

CHAPTER 3

RESULTS

1. Environmental factors

1.1 Tides and shore profile

Tides at Ko Maphrao are semi-diurnal. The maximum tidal range from the tide tables during 1978 was 2.9 meters. The highest tide was 3.7 meters and the lowest 0.45 meter above the chart datum.

The innermost mangrove forest, Station 1, lay between the extreme high water spring (EHWS) and mean high water spring (MHWS) levels, and was wetted by 42% of the tides. The middle part of the forest, Station 2, was situated between the mean high water spring (MHWS) and mean high water neap (MHN) levels and was wetted by 74% of the tides. The seaward mangrove, Station 3, between the mean high water neap (MHN) and mean low water neap (MLWN) levels, was inundated by 96% of the tides. The mud flat, Station 4, was within the mean high water neap level and was covered by 100% of the tides. The shore profile of the study area is presented in Fig. 3 with the tidal levels.

1.2 Soil

The soil composition result of each station is shown in Table 2. The mean particle diameters from each station were determined

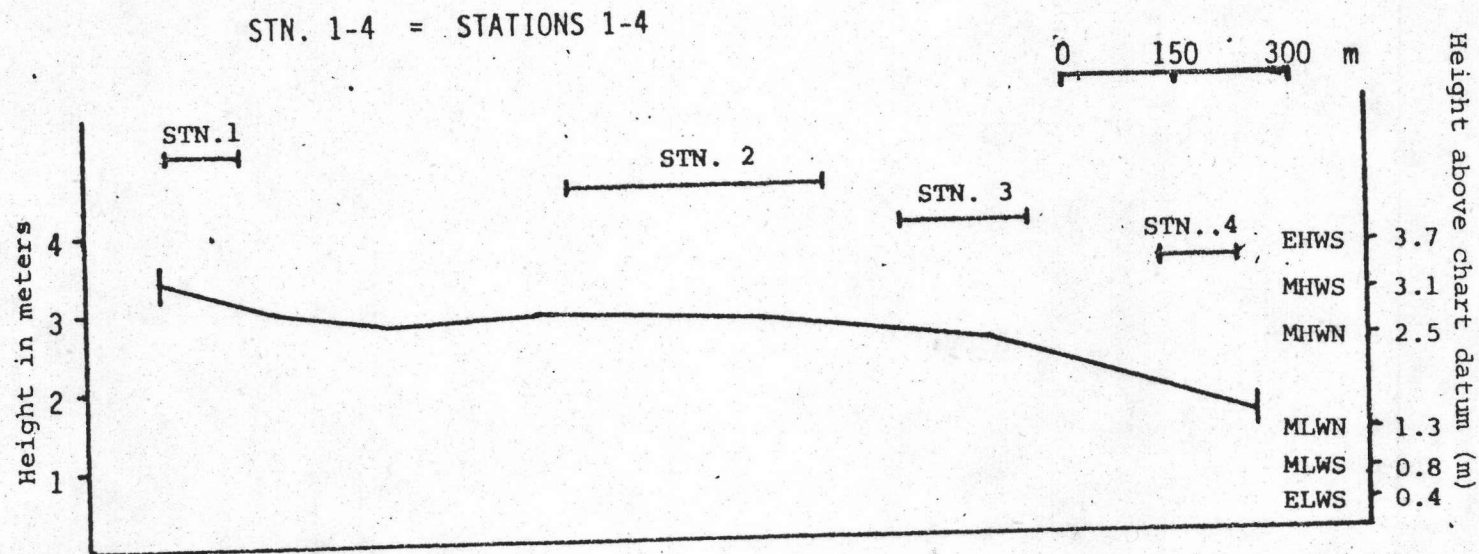


Figure 3. Shore profile of the study area at Ko Maphrao mangrove forest, Phuket, showing positions of stations with relation to tidal levels.

PERCENTAGE

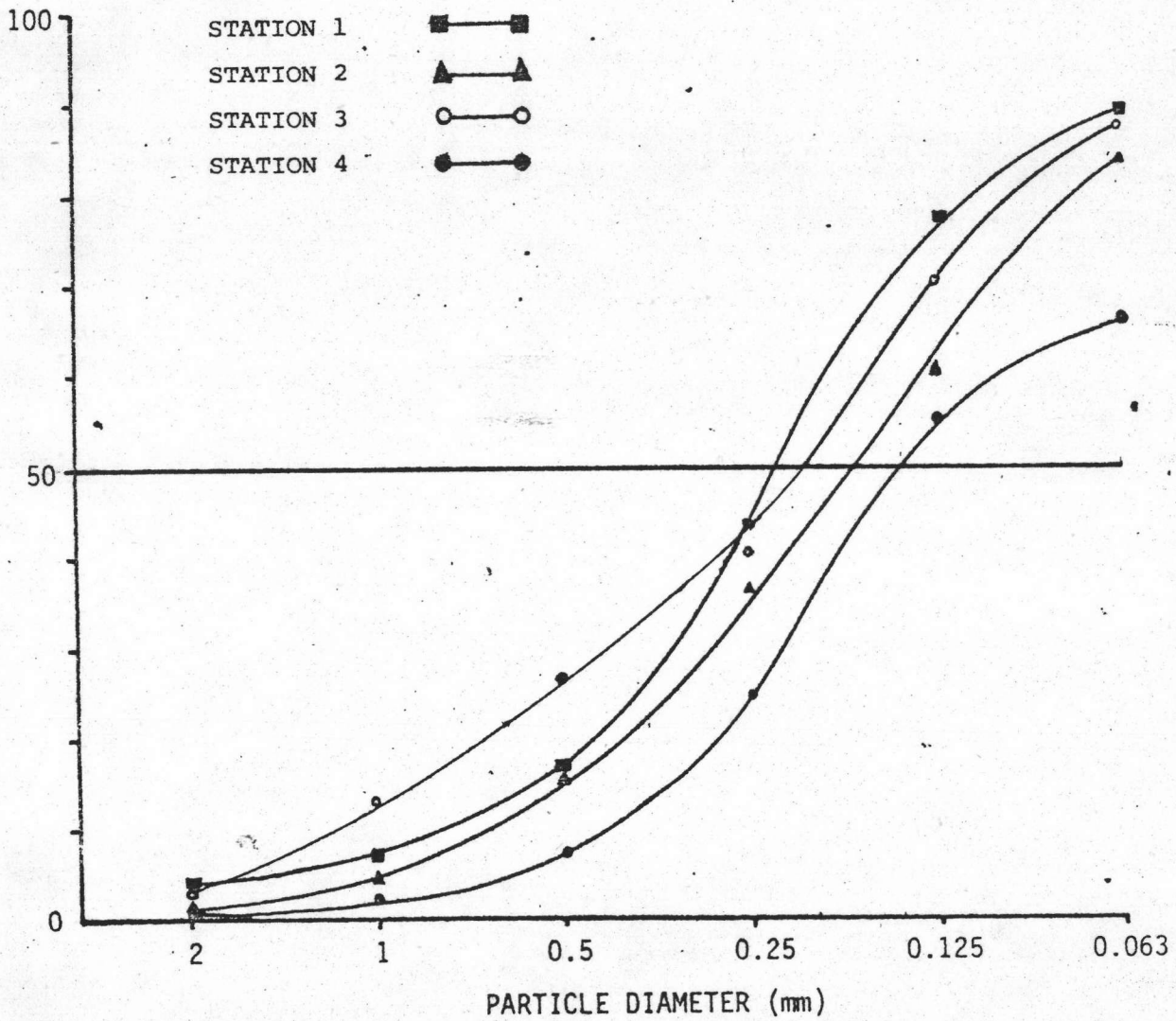


Figure 4. Cumulative curves of percentage composition of soil sediments of four stations, plotted against particle size.

