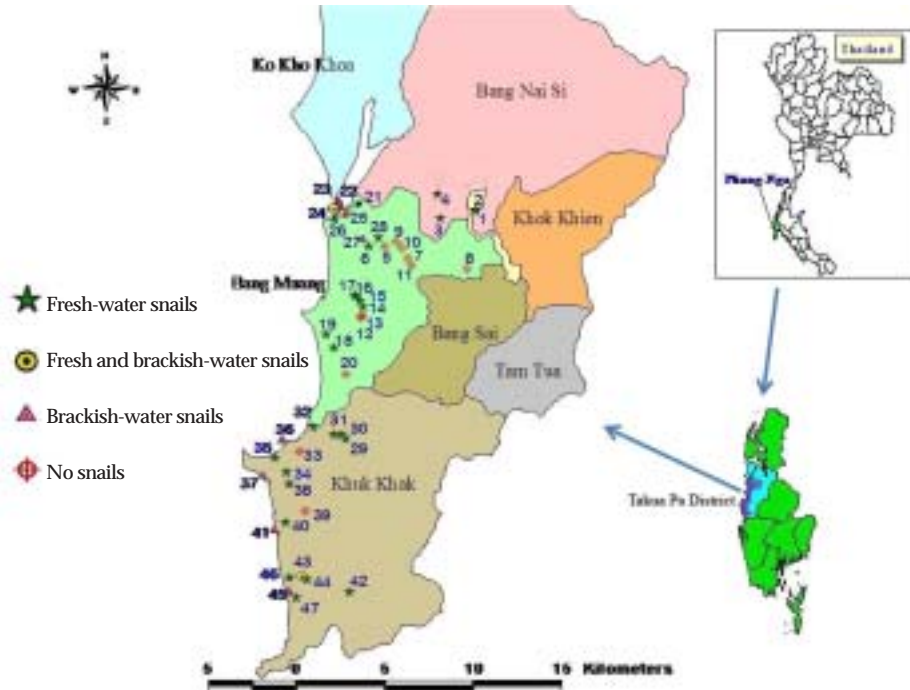


Fig 1–Map of Takua Pa District showing 47 snail collecting sites in 3 subdistricts. Eleven sites had no snails found, 25 sites had fresh-water snails, 8 sites had brackish-water snails and 3 sites had fresh- and brackish-water snails.

a new hotel.

There were no brackish-water snails present in Bang Nai Si Subdistrict (Fig 1, Tables 1, 5), only fresh-water snails were found (Table 4). Snails were found in 36 sites and not found in 11 sites (5, 7-13, 20, 33 and 39) (Fig 1, Table 1). Eight sites (22, 23, 25, 27, 36, 37, 41 and 45) had brackish-water snails only (Fig 1, Tables 1, 5) and 3 sites (21, 24 and 43) had both fresh- and brackish-water snails (Fig 1, Tables 1, 4, and 5).

Of the 46 snail species found in Takua Pa, 11 were fresh-water snails, 4 were brackish-water snails and 1 was a species of land snail; all were of medical importance (Table 6). The fresh-water snails were *Pomacea canaliculata*, *Pila angelica*, *P. gracilis*, *P. polita*, *Filopaludina (S.) martensi*, *F. (F.) s. polygramma*, *Melanoides tuberculata*,

*Indoplanorbis exustus*, *Radix rubiginosa*, *Helicorbis umbilicalis* and *Gyraulus convexiusculus* (Table 4) and the brackish-water snails were *Cerithidea cingulata*, *C. djadjarensis*, *C. alata*, *Sermyla riqueti*, and *Achatina fulica* (Burch and Lohachit, 1983) (Table 6).

Laboratory examination revealed infections of the snails (Table 7). The fresh-water snails *Indoplanorbis exustus*, *Melanoides tuberculata* and *Filopaludina polygramma* were infected with 5 types of cercariae. These were 1) Xiphidio cercaria, 2) Microcercus cercaria, 3) Furcocercus cercaria, 4) Echinostome cercaria, and 5) cercaria without eyespots but a tail with hair. Three species of brackish-water snails, *Cerithidea cingulata*, *C. djadjariensis* and *C. alata*, were positive for 6 types of cercariae, 1) cystogenous, with eyespots and collar

Table 3

Number and percent composition of brackish-water snails collected by 15-minute search in 2006 and 2007 at Takua Pa District, Phang-Nga Province, Thailand.

