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Sea Cucumber (*Holothuria arguinensis*) as a Shelter for Juvenile Fish (*Diplodus bellottii*) in the Gulf of Cadiz (Southwestern Spain)

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Abstract: During a diving survey on soft-bottom habitats in the Gulf of Cadiz (Southwestern Spain), the use of the sea cucumber *Holothuria arguinensis* (Echinodermata, Holothuriidae) as a shelter by juvenile Senegal's sea bream *Diplodus bellottii* (Chordata: Sparidae) was observed. Eight juvenile sea bream *D. bellottii* were videoed sheltering under the sea cucumber's body. This observation highlights the importance of sea cucumbers as a shelter for juvenile fish, providing a microhabitat to take refuge from predators. This is the first report of juvenile sea bream sheltered by a sea cucumber.

Keywords: refuge; microhabitat; holothurians; young fish; Atlantic Ocean

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Habitat structural complexity, protection against predators and enhanced prey availability are considered bottlenecks to explain survival success during the early life-history phases of fishes [1–3]. As a consequence, diverse teleost fish species have been shown to seek shelter around the microhabitats provided by mobile and structure–forming organisms (e.g., cnidarians and echinoderms) [4–6]. Among echinoderms, many species of juvenile reef fish have been reported using the long spines of sea urchins (to hide above or between them) [6–8]. Moreover, this relationship could also benefit the sea urchins, through the removal of ectoparasites by the fishes [6].

Sea cucumbers (Holothuroidea) feed on the organic detritus mixed with sand/silt and may be recognized by their cucumber-shaped body elongated along the oral/aboral axis. Species of the genus *Holothuria* are known to host various organisms including annelids, mollusks, crustaceans, and fish [9,10]. The harlequin crab, *Lissocarcinus orbicularis* (Dana, 1852), is an example of a symbiont crab that associates with sea cucumbers, typically seeking refuge on large holothuroid species [11]. Another example is the shrimp, *Periclimenes imperator* Bruce, 1967, which has a diverse range of hosts, among these eleven holothuriod species [12].

One of the best known associations dates back to almost two centuries ago, when Quoy and Gaimard made the first observations concerning pearlfish (Ophidiiformes: Carapidae) and sea cucumbers, during the voyages of the French research vessel l'Astrolabe [10,13]. These species of the genus *Carapus* Rafinesque, 1810 and *Encheliophis* Müller, 1842, present a singular lifestyle using the coelomic cavity of sea cucumbers as shelter [13–15]. However, these associations can provoke negative impacts on the cucumbers like injuries and consume part of your organs (e.g., gonad tissues and respiratory trees) [15]. In addition, records of the temporary association between juveniles of free-living fish and sea cucumbers providing a microhabitat (refuge/shelter) are poorly documented.

Here we describe a previously unreported association between juveniles of Senegal's sea bream *Diplodus bellottii* (Desmarest, 1823) and the sea cucumber *Holothuria arguinensis* Koehler and Vaney, 1906, through an in situ observation on soft-bottom habitats in southwestern Spain. Previous observations have shown fish of the genus *Diplodus* under artificial structures such as chains of buoys in nearby areas of the Gulf of Cadiz [16]. Thus, our recorded findings suggest that relationships with sea cucumbers may provide additional protection for juvenile fish.

The observation was made on a shallow soft-bottom habitat (9 m deep) during 20 min off the coast of San Fernando (36°24′35.9″ N 6°14′10.4″ W), in the Gulf of Cadiz (Southwestern Spain), northeastern Atlantic Ocean. This zone has ecological and cultural heritage importance due to the large number of shipwrecks from the Battle of Trafalgar, and is undergoing the process of being declared a protected marine area [17]. The sheltering behavior of *D. bellottii* under the sea cucumber was videoed (video footage in Supplementary Material).

