In situ observation of scorpionfish in seagrass meadows of the Gulf of Mannar, India

R. Jeyabaskaran*, S. Lavanya, Shelton Padua and V. Kripa

ICAR-Central Marine Fisheries Research Institute,
Kochi 682 018, India

The seagrass meadows of Sethukarai coast are unique in nature, housing high faunal diversity compared to other coastal areas. A rare live specimen of bandtail scorpionfish *Scorpaenopsis neglecta* was found near a burrow dug by an alpheid shrimp. Taxonomy, morphometric and meristic characters, adaptive, behavioural and colour-switching physiological camouflage trait of the *S. neglecta* are elaborated in this communication. Visual *in situ* documentation of feeding habits of scorpaenids and their preying behaviour, especially that of lionfish *Pterois volitans* preying on goby fish is presented. Mutualism exhibited by goby fish *Amblyeleotris gymnocephala* with the alpheid shrimp *Alpheus rapax* and the importance of habitat protection from anthropogenic activities are also discussed.

Keywords: Camouflage, mutualism, scorpionfish, seagrass meadows, underwater survey.

SEAGRASS meadows act as a nursery, shelter and feeding ground for many species of fishes and invertebrates. The seagrass beds of Sethukarai coast are unique in nature, housing high faunal diversity compared to other coastal areas. The habitat is dominated by the seagrass species *Cymodocea serrulata* and *Syringodium isoetifolium*. Unlike other seagrass habitats in Palk Bay (PB) and Gulf of Mannar (GOM), the sea bottom is found to be coarse sandy with coral rubbles and shell fragments. It has been observed that this is the only seagrass bed along the southeast coast with a large number of spiny lobsters, *Panulirus homarus* (Linnaeus, 1758). A limited number of local fishermen collect these lobsters by handpicking, which forms their main source of income. Several scorpionfish were observed in the seagrass beds of Sethukarai coast. These are generally found in coral reefs and rocky habitats, and have the tendency to live on the seafloor.

Scorpionfish are well known for the stinging venomous spines present on their head and body. The spines contain neurotoxic venom. When the spines pierce an individual, the venom gets injected immediately and it can be extremely painful. The name 'Scorpionfish' is because of this painful sting. Scorpionfish belong to the family Scorpaenidae, under the order Scorpaeniformes, consisting of more than 1400 species characterized by the presence of bony plates and spines on the head[1]. The genus *Scorpaenopsis* comes under the subfamily Scorpaeninae belonging to the family Scorpaenidae. There are 418 species belonging to 56 genera reported under the family Scorpaenidae, and 185 species of 20 genera under the subfamily Scorpaeninae[2].

The genus *Scorpaenopsis* Heckel, 1837 comprises 32 species[3] characterized by the presence of strongly compressed head; three or more suborbital spines; a combination of 12 dorsal fins and lack of palatine teeth[4–6]. So far nine species of *Scorpaenopsis* have been reported in India, viz. *Scorpaenopsis cirrosa*[7], *Scorpaenopsis gibbosa*[8], *Scorpaenopsis lactomaculata*[9], *Scorpaenopsis macrochir*[10], *Scorpaenopsis neglecta*[3], *Scorpaenopsis oxycephala*[7], *Scorpaenopsis ramaraoi*[11], *Scorpaenopsis roseus*[7] and *Scorpaenopsis venosa*[12]. Among these, *S.*

Table 1. Morphometric measurements of *Scorpaenopsis neglecta*

Morphological characters	Value (mm)
Total length (TL)	82
Standard length (SL)	73
Maximum body depth (*H*)	27.9
Minimum body depth (*h*)	8.67
Maximum body width	17.19
Minimum body width	3.82
Head length (CL)	28
Pre-dorsal distance (PD)	27
Pre-pectoral distance (PP)	31.4
Pre-pelvic distance (PV)	23
Pre-anal distance (PA)	52
Dorsal fin base length (LD)	44.6
Anal fin base length (LA)	11.74
Pectoral fin base length	14.3
Pectoral fin length (LP)	19
Ventral fin length (LV)	18.61
Caudal fin length (LC)	16.54
First dorsal spine height	5.53
Soft dorsal fin height	7.59
First anal spine height	7.32
Second anal spine height	3.6
Third anal spine height	13.02
Soft anal fin height	7.4
Ventral spine height	3.75
Soft pelvic fin length	6.95
No. of rays in the dorsal fin (D)	19
No. of rays in the pectoral fin (*P*)	18
No. of rays in the ventral fin (*V*)	6
No. of rays in the anal fin (*A*)	9
No. of rays in the caudal fin (*C*)	15
Head depth	23.95
Head width	24.91
Eye diameter (*O*)	6.61
Pre-orbital distance (PO)	10.28
Post-orbital distance (OLO)	15.88
Inter-orbital distance (IO)	3.82
Upper jaw length	18.52
Lower jaw length	16.92
Maxilla width	0.91
Snout length	11.5
Caudal peduncle depth	9.72

