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Three new pygmy seahorse species from Indonesia (Teleostei: Syngnathidae: *Hippocampus*)

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Abstract

Three new species of pygmy seahorse are described from Indonesia: *Hippocampus pontohi* and *H. severnsi* from Bunaken Island, off Sulawesi, and *H. satomiae* from Derawan Island, off Kalimantan. They are considered to be closely related to each other and to *Hippocampus colemani*. All three species are morphologically distinguished from the larger species of seahorses by the following combination of characters: 12 trunk rings, low number of tail rings (26–29), the placement of brooded young within the trunk region of males, and extremely small size (<15 mm HT, <17 mm SL). They can be separated from the previously described species of pygmy seahorses (*H. bargibanti, H. denise, H. colemani* and *H. minotaur*) based on meristics, proportions, colour and body ornamentation. All three new species have a single gill opening as does *H. colemani*. *Hippocampus pontohi* and *H. severnsi* also share distinctive fleshy appendages with *H. colemani* but can be separated from the latter based on their body shape, raised angular coronet, larger orbit diameter, narrower trunk, fewer tail rings, smaller overall size and in the case of *H. severnsi* also colour. Diagnostic features of *H. satomiae* include 9 pectoral fin rays, 13 dorsal fin rays, spinous exterior, and distinct raised coronet with laterally expanded anterior and posterior flanges.

Key words: *pontohi, severnsi, satomiae*, new species, taxonomy, Indo-Pacific, marine

Introduction

In recent years, a number of diminutive seahorse species, collectively known as ‘pygmy seahorses’, have been described from Australasia and Asia including: *Hippocampus bargibanti* Whitley 1970 (redescribed by Gomon, 1997), *H. minotaur* Gomon 1997, *H. denise* Lourie & Randall 2003, and *H. colemani* Kuiter 2003. However, these four species may actually only represent a fraction of the existing diversity of pygmy seahorses. Photographs of what appear to be additional undescribed species have appeared in books, dive magazines and on the internet (e.g. Boyer 2007; Kuiter 2000) and we have been fortunate to receive numerous additional photographs from recreational divers worldwide.

Most pygmy seahorses live in close association with particular invertebrate hosts including sea fans (e.g. *Muricella, Annella, Acanthogorgia* spp), colonial hydrozoans (e.g. *Lytocarpus, Antennellopsis*) and coralline algae (*Halimeda*). Their small size, and excellent camouflage, means that they have been long overlooked. As divers explore more habitats, in more detail, undescribed taxa are coming to light. Collecting permission for pygmy seahorses was granted to the senior author in 2001, yet the challenge of finding these diminutive animals meant that it was several years before the new species described herein were obtained.

Pygmy seahorses are currently included, along with all other seahorses, in the genus *Hippocampus* Rafinesque. They differ from the larger seahorses, however, in a number of respects, including vertebral and

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fin ray counts and position of brooded young (Lourie & Randall 2003). DNA sequence analysis of *H. bargibanti* has shown it to be basal to all other seahorses (Teske, *et al.* 2004).

Here we use morphological characters to propose species status for three previously undescribed forms. Further research, involving ecological and genetic data, is needed to test these designations.

Material and methods

Diagnoses and descriptions are based on specimens deposited at the Museum Victoria, Melbourne (NMV), the Redpath Museum, Montreal (RMMU) and the Museum Zoologicum Bogoriense, Cibinong Indonesia (MZB). Comparative materials came from the Bishop Museum (BPBM), Smithsonian Institution (USNM), Australian Museum (AMS) and the California Academy of Sciences (CAS).

Measurements and counts were taken using digital calipers under a binocular microscope following the methods of Lourie & Randall (2003). Standard length (SL) was defined as the sum of the head length (HL), trunk length following the inherent curve of the body (TrL) and tail length (TaL). Height (HT) is an approximate measure of the straight-line distance from the top of the coronet (if present) to the tip of the outstretched tail with head held at right angles to body (see Table 1 for other abbreviations). Numbers of trunk and tail segments were identified based on counts of the transverse ridges at their centre. With the exception of the first trunk segment, these ridges show a one-to-one correspondence to the placement of the vertebrae. The number of trunk segments as enumerated is thus two fewer than the number of pre-caudal vertebrae (Ginsburg 1933). Numbers of trunk and tail rings under the dorsal fin were enumerated as TrR+TaR following Dawson (1985). The counts were verified from radiographs in which the specimen was projected onto an x-ray plate which enlarged the image up to 10 times. Sex was determined based on the appearance of the genital regions (Lourie & Randall 2003) and numbers of offspring were estimated for pregnant male specimens based on the number of embryos visible through the skin under a microscope.

Pygmy seahorses are among the smallest vertebrates known (Miller 1996). Studying such tiny creatures can lead to problems in obtaining accurate counts and measurement error can be proportionally large. Furthermore, discrepancies can occur between researchers—note for example, the tail ring counts reported here differ from those for *H. colemani* type description based on the same specimens (Kuiter 2003). To reduce such bias, all counts and measurements reported in this paper were made by the senior author and have not been taken from previously published work. Analyses of variance were carried out using Statview 4.51 (Roth, *et al.* 1992-1995) with post-hoc tests (Fisher's PLSD with Bonferroni correction for multiple comparisons) to determine distinguishing characters among the species. We also produced an ordination of the specimens using a principal coordinate analysis (Gower 1966) as computed by the R-package ver. 4.0 (Casgrain & Legendre 2001) based on 14 natural log-transformed morphometric variables (head length, snout length, orbit diameter, post-orbital length, trunk length, tail length, head depth, snout depth, trunk depth between 4th and 5th trunk rings, trunk depth between 9th and 10th trunk rings, trunk width, coronet height, length of dorsal fin base, length of pectoral fin base) combined with 3 meristic variables (counts of tail rings, dorsal fin rays and pectoral fin rays).

In each species description, measurements and counts are reported for the holotype (as percentages of SL, HL or SnL as indicated) with the range displayed by the paratypes in parentheses, if different. Means, standard deviations and ranges based on all specimens for proportional measurements are shown in Table 1, meristics are shown in Tables 2 and 3. Figure 1 shows a result of the ordination.

TABLE 1. Comparative morphometric measurements: means, standard deviations and ranges (proportions expressed as percentages of SL, HL or SnL as indicated) for the seven currently described pygmy seahorse species. Abbreviations: SL-standard length (head length + curved trunk length + tail length), HT-height, TrL-trunk length, TaL-tail length, HL-head length, SnL-snout length, HD-head depth, SnD-snout depth, OD-orbit diameter, PO-post-orbital length, CH-coronet height, TD9-trunk depth just anterior to dorsal fin base, PL-pectoral fin base length (see Lourie & Randall, 2003 for diagram of measurements). See Gomon (1997) for additional data for *H. minotaur*.

