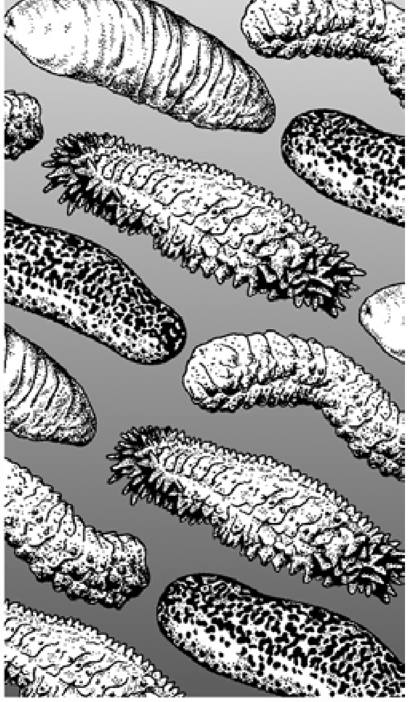

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Inside this issue

Editorial

This 40th issue of the SPC *Beche-de-mer Information Bulletin* includes 15 original articles and scientific observations from a wide variety of regions around the world.

We begin with an article by Di Simone et al. (p. 3–4), discussing the recent addition of three Holothuriidae species (teatfish: *Holothuria fuscogilva, H. nobilis* and *H. whitmaei*) to CITES (Convention on International Trade in Endangered Species) Appendix 2. Di Simone and her colleagues note that this first "listing" for holothurians will probably be closely monitored to determine whether CITES is the right instrument for their conservation.

Andréfouët and Tagliaferro made a comparative assessment of sea cucumber communities in the UNESCO Man and Biosphere Fakarava Reserve of French Polynesia and in the Entrecasteaux group of the Lagoons of New Caledonia World Heritage Area (p. 5–10). These two UNESCO-listed areas only include atolls, and the period of the study (2012–2013) was timely as it marked the official end of recent exploitations in both areas. The authors conclude that, compared with many sites in the Pacific, these atolls still harboured significant sea cucumber populations. They call for periodic holothurian surveys in the areas to estimate the possible impact of illegal or controlled legal exploitation since the period of the survey.

Eeckhaut et al. (p. 11–16) estimated the impact of predation by the crab *Thalamita crenata* on sea cucumber juveniles in a sea farming site in Madagascar. Their results show that predation by *T. crenata* is a key parameter to take into account when developing sandfish (*Holothuria scabra*) farming. Rogers et al. (p. 17–19) report on the first visual documentation that sea turtles prey on sea cucumbers on a reef in Belize. Purcell et al. (p. 20–22) examined and recorded the incidence of ectocommensal organisms on more than 60 hosts (including *Thelenota anax* and *Stichopus vastus*) collected at several sites around Lizard Island, on the northern Great Barrier Reef in Australia.

Mezali and Slimane-Tamacha (p. 23–26) describe a survey to better understand the rapidly developing sea cucumber fisheries in the Algerian territory. They conclude with a call for the urgent implementation of nine measures to manage the fishery.

Also in Algerian waters, Belbachir and Mezali (p. 27–31) studied the diet of *Holothuria poli* for four seasons in order to define the variation of the different trophic sources used by this sea cucumber species. They note that several species of sea cucumbers can share the same habitat because they do not all use the same elements of the sediment for food.

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Some holothurian species have been recorded for the first time in Pakistan through two studies, the first from Moazzam and Moazzam (p. 32–39) and the second from Quratulan and Qader (p. 40–42). New records are also reported from Algeria by Benzait et al. (p. 43–45) and from Mayotte by Mulochau and Conand (p. 46–48).

Asexual reproduction of two sea cucumber species was studied by Borrero-Pérez in the Caribbean (p. 49–50) and Borrero-Pérez and Vanegas in the eastern Pacific (p. 51–52). Desbiens and Wolfe (p. 53–55) report some observations on *Stichopus* juveniles on a coral reef in Palau, and Hartley et al. (p. 56–58) provide great photos of the spawning of *Astichopus mollis* at its northernmost subtropical locality.

Also included are various communications (p. 59), some about workshops and conferences that were held in 2019. Congratulations are expressed to Farah Slimane-Tamacha who presented her PhD titled "Sea cucumbers of the Holothuroiida order from the Ain Franine region (west coast of Algeria): Biology, ecology and exploitation" on 8 December 2019 at University Abdelhamid Ibn Badis, Mostaganem, Algeria.

We deeply regret the premature death of Professor Francour who was one of the pioneers in the study of sea cucumbers in the Mediterranean. A research team from the Abdelhamid Ibn Badis University in Algeria has written a touching tribute to Prof Francour that we reproduce in this issue (p. 62).

Igor Eeckhaut

P.S: In line with a worldwide trend to limit the impact of producing printed publications on the environment, SPC has stopped the production and distribution of printed copies of this and other information bulletins. The BDM bulletin is now only produced in digital format and remains accessible from SPC's website at:

http://www.spc.int/coastfish/en/publications/bulletins/beche-de-mer.html

Three species of teatfish to be protected by CITES

Marie Di Simone,[1] Arnaud Horellou[1] and Chantal Conand[2]

Introduction

The 18th meeting of the Conference of the Parties (CoP18) to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (CITES Secretariat 2009a) was held in Geneva in August 2019. As a result of two and a half years of work outlined in an article in the *Beche-de-mer Information Bulletin* "Towards a CITES listing of teatfish" (Di Simone et al. 2019), the proposal to include three Holothuriidae (teatfish) species – *Holothuria fuscogilva, H. nobilis* and *H. whitmaei*) in Appendix II was submitted by the European Union (EU) and co-sponsored by the United States of America (USA), Seychelles, Kenya and Senegal. Committee I of the conference debated the proposal on 25 August, and it was accepted by secret ballot, with 108 Parties in favour and 30 against. After 17 years of discussions (Bruckner 2006; Robin des Bois 2019), three sea cucumber species were, for the first time ever, listed in CITES Appendix II on 28 August 2019 in plenary session.

A proposal widely supported....

This listing proposal has received the support of a large number of Parties to CITES, including many intergovernmental organisations such as the Food and Agriculture Organization of the United Nations (FAO) and the International Union for Conservation of Nature, and non-governmental organisations such as Robin des Bois, World Wildlife Fund (WWF), and the Species Survival Network (Fig. 1). A letter of support for the proposal, initiated by Biological Diversity and signed by 26 holothurian scientists and specialists from around the world, was forwarded to CITES.

Among the all of the listing proposals submitted on marine species, only the one about teatfish has received a favourable analysis from FAO. The Sixth Expert Advisory Panel was held in Rome from 21 to 25 January 2019, to consider four listing proposals to CITES concerning commercially exploited aquatic species, including the teatfish proposal. The panel determined that the species *H. whitmaei* met the criteria for listing in CITES Appendix II, and that the other two species met the "look alike" criteria (FAO 2019).

The French CITES Scientific Authority (SA France), under the EU delegation, participated in the two teatfish side events in the margins of CoP18. The first, organised by WWF and the International Fund for Animal Welfare (IFAW), with the participation of the Sri Lankan and USA CITES Management Authority, SA France, WWF and Robin des Bois, focused on the biology and the legal and illegal trade of teatfish (Fig. 2). The second, organised by FAO, with interventions from SA France, FAO and the Pacific Community, focused on the proposal itself, including its strengths and weaknesses, and local fisheries management. The proposal has been the subject of media coverage in 2019, such as the magazine *Le Marin*, the radio programme *France Inter* and on the websites of Biological Diversity and Robin des Bois.

...but somewhat contested

There was no consensus, however, on the proposal, which is the real reason why discussions did not end with a consensus in Committee I. China, Papua New Guinea, Solomon Islands and Tonga, as well as other Asian, Pacific and Oceanian countries, did not support the proposal, mainly for fear of implementation difficulties and the needed and necessary capacity building, especially for small-scale and local fisheries.

These countries expressed concerns regarding the difficulties of implementing this listing, including its impact on communities dependent on sea cucumbers for their livelihoods, as well as the significant management burden that would result from listing the teatfish (CITES Secretariat 2019b).

Parties supporting the proposal (Australia, Chile, Senegal and the USA) have also all noted a current lack of comprehensive measures to ensure sustainable management (CITES Secretariat 2019b).

The lack of data in the proposal, raised by China at the 30th Animals Committee (19 July 2018), was not highlighted this time, as the final proposal had been strongly consolidated on this aspect. However, producing data at the local level to carry out non-detriment findings remains a challenge.

Solutions to face these challenges

In view of concerns expressed by some Pacific countries about the importance of holothurians to livelihoods and the need for capacity building, the EU committed itself to provide technical and financial support to assist Parties that may need additional capacity to effectively implement the listing

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proposal, and thus implement a global capacity building programme (CITES Secretariat 2019b).

Also, the USA, on behalf of co-sponsors, proposed to amend the proposal to delay the entry into force of this listing by 12 months. It will now enter into force on 28 August 2020 (CITES Secretariat 2019b).

The implementation of Appendix II management and control measures for the three teatfish species, organised by Article IV of CITES, will determine the future CITES listing for other sea cucumber species. This first listing for these animals at CoP is a leap into the unknown and for many, proof that CITES is the right instrument for their conservation remains to be provided. Possible future listings of other species meeting CITES criteria will only be possible with results obtained on teatfish in the coming years.

Figure 1. Sharks, fish and a sea cucumber welcome delegates to the venue as the third day of CITES CoP18 continues.

Figure 2. Intervention by France at a side event for a presentation of the teatfish proposal in Geneva at CoP18. From left to right: Daniel Fernando (Sri Lanka) explained the support of his country, which should have hosted CoP, for this proposal. Colman Criodain (WWF) was the moderator, and he explained the need to preserve these animals (in general). The French SA (Arnaud Horellou and Marie di Simone) presented the biology and habitats of teatfish. Charlotte Nithart of Robin des Bois presented the legal and illegal trade. Rosemarie Gnam (USA CITES Management Authority) presented the background of holothurians at CITES.

It is important that the listing of these three sea cucumber species in CITES Appendix II be done in an optimal way to encourage new classifications of other holothurian species, as long as some would meet the CITES listing criteria.

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A comparison of commercial sea cucumber communities in the French Polynesia and New Caledonia atolls listed as UNESCO Man and Biosphere and World Heritage Areas

Serge Andréfouët[1]* and Amélie Tagliaferro[1]

Abstract

Sea cucumber communities in the UNESCO[2] Man and the Biosphere Fakarava Reserve of French Polynesia and in the Entrecasteaux group of the Lagoons of New Caledonia's World Heritage Area were assessed in 2012–2013. These two UNESCO-listed areas only include atolls, of various sizes and depth. The 2012–2013 period marked the official end of recent exploitations of sea cucumbers in both areas. The same survey methodology was used at both locations, which allowed us to compare the commercial communities. The Entrecasteaux group had more commercial species than Fakarava Reserve, but densities overall were similar. *Bohadschia* was the most abundant genus in the Man and Biosphere Reserve, while *Thelenota ananas* was the most abundant species in Entrecasteaux. Compared with many sites in the Pacific, these atolls still harbour significant sea cucumber populations, and it is expected that their status will remain positive in 2020 due to their protection and management. The two locations, however, have been fished since at least 2016: Entrecasteaux is exposed to international poaching, and several of the Fakarava Reserve atolls are legally fished every year. This exploitation, legal or illegal, calls for the periodic re-assessment of the status of sea cucumbers through dedicated holothurian surveys.

Key-words: UNESCO, Man and the Biosphere, Fakarava Reserve, Entrecasteaux, World Heritage Area, Lagoons of New Caledonia, Atoll

Introduction

Among the French overseas territories of the Pacific Ocean, two groups of atolls have received the recognition of the United Nations Educational, Scientific and Cultural Organization (UNESCO) for their remarkable environment or cultural values. In the Tuamotu Archipelago in French Polynesia, the Man and the Biosphere (MAB) Fakarava Reserve includes – since 2006 and after a revision of its legal status in 2016 – seven atolls (Taiaro, Niau, Aratika, Kauehi, Raraka, Toau, Fakarava) that are all within the Fakarava municipality (DRMM 2017). To the northwest of New Caledonia, the Entrecasteaux Group, which is under the jurisdiction of the Government of New Caledonia, is one of the six clusters that together makes up, since 2008, the Lagoons of New Caledonia World Heritage Area (Andréfouët and Wantiez 2010). It includes seven atolls, namely Huon, Surprise, Mérite, Portail, Pelotas, Gros Guilbert and Petit Guilbert.

In addition to these prestigious listings, the Entrecasteaux group is part of the Natural Park of the Coral Sea (*Parc Naturel de la Mer de Corail,* or PNMC) implemented by the New Caledonia government in 2014. It was also since 2013 a no-take area, including for holothurians. The area also benefits since 2018 from a new zoning plan with several natural reserves and strict nature reserves[3]. The atolls of the MAB Fakarava Reserve also benefit from zoning plans that should limit fishing for large areas within each atoll lagoon (DRMM 2017; Andréfouët et al. 2019).

The comparison of the commercial sea cucumber communities for these two areas is based on data collected in December 2012 for French Polynesia, and in December 2013 for New Caledonia. This was a key period for both regions, as 2013 marked the transition towards a no-take area for Entrecasteaux, which was significantly fished before that time (Purcell et al. 2009). No precise statistics exist to our knowledge, but Purcell et al. (2009) reported that fishing was extensive around and within "Surprise" (often, for New-Caledonian locals, "Surprise" is the name for the entire Entrecasteaux group). The only professional fisher who legally fished the area was catching there half of his production, around 1–5 tonnes of sea cucumber (wet weight) during regular three-week fishing trips (Kronen et al. 2009; Purcell et al. 2009). How long this exploitation went on for was not reported, but it took place for at least several years. Similarly, the survey in the MAB Fakarava Reserve in December 2012 was achieved only a few weeks after the French Polynesia moratorium was

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[3] https://www.iucn.org/theme/protected-areas/about/protected-area-categories
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instated (Andréfouët et al. 2019). This moratorium ended three years of exploitation that ranged from extensive to nonexistent within the MAB reserve, depending on the atoll (Andréfouët et al. 2019).

The objectives of this study were to make a comparative assessment between two atoll regions, both recognized by UNESCO, and just after sea cucumber exploitation ceased officially. It was not expected to have similar figures considering that the two regions belong to two very different biogeographical provinces, but the results can be used as a baseline if new surveys occur, and to bracket the statistics from other atoll regions in other exploited Pacific atoll regions or countries. To the best of our knowledge, these are still the most recent surveys dedicated to sea cucumbers for the two regions. Recommendations for scientific monitoring are also discussed specifically for the Tuamotu Atolls and New Caledonia.

Methods

Observations in the Fakarava Reserve and the Entrecasteaux group took place from 21 November 2012 to 9 December 2012 and from 11 November 2013 to 24 November 2013, respectively. The census activity was hosted by the Global Reef Expedition of the Khaled bin Sultan Living Ocean Foundation (LOF) on board the R/V *Golden Shadow*. In the Fakarava Reserve, four atolls were surveyed: Fakarava, Raraka, Toau and Aratika. In Entrecasteaux, all atolls were surveyed except Pelotas. The number of sites were different for each archipelago (n = 31 for Entrecasteaux, n = 47 for Fakarava Reserve) and per atoll (Fig. 1), as different priorities were given to different sites by the authorities, especially in French Polynesia where Fakarava was more extensively sampled (Andréfouët et al. 2019). More sites were also surveyed at Surprise and Huon atolls than on the other, smaller, Entrecasteaux atolls. The large differences in sampling effort between atolls prompted us to generally focus on the best sampled atolls and compare trends with simple descriptive statistics.

The census method used in both regions was the same as described in Andréfouët et al. (2019). In short, the daytime census was done at depths between 30 m and the shallowest part of the visited location. All observed sea cucumber individuals were counted during a one-hour dive that was staged by depth (5' several times at 30 m, 20 m, 10 m, 5 m, 2–0 m). Most of the stations were selected by the LOF scientific cruise director, who prioritised coral and fish surveys; hence, many stations were located on oceanic forereefs dominated by corals, which are not necessarily a prime habitat for sea cucumbers. However, we could complete lagoonal surveys as a separate team when possible, especially for Raraka, Fakarava, Surprise and Huon atolls. Hereafter, densities per species are provided per minute of search time, but a correspondence with densities per surface area is reasonably possible due to the surveyor's constant swimming speed and visual coverage (Andréfouët et al. 2019). Data collected (richness, densities per species or for all species pooled together) was reported per depth range, per habitat (forereef *vs* lagoon), per station,

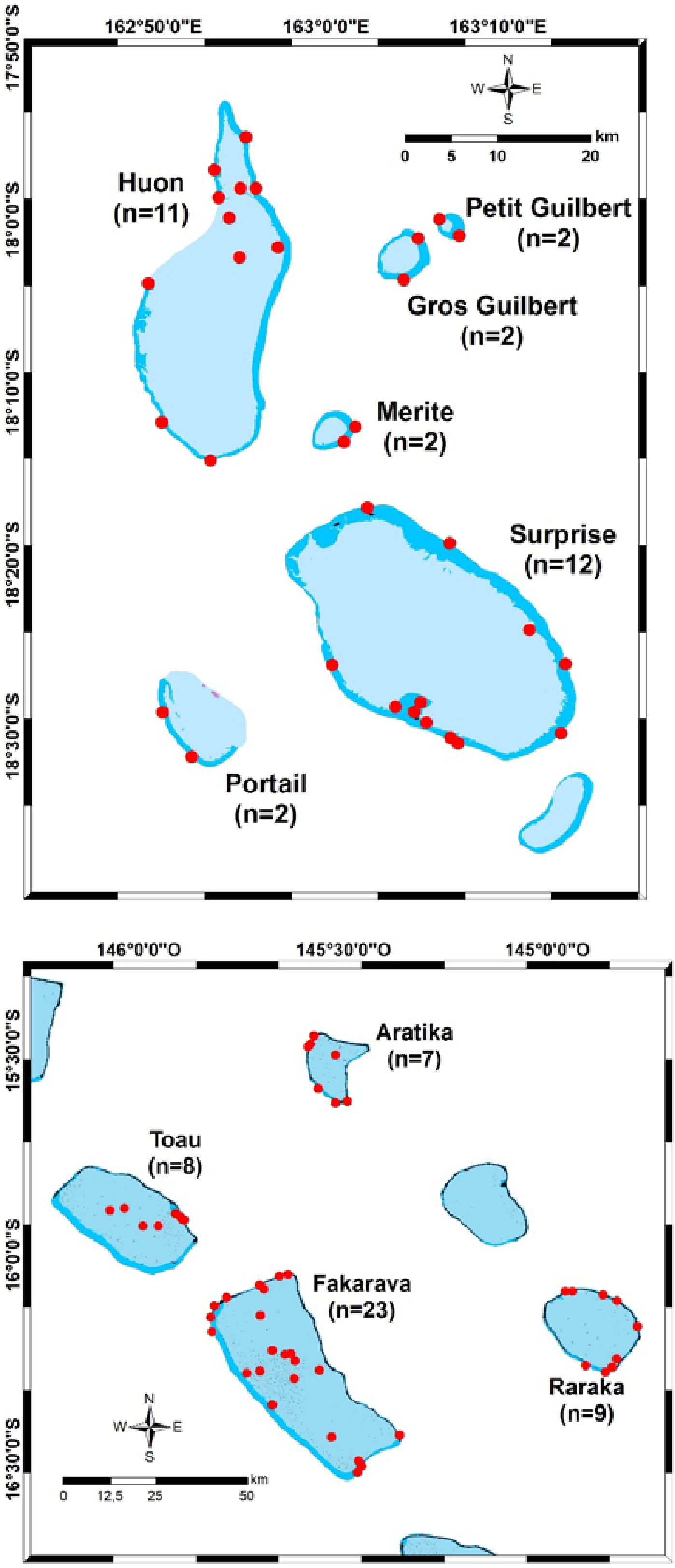

Figure 1. Study sites and survey locations. Top: The Entrecasteaux Group. Bottom: The four sampled atolls of Fakarava Reserve. n = the total number of stations per atoll (stations without any records are included).

per island, and per archipelago. Here, we focus on archipelago, island and habitat scales.

