

A New Pygmy Seahorse, *Hippocampus denise* (Teleostei: Syngnathidae), from the Indo-Pacific

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Sara A. Lourie and John E. Randall (2003) A new pygmy seahorse, *Hippocampus denise* (Teleostei: Syngnathidae), from the Indo-Pacific. *Zoological Studies* 42(2): 284-291. A new species of pygmy seahorse, *Hippocampus denise*, is described from Indonesia. It is distinguished from other seahorse species by its diminutive size, the possession of a low number of tail rings (28-29), 10-11 pectoral-fin rays, 14 dorsal-fin rays, a rounded nuchal plate without a raised coronet, a snout length 30% in head length, a snout without a bulbous tip, the inferior and ventral trunk ridges reduced to disconnected star-shaped ossifications, the limited number of tubercles on the body, the plain orange body color, and males with eggs and embryos contained within the trunk region. Further specimens from Vanuatu and Palau, in addition to photographs and other observations by the senior author, suggest that this species may be relatively widespread in the West Pacific Ocean. It is recorded from depths of 13-90 m in association with gorgonian seafans identified as *Annella reticulata* (Ellis and Solander, 1786), *Muricella* sp. Verrill, 1869, and *Echinogorgia* sp. Kölliker, 1865. Comparisons are made with *H. bargibanti* Whitley, 1970, and *H. minotaur* Gomon, 1997.
<http://www.sinica.edu.tw/zool/zoolstud/42.2/284.pdf>

Key words: New species, Taxonomy, Marine, *Hippocampus bargibanti*, Distribution.

Pygmy seahorses (genus *Hippocampus*) were first described in 1969 after a pair of individuals was found attached to a gorgonian seafan that was collected by Georges Bargibant for the Nouméa Aquarium in New Caledonia. This species was named *H. bargibanti* by Whitley (1970). Gomon (1997) described a 2nd "pygmy" seahorse from southeastern Australia (*H. minotaur*) and provided a full re-description of *H. bargibanti*. In recent years, underwater photographers have captured on film what appear to be at least 3 undescribed species (Kuitert 2000), one of which is described here.

All seahorses are currently included in a single genus; *Hippocampus* Rafinesque. A preliminary revision of the genus (Lourie et al. 1999b) suggests that it comprises at least 32 species, but

Kuitert believes that the figure is closer to 50 (Kuitert 2000). A full taxonomic revision is in preparation by the senior author, with the intention to resolve some of the continuing confusion regarding the taxonomy of these unusual fishes.

The majority of the species are between 10 and 30 cm in height and are found in shallow waters in tropical, subtropical, and temperate waters worldwide (Lourie et al. 1999b). The pygmy seahorse described in this paper, like *H. bargibanti*, appears to live at depths greater than 13 m in association with gorgonian seafans. Even among seahorses, these diminutive species are masters of camouflage; their coloration and body ornamentation in the form of tubercles, exactly match the stems and polyps of their gorgonian hosts.

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MATERIALS AND METHODS

Specimens cited in this paper are deposited in the Museum Zoologicum Bogoriense, Cibinong, Indonesia (MZB), the Bishop Museum, Hawaii (BPBM), the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM), the Australian Museum, Sydney (AMS) and the Museum of Victoria, Melbourne (NMV).

Morphological measurements follow Lourie et al. (1999a) where possible (Fig. 1). Most measurements/counts were made under a binocular microscope, using digital calipers to record measurements to 0.01 mm, and were repeated to ensure accuracy. Because of the fleshy nature of the species examined and the reduced ossification in the trunk region, counts of trunk and tail rings were verified from radiographs (Fig. 2). The num-

ber of trunk rings is equal to 2 fewer than the number of pre-caudal vertebrae (Gomon 1997). Trunk and tail lengths were measured from proportional camera lucida drawings of the specimens, using a wire to follow the curvature of the body (Lourie et al. 1999a). Standard length (SL) was used for proportional measurements and is reported in the list of specimens examined. This differs from the total length (TL) measurement used by Gomon (1997) and Vari (1992) but allows one to objectively deal with specimens which are curled to different degrees. SL is defined as the sum of the head length (HL), trunk length (TrL), and tail length (TL) following the curve of the body for the latter 2 mea-