Table 2. Environmental factors in each station at Ke Maphrao Mangrove forest.

STATION	1 (innermost)	2 (middle)	3 (seaward)	4 (mud flat)
Particle size (% of total dry weight)				
Gravel (>2 mm)	4.5	1.5	3.6	1.1
Very coarse sand (1.0-2.0 mm)	3.0	2.7	9.7	2.3
Coarse (0.5-1.0 mm)	9.7	11.4	13.0	4.3
Medium sand (0.25-0.5 mm)	26.5	20.9	14.1	17.1
Fine sand (0.125-0.25 mm)	34.5	23.6	30.7	30.6
Very fine sand (0.063-0.125 mm)	11.4	23.8	17.3	11.1
Silt-clay (<0.063 mm)	10.4	16.1	11.6	33.5
Mean particle diameter (mm)	0.24	0.17	0.21	0.14
Water content (% of wet weight)	21.9	27.5	25.4	35.7
Organic content (% of dry weight)	6.2	8.6	6.8	6.4
Soil water salinity (o/oo)	30.0	30.0	31.0	32.5
Soil water pH	6.6	6.5	6.8	7.1

graphically from the cumulative curves of percentage soil composition of each station (Fig. 4).

The soil of Station 1 is coarser compared to the other stations. It consists of 10.4% of silt-clay mixed with a high proportion of fine sand (34.5%) and medium sand (26.5%). The mean particle diameter is 0.24 mm. Soil in the mangrove forest Station 2 was the most muddy of the mangrove stations, containing 16.1% silt-clay. The mean particle diameter of 0.17 mm shows that the soil in Station 2 is finer than Stations 1 and 3. Station 3 has 11.6% silt-clay, and the mean particle diameter is 0.21 mm. Soil in the mud flat, Station 4, was rich in silt-clay, very fine sand and fine sand, totally making 75.2% of the sediment. The mean particle diameter of 0.14 mm in Station 4 is the smallest found in the study area.

It was found that water content of the soil varied in relation to particle size in such a way that, the amount of pore water decreased with increasing mean particle diameter of the sediment. Soil in the mud flat has the highest water content of 35.7%. Stations 2, 3 and 1 have values of 27.5%, 25.4% and 21.9% respectively.

The organic content of soils in the mangrove stations ranged from 6.2% to 8.6%. Generally the amount of organic matter increase with decreasing particle size of the soil (Ono, 1965; Newell, 1970). The soil of Station 4 is muddy and contains a high amount of silt-clay but the organic content of 6.4% is comparatively low (see Table 2). The result agrees with the findings of Frith et al. (1976) and Nateewathana

and Tantichodok (1980) who also found less organic matter in the fine grained mud-flat sediment compared to the mangrove forest stations having coarser soils. It indicates a different balance between input and decomposition of dead mangrove vegetation in the two types of biotopes.

1.3 Soil pore water

Salinity of soil water showed little variation, ranging from 30.0 o/oo in the innermost mangrove Station 1 to 31.0 o/oo in the seaward mangrove Station 3, and 32.0 o/oo of the mud flat soil water. Salinity measurements were determined during low tide and no rainfall. However, fluctuations in soil water salinity might be expected during a year, evidently under the influence of precipitation, evaporation and tidal factors (Sasekumar, 1974). When the high tides covered all the stations, the salinity of free water was about 31.0-32.0 o/oo through-out the forest. The study area is a typical marine environment.

The pH of soil water was also determined at low tide. Table 2 shows that the innermost and the middle parts of the forest were slightly more acidic than the seaward zone with pH ranging from 6.5 to 6.8 in the mangrove. In the mud flat, the soil water was slightly alkaline with the pH value of 7.1.

2. Fauna

At least 144 species of mangrove macrofauna were recorded from quantitative and qualitative samples from the Ko Maphrao mangrove forest. The list of macrofauna is presented in Appendix 1 together



with the mean density values. The fauna is dominated by polychaetes, crustaceans and molluscs. In addition, coelenterates, nemerteans, turbellarians, sipunculans, xiphosurans, echinoderms and fishes. Moreover, spiders, insects, snakes, birds and monkeys were present, but not studied in details.

Species in Appendix 1 without density values were not found in the quantitative quadrat samplings. They were collected in the earlier qualitative samplings. Densities of tree dwelling animals per unit area of tree trunks were not estimated, since emphasis of the present study is on fauna of the sediments.

2.1 Species composition and density of macrofauna within each station.

The fauna in each station at the Ko Maphrao mangrove forest are listed in Tables 3 to 6. They were grouped into 1) Epifauna (or surface fauna), 2) Infauna and 3) Tree fauna according to Berry (1972). Epifauna are animals living on the soil surface, sometimes venturing on to vegetation but not burrowing. Infauna are animals living beneath the surface of the soil, though often wandering on the surface. Tree fauna are confined to the vegetation.

STATION 1

This innermost mangrove station has fewer species than the more densely forested Stations 2 and 3 (Appendix 1). Fifty six species were found in this station : nemertean 1 sp., sipunculan 1 sp., polychaetes

7 spp., xiphosuran 1 sp., crustacean 34 spp., molluscs 10 spp. and fishes 2 spp. (Table 3). Only 37 species were present in the quadrat samplings, they were comprised of nemertean 1 sp., sipunculan 1 sp., polychaetes 7 spp., crustaceans 23 spp. and molluscs 5 spp..

A hermit crab, *Clibanarius padavensis*, was the only surface crustacean fauna in Station 1. Molluscs of the surface fauna were represented by two species of gastropods, *Assiminea brevicula* and *Cerithidea cingulata*. The latter was the most abundant epifaunal species in this station with mean density of $9.2/m^2$. Two species of fishes, *Ctenogobius vexillifer* and *Periophthalmus vulgaris*, were found in this station, especially on the mud bank.

The most abundant infaunal species were a sipunculan, *Phascolosoma arcuatum* and an ocypodid crab, *Tylodiplax tetratylophora*, with mean density values of 30.6 and 33.0 individuals per m^2 respectively. The common species of infauna were an errant polychaete, *Nereis onychophora*, a callianassid *Upogebia* sp., a small ocypodid crab *Ilyoplax obliquus*, a fiddler crab *Uca lactea* and a grapsid crab *Metaplax elegans* (see Appendix 1). One interesting fauna, a xiphosuran's (horse-shoe crab) juvenile species, was found semi-buried in the soil on the mud bank. The adults were not found in this station. Neither adults nor juveniles of the xiphosuran were found elsewhere in the study area.