Species list considered here for the censuses was adapted to each location. French Polynesia species were *Holothuria fuscogilva, Holothuria whitmaei, Thelenota ananas, Thelenota anax, Actinopyga mauritiana, Stichopus chloronatus,* and *Bohadschia* spp. For Entrecasteaux, *Actinopyga miliaris* and *Holothuria fuscopunctata* also occurred. Similar to Andréfouët et al. (2019) who, for French Polynesia, pooled together all *Bohadschia* species for reasons of unsolved taxonomy, we did the same for New Caledonia for the sake of comparison and added together the records for *B. argus* and *B. vitiensis*. Small species such as *H. atra* or *H. edulis* were not censused systematically and their densities are not reported here, but these species were taken into account for the overall richness.

Results and discussion

In terms of richness, Entrecasteaux had more commercially valuable sea cucumber species (11) than Fakarava Reserve (8). Note that the prized *Holothuria scabra* and *H. lessoni* were not found during the surveys at either Entrecasteaux or Fakarava Reserve. These values are underestimations of the true richness, and other species have been reported elsewhere. Wantiez et al. (2013) for instance observed fewer species than here using a 50-m-long, transect-based protocol, but found different species (*Actinopyga palauensis, A. lecanora* and *Holothuria scabra*).

In Entrecasteaux, all 31 surveyed stations at Huon, Surprise, Mérite, Portail, Gros Guilbert and Petit Guilbert atolls had records of sea cucumbers (Figs. 2 and 3). At the scale of

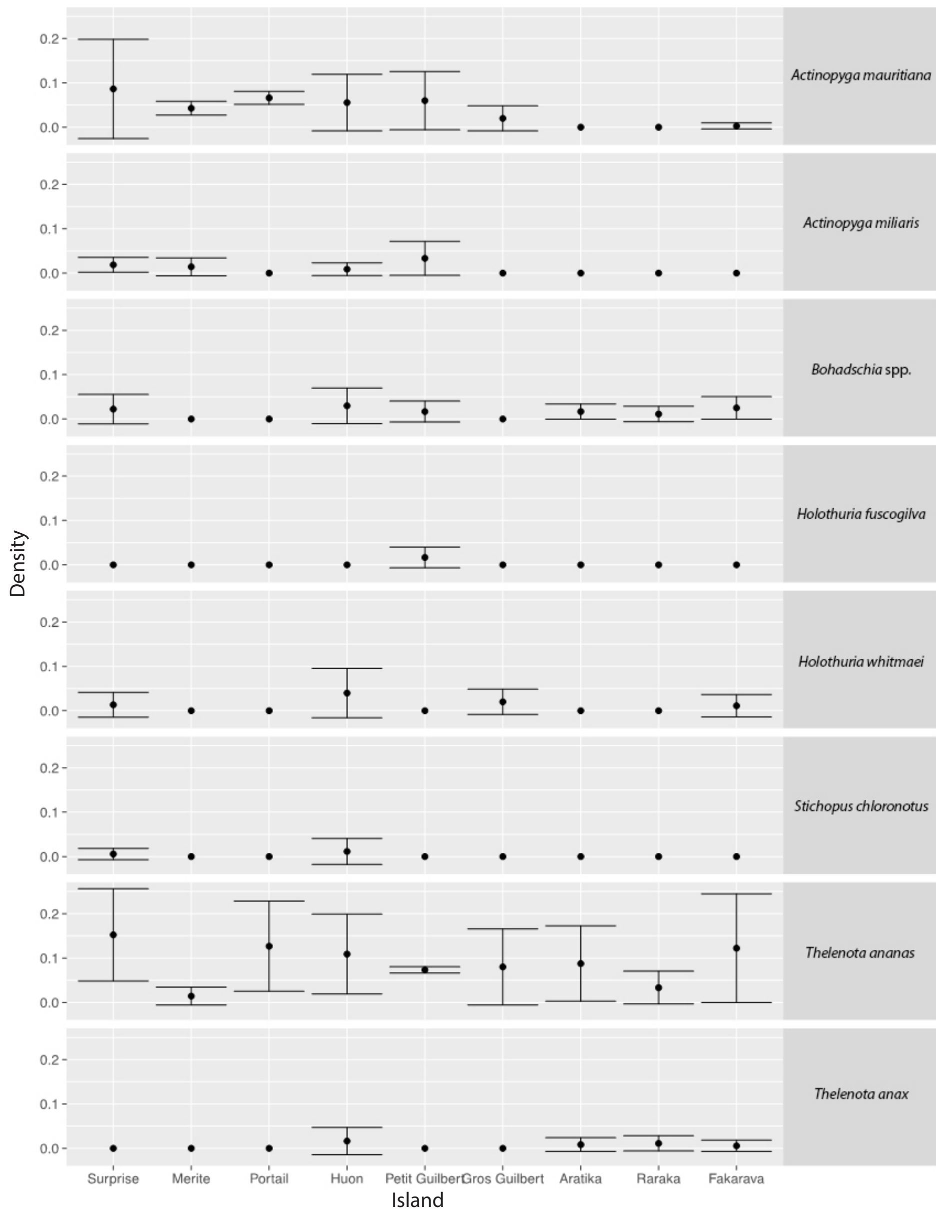

Figure 2. Density (in number of individuals per min, average ± standard deviation) per atoll, per species, and for ocean forereef stations for both the Entrecasteaux Islands and Fakarava Reserve.

the archipelago, the most frequently observed species was *Thelenota ananas* (with 142 records total), which was found on both forereefs and lagoons, especially at Huon, Portail and Surprise. *Bohasdschia* spp followed *T. ananas* in abundance, at 62 individuals. The average count per station, all species included, is provided in Table 1.

In the lagoons, *Bohadschia* spp. were more abundant than the most abundant species at Entrecasteaux (*Thelenota ananas*) (Fig. 3). Translated into density per surface area of suitable habitat, the timed-census data suggest a *Bohadschia* spp. density of 10.8 ind./ha at Fakarava Atoll *vs* 7.13 ind./ha and 5.94 ind./ha at Huon and Surprise atolls respectively, for *T. ananas.*

All species included, the densities were moderate at Entrecasteaux except for few remarkable dives at Surprise and Huon atolls (Figs. 2 and 3, Table 1). The highest scores were obtained for two lagoon stations at Surprise Atoll (47 and 39 individuals of all species) and one lagoon station at Huon (42 individuals of all species). In comparison, at Fakarava, four lagoon stations yielded 86, 74, 66 and 64 individuals. In Toau, three lagoonal stations provided 41, 48 and 78 individuals. Overall, the average abundance (all species included) found at both habitats (lagoon and oceanic forereef) are fairly similar between the two regions (Table 1). The average is slightly higher for Toau and Fakarava (22–29 individuals) than for Huon and Surprise (13–20 individuals), but much lower for all other sites. For all sites, standard deviations are high, highlighting the large differences from one habitat to another when pooling oceanic and lagoonal stations (Figs. 2 and 3, Table 1).

The highest numbers at several Tuamotu stations, due to the large number of *Bohadschia* individuals, can be explained

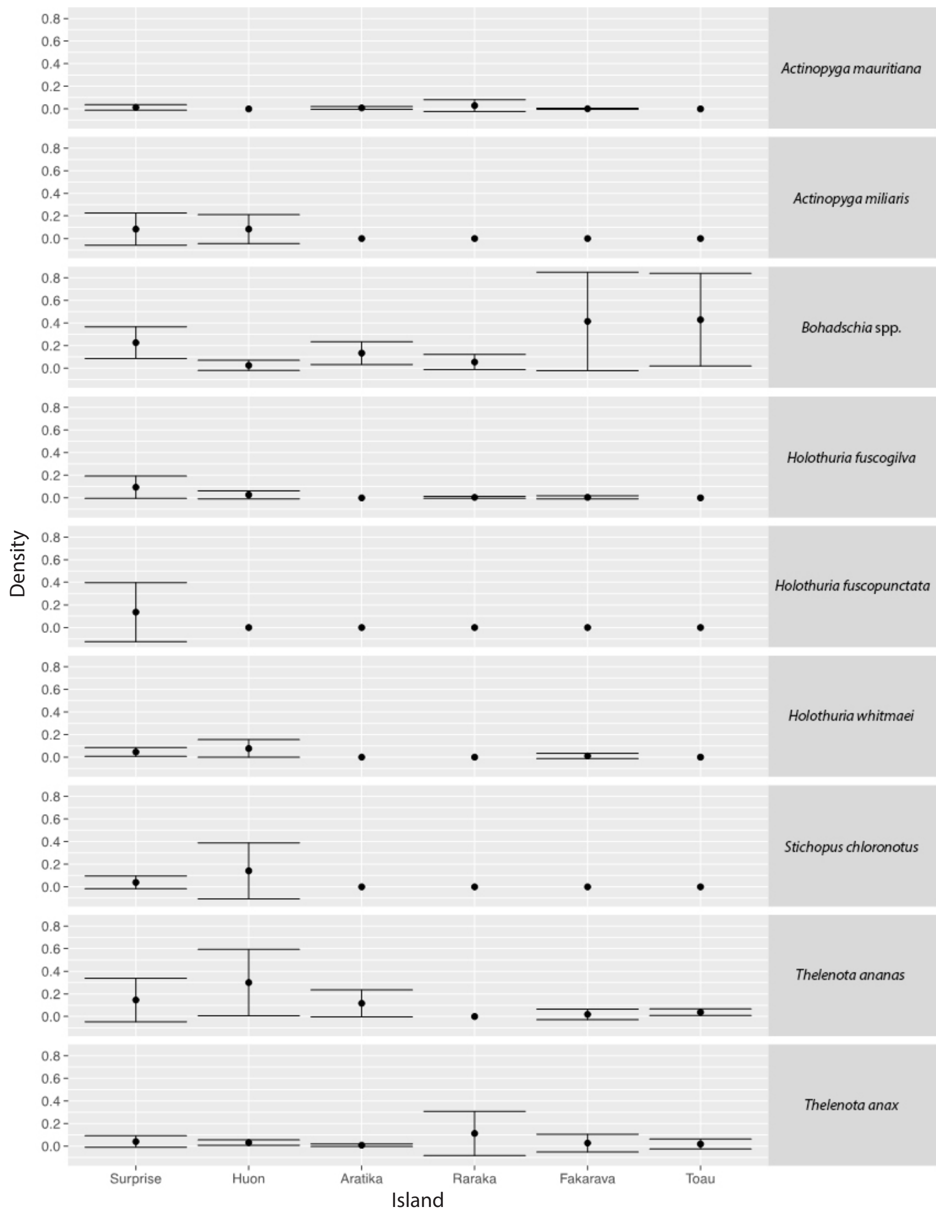

Figure 3. Density (in number of individuals per min, average ± standard deviation) per atoll, per species, and for the lagoon stations.

Table 1. Average count and standard deviation (all species included) per atoll, considering all stations with non-null records. n = number of stations.

Region	Atoll	Average count	Std. dev.	n
Entrecasteaux	Surprise	19.6	12.7	12
	Huon	13.6	12.2	11
	Portail	7.0	4.2	2
	Petit Guilbert	5.5	0.7	2
	Merite	3.5	0.7	2
	Gros Guilbert	3.0	2.8	2
Fakarava	Toau	29.1	26.0	8
	Fakarava	22.0	26.9	21
	Aratika	9.8	6.3	6
	Raraka	8.3	9.2	7

by the surveyed habitats. In the Tuamotu atolls, sampling often occurred around coral pinnacles, where the mosaic of soft bottom, rubble and hard bottom are favourable to *Bohadschia* species, especially *B. argus*. Conversely, at Huon or Surprise, lagoonal surveys were dominated by a sand bottom suitable for *B. vitiensis* (most often found buried in the sediments), but less attractive for *B. argus*. High density locations at Huon and Surprise included pavement bottoms used by *Thelenota ananas*.

Given the biogeographical differences and remoteness of the Entrecasteaux Islands, we expected to find higher densities there, but this was not necessarily the case. Only the expected highest species richness was confirmed. We assume that the long period of exploitation of the Entrecasteaux atolls by professional fishing was still impacting the census in November 2013, yielding densities comparable to recently fished areas in the Tuamotu. Seven years later, in 2020, resurveying the same locations should provide a better view of the natural population. This cannot, however, be fully guaranteed as the Entrecasteaux atolls have been significantly poached by the so-called Blue Boats from Viet Nam, which fish illegally in the waters of the Parc Naturel de la Mer de Corail, especially around Entrecasteaux. Between 2016 and 2017, up to 28 tonnes of illegally caught and unprocessed sea cucumbers were seized by authorities (Parc Naturel de la Mer de Corail 2017).

At Fakarava Reserve, fishing was authorised again in 2014, and fishers from Fakarava have been active every year at both Fakarava and Toau lagoons (Andréfouët et al. 2019, DRMM 2017). Raraka was also open to fishing, and Aratika remained unfished as before 2012. The differences today with the 2009–2012 period of fishing in French Polynesia is that fishing authorisations are subjected to a request made by a local atoll management committee, and that quotas are provided by the Direction des Ressources Marines, French Polynesia's fishery department. However, the exact status of resources is unknown, and no monitoring takes place. It is, therefore, strongly suggested to promptly assess sea cucumber stocks in both protected and non-protected areas of the MAB lagoons in the near future.

Conclusion

The UNESCO listings bring prestige and visibility to the awarded locations. It also brings responsibilities to local authorities and communities to maintain the environmental value of the sites. Here, we assessed the status of sea cucumber commercial species at two UNESCO-listed locations by comparing the Man and Biosphere Fakarava Reserve and the Entrecasteaux cluster of the Lagoons of New Caledonia World Heritage Area. These two areas are remarkable in that both include several atolls and include only these type of coral reef formations. The comparison of their sea cucumber commercial populations did not aim to establish a precise unbiased ranking of quality because the two areas are inherently different with regards to their biogeography, and because of the presence of people in the MAB reserve and not in Entrecasteaux. The two regions also have a different history of management regimes, exploitation and zoning plans. Sampling effort was also different at both locations, although we found that resource status appeared fairly similar overall, with variations related to present species and habitats. A main important conclusion is that, compared to many sites in the Pacific, these lagoons still harbour significant sea cucumber populations. This is good news, and even if the surveys were from 2012 to 2013, it is expected that the status remains positive in 2020 due to their protection and management. The two locations, however, have been fished since at least 2016: Entrecasteaux is exposed to international poaching, and several of the MAB atolls are legally fished every year. This exploitation, legal or illegal, calls for periodic re-surveying of holothurian populations.

Acknowledgements

We are grateful for the generous support of the Khaled bin Sultan Living Ocean Foundation that made this study possible. We also acknowledge the crew of the M/Y *Golden Shadow* and its scientific team, the mayors and people of the visited islands, as well as the authorities in French Polynesia and New Caledonia who authorised the expedition and delivered the research permits. French Polynesia's Direction des Ressources Marines (DRM) supported the surveys with several scientific divers. The following people helped during the surveys: Laureline Chabran-Poete (Institut de Recherche pour le Développement), Fabien Tertre (DRM), Gabriel Haumani (DRM), and Antoine Gilbert (volunteer).

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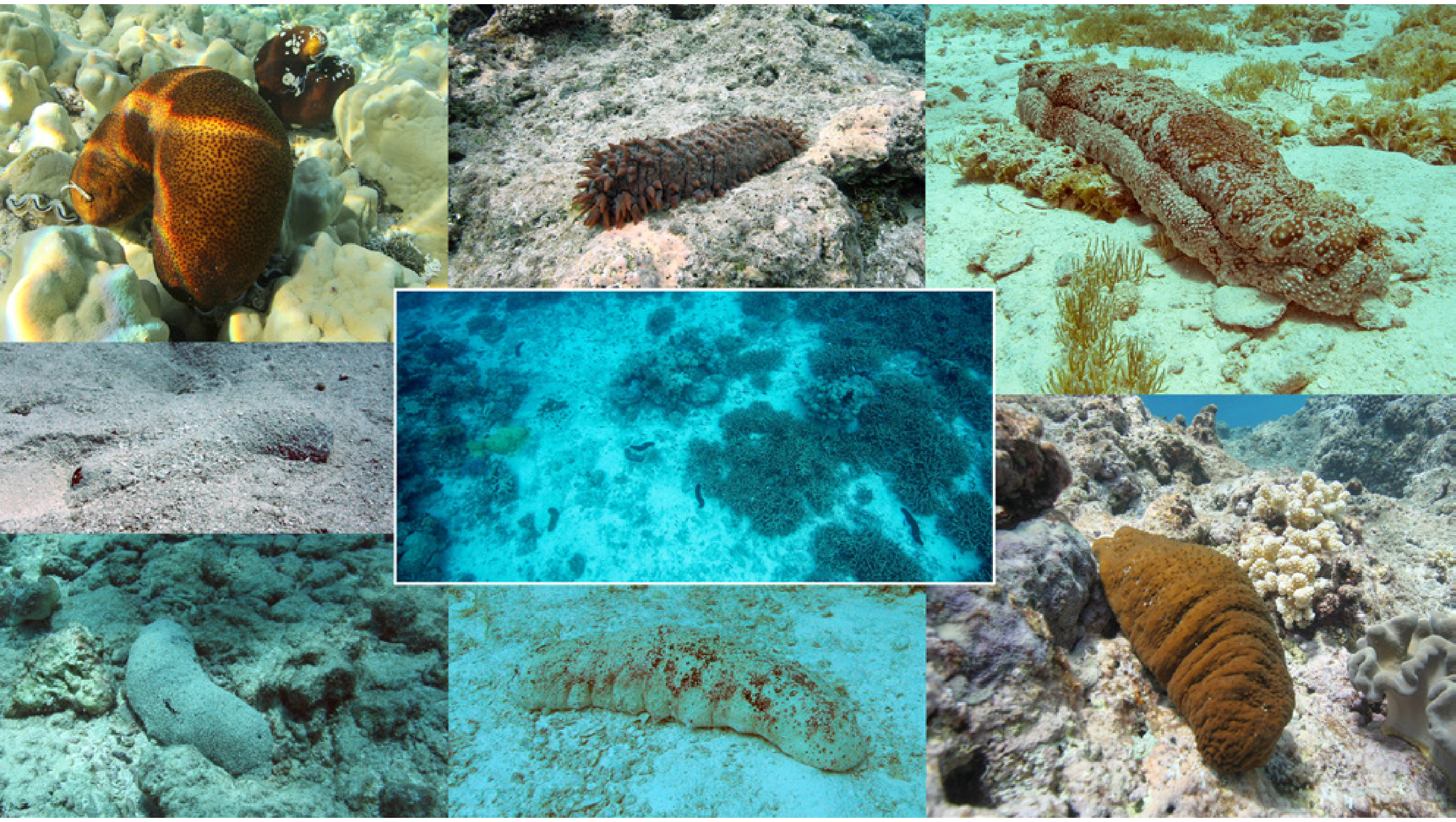

From top left, anticlockwise: *Bohadschia* sp. (Fakarava Atoll, French Polynesia), burrowed *Bohadschia vitiensis* (Surprise Atoll, New Caledonia); *Holothuria whitmaei* (Surprise Atoll, NC), *Holothuria fuscogilva* (Raraka Atoll, FP); *Actinopyga mauritiana* (Surprise Atoll, NC); *Thelenota anax* (Raraka Atoll, FP), *Thelenota ananas* (Huon Atoll, NC) - Center: Lagoon floor with numerous holothurian specimen visible (Huon Atoll, NC). (Images: Serge Andréfouët)

Impact of *Thalamita crenata* (Decapoda; Portunidae) predation on *Holothuria scabra* juvenile survival in sea farming pens

Igor Eeckhaut,[1,2,3*] Jacques Février,[1] Gildas Todinanahary[2] and Jérôme Delroisse[3]

Abstract

We evaluate the impact of predation by the crab *Thalamita crenata* on *Holothuria scabra* juvenile survival in a sea farming site in Madagascar where crab predation pressure is high. Three experiments were carried out: the first was conducted to estimate the survival of sea cucumber juveniles of different body masses when placed in open enclosures; the second compared the survival of juveniles placed in opened and closed enclosures; and the third evaluated the survival of juveniles when placed in the presence of crabs in closed enclosures. *Holothuria scabra* juveniles were of a body mass between 1 and 80 g. The results showed that predation by *T. crenata* is a key parameter to take into account when farming *H. scabra*. The seeding of juveniles at sea should be performed with large individuals weighing at least 30 g to avoid predation.

