

The penaeid prawns of the Straits of Johor: Preliminary results

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Abstract. A total of 18 species of penaeid prawns were documented through extensive surveys in mangrove, seagrass and near-shore areas of the Johor Straits in Singapore. Of these, five species (*Fenneropenaeus silasi*, *Metapenaeopsis palmensis*, *Metapenaeus anchistus*, *Metapenaeus moyebi*, and *Mierspenaeopsis sculptilis*) are new records for Singapore. The results presented here provide an insight to the macro-fauna diversity of the strait, and have established a baseline for future studies.

Key words. prawn, shrimp, Singapore, diversity, Johor Straits

INTRODUCTION

Singapore is located at the southern tip of Peninsular Malaysia and is some 137 km north of the equator. The country is separated from Peninsular Malaysia by the Straits of Johor to the north and from Indonesia's Riau Islands by the Singapore Strait to the south. Tidal estuarine habitats are found along the northern coastline of Singapore. Mangrove forests and seagrass beds are established in sheltered shores. These sheltered environments allow sediment from rivers and the sea to settle and become productive areas that provide good food sources for numerous flora and fauna (Chia, 1988). With industrialisation and development, mangrove forests are now found only in small patches at the northern part of the main island and on Pulau Tekong, Pulau Ubin and Pulau Semakau (Ng & Sivasothi, 2002).

There is little information on the penaeid prawns of the coastal waters of Singapore. Thirty-five prawn species were reported from Malayan waters (Hall, 1956, 1961), of which 11 penaeid species occurred in Singapore prawn ponds (Johnson, 1965). Of these species, *Metapenaeus ensis*, *M. mastersii* and *Penaeus indicus* were the most abundant. Tham (1968) mentioned that the prawns which were caught locally in quantity and which have a high market value were *P. indicus*, *P. merguensis*, *M. brevicornis*, *M. ensis*, and *M. burkenroadi* (now *M. moyebi*). The Johor Strait workshop was part of the Comprehensive Marine Biodiversity Survey of Singapore (CMBS) conducted to enhance the understanding of Singapore's marine biodiversity. The occurrence of 18 species of penaeid prawns collected from coastal habitats in the Straits of Johor is documented here.

MATERIAL AND METHODS

Sampling was conducted over various types of habitats along the coastline of the northern and northeastern side of Singapore (Fig. 1). Habitat surveys included near-shore areas (including the immediate vicinity of the Outward Bound School or OBS where the workshop was held) and coastal habitats such as seagrass meadows at Chek Jawa, mangrove creeks, as well as muddy and sandy flats. Additional hand sampling was undertaken farther at the rocky shore, muddy sand area and mangrove creeks exposed at low tide. Towards the landward side, the mangrove areas were also surveyed, but to a lesser extent. Mangrove specimens were collected, which were largely restricted to the fringes and along the streams in the mangrove forest.

Penaeid prawns encountered in the field surveys were collected and identified. Two types of stations were categorised according to depth. SW (for shallow water) stations were located at intertidal areas, while DW (for deeper water) stations were in offshore areas where samples were obtained using trawls and dredges. Voucher specimens were collected for the majority of species recorded. The majority of specimens were fixed in 10% formalin solution for one to two weeks, before transferring them to 70% ethanol for permanent storage. Some specimens were photographed and preserved directly in absolute alcohol for DNA analysis and these were labelled with the prefix 'JS'.

Identification was mainly based on Chan (1998) and references therein. Taxa were identified and clarified based on recently accepted species names (De Grave & Fransen, 2011). The length of a prawn is indicated by its total length (TL), which is the distance from the tip of the rostrum to the tip of the telson. Because no quantitative sampling was carried out, only species composition and their distribution are shown (Table 1). The CMBS voucher collections were lodged in the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum, National University of Singapore.

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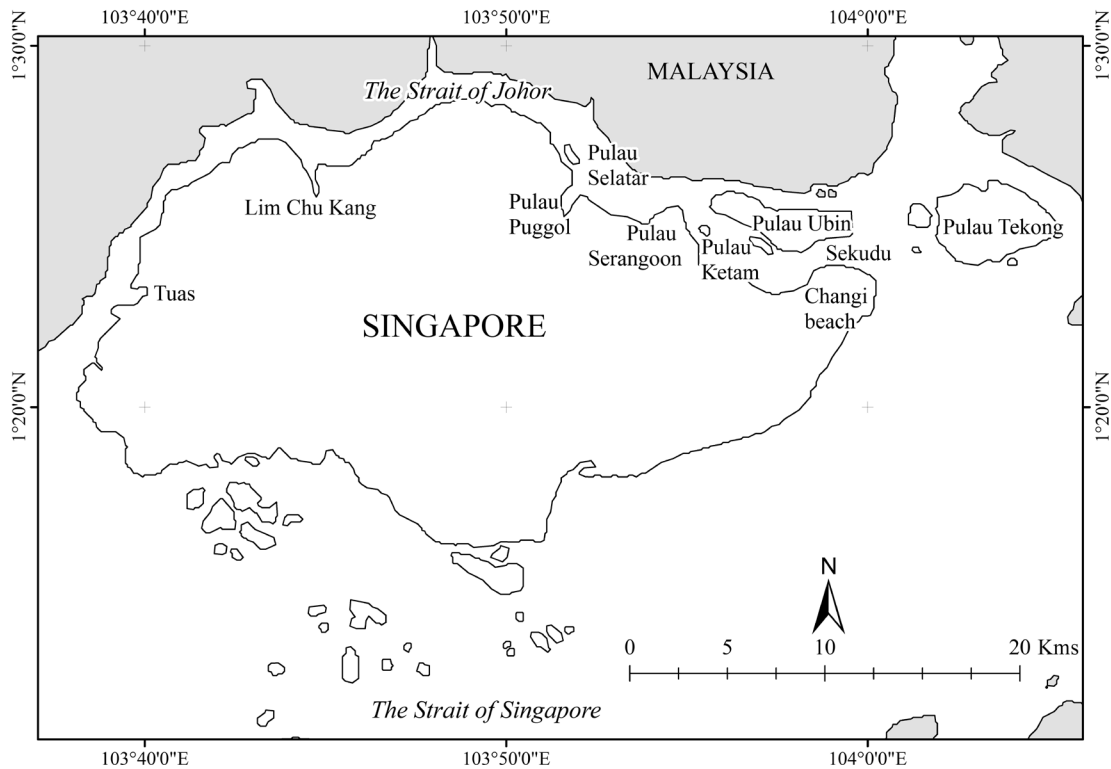


Fig. 1. Location of penaeid sampling sites along the Straits of Johor in Singapore.