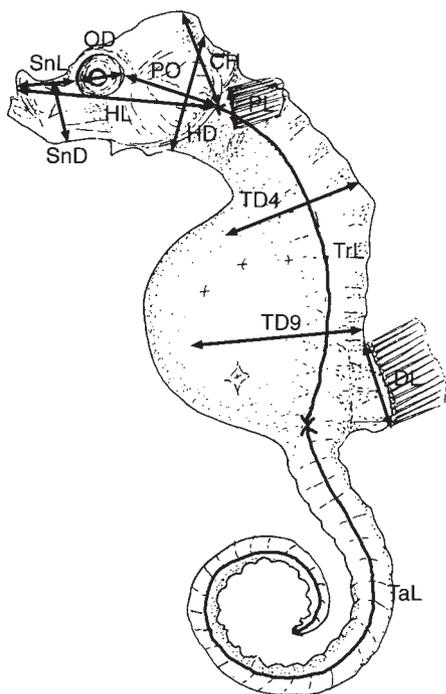


Fig. 1. Morphometric measurements (following Lourie et al. 1999a): HL, head length; TrL, trunk length; TaL, tail length; SnL, snout length; OD, orbital diameter; PO, post-orbital length; SnD, snout depth; HD, head depth; CH, coronet height; TD4, trunk depth (from the superior to the inferior trunk ridge) between the 4th and 5th trunk rings; TD9, trunk depth (from the superior to the inferior trunk ridge) anterior to the dorsal fin base, between the 9th and 10th trunk rings; PL, length of pectoral fin base; DL, length of dorsal fin base; and TW (not shown), width of trunk (anterior to the dorsal fin base). SL, standard length = HL+TrL+TaL. Meristics: TrR, number of trunk rings; TaR, number of tail rings; DF, number of dorsal fin rays; PF, number of pectoral fin rays; AF, number of anal fin rays.

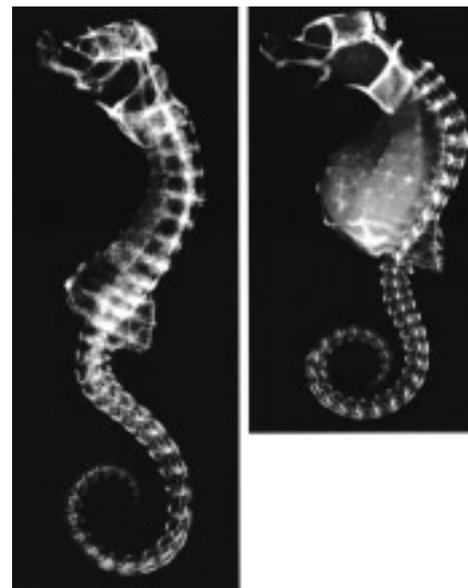


Fig. 2. Radiographs of type specimens of *Hippocampus denise*. Left: holotype MZB 10920 (♀). Right: paratype MZB 10921 (♂).

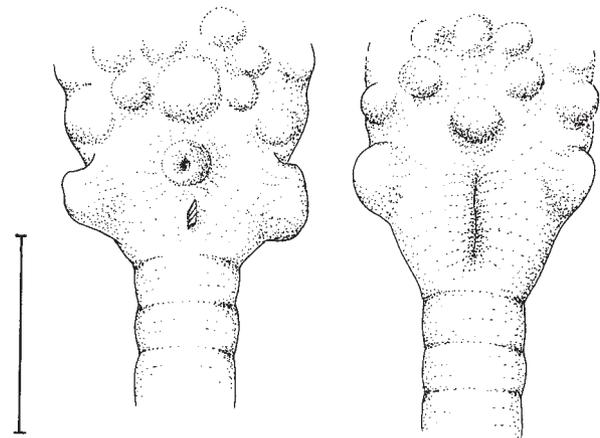


Fig. 3. Genital regions of *Hippocampus bargibanti*: ♀ on left, ♂ on right. Scale bar = 2 mm. Drawing: S. Lourie.

surements (Lourie et al. 1999a). Snout length (SnL), snout depth (SnD), orbital diameter (OD), and coronet height (CH) are reported as proportions of HL. Values for the holotype (female) are given in the description, with the range for the paratypes given in parentheses.

We made the assumption that, as in other species of seahorse, it is the male that incubates the fertilized eggs. External differences in the genital region (Fig. 3) are apparent in both *H. denise* and *H. bargibanti*, and these were matched with specimens bearing fertilized eggs or embryos in order to determine the sex of specimens without fertilized eggs or embryos.

