

Cultural and socio-demographic drivers shape seahorse uses in Malaysia: implications for conservation

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Abstract Seahorses *Hippocampus* spp. are commercially and culturally important to many communities. Although seahorses are widely used in traditional medicine, as curios and as aquarium fishes in Southeast Asia, documentation on the current nature and extent of culturally motivated seahorse uses in Malaysia is lacking. To examine how ethnicity and other socio-demographic drivers shape traditional medicinal use and underlying cultural beliefs involving seahorses, we administered a questionnaire-based survey during March 2021–April 2022 to members of the general public and fishers in Malaysia. Approximately one-fifth (21.0%) of respondents reported consuming seahorses (34.4% of these used seahorses for medicinal purposes, 55.2% for other non-medicinal uses and 10.4% for both types). Consumers of seahorses were from all ethnic groups except for Indigenous groups. In the general public group, medicinal use was more common amongst the Chinese respondents, whereas in the fisher group, other uses were more common amongst the Malay respondents. Amongst the threats facing seahorses, which include overfishing, habitat destruction, bycatch and ocean plastic pollution, only bycatch was perceived as a major threat by most of the general public and fisher respondents. The relatively low prevalence of reported seahorse use amongst Malaysians is an encouraging finding from a conservation perspective. However, the high proportion of non-medicinal uses indicates the need to focus on such other uses to ensure the sustainability of seahorse use in Malaysia.

Keywords Conservation, cultural values, *Hippocampus* spp., Malaysia, seahorses, sustainable use, traditional medicine

The supplementary material for this article is available at doi.org/10.1017/S0030605324000425

Introduction

The sustainable use of rapidly diminishing marine resources by consumers is a priority for species

conservation. Marine resources have long been used for medicinal, experiential and sensory purposes by communities globally, and there is increasing concern about overexploitation of these resources (Thomas-Walters et al., 2021). In Southeast Asia, most consumption of wildlife including marine resources is deeply rooted in the traditional beliefs and practices of local communities and is an integral part of their lives and livelihoods (Cheung et al., 2021; Thomas-Walters et al., 2021). However, these culturally driven practices are rarely integrated into species conservation measures and sustainable resource management (Cheung et al., 2021).

Seahorses *Hippocampus* spp. are a marine resource of commercial and cultural importance. They are used in multiple ways, which could make them more sought-after than other marine species. These bony fishes belong to the family Syngnathidae (Froese & Pauly, 2011) and live in tropical and temperate shallow waters in habitats such as seagrass meadows and coral reefs (Choo & Liew, 2003; Salin et al., 2005). Seahorses are closely associated with bottom habitats and considered key predators of bottom-dwelling organisms (Tipton & Bell, 1988; Foster & Vincent, 2004). They are slow swimmers and display traits of low fecundity, mate and site fidelity and obligate parental care (Vincent & Sadler, 1995; Foster & Vincent, 2004). These biological characteristics render them highly vulnerable to localized over-exploitation and depletion (Vincent, 1996; Otero-Ferrer et al., 2017).

All known seahorse species are listed on Appendix II of CITES, which regulates international trade (McPherson & Vincent, 2004). The global seahorse trade is driven by their perceived medicinal and cultural importance. For example, seahorses are valued as key ingredients in traditional medicine used to support the well-being of millions of people (WHO, 2002). Dried forms of seahorses are consumed in traditional Chinese medicine and other traditional and complementary medicinal practices, with an estimated over 20 million dried seahorses traded globally annually since the 1980s (Vincent, 1996; Foster & Vincent, 2005). Seahorses reportedly increase and balance energy flow and cure conditions such as impotence and infertility, high cholesterol, kidney disorders, goitres, asthma and skin conditions such as acne and allergies (Rosa et al., 2013). Consumers also believe that medicines derived from seahorses act as a genital tonic and an aphrodisiac and that they facilitate parturition (Vincent, 1995, 1996). Besides consuming dried seahorses for their medicinal value, coastal

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Received 18 February 2023. Revision requested 13 June 2023.

Accepted 4 March 2024.

Malay communities also use seahorse extracts in ointments for external medicinal application, and they believe in keeping dried seahorses to repel evil spirits (Choo & Liew, 2005). In addition, dried seahorses are used as curios, souvenirs and jewellery, and live seahorses are also kept as aquarium fishes (Choo & Liew, 2005; Perry et al., 2010).

The seahorse trade involves various actors including fishers, buyers, exporters, wholesalers and retailers before reaching end consumers (Vincent, 1996). In recent years, conservationists have recognized that interventions aimed at end consumers are an important approach to help curb unsustainable wildlife consumption and shift to more sustainable alternatives (Veríssimo & Wan, 2018; Veríssimo et al., 2018). To implement such interventions, it is vital to understand consumer behaviours and use patterns (Vincent, 1996). In the absence of formal records of seahorse uses, surveying resource users such as members of the public may be the best available method of gathering information across large geographical areas within practicable timeframes (Perry et al., 2010). Clarification of the role of consumers in driving unsustainable wildlife trade could also create opportunities for communities to support marine management (McKinley & Fletcher, 2012).

