

## Distribution of the family Littorinidae (Mollusca: Gastropoda) in Thailand

Kitithorn Sanpanich<sup>1,2</sup>, Fred E. Wells<sup>3</sup> and Yaowaluk Chitramvong<sup>2\*</sup>

<sup>1</sup>The Institute of Marine Science, Burapha University, Chonburi 20131, Thailand

<sup>2</sup>Biology Department, Faculty of Science, Mahidol University, Rama 6 Road, Bangkok 10400, Thailand

<sup>3</sup>Western Australian Museum, Perth, Western Australia 6000, Australia

\* Corresponding author

**Abstract** – The distribution of the family Littorinidae in mangroves and on rocky shores in Thailand was studied. Fourteen species of *Littoraria*, *Echinolittorina* and *Peasiella* were recorded from 50 survey sites, bringing the total known for the country to 16 species. Two species were recorded for the first time in Thailand. *Littoraria conica* was found in only two places in southern Thailand, both on the Andaman Sea. *Echinolittorina feejeensis* occurred on scattered granite rocks on sandy beaches in the splash zone of offshore islands where the water is clear both in the Gulf of Thailand and the Andaman Sea. It is dominant at Ko Kumpun, Trat Province. Habitats occupied by the three genera are distinct. *Echinolittorina* and *Peasiella* occur primarily on intertidal rocks though occasional individuals are found in the seaward fringe of mangroves; *Littoraria undulata* occupies a similar rock habitat. The other species of *Littoraria* occur on many species of mangroves, with some occasionally being found on rocks. Four species (*L. bengalensis*, *L. conica*, *L. scabra*, and *L. undulata*) occurred only on the Andaman Sea side of Thailand. *Littoraria bengalensis* is restricted to the Indian Ocean but the other three species occur in the Pacific Ocean east of Thailand. Their absence in the Gulf of Thailand appears to be real.

### INTRODUCTION

The family Littorinidae is a moderately diverse group of intertidal gastropods. Reid (1989a) reported there were 173 species, and more species have since been described. The family is most diverse in the Indo-West Pacific Ocean. Rosewater (1970, 1972) examined the distribution of the family in the entire Indo-Pacific using records from the major museum collections. He considered there to be one subspecies of the mangrove littorine, *Littorina scabra*, a view reiterated in a subsequent paper (Rosewater, 1980). Reid (1986a) was able to examine the species in a wide range of field localities and determined there was a suite of 20 species inhabiting different parts of the mangroves and rocky shores. He transferred the group to the genus *Littoraria*. He later (Reid, 1999) extended the study of *Littoraria* into the eastern Pacific. Reid subsequently expanded his research into several other genera of tropical Indo-Pacific littorinids, including *Mainwaringia* (Reid, 1986b), *Peasiella* (Reid, 1989b; Reid and Mak, 1998), *Nodilittorina* (Reid, 2001a), and a paper on the littorinids of Hong Kong (Reid, 1992). Williams *et al.* (2003) transferred the tropical Indo-Pacific *Nodilittorina* species to *Echinolittorina*. Reid also recorded three species of Indo-West Pacific littorines in the eastern Pacific (Reid and Kaiser, 2001). Despite their intertidal nature and the tendency for a widespread

distribution, new species of Indo-Pacific littorines continue to be found, including species of *Littoraria* (Reid, 2001b; Stuckey and Reid, 2002) and *Tectarius* (Reid and Geller, 1997). Many of the papers cited above have recorded species of littorinids in Thailand as part of broad distributional studies, but the Littorinidae of Thailand have not been examined in detail. Altogether, 14 species of littorinids have been recorded, including nine *Littoraria*, three *Echinolittorina* and two *Peasiella*. McQuaid (1996a; 1996b) presented a general review of the biology of littorinids.

Molluscs are an important component of the fauna of mangrove communities in the tropical and subtropical Indo-West Pacific, including Thailand. They are diverse (Macnae, 1967, 1968; Saenger *et al.*, 1977), and many species have a high density and/or biomass (Brown, 1971; Wells, 1983, 1984, 1986). Species living in mangroves can be divided into those that are found on adjacent rocky, sandy and muddy shores, and which simply use mangroves as an incidental habitat, and species that are restricted to mangroves. Cantera *et al.* (1983) concluded that only 20% of the gastropods in mangroves are species restricted to the tree zones. These characteristic mangrove species are often numerically dominant and ecologically important. Many have developed mechanisms such as resorbing calcium carbonate from internal shell

structures which allow them to survive in this difficult habitat (Vermeij, 1974, 1978). While there are numerous species of molluscs living in mangroves, there is very little information on their lifespan or population dynamics. *Littoraria* is particularly interesting as a mangrove mollusc genus, as most of the species occur only in mangroves, where they are the dominant molluscs in the trees, while most other mangrove gastropods live on the ground.

Most of the records of littorinids in Thailand are based on museum material collected over many years, but there have been several studies which examined distribution and/or biology of the group. Frith *et al.* (1976) studied zonation of macrofauna on a mangrove shore at Phuket Island. Details of the littorinids collected in this study were reported in a short paper by Nielsen (1976). As part of a broader study of habitat and zonation patterns of *Littoraria* in the Indo-West Pacific, Reid (1985) included sites at Phuket Island and Kanchanadit. Cook and Garbett (1989) detailed patterns of variation in mangrove littorinids at Phuket Island.

The records of littorinids in Thailand are generally patchy, with only a few localities recorded for a country with extensive coastlines on the Pacific Ocean (Gulf of Thailand) and in the eastern Indian Ocean. The present paper is the first detailed examination of littorinids in Thailand as a basis for understanding where the species occur in Thailand to facilitate future work on their biology.

#### MATERIALS AND METHODS

Snails used in this study were collected from November 2001 to August 2003 from all coastal parts of Thailand, including the eastern provinces (Chonburi, Rayong, Chanthaburi and Trat), the middle provinces (Samut Prakan and Samut Songkram), the east coast of the southern provinces (Phetchaburi, Prachuab Khiri Khun, Chumphon, Surat Thani, Nakhon Si Thammarat, Pattani, and Narathiwat) and the west coast of the southern provinces (Ranong, Phang Nga, Phuket, Krabi, Trang, and Satun).