*For correspondence. (e-mail: jbcmfri@gmail.com)

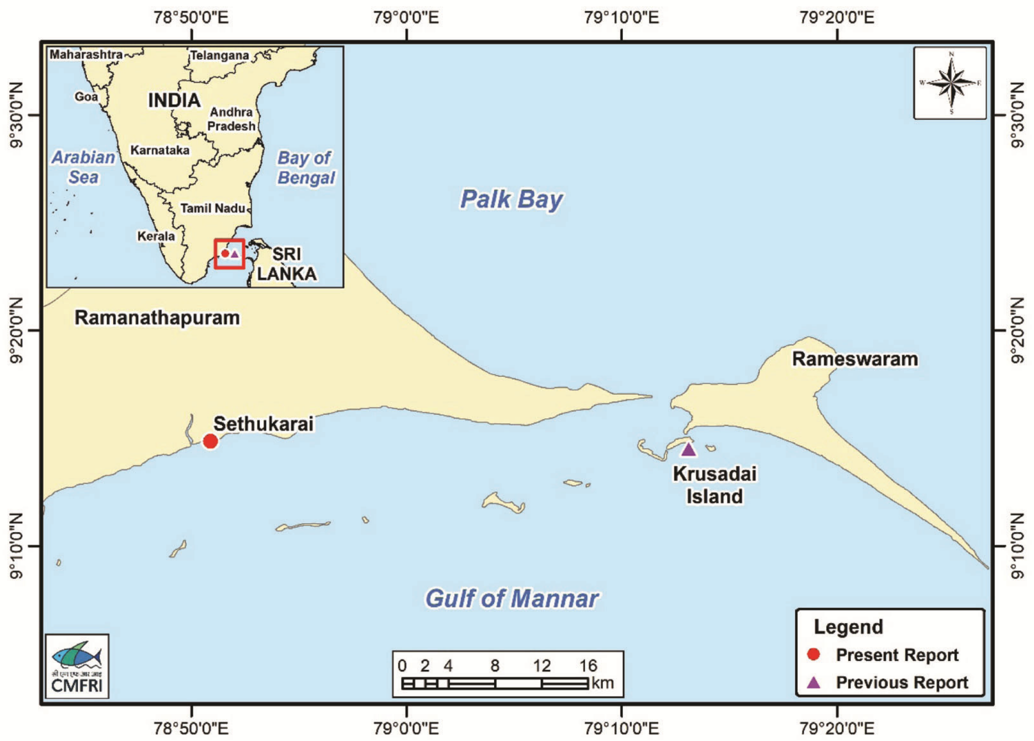

Figure 1. Map showing the location of *Scorpaenopsis neglecta* distribution (source map: Political Map of India, Survey of India, 2017, 7th edn).

roseus is not a valid species; now it has been accepted as *S. venosa*. The bandtail scorpionfish *Scorpaenopsis neglecta* Heckel, 1837 is also called yellowfin or bandtail stingfish. This species has been reported in 13 countries of the tropical Indo-Pacific region[3]. The occurrence of this species in India was first reported by the American Ichthyologist J. E. Randall. He collected a single specimen of size 8.4 cm SL; 10.8 cm TL from Krusadai Island of the Gulf Mannar on 5 March 1975. Randall had taken the specimen along with him and deposited it in USA (SU 14660)[13]. Since then, the species has not been reported from any of the Indian seas.