Comparisons were made among the holotype, lectotype, and other specimens of *H. bargibanti* and *H. minotaur*. We took 15 log-transformed morphometric variables combined with 5 meristic variables to compute a similarity matrix among all specimens, using Gower's (1971) index of similarity. From this, we produced an ordination of the specimens using the method of principal coordinate analysis (Gower 1966) as computed by the R-package vers. 4.0 (Casgrain and Legendre 2001).

***Hippocampus denise* sp. nov. (Denise's pygmy seahorse)**

Materials examined: Holotype: MZB 10920,

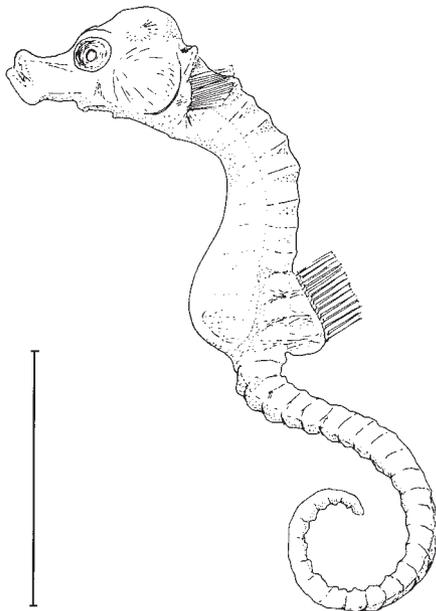


Fig. 4a. *Hippocampus denise* ♀ holotype (MZB 10920). Scale bar = 5 mm. Drawing: S. Lourie.

(SL 24.0 mm, ♀), Banta I., Nusa Tenggara, Indonesia (08°24'S 119°17'E), 26 m depth, on the gorgonian *Annella reticulata*, Feb. 2001, S. Lourie. (Figs. 2, 4a, 5). Paratypes: MZB 10921, (21.5 mm, ♂), collection data as for holotype (Figs. 2, 4b, 5); BPBM 38955, 3 specimens (14.5 mm, ♀; 13.5 mm, ♂; 13.8 mm, ♂), Ulong Rock, W. Barrier Reef, Palau (07°07.43'N 134°14.48'E), 220-260 ft (67-79 m), May 2001, P. Colin/B. Yates; USNM 368872, (16.0 mm, ♀) Ulong Rock, 0.5 mile (0.8 km) north of Ulong Channel, Palau (07°07.42'N 134°14.48'E), 275 ft (84 m) depth on the gorgonian ?*Echinogorgia*, Apr. 2001, P. Colin (Fig. 6); USNM 368873, 3 specimens (13.2 mm, ♀; 15.5 mm, ♂; 16.3 mm, ♂), Latnu I., Espiritu Santo, Vanuatu (15°06.71'S, 167°07.33'E), 200 ft (61 m) depth on gorgonian *Muricella*, Dec. 2000, D. DeMaria; USNM 370526, (13.3 mm, ♂), Tsias Tunnel, W. Barrier Reef, Palau (07°18.72'N 134°13.58'E), 220 ft (67 m) depth, on the gorgonian ?*Echinogorgia*, May 2001, B. Yates.

Comparative material examined:

Hippocampus bargibanti Whitley, 1970

Lectotype: AMS I.15418-002, (25.9 mm, ♀), Nouméa, New Caledonia, 30 m depth, on the gorgonian *Muricella* sp.

Paralectotype: AMS I.15418-001, (22.2 mm, ♂), collected with lectotype. Based on the external appearance of its genitalia, specimen AMS I.15418.001 is a male which had recently given

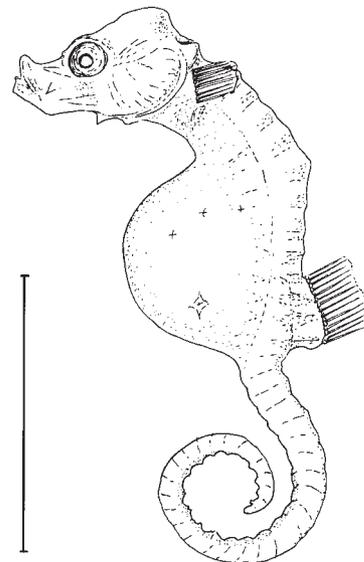


Fig. 4b. *Hippocampus denise* ♂ paratype (MZB 10921). Scale bar = 5 mm. Drawing: S. Lourie.

birth, not a female as was reported in Gomon (1997) and on the museum label.