Common tree dwelling fauna includes two species of cirripedes (*Balanus amphitrite* and *Chthamalus withersii*), two species of gastropods (*Littorina carinifera* and *L. scabra*) and two species of bivalves (*Isognomon ephippium* and *Saccostrea cucullata*). They were found common

especially on the channel banks. Tree fauna in this station were fewer in both numbers of species and individuals than the Stations 2 and 3 of the mangrove forest. They became fewer in the more landward part.

STATION 2

Station 2 is in the middle part of the mangrove forest. Eighty one species were collected from this station : nemertean 1 sp., sipunculan 1 sp., polychaetes 17 spp., crustaceans 40 spp., molluscs 19 spp. (gastropods 12 spp. and palaeocyprids 7 spp.), and fishes 3 spp. (Table 4). Only 57 species were recorded with density values, they were nemertean 1 sp., sipunculan 1 sp., polychaetes 16 spp., crustaceans 29 spp. and molluscs 1 sp..

The most abundant epifaunal species was *Cerithidea cingulata* with the density value of 41.2 /m². The common species of surface fauna were a hermit crab *Diogenes avarus*, and a gastropod *Assiminea brevicula* with mean density values of 2.4 and 1.8 per m² respectively. The number of epifaunal gastropod species in Station 2 was higher than in Station 1.

The abundant infaunal species were a sipunculan *Phascolosoma arcuatum*; crustaceans, *Upogebia* sp., *Ilyoplax delismani*, *Uca lactea* and *Tylodiplax tetratylophora*, the last species being most abundant of 36.8 per m². *Nereis onychophora* and *Perinereis aibuhitensis* were two common polychaete species. *Uca dussumieri*, *U. urvillei*, *U. vocans* were the common fiddler crabs. *Teilina opalina* and *Solen delesserti* were two common bivalve species burrowing in the soil in this area.

Table 3 : Fauna of Station 1 (the innermost mangrove station)

Surface fauna

Xiphosura	:	Xiphosuran juveniles (unidentified)
Crustacea	:	<i>Clibanarius padavensis</i>
Mollusca	:	<i>Assiminea brevicula</i> <i>Cerithidea cingulata</i>
Pisces	:	<i>Ctenogobius vexillifer</i> <i>Periophthalmus vulgaris</i>

Infauna

Nemertea	:	Nemertean sp. (unidentified)
Sipuncula	:	<i>Phascolosoma arcuatum</i>
Polychaeta	:	<i>Scoloplos sp.</i> <i>Mastobranchus sp.</i> Capitellid sp. (unidentified) <i>Ceratonereis sp</i> <i>Nereis onychophora</i> <i>Perinereis aibuhitensis</i> <i>Goniada sp</i>
Crustacea	:	Amphipod sp. (unidentified) <i>Sphaerosoma walkeri</i> <i>Ligia sp</i> <i>Petrolisthes lamarckii</i> <i>Alpheus euphrosyne</i> <i>Upogebia sp</i> <i>Thalassina anomala</i>

Ebalia malefactorix

Scylla serrata

Ilyoplax delsmanni

I. lingulatus

I. obliquus

Macrophthalmus definitus

Paracleistostoma microcheirum

Tylodiplax tetratylophora

Uca dusumieri

U. forcipata

U. lactea

U. urvillei

U. vocans

Uca juveniles

Chiromanthes indiarum

C. semperi

Holometopus sp.

Metaplax distinctus

M. elegans

Nanosesarma andersoni

Neoepisesarma versicolor

Parasesarma plicatum

Sarmatium crassum

S. germani

Grapsid juveniles (unidentified)

Mollusca

: *Striarca pectunculiformes*

Geloina erosa

Laternula truncata

Tree fauna

- Crustacea : *Balanus amphitrite*
Chthamalus withersii
- Mollusca : *Littorina carinifera*
L. scabra
Isognomon ephippium
Saccostrea cucullata
Teredo sp.

Species of tree dwelling fauna in station 2 did not differ from Station 1, but they occurred more in quantity. The common animals were *Balanus amphitrite*, *Saccostrea cucullata* and *Littorina scabra*.

STATION 3

In this seaward mangrove station, 93 species were found consisting predominantly of crustaceans 38 spp., molluscs 33 spp., and polychaetes 9 spp.. Additionally, coelenterates 2 spp., a platyhelminth species, a sipunculan species, a nemertean species, echinoderms 2 spp. and fishes 6 spp. were recorded (Table 5). Among these, 51 species were collected in quantitative samples : 2 species of sea anemones, nemertean 1 sp., sipunculan 1 sp., polychaetes 7 spp., crustaceans 23 spp., molluscs 16 spp., and fish 1 sp. (Appendix 1).

A hermit crab, *Diogenes avarus*, and a gastropod, *Assiminea brevicula* were two abundant surface fauna species. *Cerithidea cingulata* and *Naquetia (=Murex) capucina* were common on the floor. More species of epifaunal gastropods were present in this station. Fishes were represented by four species of gobiid fishes and two species of mud-skippers. The mud-skippers were common along the mud banks, however, their density was not estimated due to their rapid dispersal and escapement.

The most abundant infaunal species was a crab *Tylodiplax tetratylophora*. *Perinereis aibuhitensis*, *Lumbrinereis* sp., *Alpheus euphrosyne*, *Upogebia* sp., *Ilyoplax orientatis*, *Uca lactea*, *Metaplax elegans* and *Grafrarium tumidum* were common infaunal species. More

species of bivalve molluscs were found in this station. Two species of echinoderm fauna were collected : one holothurian species, *Holothuria parva*, and one brittle star species (unidentified). Both of them were not common.

Tree trunks and prop roots were populated by molluscs and barnacles. A mangrove oyster *Saccostrea cucullata* and a barnacle *Balanus amphitrite* were very common. *Isognomon ehippium* was found attached in clusters among the prop roots. A mangrove walking bivalve species, *Enigmonia aenigmatica*, attached to the lower tree stems and some big prop roots, but it was not common. Many gastropod species occurred higher up the tree trunks, branches and leaves; they were *Nerita articulata*, *N. chameleon*, *N. planospira*, *Littorina carinifera* and *L. scabra*.

STATION 4

In the mud flat station, 62 species were found consisting of crustaceans 25 spp., molluscs 17 spp., polychaetes 14 spp., fishes 3 spp., coelenterates 2 spp., and a nemertean species (Table 6). Fifty five of these species were collected in the quadrat samples. They were a nemertean species, polychaetes 14 spp., crustaceans 25 spp., molluscs 14 spp., and a fish species (Appendix 1).