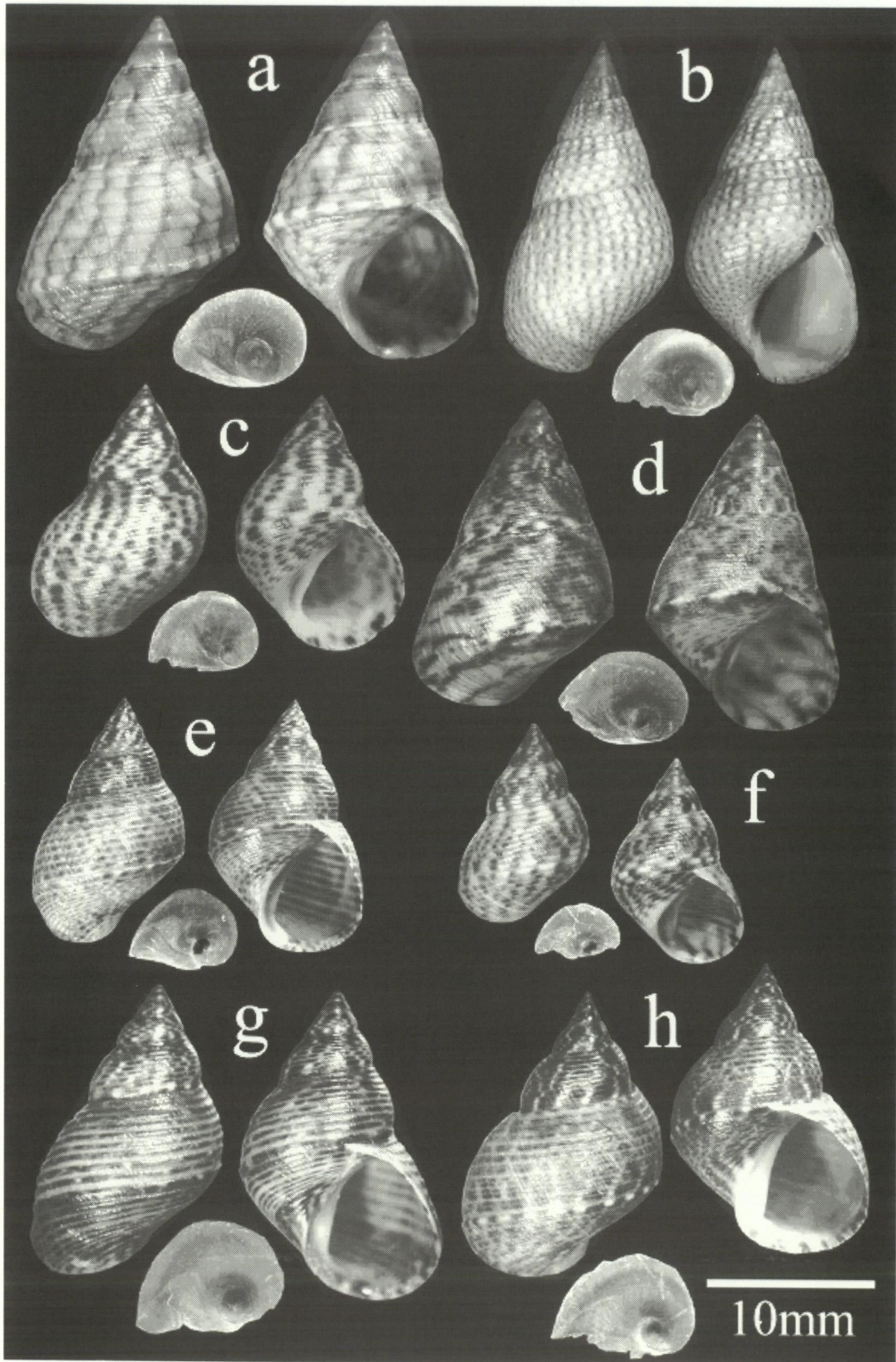
Adult specimens of similar sizes were collected by hand in two habitats. Specimens were collected from roots, trunks and leaves in mangrove areas and some animals were collected from nearby mud. Other species were collected in the splash zone of rocky shores along the islands. One to three habitats were examined at each locality. After collection, all specimens were narcotised in a 7.5% (weight/volume) solution of magnesium chloride (Reid, 2000, 2001b) then fixed in 10% formalin and retained for later dissection and identification. Representative material of all species is retained in the mollusc collections of the Burapha Institute of Marine Science, Burapha University.

Rosewater (1970, 1972) and Reid (1986a and other papers) described the shells and anatomy of these species. As they can usually be identified from shells alone, the details are not repeated here. As Reid (1986a) is not widely available in Thailand, shell photographs of all species collected are presented in Figures 1 and 2. *Littoraria strigata* and *L. articulata* are unusual in that they cannot be differentiated by their shells. Males are readily determined using the structure of the penis (Figure 2). As the differentiation of females is subtle, all records in this paper are based on males. The dendrogram was calculated using the Statistical Package in the Social Sciences (SPSS), Version 11.0.

#### RESULTS

Fourteen species: 10 *Littoraria*, 3 *Echinolittorina* and 1 *Peasiella* were recorded from 50 survey sites (Figure 3, Appendix 1, Table 1). The number of stations at which each species was found ranged considerably, from 32 for *L. strigata* to 2 for *L. conica*. Aside from *L. strigata*, the other widespread species were *E. trochoides* (26 stations), *L. articulata* (19), *E. vidua* (17), *L. pallescens* (17), *L. melanostoma* (16), and *L. carinifera* (14). The 10 species of *Littoraria* occurred at a mean of  $11.5 \pm 9.8$  (SE) stations, the three *Echinolittorina* at a mean of  $16.7 \pm 5.5$ , and the single *Peasiella* at seven stations. It was interesting that the two species which are indistinguishable on the basis of shell morphology, *L. articulata* and *L. strigata* co-occurred at all 19 of the stations at which *L. articulata* was found. In addition, *L. strigata* was found at 13 stations where *L. articulata* did not occur.

