

NOTE

## First record of ornate ghost pipefish *Solenostomus paradoxus* from mainland India

DIANA BENJAMIN<sup>1, \*</sup>, SIJO P. VARGHESE<sup>1</sup>, JACOB THOMAS<sup>1</sup>, GIFTSON P. C.<sup>1</sup>, SOLLY SOLOMON<sup>1</sup> and R. JEYABASKARAN<sup>2</sup>

<sup>1</sup>Fishery Survey of India, Cochin Zonal Base, Kochi, Kerala, India. <sup>2</sup>Fishery Survey of India, Mumbai Base, India



**ABSTRACT.** This study documents the first occurrence of a female ornate ghost pipefish, *Solenostomus paradoxus* (Pallas, 1770) from mainland India, collected at a depth of 40 m in the Arabian Sea. It provides the first detailed description of morphometric and meristic characteristics of this species from this region. Due to their small size, effective camouflage, and specific habitat needs, ornate ghost pipefish are challenging to study, and their solitary, seasonal behaviors further complicate research. This work adds valuable knowledge to the limited understanding of this elusive species and highlights the need for further exploration of underrepresented marine biodiversity.

**Key words:** False pipefish, stellate ossification, supraoccipital ridge, spinules, brood pouch, cryptic camouflage.

### Primer registro del pez pipa fantasma arlequín *Solenostomus paradoxus* en la India

**RESUMEN.** Este estudio documenta la primera aparición de una hembra de pez pipa fantasma arlequín, *Solenostomus paradoxus* (Pallas, 1770) en la India, capturada a una profundidad de 40 m en el mar Árabe. Proporciona además la primera descripción detallada de las características morfológicas y merísticas de esta especie en esta región. Debido a su pequeño tamaño, su camuflaje efectivo y sus necesidades específicas de hábitat, los peces pipa fantasma arlequines son difíciles de estudiar, y sus comportamientos solitarios y estacionales complican aún más la investigación. Este trabajo agrega conocimiento valioso a la comprensión limitada de esta especie esquiva y destaca la necesidad de una mayor exploración de la biodiversidad marina subrepresentada.

**Palabras clave:** Pez pipa falso, osificación estrellada, cresta supraoccipital, espinulas, bolsa de cría, camuflaje críptico.



\*Correspondence:  
dianabenjamin484@gmail.com

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Ghost pipefishes are an intriguing marine fish group recognized for their mysterious and well-camouflaged appearance. They belong to the superfamily Syngnathidae and family Solenostomidae consisting of a singular genus, *Solenostomus*. While closely related to seahorses, seadragons, and pipefishes within the order Syngnathiformes, ghost pipefishes distinguish themselves in their unique morphology by possessing two dorsal fins rather than one (Jungersen 1910; Orr and Fritzsche 1993; Orr 1995; Orr et al. 2002; Nelson 2006; Nelson et al. 2016). Their appearance is also characterized by a more elongated and slender body, deviating from the horse-like structure seen in seahorses. Ghost pipefishes exhibit an upright posture and a prehensile tail.

The distinctive brooding technique employed by ghost pipefishes stands out as a notable feature in their reproductive behavior. Female ghost pipefishes exhibit enlarged pelvic fins that form a brood pouch when they fuse with the abdomen along the dorsal margin, connected ventrally by a membrane. This pouch allows them to lay eggs which are then fertilized by males. Hatched offsprings are planktonic, floating freely with water currents until they find a suitable reef to settle on. In contrast, males of syngnathids, particularly seahorses, typically take on the responsibility of tending to the eggs until they hatch. This unique reproductive method adds special interest to the intriguing characteristics of ghost pipefishes in their aquatic habitat (Playfair and Gunther 1866; Orr and Fritzsche 1993).

While solenostomids and syngnathids exhibit a similar external appearance, ghost pipefishes stand out by featuring a dermal skeleton adorned with numerous stellate plates arranged sequentially, extending even to the body's sides (Orr and Fritzsche 1993). There still is a lot of confusion about how many species of ghost pipefishes actually exist; however, at present, three species have been recognized under the genus namely *Solenostomus cyanopterus* (robust ghost pipefish), *S. paradoxus* (ornate ghost pipefish) and *S. armatus* (long-tailed ghost pipefish). *S. paradoxus* species mostly exhibits solitary behavior but occasionally is also found to move in pairs or small groups. Ghost pipefishes typically feed by hanging upside down and sucking small fishes and crustaceans, particularly mysid shrimps, through a specialized snout. Ghost pipefishes typically inhabit hosts that resemble a variety of gorgonians, corals, crinoids, hydroids, algae substrata, and seagrass beds in terms of their camouflage. It is fascinating to note that the ghost pipefish gets its name from its ability to blend in so well and disguise itself that it appears and vanishes like a 'ghost'