In this station, a hermit crab *Clibanarius padavensis* became more common, fewer *Diogenes avarus* were found. *Cerithidea cingulata* was the most abundant epifauna. *Nassarius jacksonianus*, *N. globosus* and one unidentified gastropod species were also common on the mud flat. Three species of fishes were collected, but none of them were common.

Table 4 : Fauna of Station 2 (the middle mangrove station)

Surface fauna

Crustacea	:	<i>Clibanarius padavensis</i>
		<i>Diogenes avarus</i>
Mollusca	:	<i>Assiminea brevicula</i>
		<i>Cerithidea cingulata</i>
		<i>C. obtusa</i>
		<i>Telescopium telescopium</i>
		<i>Cerithium breve</i>
		<i>C. patulum</i>
		<i>Naquetia capucina</i>
		<i>Nassarius jacksonianus</i>
		<i>N. foreolatus</i>
Pisces	:	<i>Ctenogobius vexillifer</i>
		Gobiid fishes (unidentified)
		<i>Periophthalmus vulgaris</i>
Nemertea	:	Nemertean sp. (unidentified)
Sipuncula	:	<i>Phascolosoma arcuatum</i>
Polychaeta	:	<i>Heteromastus filiformis</i>
		<i>Mastobranchus sp.</i>
		<i>Parheteromastus tenuis</i>
		Capitellid sp. (unidentified)
		<i>Euclymene sp.</i>
		<i>Eteone sp. A</i>
		<i>Eteone sp. B</i>

Polynoid sp. (unidentified)

Polyodontes melanonotus

Ceratonereis sp

Leonnates sp.

Nereis onychophora

Perinereis aibuhitensis

Goniada sp.

Diopatra sp.

Ambrinereid sp. A (unidentified)

Ambrinereid sp. B (unidentified)

Crustacea

: Amphipod sp. (unidentified)

Sphaerosoma walkeri

Petrolisthes lamarckii

Alpheus euphrosyne

A. malabaricus

Upogebia sp.

Thalassina anomala

Scylla serrata

Epixanthus dentatus

Heteropanope glabra

Typhlocarcinus nudus

Ilyoplax delsmanni

I. lingulatus

I. longicarpus

I. obliquus

I. orientalis



Tylodiplax tetratylophora

Uca dussumieri

U. forcipata

U. lactea

U. triangularis

U. urvillei

U. vocans

Uca juveniles

Chiromanthes darwinensis

C. dussumieri

C. Haswelli

Clistocoeloma merguensis

Geosesarma sp.

Metaplax distinctus

M. elegans

Nanosesarma andersoni

Neopisesarma mederi

N. versicolor

Parasesarma plicatum

Sarmatium crassum

S. germani

Grapsid juveniles (unidentified)

Molluscs : *Striarca pectunculiformes*

Tellina opalina

Solen dolesserti

Laternula truncata

Tree fauna

- Crustacea : *Balanus amphitrite*
Chthamalus withersii
- Mollusca : *Nerita planospira*
Littorina carinifera
L. scabra
Isognomon ephippium
Saccostrea cucullata
Teredo sp.

Table 5 : Fauna of Station 3 (the seaward mangrove station)

Surface fauna

Platyhelminthes	:	Turbellarian sp. (unidentified)
Crustacea	:	<i>Clibanarius padavensis</i> <i>Diogenes avarus</i>
Mollusca	:	<i>Clithon oualaniensis</i> <i>Assiminea brevicula</i> <i>Cerithidea Cingulata</i> <i>Telescopium telescopium</i> <i>Cerithium patulum</i> <i>Naquetia capucina</i> <i>Nassarius jacksonianus</i> <i>N. livescens</i> <i>N. olivaceus</i> <i>N. foreolatus</i> <i>Melongena puligina</i> <i>Haminoea sp.</i> <i>Onchidium sp. A</i> <i>Onchidium sp. B</i> <i>Cassidula aurisfelis</i> <i>Ellobium aurisjudae</i>
Pisces	:	<i>Ctenogobius vexillifer</i> <i>Ctenogobius sp.</i> <i>Acanthogobius viridipunctatus</i> Gobiid fish (unidentified) <i>Boleophthalmus boddarti</i> <i>Scartalaos viridis</i>

Infauna

- Coelenterata : Sea anemone sp. A (unidentified)
Sea anemone sp. B (unidentified)
- Nemertea : Nemertean sp. (unidentified)
- Sipuncula : *Phascolosoma arcuatum*
- Polychaeta : *Mastobranchus* sp.
Parheteromastus tenuis
Euclymene sp.
Polynoid sp. (unidentified)
Nereis onychophora
Perinereis aibuhitensis
Diopatra sp.
Marphysa sp.
Imbrinereis sp.
- Crustacea : Amphipod sp. (unidentified)
Sphaerosoma walkeri
Petrolisthes lamarckii
Alpheus euphrosyne
Thalassina anomala
Upogebia sp.
Scylla serrata
Sphaerozius nitidus
Heteropanope glabra
Typhlocarcinus nudus

Camptandrium sexdentatum

Ilyoplax delsmanni

I. lingulatus

I. longicarpus

I. obliquus

I. orientalis

I. punctatus

Leipocten sordidulum

Tylodiplax tetratylophora

Uca dussumieri

U. forcipata

U. lactea

U. triangularis

Uca urvillei

U. vocans

Uca juveniles (unidentified)

Chiromanthes semperi

Clistocaeloma merguiensis

Metaplax crenulata

M. distinctus

M. elegans

Nanosesarma andersoni

Neopisesarma mederi

N. versicolor

Parasesarma plicatum

Stomatopoda

: *Chlorida rotundicauda*

- Mollusca : *Andara granosa*
Striarca pectunculiformes
Diplodonta globosa
Grafrarium tumidum
Tellina capsoides
T. opalina
Solen delesserti
Laternula truncata
- Echinodermata : *Holothuria parva*
Brittle star (unidentified)
- Tree fauna
- Crustacea : *Balanus amphitrite*
Chthamalus withersii
- Mollusca : *Nerita articulata*
N. chameleon
N. planospira
Littorina carinifera
L. scabra
Enigmonia aenigmatica
Isoygnomon ephippium
Saccostrea cucullata
Teredo sp.

Table 6 : Fauna of Station 4 (the mud flat station)

Surface fauna

Crustacea	:	<i>Clibanarius padavensis</i>
		<i>Diogenes avarus</i>
Mollusca	:	<i>Cerithidea cingulata</i>
		<i>Polinices flemingiana</i>
		<i>Nassarius globosus</i>
		<i>N. jacksonianus</i>
		<i>N. livescens</i>
		<i>Hebra nigra</i>
		<i>Melongena puligina</i>
		Unidentified gastropod species
		<i>Onchidium</i> sp. A.
Pisces	:	<i>Ctenogobius vixillifer</i>
		<i>Acanthogobius viridipunctatus</i>
		Gobiid juvenile (unidentified)
		<i>Scartelaos viridis</i>

Infauna

Coelenterata	:	Sea pen sp. A (unidentified)
		Sea pen sp. B (unidentified)
Nemertea	:	Nemertean sp. (unidentified)
Polychaeta	:	<i>Euclymens</i> sp.
		<i>Sinnotrypane</i> sp.
		<i>Eteone</i> sp. A.