Underwater exploratory survey of the seagrass ecosystem in the GOM and PB was initiated by Central Marine Fisheries Research Institute, Kochi during 2014. Since then, regular seagrass ecosystem surveys have been carried out and the *S. neglecta* specimen was not found anywhere during the initial forays. During an underwater survey in seagrass beds of Sethukarai coast (9°14′55″N lat., 78°50′53″E long.) (Figure 1) on 21 November 2017, a live specimen of *S. neglecta* was found at 75 cm depth. After detailed underwater observations, the specimen was hand-picked using a zip-lock polyethylene bag. Morphometric and meristic characters (Table 1) were analysed based on the methods followed by Randall and Eschmeyer[4], and Motomura *et al.*[14]. The specimen was later deposited in the Marine Biodiversity Museum of CMFRI (GB.38.24.40.6).

The species of genus *Scorpaenopsis* is divided into three groups. Five species, namely *S. diabolus*, *S. gibbosa*, *S. macrochir*, *S. neglecta* and *S. obtusa* are known as humpback species due to the humped appearance of strongly elevated body just behind the head[4,14]. These five species are almost exactly similar with minor variations. The colour pattern on the middle of the inner side of the pectoral fin in *S. neglecta* and *S. microchir* is similar with small black spots. The other three species have larger black spots. The upper opercular spine is divided into two or more spines in *S. diabolus*, *S. macrochir* and *S. neglecta*. The bandtail scorpionfish *S. neglecta* could be easily identified based on the ridge above the eyes which is serrated and by the divided spines on the head[4].

Scorpaenids are sluggish creatures, which can change their colour and blend with their surrounding environment[15]. This defensive mechanism helps them to escape from predators and while hunting their prey. During the underwater survey, a coral skeleton-like fish was sighted near a burrow dug by an alpheid shrimp. It was later identified as bandtail scorpionfish *S. neglecta*. On first look, its appearance was totally confusing as to whether it was a fish at all or fossilized coral skeleton covered with bivalve shells. We could not come to any conclusion even after repeated observations also. Hence we disturbed the fish by touching it with dead coral fragment and then observed the black band in the caudal fin (tail). The fish was motionless, lying in a sandy area in the seagrass bed. The body colour was dull white blended with dead *Acropora* coral skeleton (Figure 2 *a*). The caudal fin was curled and oriented towards the left side of the body. The

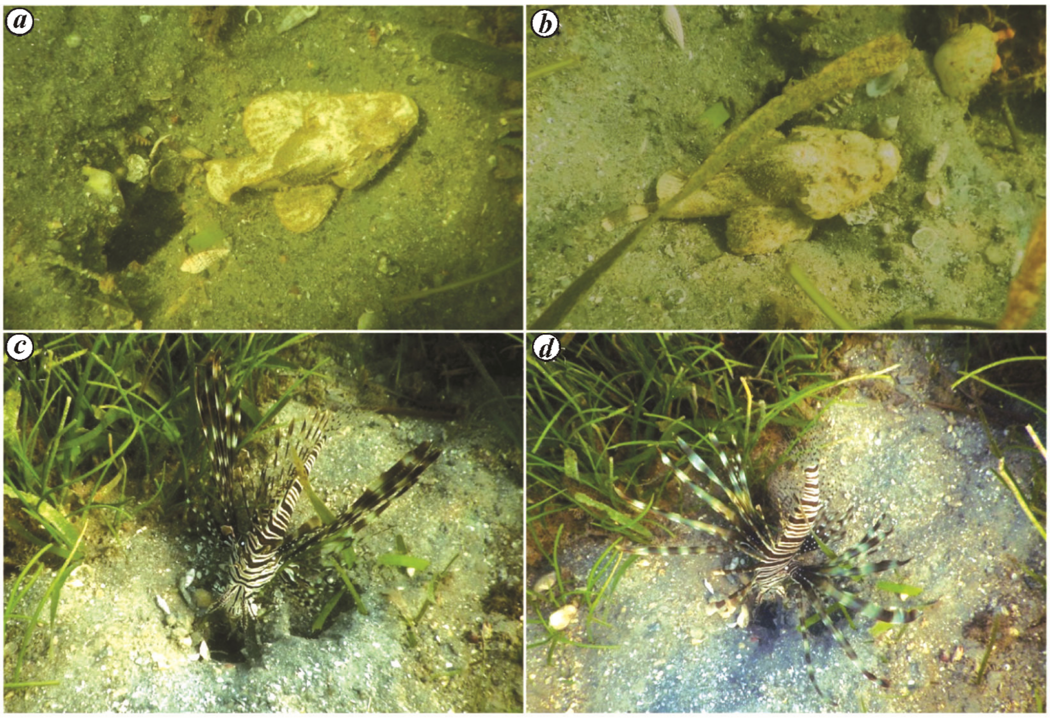

Figure 2. ***a***, Bandtail scorpionfish camouflaged like a coral skeleton. ***b***, Camouflaged bandtail scorpionfish in upright position. ***c,*** Lionfish approaching the burrow site. ***d***, Upside-down position of lionfish with enlarged fins.