Family/species	Number of brackish-water snails				
	Jun 06	Oct 06	Feb 07	Total	%
<b>Assiminidae</b>					
<i>Assimineae (Sphaerassimineae) brevicula</i> Pettit	0	40	87	127	2.38
<b>Littorinidae</b>					
<i>Littorinopsis carinifera</i> (Menke 1830)	7	7	0	14	0.26
<i>Littorinopsis melanostoma</i> (Gray 1839)	17	0	0	17	0.32
<i>Littorinopsis scabra</i> (Linnaeus 1758)	0	35	9	44	0.82
<i>Littorinopsis undulata</i> (Gray 1839)	195	190	101	486	9.09
<b>Neritidae</b>					
<i>Clithon corona</i>	0	61	13	74	1.38
<i>Clithon (Clithon) faba</i> (Sowerby 1836)	59	61	192	312	5.84
<i>Clithon (Pictoneritina) oualaniensis</i> (Lessson)	94	0	110	204	3.82
<i>Neritina (Dostia) violacea</i> (Gmelin 1790)	23	2	3	28	0.52
<i>Nerita (Nerita) articulata</i> Gould 1847	3	7	5	15	0.28
<i>Nerita (Theliostyla) planospira</i> Anton 1839	12	19	4	35	0.65
<i>Neritrodryas dubia</i> (Gmelin 1791)	3	0	0	3	0.06
<i>Neritrodryas cornea</i>	0	1	1	2	0.04
<i>Nerita chameleon</i> Linnaeus	45	32	2	79	1.48
<b>Potamididae</b>					
<i>Cerithidea (Cerithidea) obtusa</i> (Lamarck, 1822)	21	11	3	35	0.65
<i>Cerithidea (Cerithidea) quadrata</i> Sowerby, 1866	74	19	8	101	1.89
<i>Cerithidea (Cerithideopsilla) alata</i> (Phillippi)	1	12	2	15	0.28
<i>Cerithidea (Cerithideopsilla) cingulata</i> (Gmelin)	529	835	1,143	2,507	46.91
<i>Cerithidea (Cerithideopsilla) djadjariensis</i>	54	99	415	568	10.63
<i>Faunus ater</i> (Linnaeus, 1758)	239	1	42	282	5.28
<i>Telescopium telescopium</i> (Linnaeus, 1758)	6	14	25	45	0.84
<b>Thiaridae</b>					
<i>Sermyla riqueti</i> (Grateloup 1840)	29	20	40	89	1.67
<b>Ellobiidae</b>					
<i>Ellobium aurisjudae</i> (Linnaeus, 1758)	0	0	2	2	0.04
<i>Ellobium aurismidae</i> (Linnaeus, 1758)	0	0	3	3	0.06
<i>Cassidula aurisfelis</i> (Bruguiere, 1789)	21	28	5	54	1.01
<i>Cassidula multiplicata</i> Martens, 1865	22	20	0	42	0.79
<i>Cassidula mustelina</i> (Deshayes, 1830)	74	1	15	90	1.68
<b>Cerithidiidae</b>					
<i>Cerithidium</i> sp	21	21	6	48	0.90
unidentified	2	3	18	23	0.43
Total	1,551	1,539	2,254	5,344	100.00

spines, 2) cystogenous, without eyespots or collar spines, 3) cercariae with excretory granules in branches of excretory tubes,

with collar spines, 4) cercariae with excretory granules in branches of excretory tubes, without collar spines or tail fins,

Table 4  
Distribution of brackish-water snails at each site in 3 subdistricts of Takua Pa District, Phang-Nga Province, Thailand.

Family/species	Bang Nai Si sites 1-4	Bang Muang sites 5-28	Khuk Khak sites 29-47
<b>Neritidae</b>			
<i>Neritina (Neritina) pulligera</i> (Linnaeus 1767)	2		29,30,31,32,38,42,43
<b>Ampullariidae</b>			
<i>Pila angelica</i> Annandale 1920		19	
<i>Pomacea canaliculata</i> Lamarck 1819	3,4	6,19,24,26	34,35,38,40,43,44,46,47
<i>Pila gracilis</i> (Lea 1856)	4	14,15,17,18,19,28	43,47
<i>Pila polita</i> (Deshayes 1830)	3		34,35,47
<b>Hydrobiidae</b>			
<i>Clenciella microscopica</i> (Nevill 1877)		24	
<b>Lymnaeidae</b>			
<i>Radix rubiginosa</i>	4	26	40
<b>Planorbidae</b>			
<i>Gyraulus convexusculus</i> (Hutton 1849)		19,21	34,35,38,40
<i>Helicorbis umbilicalis</i> (Benson 1836)		6,19,26	
<i>Indoplanorbis exustus</i> (Deshayes 1834)	2,4	6,19,24,26	34,35,38,40,43,44,46,47
<i>Segmentina (Trochorbis) trochoideus</i> (Benson)			47
<b>Stenothyridae</b>			
<i>Stenothyra</i> sp		24	35, 38
<b>Thiaridae</b>			
<i>Melanoides tuberculata</i> (OF Muller 1774)	2,4	18,19,21,24,26	32,34,35,38,40,43,44,46,47
<i>Thiara scabra</i> (OF Muller 1774)	2		
<b>Viviparidae</b>			
<i>Filopaludina (S.) martensi</i> (Frauenfeld 1865)	1,2,4	6,19,28	34,47
<i>Filopaludina (F.) s. polygramma</i> (Marten)	4	6,19,26,28	34,40,43,44,47
<i>Filopaludina (F.) s. speciosa</i> (Deshayes 1876)	2,4	6,14,15,16,19,21,26,28	47
<b>Achatinidae</b>			
<i>Achatina fulica</i>	2		