Other specimens: AMS I.15997-001, 2 specimens (25.9 mm, ♀; 24.6 mm, ♂), off Nouméa, Canal Woodin, New Caledonia, 20-25 m depth; AMS I.19834-001, (26.9 mm, ♀) Nouméa Lagoon, New Caledonia; uncataloged (23.0 mm, ♂), 0.5 mile (0.8 km) west of the southern tip of the Passes de Boulari, Nouméa, New Caledonia, 45 m depth, on the gorgonian *Muricella* sp.; MZB 10922, 2 specimens (22.5 mm, ♀; 24.0 mm, ♂) Pulau Abadi, Lembah Strait, Sulawesi (01°26.34'N 125°12.82'E), 26 m depth, on the gorgonian *Muricella plectana* Grasshoff, 1999.

Hippocampus minotaur Gomon, 1997

Holotype: NMV A192, (54.3 mm, ♂), off Eden, New South Wales, Australia, 35-40 fm (64-74 m).

Diagnosis: The combination of an extremely diminutive body size, 14 dorsal-fin rays, 10-11 pectoral-fin rays, small or absent anal fin, 12 trunk rings, 28-29 tail rings, the body fleshy with inferior and ventral trunk ridges reduced to separated cross-shaped spicules embedded in the skin, the nuchal plate rounded without a raised coronet, the snout length approximately 30% in head length, the snout without a bulbous tip, the postorbital length approximately 40% in HL, the head depth approximately 50% in HL, the lack of spines above the eye, the trunk depth (between the 9th and 10th trunk rings) approximately 7% in SL (female) 10%-15% in SL (male), the angles of certain body ridges sometimes developed into rounded tubercles, but with tubercles distinctly fewer and less developed than in *H. bargibanti* separate *H. denise*

from the majority of the other seahorse species described thus far (Gomon 1997, Lourie et al. 1999).

The most similar species appears to be *H. bargibanti* (Table 1). It shares with *H. denise* a number of features, including 12 trunk rings, 10-11 pectoral-fin rays, and 14 dorsal-fin rays, but differs in its head and body shape. An ordination diagram in space of the 2nd (15.5% of the variance) and 3rd (6.2%) principal coordinates, reflecting morphometric variation in shape rather than size (Fig. 11), shows complete separation of the species. The pattern of tubercle development is similar in the 2 species, with the strongest development being on the dorsal angle of the 1st and 5th trunk rings, the lateral angle of the 8th trunk ring, and the dorsal and ventral angles of the 12th trunk ring,



Fig. 5. ♀ holotype MZB 10920 (left), and ♂ paratype MZB 10921 (right) of *Hippocampus denise*, Banta Island, Indonesia. Photo: J. Adam.

Table 1. Comparative counts (variations in square brackets) and morphometric measurements (proportions expressed as percentages of SL, HL or SnL as indicated) for *Hippocampus denise*, *H. bargibanti*, and *H. minotaur*

	Counts					Proportional Measurements												
	TrR	TaR	PF	DF	AF	SL	TrL:SL	TaL:SL	HL:SL	HD:HL	SnL:HL	SnD:SnL	OD:HL	PO:HL	CH:HL	TD9:SL	DL:SL	PL:SL
<i>H. denise</i> (n = 10)	12	28-29	10 [11]	14	0 [4]	16.2 (3.69)	28 (2.88)	54 (3.03)	19 (1.99)	49 (4.76)	31 (2.44)	75 (5.80)	21 (1.84)	42 (1.80)	44 (4.70)	9 (2.88)	8 (1.20)	5 (3.29)
<i>H. bargibanti</i> (n = 8)	12	31-32	10 [11]	14	0 [4]	24.4 (1.84)	28 (1.61)	56 (1.29)	17 (1.44)	66 (3.28)	22 (1.83)	100 (20.23)	18 (3.10)	57 (4.06)	57 (6.26)	13 (1.61)	8 (0.74)	3 (0.52)
<i>H. minotaur</i> (n = 1)	8	41	11	7	0	54.3	18	67	15	80	24	78	16	49	56	15	1	2
t-tests		***					*	***	***	***	***	**	***	***		*		

Values shown are mean values (standard deviation in parentheses), except for *H. minotaur* where only a single specimen was examined. Asterisks indicate significant differences in comparisons between *H. denise* and *H. bargibanti* (two-tailed t-test, * p < 0.05, ** p < 0.01, *** p < 0.001).