Introduction

Predation is one of the most important factors affecting the success or failure of sea cucumber farming. In the natural environment, newly released juveniles are attacked and eaten by different species of fish (Hamel et al, 2001; Pitt and Duy 2004), crabs (Pitt and Duy 2004) and shrimps (Pitt and Duy 2004). In Solomon Islands, during experiments with juveniles released in mangrove and seagrass habitats, the mortality of juvenile *Holothuria scabra* was mainly due to predation by fish in the families Balistidae, Labridae, Lethrinidae and Nemipteridae (Dance et al. 2003). Predation may lead to the disappearance of an entire stock of sea cucumbers in a very short period of time (Mercier et al. 2000a). The crab *Thalamita crenata* was found to be the most redoubtable predator of sea cucumbers in the Toliara region of Madagascar. Aside from the control of biotic parameters, the choice of adequate sites for building sea pens is one of the key parameters for ensuring the success of sea cucumber farming. In 2007, abnormal mortalities of juvenile *H. scabra* in sea pens were recorded by Lavitra et al. (2009) in Madagascar, while adults were unaffected. Only a few sea cucumber juveniles were found dead in the pens during the observation, and *Thalamita crenata* (Portunidae) were observed in abundance near and inside the pens. During several observations, Lavitra et al. (2009) found these crabs eating the newly transferred juveniles of *H. scabra*. Experiments in outdoor ponds showed that the crabs did not eat *H. scabra* when the sea cucumbers were fed daily. On the other hand, five crabs were enough to kill and eat 20 sea cucumber juveniles weighing, on average, 17 g within five days, and 10 juveniles of an average body mass of 54 g within 10 days when they were kept in external ponds without any food (Lavitra et al. 2009).

Some success in reducing predation of juvenile sea cucumbers released into the sea has been obtained with the use of cages to exclude large predators (Dance et al. 2003; Purcell 2004; Rougier et al. 2013). On the other hand, in experiments carried out in a sea cucumber farming site where there was a very low density of crabs, Lavitra et al. (2015) demonstrated that the use of covered sea pens is not necessary and that juveniles less than 5 g can be released in these sites with average survival rate between 78% and 84% after three months. Similar experiments made by Hair et al. (2016) in Papua New Guinea gave similar results and, contrary to expectations, short-term cage protection did not lead to higher survival rates.

The aim of the present work is to estimate the impact of predation by the crab *Thalamita crenata* on juvenile sea cucumber survival at a sea farming site in Madagascar where crab predation pressure is high.

Methods

Three types of experiments were carried out in the enclosures of the Belaza site located 20 km south of Toliara, Madagascar.

Experiment no. 1. The purpose of this experiment was to evaluate the survival rate of sea cucumbers of different body masses (i.e. wet body masses) when placed in open enclosures. The experiment lasted two months (June to July 2017) and used eight enclosures, each measuring 2 m^2. The walls of the enclosures were made of plastic netting that was embedded no less than 30 cm into the sea bed, and all enclosures were open at the top. Five to twenty sea cucumbers were placed in each enclosure, with their masses varying from one enclosure to another:

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- 20 sea cucumbers weighing 5–15 g (initial biomass of 100 g/m^2),
- 20 sea cucumbers weighing 15–30 g (initial biomass of 225 g/m^2),
- 15 sea cucumbers weighing 30–60 g (initial biomass of 338 g/m^2),
- 20 sea cucumbers weighing 60–100 g (initial biomass of 600 g/m^2),
- 10 sea cucumbers weighing 100–150 g (initial biomass of 625 g/m),
- 10 sea cucumbers weighing 150–200 g (initial biomass of 875 g/m^2),
- 5 sea cucumbers weighing 200–250 g (initial biomass of 563 g/m^2), and
- 5 sea cucumbers weighing 250–300 g (initial biomass of 688 g/m^2).

The number and condition of sea cucumbers were checked once a week. Sea pens were excavated to record all individuals, even those buried in the substrate. The number of wounded holothurians was recorded: The number of individuals with one or more ulcerations from a skin ulceration disease (SKUD) (Fig. 1A) and the number of individuals with a cut due to a crab attack were recorded (Fig. 1B).

Experiment no. 2. The purpose of this experiment was to compare the survival rate of juveniles placed in two different types of enclosures: 1) enclosures open at the top, and 2) enclosures closed by a net placed on top (Fig. 2). The disappearance of juvenile sea cucumbers in open enclosures is considered to be due to: a) crab attacks (mainly *T. crenata*), b) diseases (mainly SKUDs), and c) escapes (some individuals swell with water, thereby acquiring an overall density nearly equivalent to seawater, and are carried above the enclosures by currents). The disappearance of juvenile sea cucumbers in closed enclosures is considered to be due solely to diseases. The experiment lasted three months (June to August 2017), and used four enclosures that measured 2 m^2. Two open enclosures each contained seven individuals weighing 5–15 g, seven weighing 15–30 g, and seven weighing 30–50 g (two replicates). Two other enclosures that were closed on top each contained seven individuals weighing 5–15 g, seven weighing 15–30 g, and seven weighing 30–50 g (two replicates).

In order to check the tracking of the various calibres (i.e. body mass category), a red mark – specific to body mass – was drawn on each juvenile (Fig. 3). The red mark – which did not affect the health or behaviour of sea cucumbers – was water resistant for two weeks, and was refreshed once a week so that it was easily visible. Juveniles in sea pens were checked once a week.

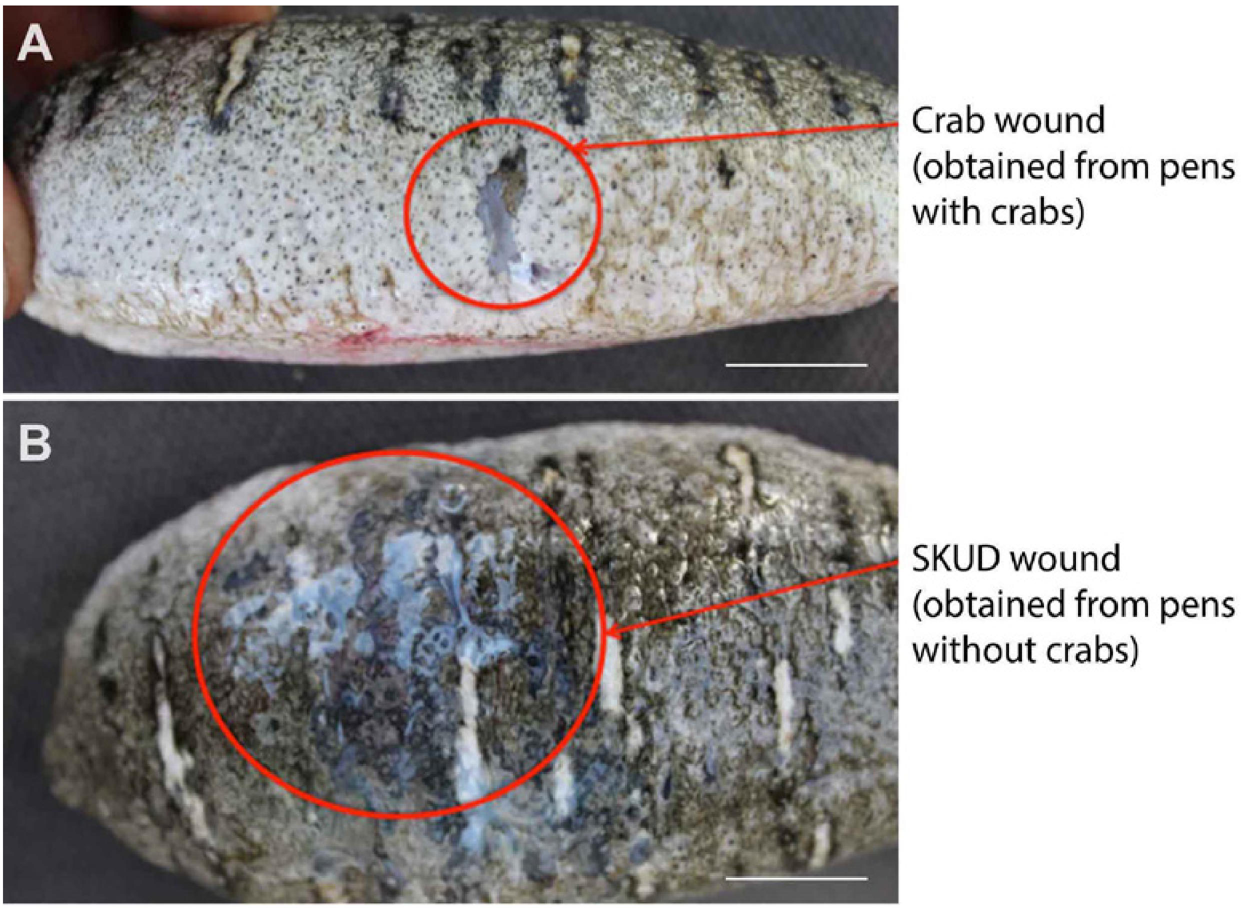

Figure 1. A) Wound due to an attack by *Thalamita crenata*, and B) ulcerations caused by a skin ulceration disease (SKUD).

Experiment no. 3. The purpose of this experiment was to estimate the survival rate of juveniles (of varying body masses) when they were released in the presence of crabs in closed enclosures. The experiment lasted about three weeks (in May 2017) and used 10 enclosures, each 2 m^2, with the tops closed. Twenty juveniles were placed in each enclosure, their body masses varying from one enclosure to another. Three enclosures had 20 juveniles weighing 5–15 g, another three enclosures had 20 juveniles weighing 15–30 g, and yet another three enclosures had 20 juveniles weighing 30–50 g, and one enclosure had 20 juveniles weighing 50–80 g. Two crabs (*T. crenata*) measuring 5 cm (i.e. width at the cephalothorax) were introduced into each enclosure.

Figure 2. Open and closed sea cucumber enclosures.

At each low tide (every 12 hours), sea pen covers were removed to count the number of juveniles (i.e. two observations each 24 hours). Like adults, juveniles of this size bury into the substrate; therefore, we had to sift through the sand to determine the number of actual juveniles present, and to check whether the two crabs were still there.

Results

Experiment no. 1. Figure 4 illustrates the percentage of individuals who survived in the pens after two months. We note that survival is positively correlated with body mass, and the survival rate varies from 43% to 100%, according to body mass categories ranging from 15–30 g to 250–300 g. Traces of crab attacks were visible only on individuals weighing less than 100 g, while traces of ulcerations due to SKUDs were visible in all weight ranges except on individuals weighing more than 250 g.

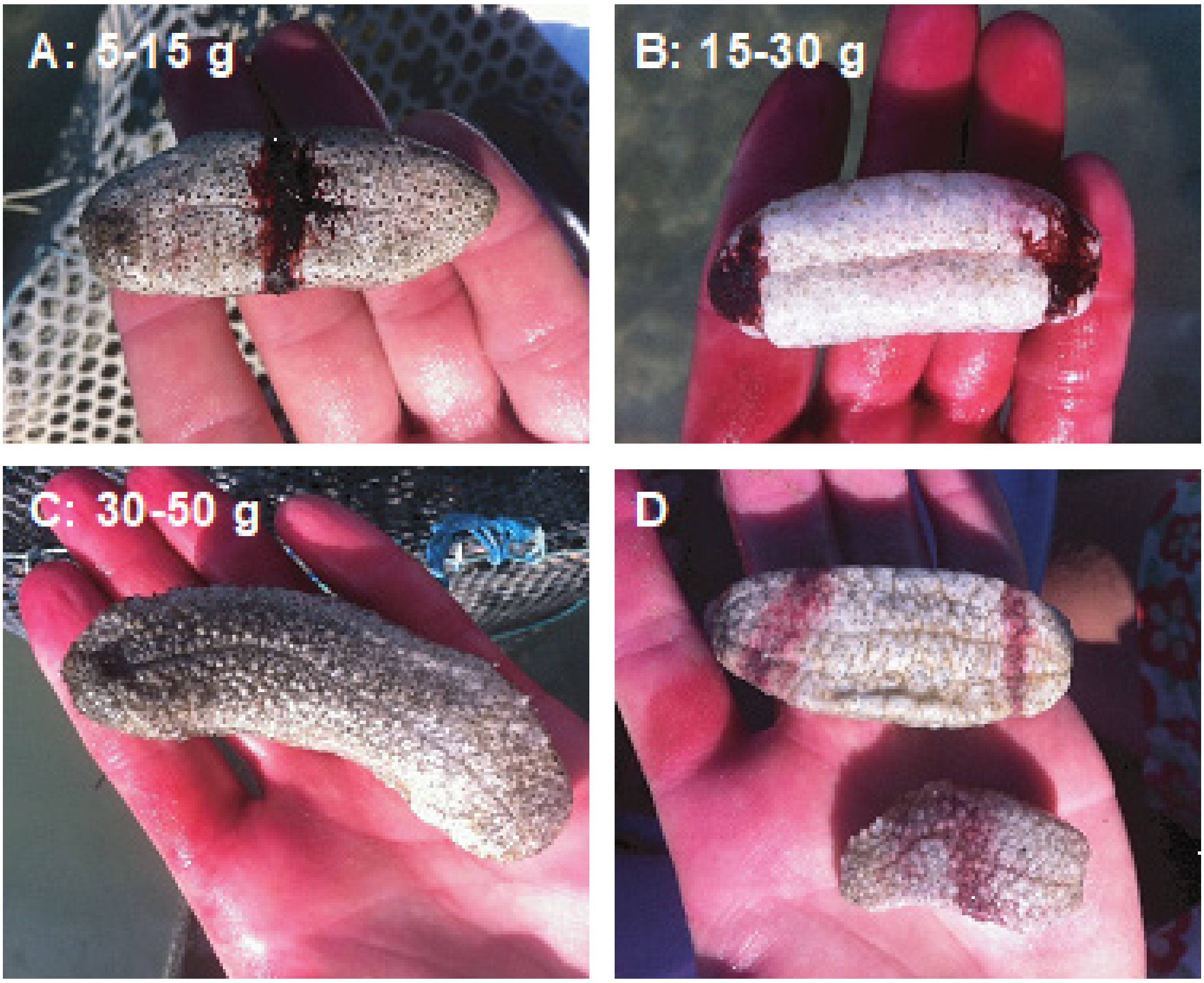

Figure 3. A-C: Red marks, specific to size and body mass category (A:5–15 g, B:15–30 g, C:30–50 g), were drawn on juvenile sea cucumbers. D: Resistance of neutral red staining after one week.

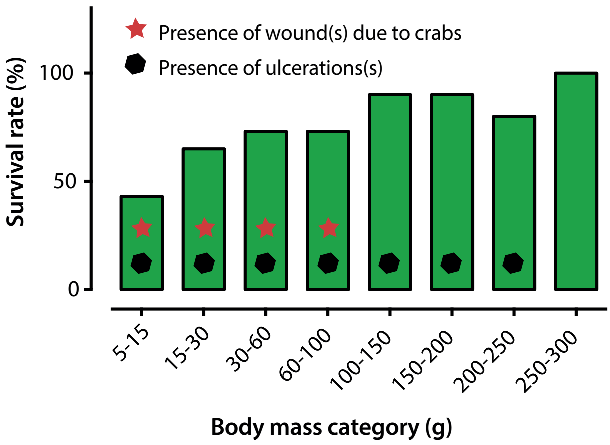

Figure 4. Survival of sea cucumbers of different masses when placed in open enclosures after two months (experiment no. 1). Additional observations of SKUD ulcerations and crab wounds are also presented.

Experiment no 2. At the end of the experiment, the survival rate of juveniles was higher when the enclosure was closed. When comparing open enclosures and closed enclosures, survival rates were 7% and 50%, respectively, for juveniles weighing 5–15 g (Fig. 5 A), 71% and 86%, and the survival rate for those weighing 15–30 g (Fig. 5 B) was 86%, and for juveniles weighing 30–50 g (Fig. 5 C) the rate was 93%.

Experiment no. 3. When juveniles were placed in the presence of crabs in closed enclosures, the survival rate was higher, at the end of the experiment, when juveniles had a higher mass. After 13 days, survival rates were 5% for the body mass category 5–15 g (Fig. 6 A), 35% for the category 15–30 g (Fig. 6 B), 48% for the category 30–50 g (Fig. 6 C) and 60% for the category 50–80 g (Fig. 6 D). The number of injured individuals was significantly higher for the first body mass category (5–15 g).