5) cercariae of the small stylet type, and 6) cercariae with eyespots, a large excretory bladder and a ventral sucker. Some radiae of trematodes were also present in *C. cinctulata* and *C. djadjariensis*.

Education regarding snails of medical importance and snail-borne diseases were given to the people of the study area. Dis-

tribution of 50 posters demonstrating local fresh- and brackish-water snails and a land snail of medical importance, and brief health education regarding local snail mediated diseases and prevention was carried out during the 2<sup>nd</sup> snail investigation of October 2006. The posters were placed on announcement boards of villages,



Table 5  
Distribution of brackish-water snails at each site in 3 subdistricts of Takua Pa District,  
Phang-Nga Province, Thailand.

Family/species	Bang Nai Si sites 1-4	Bang Muang sites 5-28	Khuk Khak sites 29-47
<b>Assiminidae</b>			
<i>Assimineia (Sphaerassimineia) brevicula</i> Pettit		21,22,25	
<b>Littorinidae</b>			
<i>Littorinopsis carinifera</i> (Menke 1830)		21,25	
<i>Littorinopsis melanostoma</i> (Gray 1839)		25	
<i>Littorinopsis scabra</i> (Linnaeus 1758)		21	37
<i>Littorinopsis undulata</i> (Gray 1839)		21,22,23,24,25,27	
<b>Neritidae</b>			
<i>Clithon (Clithon) faba</i> (Sowerby 1836)		21,24,25	36,37,41,43,45
<i>Clithon (Pictoneritina) oualaniensis</i> (Lessson)		21,22,23,25	37,45
<i>Clithon corona</i>			36
<i>Neritina (Dostia) violacea</i> (Gmelin 1790)		21,22,24,25	36,41,45
<i>Nerita (Nerita) articulata</i> Gould 1847		22,23,25	37
<i>Nerita (Theliostyla) planospira</i> Anton 1839		22,23,25	37
<i>Neritrodryas dubia</i> (Gmelin 1791)			41
<i>Neritrodryas cornea</i> (Linnaeus 1758)			37
<i>Nerita chameleon</i> Linnaeus		23	
<b>Potamididae</b>			
<i>Cerithidea (Cerithidea) obtusa</i> (Lamarck, 1822)		21,22,25	
<i>Cerithidea (Cerithidea) quadrata</i> Sowerby, 1866		21,22,25	37
<i>Cerithidea (Cerithideopsilla) alata</i> (Phillippi, 1849)		23,25	
<i>Cerithidea (Cerithideopsilla) cingulata</i> (Gmelin)		21,22,23,25	36,37,41
<i>Cerithidea (Cerithideopsilla) djadjariensis</i> (Martin)		21,22,23,25	37
<i>Faunus ater</i> (Linnaeus, 1758)		21,22,23,27	36,37,41
<i>Telescopium telescopium</i> (Linnaeus, 1758)		21,22,24,25	37,41
<b>Ellobiidae</b>			
<i>Ellobium aurisjudae</i> (Linnaeus 1758)		21	
<i>Cassidula aurisfelis</i> (Bruguere, 1789)		25	37
<i>Cassidula multiplicata</i> Martens, 1865		21,25	
<i>Cassidula mustelina</i> (Deshayes, 1830)		21,25	37
<b>Thiaridae</b>			
<i>Sermyla riqueti</i> (Grateloup 1840)		21,24	43
<b>Cerithidiidae</b>			
<i>Cerithidium</i> sp			37

health offices and primary and secondary schools with permission. On the 3<sup>rd</sup> visit in February 2007, 50 posters and 500 pamphlets were distributed to local health offices, school librarians and teachers. Com-

munity radio broadcasting regarding local snails of medical importance, diseases and prevention were aired in the southern dialogue at Ban Nam Khem where collection sites 21-26 were situated.

