Borneo Journal of Marine Science and Aquaculture
Volume: 05 (02) | Dec 2021, 83-91

Distribution of seahorse species in Malaysia, harvesting trends and conservation concerns – A review

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Abstract

Seahorse is a unique fish belonging to the genus *Hippocampus*. It has a horse-like head, tubular mouth, and the body is covered with rings of armoured plates until the tip of the prehensile tail. Seahorses are traded for human consumption and ornamental purposes. However, the dry product of seahorses has a major demand for traditional Chinese medicine (TCM). The ornamental products such as keychains, earrings and brooches also support a growing '*curio'* trade. There is a limited amount of published data on seahorse distribution in Malaysia despite increasing pressure of exploitation, this study was carried out to review the available information, identify knowledge gaps and draw attention towards sustainability of the seahorse populations. To date, twelve seahorse species have been reported in Malaysia. Most of these species are found in East Malaysia. In Sabah, 11 out of 12 tropical seahorse species have been encountered. This does not include the Japanese dwarf seahorse, *Hippocampus mohnikei.* Among the eleven species of seahorses found in Sabah are seven species of common size seahorses, *H. barbouri*, *H. comes*, *H. histrix*, *H. kelloggi*, *H. kuda*, *H. spinosissimus* and *H. trimaculatus* and four species of pygmy seahorses, *H. bargibanti*, *H. denise*, *H. satomiae* and *H. pontohi*, that were previously identified as *H. severnsi*. This study highlights the importance of conservation of wild population of seahorses and the need for farming as a means of lessening the exploitation of wild stocks while meeting the human demand.

Keywords: Seahorses, Species distribution, Overexploitation, Knowledge gaps, Sustainability concerns

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Introduction

The seahorses belong to the genus *Hippocampus*. This fish has a horse-like head, tubular mouth, and its bony plates arranged in articulated ring-like segments throughout body up to the tip of the prehensile tail (Porter et al., 2013). Seahorses of the family of Syngnathidae are placed together with seadragon, pipefish and pipehorse (Porter et al., 2013; Blanco and Planas, 2015). Syngnathid fish are known to be slow swimmers. Their swimming behaviour is highly specialized involving rapid oscillation of the dorsal fin due to the absence of caudal fin and whole caudal region (Ashley-Ross, 2002). Only seahorses swim upright, while the rest keep their bodies in a horizontal position (Kuiter, 2009; Neutens et al., 2014). Seahorse is well known to exhibit male parental care with the presence of brood pouch upon maturity to carry the eggs contributed by the female parent (Planas et al., 2010; Dudley et al., 2021).

Globally, 46 species of seahorses have been described so far (Koldewey and Martin-Smith, 2010; O'Donnell et al., 2010). Out of the 12 seahorse species found in Malaysia, 11 have been reported from Sabah but the presence of *Hippocampus mohnikei* (Lim et al., 2011; Aylesworth et al., 2016; Lourie et al., 2016) has not been confirmed. Both dwarf and pygmy seahorses are small-sized fish that begin reproducing when 1-2 inch in height (Kanuo and Kohno, 2001; Shepherd et al., 2017). The brood pouch is still prominent in male dwarf seahorses at the tail region whereas pygmy seahorses have trunk brooding habit (Smith and Tibbetts, 2008). Among the 11 species of seahorses in Sabah the most common are *H. barbouri*, *H. comes*, *H. histrix*, *H. kelloggi*, *H. kuda*, *H. spinosissimus* and *H. trimaculatus* in addition to 4 species of pygmy seahorse, *H. bargibanti*, *H. denise*, *H. satomiae* and *H. pontohi*, that were previously identified as *H. severnsi* (Lim et al., 2011; Lourie et al., 2016). Figure 1 shows 12 seahorse species reported in Malaysia.