Phyllodoce sp.

Ceratonereis sp.

Dendronereis arborifera

Nereis onychophora

Perinereis aibuhitensis

Nereid sp. (unidentified)

Goniada sp.

Diopatra sp.

Marphysa sp.

Lumbrinereid sp. B. (unidentified)

Lumbrinereid sp. C (unidentified)

Crustacea

: *Alpheus euprosyne*

A. macrodactylus

A. malabaricus

A. rapacida

A. rapax

Upogebia sp.

Thalamita crenata

Typhlocarcinus nudus

Camptandrium sexdentatum

Dotillopsis brevitarsus

Ilyoplax delsmanni

I. longicarpud

I. orientalis

Macrophthalmus definitus

Paracleistostoma microcheirum



Tylodiplax tetratylophora

Uca lactea

U. vocans

Uca juvenile (unidentified)

Metaplax crenulata

M. distinctus

M. elegans

Parasesarma plicatum

Mollusca

: *Anadara granosa*

A. trocheli

Scapharca inequivalvis

Striarca pectunculiformes

Musculus senhousia

Tellina opalina

Solen delesserti

Laternula truncata

Table 7 : Fauna collected from scoop nets and from visual observation.

From scoop nets :

Shrimps

Penaeidae

Penaeus merguensis de Man*Penaeus* sp.*Metapenaeus* sp.

Fishes

Mugilidae

Mugil dussumieri (Val.)

Centropomidae

Ambasscis kopsii

Serranidae

Epinephalus sexfasciatus (Cuvier & Val.)

Silliginidae

Sillago sihama (Forsk.)

Blennidae

Petroscirtes sp.

Eleotridae

Butis butis (Ham.)

From visual observation :

spiders

termites

mosquitoes

biting midges

ants

birds

snakes : *Cerberus rhynchops* (Schneider)monkeys : *Macaca fascicularis* (Paffles)

The most abundant infauna was a small mussel species, *Musculista senhousia*. They formed a large mat of mussels in the mud on the lower shore. The maximum density reached over 10,000 individuals per m². The polychaete *Nereis onychophora* was abundant, while the common species included *Diopatra* sp., *Euclymene* sp., and *Marphysa* sp.. Many crustacean species were also abundant in this station; they were *Typhlocarcinus nudus*, *Tylodiplax tetratylophora*, *Uca lactea*, *U. vocans*, *Metaplax crenulata*, *M. elegans* and *Upogebia* sp..

In addition, some animals which came up with tides were collected with scoop nets (Table 7). Some of these species, e.g. shrimp : *Penaeus* spp., and fishes : *Mugil dussumieri*, *Epinephalus sexfasciatus*, are commercially important. Moreover, Table 7 also shows some other animals that were sighted during the study. These included spiders, termites, mosquitoes, biting midges, red ants, monkeys, snakes and birds. They were not taxonomically studied in details.

2.2 Biomass of macrofauna

Table 8 presents the biomass values (both wet weights and dry weights) of each taxon in each station. The results would be discussed in term of g dry weight biomass, as water and inorganic calcareous portion were included in wet weights.

The highest total biomass estimate of 11.51 g/m² was obtained from the middle mangrove Station 2. The mud flat (Station 4) biomass was also high, averaging 11.17 g/m². The lowest biomass was found in the seaward mangrove Station 3 with value of 4.64 g/m². The innermost Station 1 provided a dry weight biomass of 7.07 g/m².

Table 8. Biomass of macrofauna at The Ko Maphrao mangrove forest.

STATION	Wet weight (g m^{-2})				Dry weight (g m^{-2})			
	1	2	3	4	1	2	3	4
Coelenterates	-	-	0.1351	0.0342	-	-	0.0162	0.0041
Nemertean	0.0056	0.1421	0.0539	0.0136	0.0013	0.0327	0.0124	0.0031
Sipunculans	18.4241	10.4118	0.0782	-	2.9479	1.6659	0.0125	-
Polychaetes	0.6316	3.7789	0.7416	0.7789	0.1137	0.6802	0.1335	0.1402
Crustaceans	22.4208	46.3971	10.1552	22.1561	3.8115	7.8875	1.7264	3.7665
Gastropods	3.0240	19.9242	1.1047	31.9986	0.1512	0.9962	0.0552	1.5999
Pelecypods	1.1697	4.9650	62.0110	140.1944	0.0468	0.1986	2.4804	5.6078
Fishes	-	0.1856	0.8449	0.1970	-	0.0445	0.2028	0.0473
Total	45.6758	85.8047	75.1246	193.3728	7.0724	11.5056	4.6394	11.1689