eyes of the fish were closed and appeared as a bulged stalk-like structure. All the spines on the head and body were in a depressed condition, making it difficult to distinguish them. When the fish was disturbed by slight force, it moved a distance of 8 cm, became upright in position and again became motionless (Figure 2 *b*). Then the eyes were open, body scales were visible, dorsal fins and other spines were in erected condition. Mottled black colour appeared on the skin of fish (Figure 3 *a*). The fish was then caught by hand using zip-lock polyethylene bag. Immediately it flashed the pectoral fins and the inner side of these fins came in full view exhibiting bright yellow colour with black band margin (Figure 3 *b*). This flashing behaviour of pectoral fins is considered as a warning to predators and is known as 'aposematism'[16]. It was noticed that within 4 sec, the skin of fish body changed from white to mottled black colour (Figure 3 *c*). The axial of the pectoral fins was pale yellow in colour with black spots (Figure 3 *d*).

Scorpionfish has the ability to alter its body colour according to the background substratum[17]. The simultaneous increase of red, green and blue pigments in the epidermis of fish skin causes the disappearance of white colour[18]. Another study showed that chromotophore and iridiophore cells in the skin are responsible for giving colour to the fish. The iridiophores or 'mirror cells' are responsible for giving white or silver colour to the fishes through light reflections[19,20]. Wucherer and Michiels[21] reported that the motile organelles of different types of chromophore cells enabled rapid colour change of the fishes through distribution of fluorescent pigments in the skin. Various factors like ecological implications, hormonal control, dietary factors and visual feedback are also responsible for rapid colour change in camouflaged fishes[22]. The specimen colour of the camouflaged bandtail scorpionfish *S. neglecta* was compared with photographs of specimens from other Indo-Pacific regions[23]. The colour of the fish was similar to the Japanese specimen, but was different from those of the Indonesian and Australian specimens which exhibited bright yellow colour[24,25]. Even though these fishes were collected from similar coral reef environments, they exhibited different colours. Further research on behavioural aspects of scorpionfish is needed to elucidate the mechanism of rapid colour change in its skin.

In this study the bandtail scorpionfish was lying motionless in the sea bottom when it was located. Several questions arose, such as: how does this benthic motionless fish hunt its prey? What constitutes its diet? How does it hunt its prey when its eyes are kept closed? Scorpionfish are generally known to be ambush predators, i.e. they are 'sit and wait' predators. The masked scorpionfish sits completely motionless and waits for the prey to come close to it, then it rapidly lunges forward and sucks the moving prey with its large mouth[26,27]. Stonefish has the ability to attack and suck its prey within 15 ms (ref. 28). It is reported that scorpaenids are nocturnal feeders and most of them feed during night-time[29]. Majority of