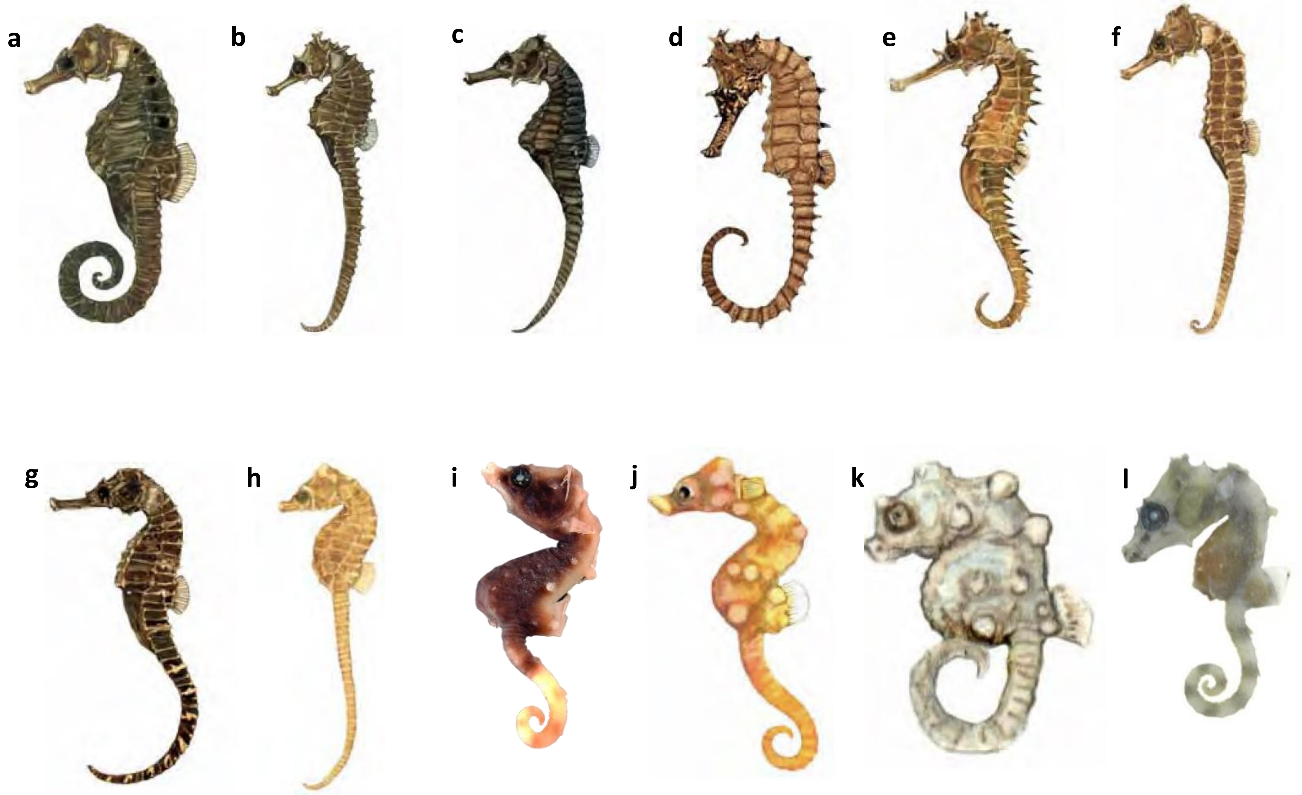

Figure 1. Seahorse species in Malaysia (a) *Hippocampus trimaculatus*, (b) *H. spinosissimus*, (c) *H. kuda*, (d) *H. barbouri*, (e) *H. histrix*, (f) *H. kelloggi*, (g) *H. comes*, (h) *H. mohnikei*, (i) *H. pontohi*, (j) *H. denise*, (k) *H. bargibanti* and (l) *H. satomiae*. Source: Lourie et al. (2004), Lourie and Kuiter (2008)

