

Parastichopus tremulus (Gunnerus, 1767) red sea cucumber, red signal sea cucumber (Sweden), rødølse (Norway and Denmark), Aspidochirotida, Stichopodidae

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Parastichopus tremulus is found in the northeast Atlantic Ocean, mainly along the coasts of Norway and Sweden, but also Iceland, the Faroe Islands and British Isles, with recorded occurrences down to the Canary Islands. *P. tremulus* can occasionally be found from 18 m down to 4000 m but is most frequent found at 50–500 m.² It is often part of bycatch from commercial bottom trawling for other species in the North Sea, with the highest abundances at 150–300 m. The depth at which this species is found has limited studies of its distribution, behaviour and ecology. This is one of the larger holothurians in this depth range in the area, along with *Cucumaria frondosa* and *Psolus pantapus*, both dendrochirotid species. Fully grown specimens of *P. tremulus* from the North Sea can reach 50 cm in length, 10 cm in width and a wet weight close to 300 g, but the average size and wet weight is around 25 cm and 200 g, respectively (Kjerstad et al. 2015; Christophersen et al. 2020). *Parastichopus tremulus* is cylindrical in shape, with slightly tapered ends and a thick body wall. The dorsal side of adults is red-orange, with varying levels of saturation, and small dark spots scattered evenly along the body (Fig. 1). It is also covered with distinct papillae that are 0.5–2.0 cm in length, giving the animal a spiky look. The ventral surface is lighter coloured, often completely white, and covered by rows of tube feet. Variations occur with regard to the red markings, mottling or stripes on the ventral side (Fig. 1). There are occasionally red suckers on the locomotory podia. Wholly red or white specimens have also been documented.

Parastichopus tremulus is quite commonly found on silt-covered rocks and pebbled substrates, and according to observations from scuba divers and remotely operated vehicle-inventories, the highest abundances have been recorded on soft sediments. The species is generally described as being part of the soft bottom community (Jespersen and Lützen 1971; Hudson et al. 2004).

When placed in flow-through tanks with a muddy-sandy substrate, the animals are often found on the hard tank wall (personal observation), and when feeding, *P. tremulus* slowly moves over the substrate with the mouth ventrally directed (Hauksson 1979). Also when feeding, it uses only 10 of its 20 peltate feeding tentacles at a time to collect organic matter and inorganic particles from the surface of the sediment

(Hudson et al. 2004). No mucous glands have been detected on either the tentacles or in the pharynx, suggesting that the particles are handled mechanically rather than by an adhesive substance (Jespersen and Lützen 1971). The sensory papillae surrounding the oral crown (Fig. 1) are used to “sense” the sediment prior to tentacular contact (Hudson et al. 2004). *P. tremulus* is a selective feeder, showing a preference for organic-rich material such as faecal pellets, and other sediment particles that are richer in organic material than the general surface sediments (Hauksson 1979), or silica particles (Hudson et al. 2004). Jespersen and Lützen (1971), however, suggested they were non-selective feeders at the level of actual selection of particles from the sediment, but rather at the level of organic matter in the sediment as maximum densities occur in areas where the sediment has been enriched with organic material. Feeding occurs throughout the night and day (Hudson et al. 2004), presumably due to a lack of large diurnal variation.

There is some evidence of seasonal fasting or aestivation occurring from October to February, so it is assumed that the species ceases feeding from the end of October until the beginning of January. Intestinal regeneration is assumed to be 60–80 days, based on laboratory observations (Jespersen and Lützen 1971). It is still unknown what triggers a potential seasonal aestivation.

The starfish *Solaster endeca* (Linnaeus, 1771) has been seen praying on *P. tremulus* in aquaria. Anecdotal reports from North Sea fishermen suggest that several species of codfish and halibut are predators of this species, as they have been found in the gut content of the fish. Because sea cucumber bycatch is dumped back into the sea, *P. tremulus* may also be eaten while sinking through the water mass. It is, therefore, uncertain whether these fish actually prey upon them in their natural habitat.

Parastichopus tremulus is either male or female, without any external sexual dimorphism, and exhibits an annual reproductive cycle. The sex ratio is estimated to be 1.3:1.0 females:males. Gametogenesis initiation begins in January, and there is a successive increase in gonadal index from January until May, when the maximum gonad size was recorded in Ålesund, Norway (Christophersen et al. 2020).