	Species	n	SL	appx HT	TrL:SL	TaL:SL	HL:SL	SnL:HL	HD:HL	SnD:SnL	OD:HL	PO:HL	CH:HL	TD9:SL	DL:SL	PL:SL
1	*H. bargibanti*	8	24.5	21.7	27.6	55.7	16.7	21.8	65.7	100.3	17.8	56.9	57.3	12.8	8.21	3.25
			1.84	1.71	1.61	1.29	1.44	1.83	3.28	20.24	3.10	4.07	6.26	3.33	0.74	0.52
			22.2–26.9	19.5–24.0	25.7–29.5	53.3–57.1	14.8–19.5	18.5–23.2	60.8–70.3	82.2–144.1	14.2–24.0	51.6–63.3	46.1–64.1	8.6–19.0	7.4–9.0	2.6–4.0
2	*H. denise*	14	15.7	13.4	27.7	52.5	19.9	32.8	48.1	73.6	20.9	42.0	42.6	9.25	8.08	4.16
			3.16	3.00	2.60	3.30	2.50	3.90	4.30	5.40	1.50	1.80	4.90	3.30	1.10	2.90
			13.2–24.0	11.2–21.1	23.1–31.7	47.4–57.2	16.0–23.1	27.1–38.7	41.1–55.7	62.7–81.2	18.8–23.5	39.1–45.2	35.2–51.6	4.1–15.5	6.37–10.1	2.17–10.9
3	*H. minotaur*	2	37.9	34.2	21.6	61.3	17.2	28.9	77.6	76.6	18.7	49.0	53.8	11.9	1.92	2.55
			23.22	21.60	4.45	7.47	3.02	6.33	3.55	1.79	3.33	0.01	3.65	4.19	0.64	0.48
			21.5–54.3	12.0–49.4	18.4–24.7	56.0–66.6	15.0–19.3	24.4–33.3	75.1–80.1	75.4–77.9	16.3–21.0	49.0–49.0	51.2–56.4	8.9–14.9	1.5–2.4	2.2–2.9
4	*H. colemani*	2	26.9	23.6	32.0	50.0	18.1	27.7	62.6	70.5	18.8	52.1	45.6	19.2	6.35	2.70
			0.62	0.43	1.06	1.51	0.45	2.68	1.32	10.17	0.20	2.85	2.91	0.40	0.47	0.50
			26.5–27.3	23.3–23.9	31.2–32.7	48.9–51.0	17.8–18.4	25.8–29.6	61.7–63.6	63.3–77.7	18.6–18.9	50.1–54.1	43.6–47.7	18.9–19.5	6.0–6.7	2.3–3.1
5	*H. pontohi*	3	16.7	14.2	33.3	45.0	21.7	23.2	60.6	84.2	24.0	51.2	47.4	13.5	7.75	2.48
	new species		0.15	0.34	0.76	1.18	1.93	1.03	1.11	4.41	2.27	2.25	2.97	2.33	0.35	0.12
			16.6–16.9	13.8–14.4	32.4–33.9	43.7–45.8	20.3–23.9	22.6–24.4	59.3–61.5	79.2–87.7	22.4–26.6	49.0–53.5	45.1–50.7	11.0–15.7	7.3–8.0	2.4–2.6
6	*H. severnsi*	3	15.2	12.9	31.0	47.3	21.7	26.0	58.3	89.8	25.1	48.8	47.0	13.6	9.39	3.34
	new species		2.37	2.16	1.82	1.23	0.73	1.82	5.78	6.91	1.00	1.83	2.68	1.60	1.63	0.69
			12.4–16.6	10.4–14.2	29.9–33.1	45.9–48.3	20.9–22.4	24.2–27.8	51.7–62.5	83.9–97.4	24.1–26.1	47.4–51.0	44.7–49.9	11.9–15.1	8.40–11.3	2.8–4.1
7	*H. satomiae*	2	13.6	11.3	30.0	48.0	22.0	27.0	51.8	86.0	23.8	45.0	40.2	13.0	8.07	2.69
	new species		0.29	0.18	1.92	2.40	0.48	0.79	1.14	4.40	0.07	0.26	1.73	3.04	0.25	0.41
			13.4–13.8	11.2–11.5	28.6–31.3	46.3–49.7	21.7–22.2	26.4–27.5	51.0–52.6	82.5–88.8	23.8–23.9	44.8–45.2	38.9–41.4	10.7–15.0	7.9–8.2	2.4–3.0

TABLE 2. Comparative tail ring counts for seven pygmy seahorse species.

	Tail Rings	n	26	27	28	29	30	31	32	33	41
1	*H. bargibanti*	8						4	3	1	
2	*H. denise*	14		2	8	3	1				
3	*H. minotaur*	2									2
4	*H. colemani*	2			1		1				
5	*H. pontohi* new species	3	1	1	1						
6	*H. severnsi* new species	3		3							
7	*H. satomiae* new species	2		1	1						

TABLE 3. Comparative fin ray counts for seven pygmy seahorse species. Note that apparent presence or absence of anal fin is not a good taxonomic character. A significant association exists between sex and presence (or visibility) of anal fin ($\chi^2 = 6.84$, d.f. = 1, $p = 0.009$) suggesting that its visibility may be a function of whether or not it is enclosed within the pouch opening.

	Fin Rays		Dorsal				Pectoral			Anal fin visible ?	
		n	7	9	13	14	9	10	11	yes	no
1	*H. bargibanti*	8				8		7	1	4	4
2	*H. denise*	14			2	12		11	3	5	9
3	*H. minotaur*	2	1	1					2	1	1
4	*H. colemani*	2				2		2		1	1
5	*H. pontohi* new species	3				3	1	2			3
6	*H. severnsi* new species	3				3		3		2	1
7	*H. satomiae* new species	2			2		2				2

Comparative material

Hippocampus bargibanti Whitley 1970.

Lectotype: AMS I.15418-002 (SL 25.9 mm, female), Nouméa, New Caledonia, 30 m depth, on gorgonian *Muricella* sp., July 1969, G. Bargibant.

Paralectotype: AMS I.15418-001 (22.2 mm, male), collection details as for lectotype.

Other specimens: AMS I.15997-001 2 specimens (26.5 mm [n.b. not 25.9 mm as reported in Lourie & Randall 2003], female; 24.6 mm, male), off Nouméa, Canal Woodin, New Caledonia, 20–25 m depth, September 1971, S. Catala; AMS I.19834-001 (26.9 mm, female) Nouméa Lagoon, New Caledonia, July 1969; RMMU 2309 (23.0 mm, male), 1/2 mile west of the southern tip of the Passes de Boulari, Nouméa, New Caledonia, 45 m depth, on gorgonian *Muricella* sp., 3 December 1980, B. Seret; MZB 10922 2 specimens (22.5 mm, female; 24.0 mm, male) Pulau Abadi, Lembeh Strait, Sulawesi (01°26.34’N 125°12.82’E), 26 m depth, on gorgonian *Muricella plectana*, March 2001, S. Lourie.

Hippocampus denise Lourie & Randall 2003.

Holotype: MZB 10920, (24.0 mm, female), Banta Island, Nusa Tenggara, Indonesia (08°24’S 119°17’E), 26 m depth, on gorgonian *Annella reticulata*, February 2001, S. Lourie.