Table 1. Penaeid prawns from different habitats in the Straits of Johor, Singapore.

Taxon	Mangrove Creek	River Mouth	Seagrass Bed	Subtidal Seabed
<i>Alcockpenaeopsis</i> Sakai & Shinomiya, 2011				
<i>Alcockpenaeopsis hungerfordi</i> (Alcock, 1905)				+
<i>Fenneropenaeus</i> Pérez Farfante, 1969				
<i>Fenneropenaeus merguensis</i> (De Man, 1888)*	+	+	+	+
<i>Fenneropenaeus silasi</i> (Muthu & Motoh, 1979)	+			+
<i>Metapenaeopsis</i> Bouvier, 1905				
<i>Metapenaeopsis barbata</i> (De Haan, 1844) [in De Haan, 1833–1850]				+
<i>Metapenaeopsis mogiensis consobrina</i> (Nobili, 1904)			+	+
<i>Metapenaeopsis palmensis</i> (Haswell, 1879)				+
<i>Metapenaeus</i> Wood-Mason in Wood-Mason & Alcock, 1891				
<i>Metapenaeus affinis</i> (H. Milne Edwards, 1837)				+
<i>Metapenaeus anchistus</i> (De Man, 1920)				+
<i>Metapenaeus brivicornis</i> (H. Milne Edwards, 1837)*				+
<i>Metapenaeus ensis</i> (De Haan, 1844) [in De Haan, 1833–1850]*				+
<i>Metapenaeus intermedius</i> (Kishinouye, 1900)	+			+
<i>Metapenaeus lysianassa</i> (De Man, 1888)	+		+	+
<i>Metapenaeus moyebi</i> (Kishinouye, 1896)*				+
<i>Metapenaeus</i> spp.			+	+
<i>Mierspenaeopsis</i> Sakai & Shinomiya, 2011				
<i>Mierspenaeopsis sculptilis</i> (Heller, 1862)				+
<i>Parapenaeopsis</i> Alcock, 1901				
<i>Parapenaeopsis hardwickii</i> (Miers, 1878)				+
<i>Penaeus</i> Fabricius, 1798				
<i>Penaeus monodon</i> Fabricius, 1798				+
<i>Penaeus semisulcatus</i> De Haan, 1844 [in De Haan, 1833–1850]	+	+	+	+
<i>Trachysalambria</i> Burkenroad, 1934				
<i>Trachysalambria curvirostris</i> (Stimpson, 1860)			+	+

RESULTS

The penaeid prawns found during the workshop in the Straits of Johor consisted of 18 species in eight genera, of which four were commercially important species (Tham, 1968; see Table 1). *Metapenaeus* shrimps were the most diverse group in this list. The common prawn species were *Fenneropenaeus merguensis* and *Penaeus semisulcatus* which were found in all habitat types. The intertidal habitats surveyed were defined as MG = mangrove, including Changi Creek and Lim Chu Kang area; SG = seagrass beds at Chek Jawa; DW = sea floor of the Straits of Johor at depth 5–25 m where the samples were collected by beam trawl, epibenthic sled, otter trawl, rectangular dredge and triangular dredge. A plus symbol (+) indicates the respective habitat(s) where the species was collected or observed. An asterisk (*) indicates commercially important species.

Genus *Alcockpenaeopsis* Sakai & Shinomiya, 2011

The 22 specimens obtained were in agreement with the description given by Chan (1998) for *Parapenaeopsis hungerfordi* Alcock, 1905. In the recent revision of Decapoda in Carideorum Catalogus (De Grave & Fransen, 2011) this species was transferred to the genus *Alcockpenaeopsis*.

The dog shrimp *Alcockpenaeopsis hungerfordi* (Alcock, 1905) (size range, TL 80–100 mm) was taken mainly by trawling. Specimens were found in moderate quantity in surveyed areas from muddy bottoms in shallow water from 6.1 to 22.5 m deep, especially at Beting Bronok off the northern coast of Pulau Tekong. Records of this species were from:

- DW18, 1 specimen, beam trawl, northern side of Pulau Ubin, 12.9–6.2 m.
- DW26, 1 specimen, beach seine and cast net, Tuas West Drive 60 at Tuas, shallow rocky coral at 0–1.2 m, sandy to a little muddy substrata.
- DW28, 1 specimen, beam trawl, eastern side off Chek Jawa, 9.6–8.2 m, Sandy to muddy substrata.
- DW36, 3 specimens (JS2493, JS2494), Beam trawl, off Pulau Serangoon, 16.8–18.6 m.
- DW56, 9 specimens, beam trawl, north of Beting Bronok, 8.2–6.1 m.
- DW79, 3 specimens, beam trawl, channel between Pengerang and East Pulau Tekong (off Tanjung Pengelih, Johor), 11.7–12.6 m, mud and rubbish/ dead wood.
- DW87, 1 specimen (JS1991), beam trawl, Changi East (off restricted area), 7.3–8.1 m, muddy substrate.
- DW129, 3 specimens (JS0229), beam trawl, near Johor (no landmark), 22.5–21.7 m, muddy with some clay.

