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Occurrence and habitat association of *Hippocampus kuda* Bleeker, 1852 in the artificial waterways of Kuwait, northwestern Arabian Gulf

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Abstract

Seahorses occurring in the Arabian Gulf remain incompletely documented despite extensive coastal modification and extreme physicochemical conditions. The yellow seahorse, *Hippocampus kuda* Bleeker, 1852, has recently been genetically confirmed from Kuwaiti waters, establishing species identity in the region (Bishop *et al.* 2024). However, specimen-linked records integrating habitat context, morphology, and archived genetic reference sequences remain limited for engineered coastal systems. Opportunistic underwater visual surveys conducted between 2012 and 2015 within the artificial waterways of Sabah Al-Ahmad Sea City (SAASC), Al-Khiran, southern Kuwait, documented three *H. kuda* individuals in naturally colonized shallow subtidal seagrass meadows at approximately 3 m depth. Individuals were observed clinging to leaf blades in a meadow dominated by *Halodule uninervis* with small patches of *Halophila ovalis* at 28°39'3.59"N, 48°22'55.74"E. Salinity was recorded in situ using a YSI 556 Multi-Probe System, and specimens were photographed alive prior to preservation. Morphometric and meristic data are presented for vouchered specimens, including ring counts, fin-ray counts, species-level indices, and proportional measurements (Tables 1–2). Partial cytochrome oxidase subunit I (COI) sequences are reported as archival genetic references linked to documented individuals and habitat observations rather than as analytical evidence (Supplementary File 1). This contribution documents the occurrence and habitat association of *H. kuda* within seagrass colonising an engineered coastal environment of the northwestern Arabian Gulf.

Key words: Syngnathidae; seahorse; artificial waterways; seagrass; *Halodule uninervis*; Arabian Gulf

Introduction

Seahorses (Syngnathidae) represent a morphologically specialised lineage of marine teleosts whose distributional records and habitat associations remain unevenly documented across the Indo-Pacific (Lourie *et al.* 2016). In environmentally marginal seas, the scarcity of specimen-linked field records and the limited availability of standardised baseline datasets constrain ecological inference and impede the development of regionally relevant faunistic syntheses.

The Arabian Gulf is a young, shallow, semi-enclosed sea with an average maximum depth of approximately 30 m (Sheppard *et al.* 2010). It is characterized by arid climatic conditions, seasonal sea surface temperatures

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reaching approximately 35 °C, and salinity reported to range from 42 to 60 ppt (Sheppard *et al.* 2010). Extensive coastal modification driven by rapid economic development has resulted in widespread dredging, infilling, and the construction of artificial waterways, contributing to the transformation of natural nearshore habitats (Sheppard *et al.* 2010). Kuwait's coastline encompasses mudflats, sandy beaches, rocky shores, seagrass meadows, and coral reef patches, with engineered coastal systems forming an increasingly dominant component of the seascape (Al-Yamani 2021). Seahorses have been reported intermittently from Arabian Gulf countries through ichthyofaunal surveys and checklists (e.g., Basson *et al.* 1977; Bishop 2003; Jawad *et al.* 2018; Bishop *et al.* 2026). Within this regional context, *Hippocampus kuda* Bleeker, 1852 has historically been recorded from Kuwait and adjacent Gulf waters (Kuronuma & Abe 1986). A recent peer-reviewed account incorporating molecular data, including cytochrome oxidase subunit I (COI), has established the occurrence and genetic identity of *H. kuda* in Kuwaiti waters (Bishop *et al.* 2024). Species identity is therefore treated as established in the present contribution and is not reassessed.

Despite this progress, specimen-linked documentation integrating habitat context, environmental parameters, and detailed morphology remains limited for Kuwait, particularly within engineered coastal environments (Stanton *et al.* 2021). Artificial waterways now constitute a substantial proportion of Kuwait's nearshore habitats, yet their role as habitat for structurally associated fishes such as seahorses remains incompletely characterised (Jones *et al.* 2012). Seagrasses and coral reefs are widely recognised as favourable habitats for seahorses (Murugan *et al.* 2008), but records of seahorses associated with seagrass colonising artificial waterways remain scarce.