Paratypes: MZB 10921, (21.5 mm, male), collection data as for holotype; BPBM 38955, 3 specimens (14.5 mm, female; 13.5 mm, male; 13.8 mm, male?), Ulong Rock, W. Barrier Reef, Palau (07°07.43’N

134º14.48'E), 220–260 ft (67–79 m), May 2001, P. Colin/B. Yates; USNM 368872, (16.0 mm, female?) Ulong Rock, 1/2 mile north of Ulong Channel, Palau (07º07.42'N 134º14.48'E), 275 ft (84 m) depth on gorgonian *Echinogorgia?,* April 2001, P. Colin; USNM 368873, 3 specimens (13.2 mm, female; 15.5 mm, male; 16.3 mm, male), Latnu Island, Espiritu Santo, Vanuatu (15º06.71'S, 167º07.33'E), 200 ft (61 m) depth on gorgonian *Muricella*, December 2000, D. DeMaria; USNM 370526, (13.3 mm, male), Tsias Tunnel, W. Barrier Reef, Palau (07º18.72'N 134º13.58'E), 220 ft (67 m) depth, on gorgonian *Echinogorgia?,* May 2001, B. Yates.

Other specimens: RM3090a–d, 4 specimens (15.2 mm, female; 14.3 mm male; 15.4 mm, male; 13.9 mm, female), Senang Island no. 2, New Hanover, Papua New Guinea, 40 m depth on gorgonian *Annella mollis,* 3 July 2003, D. DeMaria [n.b. new distribution records for *H. denise*].

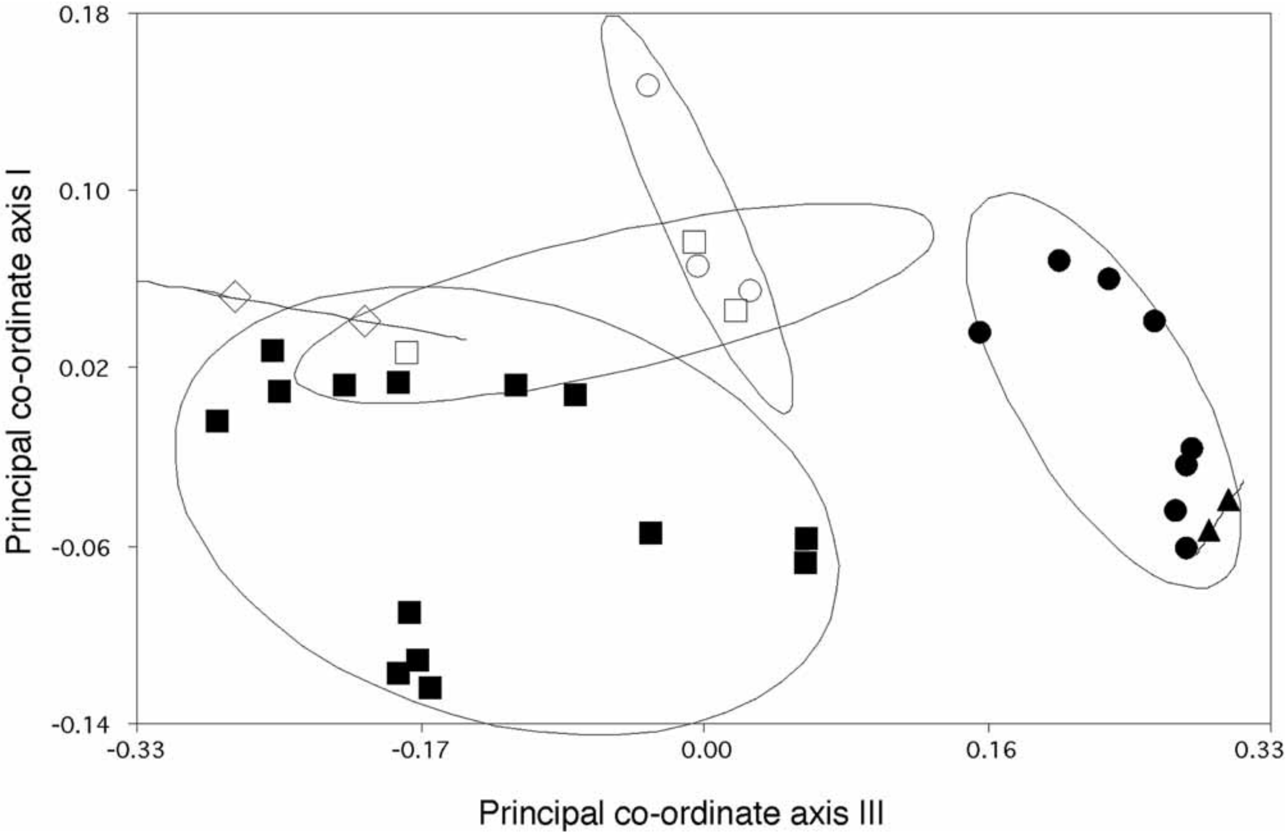

FIGURE 1. Ordination plot using the first and third axes of a principal co–ordinates analysis of 14 morphometric measurements and 3 meristic counts (see text for list of variables). Open symbols represent specimens of the three new species described in this paper: circles – *H. pontohi,* squares – *H. severnsi* and diamonds – *H. satomiae.* Filled symbols represent previously described species: circles – *Hippocampus bargibanti,* squares – *H. denise,* triangles – *H. colemani.*

Hippocampus colemani Kuiter 2003.

Holotype: AMS I.41181-001 (26.5 mm, male), near Erscott's Hole, Lord Howe Island (30º30'S 159º04'E), 5 m depth, January 2002, N. Coleman.

Paratype: AMS I.41181-002 (27.3 mm, male), collection details as for holotype.

[n.b. both specimens are male, not female as indicated in Kuiter (2003), and both have 12, not 11, trunk rings]

Hippocampus minotaur Gomon 1997.

Holotype: NMV A192, (54.3 mm, male), off Eden, New South Wales, Australia, 35–40 fm (64–74 m), December 1960, Danish seine trawl, R. Slack-Smith.

Paratype: NMV A14161 (21.5 mm, juvenile), 38 km southwest of Cape Patterson, Central Bass Strait, Australia (38º56.4'S 145º16.6'E), 70 m depth, 12 November 1981, R. Wilson.

Other specimen: CAS 13403 [labelled as *H. sp.* and newly identified by the senior author], 8 mi off Eden, New South Wales, Australia, 40 fm (74 m), 17 October 1941, Danish seine trawl, J. A. Tubbs (CSIRO).

Hippocampus pontohi sp. nov.

Type material. Holotype: MZB 13593 (16.9 mm, male), Lekuan II, Bunaken, North Sulawesi, Indonesia (1º36'5"N 124º45'56"E), 16 m depth, among algae/hydroid crops, 18 July 2003, M. Aw. Figures 2A and 3A.
Paratypes: MZB 13596 (16.8 mm, male), Negeri/Manado Tua, North Sulawesi, Indonesia (1º37'28"N 124º42'54"E), 12 m depth, among byrozoans/hydroids, 22 July 2004, R. Lahengko. MZB 13597 (16.6 mm, male?), Alung Banua, Bunaken, North Sulawesi, Indonesia (1º37'7"N 124º45'30"E), among byrozoans/hydroids, 22 July 2004, R. Lahengko.