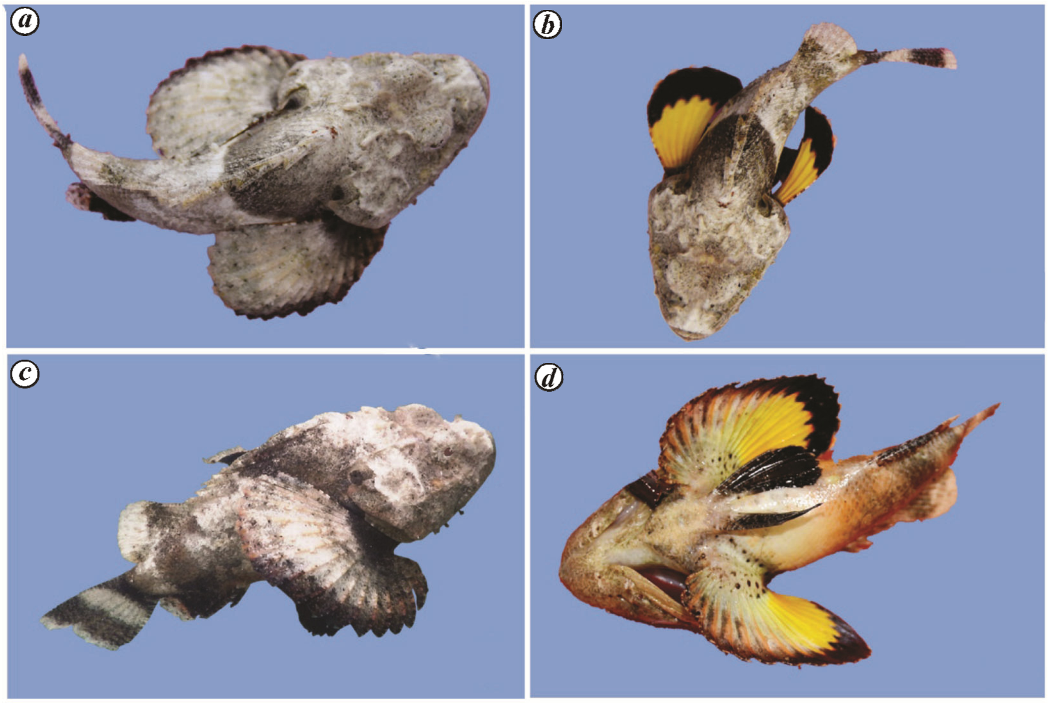

Figure 3. Colour changes in blackband scorpionfish. ***a***, Appearance of mottled black colour on the skin. ***b***, 'Flashing' behaviour of brightly coloured pectoral fins. ***c***, Change in fish body skin from white to mottled black colour. ***d***, Presence of pale yellowish colour with black spots in the axial of pectoral fins.

scorpionfish have nocturnal habits, and are dependent on their non-visual senses and lateral line to search for prey[30,31]. The lateral line is a sensory system present in all fishes to detect local water movements and sound generated by the prey[32]. For example, the dwarf scorpionfish could detect respiratory ventilation flows produced by crabs at a distance of 10 cm in dark environment using the lateral line[33]. Scorpionfish mainly feed on small benthic fishes like gobies and blennies, crustaceans and other benthic macro invertebrates found in coral reefs, rocks and algal beds[34–36].

The GOM and PB of India encompass luxuriant seagrass beds along their coastlines. Underwater exploration of seagrass beds in these areas revealed that Sethukarai coast has more number of burrows dug by alpheid shrimps. Alpheid shrimp and goby fish live together in the burrows, which is the safest place for both and also to avoid predators. The goby fish are called 'watchman gobies', which act as a guard for the predators. In the burrow, the large chela and antenna of the shrimp touch the caudal fin of the goby fish. The shrimp digs and maintains the burrows from seeping of sediment. If the goby fish finds any predator or unusual situation near the entrance, it immediately retreats into the burrow. Their symbiotic association is called 'mutualism'[37,38]. In the Sethukarai coast, the alpheid snapping shrimp *Alpheus rapax* Fabricius, 1798 was observed to dig burrows and the masked shrimgoby *Amblyeleotris gymnocephala* (Bleeker, 1853) co-habited with the shrimp in the burrows (Figure 4 *a–d*). The lionfish *Pterois volitans* (Linaeus, 1758) was abundantly seen in the seagrass beds of the Sethukarai coast. In the present study we observed the lionfish hunting the masked shrimpgoby fish in the burrows. When the lionfish approached the burrow site, it spread its fins towards the back and moved forward (Figure 2 *c*). On reaching the burrow entrance, it fully enlarged the fins and turned upside down (Figure 2 *d*). The masked shrimpgoby fish *A. gymnocephala* and snapping shrimp *A. rapax* could not escape from the burrow as the fins of the lionfish formed a barrier. The gobiid fishes are the most preferred diet of the lionfish[39]. The bandtail scorpionfish *S. neglecta* was found near the entrance of a burrow dug by the alpheid snapping shrimp *A. rapax*. Therefore, it is presumed that it feeds on shrimpgoby fish *A. gymnocephala*. Studies on feeding behaviour and diet composition are essential for understanding the ecosystem processes and also for trophic modelling. The present study would be helpful for these ecological assessments in future.