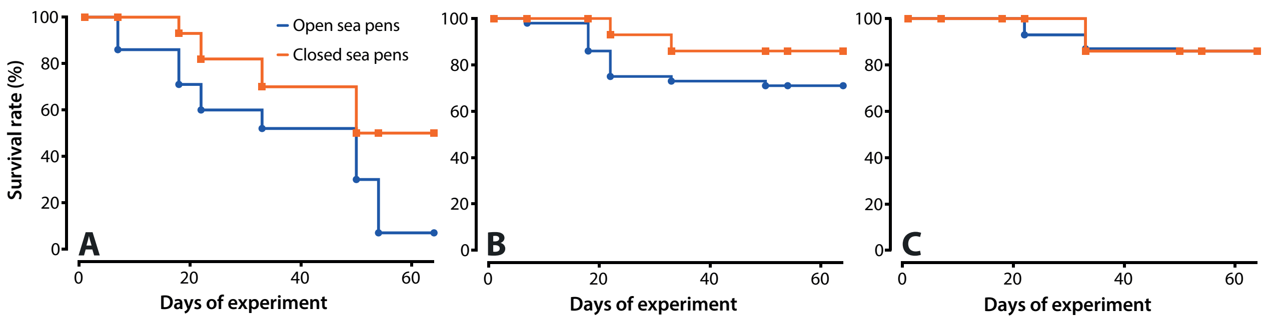

Figure 5. Survival rate of juveniles observed between open enclosures and closed enclosures, with juvenile body masses of A) 5–15 g, B) 15–30 g and C) 30–50 g.

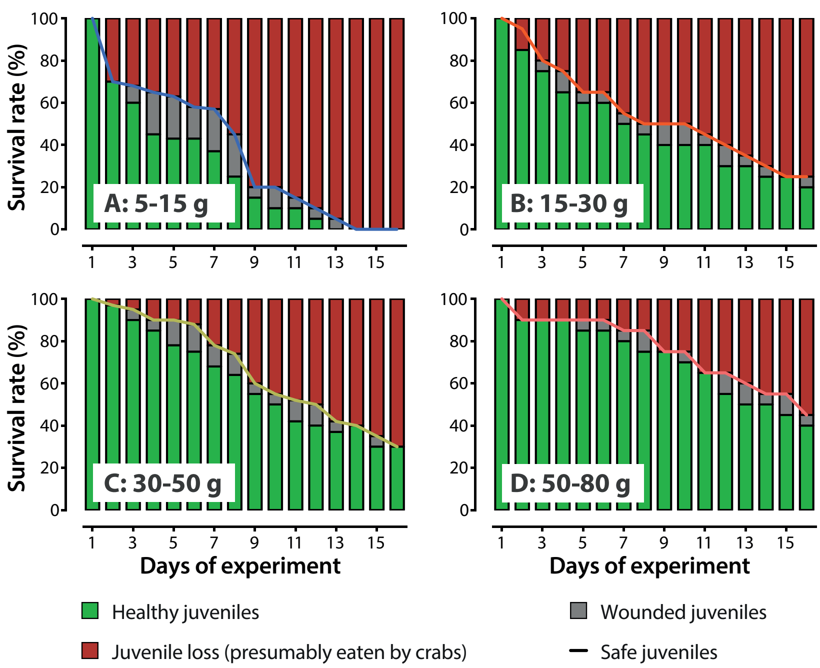

Figure 6. Survival rates of juveniles when placed in the presence of crabs in closed enclosures. Juvenile body masses were A) of 5–15 g, B) 15–30 g, C) 30–50 g and D) 50–80 g. Proportions of healthy (green), injured (grey) and missing (red) individuals are shown.

Figure 7 illustrates the linear projections of the survival rate for the four body mass categories of juveniles investigated during the experiment. The predicted death of all sea cucumber juveniles, due to the predation by *T. crenata* (density: 2 ind./m^2), occurred after 14, 21, 22 and 31 days for the body mass categories 5–15 g, 15–30 g, 30–50 g, 50–80 g, respectively.

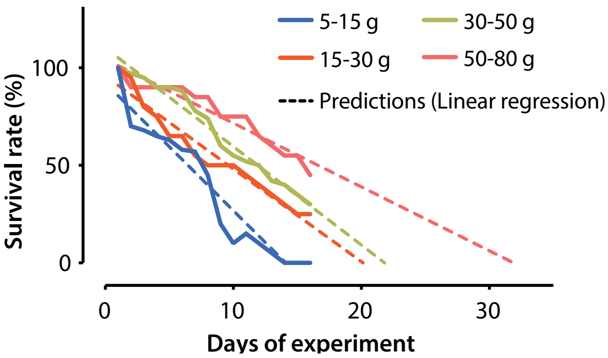

Figure 7. Linear projections of the survival rates of the four weight categories of juveniles based on the results of experiment no. 3.

Discussion

In his review of sea cucumber predators, Francour (2007) reported 76 different species, but none of these included *Thalamita crenata*. Crustaceans represent 22% of all such predators. In the southwest of Madagascar, *T. crenata* is the most significant predator of juvenile *Holothuria scabra*. *Thalamita crenata* is the mangrove swimming crab also called the crenate swimming crab or spiny rock crab. It is a swimming crab species distributed throughout marine and brackish waters of the Indo-West Pacific region. It is widely eaten in many countries. The gut content of a Kenyan *Thalamita* revealed that it is a generalist predator, its diet being mainly composed of bivalves and slow-moving crustaceans (Cannicci et al 1996).

Regarding *H. scabra* aquaculture, the experiments carried out clearly indicate that the size or mass at which juveniles are released into the sea considerably influences the survival rate of individuals and, *a fortiori*, the economic success of the activity. Our results show that the later the juveniles are released into the sea, the greater their survival rate is (experiment no. 1). Based on our results, the best option would be to release them when they reach a mass of approximately 100 g. Indeed, a survival rate of 90% was observed for this size category during our two-month experiment. The loss of juveniles is significantly higher when they are placed in the sea before they reach 30 g; in experiment no. 2, the survival rate reached a maximum of 65% after two months. A good compromise would be to release them when they reach a size of approximately 30 g. Reaching 30 g, however, requires them to be reared in a nursery pond for at least four months (after a hatchery development of three months). This, therefore, requires significant cost to build earthen ponds that will have an optimal density of 10–20 ind./m^2 (Lavitra et al. 2010). When juveniles reach 100 g, mortality is due to both SKUDs and crab attacks, while individuals over 100 g seem to be less affected by crab predation.

Our study also shows that the use of closed enclosures is useful when farming takes place in an area where *T. crenata* is present (experiment no. 2). The use of these closed pens is certainly essential if juveniles are released into the sea at a mass less than 15 g because the technique ensures that 43% of these juveniles will survive after two months. If juveniles are released at a mass greater than 30 g, the use of closed pens becomes less necessary because closed pens only ensure the survival of 7% of juveniles. In practice, in farms such as those in Madagascar where enclosures may be larger than 1 ha, it is impossible to keep all enclosures closed. It is, therefore, preferable to release larger juveniles (in terms of mass) and, if this proves difficult, to have small closed enclosures for recently released juveniles.

The third and final experiment confirms that *T. crenata* is a serious predator of sea cucumber juveniles and can affect the profitability of *H. scabra* farming. With a density of 1 crab/m2, all sea cucumber juveniles weighing less than 15 g are likely to be eaten within two weeks. The impact of this crab is also significant on juveniles over 50 g, and a linear projection suggests that in one month, these individuals could completely be wiped out due to predation by *T. crenata*. It is, however, important to note that all experiments were performed during the cold season (May–August 2018) and that a seasonal effect on global sea cucumber survival is not to be excluded. As observed in previous studies in the southwest of Madagascar, SKUDs are more present during the cold season (Lavitra et al. 2009; Eeckhaut et al. 2019).

In conclusion, predation by *T. crenata* is a parameter to take into account when developing *H. scabra* farming activities. The seeding of juveniles at sea should be done with large individuals weighing at least 30 g to avoid predation. This, however, requires an additional investment in the development of earthen ponds that accommodate juveniles before leaving hatcheries.

Acknowledgment

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Loggerhead sea turtle *Caretta caretta* found preying on a sea cucumber on a reef in Belize

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Abstract

The loggerhead sea turtle (*Caretta caretta*) is known to prey on slow-moving or sessile organisms. During annual surveys of queen conch (*Strombus gigas*) in southern Belize, the first direct visual documentation that sea turtles prey on sea cucumbers was obtained, confirming the limited evidence previously obtained from gut content analyses. An individual of *C. caretta* was observed at ~16 m depth in a habitat characterised by sand and coral rubble, with dispersed soft corals. It was seen swimming with a donkey dung sea cucumber (*Holothuria mexicana*) in its mouth, trying to bite and swallow it, releasing and picking it up again several times. Overfishing of sea cucumbers in Central America, the Caribbean and Mexico may have unknown consequences for protected species such as sea turtles, as the availability of this prey type is decreasing at an alarming rate. The present observation may also have implications for sea cucumber ranching facilities where sea turtles have often been observed.

Introduction

The loggerhead sea turtle *Caretta caretta* is an opportunistic generalist predator of slow-moving or sessile organisms such as seahorses, jellyfishes, sea pens, crabs, molluscs and tunicates (e.g. Parker et al. 2005; Plotkin et al. 1993). Despite existing reports of the presence of sea cucumber remains in the gut contents of loggerheads from Australia (Thompson 1980) and the central Mediterranean Sea (Casale et al. 2008), no direct evidence of predation by a sea turtle on a sea cucumber has been reported in the scientific literature. A recent review of the role of economically important sea cucumbers in food webs listed several specialist and opportunist predators but did not mention sea turtles (Purcell et al. 2016). Here we present the first direct photographic evidence of a sea turtle preying on a sea cucumber.

Methods

Monitoring took advantage of the annual queen conch stock assessment conducted by Reef Conservation International (ReefCI 2019). Mentionable behaviour in other groups of marine species were also recorded. The total area surveyed by scuba divers was ~600 m^2 at depths of 4–18 m. Each dive lasted about 40 min, during which two 2-m wide by 50-m long transects were surveyed in each of three sites per day, from 7 to 9 May 2018. In total, 11 sites were surveyed within the Sapodilla Cayes Marine Reserve in southern Belize. These annual surveys have been conducted at the same sites since 2004.

Results and discussion

On 8 May 2018 at 12:05 local time, an individual *C. caretta* was observed feeding on an adult sea cucumber (*Holothuria mexicana*) at a depth of ~16 m on Fore Reef in an area called Sandy Bomb (16° 6' 36.0" N 88° 7' 48.0" W), which is part of the Belize Barrier Reef. The seafloor there is characterised by sand and coral rubble with dispersed soft corals (Fig. 1). *C. caretta* was swimming with the sea cucumber in its mouth while trying to bite and swallow it (Fig. 1 a, b). It also released the sea cucumber and picked it up again several times. The white internal collagen tissue layer of the sea cucumber body wall (Fig. 1a) was seen to protrude underneath the shaved skin, as a result of successive bites. The whole event, from capture to ingestion, lasted about 2 min, after which the turtle swam away. Moreover, a similar observation was also made by sea cucumber fishers south of Sypio Caye (16° 27' 18.42" N and 88° 16' 54.78" W) around 10:00 local time on the 15 May 2015 (H. Saldivar, local fisher, pers. comm.).

Conclusions

The depletion of originally abundant sea cucumber populations through overfishing in Central America, Mexico and the Caribbean implies a progressive shortage of this easy prey (large and slow-moving) for sea turtles (Fitzpatrick et al. 2008; NMFS 2009), with as yet unknown cascading effects. On the other hand, sea turtles are often seen entering sea cucumber ranching facilities (pers. observ.). While predation on cultured sea cucumbers was never confirmed, the present note suggests that depletion of sea cucumbers from turtle feeding may be a valid concern for the industry.

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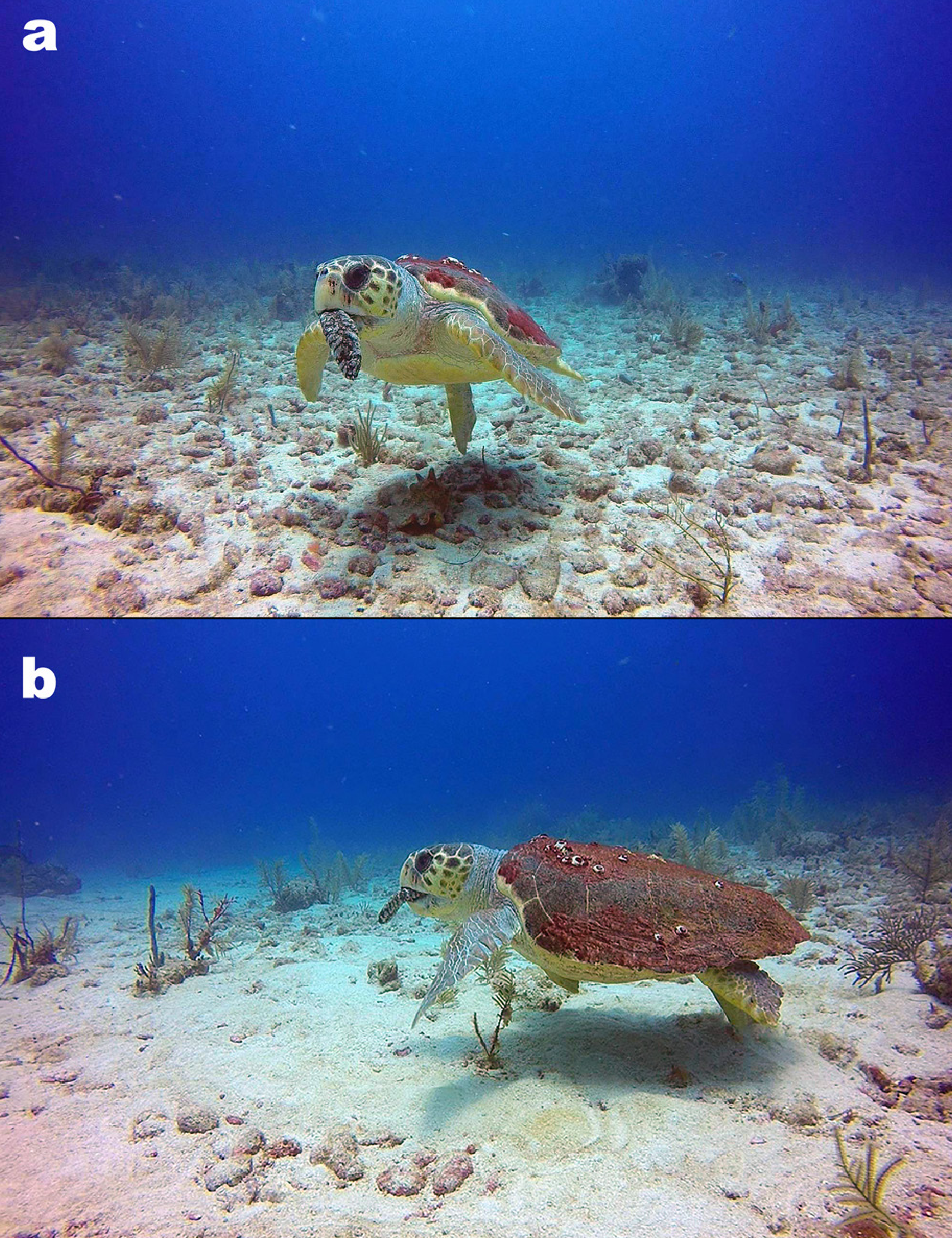

Figure 1a, b. The sea turtle *Caretta caretta* (~90 cm straight carapace length) feeding on the sea cucumber *Holothuria mexicana* (~15 cm total length) on Fore Reef in Belize. (Images: Willie Caal, ReefCI)

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Ectocommensals of the stichopodid sea cucumbers *Thelenota anax* and *Stichopus vastus* on the northern Great Barrier Reef

Steven W. Purcell,[1]* Alison Hammond[1] and Luka Meyers[1]

Abstract

Sea cucumbers can act as hosts for a wide range of commensal organisms, both externally (ectocommensals) and internally (endocommensals), but this role might vary among localities. We recorded ectocommensals on the body wall of *Thelenota anax* and *Stichopus vastus* at several coral reef sites around Lizard Island in the northern Great Barrier Reef. Few ectocommensals were found on either species, at any of the sites. Scaleworms were the most common epibiont on the sea cucumbers. Although studies at other sites have reported diverse and abundant commensal organisms on holothuroids, our study shows that the role of sea cucumbers as hosts might be minor at other localities. Further research across multiple localities is needed to better understand the ecological role of sea cucumbers in reef ecosystems.

Introduction

Offering protection, a potential source of food and displacement, sea cucumbers are a popular host choice for various commensal organisms (Lyskin and Britaev 2005; Purcell and Eriksson 2015; Caulier et al. 2012). Holothuroids host commensal organisms both externally and internally. Ectocommensal organisms of holothuroids are those living on the outer body wall of sea cucumbers, and include synaptid holothuroids, crabs, shrimps, ophiuroids, gastropods (mostly parasitic) and scaleworms (Polynoidae) (Eeckhaut et al 2004; Purcell and Eriksson 2015). Using the host animal as a vehicle, this diverse range of taxa can travel from one reef structure to another (Eeckhaut 2003). This can potentially aid the dispersal of ectocommensal animals and further enhance reef biodiversity.

At some localities, the number of ectocommensal animals on host sea cucumbers can be amazingly high (Purcell and Eriksson 2015). In other locations, the numbers of these "piggybacking" animals can be lower and quite variable (Lyskin and Britaev 2005). Sometimes, just one or two commensal organisms are found on the host holothuroid (Mercier and Hamel 2005).

As part of an ecological study of *Thelenota anax* and *Stichopus vastus*, we examined and recorded the incidence of ectocommensal animals on more than 60 hosts collected at several sites around Lizard Island on the northern Great Barrier Reef, Australia. This study provides the first focused examination of symbionts of these two holothuroids, and a further evaluation of the ecological role of holothuroids as hosts.

Methods

All fieldwork was undertaken at Lizard Island between 09:00 and 17:00 for 10 days in February 2019. Due to logistics and time constraints, no night-time observations were undertaken. The average seawater temperature was 29°C.

We collected *Thelenota anax* and *Stichopus vastus* from a range of depths (2–18 m) at five sites: Mermaid Cove, Palfrey Lagoon, Trawler Beach, Lagoon Bommie and Coconut Beach (Table 1). Body lengths of the host sea cucumbers were measured *in situ* with a ruler before placing them into labelled plastic bags. They were then taken to the surface, where they were allowed to drain off out of water for five minutes (following Skewes et al. 2004) and then weighed to the nearest 10 g using a digital hanging scale. During the draining period, sea cucumbers were checked for external commensal organisms, which were enumerated and recorded in major taxonomic groups. In total, 33 *Stichopus vastus* were examined and 30 *Thelenota anax* were examined.

Results and discussion

Body lengths of *Thelenota anax* ranged from 37 cm to 83 cm, and weights ranged from 2.0 kg to 7.2 kg. Body lengths of *Stichopus vastus* ranged from 29 cm to 48 cm, and weights ranged from 1.5 kg to 3.8 kg.