Malaysia, a multicultural country with over 65 ethnic groups, is home to vital seahorse habitats and is located at the centre of the Indo-Pacific seahorse trade (Vincent, 1996; Choo & Liew, 2005). Eight of the 12 seahorse species found in Malaysian waters are commonly traded (Lim et al., 2011; Aylesworth et al., 2016), reportedly for use in traditional Chinese medicine (Perry et al., 2010). Seahorse exportation is not banned in Malaysia, but claims of there being no such exportation have been made since 2014 (Foster, 2023). Seahorses are not protected locally, and there are no local regulations of seahorse trade or catch despite the fact that eight out of the 12 local species are categorized as Vulnerable on the IUCN Red List (IUCN, 2021). Local traditional medicinal use of seahorses has been and purportedly still is widespread for the treatment of diseases amongst Malaysian communities (Halim et al., 2017). The use of seahorses and their associated cultural value in Malaysia varies between regions (Choo & Liew, 2005), and documentation on the culturally specific uses of seahorses and the purported benefits remains sparse.

Overlooking socio-cultural complexities can undermine conservation effectiveness (Bennett et al., 2017; Margulies et al., 2019). Therefore, our study aimed to address knowledge gaps by examining how ethnicity and other socio-demographic drivers shape seahorse use amongst Malaysians, using a questionnaire-based survey. Additionally, we aimed to determine the perceptions of survey respondents regarding the level of threats to seahorses. We hypothesized that seahorse uses would be closely associated with ethnic group, gender, education level, locality, location setting and occupational background

(Kellert & Berry, 1980; Thompson & Mintzes, 2002; Choo & Liew, 2005; Suleiman, 2014; Boakye, 2018; Naylor & Parsons, 2018).

Study area

Malaysia is a Southeast Asian country that is home to three major ethnic groups: Malays (70% of the population), Chinese (23%) and Indians (6%), as well as many other, smaller groups (1%; Department of Statistics Malaysia, 2022). Ethnic composition of the population varies by region, and we considered four major regions for the purposes of this study: the west, east and south coasts of Peninsular Malaysia, and Borneo. In Peninsular Malaysia, the Indigenous communities, collectively known as Orang Asli, comprise three major groups: Negrito, Senoi and Proto-Malay. Within Borneo, of the c. 60 ethnic groups, the Kadazandusun and Iban are the major ethnic groups in the states of Sabah and Sarawak, respectively (Department of Information, 2016). In Peninsular Malaysia, fishers are predominantly Malays (65.3%), followed by Chinese (31.1%), other ethnicities (2.5%) and Indians (1.1%; Department of Fisheries Malaysia, 2021).

Methods

Survey design

To gain insights into seahorse use by the general public, we hosted a questionnaire-based survey on Google Forms (Google, 2022) for 14 months during March 2021–April 2022. Google Forms is an appropriate survey tool for gathering information over large geographical areas within practicable timeframes (Nurmahmudah & Nuryuniarti, 2020). This online approach was necessary because of the travel restrictions related to the Covid-19 pandemic that were in effect during the survey period. We distributed the form through various online and social media platforms to ensure we reached a wide range of respondents from various backgrounds. Specifically, we posted the questionnaire link on the Facebook (Meta Platforms, 2022a) and Instagram (Meta Platforms, 2022b) pages of Save Our Seahorses (SOS) Malaysia, a local NGO, and on the personal profiles of team members. In addition, we also circulated the form randomly to contacts of the authors via the messaging apps Telegram (Telegram, 2022) and WhatsApp (Meta Platforms, 2022c).

The online approach alone would probably fail to reach the fisher groups that are of interest for this study. Therefore, we concurrently conducted a survey targeted specifically at fishers, which had overlapping questionnaire components with the online public survey. We administered the fisher survey either face to face or through phone calls

with fishers from Peninsular Malaysia. We located the fisher respondents using snowball and haphazard sampling (Gubrium & Holstein, 2001), whereby we obtained fisher contacts from initial respondents, local fisher associations and fishmongers.

The questionnaire-based survey (henceforth referred to as the public survey) and the overlapping subset of the fisher survey consisted of three main sections with 26 questions (Supplementary Material 1). We determined respondent knowledge and perceptions of seahorse uses including underlying motivations to consume seahorses (medicinal and non-medicinal uses) across ethnic cultures. We also recorded the respondents' perceptions of the level of threats to seahorses. We identified the socio-demographic characteristics such as gender, age, ethnicity, location of residence (state), location setting (urban vs rural/semi-rural) and education level of the respondents. We adapted the questionnaire from other studies related to the use of seahorses (Salleh et al., 2020) and with the guidance of field experts (authors AY-HT and ACOL). We derived the options for the questionnaire sections exploring underlying motivations and aspects relating to health conditions from Salleh et al. (2020). Each questionnaire took c. 10–15 min to complete.