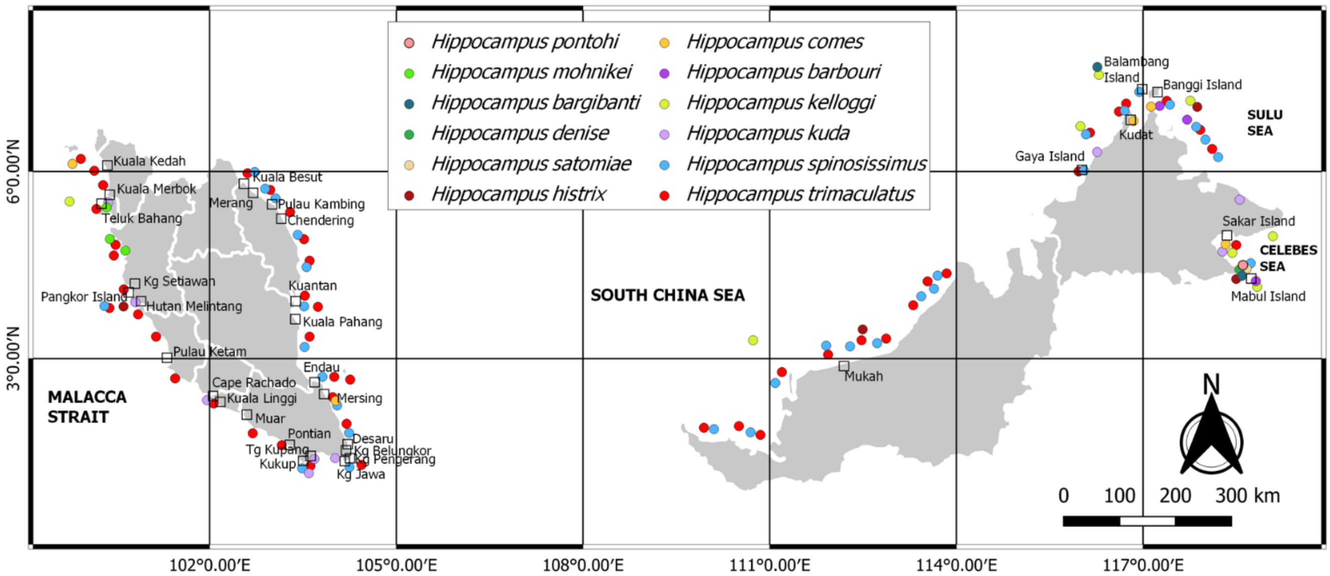

Figure 2. Distribution of seahorse species in Peninsular Malaysia (Source: Choo and Liew, 2003; 2004; Lim et al., 2011; Shapawi et al., 2015; Aylesworth et al., 2016; Wong and Teh, 2017)

Habitat and distribution of seahorses in Malaysia

Seahorses are found in shallow coastal waters of temperate and tropical regions less than 150 m deep, with the greatest diversity recorded in the Indo-Pacific (Lourie et al., 2004). Even seahorse that are known as marine species, it is possible to find some species such *H. abdominalis*, *H. capensis*, *H. kuda*, or *H. reidi* in habitats with fluctuating salinities such as estuaries or lagoons (Choo and Liew, 2004; Martin-Smith and Vincent, 2005; Dody et al., 2021). Water currents and holdfast facilities might influence the distribution of these slow swimmer seahorses (Correia et al., 2018). Seahorses usually use their prehensile tail to attach to the corals, mangrove roots, seagrasses and sponges in the muddy, sandy or rocky areas (Lourie et al., 2005; Martin-Smith and Vincent, 2005). Seahorses have also been observed attached to artificial structures in jetties or mussel farms (Kuiter, 2000). Distribution of seahorse species in Malaysia is shown in Figure 2.

The most frequently found species in Malaysia, *H. trimaculatus*, is present throughout the coastal waters of the country. It is also associated with *H. spinosissimus* on the east coast of Peninsular Malaysia, but on the west coast, *H. spinosissimus,* was found only in Pangkor Island (Choo and Liew, 2003). In East Malaysia, both the species are widely distributed in the waters along the coast of South China Sea, Sulu Sea and Celebes Sea, at 20-40 m depth of gorgonians-sea whip beds (Choo and Liew, 2004). Sand bottom is the preferable habitat for these species, with *H. spinosissimus* commonly associated with soft corals (Lim et al., 2011; Shapawi et al., 2015). In 2017, *H. trimaculatus* was observed drifting near the water surface of Port Dickson (Negeri Sembilan), indicating translocation and long-distance dispersal from deeper areas and demersal habitats (Wong and Teh, 2017).