Habitats occupied by the three genera are distinct. Nine of the 10 species of *Littoraria* occur primarily on mangroves (Table 1). They tend to occur on a wide range of mangrove and other plant species in the community. In all *Littoraria* were recorded from a total of 17 species of plants. The mean number of plant species inhabited by the mangrove *Littoraria* was  $9.2 \pm 1.2$ . The common species occurred on a wide range of plants: *L. carinifera* was found on 14 species, *L. melanostoma* and *L. pallescens* on 13, and *L. articulata* on 11. Many of these species also were found on house or pier poles, which were often of wood. Several were also found on rocky shores, but this constituted only a small portion of the population. It was noteworthy that four species (*L. articulata*, *L. carinifera melanostoma* and *L. strigata*) were found on mud or sand among the mangroves. This was a natural occurrence, and not simply that the animals were inadvertently brushed off the trees by the investigator. *Littoraria* collected in this study were most abundant near the seaward margins of the mangroves; density declined sharply with distance from the edge of the mangroves. Aside from *L. pallescens*, most individuals were found <50 cm



**Figure 1** Littorinids recorded from Thailand. a. *L. carinifera*, Ban Jebilung, Amphur Moeng, Satun Province (BIMS-M1175) b. *L. melanostoma*, E-led canal, Chumphon Islands Marine Park, Tumbon Hadsairee, Amphur Moeng, Chumphon Province (BIMS-M1176) c. *L. articulata*, Samed, Amphur Moeng, Chonburi Province (BIMS-M1177) d. *L. conica*, Ban Jebilung, Amphur Moeng, Satun Province (BIMS-M1178) e. *L. bengalensis*, Chaomai Beach, Tumbon Ko Libong, Amphur Kuntung, Trang Province (BIMS-M1179) f. *L. intermedia*, Mai ngarm Bay, Ko North Surin, Phangnga Province (BIMS-M1180) g. *L. pallescens*, Ban Dee, Tumbon LaemPo, Amphur Yaring, Pattani Province (BIMS-M1181) h. *L. scabra*, Mai ngarm Bay, Ko North Surin, Phangnga Province (BIMS-M1182)

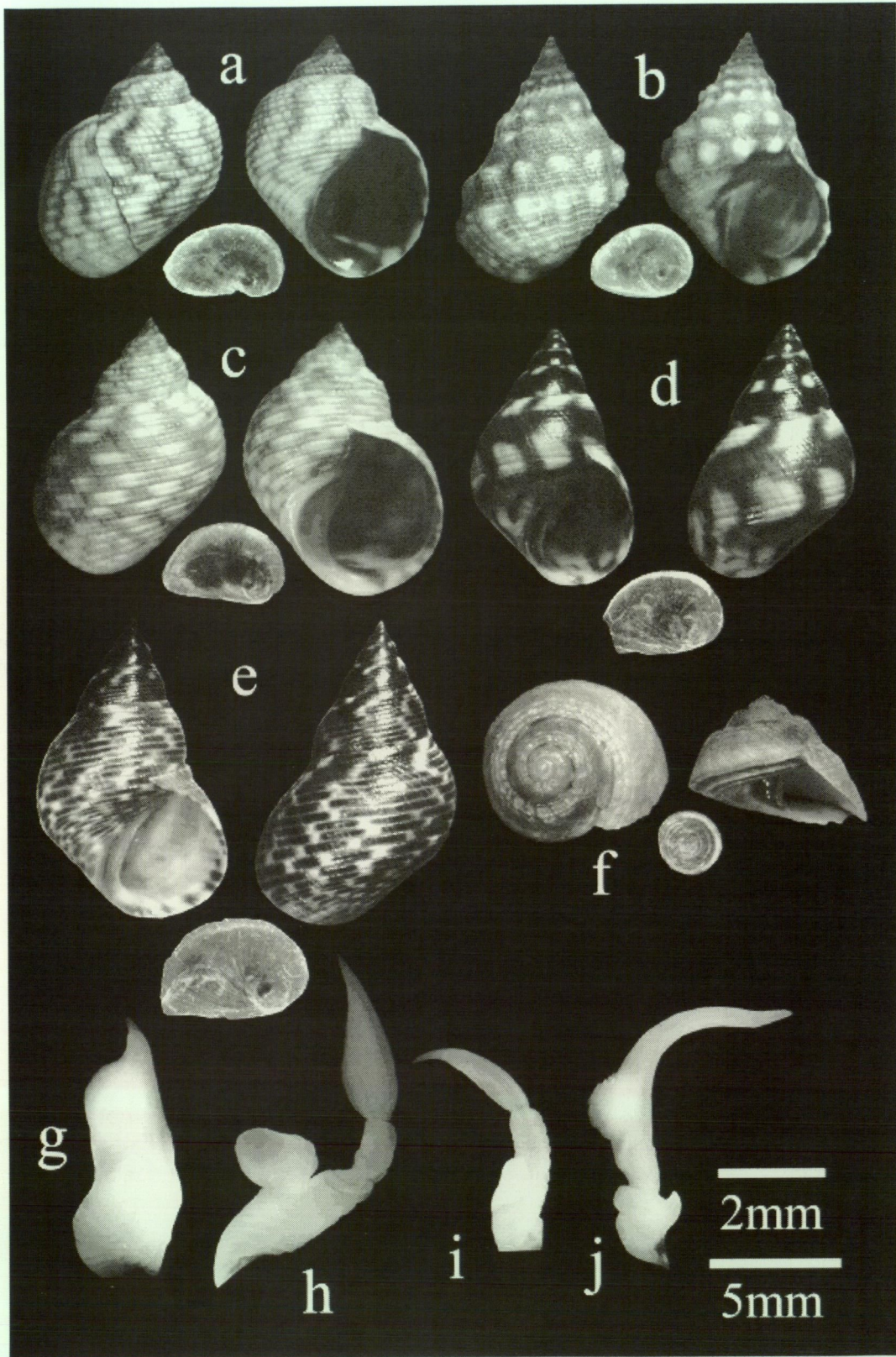


Figure 2 Littorinids recorded from Thailand. a. *E. feejeensis*, Ko Kumpun.(BIMS-M1185) b. *E. trochoides*, Ko Prao-nok, Sub-amphur Ko Chang.(BIMS-M1186) c. *E. vidua*, Yai Bay, Sub-amphur Ko Kut, Trat Province.(BIMS-M1187) d. *L. undulata*, Had Kalim, Amphur Kratu, Phuket Province.(BIMS-M1183) e. *L. strigata*, Ban Cha-ngoe, Tumbon Takienthong, Amphur Kanjanadit, Surat Thani Province.(BIMS-M1184) f. *P. roepstorffiana*, Mai ngarm Bay, Ko North Surin, Phangnga Province.(BIMS-M1188) g. Penis of *L. articulata*, Samed, Amphur Moeng, Chonburi Province. h. Penis of *L. bengalensis*, Chaomai Beach, Tumbon Ko Libong, Amphur Kuntung, Trang Province. i. Penis of *L. intermedia*, Mai ngarm Bay, Ko North Surin, Phangnga Province. j. Penis of *L. strigata*, Ban Cha-ngoe, Tumbon Takienthong, Amphur Kanjanadit, Surat Thani Province. Scales for a – e = 5mm; f – j = 2mm.

Table 1 Habitats occupied by littorinids in Thailand.