Before conducting the surveys, we tested and refined the questionnaire using test groups. The University of Malaya Research Ethics Committee (UMREC) approved the questionnaire and issued an ethical permit (UM.TNC2/UMREC – 1225). In accordance with the approved ethics protocol, the interviewer disclosed the project objectives to each respondent, requested their informed consent, informed them that participation was voluntary and anonymous and gave assurances that the interviewee could terminate the survey at any time.

We restricted the survey to members of the public and fishers of Malaysian nationality who were at least 18 years old and residing in Malaysia. Estimation of the sample size of respondents would ideally be based on data regarding the proportions of the various ethnic groups consuming seahorses, but these were not available. Using the Australian Bureau of Statistics sample size calculator and relevant adult population statistics (see Supplementary Table 1 for details), we obtained expected minimum sample sizes of 269 Malays, 86 Chinese, 26 Indians and four individuals from other ethnic groups.

Data analysis

We summarized the diversity and type of seahorse use (medicinal uses; other uses; both) and underlying motivations by ethnic group (Malay; Chinese; Indian; Indigenous; others) and background (general public; fishers). Ethnicity and culture are used synonymously in this article as ethnic identity is an important determinant of cultural values

(Loue, 2013; Mohd Yusuf et al., 2016). We categorized medicinal uses into five types: external treatments (of symptoms or diseases), internal treatments (of symptoms or diseases), support of general well-being, uses based on aphrodisiac properties, and uncertain health benefits. We categorized other (non-medicinal) uses into five types: curios/souvenirs, pets in aquariums, protection against evil spirits, to put a spell on someone, and for research and educational purposes (display material).

Given the potential bias in using online surveys for data collection (under-representation of certain groups, such as older age groups or those from rural areas), we weighted the samples to reduce such bias. We applied the raking method for weighting (Pew Research Center, 2018), and conducted univariate statistical analyses (see below) on both weighted and unweighted samples. As the conclusions drawn were similar for both weighted and unweighted samples (Supplementary Table 1), we present the results of the analyses based on the unweighted samples.

We analysed the patterns of seahorse uses using χ^2 tests and Fisher's exact tests. For ethnic-based analyses of medicinal and other uses, we pooled respondents from three groups (Indian, Indigenous, others) because of their small sample sizes. We excluded the 10 respondents who had consumed seahorses but were unsure of the health benefits from the analysis. We compared perceptions of the valuableness of seahorses and of the level of threats facing them between the general public and fisher respondents. We conducted all statistical analyses using *R 4.3.0* (R Core Team, 2023). For all comparisons, we considered $P < 0.05$ to be significant.

We used the classification tree method (a machine learning approach) to explore the key explanatory variables underlying the pattern of seahorse use. We included six socio-demographic (categorical) variables in the model-building process: gender (male; female; both/prefer not to say), age (18–30; 31–40; 41–50; 51–60; > 60 years old), ethnicity (Malay; Chinese; Indian; Indigenous; others), education (none; primary; secondary; tertiary; postgraduate), region of residence (west, east or south coasts of Peninsular Malaysia; Borneo) and occupational background (fisher; general public). We constructed the classification tree using the *party* package in *R* (Hothorn et al., 2006).

Results

We obtained 1,189 responses from 637 members of the public and 552 fishers from across all four regions in Malaysia (Figs 1 & 2). The ethnic groups represented were Malays, Chinese, Indians and Indigenous, and other minority ethnic groups collectively categorized as 'others'. The majority of public respondents were women (64.8%), whereas almost all fisher respondents were men (99.8%). Most of the public respondents were 18–30 years old (54.3%) and more than one-third were of Chinese ethnicity (38.5%). For the fisher

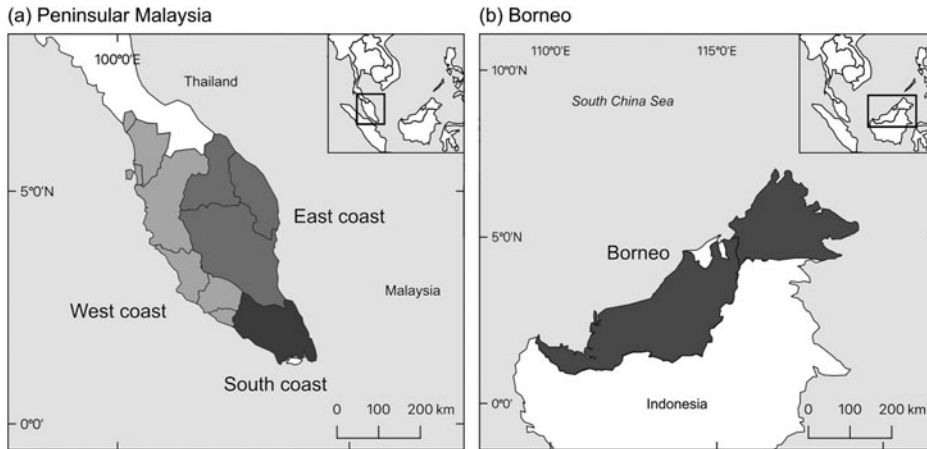


FIG. 1 Study sites across Malaysia by region: (a) Peninsular Malaysia (west, east and south coasts) and (b) Borneo. The inset maps show the location of the study areas within Southeast Asia.

respondents, one-third were 41–50 years old and most (88.0%) were from the Malay ethnic group (Table 1).

