Species and Size Composition of Seahorses (Genus *Hippocampus*, Family Syng nathidae) in the Coastal Waters and Local Market of Kota Kinabalu

Rossita Shapawi*, Adrian Leslie Anyie, Muhammad Ali Syed Hussien and Wahidatul Husna Zuldin

Borneo Marine Research Institute, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia

*Corresponding author: rossita@ums.edu.my

Running Head: Seahorses in Coastal Waters of Kota Kinabalu and Local Market

Abstrak: Kepelbagaian kuda laut (Genus *Hippocampus*, Famili Syngnathidae), komposisi saiz dan perbezaan saiz berdasarkan jantina telah dikaji pada bulan November 2012 sehingga Mac 2013 di kawasan-kawasan terpilih sekitar perairan dan pasar tempatan di Kota Kinabalu, Sabah. Sebanyak enam spesies kuda laut telah dikenalpasti melalui kajian ini iaitu: (1) *Hippocampus barbouri*, (2) *H. comes*, (3) *H. kelloggi*, (4) *H. kuda*, (5) *H. spinosissimus* dan (6) *H. trimaculatus*. Kesemua enam spesies dijual di pasaran tempatan dan didapati bahawa kebanyakan kuda laut kering adalah hasil daripada tangkapan pukat tunda dan didagangkan sebagai ubat tradisional, cenderamata dan kegunaan lain. Sebanyak empat spesies iaitu: (1) H. *barbouri*, (2) *H. comes*, (3) *H. kuda*, dan (4) *H. spinosissimus* telah ditemui menggunakan kaedah penyampelan secara terus di habitat yang berbeza sekitar perairan Kota Kinabalu. *H. comes* adalah yang terbesar dalam kalangan empat spesis hidup yang ditemui (min SL: 176.75 mm), manakala *H. barbouri* adalah yang paling kecil (min SL: 155.91 mm). Bagi sampel kering, *H. kelloggi* adalah yang terbesar (min SL: 245.25±14.55 mm) dan *H. barbouri* adalah yang terkecil (min SL: 127.21±10.01 mm). Tiada perbezaan ketara ($P>0.05$) antara panjang jantan dan betina serta, tiada perbezaan saiz berdasarkan jantina dalam setiap spesies. Sebagai kesimpulan, hasil kajian ini akan dapat memberikan beberapa data asas dalam usaha pemuliharaan teleost marin yang unik ini.

Kata kunci: Kuda Laut, Hippocampus, Syngnathidae, Kepelbagaian Spesies, Komposisi Saiz, Perbezaan Saiz mengikut Seksualiti, Kota Kinabalu

Abstract: Seahorse diversity (Genus *Hippocampus*, Family Syngnathidae), species identification, size composition and sexual diphormism were conducted from November 2012 to March 2013 in selected coastal waters around Kota Kinabalu, Sabah and local market trade. Six species of seahorses were identified in the study: (1) *Hippocampus barbouri*, (2) *H. comes*, (3) *H. kelloggi*, (4) *H. kuda*, (5) *H. spinosissimus* and (6) *H. trimaculatus*. All six species were sold at the local market and the dried seahorses were obtained mainly by local fishermen using trawl by-catch method and traded as traditional medicine, souvenirs and other uses. By direct samplings, four species: (1) H. *barbouri*, (2) *H. comes*, (3) *H. kuda*, and (4) *H. spinosissimus* were identified in various different habitats of Kota Kinabalu coastal waters. Based on the result, *H. comes* was the largest in size among the four fresh/live species found (147-150, 148.25±1.26mm), whereas *H. barbouri* was the smallest species (118-140, 129±7.81mm). For the dried samples, *H. kelloggi* was the largest (218-265mm, 245.25±14.55 mm) and *H. barbouri* was the smallest (105-142mm, 127.21±10.01 mm). From statistics, no significance difference (P>0.05) was observed in lengths between male and female in every seahorse species and there was no sexual size dimorphism in any of the species. The findings from the study are significant in providing several baseline data for marine conservation purposes of the unique seahorses.