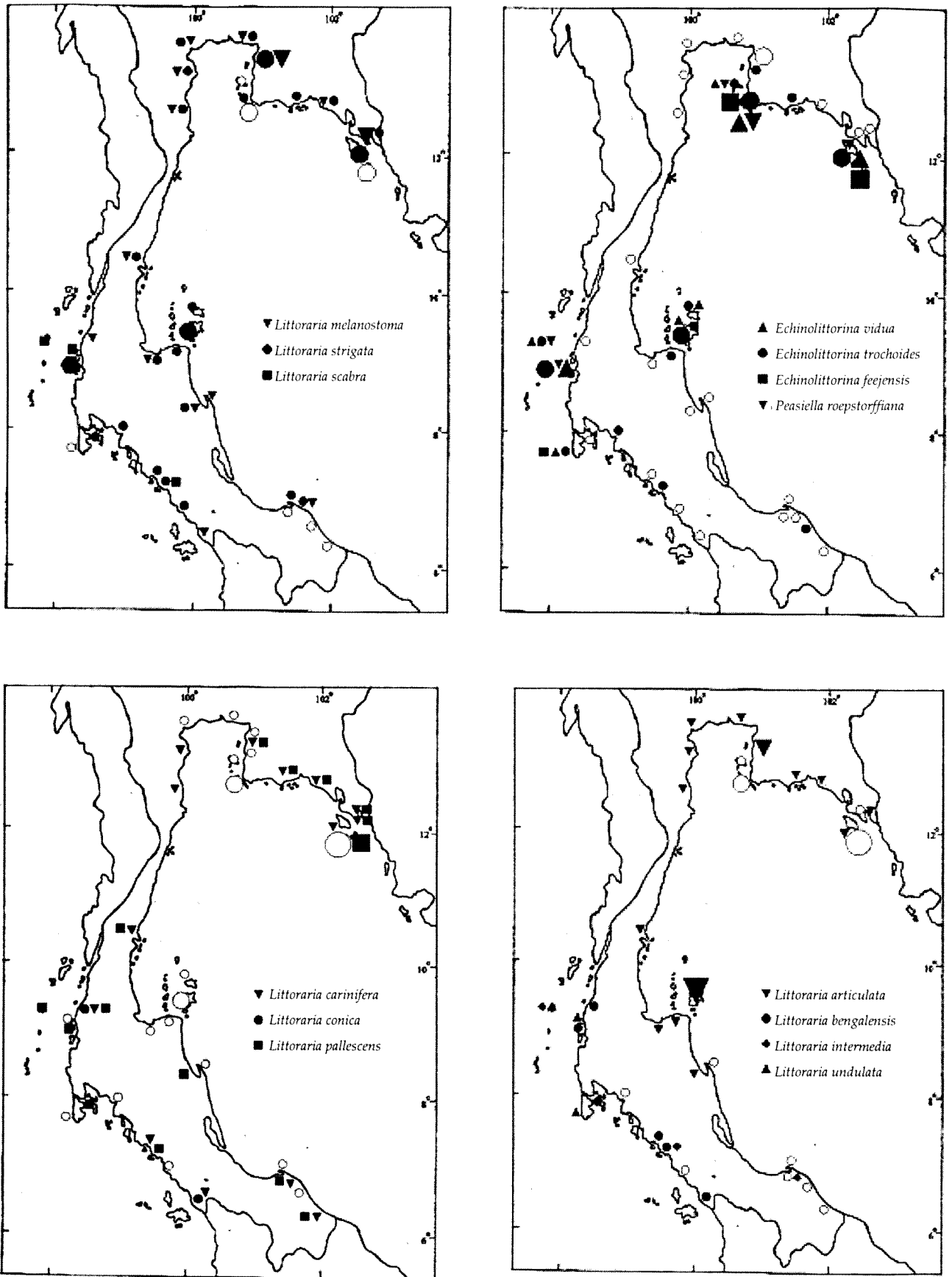
Species	No. stations	Habitats occupied
<i>Littoraria articulata</i> (Philippi, 1846)	19	Rocks and seawalls, house and pier poles, muddy sand, mangroves: <i>Rhizophora mucronata</i> , <i>Rhizophora apiculata</i> , <i>Avicennia alba</i> , <i>Avicennia marina</i> , <i>Sonneratia alba</i> , <i>Sonneratia griffithii</i> , <i>Sonneratia caseolaris</i> , <i>Lumnitzera racemosa</i> , <i>Ceriops decandra</i> , <i>Ceriops tagal</i> . Sedge: <i>Sesuvium portulacastrum</i>
<i>Littoraria bengalensis</i> Reid, 2001	6	Mangroves: <i>A. alba</i> , <i>A. marina</i> , <i>S. griffithii</i> , <i>R. apiculata</i> , <i>C. decandra</i> , <i>Aegialites rotundifolia</i> . Ground cover: <i>Finlaysonia maritima</i> .
<i>Littoraria carinifera</i> (Menke, 1830)	14	Rocks and seawalls, house and pier poles, muddy sand, mangroves: <i>R. apiculata</i> , <i>R. mucronata</i> , <i>A. alba</i> , <i>A. marina</i> , <i>C. tagal</i> , <i>Bruguiera cylindrica</i> , <i>Xylocarpus granatum</i> , <i>S. griffithii</i> , <i>L. racemosa</i> , <i>C. decandra</i> , <i>A. rotundifolia</i> . <i>Nypa fruticans</i> . Climber: <i>F. maritima</i> . Sedge: <i>S. portulacastrum</i> .
<i>Littoraria conica</i> (Philippi, 1846)	2	Mangroves: <i>R. apiculata</i> , <i>R. mucronata</i> , <i>C. decandra</i> and <i>A. rotundifolia</i> Climber: <i>F. maritima</i>
<i>Littoraria intermedia</i> (Philippi, 1846)	3	Rocks and seawalls, mangroves: <i>R. apiculata</i> , <i>A. alba</i> , <i>A. marina</i> and <i>S. griffithii</i>
<i>Littoraria melanostoma</i> (Gray, 1839)	16	Rocks and seawalls, muddy sand, mangroves: <i>A. marina</i> , <i>A. alba</i> , <i>R. apiculata</i> , <i>R. mucronata</i> , <i>S. griffithii</i> , <i>S. caseolaris</i> , <i>S. alba</i> , <i>C. decandra</i> , <i>A. rotundifolia</i> , <i>L. racemosa</i> , <i>C. tagal</i> . Sedge: <i>S. portulacastrum</i> . Climber: <i>F. maritima</i> ,
<i>Littoraria pallescens</i> (Philippi, 1846)	17	Rocks and seawalls, house and pier poles, mangroves: <i>R. apiculata</i> , <i>R. mucronata</i> , <i>A. alba</i> , <i>A. marina</i> , <i>S. griffithii</i> , <i>S. alba</i> , <i>L. racemosa</i> , <i>C. decandra</i> , <i>C. tagal</i> , <i>B. cylindrical</i> , <i>X. granatum</i> and <i>A. rotundifolia</i> Palm: <i>Nypa fruticans</i> .
<i>Littoraria scabra</i> (Linnaeus, 1758)	3	Rocks and seawalls, mangroves: <i>R. mucronata</i> , <i>R. apiculata</i> , <i>A. alba</i> , <i>A. marina</i> and <i>S. griffithii</i>
<i>Littoraria strigata</i> (Philippi, 1846)	32	Rocks and seawalls, house and pier poles, muddy sand, mangroves: <i>R. mucronata</i> , <i>R. apiculata</i> , <i>A. alba</i> , <i>A. marina</i> , <i>S. alba</i> , <i>S. griffithii</i> , <i>S. caseolaris</i> , <i>L. racemosa</i> , <i>C. decandra</i> , <i>C. tagal</i> . Sedge: <i>S. portulacastrum</i>
<b>Rocky shore species</b>		
<i>Littoraria undulata</i> (Gray, 1839)	3	Rocks and seawalls
<i>Echinolittorina feejeensis</i> (Reeve, 1857)	7	Rocks and seawalls
<i>Echinolittorina trochooides</i> (Gray, 1839)	26	Rocks and seawalls, mangroves: <i>R. apiculata</i> and <i>A. marina</i>
<i>Echinolittorina vidua</i> (Gould, 1859)	17	Rocks and seawalls, mangroves: <i>A. marina</i>
<i>Peasiella roepstorffiana</i> (Nevill, 1885)	7	Rocks and seawalls