Diagnosis. Extremely small size (height 14 mm, standard length 17 mm); 12 trunk rings; 26–28 tail rings; reduced ossification of inferior and ventral trunk ridges; 14 dorsal fin rays; 9–10 pectoral fin rays; small or absent anal fin; brooding area in males anterior to anus; medium length snout which lacks a bulbous tip; raised, angular coronet; fused (or almost fused in holotype) gill-openings on midline behind coronet supported by raised cleithral girdle; scattered tubercles on trunk and tail; distinctive branching filaments (usually red in life) attached to the enlarged superior trunk ridge spine of the fifth trunk ring; white colour, occasionally with yellow or pink especially along the dorsal surface, with fine red lines on the trunk, and reddish transverse bands across the tail.

Comparison. *Hippocampus pontohi* is most similar to *H. colemani* and is primarily separated from the latter species on the basis of tail ring counts (26–28 in *H. pontohi*, versus 28–30 in *H. colemani*), raised angular coronet, the following proportions: OD:HL (22.4–26.6% vs 18.6–18.9%), TD9:SL (11.0–15.7% vs 18.9–19.5%) and overall size (SL 16.6–16.9 mm vs 26.5–27.3 mm).

Hippocampus pontohi is much less robust overall than *H. bargibanti* and lacks the latter's very large tubercles and bulbous snout tip. It can be further distinguished from *H. bargibanti* by body colour (white vs purple with red tubercles, or grey with yellow/orange tubercles), fewer tail rings (26–28 vs 31–33), proportionally larger head (HL:SL 20.4–23.9% in *H. pontohi* vs 14.8–19.5% in *H. bargibanti*), less pronounced coronet (CH:HL 45.1–50.7% vs 46.1–64.1%), narrower snout (SnD:SnL 79.2–87.7% vs 82.2–144.1%), larger orbit (OD:HL 22.4–26.6% vs 14.2–24.0%), smaller post-orbital (PO:HL 49.0–53.5% vs 51.6–63.3%), longer trunk length (TrL:SL 32.4–33.9% vs 25.7–29.5%) and shorter tail length (TaL:SL 43.7–45.8% vs 53.3–57.1%).

It can be distinguished from *H. denise* by its body colour (white vs orange), deeper head (HD:HL 59.3–61.5% in *H. pontohi* vs 41.1–55.7% in *H. denise*), shorter snout (SnL:HL 22.6–24.4% vs 27.1–38.7%), larger orbit (OD:HL 22.4–26.6% vs 18.8–23.5%), larger post-orbital (PO:HL 49.0–53.5% vs 39.1–45.2%), longer trunk (TrL:SL 32.4–33.9% vs 23.1–31.7%), shorter tail (TaL:SL 43.7–45.8% vs 47.4–57.2%) and deeper body (TD9:SL 11.0–15.7% vs 4.1–15.5%). Both sexes of *H. pontohi* have rounded trunk profiles in comparison to female *H. denise's* narrow trunk. Furthermore, *H. pontohi* has a more pronounced coronet, fewer tail rings (26–28 vs 27–30) and fewer pectoral fin rays (9–10 vs 10–11).

Hippocampus pontohi can be differentiated from H. minotaur most clearly on the basis of meristic values: TrR 12 vs 8–9, TaR 26–28 vs 41, PF 9–10 vs 11 and DF 14 vs 7–9. It also has a significantly shallower head (HD:HL 59.3–61.5 vs 75.1–80.2%), longer trunk (TrL:SL 32.4–33.9 vs 18.4–24.7%), shorter tail (TaL:SL 43.7–45.8 vs 56.0–66.6%) and longer dorsal fin base (DL:SL 7.3–8.0 vs 1.5–2.4%).

Description. In addition to the characters given in the diagnosis: head length 20.8% (20.3–23.9%) in SL, and head depth 59.3% (60.8%–61.5%) in HL; snout length 24.4% (22.6–22.7%) in HL without bulbous tip, and snout depth 87.7% (79.2–85.5%) in SnL; orbital diameter 22.4% (22.9–26.6%) in HL; post-orbital length 50.9% (49.0–53.5%) in HL; frontal bone strongly raised posteriorly to form a sharply angled coronet (Figure 2A); pectoral fin-base raised; pectoral fin rays 10 (9–10).

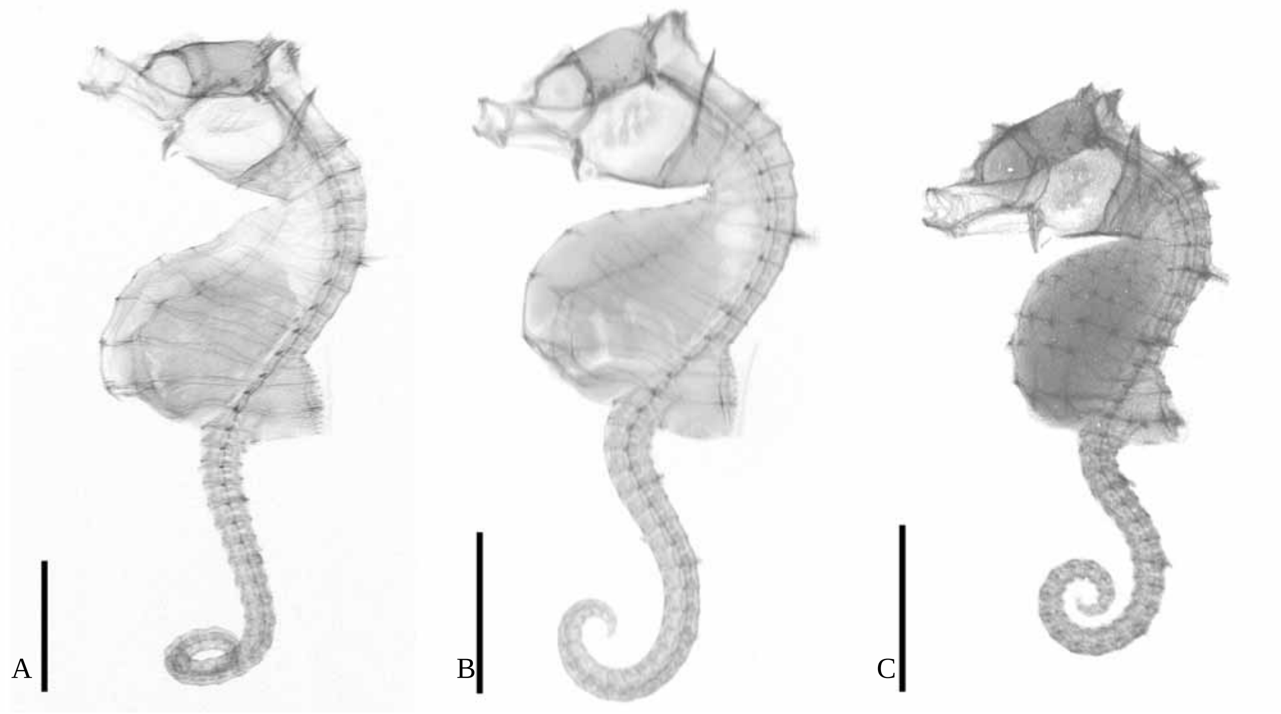

FIGURE 2. Radiographs of holotype specimens: A) *Hippocampus pontohi* (MZB 13593, 16.9 mm), B) *Hippocampus severnsi* (MZB 13594, 16.6 mm), and C) *Hippocampus satomiae* (NMV A25420–001, 13.8 mm). Scale bar = 2 mm in each case.