A total of 21.0% (n = 250) of respondents reported using seahorses, the majority being men (90%, 225). Amongst the seahorse users, 20.8% (52) were public respondents and 79.2% (198) were fishers. Amongst the public respondents, 5.9% of Malays (12), 15.1% of Chinese (37) and 2.7% of Indians (3) reported using seahorses. Amongst the fisher respondents, 39.1% of Malays (190), 10.9% of Chinese (6) and 11.1% of Indians (1) reported using seahorses. Amongst the

Malay seahorse users, most were fishers (94.1%, 190); whereas amongst the Chinese and Indian users, the majority were members of the general public (86.0%, 37 and 75.0%, 3, respectively; Fig. 3). The only reported seahorse use by respondents from the Indigenous (n = 60) and other (n = 16) groups was a single Malaysian Siamese fisher (Fig. 3). A small fraction of the fishers interviewed (2.4%) had used seahorses in the past but no longer did so. Reasons for this cessation of seahorse use included changes in the tradition of using seahorses for spiritual purposes, shifts in opinion regarding the tradition, shifts in perceptions through increased awareness of conservation aspects, lack of seahorse catches and the complexities of keeping live seahorses as aquarium fishes. Consumption status (yes or no) of seahorses was related to the ethnicity ($\chi^2 = 77.56$, $df = 3$, $P < 0.05$) and gender (two-tailed $P < 0.05$) of respondents in both the general public and fisher groups.

Amongst seahorse users, 34.4% (86) reported consuming seahorses for medicinal purposes, 55.2% (138) for other purposes and 10.4% (26) for both medicinal and other purposes. The two most common motivations for consuming seahorses for medicinal purposes were to treat diseases (73.2%) and to maintain health and prevent diseases (68.8%). Other reported motivations were cultural beliefs, the pleasant taste of seahorses and views on seahorse-based traditional medicine (e.g. compared to using modern medicine, using seahorses in traditional medicine was perceived as being more effective and having fewer side effects, or the current health condition of the respondent was perceived as not sufficiently severe to necessitate modern medication).

Proportionally, more Malay respondents reported medicinal use of seahorses than other ethnic groups. The primary traditional medicine uses of seahorses were to treat asthma (n = 45 respondents) and skin conditions (41) and to strengthen the body (22). A comprehensive list of reported medicinal uses of seahorses is available in Supplementary Table 2, and direct quotes relating to seahorse use by

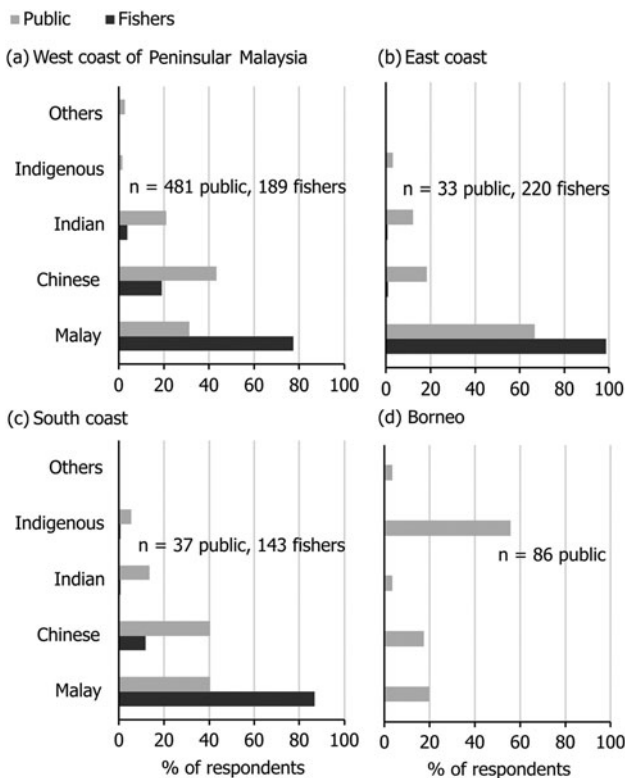


FIG. 2 Ethnic composition of the 637 general public respondents and 552 fisher respondents from the (a) west, (b) east and (c) south coasts of Peninsular Malaysia and (d) Borneo.

TABLE 1 Socio-demographic characteristics of the 637 general public respondents and 552 fisher respondents surveyed from Peninsular Malaysia and Borneo.