Keywords: Seahorse Diversity, Species Identification, Size Composition, Sexual Diphormism, Kota Kinabalu Coastal waters and Local Trade Market

INTRODUCTION

Seahorses (Genus *Hippocampus*, Family Syngnathidae) are unsual and valuable for a number of reasons including their unusual biology, unique anatomy, economic value, and conservation as well as ecological importance and alleged medicinal properties (Shapawi *et.al*, 2013). They have been exploited for several purposes including for use as traditional medicine, ornamental fish, and curious

with good market value and demand, which eventually making them vulnerable to exploitation and considered threatened (Vincent, 1996).

Seahorse species populations, and diversity as well as distribution in Malaysia have not been studied adequately. Information on the exploitation and trade of seahorses are also deficient. Regular assessments on the population abundance, size-frequency distribution and sex-ratio on any fish species can be used to track trends (increasing, equilibrium, decreasing) in local population abundance. Furthermore, a continuous assessment in many sites provides useful information about species distributions, habitat use and the impacts of large-scale environmental disturbances (King, 1995; English *et al*., 1994). The basic biological information compiled during seahorse population assessments might be useful as important baseline information available for use by marine biologists to evaluate the impacts of a planned or unexpected disturbance event on the local seahorse community. The density, size distribution, sex ratio, and reproductive activity of a species can give an insight into the life history and responses to disturbance. The structure of a population can also be used to estimate life history parameters such as growth, survival, and reproductive rates (King, 1995). In the present study, diversity, size composition, and sexual size dimorphism of Hippocampus spp. found in Kota Kinabalu, Sabah were studied.

MATERIALS AND METHODS

Collection of Specimens and Surveys

Samplings and surveys were carried out from November 2012 to March 2013 in five selected study areas: (1) Dinawan Island, (2) Layangan Island, (3) Sepangar Island, (4) Universiti Malaysia Sabah (UMS) Jetty and (5) Kampung Kibagu, (6) Gaya Island and (7) Tanjung Aru for fresh/live samples and local market for dried sample. Live seahorses were collected by direct samplings performed through roving snorkelling or scuba diving at sampling sites (Figure 1) and some specimens were purchased from fishers who used a variety of fishing gears such as trawlers, seine nets, trammel nets, portable traps, purse seines, cast nets, scoop nets and hand-picked. Fresh or recently dead seahorses were either obtained from the fisherman or caught during direct sampling were preserved in a jar immediately with 10% of formalin solution for further species identification purpose. For the dried

sample, a market survey was done in Salted Fish Market, Kota Kinabalu, Sabah. Interviews together with a set of questionnaire were used as instruments to gather information from the respondents (mainly the sellers) on catch methods, trade routes, origins, price and commercial value as well as the uses. The specimens of dried seahorses were also borrowed from the sellers and visually identified to the species level.

Species, Sex and Standard Length Identification

All the fresh/live and dried specimens collected were photographed and identified to species level, sexed and standard length (SL) measurement (sum of head length, trunk length and tail length) according to standards provided by Lourie *et al.* (2004)(Figure 2). All measurements were taken to the nearest millimetre (0.1 mm) and meristic count also used. The sexes were distinguished externally based on the presence or absence of a brood pouch on adult seahorses. Mean standard lengths for male and female of each Hippocampus spp. found were calculated.

Statistical Analysis

Two-sample *t*-test was applied to compare length differences between the two sexes in every seahorse species found. Significance differences were tested at 95% confidence interval.