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² See <http://www.obis.org> 2020

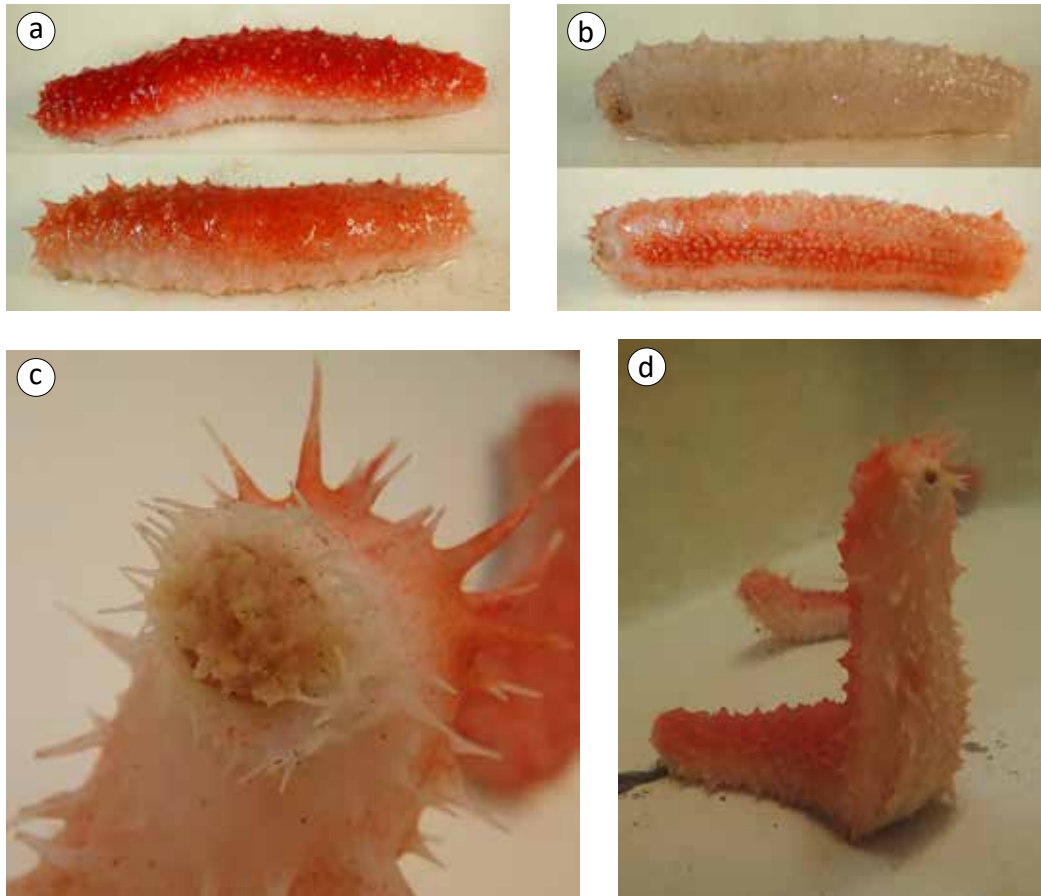


Figure 1. a) *Parastichopus tremulus* has a reddish-orange dorsal side, going from deep red (top) to a lighter hue, where the small dark spots, scattered evenly along the body, are more clearly visible (bottom); b) the ventral side is most often completely white (top), but red markings, mottling or stripes also occur (bottom); c) the 20 pelatate feeding tentacles are surrounded by sensory papillae; d) a male individual in spawning posture with the anterior body clearly raised and the mouth tightly closed. The gonopore is swollen and sperm are being released

Earlier studies state that spawning occurs slightly later, during the summer months of July and August (e.g. Rustad 1940; Lönning 1976; Holland 1981). In Sweden, successful fertilisation after induced spawning occurred between late May–July. Induced spawning has shown how first males and then females adopt the spawning posture, with the anterior part of the body more or less raised (Fig. 1d), similar to that reported for the closely related species *Parastichopus californicus* (Cameron and Fankboner 1986). Gametes are broadcasted from the gonopore into the water column, where they are fertilised. The age at which this species reaches sexual maturation is unknown, but gonads have been present in animals just 84 mm in length, although gonad viability was not checked (Christophersen et al. 2020).

No observation of any of the pelagic larval stages of *P. tremulus* have been reported from the field. Regarding newly settled juveniles, to our knowledge, there is only one observation of a juvenile < 30 mm reported by Kjerstad et al (2015) who also observed that large and small animals seem to occur at different sampling stations. Together with the observations that the size of animals differs between substrates (Jespersen and Lutzen 1971), this possibly suggests an alteration of substrate preference, so some migration is likely to occur with size or age.

In Asia, sea cucumbers are a well-known product delicacy. As of today, this species has not been formally introduced to the Asian market, but a few attempts at evaluating its potential have been made by Kjerstad et al. (2015), who reported that *P. tremulus* showed significant potential as a commercial product on the Chinese market. Their Chinese test-panel liked the properties of *P. tremulus*, such as its size, meat content, taste and nutritional content. Its red colour, although not maintained after processing, was also regarded as favourable. It was tentatively priced in the middle to lower price range.

Currently, research on spawning and artificial rearing of this species is underway in Norway and Sweden. The main aim of this novel area of research is to establish breeding and farming protocols for *P. tremulus* for use as a detritivorous component in different integrated multi-trophic aquaculture systems, for re-stocking purposes as well as for possible commercial farming. The focus of the research in Sweden is to investigate basic physiology and the physiological boundaries regarding environmental biotic and abiotic factors of *P. tremulus*. This will build the knowledge base for developing breeding, hatching and farming guidelines with a focus on animal health and welfare along with productivity for farming new sea cucumber species. The first captivity-bred juveniles of this species were successfully produced in Sweden during 2020.

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