from the sediment, and few were above 1 m. On the lower parts of the trees they occurred widely on trunks, pneumatophores, branches, and leaves. *Littoraria pallescens* occurred primarily in the foliage higher up on the trees at heights of up to 5 m. *Echinolittorina* and *Peasiella* occur on primarily on intertidal rocks though occasional individuals were found in the seaward fringe of mangroves; *Littoraria undulata* occupied a similar rock habitat.

A dendrogram calculated on the occurrences of all species at all 50 stations (Figure 4) demonstrates that there are two clear assemblages: seven species of *Littoraria* which live in close association with mangroves, and seven species which tend to occur on rocky shores, though they also occur in mangroves. The latter group includes the rocky shore *L. undulata* and two mangrove species, *L. intermedia* and *L. scabra*.

## DISCUSSION

Rosewater (1970, 1972) and Reid (1986a, 1989b, 2001a, 2001b; Reid and Mak, 1998) reported 14 species of littorinids in three genera in Thailand as part of their broader surveys of Indo-Pacific Littorinidae. All except two of these species were reported in the present paper, with many additional localities presented for most species. Reid (2001) found *Echinolittorina reticulata* along the western coast of Thailand but it was not found in the present study. *Peasiella patula* was recently described from Singapore by Reid and Mak (1998), with a record of Pattaya, Thailand included in the description. A trip was made to Pattaya and the nearby islands to search for this species, but the record could not be confirmed. Two species were recorded for the first time in Thailand. *Littoraria conica* was found in only two places in southern Thailand, both on the



**Figure 3** Distribution maps of littorinids in Thailand. Empty circles represent stations at which none of the mapped species were found. Larger symbols indicate records from more than one station that are too close to separate on the map.

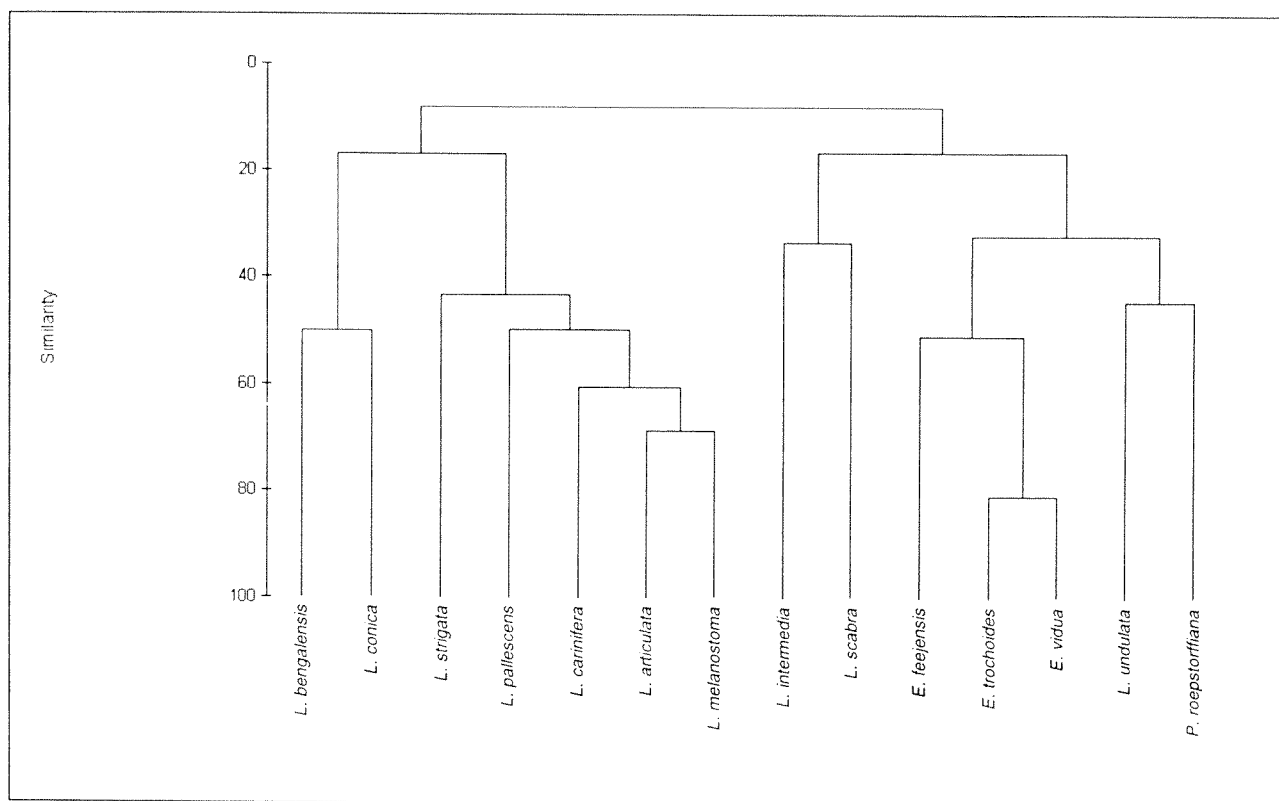


Figure 4 Dendrogram of similarity of littorinids collected at 50 stations in Thailand.