Table 6  
Medically important mollusks potentially transmitting diseases in Takua Pa District, Phang-Nga Province.

Species	Potential disease
1. <i>Achatina fulica</i>	Angiostrongyliasis
2. <i>Pomacea canaliculata</i>	Angiostrongyliasis
3. <i>Pila angelica</i>	Angiostrongyliasis
4. <i>P. gracilis</i>	Angiostrongyliasis
5. <i>P. polita</i>	Angiostrongyliasis
6. <i>Filopaludina (S.) martensi</i>	Angiostrongyliasis
7. <i>F. (F.) s. polygramma</i>	Echinostomiasis
8. <i>Melanoides tuberculata</i>	Paragonimiasis Echinostomiasis
9. <i>Indoplanorbis exustus</i>	Echinostomiasis
10. <i>Radix rubiginosa</i>	Cercarial dermatitis
11. <i>Helicorbis umbilicalis</i>	Echinostomiasis
12. <i>Gyraulus convexiusculus</i>	Echinostomiasis
13. <i>Cerithidea cingulata</i>	Small intestinal fluke infection
14. <i>C. djadjarensis</i>	Small intestinal fluke infection
15. <i>C. alata</i>	Small intestinal fluke infection
16. <i>Sermyla riqueti</i>	Small intestinal fluke infection

## DISCUSSION

Three surveys at 4 month intervals for snail collection showed an abundance and diversity of fresh- and brackish-water snails in Bang Nai Si, Bang Muang and Khuk Khak Subdistricts of Takua Pa District, Pang-Nga Province after the tsunami (Tables 2, 3). The snail populations varied by time period. The freshwater snail *Melanoides tuberculata* was the most abundant in the area, comprising 33.5% of freshwater snails collected (Table 2) and the brackish-water snail, *Cerithidea cingulata*, was the most abundant comprising 46.9% (Table 3) of brackish-water snails collected.

The distribution of fresh- and brackish-water snails was not even (Tables 4, 5). Some species of freshwater snails were found in all three subdistricts, such as *Pila gracilis*, *Melanoides tuberculata* and *Filopaludina (S.) martensi* (Table 4), but some were not, such as *Pila angelica*, *P.*

*polita* and *Segmentina trochoideus*. In none of the 3 snail surveys were brackish-water snails found in Bang Nai Si (Tables 1, 5). Reasons for this may include the limit dispersal capability of the snail itself, and the availability of fresh- and brackish-water resources in the study area (Table 1). At Site 38 of Khuk Khak Subdistrict, there was an absence of *Faunus ater*, which were found in large numbers in February 2005 two months after the tsunami (Sri-aroon *et al*, 2006). This may be due to environmental change. This species may have a high capability for dispersal, therefore, it migrated elsewhere.

Compared to the work of Sri-aroon *et al* (2006), the species of snails were different from the survey in 2005. In the tsunami affected areas of Khuk Khak Subdistrict at sites 34, 43, 44 and 46 (Table 1), only the shells of freshwater snails were found. These were *Pila polita*, *P. gracilis*, *Gyraulus convexiusculus*, *Indoplanorbis exustus*,

Table 7

Natural snail infection rate at Takua Pa District, Phang-Nga Province in June and Oct 2006, and Feb 2007