Socio-demographic characteristics	Public ¹		Fishers	
	Number	%	Number	%
Gender				
Male	213	33.5	551	99.8
Female	413	64.8	1	0.2
Both/prefer not to say	11	1.7	0	0.0
Age (years)				
18–30	346	54.3	8	1.5
31–40	107	16.8	121	21.9
41–50	99	15.6	182	33.0
51–60	60	9.4	163	29.5
> 60	25	3.9	78	14.1
Ethnicity				
Malay	204	32.0	486	88.0
Chinese	245	38.5	55	10.0
Indian	113	17.7	9	1.6
Indigenous	59	9.3	1	0.2
Others	16	2.5	1	0.2
Education				
None	3	0.5	12	2.2
Primary	1	0.1	35	6.3
Secondary	49	7.7	493	89.3
Tertiary	489	76.8	12	2.2
Postgraduate	95	14.9	0	0.0
Region				
West coast Peninsular Malaysia	481	75.5	189	34.2
East coast Peninsular Malaysia	33	5.2	220	39.9
South coast Peninsular Malaysia	37	5.8	143	25.9
Borneo	86	13.5	0	0.0
Location setting				
Urban	502	78.8		
Rural/semi-rural	135	21.2		
Not recorded			552	100.0

¹We did not collect information regarding the occupational background of the public respondents, and they were assumed to be primarily non-fishers (Lennox et al., 2022).

members of the various ethnic groups in Supplementary Table 3. A small fraction of respondents who consumed seahorses (3.6% of Malay and 4.5% of Chinese respondents) were unsure regarding the health benefits. However, medicinal use types were not associated with the ethnicity of respondents (two-tailed $P > 0.05$). More Malay respondents (92.7%) reported other use types of seahorses than the other ethnic groups collectively. The most common non-medicinal use was as curios/souvenirs ($n = 140$; see Supplementary Table 4 for an exhaustive list of other seahorse uses). Types of other uses of seahorses were closely associated with the ethnicity of respondents (two-tailed $P < 0.05$). In terms of location settings, only the Malay

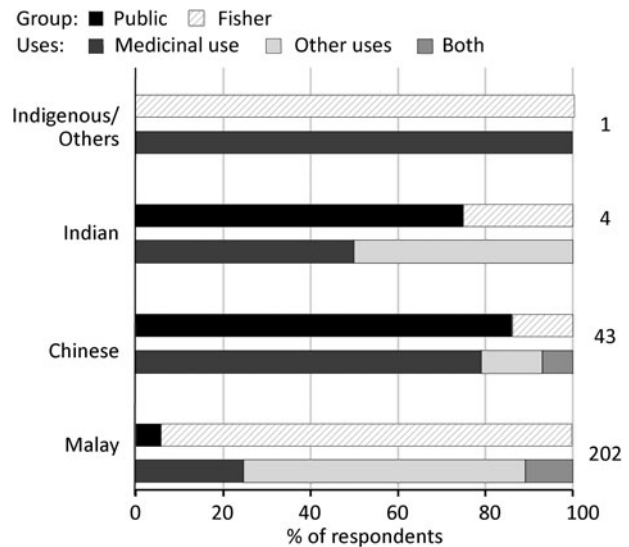


FIG. 3 Types of seahorse use amongst the 637 general public respondents and 552 fisher respondents of various ethnic groups surveyed from Peninsular Malaysia and Borneo. Percentages of prior use (medicinal use; other uses; both) and respondent group (general public; fisher) are expressed as per ethnic group; sample sizes per group are indicated to the right of each bar.

respondents were relatively well represented in both categories of uses. The Malay public respondents who lived in urban settings reported a greater diversity of medicinal uses (four types) compared to those in rural/semi-rural settings (two types).

Regarding the perceived valuableness of seahorses, a relatively large proportion of the public respondents were unsure of this with respect to health benefits (50.5%) and cultural values (41.7%). However, over one-third of the public respondents (35.8%) stated that seahorses are economically valuable, and most agreed that seahorses are valuable to the ecosystem (86.7%) and for recreational purposes (e.g. scuba diving, aquarium visit or as a pet; 76.9%). Many of the fisher respondents were unsure of the valuableness of seahorses (health: 59.4%; economical: 47.1%; cultural: 66.3%; recreational: 45.1%; ecosystem value: 42.8%; Table 2). Perceptions of valuableness were significantly associated with whether respondents used seahorses for the categories of health ($\chi^2 = 151.31$, $df = 2$, $P < 0.05$), ecosystem ($\chi^2 = 38.29$, $df = 2$, $P < 0.05$) and recreational values ($\chi^2 = 8.40$, $df = 2$, $P < 0.05$), but there was no such association for economical ($\chi^2 = 3.72$, $df = 2$, $P > 0.05$) and cultural values ($\chi^2 = 0.80$, $df = 2$, $P > 0.05$).

Many of the public respondents were aware of threats to seahorses, particularly habitat destruction (72.1% of respondents) and ocean plastic pollution (65.9%); fewer considered overfishing (42.5%) and bycatch (37.0%) as major threats (Fig. 4a). In contrast, most of the 552 fisher respondents were unsure of the existence and/or severity of the threats to seahorses. Relatively more fisher respondents (38.9%)

TABLE 2 Perceptions of the 637 general public respondents and 552 fisher respondents surveyed from Peninsular Malaysia and Borneo on the valuableness of seahorses.