Systematic investigations into ghost pipefishes are scarce, primarily due to the limited availability of adequate specimens, given their adept cryptic camouflage, hindering in-depth analyses and other biological studies. While there have been some anatomical

and morphological studies on syngnathoid fishes (Jungersens 1908, 1910; Weber and Beaufort 1922), specific research on ghost pipefishes remains limited. This study was therefore initiated because every new piece of knowledge about this rare marine fish group is significant. Thus, this study presents the initial documentation of the ornate ghost pipefish, *S. paradoxus* from off Kerala coast of the mainland India.

Specifically, one female ghost pipefish specimen (FSI/MB/2023-23/1), 82 mm standard length (SL), was captured on 13 February 2022, during a bottom trawl survey on the MFV 'Matsya Varshini', operating under the Cochin base of the Fishery Survey of India. The specimen was collected at 40 m depth at 09° 52.9' N-75° 56.4' E (Figure 1). All morphometric measurements of the specimen were taken with a Mitutoyo digital Vernier caliper with an accuracy of 0.5 mm on the specimen preserved in formaldehyde. Morphometric values were expressed as a percentage of the standard length (SL), unless specified otherwise. Measurement methods and terminology of body plates followed Orr and Fritzsche (1993) and Nakabo (2002). Values and counts obtained from the study material were compared with those reported by (Bannikov and Carnevale 2017) (Table 1). Fourteen morphometric and eight meristic characters were registered as a part of the study. Vertebrae were counted from radiographs prepared by soft X-ray (Greenz Lifecare and diagnostics, India) and second dorsal, pectoral, and anal fin rays were counted by stereomicroscope after partial dissection. The examined specimen is deposited in the Fishery Survey of India, Cochin Base (FSI), India.

## Systematics

Order: Syngnathiformes

Family: Solenostomidae

Genus: *Solenostomus* Lacepede, 1803

Species: *Solenostomus paradoxus* Pallas, 1770

Synonyms: *Fistularia paradoxa* Pallas, 1770

Specimen examined: female, 112 mm TL, 1.65 g whole body weight

(Figures 2-4)

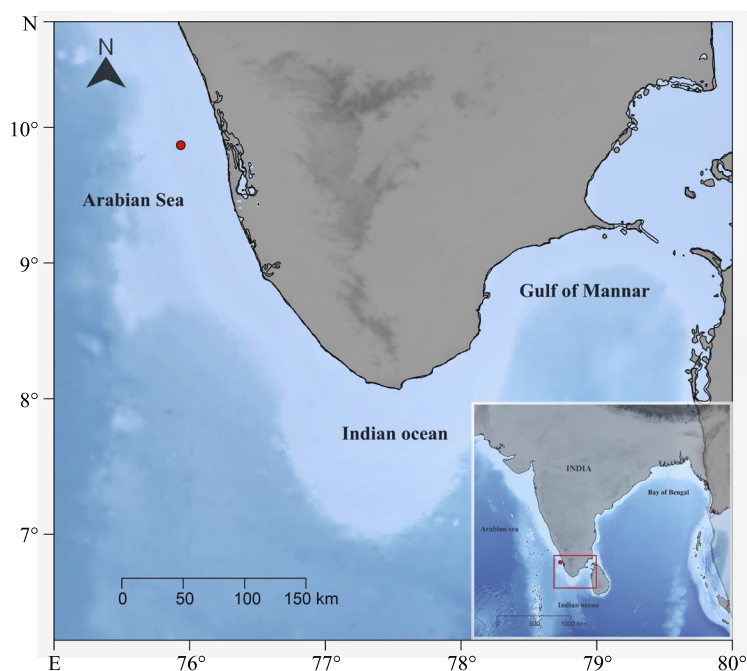


Figure 1. Map showing sampling site of *Solenostomus paradoxus* from mainland India indicated with a red dot.

### Diagnosis

Striped body with numerous scattered stellate ossifications from dorsal to pelvic fins, deeply incised caudal fin membranes. A prominent stellate ossification is seen just behind upper right side of the eye. Supraoccipital ridge present and is high with an anterodorsally directed dorsal spine. Trunk rings 14 (8 complete) (Figure 4 A), caudal peduncle rings 7 and 7 complete tail rings. Snout long and slender but lacking dorsoventral expansion, greatest snout depth 15.27% SL and least snout depth is 11.11% SL. Pelvic fin is convex and slightly extending posterior to origin of anal fin. Abdominal area profusely covered with numerous small spinules.