A small number of epibionts were found on *T. anax*, with an average of 1.3 commensal organisms per sea cucumber. The highest number was at Palfrey Lagoon, which was the shallowest site (Table 1). Scaleworms (Fig. 1) were the most prevalent commensal organism on *T. anax*, with an average of 1.1 per host across the three sites.

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Table 1. Average number of epibionts per host (*Thelenota anax* and *Stichopus vastus*) at five sites at Lizard Island, northern Great Barrier Reef, Australia.

Site	Species	Hosts (n)	Ophiuroids	Scaleworms	Gastropods
Coconut Beach	*T. anax*	11	0	0.2	0
Trawler Beach	*S. vastus*	11	0	0.2	0.1
Mermaid Cove	*T. anax*	7	0	1.7	0
Lagoon Bommie	*S. vastus*	11	0	0	0
Palfrey Lagoon	*T. anax*	12	0.2	1.5	0.3
Palfrey Lagoon	*S. vastus*	11	0	0.2	0.1

Figure 1. Scaleworms (Polychaeta: Polynoidae) on the dorsal (left) and ventral (right) body wall of *Thelenota anax* at Lizard Island, Australia. (Images: L: Alison Hammond; and R: Steven Purcell)

The overall number of epibionts on *S. vastus* was particularly low, especially in comparison with other holothuroid species in other locations. Purcell and Eriksson (2015) recorded 27 ± 40 commensals per *Stichopus herrmanni* host at one site in New Caledonia, the majority of which were ophiuroids. Only two epibiont animals, four scaleworms and two parasitic gastropods, were found in association with *S. vastus* in our study. None of the eleven *S. vastus* examined from the Lagoon Bommie site carried any visible symbiotic organisms.

Despite there being a multitude of ophiuroids on the surrounding sand at the Coconut Beach site, none of the *T. anax* that we surveyed at that location carried any brittle stars. The ectocommensal scaleworm found on *T. anax* and *S. vastus* is likely *Gastrolepidia clavigera* (Fig. 1),which is known to live on the surface of large holothuroids, including *T. anax* (Britayev and Zamishliak 1996; Martin and Britayev 1998). The average number of scaleworms on *T. anax* (1.5) is comparable with other studies, which have reported around 1.0 to 3.0 *G. clavigera* per host sea cucumber (Gibbs 1969; Britayev and Zamishliak 1996).

This study shows that ectocommensal animals can occur in low frequencies on sea cucumbers in some locations, such as Lizard Island, and that the number and diversity of epibionts are likely to vary spatially. The density of epibionts, however, does not appear to be simply due to location. A lower frequency of ectocommensals was observed for *S. vastus*. At one site in Palfrey Lagoon, where we found both species, *T. anax* was also inspected for epibionts at that site and at the same time as *S. vastus*. Our findings of low incidence of epibionts on *T. anax* and *S. vastus* call for further studies on the geographic and interspecific variation in the frequency of commensal organisms of holothuroids. Such studies will give further clarity to our understanding of their role in supporting biodiversity in marine ecosystems.

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The status of Algeria's sea cucumbers and their illegal trade

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Abstract

In Algeria, sea cucumber fishing is mainly done by divers and gleaners who target all holothurian species along the coast, especially the ones found in shallow water. To better understand how this fishery is organised, a survey took place from August to September 2018. Face-to-face interviews with fishers (gleaners and divers), members of coastal communities and local traders were carried out to gather detailed information on the fishery. In addition, an online survey was developed to allow stakeholders to respond anonymously. Seventy-eight responses were received from fishers and middlemen who were very familiar with the fishing and trade. These responses were received from 14 different *wilayas* (administrative areas) spread along the Algerian coast. The *wilaya* of Tipaza was found to be the most active in the fishery, followed by Mostaganem, Jijel and Algiers. Sea cucumber processing methods, sales and prices are also discussed, as well as, given the rapid development of the sea cucumber fishery, the urgent need for its effective management.

Key words: Sea cucumber, survey, illegal fishing, Algerian coastal waters

Introduction

Sea cucumbers are in high demand in Asian markets, mainly as a dried product called beche-de-mer (Purcell et al. 2018). Overfishing of sea cucumbers in many tropical countries has led to the capture of new target species from the Mediterranean Sea and the northeast Atlantic Ocean, such as *Holothuria tubulosa, H. poli, H. sanctori, H. arguinensis* and *Parastichopus regalis* (Gonzalez-Wangüemert et al. 2016; Neghli and Mezali 2019). The sea cucumber fishery is a minor activity in Algeria. Basic information on this fishery – such as the number of stakeholders involved, volumes caught and traded, and natural stock estimates – is lacking.

In Algeria, the law allows the collection of sea cucumbers, but not for commercial purposes (Order of 16 July 2008). The export of sea cucumbers is, therefore, illegal, which explains why so little information on the fishery is available. Nevertheless, illegal exports began in 2013 (Neghli and Mezali 2019) and this occurred following a growing Chinese presence in the country, which started in the early 2000s. This non-native population, fond of seafood and with contacts in China, and the main market for processed sea cucumbers, generated a high local demand for sea cucumbers. In response, a fishery developed along the entire Algerian coast before any monitoring or management plan could be put in place. The objective of the study described here was to collect information on the state of exploitation (catches, sales and processing) of sea cucumbers over 14 Algerian coastal *wilayas*.

Methods – Study area and survey

Our study was spread over 14 coastal *wilayas* (administrative divisions) along the Algerian coast: Tlemcen, Ain Timouchent, Oran and Mostaganem in the west; Chlef, Tipaza, Algiers, Boumerdes and Tizi-Ouzou in the middle; and Bejaia, Jijel, Skikda, Annaba and El Taref in the east. Our survey took place between July and September 2018 through face-to-face interviews with people involved in the sea cucumber trade (local traders, fishers and coastal communities). During our survey, we faced two main difficulties: 1) the reluctance or categorical refusal of the majority of fishers to answer our questions, and 2) the non-cooperation of the middlemen involved in the processing and export of the final product (i.e. beche-de-mer). For these reasons, we also developed an online survey in Arabic, the most spoken language in Algeria, which allowed people to respond anonymously.[2] It included questions such as: "Do you have a preference for a specific species of sea cucumber?" Responses allowed us to determine the most targeted species of sea cucumbers.

Results

Characteristics of the sea cucumber fishery in Algeria

In shallow infralittoral areas, holothurians are most often collected by hand and by free diving on soft or hard substratum. When sea cucumbers are no longer available at these shallow

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[2] https://forms.gle/71VWkx9cQPBBQ9XT9

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depths, fishers use small motorised boats to collect them at greater depths, using direct techniques (scuba diving), and/or indirect methods such as collecting bycatch (starfish) from fishers using demersal gill nets. In Algeria, professional and amateur fishers have long used sea cucumbers as fishing bait (Francour 1997; Mezali 1998). During our survey, we noted that longline fishers tended to replace their fishing bait of small pelagic fishes (e.g. sardines, horse mackerels, *Sardinella* spp.) and cephalopods (mainly squid) with juvenile, or parts of adult, sea cucumbers, due to the rising prices of these small pelagic fishes and cephalopods. We also noted that anglers prefer to use sea cucumbers to catch Sparidae (mainly the sea bream *Sparus aurata*), which are much appreciated in Algerian restaurants.

Most targeted sea cucumber species and sizes

All local sea cucumber species are targeted. Out of 78 respondents, 30% declared a preference for *Holoturia poli*, 27% for *H. tubulosa*, 25% for *H. arguinensis* and 18% for *H. sanctori* (Fig. 1).

Holothuria poli and *H. tubulosa* (Fig. 3A) are the most abundant sea cucumbers in Algerian waters. *H. arguinenis* (Fig. 3B) is a species originating from the Atlantic Ocean but recently reported as occurring in Algerian coastal waters by Mezali and Thandar (2014). *H. arguinenis* is highly valued for its thick body wall. *H. sanctori* (Fig. 3C and D) releases, soon after capture, Cuvierian tubules, which are sticky white threads that function as a defence mechanism. Once ejected, these tubules instantaneously stick to anything (such as hands of a collector) (Flammang 2006). This may explain why it is the least preferred of the four main species.

All sizes of sea cucumbers are targeted: small and medium-sized individuals are used as fishing bait, while medium and large individuals are sold and processed into beche-de-mer.

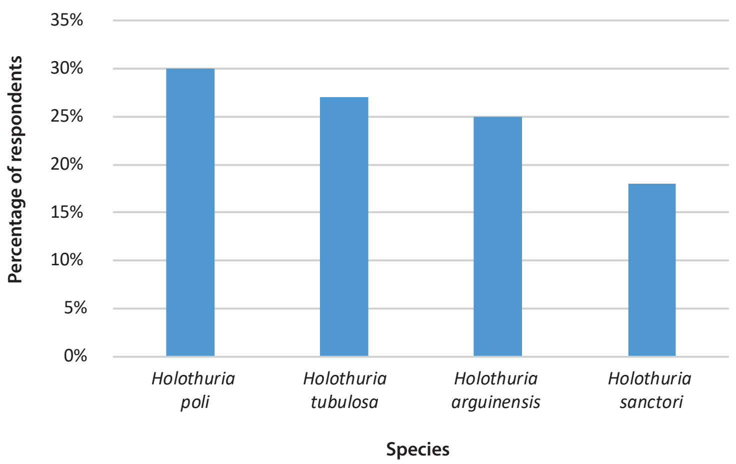

Figure 1. Fishers' preference for targeted species (in percentage).

Catch rates in the different wilayas

Sea cucumbers are fished all along the Algerian coast, but according to our survey, the best catch rates are obtained along the central coast (Tipaza and Algiers), followed by Jilel in the east and Chlef in the south (Fig. 2).

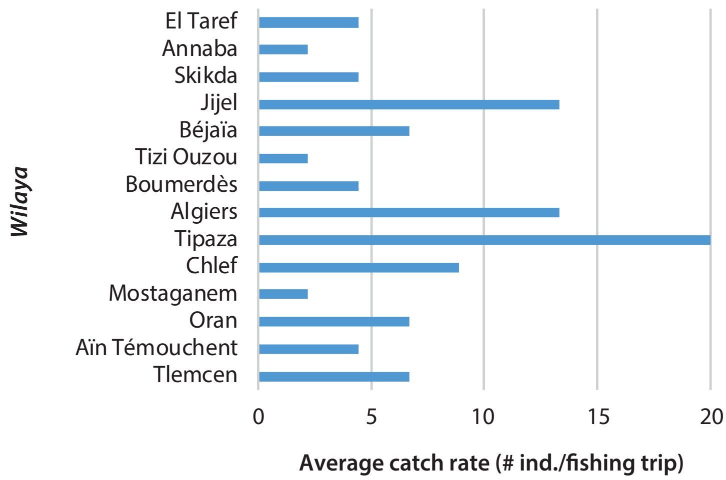

Figure 2. Catch rates (number of sea cucumbers collected per fishing trip) in each of the 14 surveyed wilayas.

Processing of sea cucumber catches in Algeria

Harvested sea cucumbers are usually kept in basins and stored in large quantities before their transformation into beche-de-mer by processors (Fig. 3).

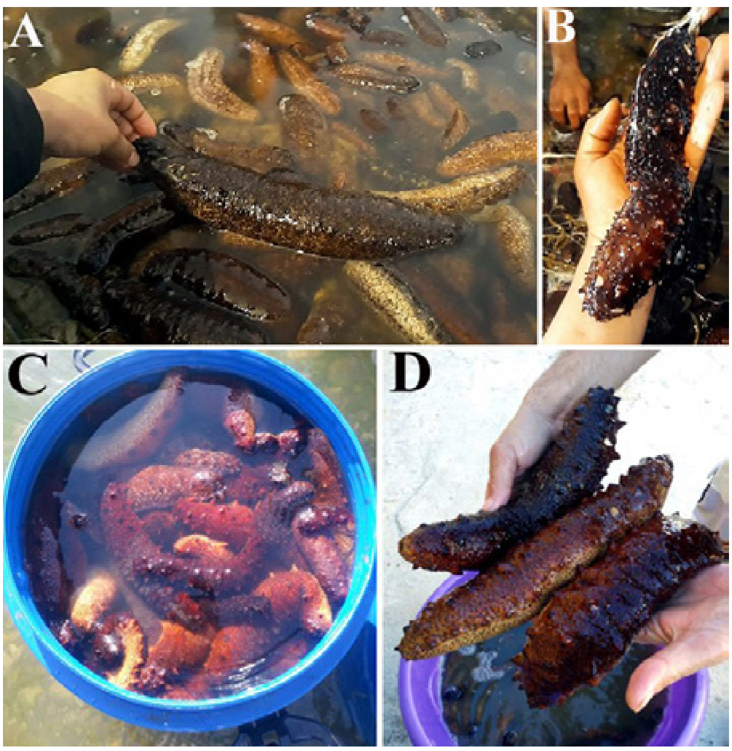

Figure 3. The processing of sea cucumbers: A) Individuals of different species kept alive in a basin. The processor is holding a specimen of *Holothuria tubulosa*; B) *H. sanctori*; C) Adult *H. arguinensis*; D) *H. arguinensis*. (Photos taken by a sea cucumber processor in Algiers, 2019)

According to our survey, 75% of harvested sea cucumbers are sold fresh to processors, but also to anglers as bait, and to Chinese nationals who reside in Algeria. Fishers are ignorant of the fate of these captured and sold animals. The remaining 25% is directly processed by fishers into beche-de-mer, using processing methods tailored to the targeted export market requirements. The most commonly used sea cucumber processing method involves: 1) evisceration, which can be done by the fishers themselves or by processors; 2) cooking in seawater for two hours; and 3) sun drying for six consecutive days or more. The duration of this last step depends on the season and geographical location. Some processors also salt and/or smoke sea cucumbers as a method of conserving them before drying and selling. These traditional methods of processing sea cucumber into beche-de-mer are the ones used in Algeria.

Sea cucumber trade and sale in Algeria

According to our survey, the selling price of sea cucumbers varies from one *wilaya* to another. Fresh animal prices vary from DZD[3] 200–700/kilo (EUR 1.5–5.9/kilo), while dried specimens (beche-de-mer) range in price from DZD 4800–12,000/kilo (EUR 36–90/kilo). Price also depends on demand for the product, its size, its availability and its destination.

Regulation of the sea cucumber fishery in Algeria

Algeria should be inspired by countries in the Pacific Islands region, where minimum sizes and seasonal closures of the fishery are commonly used measures to regulate the sea cucumber fishery (Kinch et al. 2008). In the hope of regulating sea cucumber exploitation, preventing overfishing and avoiding problems with customs (at the trade port), the administration in charge of the fisheries sector published two orders in the official newspaper of the Algerian Republic. The first (Order of 16 July 2008) to allow the collection of sea cucumbers by gleaning and by diving, but not to exploit them commercially because they are not listed in the National Plan of the Marine Biological Resources Regulation, which defines the minimum sizes allowed for commercially exploited resources (Neghli and Mezali 2019); and the second (Decree of 29 Ramadhan 1440, corresponding to 3 June 2019) to set a yearly 46-day closing period (from 1 August to 15 September) for sea cucumber fishing.

Unfortunately, the administration in charge of the fisheries sector does not collaborate with scientists and ignores the fisheries data they have already collected, as well as the scientific work (mainly on reproductive biology) they have already carried out and published in international journals (Neghli et al. 2013; Mezali and Soualili 2014; Mezali et al. 2014; Slimane-Tamacha et al. 2019). The 46-day closure, for example, only partially covers the breeding season of the various sea cucumber species present in Algerian waters.

Discussion

In Algeria, sea cucumber fishing is carried out mainly by hand in infralittoral waters, especially in shallow habitats of seagrass (*Posidonia oceanica*) meadows (Mezali 1998, 2004, 2008). This ease of access allows for intense fishing pressure in these areas, often leading to a local collapse of the most common sea cucumber populations. Fishers who collect sea cucumbers mostly sell them to processors or exporters. However, a survey conducted in the Algerian central region (Neghli and Mezali 2019) revealed the existence of a nascent network of fishers who process sea cucumbers into beche-de-mer by themselves. The depletion of sea cucumbers in shallow water areas of some Algerian *wilayas* has led to exploration of deeper zones. This spatial expansion has already been described for many tropical sea cucumber fisheries (e.g. Maldives, Philippines and Sri Lanka), where sea cucumbers catches first started manually near the coast before being done by diving or even trawling as shallow stocks diminished (Anderson et al. 2011).

According to the interviews we conducted with fishers in different Algerian *wilayas*, the sales price of fresh and dried sea cucumbers varies greatly from one *wilaya* to another and from one fisher to another. In some cases, it was difficult for us to know the exact selling price and destination of the final product due to the withholding of information by some traders. In general, it is estimated that, despite being the main actors in this illegal fishery, fishers are the ones within the market chain who benefit the least from the trade. The dry weight of the most properly processed sea cucumbers is 5–12% of their wet weight (Choo 2008). According to the information provided in our survey, the price of a dry processed sea cucumber is generally 17–24 times higher than the price of fresh (wet) sea cucumber. The majority of fishers do not master all of the steps of processing sea cucumbers into beche-de-mer. In fact, the only part of processing they master is evisceration, which brings very little added value to the product.

Furthermore, the lack of control over actual catches makes it difficult to develop analytical models to support the management of sea cucumber stocks. It is important to adopt a well-defined management plan to preserve this marine resource.

In order to manage sea cucumber resources in Algeria, several important measures must be taken. The development of guidelines for the management of natural stocks of sea cucumbers, and the monitoring of natural stock replenishment, are a priority. The management plan should also include the following measures:

1) Prohibit the collection of sea cucumbers during the breeding season of each species; the closing period should be extended (to June–September) or shifted (to July–August, rather than August–September) (Neghli et al. 2013; Mezali and Soualili 2014; Mezali et al. 2014; Slimane-Tamacha et al. 2019).

[3] DZD = Algerian dinars (DZD 100 = EUR 0.76 = USD 0.83, as of 12 February 2020)

2) Introduce a quota system.
3) Define minimum sizes for each species.
4) Create permanent protected areas in different *wilayas* along the Algerian coastline.
5) Issue fishing licenses to sea cucumber fishers.
6) Draft detailed datasheets, and make it mandatory for fishers, processors and traders to fill in and return these sheets to local fisheries authorities.
7) Train beche-de-mer processors to upgrade their skills.
8) Train all stakeholders who participate in the protection of coastal marine resources (e.g. coastguard officials, custom officers, fisheries directorate agents) in the proper identification of sea cucumber species exploited in Algeria, both in their live and dried forms, using illustrated guides and manuals.
9) Monitor all stages of the commercial sea cucumber trade in the country.