Genus *Fenneropenaeus* Pérez Farfante, 1969

Two *Penaeus* prawns were identified as *P. merguensis* De Man, 1888 and *P. silasi* Muthu & Mothoh, 1979 in agreement with the description given by Chan (1998) based on the feature of distal two segments of third maxilliped of male prawn. In 1997, Pérez Farfante and Kensley published a monograph of the penaeoid and sergestoid shrimps and prawns of the world (Pérez Farfante & Kensley, 1997). It incorporated a

proposed taxonomic revision by raising former subgenera in the genus *Penaeus* to generic rank. This resulted in the transfer of the two species *P. merguensis* and *P. silasi* into the genus *Fenneropenaeus*, which is now generally accepted (De Grave & Fransen, 2011). It is necessary to correct the nomenclature of this species given earlier by the present work.

The banana prawn *Fenneropenaeus merguensis* (De Man, 1888) (size range, TL 110–150 mm) was one of the largest penaeid prawns collected during the workshop and was commonly found throughout the Johor Straits. The species was caught on sandy and muddy bottoms, from the coastline and river mouths to depths of up to 18.6 m in seagrass beds, estuarine areas near OBS camps, Lim Chu Kang mangrove, as well as other coastal areas of the Strait of Johor. It is difficult to distinguish female and juveniles of *F. merguensis* from *F. silasi*, but *F. merguensis* appeared to be more widely distributed than *F. silasi*. Records of specimens for this species were from:

- SW12, 1 specimen (JS0826), push net, unnamed stream and outlet at beach immediately off OBS Camp 1.
- DW18, 2 specimens (JS1116), beam trawl, northern side of Pulau Ubin, 12.9–6.2 m.
- DW36, 2 specimens (JS2496), beam trawl, off Pulau Serangoon, 16.8–18.6 m.
- DW38, 2 specimens, beam trawl, off Pulau Serangoon, 13.5–14.7 m.
- DW58, 1 specimen, beam trawl, east of Pulau Tekong, 11.3–10.9 m, laterite gravel bottom.
- DW64, 1 specimen, beam trawl, channel between Pulau Seletar and Nee Soon, 4.2–4.8 m depth.
- DW66, 1 specimen, otter trawl, north of Pulau Ponggol, 13.9 m depth.
- SW73, 3 specimens (JS1826), gill net, mouth of Sungei Teris near OBS Camp 2, <2 m depth, muddy bottom.
- SW106, 3 specimens (JS2511, JS2512), hand collected by net and tangle net, mangrove area of Lim Chu Kang, muddy substratum.
- SW125, 1 specimen, beach seine, low tide sandy shore near OBS Camp 2, depth ~ 0.6 m, seagrass bed.

The false white prawn *Fenneropenaeus silasi* (Muthu & Mothoh, 1979) (maximum body length 140 mm) was found on muddy bottoms in shallow water, from intertidal mangroves to subtidal depths up to 21.7 m deep. The areas of concentration of these prawn resources were in Changi Creek, Pulau Ponggol's mangroves and the coastal waters of Changi and Pulau Ubin. This prawn is an abundant species in the markets of Singapore and is of commercial importance (Chan, 1998). This shrimp can be easily confused with *F. merguensis*. Records of catch for this species were from:

- DW17, 1 specimen (JS0741), gill net and tangle net, OBS Camp 1 and Serangoon Harbour to between Camp 1 and Ponggol at Pulau Ubin.
- SW49, 6 specimens, hand collected using seine net and hand net, mangrove creek at Changi, muddy to sandy substrata.
- DW66, 1 specimen, Otter trawl, north of Pulau Ponggol, 13.9 m.
- SW126, 14 specimens (JS0225), hand collected using seine net and hand net, Sungei Buloh, muddy to sandy substrata.

Genus *Metapenaeopsis* Bouvier, 1905

The 15 specimens all agreed well with descriptions provided in the identification key to *Metapenaeopsis* species given by Chan (1998). Using the presence and position of stridulating organs, two species of shrimps were determined, namely *Metapenaeopsis barbata* (De Haan, 1844) and *Metapenaeus palmensis* (Haswell, 1879). One shrimp species without stridulating organs was identified as *Metapenaeopsis mogiensis* (Rathbun, 1902). This shrimp has four subspecies that are widely distributed in the Indo-West Pacific region from India to Japan and Australia, namely *Metapenaeopsis mogiensis complanata* Crosnier, 1991 from Australia and New Caledonia; *Metapenaeopsis mogiensis consobrina* (Nobili, 1904) from East Africa and the Red Sea to South China Sea and Indonesia; *Metapenaeopsis mogiensis intermedia* Crosnier, 1991 from Taiwan to Indonesia and the Philippines; and *Metapenaeopsis mogiensis mogiensis* (Rathbun, 1902) from Japan (Crosnier, 1991). The *mogiensis* shrimp obtained in this workshop comprised of only four specimens. They were all small in size and not fully grown. These were considered to be *Metapenaeopsis mogiensis consobrina* based on their geographical distribution.

The whiskered velvet shrimp *Metapenaeopsis barbata* (De Haan, 1844) [in De Haan, 1833–1850] (size range, TL 30–70 mm) was mostly found on sand, mud or sandy-mud bottoms, at depths of between 6.2 and 23.6 m. It was the most common species of the genus in the area. The records of this shrimp were from:

- DW4, 1 specimen, rectangular dredge, ~400m off southeast of Pulau Sekudu, 6.9–7.3 m, coarse sand/?dead shells.
- DW18, 1 specimen, beam trawl, northern side of Pulau Ubin, 12.9–6.2 m.
- DW78, 2 specimens, beam trawl, channel between Changi Ferry Terminal and West Pulau Tekong (Kuala Johor), 20.5–23.6 m, with dead wood.
- DW79, 1 specimen, Beam trawl, channel between Pengerang and East Pulau Tekong (off Tanjung Pengelih), 11.7–12.6 m, mud, rubbish and dead wood.
- DW119, 1 specimen (JS0217), otter trawl, between Changi Point Ferry Terminal and Pulau Sekudu, 17.3–18.2 m, sand.
- DW128, 1 specimen, rectangular dredge, Near Johor (no landmark), 21.8–18.3 m, mud.