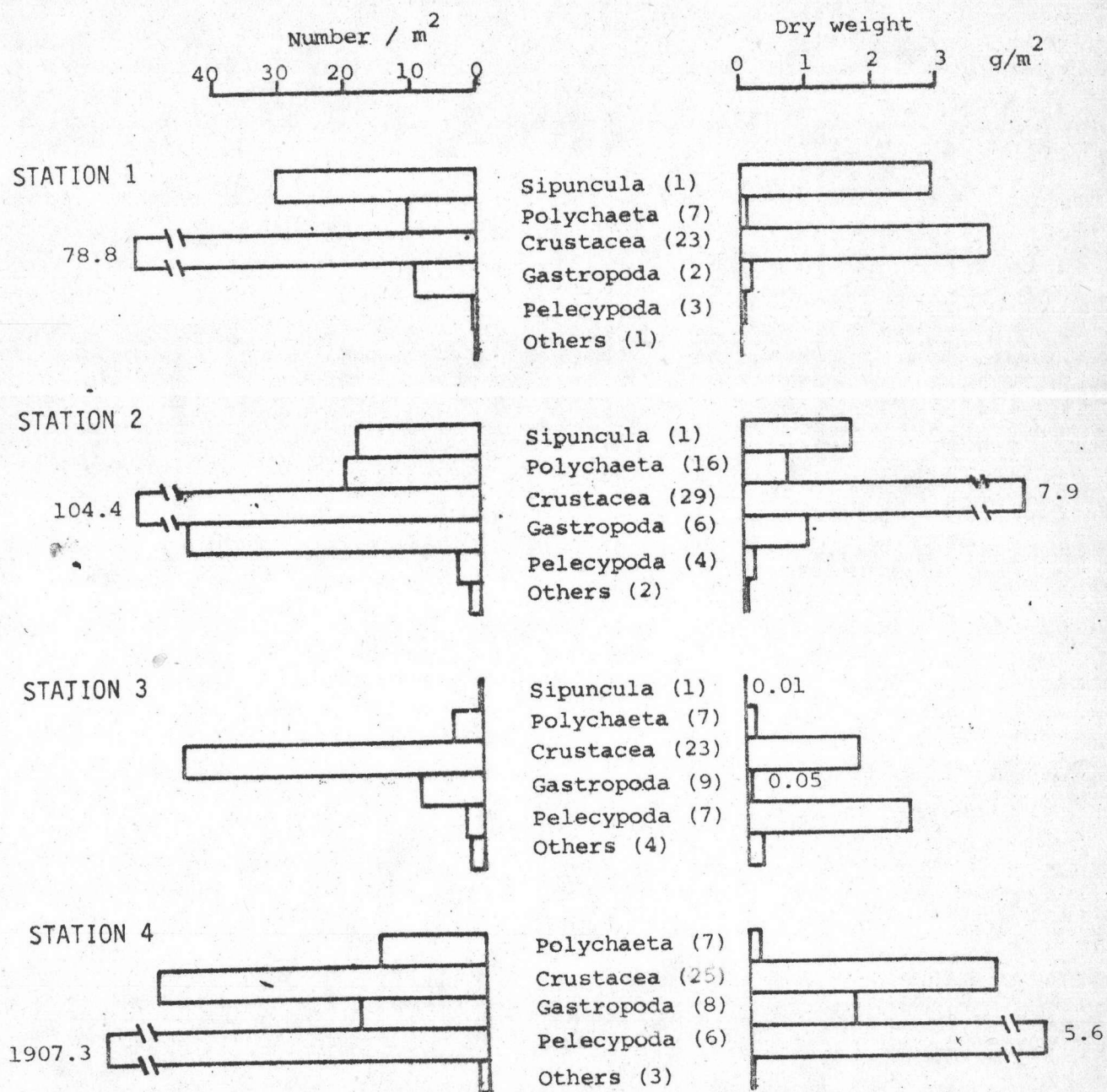


Figure 5. Diagram showing mean dry weights and mean density values of fauna in major taxa in each station.

Number of species in each major taxon is given in brackets.

It was shown that crustacea was the numerically dominant group in the mangrove stations, as well as a major contributor to the total dry weight biomass. Sipuncula was represented by only one species *Phascolosoma arcuatum* which also provided high dry weight biomass in the mangrove stations with little tidal inundation. In the mud flat station, bivalves took over from crustaceans as the dominant group and it accounted for 50% of total dry weight biomass.

Figure 5 shows the diagram illustrating the density and dry weight biomass estimates in each major taxon in each station.

2.3 Ecological notes on the animal distribution and habitats.

Coelenterata

Four species of coelenterates, which included two species of sea anemones and two species of sea pens, were found and unidentified. They were not common.

Two species of sea anemones were all found in the seaward mangrove (Station 3). One species was found attached to prop roots or rotten logs. The other species was a minute tubelike anemone which was found burrowing in the sandy mud. The latter species probably belongs to the edwardsioid group of anemones.

Two species of sea pens were found standing upright their stalks from the mud in Station 4 (the mud flat). One species has a long, thin reddish stalk, the other has thick flesh and a milky white stalk which bears distally spiny lobes on both sides.

Platyhelminthes

A free living flatworm species (unidentified) was found gliding and crawling on the floor in the seaward mangrove Station 3. It has a slimy leaf-like body and only two individuals were collected.

Nemertea

Due to the difficulty in identification and taxonomic problems, all nemerteans are pooled into one group but certainly, there would be more than one species. They were found burrowing in soil, under dead wood, leaves in every station, but not very common. They were found very few in Stations 1 and 2.

Sipuncula

One species of sipunculans, *Phascolosoma arcuatum*, occurred in the mangrove forest, none were found in the mud flat station. They burrow in mud just beneath the surface to a depth of about 20 cm, even in an anoxic layer. *P. arcuatum* was very abundant above the mean tide level, especially in Stations 1 and 2.

Polychaeta

Twenty five species of polychaetes accounting for 17.4% of total no. of species were recorded from the study. Polychaetes are traditionally divided into two major groups : errant polychaetes and sedentary polychaetes. The first group has anterior appendages differentiated into palps, antennae, etc. and jaws, but the latter has reduced anterior appendages and a limited number of body segments. Seven species collected were errant polychaetes and eighteen species were sedentary polychaetes.

Sedentary polychaetes collected included *Scoloplos* sp., *Heteromastus filiformis*, *Mastobranthus* sp., *Parheteromastus tenuis*, Capitellid sp., *Euclymene* sp. and *Ammotrypane* sp.. Among these, *Mastobranthus* sp. was most abundant, particularly in the middle and innermost mangrove stations. No sedentary polychaetes were found in the mud flat, apart from *Euclymene* sp. and *Ammotrypane* sp.. The latter species was exclusively found in the mud flat. Most of sedentary polychaetes found were restricted to the mangrove biotope.

Of 18 errant polychaetes, a nereid worm *Nereis onychophora* was abundant and it occurred in all stations. Four species, namely, *Phyllococe* sp., *Dendronereis arborifera*, a nereid species (unidentified) and a Lumbrinereid sp. C (unidentified) were exclusively found in the mud flat station. Six species consisting of *Eteone* sp. B, Polynoid sp. (unidentified), *Polyodontes melanonotus*, *Leonnates* sp., *Lumbrinereis* sp., and Lumbrinereid species A (unidentified) occurred in the mangrove biotope. The rest were found in both mangrove and mud flat stations.

Few sedentary polychaetes were collected from the innermost Station 1, particularly no eunicid worm was found in this station where the soil was coarser and was wetted by less than 40% of tidal inundation. On the mud flat and on the mud bank, *Diopatra* sp. and *Marphysa* sp. formed conspicuous tubes made of leaves and mucus secreted by the worms. They were found to chew up the mangrove leaves and attach the remains to the tubes (Hylleberg, pers. comm.).

Crustacea

Fifty nine species of crustaceans and a xiphosuran species, accounting for 41.7% of total no. of species, were found at the Ko Maphrao mangrove forest. The crustaceans consisted mainly of brachyuran decapods, of which 18 species were ocypodid crabs, 17 species grapsid crabs, and 8 species leucosiid, portunid, xanthid and goneplacid crabs, totally accounting for 72.8% of the crustaceans collected. In addition, 2 species of cirripedes, and amphipod species, 2 isopods, 5 species of alpheid, 5 species of anomuran decapods and a stomatopod species were recorded.

According to the study on egg-laying habits of two horse-shoe crab species in the Gulf of Thailand (Sekiguchi et al, 1977), the horse-shoe crab juveniles collected in the innermost station might possibly be *Carcinoscorpius rotundicauda*, which lays eggs in the muddy sand of the upper stream of the mangrove forest.

The cirripedes, *Balanus amphitrite* and *Chthamalus withersii*, were found attached to prop roots, tree trunks and even on the bivalve shells, e.g. on *Crassostrea cucullata* and *Isognomon ehippium*. *C. withersii* differs from *B. amphitrite* in having a rhomboid aperture and the shell plates being more loosely held together. *B. amphitrite* occurred commonly in areas between Station 2 and Station 3, further up landward more *C. withersii* occurred

Amphipods were collected from or under rotten wood, leaves within the mangrove forest. The scarcity of amphipods was striking, only one species was recorded, and its numbers were very small. One might expect

to find a high number of them, since this group of animals play an important role in vascular degradation. The isopods, *Sphaeroma walkeri* and *Ligia* sp., were not common, either. They were collected from prop roots, dead wood, and rotting vegetation. These animals are also believed to degrade the dead vegetation.