The present study documents the occurrence and habitat association of *Hippocampus kuda* within seagrass habitats colonising artificial waterways at Sabah Al-Ahmad Sea City (SAASC), Al-Khiran, southern Kuwait. The study integrates specimen-linked morphometric and meristic data, species-level indices, environmental measurements recorded in situ, photographic documentation of live individuals, and archived COI sequences deposited as genetic reference material. No type material is designated in the present study.

Materials and Methods

Study area and survey design

Underwater visual surveys were conducted between 2012 and 2015 within naturally colonised seagrass meadows in the artificial waterways of Sabah Al-Ahmad Sea City (SAASC), Al-Khiran, southern Kuwait. Surveys were undertaken by SCUBA diving at approximately 3 m depth during summer months (June–September) and winter (December), following standard survey approaches previously applied in the region (PERSGA/GEF 2004).

Seahorses were observed in a subtidal seagrass meadow located at 28°39'3.59"N, 48°22'55.74"E, dominated by *Halodule uninervis* with small patches of *Halophila ovalis*. Individuals were observed clinging to seagrass leaf blades.

Environmental measurements

Salinity (ppt) was recorded in situ using a YSI 556 Multi-Probe System. Salinity at the observation site measured 42 ppt.

Specimen collection, documentation, and preservation

Three individuals were encountered alive across the study period and collected manually using 1 L zip-lock bags containing ambient seawater. Specimens were temporarily maintained in an 80 L all-glass aquarium supplied with filtered seawater and aeration. Temperature was maintained at 25 °C using a thermostat-controlled heater (Eheim), and salinity was maintained at 42 ppt. Live individuals were photographed using a Panasonic LUMIX TZ5 digital camera fitted with a waterproof housing. Specimens were subsequently preserved in molecular-grade ethanol.

Morphometric and meristic data

Morphometric and meristic data were recorded from live and preserved specimens following standardised seahorse measurement protocols (Lourie *et al.* 2004). Counts included trunk rings, tail rings, dorsal-fin rays, and pectoral-fin rays. Species-level indices recorded included spininess index, coronet index, keel index, and chin shape index.

Genetic reference data

Fin clips (anal fin) were obtained from the tail of each specimen following Woodall *et al.* (2011). DNA was extracted using DNeasy Blood and Tissue Kits (Qiagen). A partial fragment (~630 bp) of the mitochondrial COI gene was amplified using primers COX-F and COX-R (Ward *et al.* 2005) and sequenced on an ABI 3500 DNA analyser. Sequence quality was assessed in FinchTV, homology examined using BLAST (Altschul *et al.* 1990), and alignments generated using MUSCLE (Edgar 2004). COI sequences are treated here as archival genetic reference material rather than as analytical evidence.

Specimen deposition

All examined specimens are preserved in molecular-grade ethanol and are deposited in the reference collection of the Kuwait Institute for Scientific Research (KISR), Kuwait. Voucher material is available for examination upon request.

Results

Material examined

Kuwait: Al-Khiran, Sabah Al-Ahmad Sea City (28°39'3.59"N, 48°22'55.74"E), artificial waterway with *Halodule uninervis* seagrass, ca. 3 m depth; 1 specimen, 27 June 2012; 1 specimen, 6 September 2015; 1 specimen, 26 December 2012; collected by SCUBA, preserved in ethanol; GenBank accessions OQ776910–OQ776912.

Field observations and habitat association

Three *Hippocampus kuda* individuals were documented between 2012 and 2015 within shallow subtidal seagrass colonising artificial waterways at SAASC. Observations were made at approximately 3 m depth in dense *Halodule uninervis* with small patches *of Halophila ovalis*. Individuals were observed clinging to seagrass leaf blades. Salinity recorded at the site was 42 ppt.