H. kelloggi, it is exclusively found in Tukun Perak Island, Peninsular Malaysia, at 65-90 m (Choo and Liew, 2003). While in East Malaysia, *H. kelloggi* also appeared on gorgonian beds of South China Sea, Sulu Sea and Celebes Sea, in much the same way as *H. trimaculatus* and *H. spinosissimus*, but in the deeper (40-80 m) offshore areas (Choo and Liew, 2004). According to Lim *et al.* (2011), both *H. comes* and *H. histrix* were discovered earlier in East Malaysia than in Peninsular Malaysia. *Hippocampus histrix* is considered scarce since they are only found in certain areas like Jarak Island in Peninsular Malaysia, Mukah in Sarawak, Banggi Island and Semporna Island in Sabah (Choo and Liew, 2004; Lim et al., 2011). The habitat for *H. histrix* in Malaysia remains unclear as it was only caught by trawlers together with *H. trimaculatus* and *H. spinosissimus* from deeper areas (Choo and Liew; 2004). However, Lim et al. (2011) believed that *H. histrix* populated the *Halimeda* beds and was potentially associated with seagrasses. *Hippocampus comes* is found in Langkawi and Mersing Islands in Peninsular Malaysia, whereas in Kudat, Banggi Island and Sakar Island in East Malaysia it is seen associated with either the hard coral reef, sponges, seagrasses or seaweeds such as *Sargassum* sp. at about 2 m depth (Lim et al., 2011; Choo and Liew, 2004). Besides, *H. comes* was found near the Jetty of Universiti Malaysia Sabah (UMS), Kota Kinabalu (Shapawi et al., 2015).

The existence of *H. kuda* has been reported from specific places on the west and south coasts of Peninsular Malaysia, like Kuala Merbok, Dinding River, Cape Rachado, Johor River, Pulai River and Kuala Skudai (Choo and Liew, 2003; Lim et al., 2011). It is also found in Sandakan, Gaya Island, Balambangan Island and Sakar Island, Sabah (Choo and Liew, 2004, Lourie et al., 2005). Usually, *H. kuda* can be found attached to seagrass, *Enhalus* sp. either in river mouths or estuaries with depth between 1-3 m. In East Malaysia, *H. kuda* sometimes occurs in beds of *H. barbouri* in *Halimeda* (Choo and Liew, 2004; Lim et al., 2011). Neither of these has been reported from Sarawak waters. Both *H. kuda* and *H. barbouri* also occur around the UMS Jetty, Kota Kinabalu (Shapawi et al., 2015). At Gaya Island, Balambangan Island, Tanjung Aru, Banggi Island and Mabul Island, *H. barbouri* is also reported in *Halimeda* beds and in shallow and sheltered bays (1-2 m depth) but is only occasionally caught by trawlers at the 20 m in depth (Choo and Liew, 2004; Shapawi et al., 2015).

Hippocampus barbouri with all the four pygmy seahorses, *H. bargibanti, H. denise*, *H. pontohi* and *H. satomiae,* are only reported from the coastal waters of East Malaysia. However, the presence of *H. pontohi*, previously known as *H. severnsi,* in Malaysia, is yet to be confirmed, as only described in anecdotal sources (Lim et al., 2011). Both *H. denise* and *H. bargibanti* are found in Semporna and Spratly Islands, whereas *H. satomiae* was encountered in Semporna, occupying the gorgonians (sea fans) area in depth between 12-25 m (Lourie and Randall, 2003; Lourie and Kuiter, 2008; Lim et al., 2011). Unlike the pygmy seahorse, *H. mohnikei*, is the only species of dwarf seahorse that can be found in mangrove and seagrass areas (1-6 m depth) of Kuala Gula, Sepetang and Bagan Dalam (Aylesworth et al., 2016). Figure 3 illustrates the potential habitat and average depth segregations in the coastal waters of Malaysia, from the shallow estuaries (1-3 m) all the way up to deep-waters associated with gorgonians (<95 m). Different findings described various habitat and depth segregations of the 11 seahorse species in Malaysia.