Sethukarai is a famous pilgrimage location and as part of a religious ceremony, the pilgrims discard their clothes into the sea. Due to nearshore water current and wave actions, the discarded clothes spread across the seashore and adjacent seagrass beds. Such smothering leads to degradation of seagrass beds and loss of habitats, especially feeding grounds for several species, including scorpionfish and shrimp. This would have cascading effects and finally affect the biodiversity of seagrass

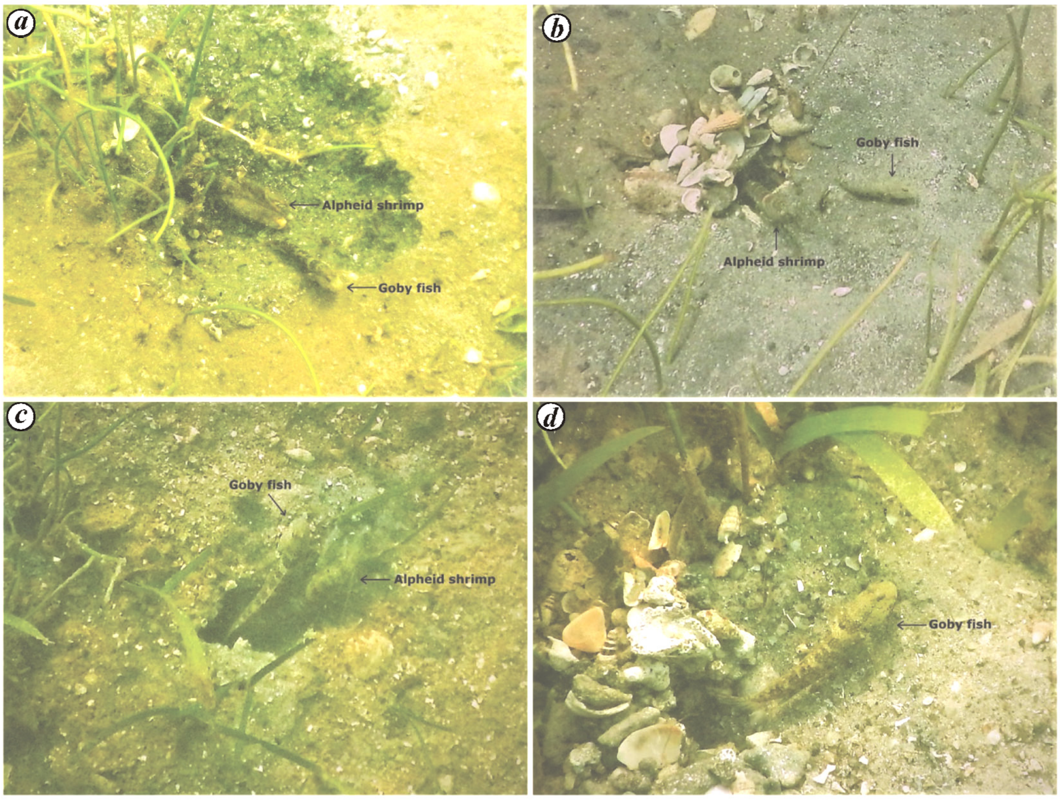

Figure 4. ***a–d***, 'Mutualism' of alpheid snapping shrimp *Alpheus rapax* co-habited with masked shrimpgoby *Amblyeleotris gymnocephala* in the burrows.

ecosystems and dependent fisheries. It is recommended that the local panchayat takes necessary action to collect the discarded clothes from the coastal waters and dispose them in an eco-friendly manner. Action on these lines can save the most diverse and luxuriant seagrass beds and associated fauna of the southeastern coast of India.