The Mogi velvet shrimp *Metapenaeopsis mogiensis consobrina* (Nobili, 1904) and southern velvet shrimp *M. palmensis* (Haswell, 1879) were collected in moderate quantities. Both species were found on hard bottoms in the shallow water from intertidal area to 24 m deep. The catches of *M. mogiensis consobrina* were at station SW31; 3 specimens, hand collection, intertidal area of whole Palau Sekudu during lowtide, Sandy /seagrass-algae patches; and station DW36; 1 specimen, Beam trawl, off Pulau Serangoon, 16.8–18.6 m.

The southern velvet shrimp *M. palmensis* was reported from the following locations:

- DW39, 1 specimen, beam trawl, off Pulau Ubin jetty, 24–22 m.
- DW40, 2 specimens (JS0808), rectangular dredge, opposite Changi Chalet Radar, 21–15.6 m.

- DW82, 1 specimen (JS0220), rectangular dredge, north-east of Pulau Tekong, 8.1–11.6 m, laterite gravel.

Genus *Metapenaeus* Wood-Mason in Wood-Mason & Alcock, 1891a

Metapenaeus comprised the most diverse genus among the penaeids from northern Singapore waters. Seven species were classified following the identification key of Chan (1998). Miquel (1982) categorised *Metapenaeus* shrimps into four groups according to the morphology of the rostrum, sexual organs, and telson fan. These are “*brevicornis* group” (= *M. brevicornis* and *M. lysianassa*), “*intermedius* group” (= *M. anchistus* and *M. intermedius*), “*monoceros* group” (= *M. affinis* and *M. ensis*) and “*moyebi* group” (= *M. moyebi*).

A number of young *Metapenaeus* shrimps caught during the survey could not be identified positively because of unclear sexual organ characteristics. However *M. moyebi* was present in small numbers during this survey, and some of these immature shrimp could be referred as *M. ensis* in the “*intermedius* group” according to the distinguishing characteristic of their rostrum and telson fan. The records of *Metapenaeus* spp. were from:

- SW23, 5 specimens, hand collection and seine net, low tide on seagrass patch at Chek Jawa, seagrass and green algae.
- SW32, 1 specimen, hand collection and 15 feet seine net, northern end of Chek Jawa during low tide, Sandy and muddy.
- DW36, 1 specimen, beam trawl, off Pulau Serangoon, 16.8–18.6 m depth.
- DW39, 2 specimens, beam trawl, off Pulau Ubin jetty, 24–22 m depth.
- SW71, 1 specimen, triangular dredge, between OBS Camp 1 and Camp 2, ~5 m, muddy substratum.
- DW79, 1 specimen, beam trawl, channel between Pengerang and East Pulau Tekong (off Tanjung Pengelih), 11.7–12.6 m, mud and rubbish, dead wood.
- DW117, 1 specimen, beam trawl, ~100 m from shore of Changi beach towards CAFHI Jetty, 5.3–9.9 m, muddy.

The Jinga shrimp *Metapenaeus affinis* (H. Milne Edwards, 1837), spiny greasyback shrimp *M. anchistus* (De Man, 1920) and yellow shrimp *M. brevicornis* (H. Milne Edwards, 1837) were less abundant. A single specimen of each species was caught by beam trawl from depths of between 6.2–12.9 m in the north of Pulau Ubin (DW18).

The greasyback shrimp *Metapenaeus ensis* (De Haan, 1844) [in De Haan, 1833–1850] (size range, TL 80–145 mm) was the most abundant *Metapenaeus* prawn in the Straits of Johor. It was found in water depths ranging from 13 to 22 m off Pulau Serangoon and Pulau Ponggol. Records for the species were from:

- DW36, 2 specimens (JS2500), beam trawl, off Pulau Serangoon, 16.8–18.6 m depth.
- DW66, 3 specimens (JS0224), otter trawl, north of Pulau Ponggol, 13.9 m depth.
- DW129, 4 specimens (JS0228), beam trawl, near Johor (no landmark), 22.5–21.7 m, muddy with some clay.

Middle shrimp *Metapenaeus intermedius* (Kishinouye, 1900) was found in small numbers at a mangrove creek. A single specimen was caught using seine and hand nets at Changi mangrove creek during low tide in a muddy mangrove area (SW49).

The bird shrimp *Metapenaeus lysianassa* (De Man, 1888) was found in moderate quantity in Lim Chu Kang, Chek Jawa, Pulau Tekong and Pulau Seletar. It was found on mud bottom in mangroves, seagrass beds and near-shore waters of about 11 m depth. Records of this species were from:

- SW23, 1 specimen, hand collection using seine net, seagrass patch at Chek Jawa.
 DW58, 1 specimen, beam trawl, east of Pulau Tekong, 11.3–10.9 m, laterite gravel bottom.
 DW64, 7 specimens, beam trawl, channel between Pulau Seletar and Nee Soon, 4.2–4.8 m.
 SW106, 1 specimen, collected by hand and tangle nets, mangrove area at Lim Chu Kang, muddy substrate.

Moyebi shrimp *Metapenaeus moyebi* (Kishinouye, 1896) was relatively less abundant and tended to inhabit the same area with other penaeid species, but this species was commonly found on mud bottoms in the vicinities of Pulau Ponggol, Pulau Seletar, Pulau Serangoon and Changi in water depths ranging from 4.2 to 18.6 m. Records of this species were from:

- DW36, 1 specimen (JS2501), beam trawl, off Pulau Serangoon, 16.8–18.6 m.
 DW64, 1 specimen, beam trawl, channel between Pulau Seletar and Nee Soon, 4.2–4.8 m.
 DW66, 1 specimen (JS0223), otter trawl, north of Pulau Ponggol, 13.9 m.
 DW117, 1 specimen, beam trawl, ~100 m from shore of Changi beach towards CAFHI Jetty, 5.3–9.9 m, muddy bottom.

Genus *Mierspenaeopsis* Sakai & Shinomiya, 2011

A single specimen (JS1954; body length, TL 100 mm) obtained was in agreement with the description given by Chan (1998) as *Parapenaeopsis sculptilis* (Heller, 1862). In the recent revision of Decapoda in Carideorum Catalogus (De Grave & Franssen, 2011) this species was referred to as *Mierspenaeopsis sculptilis* (Heller, 1862). It is necessary to correct to nomenclature of this species given earlier by the present work. This rainbow shrimp was caught by beam trawl at depths of between 16.8 and 18.6 m off Pulau Serangoon at station DW36.