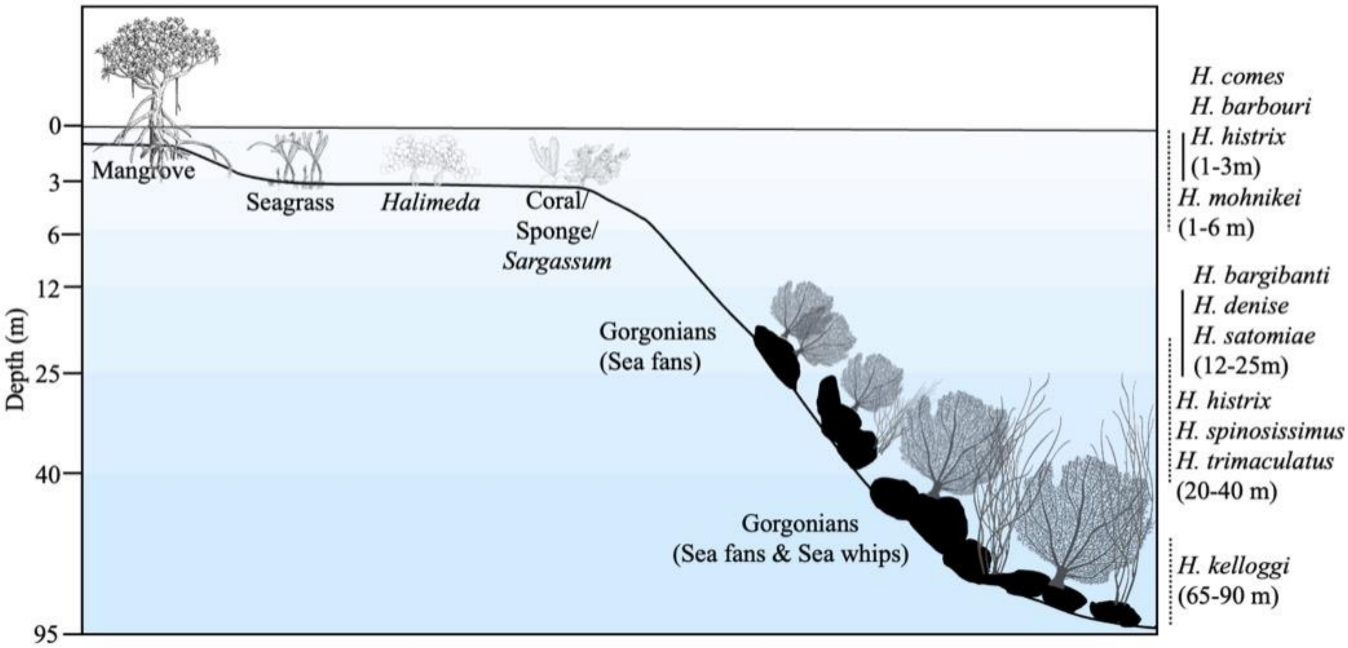

Figure 3. Potential habitat and average depth segregations of eleven seahorse species in water of Malaysia (Source: Choo and Liew, 2003; Liew, 2004; Lim et al., 2011; Aylesworth et al., 2016)