RESULTS

The data was obtained from 11 interviews with sellers from local market where a total of 315 dried seahorses (154 males and 161 females) were borrowed and 18 fresh/live seahorses (10 males and 8 females) were collected with 12 samples purchased from local fishers and 6 samples caught during direct samplings (Figure 3). Among the seven sampling stations, the seahorses were only found in three stations namely UMS Jetty, Gaya Island and Tanjung Aru (Table 1). Ten individuals of *H.barbouri* were found mainly in the outer fringes of the estuary of Gaya Island and Tanjung Aru and one individual was obtained during sampling at UMS Jetty at depths of between 7-10m. Meanwhile, all four individuals of *H. comes* were obtained from under UMS Jetty caught between 5-8m through several diving. Two females of *H. spinosissimus* were found in a shallow reef flat at Tanjung Aru, with

depth ranging between 8-10m according to the fisher's memory. One female of *H. kuda* was obtained around UMS Jetty's surroundings (approximately 1-3m) during a direct sampling.

Species Composition

Six species of seahorses were identified around the coastal waters and local market of Kota Kinabalu: *Hippocampus barbouri*, *H. comes*, *H. kelloggi*, *H. kuda*, *H. spinosissimus* and *H. trimaculatus*. Different species have unique and distinctive characteristics that differentiate them from one another based on the morphological identification on fresh/live samples. All the six species were identified on the lent dried samples; meanwhile, only four species were identified on the fresh/live samples: *H. barbouri, H. comes*, *H. kuda* and *H. spinosisimus*. Among all the fresh/live samples, *H. barbouri* were the most abundant species with 61% species composition. From the species composition among the dried specimens, *H. spinosissimus* comprised 35% of the total, representing the most heavily exploited species. This was followed by *H. barbouri* (24.8%), *H. comes* (16.5%), *H. trimaculatus* (11.8%), *H. kelloggi* (7.6%) and *H. kuda* (4.4%). The small percentages of *H. kelloggi* and *H. kuda* in the collections suggested that there were relatively few of them in the wild. (Table 1).

Size Composition and Sexual Size Diphormism

For the fresh/live sample, *H. comes* was the largest among the four species, with mean standard length reaching 148.25±1.26mm, whereas *H. barbouri* was the smallest species with mean standard length 129±7.81mm. Length between the two sexes in *H. comes* and *H. barbouri* were similar and showed no sexual dimorphism in both species. Meanwhile, length differences between male and female for *H. spinosissimus* and *H. kuda* cannot be accomplished since only females' specimens were available (Table 2).

Otherwise; for the dried samples, *H. kelloggi* was the largest with overall mean standard length of 245.25±14.55 mm and *H. barbouri* was the smallest with overall mean standard length reaching 127.21±10.01 mm. *H. kelloggi* was the largest among the six species, with mean for male and female standard lengths reaching 240.57±15.88 (SD) mm and 244.60±12.91 (SD) mm respectively, while *H. barbouri* was smallest (male mean standard length: 125.21±10.51 (SD) mm; female mean standard length: 129.53±9.00 (SD) mm). The second largest species was *H. trimaculatus* with mean for male and female standard lengths of 171.33±12.78 (SD) mm and

167.50±10.51 (SD) mm respectively, followed by *H. kuda* with mean for male and female standard lengths of 163.89±12.19 (SD) mm and 164.00±15.39 (SD) mm correspondingly. Meanwhile, mean standard length in *H. comes* were 147.90±13.47 (SD) mm for male and 145.66±11.80 (SD) mm for female. Lastly, mean standard lengths of male and female *H. spinosissimus* were 141.06±9.03 mm and 138.81±7.71 mm respectively. There are no significance difference between length differences between male and female in every seahorse species ($p>0.05$), therefore, the results show no sexual size dimorphism in any of the species (Table 3).

Market Survey

A total of 11 respondents have provided information on the catch methods, trade routes, origins, price and commercial value as well as the uses of the local dried seahorses (Table 4). The dried seahorses were mpstly obtained from the fishery by-catches and sold locally with price up to RM100 per pair of seahorse depending on size and other physical attributes (eg, colour). About 80% of the respondent states that dried seahorses sold in the market were originated locally and 20% referred them as imported seahorses from neighbouring countries such as Philippines and Indonesia.