Five species of alpheid shrimps (or snapping prawns) were found. These included *Alpheus euphrosyne*, *A. malabaricus*, *A. macrodactylus*, *A. rapacida* and *A. rapax*, of which *A. euphrosyne* and *A. malabaricus* were found in both mangrove and mud flat biotopes. The alpheid shrimps were common in the mud flat station. All of the five species were found there.

Ancauran crabs collected from Ko Maphrao were represented by two species of callianassid crustaceans, *Thalassina anomala* (mud-lobster) and *Upogebia* sp. (mud shrimp); two species of hermit crabs *Clibanarius padavensis* and *Diogenes avarus*; and one species of porcellain crabs, *Petrolisthes lamarckii*. Only *T. anomala* and *P. lamarckii* were confined to the mangrove forest.

The most conspicuous feature in all in all mangrove stations, particularly in Station 1, was the many big mounds of the mud lobsters, *Thalassina anomala*. The mound entrance's hole would lead to the main burrow which was very deep ranging from 1-3 m. The main burrow might have many branched burrows that could connect with the other mounds. Mud-lobsters were present in some elevated areas in Station 3. They prefer the dry area. *Upogebia* sp. was found burrowing in the sediments.

The hermit crab, *Clibanarius padavensis*, was found more common in the mud flat station, very few were found in the mangrove stations. In contrast, *Diogenes avarus* was more common in the mangrove stations, and very few on the mud flat. *D. avarus* was smaller and occurred commonly on the mud banks and streams. It utilizes the shells of *Cerithidea cingulata*.

The number of porcellain crab, *Petrolisthes lamarekii*, was low and found in between loose bark and wooden part of mangrove fallen logs. Because of its small and flat shape, the crab can easily live beneath loose barks. *P. lamarckii* feeds on suspended matter filtered by their 2nd maxillipeds (Macnae and Kalk, 1958).

Brachyuran decapods were found consisting predominantly of ocypodid crabs and grapsid crabs. One species of leucosiid crab, *Ebalia malefactorix* occurred in Station 1. Three species of xanthid crabs, *Epixanthus dentatus*, *Sphaerozius nitidus*, and *Heteropanope glabra*, were found in the mangrove forest and none of them were common. One species of goneplacid crabs *Typhlocarcinus nudus*, was found in both mangrove and mud flat biotopes, but it was abundant in the mud flat station.

Three species of portunid crabs were collected and all of the three species were fished by the people for consumption. *Portunus pelagicus* was seen running on the seaward edge and on the mud flat. *Scylla serrata* was burrowing deep in a hole under the prop roots of *Rhizophora* spp.. *Thalamita crenata* which was found only on the mud flat, was quite common.

Among ocypodid crabs, *Uca* spp. (fiddler crabs), were one of the most characteristic groups of mangrove fauna. Fiddler crabs were represented by 6 species: *Uca dussumieri dussumieri*, *U. forcipata*, *U. lactea annulipes*, *U. triangularis*, *U. urvillei* and *U. vocans vocans*. *U. lactea* showed a wide distribution and abundance throughout the study area. It occurred most abundantly in Stations 1 and 2. *U. dussumieri*, *U. forcipata*, *U. triangularis* and *U. urvillei* were exclusively found in the mangrove forest and they were more common in the landward part. *U. vocans* also widely distributed, but it was common on the more exposed areas, especially in the mud flat station. Some fiddler crab juveniles were collected and grouped together as *Uca* juveniles, since it was not possible to give the species identity. They were found in low numbers, it might be possibly due to overlooking these very small crabs.

Ilyoplax, comparatively small crabs (5-8 mm), included 6 species: *Ilyoplax delsmanni*, *I. lingulatus*, *I. longicarpus*, *I. obliquus*, *I. orientalis* and *I. punctatus*. Among these, *I. lingulatus* and *I. obliquus* occurred exclusively in the mangrove forest. The remaining four species were found in both mangrove and mud flat biotopes. *I. delsmanni* was found most abundant in the middle mangrove station, *I. obliquus* in the innermost station, and *I. orientalis* in the mud station.

The most abundant species of all the crustaceans was *Tylodiplax tetratylophora* with mean density of $36.8/m^2$, particularly high in the landward stations. The high abundance of it has never been recorded elsewhere. *T. tetratylophora* was found burrowing in the mud.



Macrophthalmus definitus, *Camptandrium sexdentatum*, and *Dotillopsis brevitarsus* were found in the mud flat station. First two species were common in the Station 4, the latter was very few. *Paracleistostoma microcheirum* was found on the channel banks in the mangrove forest and the mud flat; and *Leipocten sordidulum* was found in fallen log in Station 1. Both of them were not common.

All the seventeen species of grapsid crabs found in the study area are members of subfamily Sesarmininae, 13 of which were found exclusively within the mangrove forest, the others were found in both biotopes. The grapsid crabs were not as abundant as the ocypodid crabs. High diversity of grapsid species were found in the landward parts, i.e. Stations 1 and 2. Five species of *Chiromanthes* were collected: *C. jarwinensis*, *C. dussumieri*, *C. haswelli*, *C. indiarum*, and *C. semperi*. They were restricted to the middle and innermost station. None of them were common in both areas. *Clistocoeloma merguensis*, *Geosesarma* sp., *Holometopus* sp., *Sarmatium crassum* and *S. germani* were mostly found in the drier areas. They were collected from burrows, dead wood (both in and beneath the wood)

The bigger sesarimid crabs (*Nanosesarma andersoni*, *Neopisesarma mederi*, *N. versicolor* and *Parasesarma plicatum*) were often seen climbing the mangrove tree trunks or running to hide in the prop root tangles. But they were also collected from the burrows around the base of mangrove trees.

Only *Metaplex elegans* was an exceptionally abundant grapsid crab. It distributed over the study area and preferred particularly the mud banks and mud flat. *M. distinctus* and *M. crenulata* are two larger species. The first species was found in all stations, but the latter was typically found on the foreshore including seaware mangrove fringe and mud flat areas.

A stomatopod species, *Chlorida rotundicauda*, was collected from a burrow at the base of *Rhizophora apiculata* prop roots in Station 3 (the seaward station).

Mollusca

Forty three species of mollusc fauna, accounting for 29.9% of total no. of species, were found consisting of 27 species of gastropods and 13 species of bivalves. Of the gastropod species, 18 species occurred exclusively within mangrove and 4 species in the mud flat biotope; and of the bivalve species, 8 species were found in the mangrove biotope and 3 species within the mud flat biotope. The remainders were collected in both biotopes.