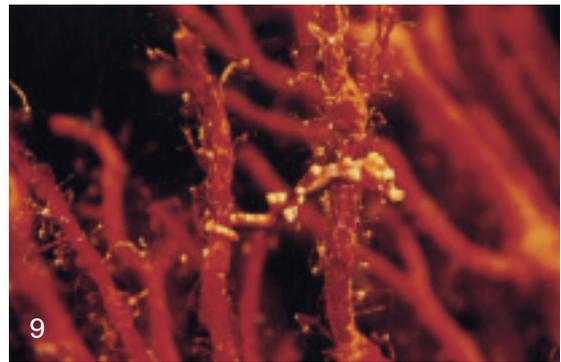
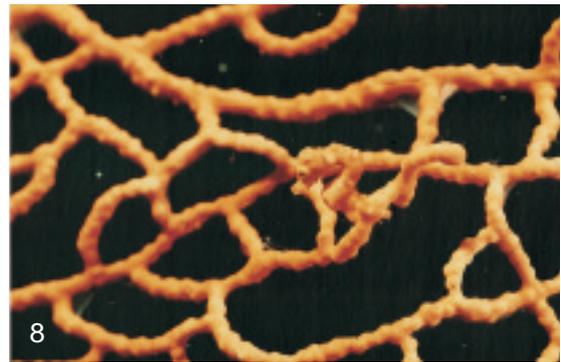
but the degree of development is much greater (with significant bony supports as seen on a radiograph) in *H. bargibanti*. In comparison to *H. denise*, *H. bargibanti* has a number of additional tubercles on its ventral trunk region. The species are further differentiated by the number of tail rings (28-29 in *H. denise*, 31-32 in *H. bargibanti*).

Hippocampus denise, like *H. bargibanti* is easily differentiated from *H. minotaur* by differences in tail ring and fin ray counts (Table 1), as well as in the shape of the head and neck, both of which are very large in *H. minotaur* but more delicate in *H. denise* (Fig. 11).

Description: *Hippocampus denise* is a small, relatively delicate seahorse species compared with *H. bargibanti* (Table 1), and unlike *H. bargibanti*, shows significant external shape differences between the 2 sexes (Figs. 2, 4-10). Proportional measurements (expressed as percentages of SL, HL or SnL as indicated) for the holotype are reported below, with variations across all specimens examined ($n = 10$) shown in parentheses. Head length 16.0% (16.0%-21.4%) in SL; head shallow in comparison with *H. bargibanti*, depth 50.4% (47.9%-57.2%) in HL; snout of medium length

29.8% (27.1%-35.6%) in HL without bulbous tip; snout depth 71.9% (62.7%-81.2%) in SnL; orbital diameter 18.8% (18.8%-23.5%) in HL; postorbital length 45.2% (39.1%-45.2%) in HL; no tubercles or spines present above eye or along midline of snout; nuchal plate low and rounded without prominent raised coronet; pectoral-fin base strongly raised; pectoral-fin rays 11 (10-11).

Trunk rings 12; trunk length 28.7% (23.1%-31.7%) in SL; trunk depth just anterior to the dorsal-fin base 6.5% (6.5%-15.5%) in SL; dorsal-fin base strongly raised and angled with respect to the trunk (highest posteriorly); dorsal-fin base starting



Figs. 6-10. Specimens of *Hippocampus denise* found on a variety of gorgonian host species. **Fig. 6.** ♀? paratype of *Hippocampus denise*, Palau. USNM 368872. Photo: P. Colin. **Fig. 7.** ♂ *Hippocampus denise*, Wakatobi, Indonesia. Photo: P. Hardt. **Fig. 8.** ♀ *Hippocampus denise*, Wakatobi, Indonesia. Photo: P. Hardt. **Fig. 9.** ♀ *Hippocampus denise*, Lembah Strait, Sulawesi, Indonesia. Photo: J. Randall. **Fig. 10.** ♂ *Hippocampus denise*. Tulamben, Bali, Indonesia. Photo: A. Ogawa.

immediately anterior to the 10th trunk ring, and ending immediately posterior to the 12th trunk ring (covering 3+0 rings); dorsal-fin rays 14; in males, developing embryos are housed entirely within the trunk region anterior to the anus; pouch slit (in male only) barely visible, elongate, on the midventral line between the 11th and 12th trunk rings; female urinogenital opening round and slightly raised, on the midventral line between the 11th and 12th trunk rings; anal fin not visible in holotype, but present in 2 paratypes (anal fin rays 4); first tail ring quadrangular; tail rings 28 (28-29); tail length 55.6% (47.9%-57.2%) in SL.