Andaman Sea. *Echinolittorina feejeensis* occurred on scattered granite rocks on sandy beaches in the splash zone of offshore islands where the water is clear both in the Gulf of Thailand and the Andaman Sea. It is dominant at Ko Kumpun, Trat Province. Altogether, there have now been 16 species of Littorinidae recorded in Thailand.

The two coasts of Thailand are both part of the vast Indo-West Pacific faunal region. While the Indo-West Pacific is considered to be a distinct biogeographical region, it is well known that there are some differences between the biota of the western Pacific Ocean and eastern Indian Ocean. Most mollusc species are widespread throughout the region. Wells (2002) studied distribution patterns of 1268 species of shallow water molluscs in the Indo-West Pacific, including littorinids. Diversity was higher (745 species) in the coral triangle, which included the Pacific coast of Thailand than in the eastern Indian Ocean (542 species), which included the Andaman Sea coast of Thailand. A small proportion (<6%) of the molluscs were restricted to one of the two areas. Recent studies (e.g. Benzie, 1999; Williams *et al.*, 2002) have shown that the distinction between Indian and Pacific Ocean populations also occurs at a genetic level within a single species. The reasons for the separation of the two areas are complex. At present the oceans are continuous, which allows at least some genetic exchange between the two areas.

During Pleistocene periods of lower sea level the tropical portions of the two oceans were separated, allowing allopatric speciation to occur. The most recent period of lowered seawater was approximately 18,000 years ago, when sea levels were 130 m lower than now (Chappel and Shackleton, 1986).

The distribution of littorinids in Thailand fits into this general pattern. Most (10) of the littorinids found in the present study occurred on both coasts of Thailand, including all of the species of *Echinolittorina* and *Peasiella*, and most of the *Littoraria*. Four of the *Littoraria* (*L. bengalensis*, *L. conica*, *L. scabra*, and *L. undulata*) occurred only on the Andaman Sea side of the country. The known distribution of *L. bengalensis* is restricted to the Indian Ocean between India and Thailand (Reid, 1999). Reid (1986a) records *L. conica* and *L. scabra* from sites in the Pacific Ocean east of Thailand, and Rosewater (1970) presents similar data for *L. undulata*, and the species have been found in peninsular Malaysia. However, neither author records these species in the Gulf of Thailand. Granted the relatively few sites that had been examined in the Gulf of Thailand, the absence of records in the Gulf could have been real or an artefact of the lack of samples. The present study demonstrates the absence is real.

In most respects, the habitats occupied by *Littoraria* in Thailand are similar to those reported

by Reid (1985; 1986a, 2001b), though individual species in Thailand occur on mangroves from which they were previously not recorded. In fact, individual species were found on up to 14 different plant species. Reid (1985) showed that individual species are zoned on the shoreline. The present study demonstrates that the zonation is not specific to a particular type of tree, or necessarily even restricted to trees, but at the right tidal height species living in mangroves will inhabit a wide variety of trees. Some are also found on rocky or other wooden substrates, as noted by Reid (1986a). The main habitat difference that we found is a small proportion of several species, such as *L. strigata*, *L. articulata* and *L. melanostoma*, occurring on intertidal sand and mud among the mangroves, including the seaward pneumatophore zone. These animals were actively crawling between the pneumatophores and had not been dislodged from an overhanging part of the mangrove. Perhaps the presence of a small proportion of the populations on the mud surface is due to the moister conditions and heavier rainfall in Thailand compared with Townsville, Australia, where Reid (1986a) did most of his work. He also (Reid, 1985) worked in other areas, including two localities in Thailand, but did not find *Littoraria* on the mud surface in the other areas he examined.

Aside from *L. undulata*, all of the *Littoraria* species found in Thailand were mangrove species. Reid (1986a) reported that at least three of the *Littoraria* species living in mangroves are "oceanic" species which live in less turbid water than "continental" species which live in areas of greater turbidity. The "oceanic" species are *L. intermedia*, *L. pallescens* and *L. scabra*. The dendrogram (Figure 4) provides some support for this hypothesis. There is a clear grouping of rocky shore species comprised of the three species of *Echinolittorina*, one species of *Peasiella roepstorffiana* and *L. undulata*. Two of the three "oceanic" species (*L. intermedia* and *L. scabra*) have a loose association with the rocky shore species. The combination of rocky shore and mangrove habitats occupied by the two species allows them to live in both coastal and oceanic regions. However, the third "oceanic" species, *L. pallescens*, is clearly grouped with the *Littoraria* species found in mangroves, not with the rocky shore species. Examination of the distributional maps presented by Reid (1986a) indicates that the three "oceanic" species occur in the open water areas of the Pacific Ocean but also in the muddier waters of southeast Asia, including Thailand and the Malaysian peninsula. An alternative hypothesis is that diversity of *Littoraria* is greatest in the southeast Asian area, and decreases with increasing distance in all directions (east, west, north and south) in the Indo-Pacific. This parallels the general distributional pattern found in molluscs (e.g. Wells, 2002) and many other groups. In this context, the

distributional patterns of *Littoraria* are consistent with the centre of biodiversity in the 'coral triangle', with lower diversity with increasing distance from the central triangle rather than a division into "continental" and "oceanic" species.

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## Appendix 1 Descriptions of sites examined for littorinids in Thailand.