The gastropods included 6 spp. of Nassaridae, 4 spp. of Neritidae, 3 spp. of Potamididae, 2 spp. of Littorinidae, 2 spp. of Cerithiidae, 2 spp. of Onchiidae, 2 spp. of Ellobiidae, one species of each of the following families : Assimnidae, Naticidae, Muricidae, Melongenidae, Haminoeidae and one unidentified species.

Meritid molluscs were represented by *Nerita articulata*, *N. chameleon*, *N. planospira* and *Clithon oualaniensis*; all of them were found in the mangrove forest. *N. articulata* was the tree dwelling gastropod; *N. chameleon*, *N. planospira* were found on lower stem, prop roots and on mangrove floor. *C. oualaniensis* occurred in the seaward mangrove edge near the mud flat. None of them were common.

Littorina carinifera and *L. scabra* were 2 species of littorinid molluscs found in the mangrove forests. They showed wide distribution, occurring in all mangrove stations. Most of these two species were found crawling on tree trunks, branches and leaves of mangrove trees. *L. scabra* was found more common than *L. carinifera*; and the first species occurred at higher heights (one individual was found at about 7 m high in Station 2), the latter species was usually found at heights of 50-100 cm from the ground.

The tiny, red gastropod species, *Assiminea brevicula*, was one of the most abundant mollusc species. It was found on the mangrove floor and particularly abundant in the mangrove Station 3.

Family Potamididae is represented by *Cerithidea cingulata*, *C. obtusa* and *Telescopium telescopium*. *C. cingulata* was the most abundant epifaunal gastropod. It showed the wide distribution and abundance throughout the study area, but the maximum was in Station 2. *C. obtusa* was found on the floor and often on the prop roots, and a small number was seen. *T. telescopium* was often seen in pairs of clumps in puddles or moist substrate in the mangrove floor.

Cerithium breve and *C. patulum*, representing family Cerithiidae, and *Naquetia* (=Murex) *capucina*, representing family Muricidae, were collected from the mangrove, occurring more common on the mud banks and seaward mangrove station. None of these species were common.

Six species of Nassariidae were found : *Nassarius globosus*, *N. jacksonianus*, *N. livescens*, *N. olivaceus*, *N. foreolatus* and *Hebra nigra*. *N. globosus*, *Hebra nigra*, *Melongana puligina* (representing Melongenidae) and one unidentified gastropod species were found only on the mud flat. Of these species, the unidentified gastropod species and *N. globosus* were common. The unidentified gastropod species has been in waiting for identification in the British Museum (N.H.) through Dr. David Ward. *N. jacksonianus* and *N. livescens* were found in both biotopes, and both species were more common in the mud flat station.

Two species of Ellobiidae, *Cassidula aurisfelis* and *Ellobium aurisjudae*, and *Haminoea* sp. of Haminoeidae were restricted to the seaward mangrove Station 3. They were seen crawling on the soil surface, prop roots and decaying vegetation (leaves and wood). Two species of Onchiidae, *Onchidium* sp. A and sp. B were found. The species A was collected from both seaward mangrove station and the mud flat station, while the species B was found only in the seaward mangrove station. None of these species were common.

The bivalve molluscs were represented by 11 families : Arcidae (4 species), Mytilidae (1 species), Anomiidae (1 species), Isognomonidae (1 species), Ostreidae (1 species), Ungulinidae (1 species), Veneridae (2 species), Tellinidae (2 species), Solenidae (1 species), Teredinidae (1 species), and Laternulidae (1 species).

Arcidae included 4 species of cockles (or clams) : *Anadara granosa*, *A. trocheli*, *Scapharca inequivalvis* and *Striarca pectunculiformes*, of which the first three species are edible cockles. All of these species were found on the mud bank and the mud flat station, where there was soft mud substratum. *Striarca pectunculiformes* was found to penetrate deeper in the landward direction. None of them were common.

The most abundant fauna found in this study was a small edible mussel species, *Musculista senhousia*, it formed clusters or mats of thousands of mussels entangled with their own byssus threads and silt-clay. They occurred in lower mud shore where was covered by most of the tides.

The sessile or encrusting bivalve molluscs on the mangrove stems or prop roots were represented by three species : *Enigmonia aenigmatica* (Anomiidae), *Isognomon ephippium* (Isognomonidae), and *Saccostrea cucullata* (Ostreidae). *E. aenigmatica* is the only motile bivalve species that is found attached byssally to mangrove stems and prop roots on its right shell valve. This species can be said to represent the bivalve attempts at a limpet-like mode of life (Morton, 1976). *E. aenigmatica* is, however, a filter feeder, whereas true limpets are grazers.

Isognomon ephippium, a winged oyster, occurred usually in the axes of the prop roots in clumps. This thin shelled oysters were found more common at the seaward mangrove station. Another rock oyster, *Saccostrea cucullata*, was typically found encrusting the prop roots. These two species were also found in Station 1, just in transition between Station 1 and Station 2, but not innermost landward part where was covered by less than 20% of tides.

Diplofonta globosa, *Grafrarium tumidum*, *Geloina erosa* and *Tellina capsoides* were found burrowing in the mangrove biotope ; whereas *T. opalina*, *Solen delesserti* and *Laternula truncata* were found in both mangrove and mud flat habitats. It is noteworthy that *Geloina erosa* occurred in the innermost station and *Solen delesserti* was found more common in the middle mangrove station. *Laternula truncata* showed the wide distribution throughout the study area, but it was not common. *Teredo sp.* was found boring in the mangrove wood. It was found in every station where tree stumps were fallen and decaying.

Echinodermata

A holothurian species, *Holothuria parva*, and a brittle star species (unidentified) were found in Station 3. *H. parva* was the only sea cucumber ever recorded in the mangrove habitat (Macnae and Kalk, 1958) It was found burrowing in the mud under and between the prop roots, mostly of *Rhizophora apiculata*. The brittle star was found moving under the loose barks of fallen logs. Both of them were uncommon.

Fishes

Four species of gobiid fishes and 3 species of periophthalmid fishes (mud-skipper) were found in the study area. Of the gobiid fishes, *Ctenogobius vexillifer* showed a wide distribution, occurring in all the stations. The gobiid fishes were found semi-buried in the moist muddy substratum. One unidentified gobiid fish was found under the bark of the fallen stumps or prop roots. The mud-skipper were represented by

Periophthalmus vulgaris, *Boleophthalmus boddarti* and *Scartelaos viridis*.

P. vulgaris occurred in Stations 1 and 2 and *B. boddarti* was found in the seaward mangrove station. *Scartelaos viridis* was found occurring both the seaward station and the mud flat station. The fishes were common along the mud banks and moist areas, e.g. in puddles or in small pools.

Other animals

Three individuals of a snake species, *Cerberus rhynchops*, were seen during the study, one was seen catching a crab. Herds of monkeys, *Macaca fascicularis*, were sighted wandering around the mangrove forest. They were found to be an omnivore whose diet includes mangrove vegetation, sipunculans and crabs (Sasekumar, 1980). Many species of birds were seen in Ko Maphrao mangrove forest. They might be both visitor and residents of mangrove forest. The most common ones were kingfishers.