1. Paxton, J. R. and Eschmeyer, W. N., *Encyclopedia of Fishes*, Academic Press, San Diego, CA, USA, 1998, 2nd edn, ISBN: 978-0125476652.
2. Nelson, J. S., *Fishes of the World*, Wiley, Hoboken, NJ, USA, 2006, 4th edn.
3. Froese, R. and Pauly, D. (eds), *FishBase*, *Scorpaenopsis* Heckel, 1839. World Wide Web electronic publication, 2018; www.fishbase.org. Accessed through: World Register of Marine Species at: http://marinespecies.org/aphia.php?p=taxdetails&id=204563 on 2018-08-09.
4. Randall, J. E. and Eschmeyer, W. N., Revision of the Indo-Pacific scorpionfish genus *Scorpaenopsis*, with description of eight new species. *Indo-Pac. Fishes*, 2001, **31**, 1–79.
5. Motomura, H., *Scorpaenopsis insperatus*, a new species of scorpionfish from Sydney Harbour, New South Wales, Australia (Scorpaeniformes: Scorpaenidae). *Copeia*, 2004, 546–550; doi:10.1643/CI-03-298R
6. Motomura, H. and Senou, H., Validity of the scorpionfish genus *Hipposcorpaena* Fowler and a redescription of *H. filamentosa* Fowler (Scorpaeniformes: Scorpaenidae). *Zool. Stud.*, 2005, **44**, 210–218.
7. Day, F., The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. 1878, Part 4: i–xx, pp. 553–779, pls. 139–195.
8. Rao, D. V., Kamla Devi and Rajan, P. T., An account of Ichthyofauna of Andaman & Nicobar Islands, Bay of Bengal. *Rec. Zool. Surv. India*, 2000, Occs. Paper No. 178, 1–434.
9. Dash, G., Dash, S. S., Koya, K. M., Sreenath, K. R., Mojjada, S. K., Bharadiya, S. A. and Kiran, K., On the first record of the scorpion fish, *Scorpaenopsis lactomaculata* (Herre, 1945) from inshore waters of Veraval, Gujarat. *Mar. Fish. Inf. Serv. T&E Ser.*, 2013, **216**, 22–23.
10. Naranji, M. K. and Kandula, S., New record of the Tassled Scorpion Fish, *Scorpaenopsis oxycephala* (Bleeker, 1849) (Order: Scorpaeniformes, family: Scorpaenidae) from Visakhapatnam coast, Indian waters. *J. Mar. Biol. Aquacult.*, 2016, **2**(2), 1–4.
11. Ray, D., Mohapatra, A. and Mishra, S. S., First record of Rama Rao's scorpionfish, *Scorpaenopsis ramaraoi* Randall and Eschmeyer, 2001 (family: Scorpaenidae) from Indian waters. *Proc. Zool. Soc.*, 2015, **68**(2), 199–201.
12. Russell, F., *Description and figures of two hundred fishes collected at Vizagapatam on the coast of Coramandel,* W. Bulmer & Co., London, 1803.
13. Randall, J. E., *Scorpaenopsis neglecta*. In John E. Randall's Fish Photos, 1975; http://pbs.bishopmuseum.org/images/JER/detail.asp?size=i&cols=0&ID=708209 516203
14. Motomura, H., Yoshino, T. and Takamura, N., Review of the scorpionfish genus *Scorpaenopsis* (Scorpaeniformes: Scorpaenidae) in Japanese waters with three new records and an assessment of standard Japanese names. *Jpn. J. Ichthyol.*, 2004, **51**(2), 89–115.
15. Zimmermann, C. and Kunzmann, A., Baseline respiration and spontaneous activity of sluggish marine tropical fish of the family Scorpaenidae. *Mar. Ecol-Prog. Ser.*, 2001, **219**, 229–239.
16. Ruxton, G. D., Sherratt, T. N. and Speed, M. P., *Avoiding Attack: The Evolutionary Ecology of Crypsis, Warning Signals and Mimicry*, Oxford University Press, Oxford, UK, 2004.