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Seasonal variation in food intake of *Holothuria* (*Roweothuria*) *poli* (Holothuroidea: Echinodermata) of Stidia in Mostaganem, Algeria

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Abstract

A study of the diet of *Holothuria poli* from the southwestern Mediterranean Sea (Stidia, Mostaganem) was carried out at a depth of 3 m during four seasons in order to gain an idea of the variation of the different trophic sources used and appreciated by this sea cucumber species. *H. poli* feeds on plants and animals, although diatoms constitute its most consumed food source. *H. poli* consumes large amounts of cyanophyceae in summer and algae in spring. The dead or living leaves of the seagrass *Posidonia* are also part of the diet of *H. poli*, but only in small proportions. In terms of animals consumed, foraminifera constitute the most important resource. A relatively large amount of sponge fragments, however, was observed in the digestive tract of *H. poli.* In addition, crustaceans are widely consumed in spring while nematodes and bivalve mollusc fragments are less consumed.

Key words: *Holothuria* (*R.*) *poli,* selective feeding, diet, seasonal variation, *Posidonia* meadow, Algeria

Introduction

Sea cucumbers play an important role in the recycling of organic matter within the food web of the *Posidonia oceanica* ecosystem (Zupo and Fresi 1984; Uthicke and Karez 1999; MacTavish et al. 2012). During feeding, these deposit-feeder organisms collect sediments with their tentacles to extract organic matter. The collection is done selectively with respect to the richness of organic matter particles (Mezali and Soualili 2013; Belbachir et al. 2014), which could be a strategy for ecological niche partitioning between different sea cucumber species. *Holothuria poli* (Delle Chiaje, 1824) is the most abundant holothurian in Algerian coastal waters (Mezali 2008; Belbachir 2018). The sediment ingested by this species consists mainly of inorganic matter (coral detritus, skeletons of marine organisms and benthos inorganic remains), detrital organic matter (marine plants, algae, decaying or dead animals) or microorganisms (bacteria, diatoms, protozoa and cyanophyceae) (Massin 1982; Moriarity 1982; Gao et al. 2014). Physical selectivity (size of sedimentary particles) and chemical selectivity (organic matter) of *H. poli* have been discussed for Algerian coastal areas (Mezali et al. 2003; Mezali and Soualili 2013; Belbachir et al. 2014) but data on the seasonal variations of its diet are lacking (Mezali et al. 2003). The aim of the present paper is to present a study of the diet of *H. poli* over the four seasons.

Methods

Ten individuals (20-cm long on average, contracted length) of *H. poli* and the uppermost millimeters of the sediment were collected during each of the four seasons (summer and autumn 2016, winter and spring 2017) at Stidia (35°49'N / 0°01'W) on the southwestern Algerian coast (Fig. 1). This site is located between two great commercial harbours (Mostaganem and Arzew), which are considered to be two potential pollution sources (Belbachir 2012). The seabed at Stidia is mainly composed of a succession of rocky and sandy substrata. The seagrass meadow (*Posidonia oceanica*) in the area is considered to be of type II (dense meadow, 400–700 plants/m^2), according to the classification by Giraud (1977). The fauna at the sampling site is mainly represented by echinoderms (*Ophioderma* sp. and *Paracentrotus lividus*), sponges, crustaceans (*Chthamalus* sp. and *Pachygrapsus* sp.), molluscs (*Littorina* spp. and *Patella* spp.) and fishes (*Coris* sp., *Diplodus* spp., *Serranus* spp. and *Sarpa* sp.) (Belbachir 2012). Flora is mainly represented by red algae (*Corallina* spp.), green algae (*Ulva* spp., *Caulerpa* spp.) and brown algae (*Padina* sp. and *Cystoseira* spp.) (Belbachir 2012). The invasive alga *Caulerpa racemosa* has also been present at Stidia since 2009 (Bachir Bouiadjra et al. 2010). This species has a hard body covered with a thin layer of sand (Mezali 2008), and inhabits detrital bottoms and *Posidonia* seagrass (Francour 1984; Mezali 2004).

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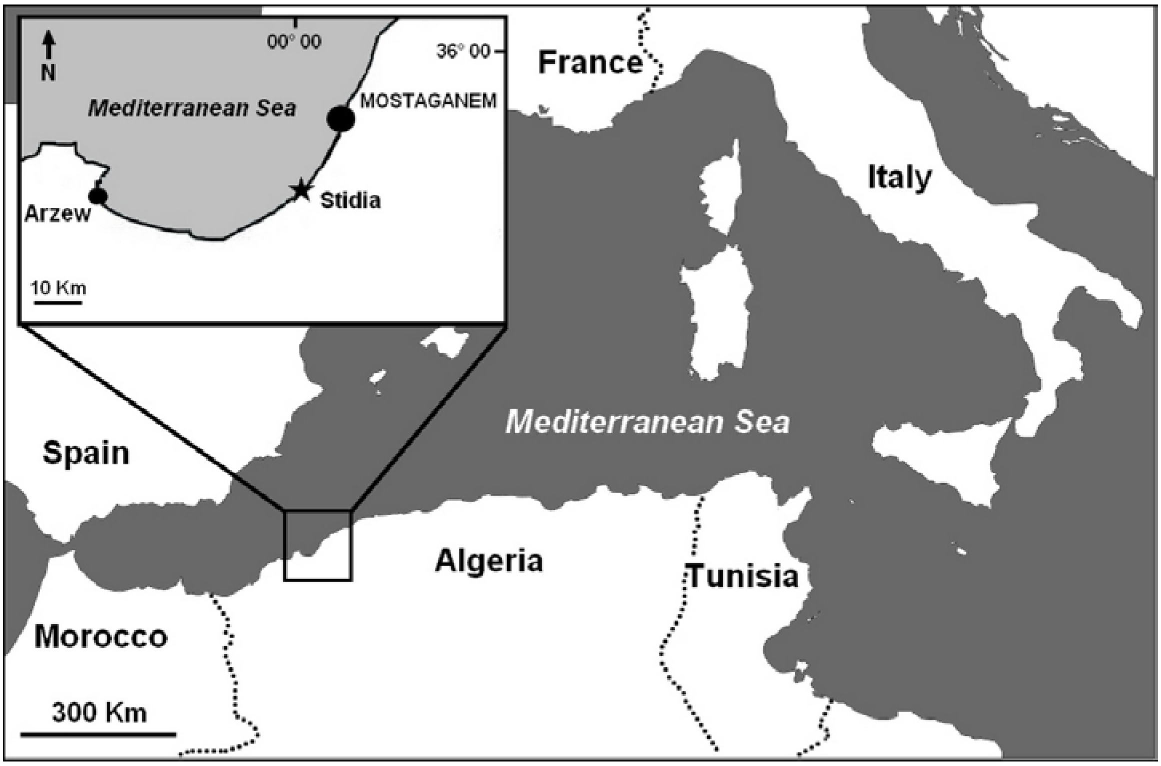

Figure 1. Geographical location of Stidia (star) where samples of *Holothuria poli* were collected.

Each specimen of *H. poli* and each sediment sample originating from the biotope collected were isolated in a plastic bag containing seawater for further processing. In the laboratory, each individual was dissected and the digestive tract content carefully collected for microscopic observations. The method developed by Jones (1968) and later modified by Nedelec (1982), was used for the digestive content analysis (see Belbachir and Mezali 2018). This method was also used for the sediment (holothurian biotope) analysis. Holothurian selectivity in food choice was studied by calculating the Ivlev electivity index $E' = (ri - pi) / (ri + pi)$, where ri is the ratio of a food item in the digestive content, and pi is the ratio of the same food item in the sediment (Ivlev 1961; Belbachir and Mezali 2018). Permutational multivariate analysis of variance (PERMANOVA) (Anderson 2001) was carried out using R v3.4.1 software (R Core Team 2017) to test the dissimilarity of the diet of *H. poli* during the different seasons.

Results

Seasonal variation of trophic resources

Summer

During summer, diatoms and cyanophycea are the most consumed vegetal components (30.7% and 14.7% of the diet, respectively) (Fig. 2). Macrophytes algae (mainly coralline) comprise 5.3% of the diet; dead and live leaves of *Posidonia* comprise 4.7% and 0. 7%, respectively (Fig. 2). The animal portion of the diet is mainly composed of foraminifera and sponge fragments (16.7% and 12.0%, respectively) (Fig. 2). Crustaceans, nematodes and bivalve mollusc fragments represent 5.3%, 5.3% and 2.0% of the diet, respectively (Fig. 2).

Autumn

During autumn, the vegetal component of the diet of *H. poli* is composed of diatoms (26.7%) and algae (10.0%), followed by cyanophycea (2.0%). The leaves of *Posidonia* (live or dead) are absent (Fig. 2). For the animal component of the diet, foraminifera is dominant (20.0%), whereas sponge fragments, crustaceans, nematodes and bivalve mollusc fragments are only present in small proportions (6.7%, 6.0%, 6.0% and 5.3%, respectively) (Fig. 2).

Winter

In winter, diatoms, cyanophycea and algae are the dominant vegetal sources at 31.1% 10.0% and 9.3%, respectively (Fig. 2). The dead and live leaves of *Posidonia* are present in low proportions (2.7% for the two items) (Fig. 2). Sponge fragments are highly represented in the gut during this coldest season of the year (17.9%) (Fig. 2). Animal sources, such as foraminifera, bivalve mollusc fragments, crustaceans and nematodes make up a small portion of the diet (6.6%; 4.1%, 4.0% and 1.3%, respectively) (Fig. 2).

Spring

In spring, diatoms are clearly dominant in the diet (38.0%), followed by algae (14.7%) (Fig. 2). Cyanophycea, live and dead *Posidonia* leaves represent 6.0%, 2.0% and 1.3% of the diet, respectively (Fig. 2). The animal component of the diet is mainly composed of foraminifera (14.0%) and crustaceans (13.3%) (Fig. 2). Sponges and nematodes represent only 2.0% and 1.3% of the diet, respectively, while bivalve mollusc fragments are not consumed during this time of year (Fig. 2).

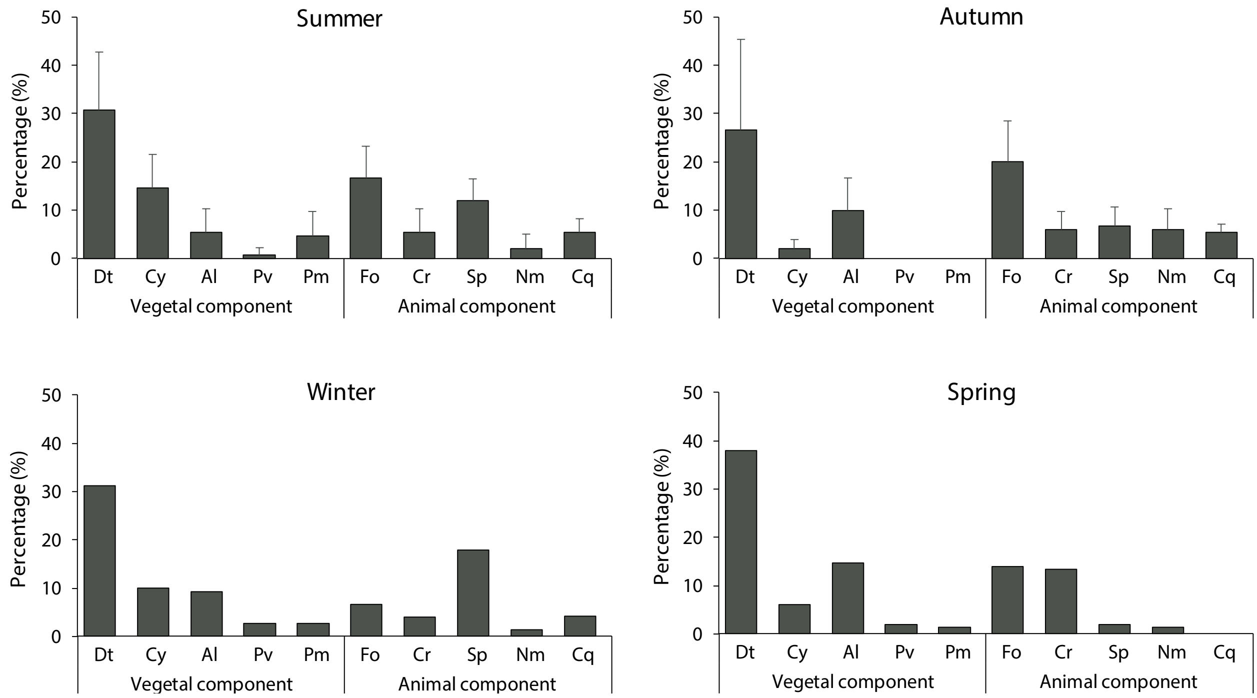

Figure 2. Seasonal variation (in percentage of diet components) of the different trophic sources of the diet of *Holothuria poli*. Dt: diatoms; Cy: cyanophyceae; Al: macrophytes algae; Pv: live Posidonia leaves; Pm: dead Posidonia leaves; Fo: foraminifera; Cr: crustaceans; Sp: sponge fragments; Nm: nematodes; Cq: bivalve mollusc fragments.

Selective behaviour towards food sources

PERMANOVA reveals a difference in diet between the four seasons ($P<0.001$). Although diatoms are dominant throughout the year, this food source is hardly selected in winter and spring (*E'* = 0.1) by *H. poli* and is avoided in summer and autumn (*E'*<0) (Fig. 3). The dead leaves of *Posidonia* are consumed during most seasons, and is sometimes the most preferred (*E'* = 0.6 in summer) (Fig. 3). Live *Posidonia* leaves are also consumed throughout the year, with the highest electivity index for this trophic source in spring (*E'* = 0.4) (Fig. 3). Algae and cyanophycea were also consumed, and the maximum electivity index for algae (*E'* = 0.3) was obtained in summer, while th maximum index for cyanophycea (*E'* = 0.5) was obtained in the spring (Fig. 3). Sponge fragments are a slightly preferred component of the diet, and the electivity index reaches its maximum values in summer (*E'* = 0.2, Fig. 3). Foraminifera show a negative electivity index throughout winter and spring (*E'* = -0.3 and -0.4, respectively), with the highest value obtained in summer and autumn (*E'* = 0.1, Fig. 3). Except during summer, *H. poli* preferentially consume crustaceans; the most important electivity index is obtained in autumn and spring (*E'* = 0.3 for both seasons) (Fig. 3). *H. poli* also preferentially consumes nematodes in autumn (*E'* = 0.3) and winter (*E'* = 0.2) (Fig. 3), although this food source is poorly represented in the gut contents.

Discussion

Food sources for *H. poli* are very diverse and their respective roles vary with seasons. The Ivlev electivity index reveals that diatoms are avoided in summer and autumn, although paradoxically, they still constitute the highest portion of the food content in the digestive tract of *H. poli,* which is probably due to their high availability in the environment during certain periods. In fact, nutrients originating from fertilisers used in agricultural areas adjacent to Stidia could be the reason for the high availability of diatoms. In spring, *H. poli* prefers photosynthetic organisms such as algae, diatoms and live *Posidonia oceanica* leaves. The high rates of diatoms and algae found in the digestive contents of holothurians was also reported by Sonnenholzner (2003) for *Holothuria theeli* from the Gulf of Guayaquil (Ecuador). The consumption of dead *Posidonia* leaves by detritus-feeders has been reported in the literature (e.g. Buia et al. 2000; Walker et al. 2001); this could have a significant impact on the primary production transfer from *Posidonia* plant. In fact, the litter biota mainly composed of dead leaves of *Posidonia* is an important source of organic matter for communities living in seagrass beds (Walker et al. 2001); it is even the main pathway for the organic matter transfer from *Posidonia oceanica* meadow (Cebrian et al. 1997). The consumption of live *Posidonia* leaves by *H. poli* is interesting as few marine animals consume them. In autumn, *H. poli* concentrates more on the animal component of its food sources, particularly on foraminifera and to a lesser degree on crustaceans, bivalve mollusc's fragments, and sponge fragments. Holothurians tend to change their food preferences according to seasons, and this is probably due to the availability of food items and their nutritional qualities. From our results, we think that *H. poli* exhibits a feeding plasticity in response to food items and their availability, which suggests that this sea cucumber is a generalist species.

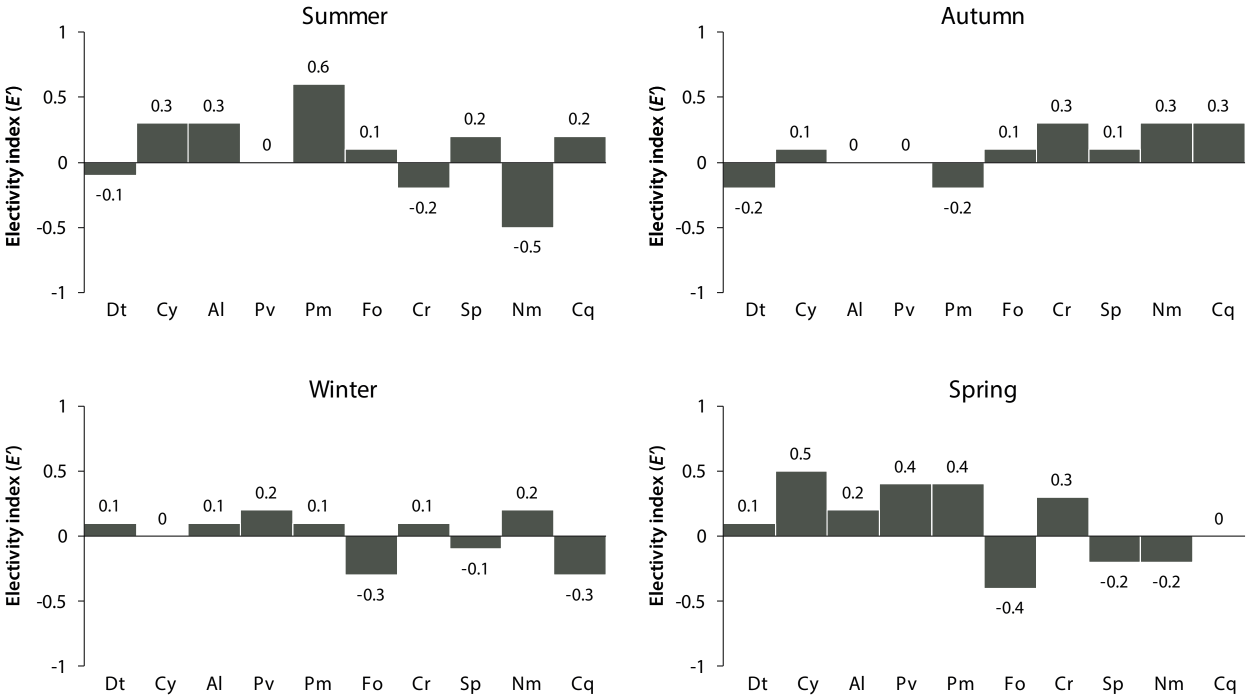

Figure 3. Ivlev electivity index indicating the preference or avoidance of a food source by H. (R.) poli. Dt: diatoms; Cy: cyanophyceae; Al: macrophytes algae; Pv: live Posidonia leaves; Pm: dead Posidonia leaves; Fo: foraminifera; Cr: crustaceans; Sp: sponge fragments; Nm: nematodes; Cq: bivalve mollusc fragments.

The components of the sediment are not all assimilated in the same way by the different sea cucumber species that inhabit the same place (Belbachir and Mezali 2018). In addition, sea cucumber species are distributed heterogeneously in various biotopes present at the same site (Mezali 2004). Consequently, even if all species ingest sediment, they can live in the same place as they are not really in competition with each other for food.