DISCUSSION

The seahorse species compositions in the coastal waters of Kota Kinabalu were found to be consistent with the species previously reported in Peninsular Malaysia (Choo & Liew, 2003) as well as in East Malaysia (Choo & Liew, 2004). Besides, the species are also slightly alike with those of the neighbouring countries. For example, two species found from this study (*Hippocampus spinosissimus* and *H. kuda*) had been documented in the waters of Vietnam, Philippines and Indonesia (Lourie *et al*., 2004) as well as in the waters around Thailand (Natheewatana *et al*., 1993). Lourie *et al*., (2004) suggested that *H. kuda* is the most dominant species in Indo-Pacific basin. In the present study, the species was not encountered often in both field and market surveys in which might indicate a fishing pressure of the species.

Ten species of the subfamily Hippocampinae were previously recorded in Malaysia and all ten confirmed species were also reported in Sabah (Choo & Liew, 2004; Lim *et al*., 2011). Sabah waters

have a relatively high diversity of seahorse species, containing almost all the seahorse species in the Southeast Asia including pygmy seahorses, excluding only *H. mohnikei* (Lourie *et al*., 2004). Pygmy seahorses; *H. bargibanti*, *H. denise* and *H. satomiae* had only been spotted in the east side of Sabah around Semporna Islands (Lim *et al.*, 2011). Faleiro and Narcisco (2011) reported that, given the lack of sexual dimorphism in seahorse length, size-assortative mating can be advantageous and optimize the reproductive potential of seahorse couples. In *H.erectus*, males exhibit longer standard lengths, shorter trunks with isometric growth, and longer tails with positively allometric growth. Whereas, females demonstrate positively allometric growth of trunk length and isometric tail length. There was no observed dimorphism in the weight-length relationship of this species (Anderson, 2012).

The species distribution of seahorses was strongly dependent on the habitat availability. Sabah is blessed with its rich marine biodiversity and complex coastal geomorphology (Lim *et al*., 2011) and thus offers a wide range of habitat types, thus this could explain the richness of seahorse diversity in Sabah as compared to other parts of Malaysia. There was a clear habitat separation for most species and these habitats were generally consistent with those stated in Lourie *et al*., (2004). Interestingly, this study did not find any seahorses in coral reef ecosystems at both Layangan Island and Dinawan Island which was dominated by scleractinian corals harbouring diverse fish species. In fact, they were often found in cryptic habitats such as seaweeds and gorgonian corals. Food competition and predation could be the major causes that lead seahorses to avoid inhabiting the scleractinian zone, since many coral reef fishes are either fast-swimming plankton eaters or piscivores. In addition, the feeding habits of many seahorse species as slow moving ambush predators might be most successful in cryptic habitats. This study provides some inferences as to the distribution of seahorse species in areas not covered by this particular survey, which would be useful for further investigation as well as for management and conservation purposes.

The *Hippocampus barbouri* could be found in waters off most of the islands and in shallow bays or lagoons in Sabah, since *Halimeda* sp. seaweed (their associated substrate) is likely to thrive in such area (Choo & Liew, 2004). On the other hand, *H. comes* could be widespread in the shallow reef along Sabah coastlines and islands (Choo & Liew, 2004), but fish bombing, which is practised in some areas, could severely impact the whole population of this species which is known to be extremely site-faithful (Perente *et al*., 2002). In addition, *H. kuda* was extant in Sepanggar Island in the past, where there used to be abundant tropical eelgrass (Choo & Liew, 2004). However, there

was none found in the areas most probably because the seagrass beds were heavily perturbed by boat activities, fish bombing, netting, and dredging for land reclamation. Thus *H. kuda* populations which previously existed probably have been severely decimated. Labuan Island and several estuaries on the northeast of Sabah, and perhaps the estuaries in Sarawak, might harbour populations of *H. kuda*. Therefore, future work should aim at investigating these areas with more sampling frequency on different sampling sites.