Trunk rings (TrR) 12, dorsal surface of TrR1 and TrR2 expanded laterally (but without spines); trunk length 33.6% (32.4–33.9%) in SL; trunk depth just anterior to dorsal fin base 15.7% (11.0–13.8%) in SL; dorsal fin base strongly raised and angled with respect to trunk (highest posteriorly); dorsal fin base starting immediately posterior to 9th trunk ring and ending immediately posterior to 12th trunk ring (covering 3+0 rings); dorsal fin rays 14; no external pouch visible in males, developing young housed entirely within trunk region anterior to the anus; anal fin not visible in any of the type specimens; first tail ring quadrangular; tail rings 26 (27–28); tail length 45.6% (43.7–45.8%) in SL.

Sexual dimorphism appears to be limited to differences in the genital region: males with vertical pouch slit, females with slightly raised, circular genital opening (see Lourie & Randall, 2003 for diagram).

Body ornamentation: prominent rounded spine above each eye, on midline of snout between eyes, and on either side of head below coronet; shoulder spine at base of pectoral fin; cheek spine; orbital ring with 12 small spines of alternating colours (brown/white); unbranched filament attached to anterior part of coronet in MZB 13596, other specimens without head filaments; greatly enlarged rounded spines on superior ridge of 5th trunk ring to which distinctive branched red filaments are attached; greatly enlarged rounded spine on superior ridge of 12th trunk ring and smaller, but still prominent, rounded spines on the lateral ridge of 8th trunk ring; small, rounded spines on the inferior ridges of 8th, 9th, 10th and 11th trunk ring (visible as tiny spines in MZB 13596). Enlarged rounded spines on superior ridge of tail align with bands of colour across 5th, 8th (or 9th), 12th, and 15th (or 16th) rings.

Colour in life: white, pinkish or yellowish-white (slightly darker on dorsal surface) with fine red lines tracing the superior trunk ridge and extending ventrally in broad loop around 5th and 8th trunk ring; 3–5 red transverse bands across tail that correspond to the position of enlarged superior tail ridge spines; scattered dark markings on head; sporadic dark markings on ventral midline between horizontal trunk ridges; dark patch immediately posterior to anus (Figure 4A). Colour in alcohol: pale cream with mid-ventral markings and bands on tail retained but muted. Dorsal and pectoral fins with dark spots in line near dorsal margin (Figure 3A).

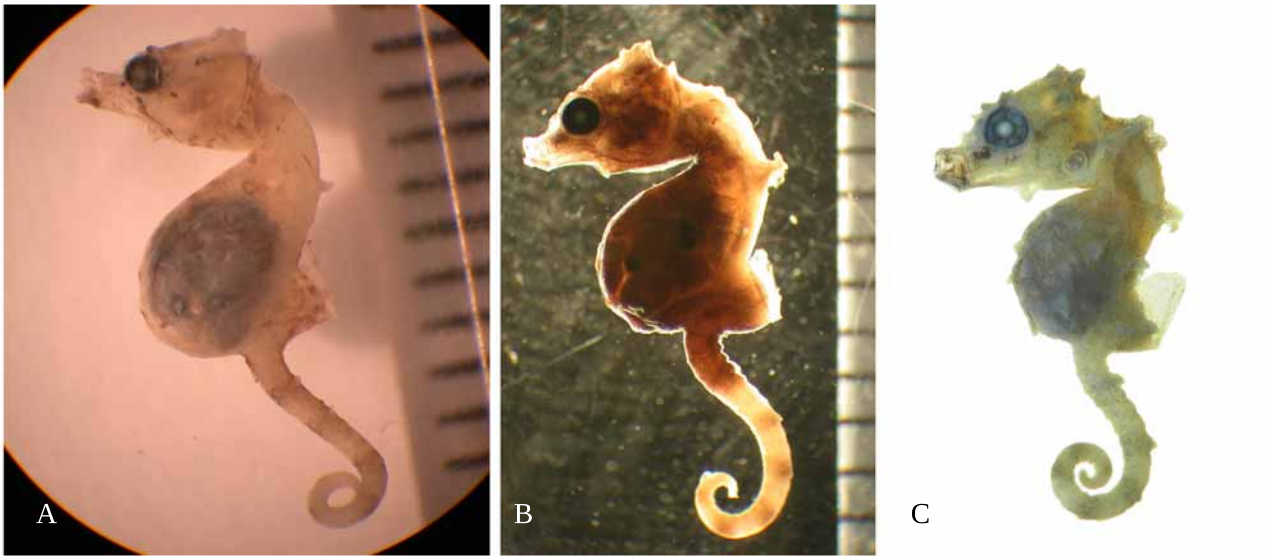

FIGURE 3. Preserved holotype specimens of A) *Hippocampus pontohi* (MZB 13593, 16.9 mm), B) *Hippocampus severnsi* (MZB 13594, 16.6 mm), and C) *Hippocampus satomiae* (NMV A25420–001, 13.8 mm). Scale bar in mm.

Discussion. Two other specimens examined: NMV 24979-001 (17.3 mm, male; 16.6 mm, female), Milne Bay, Papua New Guinea (10º20'S 150º25'E), 12 m depth, in *Halimeda*, November 2002, L. Maleta are tentatively identified as *H. colemani* on the basis of tail ring number, lack of raised coronet, TaL:SL, HD:HL, as well as their geographic locality. The specimens are, however, much smaller than the type specimens of *H. colemani* and have other proportions that are more similar to *H. pontohi* **sp. nov.** than to *H. colemani*. It is possible that future research will reveal that *H. pontohi* and *H. colemani* represent a cline of variation within a single species. In the interests of clarity, and given the present lack of additional data, comparisons in the text descriptions and Tables 1 to 3 are restricted to the type specimens of *H. colemani*.

Etymology. This species is named in honour of Hence Pontoh, the Indonesian dive guide who first brought these pygmy seahorses to our attention.

Distribution and ecology. *Hippocampus pontohi* has been observed on the coralline algae *Halimeda*, as well as on the hydroid *Aglaephenia cupressina* (Müller and Severns, *pers. comm.*). Severns noted it particularly in areas where *Halimeda* is growing on reef walls. It has been recorded at a number of areas in Indonesia (Bunaken, Cape Sri, Sorong, Wakatobi, Lembeh Straits), at depths of between 11–25 m particularly on vertical walls or in rock fissures (Müller, *pers. comm.*). See figure 5A for map.

Hippocampus pontohi is commonly found in pairs and, like *H. denise*, is relatively active (Müller, *pers. comm.*). Two of the specimens examined were pregnant (MZB 13593 and MZB 13596) and each contained approximately 11 embryos. Both were collected in July.

Hippocampus severnsi sp. nov.

Type material. Holotype: MZB 13594 (16.6 mm, male), between Alung Banua and Cela Point, Bunaken, North Sulawesi, Indonesia (1º37’07” to 1º36’47” N 124º45’30” to 124º46.03” E, 50 ft (15.2 m) depth, June

2002, M. Severns & H. Pontoh. Figures 2B and 3B.