Genus *Parapenaeopsis* Alcock, 1901

The spear shrimp *Parapenaeopsis hardwickii* (Miers, 1878) (size range, TL 30–120 mm) was the most abundant prawn in the Straits of Johor. This species was commonly found along the coastline of northern Singapore and was most abundant off Pulau Serangoon. It was found in water depths ranging from 5.6 to 22.5 m. Records of this shrimp were from:

- DW18, 1 specimen, beam trawl, northern side of Pulau Ubin, 12.9–6.2 m.

- DW26, 1 specimen, beach seine and cast net, West drive 60 at Tuas, shallow rocky coral at 0–1.2 m, Sandy to a little muddy.
 DW28, 1 specimen, beam trawl, eastern side off Chek Jawa, 9.6–8.2 m, Sandy to muddy sea floor.
 DW36, 19 specimens (JS2491, JS2497, JS2498, JS2502, JS2503), beam trawl, off Pulau Serangoon, 16.8–18.6 m.
 DW38, 1 specimen (JS1649), beam trawl, off Pulau Serangoon, 13.5–14.7 m.
 DW40, 1 specimen, rectangular dredge, opposite Changi Chalet Radar, 21–15.6 m.
 DW56, 1 specimen, beam trawl, north of Beting Bronok, 8.2–6.1 m.
 DW57, 1 specimen, beam trawl, east of Pulau Tekong, 10.3–10.6 m.
 DW78, 1 specimen, beam trawl, channel between Changi Ferry Terminal and West Pulau Tekong (Kuala Johor), 20.5–23.6 m, some dead wood.
 DW79, 1 specimen, beam trawl, channel between Pengerang and East Pulau Tekong (off Tanjung Pengelih), 11.7–12.6 m, mud and rubbish/ dead wood.
 DW82, 1 specimen, rectangular dredge, north-east of Pulau Tekong, 8.1–11.6 m, laterite gravel.
 DW86, 1 specimen (JS1989), beam trawl, Changi Park, 5.6–14.7 m, mud.
 DW87, 1 specimen (JS1988), beam trawl, Changi East off restricted area, -, 7.3–8.1 m, mud.
 DW89, 3 specimens (JS1985, JS1986), otter trawl, channel between Chek Jawa and Pulau Tekong, 20.5–22.1 m.
 DW119, 1 specimen, otter trawl, between Changi Point Ferry Terminal and Sekudu, 17.3–18.2 m, sand.
 DW128, 1 specimen, rectangular dredge, near Johor (no landmark), 21.8–18.3 m, mud.
 DW129, 1 specimen (JS0230), beam trawl, near Johor (no landmark), 22.5–21.7 m, muddy with some clay.

Genus *Penaeus* Fabricius, 1798

The giant tiger prawn *Penaeus monodon* Fabricius, 1798 (size range, TL 140 mm) was not common during the survey. However by size, this species was one of the larger penaeid prawns present in this region. One individual was caught off Pulau Serangoon at depths of 16.8 to 18.6 m using a beam trawl at station DW36.

The green tiger prawn *Penaeus semisulcatus* De Haan, 1844 [in De Haan, 1833–1850] (size range, TL 70–140 mm) was found in small quantities. It was observed over sand, mud or sandy-mud bottoms. The larger prawns were caught in deeper waters. A sub-adult prawn was also found in a seagrass patch at Chek Jawa, but no specimen was collected. Records for this species during the workshop were from:

- DW4, 1 specimen (JS0806), rectangular dredge, 6.9–7.3 m ~400m off southeast of Pulau Sekudu, coarse sand/ dead shells.
 SW12, 1 specimen (JS0827), push net, unnamed stream and outlet at beach immediately off OBS Camp 1.
 SW23, 1 specimen, hand collection, seagrass patch at Chek Jawa.
 SW49, 1 specimen, hand collection, Changi Creek, muddy mangrove.
 DW64, 1 specimen, beam trawl, channel between Pulau Seletar and Nee Soon, 4.2–4.8 m.
 DW87, 1 specimen (JS1993), beam trawl, Changi East off restricted area, 7.3–8.1 m, mud.
 DW129, 1 specimen (JS0227), beam trawl, Near Johor (no landmark), 22.5–21.7 m, mud with some clay.

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Table 2. Occurrence of penaeid prawns during the workshop categorised by location in the Straits of Johor, Singapore.

Taxon	Mainland Singapore											
	Tuas	Lim Chu Kang	Pulau Seletar	Pulau Ponggol	off Pulau Serangoon	Changi	Changi Creek	Changi East off restricted area	Changi Park	Opposite Changi Chalet Radar	Channel between Changi Ferry Terminal and West Pulau Tekong (Kuala Johor)	Near Johor, no landmark
<i>Alcockpenaeopsis hungerfordi</i>	+				+			+				+
<i>Fenneropenaeus merguensis</i>		+	+	+	+							
<i>Fenneropenaeus silasi</i>				+		+	+					
<i>Metapenaeopsis barbata</i>						+					+	+
<i>Metapenaeopsis mogiensis consobrina</i>					+							
<i>Metapenaeopsis palmensis</i>										+		
<i>Metapenaeus affinis</i>												
<i>Metapenaeus anchistus</i>												
<i>Metapenaeus brivicornis</i>												
<i>Metapenaeus ensis</i>				+	+							+
<i>Metapenaeus intermedius</i>							+					
<i>Metapenaeus lysianassa</i>		+	+									
<i>Metapenaeus moyebi</i>			+	+	+	+						
<i>Metapenaeus spp.</i>					+	+						
<i>Mierspenaeopsis sculptilis</i>					+							
<i>Parapenaeopsis hardwickii</i>					+	+		+	+	+	+	+
<i>Penaeus monodon</i>					+							
<i>Penaeus semisulcatus</i>			+				+	+				+
<i>Trachysalambria curvirostris</i>												+