Valuableness of seahorses	% of public respondents			% of fisher respondents		
	Yes	No	Unsure	Yes	No	Unsure
Health/medicinal	25.3	24.2	50.5	30.1	10.5	59.4
Economical/monetary	35.8	29.0	35.2	13.0	39.9	47.1
Cultural	39.6	18.7	41.7	14.0	19.7	66.3
Ecosystem	86.7	3.4	9.9	52.9	4.3	42.8
Recreational	76.9	11.2	11.9	42.2	12.7	45.1

ranked bycatch as a major threat compared to the other threats (Fig. 4b).

The classification tree identified four variables that were important in explaining the patterns of seahorse use: education level, region of residence, ethnicity and gender. Respondents with tertiary or postgraduate education were less likely to use seahorses in any manner, with the exception of men of Chinese ethnicity (Fig. 5). For individuals with lower education levels (no formal education, or with primary- or secondary-level education), seahorse use was associated with region of residence and ethnicity: those of Malay or Indian ethnicities, and those belonging to various non-Indigenous minority groups, who lived in the east and south coast areas of Peninsular Malaysia had a greater likelihood of seahorse use (Fig. 5).

Discussion

Our study shows that seahorse uses amongst Malaysians are closely associated with ethnic groups, which can be

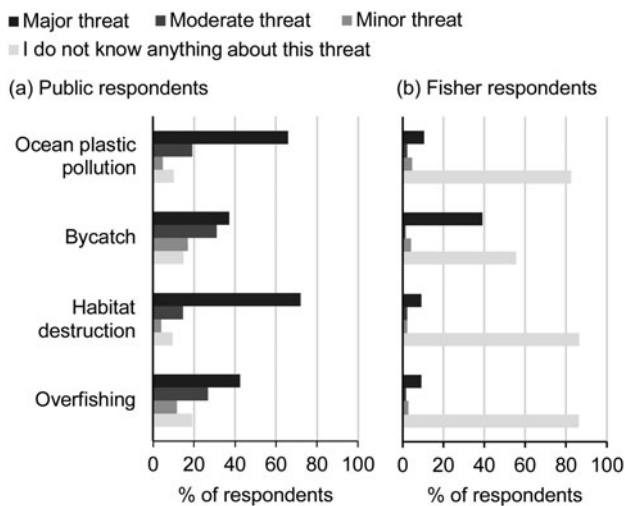


FIG. 4 Perceptions of the levels of threats facing seahorses amongst (a) 637 general public respondents and (b) 552 fisher respondents from Peninsular Malaysia and Borneo.

attributed to culturally specific (ethnomedicinal) practices (Choo & Liew, 2005; Boakye, 2018). To our knowledge, this study provides the first documentation of seahorse use by Indian and Malaysian Siamese respondents in Malaysia. Such sociocultural insights could enable conservationists to develop effective interventions that are strategically targeted at particular demographic groups (Cheung et al., 2021). That traditional medicine use of seahorses has not previously been reported within the Indian community could be attributed to the primary use of plant-based ingredients in Indian medicinal practice (Adhikari & Paul, 2018).

The practice of traditional and complementary medicine is relatively widespread; a previous study found that 69.4% of Malaysians ($n = 6,947$) had used traditional and complementary medicine (Siti et al., 2009). However, we found a low prevalence of the medicinal use of seahorses, which is consistent with results from a week-long online poll administered via the Facebook page of SOS Malaysia, in which 87.0% of Malaysian respondents (54) indicated they had not used seahorses in any way (Lim, 2021). Nevertheless, the reported medicinal uses and benefits in our study are consistent with previous studies that noted seahorses as the most frequently mentioned marine resource in traditional medicine because of their perceived efficacy for treating a variety of ailments and for promoting well-being (Vincent, 1996; Sari et al., 2018; Salleh et al., 2020). Medicinal use by the Chinese ethnic group, especially amongst the respondents from the general public, could be attributed to the centuries-long strong establishment of seahorses in Chinese pharmacopoeia (Vincent, 1996).

Ethnicity influences non-medicinal uses of seahorses, which, along with medicinal uses, are classified as consumption uses of natural resources (Gomez et al., 2022). Amongst the fisher respondents, the Malay ethnic group commonly reported consuming seahorses for non-medicinal uses. The influence of psychosocial factors such as perceptions, beliefs, attitudes and cultural values in shaping food choices and behaviours (Nestle et al., 1998) could have driven their choice to consume seahorses, especially via word of mouth or hearsay amongst family members and friends. A preliminary study showed that seahorse curios represented the second most common type of seahorse trade after traditional medicine on online market platforms in Malaysia (Aminuddin et al., 2021). Thus, conservation strategies should focus on managing these types of seahorse use in both physical and online marketplaces (Challender et al., 2015; Di Minin et al., 2019).