Body ornamentation: tubercles developed to varying degrees (least developed in type specimens and most developed, into rounded blunt spines, in some specimens known only from photographs) on the angles of the superior ridge of the 1st and 5th trunk rings, the lateral ridge of the 8th trunk ring, and the superior and inferior ridges of the 12th trunk ring; dermal filaments absent; inferior and ventral trunk ridges much reduced (especially in males) to a series of disconnected, star-shaped ossifications embedded in the skin; lateral trunk ridge similarly reduced in males, but more or less entire in females; posterior 2 trunk rings more completely ossified; female trunk elongate, that of the male more rounded.

Color in life plain orange with slightly darker rings around tail; color in ethanol pale orange with tiny dark brown flecks of pigment on the nape of the neck, and all over in some specimens.

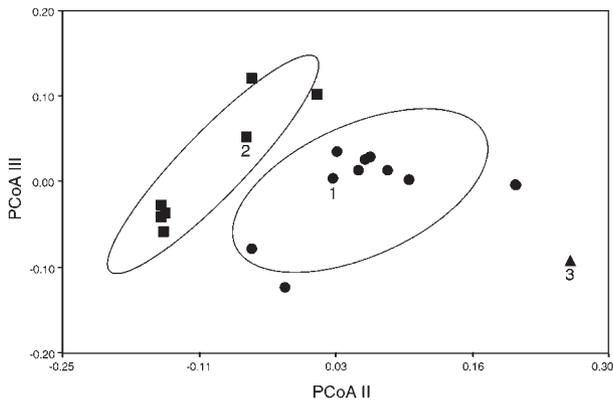


Fig. 11. Ordination plot using the 2nd and 3rd axes of a principal coordinate analysis based upon 15 morphometric and 5 meristic variables (see Fig. 1 for list of variables) combined using Gower’s index of similarity. Circles represent specimens of *Hippocampus denise*, squares are *H. bargibanti*, and the triangle is *H. minotaur*. Numbers represent positions of the holotype/lectotype specimens (1 = *H. denise*, 2 = *H. bargibanti*, 3 = *H. minotaur*) 95% ellipses shown.

Etymology: This species is named in honor of Denise Tackett (*denise* as a noun in apposition). Denise first brought this species to the notice of the authors on separate occasions, and has spent hundreds of hours underwater observing the behavior of pygmy seahorses, primarily *Hippocampus bargibanti*. The name “Denise” also means “follower of Dionysus, the Greek god of wine; wild, frenzied”. In comparison to *H. bargibanti* this new species is indeed more active.

Distribution and Ecology: *Hippocampus denise* appears to be relatively widespread in the West Pacific (Fig. 12). Specimens have been collected from Banta I., Nusa Tenggara, Indonesia, as well as from Vanuatu and Palau (Fig. 6). Photographs that can be confidently identified as this species suggest that it is also found in Derawan, E. Kalimantan, Indonesia (J. Adam 1999 in litt.); the Karimunjawa Islands, Java, Indonesia (05°48.65'S 110°30.45'E), 13 m depth, (S. Lourie 2001 pers. obs.); Wakatobi National Park, Tukang Besi Islands, Sulawesi Indonesia (P. Hardt 2001 in litt.) (Figs. 7, 8); Lembah Strait, N. Sulawesi, Indonesia (D. Tackett 1999 in litt., C. Petrinis 2001, JR pers. obs.) (Fig. 9); Tulamben, Bali (A. Ogawa 2000 in litt.) (Fig. 10); Mabul, Malaysia (Yoshi 2000 in litt.); the Solomon Islands (M. Gibbs