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Annotated checklist of sea cucumbers from Pakistan with new records of *Holothuria* (*Theelothuria*) *hamata* (Pearson, 1913) and *Stichopus herrmanni* (Semper, 1868)

Muhammad Moazzam[1]* and Naseem Moazzam[2]

Abstract

Sea cucumbers (class Holothuroidea) are among the least-studied group of marine invertebrates of Pakistan, and previously, only 19 species of holothurians were recorded from there. Among these, *Holothuria* (*Thymiosycia*) *arenicola* (Semper, 1868) seems to be the most dominant species, which is exported in small quantities in the form of beche-de-mer. The present paper provides an annotated checklist of holothurian species found along Pakistan's coast. In addition, a new record of *Holothuria* (*Theelothuria*) *hamata* (Pearson, 1913) is included, which seems to be occasionally found in the offshore waters on the continental shelf along Pakistan's coast. In addition, *Stichopus herrmanni* (Semper, 1868) has been photographed from Churna Island, Balochistan, which is also reported for the first time from Pakistan.

Keyword: holothurian, Pakistan, *Stichopus herrmanni*, *Holothuria (Theelothuria) hamata*, beche-de-mer

Introduction

Despite their common occurrence in intertidal and subtidal areas, holothurians are among the least-studied group of marine invertebrates in Pakistan. It was possibly Haque (1969) who first studied holothurians during his work on Pakistan's echinoderms, and he reported five species. Clark and Rowe (1971), in their review of Indo-Pacific echinoderms, reported 12 species of sea cucumbers from the west coast of India and Pakistan. Anonymous (1972) reported four species from rocky shores and one species from muddy and sandy shores along Pakistan's coast. Tahera and Kazmi (2005) reported 12 species from Pakistan, and Tahera and Kazmi (1995), Tahera (1992, 1996) and Massin (1999) reported five species from the country. Munir and Almas (2005) reported six species from the collection of Pakistan's Zoological Survey Department. Finally, Ahmed et al. (2016) reported 2 species whereas Ahmed and Ali (2018) recently reported 10 species from the Karachi coast.

The present paper provides an annotated list of sea cucumber species of the class Holothuroidea recorded from Pakistan. It also reports on a new record of *Holothuria* (*Theelothuria*) *hamata* (Pearson, 1913), which was collected from offshore waters on Pakistan's continental shelf. In addition, *Stichopus herrmanni* (Semper, 1868), which was photographed at Churna Island is reported for the first time from Pakistan. This paper also describes Pakistan's sea cucumber fishery.

Methods

A review of publications that reported holothurians from Pakistan was made, and species were arranged in alphabetical order. Samples of *Holothuria* (*Theelothuria*) *hamata* – collected from cruises onboard the Iranian research vessel R/V *Firdous* and the FAO/NORAD[3] research vessel R/V *Fridtjof Nansen* – were included.[4] In addition, a number of specimens were collected during commercial trawling operations along Pakistan's coast in 2015 and 2016. Samples of sea cucumbers were photographed before preservation in 5% formalin, and are now housed at the Museum of Marine Fisheries Department in Karachi. Information about processing and exports was obtained from the Marine Fisheries Department and exporters that are engaged in this trade.

Results

To date, 21 species of sea cucumbers have been reported from Pakistan, with Quratulan and Qadeer, in this issue of the *Beche-de-mer Information Bulletin* (p. 40), adding the last two species *Actinocucumis typica* and *Holothuria notabilis*. Most specimens were collected from intertidal areas. An annotated list of known species, in alphabetical order, follows.

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[2] B-205, Block 4-A, Gulshan-e-Iqbal, Karachi 75300, Pakistan
[3] FAO/NORAD – Food and Agriculture Organization of the United Nations/Norwegian Agency for Development Cooperation
[4] The research cruise by the R/V Firdous occurred in 2009 and the cruise by the R/V Fridtjof Nansen occurred in 2010.
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Figure 1. The Pakistan coast.

***Actinocucumis typica* (Ludwig, 1875)**. This species was reported from Pakistan by Clark and Rowe (1971). It is known to be widely distributed in the Indo-Pacific region. Its type specimen was collected from Queensland, Australia (O'Loughlin et al. 2014). No record of this species from Pakistan has been made since Clark and Rowe (1971). See also Quratulan and Qadeer in this issue of the *Beche-de-mer Information Bulletin* (p. 40).

***Actinopyga mauritiana* (Quoy and Gaimard, 1834).** Haque (1969) reported this species for the first time from Cape Monze near Karachi, Pakistan. It was also reported on by Anonymous (1972) from the same area. Clark and Rowe (1971) and Munir and Almas (2005) also reported this species from Pakistan's coast but with no mention of a specific location. Tahera (1996) and Tahera and Kazmi (2005) reported it from intertidal areas, where it was found hiding under small rocks exposed to surge and currents.

***Aslia forbesi* (Bell, 1886).** Clark and Rowe (1971) reported this species for the first time from the west coast of India and Pakistan, but with no mention of a specific location. Ahmed and Ali (2018) reported it from Sorana and Buleji near Karachi. According to Tahera (2004) and Tahera and Kazmi (2005), this species is found on rocks and in crevices. Tahera (1996, 2004) reported this species from Buleji and Paccha on the Karachi coast. Anonymous (1972) and Haque (1969) reported this species as *Shereoderma forbesi* from rocky shores at Cape Monze near Karachi.

***Cladolabes aciculus* (Semper, 1867).** This species has only been reported on by Clark and Rowe (1971). Its holotype was collected from the Philippines. It is reported to occur in intertidal areas of the Indo-west Pacific. No record of this species in Pakistan exists since Clark and Rowe (1971).

***Hemithyone semperi* (Bell, 1884).** This species was recorded from Pakistan by Clark and Rowe (1971) and Massin (1999), but with no mention of a specific location. It has pliable body that is variably coloured white-brown and red with purple tentacles and tube feet. It is mainly found in intertidal areas of the Indian Ocean, Mozambique, Madagascar, Sri Lanka, India, Indonesia, Viet Nam, South China Sea, Australia, Singapore and Pakistan (Ong et al. 2016; Pawson 1967).

***Holothuria (Halodeima) atra* (Jaeger, 1833).** Tahera (1996) and Tahera and Kazmi (2005) reported this species from shallow waters with sandy bottoms. Ahmed and Ali (2018) reported it from Buleji and Sonara along the Karachi coast. Ahmed et al. (2018b) studied length-weight relationships and condition factors in this species from the Karachi coast.

***Holothuria (Lessonothuria) pardalis* (Selenka, 1867).** Clark and Rowe (1971), Massin (1999) and Tahera and Tirmizi (1995) reported this species from Pakistan's coast but with no mention of a specific location. Tahera (1996) and Tahera and Kazmi (2005) reported this species from the intertidal zone under rocks. Ahmed and Ali (2018) reported this species from Buleji and Sonara on the Karachi coast. Ahmed et al. (2018b) studied length-weight relationships and condition factors in this species from the Karachi coast. Samyn et al. (2019) recently redescribed *Holothuria lineata* based on a morphological study, which revealed that *H. lineata* is a distinct and well-described taxon, despite earlier claims (Panning 1935) to consider it as a junior subjective synonym of *H. pardalis*. *Holothuria lineata* can be distinguished on the basis of: its large body – up to 12 cm as compared with 6 cm for *H. lineate*; rods of massive tube feet (slender in the case of *H. lineata*) that are curved, with 1–3 distal perforations; perforated plates of dorsal tube feet with three to four rows of holes (with two to seven holes at the extremities, and perforated plates of dorsal tube feet with two rows of holes in the case of *H. lineata*).

Holothuria **(*Lessonothuria*) *verrucosa*** **(Selenka, 1867).** This species was reported from Buleji and Sonara by Ahmed et al. (2016) and Ahmed and Ali (2018). This is a benthic species that lives inshore, and is a deposit feeder. It is a cryptic species that is found buried in sand, seaweed and rubble. Ahmed et al. (2018a) studied the process of asexual reproduction in this species, whereas Ahmed et al. (2018b) studied length-weight relationships and condition factors. Samyn et al. (2019) pointed out that *Holothuria verrucosa* is characterised by fully developed tables with numerous (more than eight) peripheral holes and with the edge of the disk bearing numerous minute spines versus reduced tables in *H. pardalis*. *Holothuria verrucosa* is also characterised by the presence of 24–30 tentacles versus 18–20 for *H. pardalis*.

Holothuria **(*Mertensiothuria*) *leucospilota*** **(Brandt, 1835).** Clark and Rowe (1971) Tahera and Tirmizi (1995), Massin (1999), and Munir and Almas (2005) all reported this species from Pakistan, but with no mention of a specific location. Ahmed and Ali (2018), Tahera and Kazmi (2005) and Tahera (1996) reported this species from tidal pool under small stones. It was reported for the first time from Solomon Islands by Brandt in 1835. The status and whereabouts of its holotype is undetermined (Rowe and Gates 1995). It is widely distributed in the tropical and subtropical Indo-Pacific region (Massin 1999; Samyn and Massin 2013).

Holothuria (Platyperona) difficilis **(Semper, 1868).** Haque (1969), Massin (1999), Tahera (1996) and Tahera and Kazmi (1995, 2005) have all reported this species attached to green seaweeds on Pakistan's coast. It is known to occur from the Red Sea and Madagascar to the tropical coasts of Central America and Mexico, and from Japan and China to New Caledonia and Easter Island (Massin 1996).

Holothuria **(*Semperothuria) cinerascens*** **(Brandt, 1835).** Ahmed et al. (2016), and Ahmed and Ali (2018) reported it from Buleji and Sonara along the Karachi coast. This species is benthic, lives inshore, and is a detritus feeder (Ahmed et al., 2016; Rowe and Gates 1995). It can be found on rocky sea bottoms and in crevices with strong wave action where it suspension-feeds on organic particles from the water column (Ahmed et al. 2016; Purcell et al. 2012). Massin (1996) reported its distribution from the Red Sea and Madagascar to Hawaii and Easter Island, and from Japan to northern Australia.

Holothuria **(*Theelothuria*) *hamata*.** Reported on in the present study.

Holothuria (Thymiosycia) arenicola **(Semper, 1868).** This species was recorded from Cape Monz and Sonara near Karachi by Tahera (1996) and Tahera and Tirmizi (1995). Tahera and Kazmi (2005) and Munir and Almas (2005) also reported this species from Pakistan but did not mention a specific location. Ahmed and Ali (2018) reported this species from Buleji and Sonara. Siddiqui and Ayub (2015) have studied the population dynamics and reproduction of this species from the Manora and Buleji . Ahmed et al. (2018b) studied length-weight relationships and condition factors in this species from the Karachi coast.

Leptosynapta inhaerens **(O.F. Müller, 1776).** It was Haque (1969) who reported this species for the first time from the muddy sandy shores of Buleji, Karachi. This was also reported by Anonymous (1972) from the same area. Haque (1969), Tahera (1996), Tahera and Kazmi (2005) and Munir and Almas (2005) reported this species from Pakistan but with no mention of a specific location. According to Massin et al. (2014), the holotype of this species was collected from southern Norway although it is widely distributed from the North Sea to northern Norway, England, the Atlantic coast of Denmark, Germany, France, Spain, Portugal, the Canary Islands, the Mediterranean coast of Spain, France, Italy, the Adriatic Sea (Greece), the Black Sea, Israel, Korea, Japan and China. However, Massin et al (2014) pointed out that it is likely that the so-called *L. inhaerens* specimens from Asiatic populations are, in fact, a different species. The same may be true for specimens from Pakistan.

Ohshimella ehrenbergii **(Selenka, 1868).** Clark and Rowe (1971) reported this species from Pakistan but with no mention of a specific location. Ahmad et al. (2016) reported this species from Buleji, and Ahmed and Ali (2018) reported it from Buleji and Sonara. This species occurs in rock crevices and under stones (Thandar 1989). Its holotype was collected from the Red Sea (Thandar 1989). It is distributed throughout southeast Arabia, India, Pakistan, Maldives, Sri Lanka, the Red Sea and the east coast of Africa (Clark and Rowe 1971; Thandar 1989).

Staurothyone rosacea **(Semper, 1869).** Haque (1969) reported this species for the first time from Buleji. It was also reported by Anonymous (1972) from the same area, and Ahmed and Ali (2018) reported it from Buleji and Sonara. Tahera (1996) and Tahera and Kazmi (2005) reported it attached to rocks. Clark and Rowe (1971) and Munir and Almas (2005) also reported this species from Pakistan but did not mention a specific location.

Stichopus herrmanni **Semper, 1868.** Reported on in the present study.

Stolus conjungens **(Semper, 1867).** Clark and Rowe (1971) reported this species from Pakistan but did not mention a specific area. Tahera and Kazmi (2005) and Tahera (2004) reported this species from seagrass beds. *Stichopus conjungens* has only been encountered four times since its first description (Thandar 2005; Pearson 1903; Gravely 1927; Satyamurti 1976; Rowe and Gates 1995).

Stolus buccalis **(Stimpson, 1855).** Haque (1969) reported this species for the first time from Buleji, and it was also reported by Anonymous (1972) from the same area. Tahera (1996) and Tahera and Kazmi (2005) reported it occurring under stones and attached to rocks. Clark and Rowe (1971) and Munir and Almas (2005) reported it but did not mention a specific area in Pakistan. Ahmed and Ali (2018) reported this species from Buleji and Sonara along the Karachi coast.

***Synaptula recta* (Semper, 1867).** This species was reported from Pakistan by Tahera (1997) as *Synaptula hydriformis*. It was reported later on by Massin (1999) and Tahera and Kazmi (2005) from Pakistan but with no mention of a specific location. This species is highly variable in colour (Ong and Wong 2015; Clark 1907; Massin 1999). It is a medium to large species with a length of up to 21.0–25.4 cm (James 1982; Clark 1907; Ong and Wong 2015). According to James (1982) the colour when it is alive is pink with red longitudinal and interrupted stripes. He also noted that this species was found to be gregarious and to live on algae in shallow water. It is known to occur in the Red Sea, Comoros Archipelago, Maldives Sri Lanka, Bay of Bengal, East Indies, Singapore, Micronesia (Chuuk, Pohnpei), Papua New Guinea, Guam, Viet Nam, Philippines, Malaysia, Indonesia, northern Australia, and islands in the South Pacific (James 1982; Lee and Shin 2014; Ong and Wong 2015; Samyn et al. 2005).

***Thyone dura* (Koehler andVaney, 1908)**. This species was reported from Pakistan by Clark and Rowe (1971), and was originally described by Koehler and Vaney (1908) from specimens collected during surveys of the Royal Indian Marine Survey Ship, the *Investigator* from India's west coast (about 150 km southeast of the border with Pakistan). It is reported from continental and insular shelves of the western and central Indo-Pacific, from India and the northeastern Arabian Sea (Koehler and Vaney 1905; Sane and Chhapgar 1962), and the Andaman and Nicobar islands (James 1983; Sastry 2005).

New records

***Holothuria* (*Theelothuria*) *hamata* (Pearson, 1913)**

Figure 1. *Holothuria* (*Theelothuria*) *hamata,* collected on 19 November 2010 at 24° 06.16' N; 66° 34.24' E (dorsal view)

Figure 2. *Holothuria* (*Theelothuria*) *hamata* collected on 29 September 2015 from 24° 00.100' N and 66° 20.350'E (dorsal view).

Figure 3. *Holothuria* (*Theelothuria*) *hamata* collected on 29 September 2015 from 24° 00.100' N and 66° 20.350'E (ventral view).

Specimens examined

- two specimens collected by the Iranian research vessel R/V *Firdous* on 1 November 2009 at 24° 57.55' N and 66° 38.12' E (classification code: MFD/INV/HOL/012-13)
- four specimens collected from the FAO/NORAD research vessel R/V *Fridtjof Nansen* on 19 November 2010 at 24° 06.16' N and 66° 34.24' E (classification code: MFD/INV/HOL/014-17)
- seven specimens collected from commercial trawler *Safina-e-Zhoaib* on 29 September 2015 at 24° 00.100' N and 66° 20.350'E (classification code: MFD/INV/HOL/037-043)
- two specimens collected from commercial trawler *Al Sultan* on 21 November 2016 at 24° 33.110' N and 66° 21.505'E (classification code: MFD/INV/HOL/044-045)

Description (based on Aydin et al. 2019)**:** Body elongate, tapering at both ends; bivium convex, trivium flattened. Papillae of trivium predominantly in ambulacral areas, but with some spreading into the interambulacral areas, arrangement in 5 rows, about 25 papillae per row. Papillae of bivium only in ambulacral areas, in 2–3 irregular rows; some 30 papillae per row. All dorsal, lateral and ventral papillae non-retractable. Cuvierian tubules absent.

Colour: Body colour (live): dorsal grayish to yellowish-brown with prominent conical brown papillae with lighter tip and surrounded by a lateral papillae ± 20 in number on each side. Pale lilac to white, patterns purplish or brownish. Teo and Ng (2009). Rowe and Doty (1977) noted the great variability of colour patterns.

Distribution: Widely distributed in the Indo-Pacific region. It is known from Suez Bay (Pearson 1913; Panning 1935; Cherbonnier 1955, 1959), the Red Sea (Rowe 1969), Maldives (Clark and Rowe 1971), Seychelles, Aldabra (Sloan et al. 1979), Kenya (Samyn 2003); Singapore (Teo and Ng 2009) and Indian Ocean, exact locality not specified (Domantay 1957), and northern Australia (Rowe and Gates 1995). Rowe and Gates (1995) noted a bathymetric distribution from 9–190 m. Along the coast of Pakistan, it is frequently collected from trawl fishing grounds in offshore waters between depths of 35 m and 190 m. It is mostly found on sandy or muddy bottoms. This is the first record of this species from Pakistan, and the colour and general morphology of specimens are similar to those described by Teo and Ng (2009) from Singapore as *Holothuria ocellata* (Jaeger, 1833).

***Stichopus herrmanni* (Semper, 1868)**

Specimen examined:

- Underwater photograph taken on 3 February 2015 at Churna Island near the Balochistan coast near Karachi.

Description: Body is broad and considerably flattened ventrally. Dorsal side is slightly arched and the lateral sides are almost vertical. The body wall is fairy thick and soft. Dorsal side is wrinkled or deeply ridged, and body is firm and rigid. Irregular and conspicuous conical warts; smaller papillae disbursed in between conical-shaped papillae.

Colour: Body grey mottled with small dark black spots on the dorsal surface. Dorsal papillae bluish-grey with brown tips.

Distribution: Widely distributed in the tropical Indo-west Pacific Ocean (Rowe and Gates 1995; Massin 1999; Woo et al. 2015). It is a benthic and inshore species that is a deposit feeder, and found at depths of 0–20 m (Rowe and Gates 1995). It is widely distributed along the Indian Coast (Deepa and Kumar 2010) and Iran (Majid et al. 2012). This is the first record of this species from Pakistan.