Table 2...continued

Taxon	Pulau Ubin								Pulau Sekudu		Pulau Tekong		
	OBS Camp 1	Between OBS Camp 1 and Camp 2	OBS Camp 2	Pulau Ubin	off Pulau Ubin jetty	Channel between Chek Jawa and Pulau Tekong	Chek Jawa	off Chek Jawa	Sekudu	near Pulau Sekudu	Pulau Tekong	Channel between Pengerang and East Pulau Tekong (off Tanjung Pengelih)	Beting Bronok
<i>Alcockpenaeopsis hungerfordi</i>				+				+			+	+	
<i>Fenneropenaeus merguensis</i>	+		+	+							+		
<i>Fenneropenaeus silasi</i>				+									
<i>Metapenaeopsis barbata</i>				+						+	+		
<i>Metapenaeopsis mogiensis consobrina</i>									+				
<i>Metapenaeopsis palmensis</i>					+						+		
<i>Metapenaeus affinis</i>				+									
<i>Metapenaeus anchistus</i>				+									
<i>Metapenaeus brivicornis</i>				+									
<i>Metapenaeus ensis</i>													
<i>Metapenaeus intermedius</i>					+								
<i>Metapenaeus lysianassa</i>							+			+			
<i>Metapenaeus moyebi</i>													
<i>Metapenaeus spp.</i>		+			+		+				+		
<i>Mierspenaeopsis sculptilis</i>													
<i>Parapenaeopsis hardwickii</i>				+		+		+			+	+	
<i>Penaeus monodon</i>													
<i>Penaeus semisulcatus</i>	+						+		+				
<i>Trachysalambria curvirostris</i>			+								+		

Genus *Trachysalambria* Burkenroad, 1934

The Singapore specimens were in agreement with the description given by Chan (1988) for *Trachypenaeus curvirostris* (Stimpson, 1860). In the recently published revision of Decapoda in Carideorum Catalogus (De Grave & Franssen, 2011) this species was referred to as *Trachysalambria curvirostris* (Stimpson, 1960).

The southern rough shrimp *Trachysalambria curvirostris* (Stimpson, 1860) (size range, TL 20–45 mm) was found in moderate numbers during the survey. Specimens were obtained from muddy bottoms 11.7 to 22.5 m depth and *Ulva* beds at OBS camp 2. Records of this species were from:

- DW79, 1 specimen (JS0231), beam trawl, channel between Pengerang and East Pulau Tekong (off Tanjung Pengelih), 11.7–12.6 m, mud and rubbish, dead wood
- SW125, 1 specimen, beach seine, sandy shore at low tide near OBS Camp 2, ~ 0.6 m, *Ulva* bed
- DW128, 4 specimens, rectangular dredge, near Johor (no landmark), 21.8–18.3 m, muddy
- DW129, 2 specimens, beam trawl, near Johor (no landmark), 22.5–21.7 m, muddy with some clay

The results from this CMBS indicated that the prawns were caught both in intertidal areas as well as subtidal areas to 24 m deep. Most of the prawn species were found to be abundant from the depth range of 17–21 m (39%) and less so in the intertidal zone (14%). Results of the surveys suggested that the prawns were taken and were more diverse in the northeastern of Singapore such as Pulau Ubin and off Pulau Serangoon. The distributions of various species in the Johor Straits are summarized in Table 2.

DISCUSSION

The Comprehensive Marine Biodiversity Survey aimed to document the biodiversity (fauna and flora) of the Strait of Johor. The workshop provided the means to conduct a qualitative biodiversity survey in a poorly known area of Singapore using various types of equipment such as the epibenthic sled, beam trawl, rectangular dredge, otter trawl and hand collecting from intertidal and subtidal areas up to a depth of 24 m. The results showed that at least 18 shrimp species in eight genera inhabit the Johor Straits ecosystem. Of these, four are commercially important species (*Fenneropenaeus merguensis*, *Metapenaeus brivicornis*, *M. ensis*, and *M. moyebi*). Most species listed are common in both Indian Ocean and Indo-Pacific regions (Chan, 1998). Eighty-five species have been documented in the Indo-Malayan sub-region, which includes Vietnam, Taiwan, Papua New Guinea and the Solomon Islands (Dall et al., 1990). The species composition in the Johor Straits in comparison with other adjacent regions is shown in Appendix 1. Rajali (1994) reported 15 species of penaeid prawns from Sarawak waters in Borneo, while 45 species in 15 genera were reported from Thai waters (Chaitiamvong & Spongpan, 1992), and six prawn species were found in the mangrove area of Pancer Balok, Cimanuk River Estuary, West Java (Manuputty, 1984). Among these lists, 35 species in 16 genera were recorded

from the Malaya (the Malay Peninsula and the island of Singapore) waters based on previous literature (Johnson, 1965; Hall, 1956, 1961). Although some 23 species were neither collected nor observed during this study period, five species recorded in this study are new records for Singapore, namely *Fenneropenaeus silasi*, *Metapenaeopsis palmensis*, *Metapenaeus anchistus*, *Metapenaeus moyebi*, and *Mierspenaeopsis sculptilis*.

The distribution of most species was found to be in and around near-shore stations. For the frequency of occurrence, *Parapenaeopsis hardwickii* was the species mostly often found from all near-shore stations at water depths ranging between 17 and 21 m. Eight prawn species were reported from the intertidal zone of mangrove creeks, river mouths and seaweed or seagrass beds. As to species dominance, *Fenneropenaeus merguensis* and *Penaeus semisulcatus* were dominant species ranked in order of their occurrence of species in all habitat types. Furthermore, sub-adult prawns of the *Penaeus* and *Metapenaeus* species were also found in and around mangrove estuaries and seaweed/seagrass beds. Penaeid prawns are known to breed in brackish water or near-shore habitats, and live in shallow water for only a short period before migrating to deeper waters (Dall et al., 1990; Nagelkerken et al., 2008). For example, *F. merguensis* prefers mangrove areas as nursery ground (Staples et al., 1985; Vance et al., 2002; Sheaves et al., 2012), while *P. semisulcatus* prefers seagrass and algal beds as nursery areas (Vance et al., 1996). These observations seem to agree with Johnson (1965) who reported 11 species belonging to the genera *Penaeus* and *Metapenaeus* from Singapore in the prawn ponds of Jurong Swamp and Merbok estuary in Perak. These prawns entered the swamps as juveniles and returned to the sea to breed. These results reiterate the general observations that many penaeids are very closely associated with coastal habitats that are used variously as nursing ground, feeding area and residence.