Morphometrics, meristics, and indices

Trunk rings 11; tail rings 35–36; dorsal-fin rays 16–17; pectoral-fin rays 13–14. Specimens ranged from 62.7 to 103.4 mm standard length (SL). Trunk length measured 22.7–29.4% SL, tail length 53.4–59.8% SL, and head length 15.9–18.9% SL. Snout length was 40.7–41.1% of head length and snout depth 27.8–30.9% of snout length. Coronet height measured 34.9–45.9% of head length. Trunk depth increased from 6.0–6.7% SL at the fourth to fifth trunk ring to 8.3–8.8% SL at the ninth to tenth trunk ring. Trunk width relative to lateral ridge spine distance measured 69.1% (Tables 1–2).

Spininess index 1; coronet index 1; keel index 2; chin shape index 2. Trunk and tail spines reduced to minute tubercles or absent. All individuals lacked a brood pouch and exhibited sub-adult morphology. These characters conform to the diagnosis of *H. kuda* provided by Lourie *et al.* (2016).

Photographic documentation

Live individuals maintained in aquaria displayed yellow to greenish colouration consistent with seagrass camouflage (Figure 1a, c). Preserved specimens retained diagnostic features including reduced coronet and minimal spinulation (Figure 1b, d).

Genetic reference sequences

COI sequences (OQ776910–OQ776912) exhibited 99.39–99.85% identity with published *Hippocampus kuda* sequences from the Arabian Gulf (e.g., KU236029; see Supplementary File 1 for accession list). These sequences are provided as archival genetic references linked to documented specimens and habitat context (Rabaoui *et al.* 2019).