On the conservation issue, currently, 38 species of seahorses worldwide are listed in the 2012 IUCN Red List Red List of Threatened Species (IUCN, 2012). Of the six seahorse species found from the present study, all have been listed on the 2012 IUCN Red List as vulnerable. The current overexploitation of seahorses is largely due to the market demand for traditional Chinese medicine (TCM) or traditional medicine (*jamu* and folk medicine), souvenirs and others proven by the market survey data from the findings. Any *Hipppocampus* sp. that are available are traded as TCM, *jamu* and folk medicine and believed to be highest in medicinal value and the most valuable for the trade among other syngnatids such as pipefishes (Vincent, 1996). Indeed, Malaysia is touted as an important supplier of seahorses (Perry *et al*., 2010) together with pipefishes and pipehorses (Martin-Smith *et al.*, 2003).

Given the increasing anthropogenic threats to the Malaysian ichthyofauna (Chong *et al.*, 2010), integrated coastal or ecosystem-based management seems more urgent than ever to help conserve the local seahorses and fisheries resources in general. Two species of seahorses from the findings (*Hippocampus barbouri* and *H. spinosissimus*) were found to inhabit macroalgae at some distance from Marine Park Island like Tunku Abdul Rahman Park. Thus, it appears that with good enforcement, Marine Protected Areas can play a vital role in protecting some species of seahorses and their habitats. Moreover, mangroves area, coral reefs and sea grass beds in estuaries those act as sanctuaries for some seahorse species must be protected and managed wherever possible. These are the prime habitats for many seahorse species, so loss and degradation will affect the fishes. Plus, undeveloped areas that support remnant seahorse populations ought to be preserved. Artificial reefs are also likely shelters for seahorses, as divers have reported them in concrete and tyre man-made reefs (Choo & Liew, 2005). When established near gorgonian beds, artificial reefs could also boost seahorse's populations and repel local extinction. In addition, culturing seahorses is also an option to

reduce pressure on wild seahorses. The demand for seahorses cannot be met by harvesting wild stock; as a result, it is important to establish the seahorse farm (Vincent, 1996).

CONCLUSION

In summary, six species of seahorses were identified around the selected coastal waters and local market of Kota Kinabalu which are also found in other parts of Malaysia. All the six species were traded as dried seahorses in the market and used for various purposes. *H. kelloggi* was the largest among the six species and *H. barbouri* was the smallest. There was no significance difference of lengths between male and female in every species and no sexual size dimorphism was detected in any of the species. In conclusion, the findings from the study are significant to support the seahorse's conservation efforts.

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Table 1: Species Composition and Sexes of Fresh/Live and Dried Seahorses Sample found in Coastal Waters and Local Market of Kota Kinabalu.

Types of Sample	**Fresh/Live**					**Dried**			
Species	**Sampling Station**	**No. of Individuals**	**(%)**	**Male**	**Female**	**No. of Individuals**	**(%)**	**Male**	**Female**
Hippocampus barbouri	Gaya Island, Tanjung Aru and UMS Jetty	11	61	7	4	78	24.8	42	36
Hippocampus comes	UMS Jetty	4	22	3	1	52	16.5	20	32
Hippocampus kellogi	-	-		-	-	24	7.6	14	10
Hippocampus kuda	UMS Jetty	1	6	-	1	14	4.4	9	5
Hippocampus spinosissimus	Tanjung Aru	2	11	-	2	110	35	48	62
Hippocampus trimaculatus	-	-		-	-	37	11.8	21	16
Total Individuals	18					315			

Table 2: Morphological analysis of fresh/live seahorse species found in Kota Kinabalu.