Conservation

About ten million seahorses sourced from the wild population were traded every year between 80 countries to meet the demands for traditional Chinese medicine (TCM), aquarium industry and souvenir (also known as 'curio') trade (Vincent et al., 2014). Most of the catch is sold for TCM (Vincent et al., 2011). All the species of seahorse are used in TCM since it is believed to enhance energy flows in the body, healing effects on health problems, for example, asthma, high cholesterol, goiter, kidney malfunction and skin problems such as acne and nodules. Scientific literature only described the therapeutic value as antitumor and antiaging effects, without any clinical trials (Zhang et al., 2017). Seahorse is also required as an ingredient in TCM derivatives in Korea and Japan, known as *hanyak* and *kanpo,* respectively, as well in traditional medicine in Indonesia called *jamu* (Kumaravel et al., 2012). Seahorses used in TCM are typically ground to a powder and encapsulated, applied directly to wounds, or mixed with a liquid (usually warm water). Additionally, sometimes whole seahorses are soaked in alcohol, oil or even prepared in soups (Rosa et al., 2013). Usually, large size seahorse with pale coloration and without bodily spine is the most preferred in TCM (Vincent, 1996). However, processing the catch into powder eliminates the preference for the species, and species such as *H. barbouri* are traded for TCM alongside *H. spinosissimus*, *H. comes*, *H. kuda* and *H. trimaculatus* (Perry et al., 2010). Moreover, seahorses are also commonly used in folk medicines practiced in Africa, India, Philippines and Latin America (Baum and Vincent, 2005; Rosa et al., 2013). In Brazil, seahorses are commonly traded for medicinal purposes (Rosa, 2005; Alves and Rosa, 2010). They are also known as the most flexible fish species for therapeutic indications (Rosa et al., 2013).

As mentioned earlier, besides TCM, the dried seahorse is also sold for *curio* trade, that includes products such as keychain or ornaments such as earrings and brooches (Vincent, 1996; Grey et al., 2005; Alves et al., 2006). Curio trade for 65 000 seahorses was valued at USD 10 000 yearly (Grey et al., 2005). Dried seahorse product is mainly sourced from Asia and traded among the Asian countries, including Hong Kong, Taiwan, China, Singapore and Japan, besides small quantities being exported to United Kingdom, United States and Australia (Perry et al., 2010; Evanson et al., 2011). In TCM trade, the price of dried seahorse can reach USD 1200 kg^{-1} (Vincent, 1996; Perry et al., 2010). Ornamental fish hobbyists and public aquaria also demand live seahorses, albeit, in much smaller numbers compared to the quantities in dried product trade (Vincent, 1996). Live seahorses are sourced from Asian countries (Vietnam, Sri Lanka Philippines and Indonesia) for export to North America or European Union, besides Australia, Hong Kong, Japan and Taiwan, which involved up to a million of seahorses annually (Vincent, 1996). For the marine aquarium industry, live seahorse produced in captivity are sold at a price range of USD 60-950 individually, higher compared to USD 1-80 individually for seahorse sources from wild-caught. (Vincent et al., 2011).

Small numbers of seahorses come from subsistence fishermen in developing countries caught either by hand during diving or using dip-nets from rafts in waist-deep water (Vincent, 1996; Martin-Smith et al., 2004; Rosa et al., 2006). Almost 95% of seahorses traded were sourced either directly or as bycatch from shrimp trawling. Seahorses live in the same zone as shrimp (demersal mode), and due to slow swimming behaviour and mesh size (Martin-Smith and Vincent, 2006; Vincent et al., 2011) they are caught in bulk quantities. Although only small proportions of seahorses are caught by individual vessels, the cumulative number of seahorse bycatch annually is large. In Vietnam alone, the recorded catch was 1-2 seahorse(s) vessel^{-1} day^{-1} but the total annual catch reached up to 6.5 tonnes, consisting of about 2.2 million seahorses (Giles et al., 2006). Few countries bring a significant number of seahorse bycatch through shrimp trawlers, including Malaysia. However, trade surveys conducted worldwide indicate a pattern of decline in seahorse landings (Vincent et al., 2011). In Vietnam, seahorse bycatch dropped from 30-60% within three years, while on the coasts of Pacific and Atlantic Oceans, seahorse bycatch reduced more than 75%, and in Malaysia, the decrease was about 70% (Baum et al., 2003; Giles et al., 2006; Perry et al., 2010). Besides seahorse bycatch, coastal developments also threaten the seahorse population due to degradation or loss of seahorse habitats. For example, extensive port development in Pulai Estuary in Malaysia destroyed the seagrass meadows and reduced the numbers of *H. kuda* (Sabri, 2009). The destruction of seagrass habitats during the construction of a nearby marina also resulted in decline of *H. zosterae* population in Tampa Bay, Florida (Masonjones et al., 2010).