In term of species richness and frequency of occurrence, the major prawning grounds in the northern region of Singapore occurred predominantly in shallow water areas adjacent to coastal mangrove in the eastern part of the Strait of Johor around Pulau Serangoon to Pulau Ubin and Pulau Tekong at depths less than 24 m. These results corresponded to the findings of Chong et al. (1994), which indicated that the major prawn fishing grounds of Singapore are located in the same areas. These areas are characterised by sheltered environments, which allow settlement of sediment runoff from various rivers in southern Johor and result in the development of productive areas such as mangroves and seagrass beds. It is in such conditions that good food sources become available to allow many prawn species to co-exist.

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APPENDIX

Appendix 1. Penaeid prawns recorded in Malayan and adjacent regions. The plus symbol (+) indicates where the species were reported, and species originating from outside the region are enclosed in parentheses.

Taxon	Johor Straits	Malaya	Thailand	Sarawak (Borneo)	West Java
Family PENAEIDAE Rafinesque, 1815					
<i>Alcockpenaeopsis</i> Sakai & Shinomiya, 2011					
<i>Alcockpenaeopsis hungerfordi</i> (Alcock, 1905) = <i>Parapenaeopsis hungerfordi</i> (Alcock, 1905) ^{2,3,4}	+	+	+	+	
<i>Atypopenaeus</i> Alcock, 1905					
<i>Atypopenaeus stenodactylus</i> (Stimpson, 1860)		+	+		
<i>Batepenaeopsis</i> Sakai & Shinomiya, 2011					
<i>Batepenaeopsis venusta</i> (De Man, 1907) = <i>Parapenaeopsis venusta</i> De Man, 1907 ^{2,3}		+	+		
<i>Fenneropenaeus</i> Pérez Farfante, 1969					
<i>Fenneropenaeus indicus</i> (H. Milne Edwards, 1837) = <i>Penaeus indicus</i> H. Milne Edward, 1837 ^{1,4}		+		+	
<i>Fenneropenaeus merguensis</i> (De Man, 1888) = <i>Penaeus merguensis</i> (De Man, 1888) ^{1,3,5}					
= <i>Penaeus (Fenneropenaeus) merguensis</i> (De Man, 1888) ³	+	+	+	+	+
<i>Fenneropenaeus penicillatus</i> (Alcock, 1905) = <i>Penaeus penicillatus</i> Alcock, 1905 ¹					
= <i>Penaeus (Fenneropenaeus) penicillatus</i> Alcock, 1905 ³		+	(+)		
<i>Fenneropenaeus silasi</i> (Mathu & Motoh, 1979) = <i>Penaeus (Fenneropenaeus) silasi</i> Mathu & Motoh, 1979 ³	+		+		
<i>Ganjampenaeopsis</i> Sakai & Shinomiya, 2011					
<i>Ganjampenaeopsis uncta</i> (Alcock, 1905) = <i>Parapenaeopsis probata</i> Hall, 1961 ² = <i>Parapenaeopsis uncta</i> Alcock, 1905 ³		+	+		
<i>Heteropenaeus</i> De Man, 1896					
<i>Heteropenaeus longimanus</i> De Man, 1896		+			
<i>Kishinouyepenaeopsis</i> Sakai & Shinomiya, 2011					
<i>Kishinouyepenaeopsis cornuta</i> (Kishinouye, 1900) = <i>Parapenaeopsis cornuta</i> (Kishinouye, 1900) ^{3,4}			+	+	
<i>Kishinouyepenaeopsis maxillipedo</i> (Alcock, 1905) = <i>Parapenaeopsis maxillipedo</i> Alcock, 1905 ^{2,3}		+	+		
<i>Marsupenaeus</i> Tirmizi, 1971					
<i>Marsupenaeus japonicus</i> (Spence Bate, 1888) = <i>Penaeus japonicus</i> Spence Bate, 1888 ¹ = <i>Penaeus (Marsupenaeus) japonicus</i> Spence Bate, 1888 ³		+	+		
<i>Melicertus</i> Rafinesque, 1814					
<i>Melicertus canaliculatus</i> (Olivier, 1811) = <i>Penaeus (Melicertus) canaliculatus</i> (Olivier, 1811) ³			+		
<i>Melicertus latisulcatus</i> (Kishinouye, 1896) = <i>Penaeus latisulcatus</i> Kishinouye, 1896 ¹ = <i>Penaeus (Melicertus) latisulcatus</i> Kishinouye, 1896 ³		+	+		
<i>Melicertus longistylus</i> (Kubo, 1943) = <i>Penaeus jejunus</i> Hall, 1956 ¹ = <i>Penaeus longistylus</i> Kubo, 1943 ¹ = <i>Penaeus (Melicertus) longistylus</i> Kubo, 1943 ³		+	+		