Paratypes: MZB 13595 (16.5 mm, female), collection details as for holotype; NMV A24980-001 (12.4 mm, female), Milne Bay, Papua New Guinea (10º20'S 150º25'E), 12 m depth, black coral, November 2002, L. Maleta.

FIGURE 4. Live specimens of new species of pygmy seahorses from Indonesia. A) *Hippocampus pontohi*: Bunaken, Sulawesi, M. Boyer; Bunaken, Sulawesi, M. Aw; Raja Ampat, West Papua, L. Tackett. B) *Hippocampus severnsi*: Bunaken, Sulawesi, S. Wong & T. Uno; Bunaken, Sulawesi, M. Severns (type specimens); Raja Ampat, West Papua, L. Tackett. C) *Hippocampus satomiae*: Derawan Kalimantan, S. Wong & T. Uno; Derawan, Kalimantan, J–S. Chen; Derawan, Indonesia, S. Onishi (type specimen).

Diagnosis. Extremely small size (height 13 mm, standard length 15 mm); 12 trunk rings; 27 tail rings; reduced ossification of inferior and ventral trunk ridges; 14 dorsal fin rays; 10 pectoral fin rays; small or absent anal fin; medium length snout which lacks a bulbous tip; raised, angular coronet; single gill opening on midline directly behind coronet supported by raised cleithral bone; scattered tubercles on trunk and tail; predominant colour dark brown (sometimes slightly marbled) with large, bright red patch covering dorso-lateral surfaces of TrR 1–4; tiny white dots scattered all over; pale posterior section of tail with dark transverse bands.

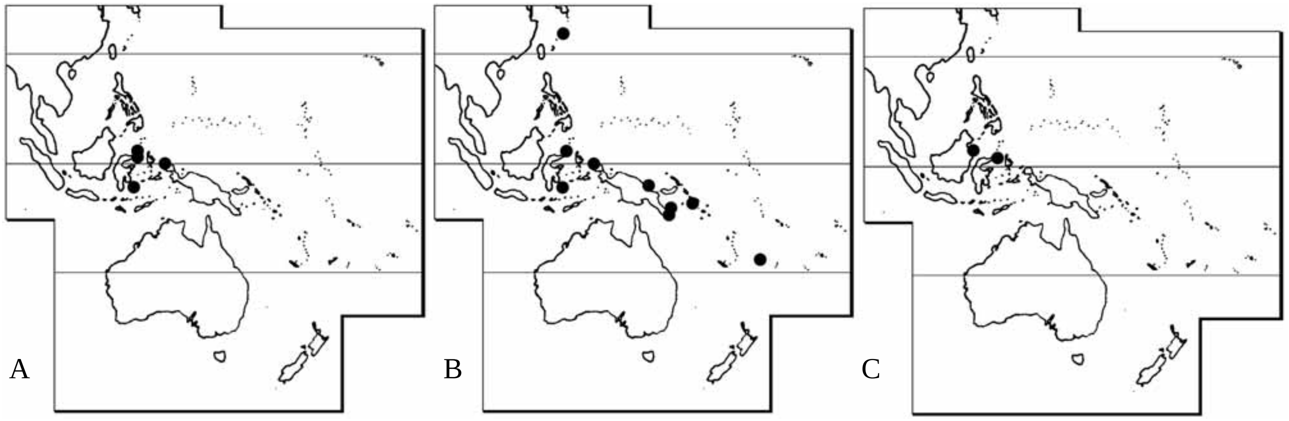

FIGURE 5. Distribution records for A) *Hippocampus pontohi*, B) *Hippocampus severnsi*, C) *Hippocampus satomiae*.

Comparison. *Hippocampus severnsi* shares most meristic characters with *H. pontohi*. They differ primarily in live colour and pattern.

H. severnsi can be separated from *H. colemani* in the same way as *H. pontohi*, with an additional difference being body colour (brown vs white). Tail ring counts are 27 in *H. severnsi* vs 28–30 in *H. colemani*. Other differences include *H. severnsi's* raised angular coronet and the following proportions: OD:HL (24.1–26.1% vs 18.6–18.9%), TD9:SL (11.9–15.1% vs 18.9–19.5%), DL:SL (8.4–11.3% vs 6.0–6.7%) and overall size (SL 12.4–16.6 mm vs 26.5–27.3 mm).

H. severnsi is much less robust overall than *H. bargibanti* and lacks *H. bargibanti's* very large tubercles, and bulbous snout tip. It can be further distinguished from *H. bargibanti* by its body colour (brown vs purple with red tubercles or grey with yellow/orange tubercles), fewer tail rings (27 vs 31–33), proportionally larger, but less deep head (HL:SL 20.9–22.4% in *H. severnsi* vs 14.8–19.5% in *H. bargibanti*; HD:HL 51.7–62.5% vs 60.8–70.3%), less pronounced coronet (CH:HL 44.7–49.9% vs 46.1–64.1%), larger orbit (OD:HL 24.1–26.1% vs 14.2–24.0%), smaller post-orbital (PO:HL 47.4–51.0% vs 51.6–63.3%), longer trunk (TrL:SL 29.9–33.1% vs 25.7–29.5%) and shorter tail (TaL:SL 45.9–48.3% vs 53.3–57.1%).

It can be distinguished from *H. denise* by its body colour (brown vs orange), deeper head (HD:HL 51.7–62.5% in *H. severnsi* vs 41.1–55.7% in *H. denise*), shorter and deeper snout (SnL:HL 24.2–27.8% vs 27.1–38.7%; SnD:SnL 83.9–97.4% vs 62.7–81.2%), larger orbit (OD:HL 24.1–26.1% vs 18.8–23.5%), larger post-orbital (PO:HL 47.4–51.0% vs 39.1–45.2%), deeper trunk (TD9:SL 11.9–15.1% vs 4.1–15.1%), longer trunk (TrL:SL 29.9–33.1% vs 23.1–31.7%) and shorter tail (TaL:SL 45.9–48.3% vs 47.4–57.2%). Both sexes of *H. severnsi* have rounded trunk profiles in comparison to female *H. denise's* narrow trunk. Furthermore, it has a much more pronounced coronet and fewer tail rings (27 vs 27–30).

Hippocampus severnsi can be differentiated from *H. minotaur* most clearly on the basis of meristic values: TrR 12 vs 8–9, TaR 27 vs 41, PF 10 vs 11 and DF 14 vs 7–9. It also has a significantly shallower head (HD:HL 51.7–62.5 vs 75.1–80.2%), longer trunk (TrL:SL 29.9–33.1 vs 18.4–24.7%), shorter tail (TaL:SL 45.9–48.3 vs 56.0–66.6%) and longer dorsal fin base (DL:SL 8.4–11.3 vs 1.5–2.4%).

Description. In addition to the characters given in the diagnosis: head length 20.9% (21.6–22.4%) in SL, and depth 60.8% (51.7–62.5%) in HL; snout length 24.2% (25.8–27.8%) in HL without bulbous tip, and depth 83.9% (88.0–97.4%) in SnL; orbital diameter 24.1% (25.2–26.0%) in HL; postorbital length 48.1%

(47.4–51.0%) in HL; frontal bone strongly raised posteriorly to form a sharply angled coronet (Figure 2B); pectoral fin–base raised; pectoral fin rays 10.