The body of the ornate ghost pipefish is covered with intricate striped patterns and distinct patchwork coloration, bony plates, and features pelvic fins and dorsal fin spines (Orr and Fritzsche 1993; Senou 2002), as observed in the specimen studied. Scattered stellate ossifications present just dorsal to pelvic fins, caudal peduncle narrow (8.54% SL),

snout long slender (Figure 4 B), small spinules present in the abdominal area, dorsal fin, pelvic fin and beyond. Snout depth is deeper than eye diameter. Body depth 17.07% SL; greatest snout depth 15.27% SL; least snout depth 11.11% SL; Supraoccipital ridge high with 6 spines with dorsal most spine directed anterodorsally. Orbit depth 8.33% SL; pre-trunk length 34.15% SL; trunk length 48.78% SL; caudal peduncle length 8.54% SL; caudal peduncle depth 3.65% SL; spinous dorsal fin length 28.05% SL; pelvic fin length 24.39% SL; caudal fin length 36.59% SL; mandible length 15.28% SL. Caudal fin is ovate in shape with membranes deeply incised. Posterior margin of pelvic fins convex. Spinous dorsal fin extending to the middle of the soft dorsal fin, Pelvic fin extending slightly posterior to origin of anal fin, posterior margin convex. Small isolated individual spines are dispersed along the outer margin of the entire body, beginning from the head region behind the eye and extending to the caudal peduncle, with consistent spacing between them. Simple cirri

Table 1. Counts and measurements of *Solenostomus paradoxus* specimen. SL: standard length.

	Orr et al. (2002)	Present study
Morphometrics (% SL)		
Head length (HL)	37.2-53.5	43.90
Snout length	25.8-38.6	30.49
Body depth	13.1-25.1	17.07
Pretrunk length	4.5-19.0	34.15
Trunk length	37.5-50.5	48.78
Caudal peduncle length	4.4-20.2	8.54
Caudal peduncle depth	2.3-8	3.65
Spinous dorsal-fin length	14.8-33.5	28.05
Pelvic-fin length	18.5-30.9	24.39
Caudal-fin length	15.9-35.1	36.59
Morphometrics (% HL)		
Mandible length	10.3-18.7	15.28
Greatest snout depth	7.4-16	15.27
Least snout depth	7.1-13.6	11.11
Orbit depth	8.3-14.4	8.33
Meristics		
Vertebrae	32-38	32
Dorsal fin rays	17-21	17
Anal fin rays	18-22	18
Total rings	31-35	35
Pretrunk rings	4 complete	4 complete
Trunk rings	11-14 (4-8 complete)	14 (8 complete)
Caudal peduncle rings	7-12	7
Tail rings	14-18 (5-11 complete)	7 complete

present on ventral snout ridges and on margins of spinous dorsal, pelvic and caudal fins. X-ray image allows detection of 32 vertebrae (Figure 3). Colour: semi-transparent with red, yellow, white striped markings, blotches and spots.

The ornate ghost pipefish, *S. paradoxus*, Sole-nostomidae (Pallas, 1770) is widely distributed in the Indian and western Pacific oceans from Red Sea and East Africa to Fiji, north to southern Japan, south to southeast Australia and New Caledonia

(Orr and Fritzsche 1993). This species was also recorded in Tonga (Orr et al. 2002). *Solenostomus paradoxus* was also surveyed from Andaman and Nicobar waters along with *S. cyanopterus* (Rajan et al. 2018). However, in the present study it was reported for the first time from mainland India with detailed description and photographic evidence.

The ornate ghost pipefish resides in a variety of habitats, ranging from coral reefs to seagrass beds (Orr and Fritzsche 1993). In the present study, it



Figure 2. Lateral view of ornate ghost pipefish *Solenostomus paradoxus*.