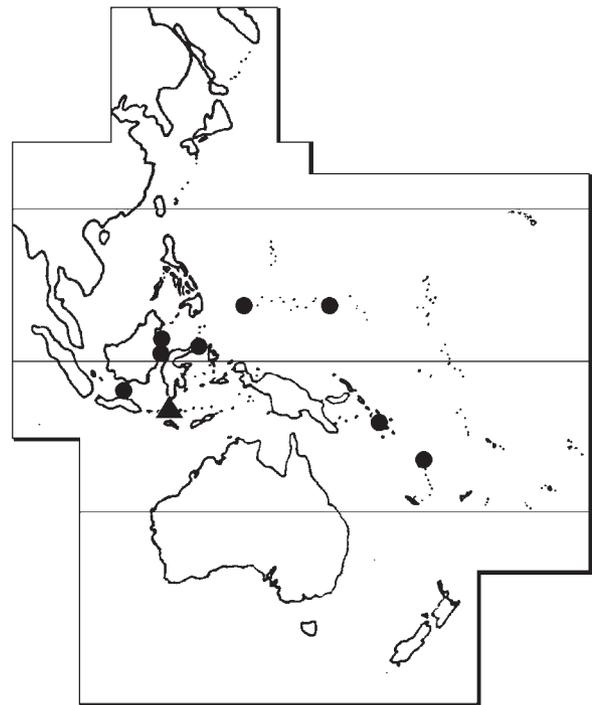


Fig. 12. Known distribution of *Hippocampus denise*. Holotype location indicated by triangle.

2000 in litt., B. Carlson 2000 in litt.); and Pohn Pei, Micronesia (L. Bell-Colin 2003 in litt.).

Like *H. bargibanti*, *H. denise* lives on gorgonian sea fans. It has been found on specimens of *Annella reticulata*, *Muricella*, and ?*Echinogorgia* (Figs. 6-10). By contrast, *H. bargibanti* seems to be more host-specific, and has only been found on 2 species of *Muricella* (*M. plectana*, and *M. paraplectana*).

Two specimens (MZB 10921 and USNM 370526) were pregnant. The former had approximately 16 large (presumably fertilized) eggs within its body cavity, the latter had 4 partially developed embryos. Sexual maturity must therefore occur at less than 13.3 mm SL. Nothing is known about the sexual cycle or reproductive behavior of this species, although pregnant specimens have been found in the months of Feb., May, and Oct. (latter from a photograph), suggesting that breeding may occur year-round.

In general *H. denise* is more active than *H. bargibanti*, and can often be seen during daytime observations swimming across the surface of the seafan on which it lives (D. Tackett pers. comm., SL pers. obs., JR pers. obs.).

DISCUSSION

Hippocampus denise is the smallest seahorse described to date, and, matures at one of the smallest sizes (less than 13.3 mm SL) among teleost fishes (*Trimmatom nanus* Winterbottom and Emery, 1981 currently holds the record at 10 mm SL). It appears most similar to *H. bargibanti*, and we propose that the 2 are sister species. In comparison to other species in the genus, these 2 have the fewest tail rings, and an identical, low number of fin rays. We suggest that these characters, in addition to the placement of their eggs/developing young are indicative of a common ancestry.

In all syngnathids, it is the male who broods the young. In most seahorse species, this takes place in a fully enclosed pouch that is located on the ventral side of the tail. In *H. denise*, as in *H. bargibanti*, there does not appear to be a separate pouch structure, but instead the eggs/developing embryos are housed entirely within the trunk region. In *H. minotaur* the eggs/developing embryos occupy a pouch that is on the tail, but is pushed anteriorly such that its origin appears level with the penultimate trunk ring (Gomon 1997). The placement of eggs/developing young has

been used as a crucial division within the Syngnathidae: in species of Gastrophori they are located on the trunk region, and in species of Urophori they are on the tail (Duncker 1915). In *H. bargibanti* and *H. denise*, although the eggs/developing young are enclosed within the trunk region, the entrance to the brooding cavity is via a single post-anal slit as seen in other species of seahorse such as *H. zosterae* Jordan and Gilbert, 1882. Brooding the young within the trunk region may be a modification related to the small size of these pygmy seahorses. Based on molecular evidence, seahorses are believed to have been derived from a common ancestor with *Syngnathus*, a pipefish genus within the Urophori with an "inverted" pouch type (Wilson et al. 2001). If seahorses are monophyletic (as we believe they are) this would mean that *H. bargibanti* and *H. denise* must have secondarily acquired the trunk-brooding habit. It is unlikely that *H. minotaur* was an intermediary in this process, even though it appears to be tail-brooding, as it is more extreme in its differences with respect to the majority of seahorse species (e.g., in the trunk and tail ring, and fin ray counts) than are *H. bargibanti* and *H. denise*.