Species	***Hippocampus barbouri***		***Hippocampus comes***		***Hippocampus spinosissimus***		***Hippocampus kuda***	
Sex	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Height (mm)	120-140	118-139	147-150	148	#N/A	123-134	#N/A	126
Snout length (SnL) (mm)	11-13	12-13	12-13	12	#N/A	12-13	#N/A	11
Head length (HL) (mm)	25-28	25-28	28-29	29	#N/A	25-28	#N/A	23
HL/SnL (calculated)	2.0-2.3	2.1-2.2	2.3-2.4	2.4	#N/A	2.1-2.2	#N/A	2.1
Tail rings	33-35	33-35	35-36	35	#N/A	17-18	#N/A	35
Dorsal fin rays	16-19	17-20	18-19	17	#N/A	17	#N/A	17
Pectoral fin rays	15-18	16-18	17-18	16	#N/A	11	#N/A	16
Trunk rings	11	11	11	11	#N/A	12	#N/A	11
Trunk rings supporting the dorsal fin	2	2	2	2	#N/A	1	#N/A	2
Tail rings supporting the dorsal fin	1	1	1	1	#N/A	1	#N/A	1
Cheek spines	2	2	2	2	#N/A	1	#N/A	1
Eye spines	1	1	2	2	#N/A	1	#N/A	0

Table 3: Size range between males (m) and females (f) for dried seahorse species sold in Kota Kinabalu Salted Fish Market.

Species	Sex	Mean standard length (mm) ±SD	N	*t* Critical two-tail	*P* 95% confidence limit Sig. (two-tailed)
Hippocampus spinosissimus	(m) (f)	141.06±9.03 138.81±7.71	48 62	1.986	0.170
Hippocampus barbouri	(m) (f)	125.21±10.51 129.53±9.00	42 36	1.992	0.055
Hippocampus comes	(m) (f)	147.90±13.47 145.66±11.80	20 32	2.028	0.544
Hippocampus trimaculatus	(m) (f)	171.33±12.78 167.50±10.51	21 16	2.030	0.324
Hippocampus kelloggi	(m) (f)	240.57±15.88 244.60±12.91	14 10	2.074	0.501
Hippocampus kuda	(m) (f)	163.89±12.19 164.00±15.39	9 5	2.365	0.989

Table 4: Responses from the Local Market Survey.

Topic	Information
Catch Methods	1. Trapped by trawlers 2. Landed as by-catch 3. Dragged in by beach seines net or disentangled from their holdfasts on gill nets 4. Catch by hand (diving) and others by push-nets or scoop nets
Trade Routes	1. Sold to tourists. 2. Exported to wholesalers from Peninsular Malaysia
Origins	1. Kota Kinabalu, Kudat, Semporna, Sandakan, Kota Belud and Kinarut (Malaysia) 2. Sulu Sea, Philippines 3. Indonesia
Price	Dried: single (RM 15 to RM 35), by pair (RM 25 to RM 95)
Commercial Value	The commercial values of the seahorses are depending on sizes and conditions. Larger and coloured seahorses were sold at higher prices than smaller and bleached seahorses
Uses	1. Traditional Chinese Medicinal Application 2. Malay Traditional and Folk Medicine 3. Souvenirs (Decorative items) 4. Local Traditional Magical Beliefs items (Folklore beliefs)