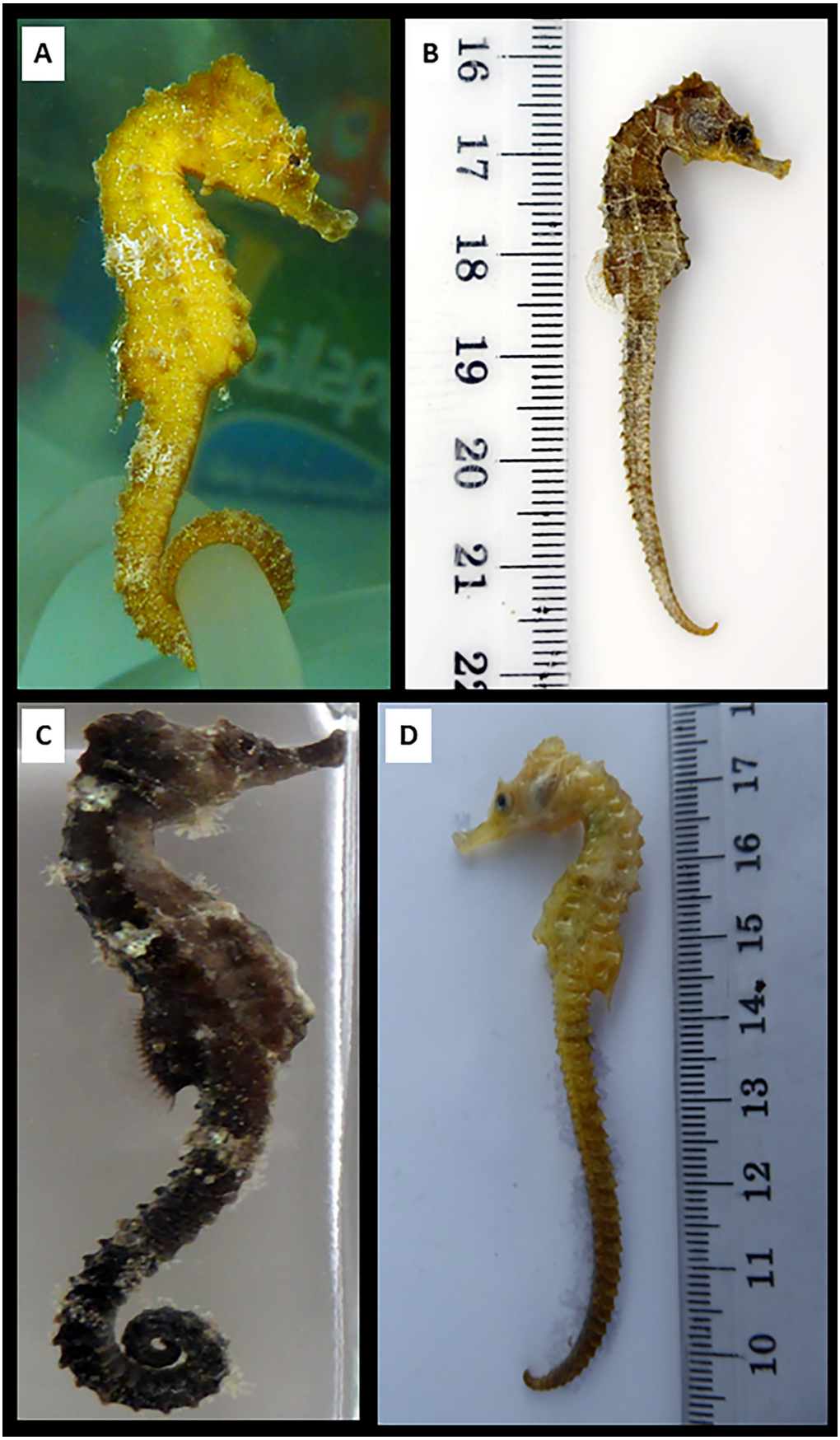

FIGURE 1. *Hippocampus kuda* Bleeker, 1852 collected from Sabah Al-Ahmad Sea City (SAASC), Al-Khiran, Kuwait. a. live individual maintained in an aquarium (27 June 2012); b. preserved juvenile, SL: 62.7 mm (27 June 2012); c. live individual in an aquarium (6 September 2015); d. preserved juvenile, SL: 97.9 mm (6 September 2015).

TABLE 1. Morphometric characteristics (mm ± SD) of the *Hippocampus kuda* specimens collected from Kuwaiti waters.

Morphometric character	Present study (n = 3)	Charles *et al.* 2024 (n = 1)
Standard Length (SL)	103.4 ± 18.05	105.2
Trunk Length	22.73 ± 7.86	29.40
Tail Length	53.39 ± 7.96	53.60
Head Length	15.91 ± 2.18	17.00
Head Depth (HD)	8.23 ± 0.07	17.00
Snout Length (SnL)	6.56 ± 1.38	-
Snout Depth (SnD)	1.98 ± 0.14	-
Coronet Height (CH)	7.35 ± 1.65	-
Trunk Depth at 4th and 5th ring (TD4)	6.0 ± 1.33	6.70
Trunk Depth between 9th and 10th trunk rings (TD9)	8.31 ± 1.50	8.80
Trunk width between 9th and 10th trunk rings (TW)	2.71 ± 0.34	-
Distance between the 9th trunk ring lateral ridge spine tips (SpW)	3.93 ± 0.47	-
Dorsal Fin base Length (DL)	5.94 ± 0.67	-
Pectoral fin base length (PL)	3.39 ± 0.67	-

TABLE 2. Relative values of individual morphometric characters (mean ± SD) as a percentage for *Hippocampus kuda* collected from Kuwait in comparison with a record from Red Sea, Saudi Arabia (Charles *et al.* 2024).