Differences in the development of body ornamentation and tubercles between *H. denise* and *H. bargibanti* may reflect the gorgonian hosts on which the 2 species are found: the orange sea fan on which the type specimens of *H. denise* were found, was relatively smooth in appearance. Tackett and Tackett (1997) noted that in general, the fans on which *H. denise* occur, rarely have their polyps open during the day, whereas those on which *H. bargibanti* are often found (*Muricella* sp.) have large, bulbous polyps which are commonly open during the day. The color of the 2 species also reflects that of their hosts: plain orange, or orange with dark flecks for *H. denise*, and for *H. bargibanti* striated gray, with orange/yellow tubercles for specimens on *M. paraplectana* (as the holotype), or red/pink tubercles when on *M. plectana*. *Hippocampus bargibanti* also has a striped tail and circular markings on the dorsolateral surfaces of the tail. It is unknown whether individuals can change color or change the development of their tubercles if they change hosts. Photographs and the paratype specimens of *H. denise* suggest that this species can utilize at least 3 different gorgonian host species (Figs. 6-10). Some other seahorse species are able to change color to match their surroundings (e.g. *H. whitei*, Vincent and Sadler 1995).

Kuiter (2000) has argued that specimens of

H. denise represent young of *H. bargibanti*. The discovery of pregnant *H. denise* specimens clearly refutes this idea. Further evidence comes from observations of young *H. bargibanti*. Newborns are about 2 mm in height with fully formed fins and ossified trunk and tail rings. The tail-ring counts from 3 such specimens are consistent with *H. bargibanti* and not with *H. denise* (S. Lourie, unpubl. data). Juvenile *H. bargibanti* have also been seen (in the wild, S. Lourie pers. obs., and in photographs, J. Adam 2000, R. Kuitert 2000) and these show the distinctive enlarged tubercle development, bulbous snout tip and constriction in the snout, as well as the striped tail and circles on the dorsolateral surfaces of the tail. We conclude that *H. denise* is closely related to, but clearly a distinct species from, *H. bargibanti*.

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REFERENCES

- Casgrain P, P Legendre. 2001. The R package for multivariate and spatial analysis, vers. 4.0 d5 - user's manual. Departement de Sciences Biologiques, Université de Montréal. Available from <<http://www.fas.umontreal.ca/BIOL/legendre/>>.
- Duncker G. 1915. Revision der Syngnathidae. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten **32**: 9-120.
- Gomon MF. 1997. A remarkable new pygmy seahorse (Syngnathidae: *Hippocampus*) from south-eastern Australia, with a redescription of *H. bargibanti* Whitley from New Caledonia. Mem. Mus. Victoria **56(1)**: 245-253.
- Gower JC. 1966. Some distance properties of latent root and vector methods used in multivariate analysis. Biometrika **53**: 325-338.
- Gower JC. 1971. A general coefficient of similarity and some of its properties. Biometrics **27**: 857-872.
- Jordan DS, CH Gilbert. 1882. Notes on fishes observed about Pensacola, Florida and Galveston, Texas with description of new species. Proc. US Nat. Mus. **56**: 265-266.
- Kuitert RH. 2000. Seahorses, pipefishes and their relatives. Chorleywood, UK: TMC Publishing.
- Lourie SA, JC Pritchard, SP Casey, TS Ky, ACJ Vincent. 1999a. The taxonomy of Vietnam's exploited seahorses. Biol. J. Linn. Soc. **66(2)**: 231-256.
- Lourie SA, ACJ Vincent, HJ Hall. 1999b. Seahorses: an identification guide to the world's species and their conservation. London: Project Seahorse.
- Petrinis C. 2001. Realm of the pygmy seahorse: an underwater photography adventure. Athens: Starfish Press.
- Tackett D, L Tackett. 1997. Pygmy seahorse. Asian Diver. **Oct./Nov.**: 61-63.
- Vari R. 1982. Fishes of the western north Atlantic, subfamily Hippocampinae. The seahorses. Sears Foundat. Mar. Res. Mem. (Yale Univ.) **1(8)**: 173-189.
- Vincent ACJ, LM Sadler. 1995. Faithful pair bonds in wild seahorses, *Hippocampus whitei*. Anim. Behav. **50**: 1557-1569.
- Whitley GP. 1970. Abstract of the proceedings. Ordinary general meeting. 26th November, 1969. Proc. Linnaean Soc. New South Wales **94**: 292-295
- Wilson AB, A Vincent, I Ahnesjö, A Meyer. 2001. Male pregnancy in seahorses and pipefishes (family Syngnathidae): rapid diversification of the paternal brood pouch inferred from a molecular phylogeny. J. Hered. **92**: 159-166.
- Winterbottom R, AR Emery. 1981. *Trimmatom nanus* new genus, new species and *Trimmatom offucius* new species, of gobiid fishes (Perciformes) from the Chagos Archipelago, central Indian Ocean. Environ. Biol. Fish. **62**: 139-149.