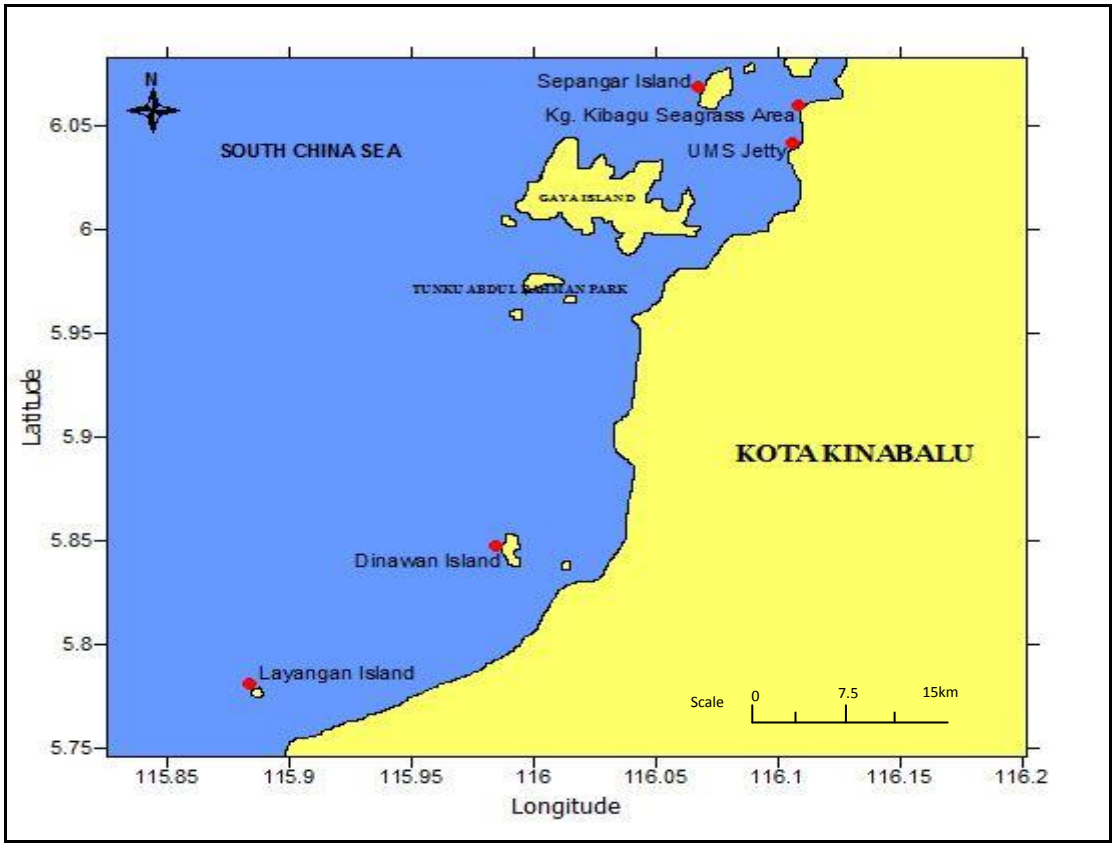

Figure 1: Map of coastal areas of Kota Kinabalu. The red dots indicate the sampling sites for seahorse survey.