- Site 1.** Yai Bay, Ko Kut, Ko Kut sub-amphur, Trat (11°36'37.5"N; 102°35'38.5"E) 5 Apr 2002. Rocky shore. *L. pallescens*, *L. strigata*, *E. feejeensis*, *E. trochoides*, *E. vidua*, *P. roepstorffiana*. **Site 2.** South of Ko Rad, Ko Kut sub-amphur, Trat (11°40'22"N; 102°31'35.5"E) 19 Nov 2001 Sandy beach with rocks. *L. strigata*, *E. feejeensis*, *E. trochoides*, *E. vidua*. **Site 3.** Hin Kongwaichaek, Ko Chang, Trat (11°57'21.2"N; 102°21'41.6"E) 18 Nov 2001 Rocky shore. *E. trochoides*, *E. vidua*. **Site 4.** Ko Krum, Ko Chang, Trat (11°55'1.7"N; 102°21'43.2"E) 18 Nov 2001 Rocky shore. *L. pallescens*, *E. trochoides*. **Site 5.** Ko Karm, Mak Is., Ko Chang, Trat (11°49'27.3"N; 102°27'48.2"E) 20 Nov 2001 Rocky shore. *E. trochoides*, *E. vidua*. **Site 6.** East of Ko Ra yungnork, Mak Is., Ko Chang, Trat (11°41'17.8"N; 102°27'16.6"E) 20 Nov 2001 Rocky shore. *E. trochoides*, *E. vidua*. **Site 7.** Ko Kumpun, Mak Is., Ko Chang, Trat (11°46'35.9"N; 102°21'48.6"E) 21 Nov 2001 Rocky shore. *E. feejeensis*, *E. trochoides*, *E. vidua*. **Site 8.** Ko Prao nok, Ko Chang, Trat (11°58'15.5"N; 102°23'47.5"E) 22 Nov 2001 Pier poles. *L. strigata*. **Site 9.** Ban Salukpet, Ko Chang, Trat (11°59'45.5"N; 102°22'32.5"E) 18–19 Nov 2001 A few *Avicennia marina* 2–3 m high and house poles. *L. pallescens*, *L. carinifera*, *L. strigata*, *L. articulata*. **Site 10.** Laem Hin, Ban Prednai, Moeng, Trat (12°9'48"N; 102°34'36.3"E) 17 Nov 2001 *Rhizophora apiculata* and *Avicennia alba* 5–7 m high and flat stones. *L. carinifera*, *L. pallescens*, *L. melanostoma*. **Site 11.** Ban Prednai mangrove, Moeng, Trat (12°7'38.9"N; 102°30'22.9"E) 7 Nov 2001 *Sonneratia griffithii*, *Avicennia alba*, *A. marina*, *Rhizophora apiculata*, *R. mucronata*, *Ceriops tagal*, *Bruguiera cylindrica*, and *Xylocarpus granatum* 5–10 m high. *L. pallescens*, *L. carinifera*, *L. strigata*, *L. articulata*, *L. melanostoma*. **Site 12.** Kung Kraben, Tamai, Chanthaburi (12°33'54.1"N; 101°54'9"E) 15 Dec 2002 Plantation area, with plants 1.5–4 m high, mostly *R. apiculata*, but also *R. mucronata*, *Lumnitzera racemosa*, *Ceriops decandra*, *C. tagal*, *A. alba*, *A. marina* and *Sonneratia alba*. *L. pallescens*, *L. carinifera*, *L. strigata*, *L. articulata*, *L. melanostoma*. **Site 13.** Tumbon Bankrum, Klaeng, Rayong (12°39'31.2"N; 101°39'52.3"E) 3 Dec 2001. Scattered *A. alba*, and some *R. apiculata* and *R. mucronata* and a small rock wall for protection from waves. *L. pallescens*, *L. carinifera*, *L. strigata*, *L. articulata*, *E. trochoides*. **Site 14.** Kord beach, Sattahip, Chonburi (12°41'45"N; 100°51'25.5"E) 29 Nov 2001 Scattered rocks. *E. trochoides*, *E. vidua*. **Site 15.** Krajong Bay, Ko Kram, Sattahip, Chonburi (12°41'15.5"N; 100°46'47.5"E) 26 Jan 2002 Rocky shore. *E. feejeensis*, *E. trochoides*, *E. vidua*, *P. roepstorffiana*. **Site 16.** Kam Bay, Ko Kram, Sattahip, Chonburi (12°41'9.8"N; 100°47'38.5"E) 27 January 2002 Scattered rocks. *E. trochoides*, *E. vidua*, *P. roepstorffiana*. **Site 17.** Ko Yor, Sattahip, Chonburi (12°37'1.5"N; 100°53'7.5"E) 27 Jul 2002 Scattered rocks. *E. feejeensis*, *E. trochoides*, *E. vidua*, *P. roepstorffiana*, *L. strigata*. **Site 18.** Ko Larn, Pattaya, Chonburi (12°54'58.2"N; 100°46'19.4"E) 23 Feb 2002 Rocks. *E. trochoides*, *E. vidua*, *P. roepstorffiana*. **Site 19.** Koa Sammuk, Moeng, Chonburi (13°18'35.5"N; 100°54'21.4"E) 30 Oct 2002 Rocky shore. *L. strigata*, *L. articulata*, *E. trochoides*. **Site 20.** Bang Prong canal, Angsila, Moeng, Chonburi (13°18'33.8"N; 100°55'7.3"E) 30 Jul 2002 *A. marina*, *S. griffithii* and *Sesuvium portulacastrum*. *L. pallescens*, *L. strigata*, *L. articulata*, *L. melanostoma*, *L. carinifera*. **Site 21.** Samed, Moeng, Chonburi (13°20'21.2"N; 100°57'31.7"E) 4 Nov 2002 *A. alba* 4–7 m high. *L. strigata*, *L. articulata*, *L. melanostoma*. **Site 22.** Bangpu, Bangpu, Samut Prakarn (13°30'39.7"N; 100°38'56.2"E) 21 Jul 2002 *A. marina* and *A. alba* 3–7 m high and rocks. *L. strigata*, *L. articulata*, *L. melanostoma*. **Site 23.** Had, Laemloug, T.Laempukbia, Banlaem, Phetchaburi (13°2'13.4"N; 100°5'50.3"E) 14 Dec 2002 *R. apiculata*, *R. mucronata*, and *A. alba* 7–10 m high. *L. strigata*, *L. articulata*, *L. melanostoma*, *L. carinifera*. **Site 24.** PTT mangrove, T. Paknampran, Pranburi, Prachuap Khiri Khan (12°23'17.5"N; 99°59'2.3"E) 9 Dec 2002 *A. marina*, *R. mucronata*, and *R. apiculata* 3–4 m high. *L. strigata*, *L. articulata*, *L. melanostoma*, *L. carinifera*. **Site 25.** E-led canal, Chumphon Islands Marine Park, Chumphon (10°21'1.2"N; 99°14'2.1"E) 24 Dec 2001 *R. apiculata* and *R. mucronata* 15 m high, but some planted areas 1.5 m high. *L. strigata*, *L. articulata*, *L. melanostoma*, *L. carinifera*, *L. pallescens*. **Site 26.** Ban Cha-ngoe, Tumbon Takienthong, Kanjanadit, Surat Thani (12°40'53.9"N; 100°46'38.7"E) 3 Dec 2002. *R. apiculata* mixed with *A. marina*. *R. mucronata* and *S. alba* 5–15 m high. *L. strigata*, *L. articulata*, *L. melanostoma*. **Site 27.** Don Sak Ferry, Don Sak, Surat Thani (9°19'55.7"N; 99°41'28.5"E) 19 Dec 2001 Rocks. *L. strigata*, *L. articulata*, *E. trochoides*. **Site 28.** Ban Taling ngam, Ko Samui, Surat Thani (9°42'47"N; 99°58'33.7"E) 22 Dec 2001 Granite rocks. *L. strigata*, *L. articulata*, *E. trochoides*. **Site 29.** Ko Kor Ma, Ko Pangun, Surat Thani (9°47'27"N; 99°58'52.8"E) 21 Dec 2001 Scattered rocks. *L. strigata*, *L. articulata*, *E. trochoides*, *E. vidua*. **Site 30.** Laem Yai, Ko Samui, Surat Thani (9°33'50.6"N; 99°55'6.9"E) 20 Dec 2001 Rocky shore. *L. strigata*, *L. articulata*, *E. trochoides*, *E. vidua*, *E. feejeensis*. **Site 31.** Hin Ta Hin Yai, Ko Samui Surat Thani 22 Dec 2001 (9°27'3.7"N; 100°2'37.5"E) Scattered granite rocks. *L. strigata*, *L. articulata*, *E. trochoides*. **Site 32.** Tumbon Pak Nakorn, Moeng, Nakhon Si Thammarat (8°28'7.8"N; 100°3'52.9"E) 28 Aug 2002 *R. mucronata*, *A. alba* and *A. marina* 2–4 m high. *L. strigata*, *L. articulata*, *L. melanostoma*, *L. pallescens*. **Site 33.** Pak Panung Bay, Pak Panung, Nakhon Si Thammarat (8°23'40.7"N; 100°10'18.5"E) 27 Aug 2002. Mouth of Pak Panung canal. Mostly *R. apiculata*, and *R. mucronata* 5–15 m high. *L. melanostoma*. **Site 34.** Ban Laem, Tachi, Yaring, Pattani (6°55'40.8"N; 101°14'38.0"E) 13 Oct 2002 Rock seawall. *L. strigata*. **Site 35.** Ban Dee, Yaring, Pattani (6°55'15.5"N; 101°19'35.5"E) 13 Oct 2002 *R. mucronata* 5 m high in Pattani Bay. *L. pallescens*. **Site 36.** Ban Da To, Yaring, Pattani (6°54'18.4"N; 101°20'19.2"E) 13 Oct 2002 *A. marina* 4–5 m high, Pattani Bay. *L. strigata*, *L. melanostoma*, *L. carinifera*, *L. intermedia*. **Site 37.** KaeKae Beach, Tumbon Nambo, Panarei, Pattani (6°50'16.3"N; 101°33'28.9"E) 4 Dec 2002 Scattered rocks. *E. trochoides*. **Site 38.** Naratat Beach, Moeng, Narathiwat (6°26'32.5"N; 101°49'18.6"E) 4 Dec 2002 Small *L. racemosa* and *Nypa fruticans*. *L. carinifera*, *L. pallescens*. **Site 39.** Ban Je Bilung, Je Bilung, Satun (6°38'21.2"N; 99°58'3.8"E) 5 Dec 2002. *R. apiculata* and *R. mucronata* 5–10 m. *L. carinifera*, *Littoraria conica*, *L. bengalensis*, *L. melanostoma*. **Site 40.** Petra Is. Nat.Park, Tumbon Pakbara, Langu, Satun (6°49'43"N; 99°45'31.1"E) 5 Dec 2002 Scattered *A. marina* 3–4 m high. *L. strigata*. **Site 41.** Chaomai Beach, Kun Tung, Trang (7°18'5.5"N; 99°24'19.1"E) 31 Aug 2002 *A. alba*, *A. marina*, and *S. griffithii*. *L. pallescens*, *L. strigata*, *L. intermedia*, *L. bengalensis*, *L. scabra*, *E. trochoides*. **Site 42.** Pak Meng Beach, Tumbon Ko Libong, Kun Tung, Trang (7°27'37.6"N; 99°20'23.6"E) 6 Dec 2002 *A. marina* 3–5m high. *L. carinifera*, *L. bengalensis*, *L. strigata*. **Site 43.** Shell cemetery, Tumbon Saithai, Moeng, Krabi (8°00'53.2"N; 98°53'11.8"E) 6 Dec 2002 Rocky shore and dead wood. *L.*