Our findings indicate that culturally sensitive outreach strategies for conserving seahorses need to target the medicinal uses amongst Malay and Chinese communities, but that this is less relevant for other ethnic groups. A previous study concluded that conservation management awareness campaigns should be targeted at communities of specific ethnic backgrounds in the context of users of pangolin body

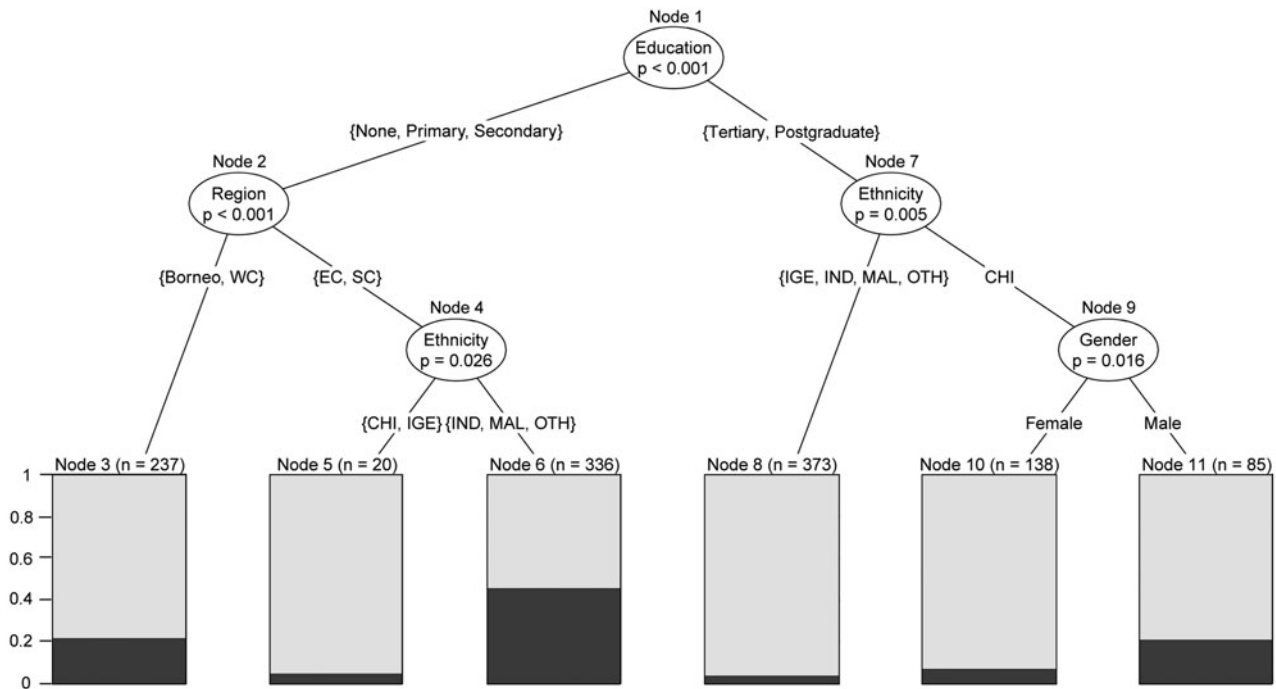


Fig. 5 Classification tree model exploring patterns of seahorse use amongst the 637 general public respondents and 552 fisher respondents from Peninsular Malaysia and Borneo based on socio-demographic variables: education, region (WC = west coast, EC = east coast and SC = south coast of Peninsular Malaysia; Borneo), ethnicity (MAL = Malay; CHI = Chinese; IND = Indian; IGE = Indigenous; OTH = others) and gender. The tree model begins with the entire dataset, forming a root node (variable) at the top of the tree, and uses recursive binary splits by evaluating every predictor to form partitions of the sample into more homogeneous subsets (or nodes) that represent intermediate decisions. Six final nodes at the bottom of the tree represent the final outcomes. The dark and light grey portions of the bars represent the proportion of respondents who do and do not use seahorses, respectively. Probabilities of seahorse use (on a scale from 0 to 1) are indicated within each node, including the final nodes.

parts for traditional medicine in Ghana (Boakye, 2018). This indicates the need to design conservation efforts to be appropriate to the nature and circumstances of the communities they target. Enforcement-led approaches to marine resource management are most effective when they are built upon values that are compatible with those held by the most affected communities (Challender et al., 2015; Cooney et al., 2017).

Locality is a socio-demographic variable that affects the attitudes of people towards the natural environment (Naylor & Parsons, 2018). We found greater diversity in medicinal uses of seahorses amongst the Malay public members residing in urban compared to rural/semi-rural settings. Knowledge transfer regarding traditional medicine uses may be more widespread amongst individuals from urban areas because of their greater use of the internet and social media, thereby influencing their positive perceptions of the health benefits of seahorses. Others have noted that the transfer of knowledge is vital for preserving medical practices in the community (Suleiman, 2014; Jamshed et al., 2016). Stronger seahorse consumer markets and a greater influence of traditional Chinese medicine, especially because there are more traditional Chinese medicine shops in urban areas, may facilitate access to seahorses in cities compared to rural/semi-rural areas (Zhao et al.,

2022). The greater seahorse use amongst respondents on the east coast of Peninsular Malaysia is probably linked to the greater quantities of seahorses caught there compared to other regions (Perry et al., 2010). It is also a common practice amongst Malay east coast fishers to eat deep-fried seahorses as crackers (Choo & Liew, 2005).