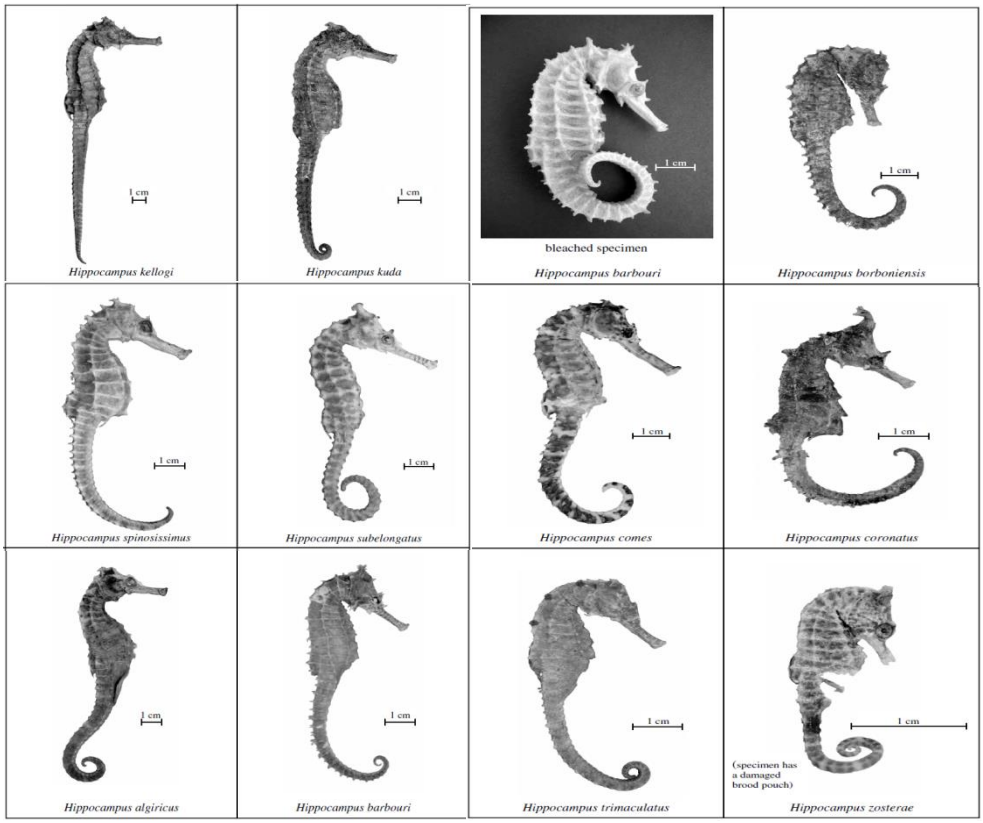

Figure 2: Photographic atlas of dried seahorses (Source: Lourie et al., 2004).

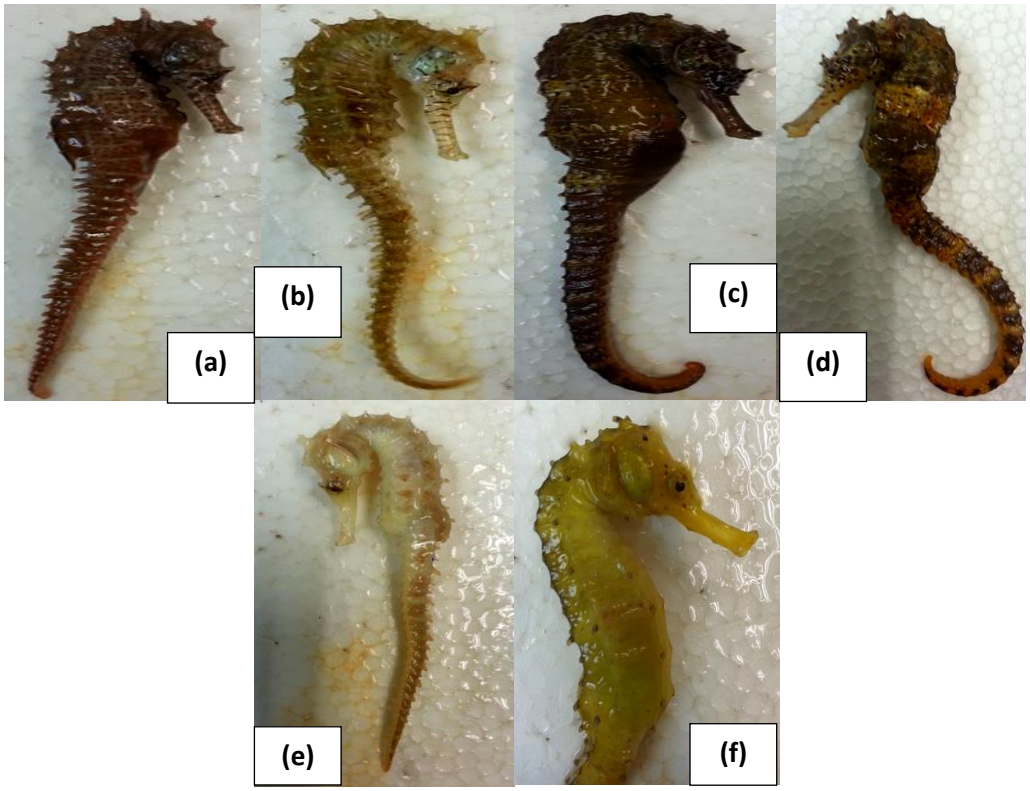

Figure 3: The photographs of identified live specimens. (a) male H.barbouri, (b) female *H.barbouri,* (c) male *H.comes*, (d) female *H.comes*, (e) female *H.spinosissimus* and (e) female *H.kuda.*