We found an individual of the sea cucumber, *H. arguinensis* (about 30 cm total length) resting on the soft-bottom with a group of about eight juvenile sea bream *D. bellottii* (about 7–8 cm total length) sheltering under the sea cucumber's body on 11 August 2021 (Figure 1a,b). All individuals were motionless and partially buried by sediment (Figure 1a,b). Some juvenile fish fled in response to the diver's presence (Figure S1b; Supplementary Material), but subsequently returned to shelter again under the holothurian. Escape behavior can occur when fish react to humans as potential predators [18].

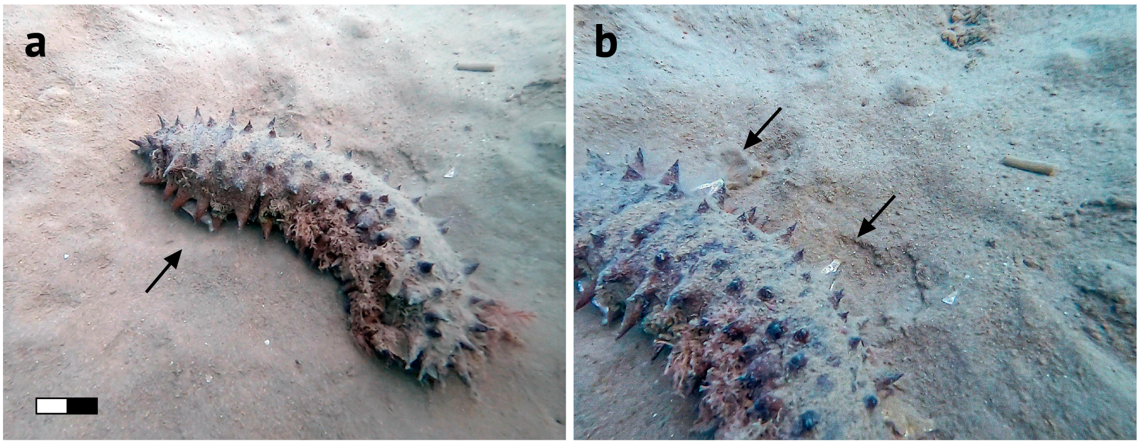

Figure 1. Sea cucumber as a shelter for juvenile fish. Overview (**a**) and close-up (**b**) of the sea cucumber, *Holothuria arguinensis*, resting on the soft-bottom habitat. Arrows show juveniles of Senegal's sea bream *Diplodus bellottii* sheltering under the sea cucumber's body. Scale bar: 5 cm.

The limited natural habitat complexity on soft bottoms compared to reef ecosystems and structurally complex benthic organisms (e.g., cnidarians) [4,5], may favor inter- and intra-specific relationships of structurally complex organisms with low mobility, as in this case. Other benthic features like underwater caves were close (3–4 m) to the sea cucumber, but they were used by adult fishes. Thus, this finding highlights the importance of sea cucumbers as an alternative shelter for small-bodied fish, when the availability of natural refuges is scarce.

According to Ventura et al. [19], the distribution of juvenile sea bream *Diplodus* spp., in shallow waters is thought to be influenced by food supply and higher encounter rates with their prey. Juveniles of *D. bellottii* are omnivorous and feed mostly on benthic sources from the soft bottoms, such as algae (Rhodophyta), bivalves and mysids [20]. This shows that these juvenile sparids can forage in the same locations where they find refuge. This way, in addition to protection, we can raise the hypothesis that the bioturbation of sediments performed by sea cucumbers [10] could also expose potential prey and benefit the young fish.

This is the first report on the use of sea cucumbers as a shelter for the juvenile sea bream, which demonstrates an example of the supply of microhabitats for small-bodied fish. Further research is needed for a better understanding of the association of juvenile fish with sea cucumber (e. g. occasional; facultative), especially because of its role in sedimentary health, nutrient recycling and its importance to fishing.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d14100872/s1, Video S1: Sea cucumber as a shelter for juvenile fish in the Gulf of Cadiz (Southwestern Spain). Figure S1: Sea cucumber resting on the soft-bottom habitat with an outline with red lines and arrows to view the juvenile fishes, as in Figure 1.

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