Trunk rings (TrR) 12, the dorsal surface of TrR1 greatly expanded laterally (and TrR2 to a lesser extent) without spines; trunk length 33.1% (29.9–30.0%) in SL; trunk depth just anterior to dorsal fin base 15.1% (11.9–13.6%) in SL; dorsal fin base strongly raised and angled with respect to the trunk (highest posteriorly); dorsal fin base starting immediately posterior to the 9th trunk ring and ending immediately posterior to the 12th trunk ring (covering 3+0 rings); dorsal fin rays 14; no external pouch visible in males, developing young housed entirely within trunk region; anal fin not visible in the holotype but present (with 4 fin rays) in paratypes; first tail ring quadrangular; tail rings 27; tail length 45.9% (47.7–48.3%) in SL.

Sexual dimorphism appears to be limited to differences in the genital region: males with vertical pouch slit, females with slightly raised, circular genital opening.

Body ornamentation: prominent rounded spine above each eye, on midline of snout between eyes, and on either side of the head below the coronet; shoulder spine at base of pectoral fin; cheek spine; black orbital ring with 12 small spines; thick branched or unbranched filament attached to anterior part of coronet; small rounded spine on the superior ridge of the 1st trunk ring; greatly enlarged rounded spines on the superior ridge of the 5th trunk ring with distinctive branched red filaments attached; greatly enlarged rounded spine also on superior ridge of the 12th trunk ring and smaller, but still prominent, spines on lateral and inferior ridges of the 8th and inferior ridge of 11th trunk ring. In NMV A24980–001 lateral TrR5 and inferior TrR5–10 spines also developed. Enlarged rounded spines on superior ridge of the tail correspond to bands of colour across 5th, 9th, and 12th (or 4th, 8th, 11th, 14th in NMV A24980–001) rings.

Colour in life: brown (solid, or slightly marbled) with large red patch covering dorsal and lateral surfaces of TrR1–4; posterior part of tail pale, with transverse brown bands at TaR5, 9 and 12 (or 4, 8, 11, 14); scattered white dots on head, trunk and tail (Figure 4B). Colour in alcohol: brown with pale posterior part of tail; transverse brown bands visible on tail (Figure 3B).

Etymology. *Hippocampus severnsi* is named in honour of Mike Severns who, with Hence Pontoh, collected the first specimens.

Distribution and ecology. *Hippocampus severnsi* is known from Indonesia (Bunaken, Wakatobi, Raja Ampat Islands, Kawe Island), Japan (Ryukyu Islands), Papua New Guinea (Milne Bay, Madang), Solomon Islands (Mborokua) and Fiji at depths of 8–20 m. See figure 5B for map. It has been observed both during the day and the night but is apparently more active in the morning and late afternoon when it is not in direct sunlight (Müller, *pers. comm.*). In Indonesia it has been recorded in association with a yellow coloured bryozoan, *Catenicella* sp., on different kinds of hydrozoans including *Lytocarpus phoenicea*, *Antennellopsis integerrima* and *Halicordyle disticha* (Müller, *pers. comm.*) as well as in sheltered spots on a reef wall in association with *Halimeda* (Brett, *pers. comm.*). It is also recorded from fissures on current–swept walls where it will tend to occur on the side of the fissure that faces away from the current, but in all cases where there is some upward current (Müller, *pers. comm.*) and has been seen swimming over a fungiid coral (Hardt, *pers. comm.*). In Papua New Guinea it has been observed in a healthy reef passage with a regular current of up to two knots on a gorgonian of the genus *Muricella* at 12 m depth (Halstead, *pers. comm.*) and in Fiji it was found on gorgonian species, possibly *Menella* sp.? (Tackett, *pers. comm.*)

The holotype of *H. severnsi*, collected in June, had approximately 11 embryos within its pouch.

Hippocampus satomiae

Type material. Holotype: NMV A25420–001 (13.8 mm, male), Derawan Island, Kalimantan, Indonesia (02°17.690’N, 118°15.692’E), 10–18 m depth, on gorgonian *Carijoa* sp.? Muller 1867, October 2003, Satomi Onishi. Figures 2C and 3C.

Paratype: NMV A25420–002 (13.4 mm, female), collection details as for holotype.

Diagnosis. Extremely small size (height 11 mm, standard length 14 mm); 12 trunk rings; 27–28 tail rings; reduced ossification of inferior and ventral trunk ridges; 13 dorsal fin rays; 9 pectoral fin rays; small or absent anal fin; brooding area in males anterior to anus; well–developed spine on snout between eyes; distinct raised coronet with laterally expanded anterior and posterior flanges ('H–shaped' when viewed from above); snout without a bulbous tip; single gill opening on midline directly behind coronet supported by raised cleithral bone; large spines above eyes (double), laterally on head, on shoulder (cleithral) ring, bordering throat, and on superior trunk ridge (especially well–developed on TrR1–2,5,8 and 12 and TaR4,8,11,14); spines also present on lateral and ventral angles between trunk ridges and rings; spines on superior ridge of first and second trunk rings appear externally as if they are fused.

Comparison. The spines covering the body of *H. satomiae* gives it a rough appearance. They contrast with the large rounded tubercles invariably seen in *H. bargibanti*, occasionally in *H. denise*, and the scattered, narrower, rounded spines in *H. pontohi* and *H. severnsi.* Its colour and pattern contrast with the other species of pygmy seahorses: white–pale brown or greyish–transparent, with dark spot anterior to the eye in *H. satomiae* vs purple with red tubercles, or grey with yellow/orange tubercles in *H. bargibanti,* orange in *H. denise,* white in *H. colemani* and *H. pontohi,* and brown in *H. severnsi.* In addition to differences in body ornamentation and colour *H. satomiae* can be distinguished from *H. pontohi* and *H. severnsi* by shallower head (HD:HL 51.0–52.6% vs 59.3–61.5% or 51.7–62.5%), smaller post-orbital (PO:HL 44.8–45.2% vs 49.0–53.5% or 47.4–51.0%), and fewer pectoral (PF 9 vs 10) and dorsal (DF 13 vs 14) fin rays.

It can be separated from *H. colemani* by its shallower head (HD:HL 51.0–52.6% vs 61.7–63.6%), larger orbit (OD:HL 23.8–23.9% vs 18.6–18.9%), smaller post-orbital (PO:HL 44.8–45.2% vs 50.1–54.1%), narrower body (TD9:SL 10.7–15.0% vs 18.9–19.5%) and fewer pectoral (PF 9 vs 10) and dorsal (DF 13 vs 14) fin rays.

It can be differentiated from *H. bargibanti* by its longer, but less deep head (HL:SL 21.7–22.2% vs 14.8–19.5%, HD:HL 51.0–52.6% vs 60.8–70.3%), longer snout (SnL:HL 26.4–27.5% vs 18.5–23.2%), less pronounced coronet (CH:HL 38.9–41.4% vs 46.1–64.1%), larger orbit (OD:HL 23.8–23.9% vs 14.2–24.0%), smaller post-orbital (PO:HL 44.8–45.2% vs 51.6–63.3%), shorter tail (TaL:SL 46.3–49.7% vs 53.3–57.1%), fewer tail rings (TaR 27–28 vs 31–33), fewer pectoral (PF 9 vs 10–11) and dorsal (DF 13 vs 14) fin rays.