Morphometric character	Present study (n = 3)	Charles *et al.* 2024 (n = 1)
Trunk Length (TrL) (% SL)	24.81 ± 4.47	29.40
Tail Length (TaL) (% SL)	59.75 ± 6.63	53.60
Head Length (HL) (% SL)	17.88 ± 2.60	17.00
Head Depth (HD) (% HL)	55.63 ± 1.20	53.97
Snout Length (SnL) (% HL)	41.06 ± 4.74	40.74
Snout Depth (SnD) (% SnL)	30.93 ± 5.27	27.79
Trunk Width (TW) (% SpW)	69.13 ± 4.07	-
Trunk Depth at 4th and 5th ring (TD4) (% SL)	6.65 ± 0.57	6.70
Dorsal Fin base Length (DL) (% TrL)	11.51 ± 0.34	-
Pectoral fin base length (PL) (% HD)	38.63 ± 4.86	-
Coronet Height (CH) (% HL)	45.87 ± 8.32	34.92

Discussion

Occurrence in engineered seagrass habitats

The present records document *Hippocampus kuda* associated with seagrass colonising artificial waterways at SAASC, Al-Khiran. Observations were restricted to shallow subtidal habitats at approximately 3 m depth, with individuals clinging to *Halodule uninervis* leaf blades. The engineered nature of these waterways is central to the ecological context of the records, as artificial coastal systems represent an increasingly dominant component of Kuwait's nearshore environment (Jones *et al.* 2012). Seagrass colonisation in such systems may provide structural complexity analogous to natural meadows, supporting habitat-associated species despite anthropogenic origins (Erftemeijer & Shuail 2012).

Environmental context and limits of inference

Observations were made under elevated salinity conditions (42 ppt) consistent with the Arabian Gulf (Sheppard *et al.* 2010), with individuals recorded during both summer and winter periods. Seasonal persistence at the site aligns with known environmental tolerances of *H. kuda* in marginal habitats (Lourie *et al.* 2016), though no quantitative

physiological data were collected. Although individuals were recorded across multiple years and seasons, the opportunistic survey design and limited number of specimens (n=3) preclude inference regarding abundance, density, or persistence. Interpretation is therefore restricted to documented occurrence and habitat association, with no broader population-level claims warranted.

Regional comparison

Within the Arabian Gulf, *Hippocampus kuda* is distinguishable from *H. trimaculatus* by its reduced coronet (index 1 vs. more developed), lower trunk depth (6.0–8.8% SL vs. higher), and higher tail-ring counts (35–36 vs. 32–34) (Bishop *et al.* 2024). It differs from *H. kelloggi* by its smaller body size (SL <110 mm vs. >150 mm in adults), less robust trunk, and differing fin-ray counts (dorsal-fin rays 16–17 vs. 18–20) (Lourie *et al.* 2016). The combination of meristic values (trunk rings 11; tail rings 35–36), reduced coronet development, and minimal trunk spinulation observed in the present material is consistent with published diagnoses of *H. kuda* (Lourie *et al.* 2016). These distinctions facilitate regional faunistic differentiation without requiring molecular reassessment.

Conservation context

Syngnathid fishes in the Arabian Gulf remain characterised by limited baseline datasets, and no population metrics or trend estimates are currently available for *Hippocampus kuda* in Kuwaiti waters (Stanton *et al.* 2021). No directed fisheries or documented trade records for seahorses have been reported from Kuwait (Stanton *et al.* 2021), and all observations in the present study were derived exclusively from diver-based surveys rather than fisheries bycatch. Standardised surveys incorporating repeated sampling and quantitative effort will be required before assessment at a regional scale can be undertaken (Vincent *et al.* 2011).

Conclusions

Three *H. kuda* individuals were documented between 2012 and 2015 in shallow subtidal seagrass at approximately 3 m depth within the artificial waterways of Sabah Al-Ahmad Sea City, Al-Khiran, southern Kuwait. Observations were associated with *Halodule uninervis*-dominated seagrass containing small patches of *Halophila ovalis* at salinity 42 ppt. Specimen-linked morphometric and meristic data, species-level indices, photographic documentation, and archived COI reference sequences (OQ776910–OQ776912) provide a documented occurrence record of *H. kuda* associated with seagrass colonising an engineered coastal environment of the northwestern Arabian Gulf.

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Supplementary Materials. The following supporting information can be downloaded at the DOI landing page of this paper:

Table S1. List of GenBank accession numbers of COI sequences used for comparison (NA = data not available).