Threat to seahorse population has drawn attention towards conservation measures. Based on the IUCN (2020), the status of seahorse species in Malaysia is listed in Table 1, with eight species as Vulnerable (VU), three species Data Deficient (DD) and only one listed as Least Concern (LC). The VU status is due to their sparse distribution, low mobility, small home ranges, low fecundity, lengthy parental care, and mate fidelity, which make them vulnerable to overfishing and habitat damage (Foster and Vincent, 2004). The DD indicates that more information is needed to improve the understanding of biology and ecology (Planas et al., 2021). Despite the lack of population data, species with no known threats can be classified as LC (Pollom et al., 2021). In 2002, all seahorse species were listed in Appendix II of CITES (Convention for the International Trade in Endangered Species of Wild Fauna and Flora), implemented in 2004 (CITES, 2002). This requires all CITES Parties to ensure that the international trade does not adversely affect wild populations. Since then, aquaculture has been developed to ensure the sustainability of the seahorse trade (Job, 2005).

Table 1. List of seahorses, *Hippocampus* sp. in Malaysia with morphology description, locality, habitat preferences and IUCN status.

No.	Species	Morphology description	Locality	Habitat	IUCN status	References
1.	*H. barbouri*	White to pale yellow to pale brown body color, strips on snout, sometimes with fine line radiating from eye. Well-developed spines on body with longer 1st dorsal spine, regular series of long and short tail spine, Single eye and nose spine, double cheek spine.	Sabah-Gaya Island, Balambangan Island, Banggi Island, Mabul Island, Tanjung Aru and UMS Jetty	Seaweeds-*Halimeda* sp.	VU	Choo and Liew (2004), Lim et al. (2011), Shapawi et al. (2015)
2.	*H. bargibanti*	Body color-pale grey or purple with pink or red tubercles, yellow with orange tubercles. Bulbous tubercles scattered over body and tail. Single eye and cheek spine.	Sabah-Semporna and Spratly Island	Gorgonians (sea fans)	DD	Lim et al. (2011)

3.	*H. comes*	Black and yellow in color, alternating along the tail. Smooth to rather spiny body. Sharp and curved backward eye spine, double cheek spine. Dark bands surround eye socket.	Kedah-Langkawi; Johor-Mersing Island; Sabah-Kudat, Sakar Island, Banggi Island and UMS Jetty	Hard coral, sponges, seagrasses or seaweeds-*Sargassum* sp.	VU	Choo and Liew (2004), Lim et al. (2011), Shapawi et al. (2015)
4.	*H. denise*	Plain orange color with limited number of tubercles on body and slightly darker rings around tail	Sabah-Semporna and Spratly Island	Gorgonians (sea fans)	DD	Lim et al. (2011)
5.	*H. histrix*	Whitish body-color with long, sharp, pointed and dark-tipped spines. Single eye and nose spines. Long and slender snout. Small head. Tail short in comparison to body length.	Perak-Pulau Jarak; Sabah-Banggi Island and Semporna Island; Sarawak-Mukah	Seaweeds-*Halimeda* sp.	VU	Choo and Liew (2004), Lim et al. (2011)
6.	*H. kelloggi*	Pale yellow with often black or dark brown body color. Thick body rings with smooth or slightly raised spines on body. Prominent spine above eye, single knob-like and rounded cheek spine.	Perak-Tukun Perak Island; Sabah and Sarawak-deeper offshore water	Gorgonians (sea whip)	VU	Choo and Liew (2003, 2004)
7.	*H. kuda*	Black to yellow, pale yellow color with fairly dark spots on body. Low spines, only rounded bumps.	Kedah-Kuala Merbok; Perak-Dinding river, Melaka-Cape Rachado; Johor-Johor River, Pulai River and Kuala Skudai; Sabah-UMS Jetty, Gaya Island, Balambangan Island, Sakar Island, Sandakan	Seagrass-*Enhalus* sp., seaweeds-*Halimeda* sp.	VU	Lim et al. (2011), Shapawi et al. (2015)