Both sexes of *H. satomiae* have rounded trunk profiles in comparison to female *H. denise's* narrow trunk. From *H. denise* it can be separated additionally by its shorter snout (SnL:HL 26.4–27.5% vs 27.1–38.7%), and fewer pectoral (PF 9 vs 10–11) and dorsal (DF 13 vs 13–14) fin rays.

Hippocampus satomiae can be differentiated from *H. minotaur* most clearly on the basis of meristic values: TrR 12 vs 8–9, TaR 27–28 vs 41, PF 9 vs 11 and DF 14 vs 7–9. It also has a significantly shallower head (HD:HL 51.0–52.6 vs 75.1–80.2%), longer trunk (TrL:SL 28.6–31.6 vs 18.4–24.7%), shorter tail (TaL:SL 46.3–49.7 vs 56.0–66.6%) and longer dorsal fin base (DL:SL 7.9–8.2 vs 1.5–2.4%).

Description. In addition to the characters given in the diagnosis: head length 22.3% (21.6%) in SL; head depth 51.0% (52.6%) in HL; snout length 27.5% (26.4%) in HL without bulbous tip; snout depth 88.8% (82.5%) in SnL; orbit diameter 23.7% (23.9%) in HL; post-orbital length 44.8% (45.2%) in HL; coronet well–developed with a broad transverse flange anteriorly, a narrower one posteriorly, connected by a narrow longitudinal ridge; pectoral fin base raised; pectoral fin rays 9.

Trunk rings 12; trunk length 31.3% (28.6%) in SL; trunk depth just anterior to dorsal fin base 15.0% (10.7%) in SL; dorsal fin base strongly raised posteriorly; dorsal fin base starting immediately posterior to 9th trunk ring and ending posterior to 12th trunk ring (covering 3+0 rings); dorsal fin rays 13; no external pouch visible, male with young carried within the trunk region; anal fin not visible in either specimen; first tail ring quadrangular; tail rings 27 (28); tail length 46.3% (49.7%) in SL.

No pronounced differences in shape were observed between the sexes beyond those of the genital region.

Body ornamentation: double spines above each eye; angular nose–spine; heavy square–tipped lateral spines (Y–shaped in cross–section) on temporals; long cheek (throat) spine curving slightly anteriorly; mid–cleithral spine (upper shoulder–ring spine) located at base of pectoral fin; broad 'wing–like' projections from superior ridge of TrR1,2 and large spines also on superior ridge of TrR5,8 and 12 and TaR4,8,11,14; numerous scattered spines on trunk (giving it a rough appearance); spines square– or sharp–tipped; spines supported by bony extrusions visible in radiographs; small (unbranched) dermal filaments stemming from anterior part of coronet.

Colour in life: white to pale brown or greyish base colour; black spot immediately anterior to eye; blotchy red markings on operculum and on dorsal and lateral surfaces of TrR5 and TaR4; brown transverse bands across TaR8,11,14 etc (Figure 4C). Colour in alcohol: pale grey, almost transparent (internal organs clearly visible through skin); black orbital ring; black spot anterior to eye; coronet dark; slightly darker transverse bands on tail (Figure 3C).

Etymology. This species is named in honour of Miss Satomi Onishi, the dive guide who collected the type specimens.

Distribution and ecology. *Hippocampus satomiae* is known from scattered localities in Indonesia, including Derawan (type locality), and Lembeh Strait (northern Sulawesi), as well as northern Borneo, Malaysia. See figure 5C for map. It congregates at night in groups of 3–5 individuals on small seafans, at depths of 15–20 m depth on the bottom below reef overhangs. Photographed individuals (in Boyer, 2007) from the Togean Islands, Indonesia on a species of *Nepthea* Auduoin, 1826 on the reef front in water as shallow as 5 m are tentatively identified as *H. satomiae*.

During the day *H. satomiae* are difficult to find, even in areas where they are known to occur. At dawn individuals become active. Birth has been observed on a number of occasions and also photographed. At birth, the young are jet–black, about 3 mm in height and shaped similarly to the adults. They settle on the bottom near to their place of birth (Onishi, *pers. comm.*). The holotype, collected in October, was pregnant and carrying approximately eight young.

Discussion

The three new species described in this paper bring the total number of described pygmy seahorse species to seven. Our knowledge of their relationships, ecology and population status is still rudimentary. However, a few patterns are beginning to emerge: *Hippocampus bargibanti, H. colemani, H. pontohi, H. satomiae* and *H. severnsi* show similar meristic counts, overall body shape, size and position of the brooding area suggesting a pontential close relationship. The latter four may form a subclade, united by the complete (or almost complete) fusion of the gill openings into a a single aperture behind the coronet supported by a strongly raised cleithral girdle. *Hippocampus denise* shows similar meristics, yet has a more elongate body shape, particularly the female. The other species that has been described as a pygmy seahorse *H. minotaur* Gomon 1997, grows much larger than the six previously mentioned – up to at least 54 mm SL. It also has a number of unique features, such as 8–9 trunk rings, 41 tail rings, 7–9 dorsal fin rays and 11 pectoral fin rays, extreme lateral compression, and thick neck, that suggest a more distant relationship from both the six pygmy seahorse species mentioned above and other species of seahorse of larger body size.

The form, colour and body ornamentation of each of the pygmy seahorse species closely match their respective habitats and camouflage them against potential predators. They are found in an increasingly wide variety of habitats. *Hippocampus bargibanti* lives on the gorgonian sea fans *Muricella plectana* and *M. paraplectana,* and *H. denise* lives on *Annella reticulata* and *Acanthogorgia* spp. (Gomon 1997; Lourie & Randall 2003). The type specimens of *Hippocampus colemani* were collected amongst seagrass (genera *Zostera* and *Halophila*) (Kuiter 2003) while photographs of the new species described herein show them to be attached to a variety of sea fans (possibly *Carijoa* sp., *Subergorgia* sp. and *Acanthogorgia* sp.), colonial hydrozoans (e.g.

Lytocarpus phoenicea, *Antennellopsis integerrima*, *Halicordyle disticha*) or bryozoans (e.g. *Catenicella* sp.) and coralline algae (*Halimeda*) (Colin & Arneson 1995; Fabricius & Alderslade 2001). The species described in this paper have also been seen moving over hard coral (e.g. *Fungia* sp.) and encrusting sponges or in rocky crevices (Müller & Hardt *pers. comm.*). It is possible that selective pressure for effective camouflage has led to host–specificity, habitat partitioning and speciation among pygmy seahorses. Such driving forces have been suggested to be the case for the commensal Pontoniinae shrimps that show high host–specificity and high species diversity (Zmarzly 1990).

Systematic genetic data coupled with studies of habitat are required in order to further assess relationships among these species, and will be valuable in the quest to elucidate factors driving their evolution and the degree to which colour, and habitat preferences reflect potential reproductive isolation and incipient speciation.

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