*strigata*, *E. trochoides*. **Site 44.** Ta la Beach, Tumbon Ban pa klok, Talang, Phuket (8°1'10.8"N; 98°24'51.2"E) 7 Dec 2002 *A. marina*, *R. mucronata*, and *S. griffithii* 5–7 m high. *L. pallescens*, *L. strigata*, *L. bengalensis*. **Site 45.** Kalim Beach, Kratu, Phuket (7°54'11"N; 98°17'53.6"E) 7 Dec 2002 Scattered rocks. *L. undulata*, *E. trochoides*, *E. vidua*, *E. feejeensis*. **Site 46.** Mai ngarm Bay, Ko North Surin, Phangnga (9°26'27.7"N; 97°52'48.5"E) 20 Apr 2002 Rocky shore with scattered *R. apiculata* and *R. mucronata*. *E. trochoides*, *E. vidua*, *P. roepstorffiana*, *L. undulata*, *L. intermedia*, *L. scabra*, *L. pallescens*. **Site 47.** Ko Jong, Kuraburi, Phangnga (9°13'12.5"N; 98°20'55.7"E) 2 Sep 2002 *A. marina*, *R. mucronata*, and *S. griffithii*. *L. scabra*, *L.*

*strigata*, *L. bengalensis*, *L. pallescens*, *E. vidua*, *E. trochoides*. **Site 48.** Ko Ra, Kuraburi, Phangnga (9°15'21.5"N; 98°22'30.5"E) 2 Sep 2002 Rocky shore. *E. trochoides*, *E. vidua*, *P. roepstorffiana*, *L. undulata*, *L. strigata*. **Site 49.** Laem Mai Kaew, Ban Ta lei nok, Tumbon Naka, Suksumran sub-amphur, Ranong (9°27'58.5"N; 98°26'13.9"E) 3 Sep 2002 *Finlaysonia maritima*, *C. decandra* and *Aegialites rotundifolia*. *L. carinifera*, *L. melanostoma*, *L. bengalensis*, *L. conica*, *L. pallescens*. **Site 50.** Klong Kone, Tumbon Klong Kone, Moeng, Samut Songkram (13°19'34.5"N; 99°58'30"E) August 2003. *Sonneratia caseolaris*, 5–10 m high. *L. articulata*, *L. strigata*, *L. melanostoma*.

# Guide to Authors

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