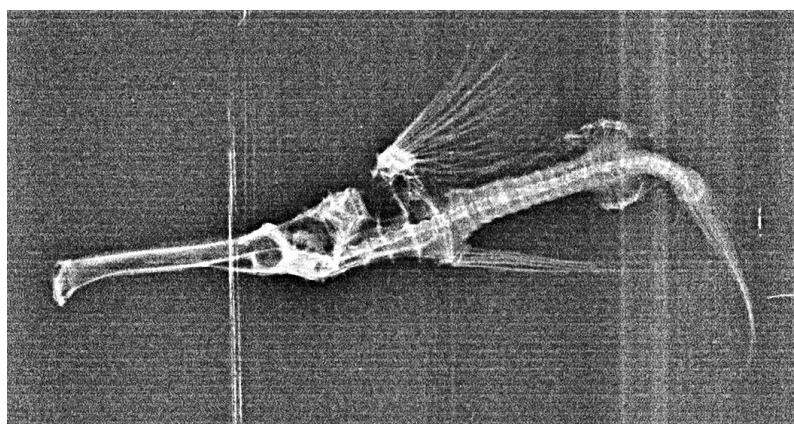


Figure 3. X-ray image of ornate ghost pipefish *Solenostomus paradoxus*.

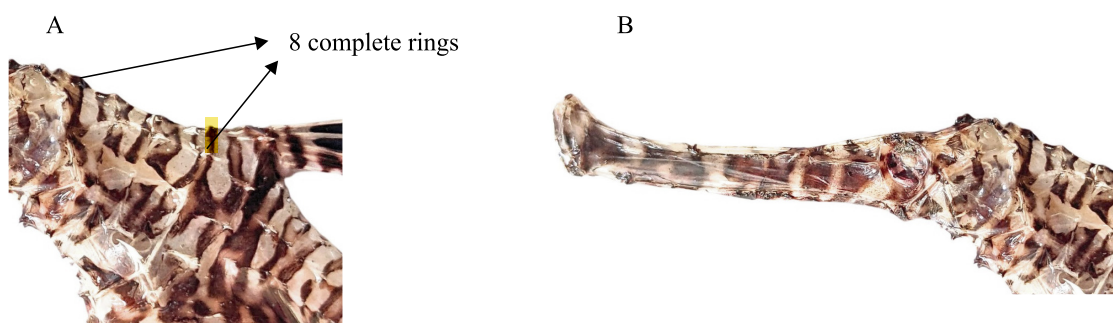


Figure 4. *Solenostomus paradoxus*: eight complete rings in trunk region (A); elongated slender snout of (B).

was also observed in the coral reef area from a shallow depth of 40 m in mainland India. Female ghost pipefishes, particularly the species *S. paradoxus*,

are significantly larger than their male counterparts. On average, females measure around 130 mm, while males are approximately 37% smaller.

This species is very unique in its morphology and reproduction. The meristic and morphometric traits observed in the present specimen align with the descriptions provided by Orr and Fritzsche (1993). The comparison of selected morphometric and meristic characters of *Solenostomous paradoxus* obtained in the present study as well as the *S. paradoxus* from Monte Bolca, Italy (Bannikov and Carnevale 2017) revealed that the present specimen of *S. paradoxus* from mainland India lies within the acceptable range for this species (Table 1). *Solenostomous paradoxus* stands out from its related species, such as *S. cyanopterus* and *S. armatus*, due to its simple cirri, along with the presence of numerous stellate ossifications and intricately designed striped markings scattered across its entire body, rendering it uniquely identifiable.

The IUCN conservation status of *S. paradoxus* has been evaluated as 'Least Concern' (Dick and Pollom 2017). This study reveals the first record of ornate ghost pipefish, *S. paradoxus* from mainland India. The nature of the sea bottom from where the individual was obtained were observed to be sandy and muddy in nature. The individual obtained was recognized as female ghost pipefish characterized by a distinct brood pouch but no eggs were present.

Ghost pipefishes, including the ornate ghost pipefish, are among the least studied marine species due to their small size, excellent camouflage, and specific habitat requirements that make them difficult to locate and observe. Their solitary and seasonal behaviors are added to the challenge, while research often prioritizes larger or commercially significant species. Limited funding and taxonomic complexities further contribute to the lack of detailed studies on these elusive creatures.

In conclusion, studying ghost pipefishes from India is crucial for understanding marine biodiversity and ecosystem health. They are delicate beings, highly sensitive to changing environmental conditions and are easily affected by habitat degradation and pollution. Furthermore, this survey not only provides insights into species distribution and habitat conditions, but also encourages con-

servation efforts, enhances scientific knowledge and promotes the protection of vulnerable marine environments.

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## Author contributions

Diana Benjamin: conceptualization; methodology; investigation; writing original draft; data curation; formal analysis. Sijo P. Varghese: validation; formal analysis; visualization; supervision; writing review and editing. Jacob Thomas: data curation; resources; visualization. Giftson P. C.: software validation; mapping. Solly Solomon: validation; resources. R. Jeyabaskaran: validation; writing review and editing; supervision; project administration.

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