17. Sugimoto, M., Morphological color changes in fish: regulation of pigment cell density and morphology. *Microsc. Res. Tech*., 2002, **58**(6), 496–503.
18. Sim, W. L. and Quek, J., Preliminary observational study of colour change in keratinised epidermal layer of stonefish (model: *Synanceia horrida*). Department of Biological Sciences, National University of Singapore, 2009; www.nus.edu.sg/nurop/2009/.../Sim%20Wee%20Leong%20Eugene_U052365H.pdf
19. Wallin, M., Nature's palette. How animals, including humans, produce colours. *Biosc. Explained*, 2002, **1**(2), 1–12; www.bioscience-explanined.org/EN1.2/pdf/paletteEN.pdf
20. Ligon, R. A. and McCartney, K. L., Biochemical regulation of pigment motility in vertebrate chromatophores: a review of physiological color change mechanisms. *Curr. Zool.*, 2016, **62**, 237–252.
21. Wucherer, M. F. and Michiels, N. K., A fluorescent chromatophore changes the level of fluorescence in a reef fish. *PLoS ONE*, 2016, **7**(6), e37913; doi:10.1371/journal.pone.0037913
22. Duarte, R. C., Flores, A. A. V. and Stevens, M., Camouflage through colour change: mechanisms, adaptive value and ecological significance. *Philos. Trans. R. Soc. London, Ser. B*, 2017, **372**, 20160342; http://dx.doi.org/10.1098/rstb.2016.0342
23. Randall, J. E., Randall's tank photos. Collection of 10,000 large-format photos (slides) of dead fishes. 1997; https://www.fishbase.de/photos/PicturesSummary.php?StartRow=3&ID=12555&what=species&TotRec=5
24. Allen, G. R. and Adrim, M., Coral reef fishes of Indonesia. *Zool. Stud.*, 2003, **42**(1), 1–72.
25. Allen, G. R. and Erdmann, M. V., *Reef Fishes of the East Indies, Volumes I–III*, Tropical Reef Research, Perth, Australia, 2012; ISBN: 978-0-9872600-0-0
26. Harmelin-Vivien, M. L., Kaim-Malka, R. A., Ledoyer, M. and Jacob-Abraham, S. S., Food partitioning among scorpaenid fishes in Mediterranean seagrass beds. *J. Fish. Biol.*, 1989, **34**, 715–734.
27. deVries, M. S., Murphy, E. A. K. and Patek, S. N., Strike mechanics of an ambush predator: the spearing mantis shrimp. *J. Exp. Biol.*, 2012, **215**, 4374–4384.
28. Michael, S. W., *Reef Fishes Volume 1, A Guide to Their Identification, Behavior and Captive Care*, Microcosm, Shelburne, USA, 1998.
29. Harmelin-Vivien, M. L. and Bouchon, C., Feeding behaviour of some carnivorous fishes (*Serranidae* and Scorpaenidae) from Tulear (Madagascar). *Mar. Biol*., 1976, **37**, 329–340.
30. Bassett, D. K., Carton, A. G. and Montgomery, J. C., Saltatory search in a lateral line predator. *J. Fish. Biol.*, 2007, **70**, 1148–1160.
31. Montgomery, J. C., Coombs, S. and Halstead, M., Biology of the mechanosensory lateral line in fishes. *Rev. Fish. Biol. Fisher*., 1995, **5**, 399–416.
32. Dijkgraaf, S., The functioning and significance of the lateral-line organs. *Biol. Rev*., 1962, **38**, 51–105.
33. Montgomery, J. C. and Hamilton, A. R., Sensory contributions to nocturnal prey capture in the Dwarf scorpionfish (*Scorpaena papillosus*). *Mar. Freshw. Behav. Physiol*., 1997, **30**, 209–223.
34. Hureau, J. C. and Lituinenko, N. J., Fishes of the Northeastern Atlantic and the Mediterranean. In *Scorpaenidae* (eds Whitehead, P. J. P. *et al.*), UNESCO, Paris, 1986, vol. 3, pp. 1211–1229.
35. Bradai, N. and Bouain, A., Feeding pattern of *Scorpaena porcus* and *S. scrofa* (Teleostei, Scorpaenidae) from Gulf of Gabes, Tunisia. *Cybium*, 1990, **14**, 207–216.
36. Relini, G., Relini, M., Torchia, G. and De Angelis, G., Trophic relationships between fishes and an artificial reef. *ICES J. Mar. Sci*., 2002, **59**, S36–S42.
37. Yanagisawa, Y., Studies on the interspecific relationship between gobiid fish and snappin shrimp. i. Gobiid fishes associated with snapping shrimps in Japan. *Publ. Seto Mar. Biol. Lab*, 1978, **24**(4–6), 269–325.
38. Yanagisawa, Y., Social behaviour and mating system of the gobiid fish *Amblyeleotris japonica*. *Jpn. J. Ichthyol.*, 1982, **28**(4), 401–422.
39. Tornabene, L. and Baldwin, C. C., A new mesophotic goby, *Palatogobius incendius* (Teleostei: Gobiidae), and the first record of invasive lionfish preying on undescribed biodiversity. *PLoS ONE*, 2017, **12**(5), e0177179; https://doi.org/10.1371/journal.pone.0177179

ACKNOWLEDGEMENTS. We thank the Director, Central Marine Fisheries Research Institute, Kochi for providing the necessary facilities. We also thank Dr Hiroyuki Motomura, Kagoshima University Museum, Japan for help in the identification of the fish and N. Raji and P. Vysakhan for support during the survey.

Received 4 September 2018; revised accepted 23 January 2020

doi: 10.18520/cs/v118/i10/1615-1620