Appendix 1...continued

Taxon	Johor Straits	Malaya	Thailand	Sarawak (Borneo)	West Java
Megokris Pérez Farfante & Kensley, 1997					
<i>Megokris granulosis</i> (Haswell, 1879)					
= <i>Trachypeneus furcilla</i> Hall, 1961 ²					
= <i>Trachypeneus granulosis</i> (Haswell, 1879) ^{2,3}		+	+		
<i>Megokris pescadoreensis</i> (Schmitt, 1931)					
= <i>Trachypeneus pescadoreensis</i> Schmitt, 1931 ³			+		
<i>Megokris sedili</i> (Hall, 1961)					
= <i>Trachypeneus sedili</i> Hall, 1961 ^{2,3}		+	+		
Metapenaeopsis Bouvier, 1905b					
<i>Metapenaeopsis andamanensis</i> (Wood-Mason in Wood-Mason & Alcock, 1981)		+			
<i>Metapenaeopsis barbata</i> (De Haan, 1850)	+	+	+	+	
<i>Metapenaeopsis ceylonica</i> Starobogatov, 1972			+		
<i>Metapenaeopsis lamellata</i> (De Haan, 1844) [in De Haan, 1833–1850]			+		
<i>Metapenaeopsis mogiensis</i> (Rathbun, 1902)		+	+		
<i>Metapenaeopsis mogiensis</i> cf <i>consobrina</i> (Nobili, 1904)	+				
<i>Metapenaeopsis novaeguineae</i> (Haswell, 1879)		+			
<i>Metapenaeopsis palmensis</i> (Haswell, 1879)	+		+		
<i>Metapenaeopsis stridulans</i> (Alcock, 1905)		+	+		
<i>Metapenaeopsis toloensis</i> Hall, 1962			+		
Metapenaeus Wood-Mason in Wood-Mason & Alcock, 1891					
<i>Metapenaeus affinis</i> (H. Milne Edwards, 1837)					
= <i>Metapenaeus mutatus</i> (Lanchester, 1901) ²					
= <i>Metapenaeus necopinans</i> Hall, 1956 ¹	+	+	+	+	
<i>Metapenaeus anchistus</i> (De Man, 1920)	+		+		
<i>Metapenaeus brivicornis</i> (H. Milne Edwards, 1837)	+	+	+	+	+
<i>Metapenaeus conjunctus</i> Racek & Dall, 1965					
<i>Metapenaeus dobsoni</i> (Miers, 1878)			+		
<i>Metapenaeus elegans</i> De Man, 1907			+		
<i>Metapenaeus ensis</i> (De Haan, 1844) [in De Haan, 1833–1850]					
= <i>Metapenaeus mastersii</i> Hall, 1962 ²	+	+	+	+	
<i>Metapenaeus intermedius</i> (Kishinouye, 1900)	+	+	+		+
<i>Metapenaeus joyneri</i> (Miers, 1880)				+	
<i>Metapenaeus krishnatrii</i> Silas & Muthu, 1976			+		
<i>Metapenaeus lysianassa</i> (De Man, 1888)	+	+	+	+	+
<i>Metapenaeus monocerus</i> (Fabricius, 1798)		+			
<i>Metapenaeus moyebi</i> (Kishinouye, 1896)					
= <i>Metapenaeus burkenroadi</i> Kubo, 1954	+		+		
<i>Metapenaeus suluensis</i> Racek & Dall, 1965			(+)		
<i>Metapenaeus tenuipes</i> Kubo, 1949					
= <i>Metapenaeus spinulatus</i> Kubo, 1949 ¹		+	+		+
Mierspenaeopsis Sakai & Shinomiya, 2011					
<i>Mierspenaeopsis cultrirostris</i> (Alcock, 1906)					
= <i>Parapenaeopsis cultrirostris</i> (Alcock, 1906) ²		+			
<i>Mierspenaeopsis hardwickii</i> (Miers, 1878)					
= <i>Parapenaeopsis hardwickii</i> (Miers, 1878) ^{2,4}		+	+	+	
<i>Mierspenaeopsis sculptilis</i> (Heller, 1862)					
= <i>Parapenaeopsis sculptilis</i> (Heller, 1862) ^{3,4}	+		+	+	+
Parapenaeopsis Alcock, 1901					
<i>Parapenaeopsis coromandelica</i> Alcock, 1906			+		
<i>Parapenaeopsis gracillima</i> Nobili, 1903	+	+	+	+	
<i>Parapenaeopsis tenella</i> (Spence Bate, 1888)		+	+		

Appendix 1...continued

Taxon	Johor Straits	Malaya	Thailand	Sarawak (Borneo)	West Java
<i>Parapenaeus</i> Smith, 1885					
<i>Parapenaeus fissurus</i> (Spence Bate, 1881)		+			
<i>Parapenaeus longipes</i> Alcock, 1905			+		
<i>Penaeus</i> Fabricius, 1798					
<i>Penaeus semisulcatus</i> De Haan, 1844 [in De Haan, 1833–1850]					
= <i>Penaeus (Penaeus) semisulcatus</i> (De Haan, 1844) [in De Haan, 1833–1850] ³	+	+	+		
<i>Penaeus monodon</i> Fabricius, 1798					
= <i>Penaeus bubutus</i> Kubo, 1949 ¹					
= <i>Penaeus (Penaeus) monodon</i> (De Haan, 1844) [in De Haan, 1833–1850] ³	+	+	+	+	
<i>Trachysalambria</i> Burkenroad, 1934					
<i>Trachysalambria albicoma</i> (Hayashi & Toriyama, 1980)					
= <i>Trachypenaeus albicomus</i> Hayashi & Toriyama, 1980 ³			(+)		
<i>Trachysalambria aspera</i> (Alcock, 1905)					
= <i>Trachypenaeus asper</i> Alcock, 1905 ³			+		
<i>Trachysalambria curvirostris</i> (Stimpson, 1860)					
= <i>Trachypenaeus curvirostris</i> (Stimpson, 1860) ^{2,3}	+	+	+		
<i>Trachysalambria fulvus</i> (Dall, 1957)					
= <i>Trachypenaeus fulvus</i> Dall, 1957 ⁴					
= <i>Trachypeneus unicus</i> Hall, 1961 ²		+		+	
<i>Trachysalambria longipes</i> (Paulson, 1875)					
= <i>Trachypenaeus longipes</i> (Paulson, 1875) ³			+		
<i>Trachysalambria malaiana</i> (Balss, 1933)					
= <i>Trachypenaeus malaianus</i> Balss, 1933 ³			+		

Sources: Hall (1956)¹; Hall (1961)²; Chaitiamvong & Supongpan (1992)³; Rajali (1994)⁴; Manuputty (1984)⁵