Site no.	Snail species	Jun 06		Oct 06		Feb 07	
		% Infection rate	Cercaria type	% Infection rate	Cercaria type	% Infection rate	Cercaria type
<b>Brackish-water snails</b>							
22	<i>C. cinctulata</i>	None	None	3.3 <sup>a</sup> (2/60) <sup>b</sup>	1 <sup>c</sup> (E) <sup>d</sup> , 1 (F)	1.9 (3/154)	1 (I), 1 (F), 1 (R)
	<i>C. djadjariensis</i>	18.5 (5/27)	2(B), 1(C), 1(R), 1(D)	6.7 (4/60)	4 (D)	0.6 (1/154)	1 (R)
23	<i>C. cinctulata</i>	1.3 (1/75)	1(R)	None	None	None	None
25	<i>C. cinctulata</i>	1.3 (1/75)	1(B)	2.2 (1/46)	1 (B)	None	None
	<i>C. djadjariensis</i>	None	None	25 (2/8)	1 (A), 1(C)	24.2 (24/99)	10 (B), 13 (E), 1(R)
	<i>C. alata</i>	None	None	25 (3/12)	1 (A), 1 (B), 1 (E)	None	None
37	<i>C. cinctulata</i>	None	None	None	None	6.4 (7/110)	7 (A)
	<i>C. cinctulata</i>	None	None	None	None	0.9 (1/110)	1 (B)
<b>Fresh-water snails</b>							
2	<i>M. tuberculata</i>	None	None	None	None	32 (8/25)	8 (L)
4	<i>F. polygramma</i>	None	None	1.3 (2/149)	2 (L)	None	None
	<i>I. exustus</i>	None	None	1.9 (1/54)	1 (E)	None	None
6	<i>I. exustus</i>	None	None	None	None	25 (1/4)	1 (I)
32	<i>M. tuberculata</i>	None	None	3.4 (1/29)	1 (H)	9.4 (5/53)	5 (H)
34	<i>M. tuberculata</i>	None	None	None	None	5.9 (2/34)	2 (H)
	<i>I. exustus</i>	None	None	6.3 (1/16)	1 (H)	None	None
35	<i>M. tuberculata</i>	None	None	None	None	5.2 (3/58)	3 (H)
	<i>I. exustus</i>	None	None	None	None	3.6 (1/28)	1 (K)
38	<i>M. tuberculata</i>	None	None	None	None	3.8 (2/52)	2 (H)
40	<i>M. tuberculata</i>	None	None	None	None	4.8 (1/21)	1 (K)
	<i>I. exustus</i>	None	None	1.4 (3/215)	2 (J), 1 (I)	11.4 (5/44)	5 (H)
47	<i>M. tuberculata</i>	None	None	None	None	25 (1/4)	1 (L)
	<i>I. exustus</i>	None	None	5.1 (3/59)	3(K)	80.6 (29/36)	27 (K), 2 (H)

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

c, number of positive snail(s) found, d, cercaria type

A, cystogenous, with eyespots and collar spines, B, cystogenous, without eyespots or collar spines, C, excretory granules in branched excretory tube, with collar spines; D, excretory granules in branched excretory tube, without collar spines or tail fins; E, small stylet type; F, with eyespots, large excretory bladder and ventral sucker; H, *Xiphidio cercaria*; I, *Furcocercus cercaria*; J, *Microcercus cercaria*; K, *Echinostome cercaria*; L, no eyespots, tail with hair; R, redia; None, no cercaria found.

*Melanoides tuberculata*, *Filopauludina martensi* and *F. polygramma*. In contrast, during these 3 investigations, there were many species of freshwater snails found.

These were *Pomacea canaliculata*, *Pila polita*, *P. gracilis*, *Gyraulus convexiusculus*, *Indoplanorbis exustus*, *Melanoides tuberculata*, *Filopaludina (S.) martensi* and *F. (F.) s.*

*polygramma* (Tables 1, 4). These phenomena clearly demonstrate contamination with seawater affected the mortality of freshwater snails. However, when the habitat became more favorable by dilution with rain water, the surviving snails started to breed, therefore, many species of freshwater snail were recovered. For brackish-water snails, *Littorinopsis scabra* and *Nerita articulata* were absent in the survey in 2005, but were present in this survey (Table 5).

Construction around snail habitats situated in tsunami affected areas had an affect. New houses, buildings and hotels were already constructed or were being planned. The snail habitats changed. Adverse affects on snail species and their distribution and abundance could not be concluded by this study.

In Takua Pa District, Pang-Nga Province we found 11 fresh-water, 4 brackish-water and 1 land snail species of medical importance, with the potential of transmitting angiostrongyliasis, cercarial dermatitis, echinostomiasis, paragonimiasis and small intestinal fluke infection (Table 6). Natural infections were found in 3 species of fresh-water snails of medical importance: *Indoplanorbis exustus*, *Melanoides tuberculata* and *F. (F) s. polygramma*. These infections were found in October and February (Table 7), even those snails were also found in June (Table 2). Infections of medical importance were found in 3 species of brackish-water snails: *Cerithidea alata*, *C. cinculata* and *C. djadjariensis*; the first species was found infected only in October while the rest were positive for infection in all 3 snail surveys (Table 7).

Education regarding snails of medical importance and snail-borne diseases was given to the people of the study areas through posters, pamphlets, and radio broadcasts. An additional 50 posters and 500 pamphlets were distributed to visit-

ing nurses, school librarians and teachers to help propagate this knowledge to the people and schoolchildren of Takua Pa. Community radio broadcasting in the southern dialect in Ban Nam Khem provided additional knowledge regarding local snails of medical importance to the villagers.

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