8.	*H. mohnikei*	Dark brown body color. Double cheek spine, double below eye spine. Some enlargement on specific trunk or tail ring. Tail long in comparison to body length.	Perak-Kuala Gula, Sepetang; Penang-Bagan Dalam	Mangrove and seagrass, *Enhalus acoroides*	VU	Aylesworth et al. (2016)
9.	*H. pontohi*	Brown body color with large red patch covering, pale tail. White dots scattered on the head, trunk and tail. Single eye, nose and cheek spines.	Only anecdotal report on the presence		LC	Lim et al. (2011)
10.	*H. satomiae*	White to pale brown or greyish body color. Double eye spine, single nose and cheek spine.	Sabah-Semporna	Gorgonians (sea fans)	DD	Lim et al. (2011)
11.	*H. spinosissimus*	Yellow, brown, pale, purplish-grey body color, darker saddle across the dorsal-lateral surface. Sharp and well-developed spines: longer 1st, 4th, 7th and 11th dorsal spines; single above eye spine; single/double cheek spine.	Perak-Pangkor Island; East coast of Peninsular Malaysia; coast of Sabah and Sarawak	Soft coral, sandy bottom, gorgonians (sea whip)	VU	Choo and Liew (2003, 2004), Lim et al. (2011), Shapawi et al. (2015)
12.	*H. trimaculatus*	Black, brown, yellow, pale white, golden orange body color with rarely large dark spot on 1st, 4th and 7th trunk rings. Smooth body with pointed backward eye spine and hook-like cheek spine.	Coast of Peninsular Malaysia; coast of Sabah and Sarawak	Sandy bottom, gorgonians (sea whip)	VU	Choo and Liew (2003, 2004), Lim et al. (2011), Wong and Teh (2017)

IUCN status: LC = Least concern, DD = Data deficient, VU = Vulnerable
Morphology description referring to Lourie et al. (2004), Lourie and Kuiter (2008)

The proportion of cultured seahorses in the aquarium trade increased rapidly after their listing in CITES. However, the industry is still struggling to produce adequate numbers of juveniles for farming. The economic viability of captive breeding is technically challenging in terms of diet and healthcare (Pollom et al., 2021; Cohen et al., 2017). The success of seahorse aquaculture will largely depend on its ability to provide an alternative livelihood. Currently, the number of enterprises producing seahorse on a commercial scale for aquaculture industry worldwide is limited (Zhang et al., 2017). Several attempts have been made to cultivate seahorses in Malaysia. The outcome is promising but much remains to be done mainly economizing the farming system and raising healthy stocks to harvestable size for the market.

Limited studies have been conducted on Malaysian seahorses. Perhaps, the first report on seahorse diversity and distribution was published by Choo and Liew (2003; 2004). The data was later updated by Lim et al. (2011). There is a paucity of published information on various aspects including population density, sex ratio and home range of Malaysian seahorse in wild population It is important to understand the population dynamics of seahorses sustainable management and conservation purposes (Freret-Meurer and Andreata, 2008). Besides the ecological information, conservation planning and management also requires data on population genetic structure, reproductive dynamics and local adaptations (Garner et al. 2020). The scarcity of genetic data for threatened species impedes assessing genetic diversity that can provide unique insights into population health, demography and persistence (Wilson et al., 2021). Genetic tools have been used to describe new species and reduce misidentification (Koning and Hoeksema, 2021). Traceability of traded seahorses can be improved with the help of cost-effective approaches to identify the harvest from captivity or natural population.

Acknowledgement

Universiti Malaysia Sabah funded this study through Skim Penyelidikan Pensyarah Lantikan Baru (vot no. SLB2012).

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