Education is another factor that affects attitudes towards conservation issues (Kellert & Berry, 1980). Our study indicated that individuals with a lower educational level generally showed a higher likelihood of seahorse use. Education is also likely to change individual perceptions of biodiversity conservation (Kellert, 1996), as seen in various studies linking higher educational levels to improved public knowledge of various marine species and a more conservation-positive attitude towards them (Thompson & Mintzes, 2002; Barney et al., 2005; O'Bryhim & Parsons, 2015). With most fishers having lower educational levels, general awareness of marine life, including seahorses, amongst coastal people in Malaysia remains an educational priority (O'Bryhim & Parsons, 2015; Naylor & Parsons, 2018).

Amongst those with a higher education level, men of Chinese ethnicity are more likely to consume seahorses than women or those from other ethnicities. The attitudes of men and women regarding marine conservation issues

were previously found to be significantly different (Naylor & Parsons, 2018). Women tend to value animals more highly and are more concerned about their exploitation, leading to stronger conservation attitudes; in contrast, men are more inclined to value animals in terms of recreational and practical purposes (Kellert & Berry, 1980). This suggests that gender is another demographic factor that should be considered when shaping conservation messages.

From a conservation standpoint, it is positive that most respondents, including fishers, regarded seahorses as more valuable alive (i.e. in the ecosystem) than when harvested for medicinal or culturally motivated uses. Attitudes towards marine conservation can vary considerably depending on the issue in question (Naylor & Parsons, 2018). The greater awareness of the severity of habitat destruction and ocean plastic pollution amongst the wider public could be because of the increased global media attention given to these issues in recent years (Barney et al., 2005). However, the lack of awareness of the severity of overfishing and bycatch, including of seahorses, suggests that more efforts are required to promote public discourse on these issues, including amongst fishers.

In an earlier study, traders reported a decrease in seahorse sales and demand because of diminishing interest in consuming seahorses as traditional medicine, especially amongst the younger generations (Perry et al., 2010). We corroborated this in another aspect of our study via informal interviews with traditional medicine practitioners and seahorse traders (R.M.Y. Ng, A.C.O. Lim, C.N.B. Henry Chin Siew Lee, N.B. Abdul Majib, M.A. Syed Hussein & A.Y.H. Then, unpubl. data, 2024). These declines could be attributed to reported declines in bycatch volumes by fishers (Choo & Liew, 2005; Perry et al., 2010), driven by overfishing and/or habitat degradation (Perry et al., 2010). Collectively, this evidence suggests that seahorse use amongst Malaysians has decreased and is now generally low.

Seahorse uses amongst minority ethnic groups and elderly people in Malaysia were less well documented in the public survey because of the limited ability to reach these groups online. Future survey-based studies should focus on reaching these groups and on including occupational information (Perry et al., 2010; Naylor & Parsons, 2018) to gain insights into these aspects. Regarding the effects of location setting on seahorse use amongst members of the public, there is an under-representation of perceptions from the rural/semi-rural settings. Given the relatively large scale of seahorse harvesting amongst the rural communities of the east coast of Peninsular Malaysia (Choo & Liew, 2005), targeted efforts to survey these communities should be undertaken to better understand seahorse uses in these settings.

In summary, we found that most of the general public and fisher respondents in Malaysia do not use seahorses in any way. A minority reported using seahorses as traditional medicine, ornaments, pets, for spiritual purposes and for research and in educational display materials.

However, these findings may not be a true reflection of the level of seahorse exploitation in Malaysia considering the significant involvement of Malaysia in global seahorse exportation (Louw & Bürgener, 2020). Socio-demographic variables such as ethnicity, location setting, region, education and gender also play significant roles in shaping the use of seahorses amongst Malaysians. In terms of management implications, culturally specific seahorse uses by the public and fishers had been largely overlooked prior to this study. Future conservation and educational outreach measures should utilize our findings to design socially and culturally appropriate campaigns (Bennett et al., 2017; Margulies et al., 2019), setting a precedent for holistic approaches to promoting the sustainable use of seahorses and other marine resources.

Author contributions Study design: all authors; fieldwork: RMYN, ACOL; data analysis, writing: RMYN, AY-HT.

Acknowledgements The research was funded by Yayasan Haji Zainuddin (YHZ; PV008-2021), The Rufford Foundation (34121-1, IF008-2022) and The Incitement through crowdfunding. We thank the members of the public and fishers who participated in the survey; and two anonymous reviewers for their comments. This work forms part of an MSc study undertaken by RMYN.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. An ethical permit (UM.TNC2/UMREC – 1225) was granted by the University of Malaya Research Ethics Committee (UMREC).

Data availability The data that support the findings of this study are available on request from the corresponding author, AY-HT. The data are not publicly available to preserve the anonymity of the research participants.

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