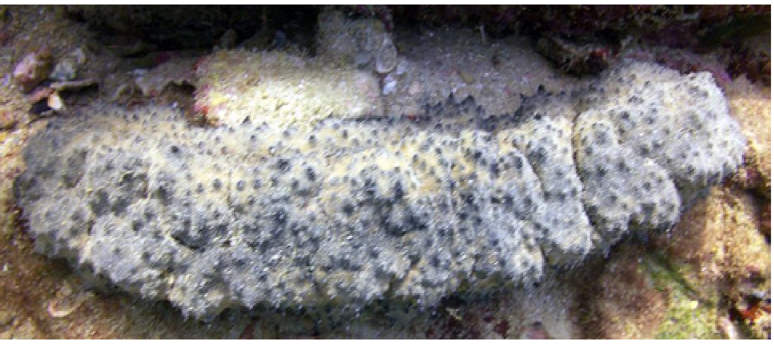

Figure 4. *Stichopus herrmanni* at Churna Island (Karachi) on 3 February 2015.

The sea cucumber fishery in Pakistan

Sea cucumbers are not consumed in Pakistan and there is no organised fishery for harvesting or processing sea cucumbers. A number of attempts have been made since 1990 to process them into beche-de-mer, but none of them were successful until 2012 when one of the seafood processors started producing beche-de-mer from *Holothuria* (*Thymiosycia*) *arenicola*. This species is harvested from rocky and sandy shores along the Karachi coast. The sand sea cucumber, as it is commonly known, is found underneath stones and boulders on beaches at Buleji, Manora, Goth Mubbarak and Sonara along the Karachi coast. Sea cucumbers are handpicked and kept in seawater, allowing them to empty the content of their stomachs. Sea cucumbers are processed by cutting, salting, cooking and drying (Fig. 5).

Beche-de-mer produced from *Holothuria* (*Thymiosycia*) *arenicola* has been exported to Malaysia, China and Thailand but only about 350 kg of beche-de-mer were exported in 2012. Annual exports of beche-de-mer have been increasing, from 460 kg in 2013, 490 kg in 2014 and 350 in 2015 (Table 1). However, only smaller quantities (less than 200 kg) were exported during 2016 and 2017. No exports of beche-de-mer were made during 2018. The fluctuation in the quantity of exports is attributed to limited stocks of sand sea cucumbers, difficulties with harvesting, and the lack of knowledge about these animals among local communities. In order to enhance the export of beche-de-mer, there is a need to explore new fishing grounds for *Holothuria* (*Thymiosycia*) *arenicola* along the Pakistan coast. Possibility of farming of this and other lucrative species may also be examined that could help with the establishment of an organised beche-de-mer processing industry in Pakistan

Table 1. Exports of beche-de-mer from Pakistan (in kg, dry weight).

Destination	2012	2013	2014	2015	2016	2017	2018
Malaysia	-	410	380	310	110	90	0
China	350	50	110	150	-	30	0
Thailand	-	-	-	70	60	25	0
Total	350	460	490	530	170	145	0

Source: Marine Fisheries Department, Government of Pakistan

Figure 5. Beche-de-mer produced from *Holothuria* (*Thymiosycia*) *arenicola*.

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Holothurians from Pakistan: New addition of *Holothuria* (*Theelothuria*) *notabilis* (Ludwig, 1875) and rediscovery of *Actinocucumis typica* (Ludwig, 1875) from the Karachi coast, northern Arabian Sea

Quratulan Ahmed[1*] and Qadeer Mohammad Ali[1]

Abstract

In total, 63 specimens of sea cucumbers were collected from the Sunehri (24°52'33.49" N, 66°40'40.20" E, on 19 January 2015) and Buleji coasts (24°50'20.41" N, 66°49'24.15" E on 31 August 2015) in the intertidal zone. Among them, *Holothuria notabilis* is a new record from Pakistan and *Actinocucumis typica* (Ludwig 1875) is rediscovered after 45 years (earlier recorded by Clark and Rowe in 1971). We present a morphological description and habitat characteristics of the collected specimens. The identified specimens are deposited in the repository of Marine Reference Collection and Resource Centre at the University of Karachi (catalogued as Holo-20 and Holo-21).

Keywords: *Holothuria notabilis, Actinopyga typica,* northern Arabian Sea

Introduction

The number of holothurian species worldwide is about 1717 (Paulay 2014). Nineteen species – belonging to the class Holothuroidea – have been reported from Pakistan, of which eight belong to the family Holothuriidae, three to the family Cucumariidae, two to the family Synaptidae, two to the family Sclerodactylidae and four to the family Phyllophoridae (Tahera1992, 1997, 2004; Tahera and Tirmizi 1995; Tahera and Kazmi 1995, 2005; Ahmed et al. 2016).

Actinocucumis typica belongs to the family Cucumariidae, which includes small to medium-size animals, characterised by ten branching tentacles of which the lowest two are often smaller than the others. They are filter feeders, and use their tentacles to catch micro-organisms and pass them to their mouth. They are found on coral reefs but mostly live in deep water on sand and gravel substrates. From Pakistan, four genera *Aslia*, *Staurothyone*, *Stolus* and *Cucumaria* have been reported (Clark and Rowe 1971; Tahera 2004).

The genus *Cucumaria* is represented in Pakistan by a single species *Cucumaria conjungens* (Semper, 1868). It was recorded for the first time in Pakistan by Tahera (2004). The genus *Actinocucumis* is also represented in Pakistan by a single species *A. typica* (Ludwig 1875), which was first reported from the northern Arabian Sea in Pakistan by Clark and Rowe (1971). This document contains morphological descriptions, and the distribution and habitat characteristics in the northern Arabian Sea of the new species *Holothuria notabilis* and the rediscovered species *A. typica,* 45 years after Clark and Rowe (1971).

Methods

Specimens were collected from intertidal zones from January to December 2015 on Pakistan's Karachi coast. In total, 63 specimens were collected from Buleji 24°50'20.41" N, 66°49'24.15" E and Sunehri 24°52'33.49" N, 66°40'40.20" E (Fig. 1).

Specimens were brought to the laboratory and kept in a well-aerated aquarium. Specimen length (mm) and weight (g) were recorded. After relaxation, specimens were preserved in 5% neutralised formaldehyde and later transferred to 70% ethyl alcohol. For further taxonomic studies and identification, morphological features were examined and microscopic studies were conducted. Ossicles were taken from three positions (dorsal and ventral body walls, and tentacles). A small piece of skin tissue was placed on a slide with a few drops of 3.5% bleach sodium hypochloride (NaOCl); the slides were then rinsed with drops of distilled water, and then examined under a microscope at 10 x 10 magnification. Microphotography was also performed using a digital camera (Olympus 16 MP).

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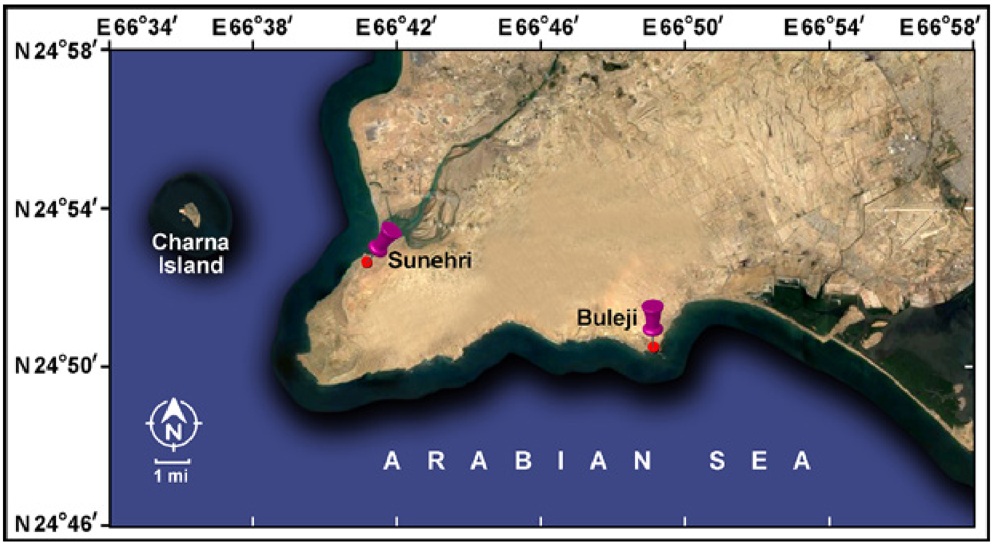

Figure 1. Sea cucumber sampling localities.

Results and discussion

Actinocucumis typica (Ludwig, 1875)

Taxonomic account: order Dendrochirotida, family Cucumariidae, genus *Actinocucumis*

Material examined: One specimen (catalogued as Holo-21) of *Actinocucumis typica* was collected from Buleji beach at 24°50'20.41" N, 66°49'24.15" E on 31 August 2015.

Habitat: The specimen was found hardly attached to a rock in the intertidal zone. This species inhabits the lower mid-littoral zone on rock and sand substrate.

Distribution: Indo-west Pacific: western India and Pakistan, Ceylon area, Bay of Bengal, East Indies, north of Australia, China and Japan, South Pacific Islands.

Description: Species length: 65 mm; weight 11.42 g; body cylindrical in shaped and tapering from mouth towards anus. The dorso-ventral colour of specimen is creamy-brown (Figs. 2A and B). Body covered by well-developed conspicuous stiff and non-retractile pedicels. Podia arranged in distinct bands side by side. Mouth possesses 10 dark coloured tentacles. Dorso-ventral spicules figure eight-shaped or pear-shaped (Fig. 2C). Body wall buttons numerous and equal although some are irregular (Fig. 2D). Small perforated plates and irregular tables with pointed spires present (Fig. 2E) and tentacle rods (Fig. 2F). Calcareous ring consists of five radials and five inter-radials (Fig. 2G).

Remark: The specimen *Actinocucumis typica* is a rediscovery from Pakistan's coastal waters in the northern Arabian Sea, 45 years after Clark and Rowe (1971). It is one of a species complex (Gustav Paulay, pers. comm.). Spicules of this specimen are similar to those described by James (1984), collected from Mandapam: Gulf of Mannar, Ratnagiri (Arabian Sea) and Port Okha (Gulf of Kutch).

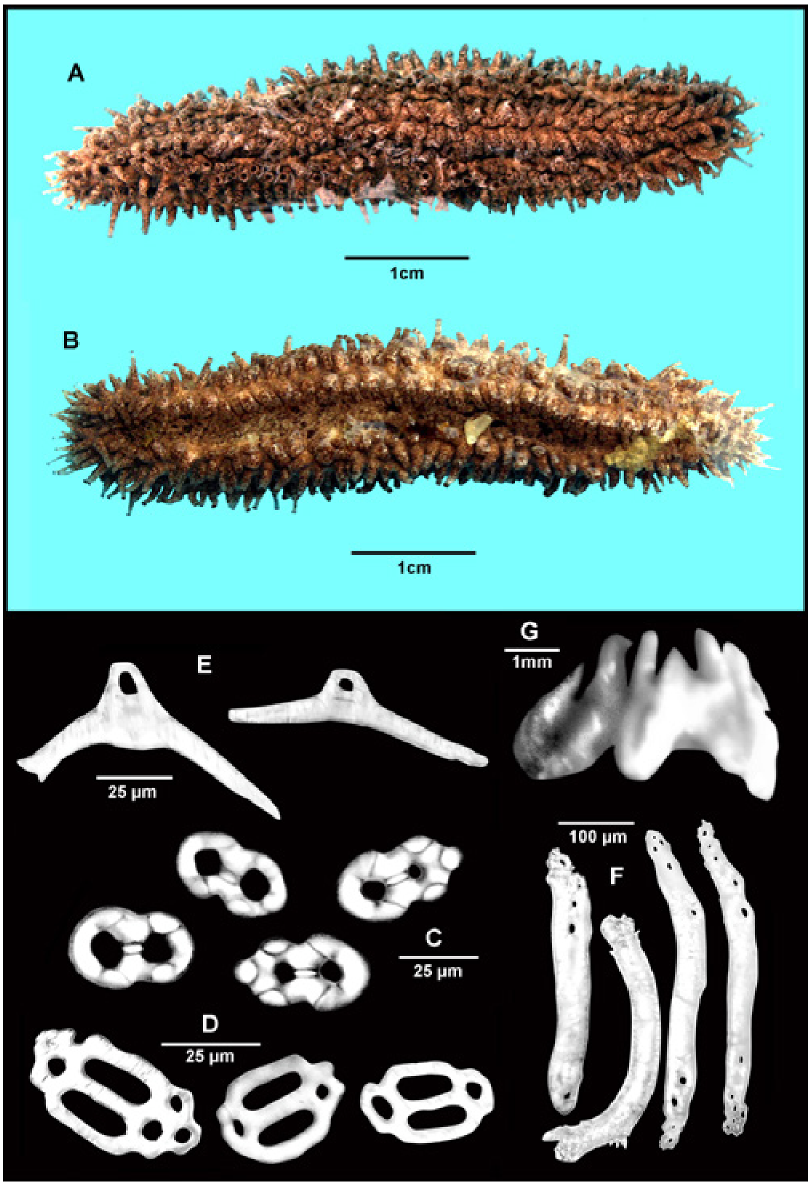

Figure 2. *Actinocucumis typica* (Ludwig 1875). A and B: dorso-ventral body; C: figure eight-shaped or pear-shaped spicules from dorso-ventral body wall; D: equal and irregular buttons from dorso-ventral body wall; E: small perforated plates and irregular tables with pointed spires; F: tentacle rods; G: calcareous ring.

Holothuria notabilis (Ludwig 1875)

Taxonomic account: order Aspidochirotida, family Holothuriidae, genus *Holothuria,* subgenus *Theelothuria*

Material examined: one specimen (catalogued as Holo-20) of *Holothuria notabilis* collected from Sunahri beach at 24°52'33.49" N, 66°40'40.20" E on 19 January 2015.

Habitat: The specimen was collected from under a rock (boulder) from a rocky shore during low tide.

Distribution: Great Barrier Reef, Australia and found at localities in the Indian Ocean, including Madagascar, Mozambique and eastern Indonesia.

Description: Species length: 60 mm; weight: 9.34 g; body cylindrical in shaped and tapering at the ends. The tegument colour is creamy white with many dark-brown blotches. On the dorsal surface there are two rows of 8–10 dots (Fig. 3A). Ventral surface teguments are dark brown in colour (Fig. 3B). Dorsal and ventral papillae are yellowish. The mouth is on the ventral side with 20 small light-yellowish tentacles. Spicules of the specimen are irregular and not uniform in size; tables round and normal with a spiny disc; small concave plates with perforations (Fig. 3C); buttons with knobs that were not in similar size; some buttons found with three pairs of holes and some with six pairs of holes (Fig. 3D). Dorsal body wall buttons (with three pairs of holes) were smaller than ventral side buttons (with six pairs of holes). Calcareous ring well developed (Fig. 3G). Tentacles rods present (Fig. 3E). Podia with end-plates and elongate rods with central and terminal perforations (Fig. 3F). Tentacles slightly bent, non-perforated rods usually with slightly spinose margins (Fig. 3E).

Remarks: *Holothuria notabilis* (Ludwig 1875) is a new addition to the coastal fauna of Pakistan.

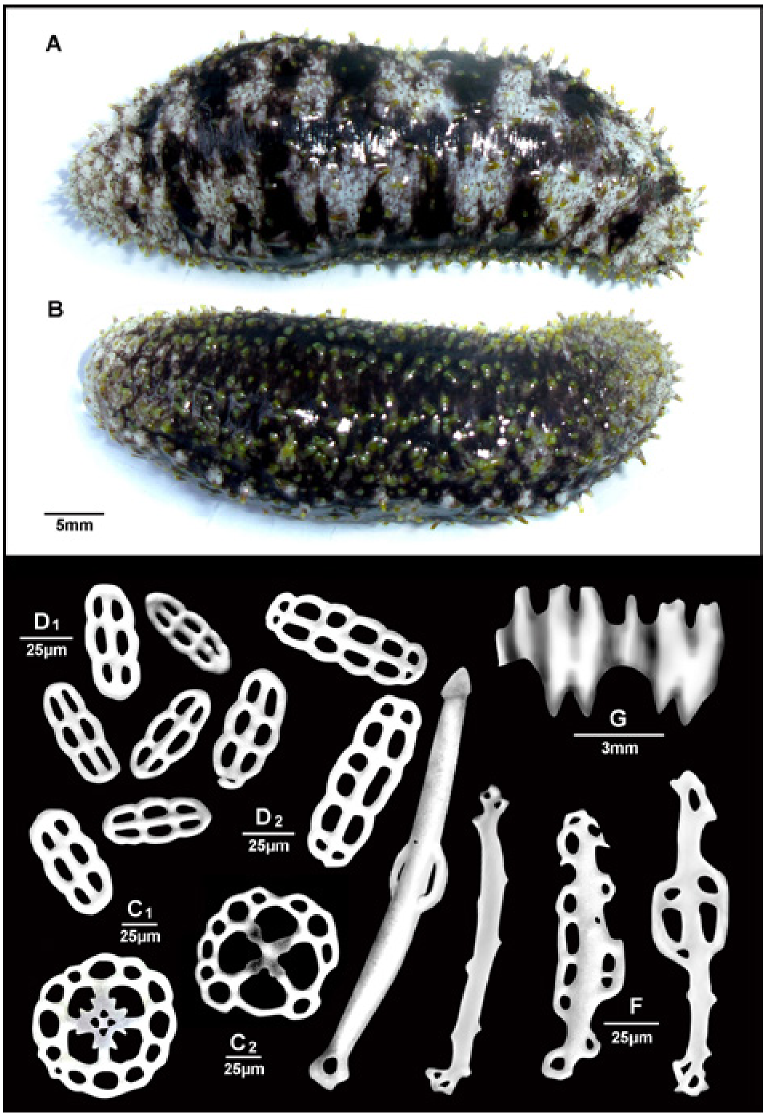

Figure 3. *Holothuria notabilis* (Ludwig, 1875). A: dorsal body; B: ventral body; C1: table from dorsal body wall; C2: table from ventral body wall; D1: knobbed buttons from dorsal body wall; D2: buttons from ventral body wall; E: tentacles rods; F: podia with end-plates and elongate rods with central and terminal perforations; G: calcareous ring.

Acknowledgements

We acknowledge Dr C. Conand and Dr G. Paulay who helped with the identification of the species. Also, we would like to acknowledge the photographer, Mr Abrar.

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Note on *Parastichopus regalis* (Cuvier, 1817) from the Sidi-Medjdoub area of Mostaganem, Algeria

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Abstract

Parastichopus regalis (Cuvier, 1817) is a sea cucumber species reported from several areas of the Mediterranean Sea. Three individuals of this species were collected by small-scale fishers at the Sidi-Medjdoub area of Mostaganem, Algeria in February 2019 at a depth of 53 m. A morphological, anatomical and endoskeletal description was carried out on each individual.

Keywords: *Parastichopus regalis*, small-scale fisheries, Mostaganem, Algeria.

Introduction

In Algeria, no studies have been conducted on the Stichopodidae family, which is represented in the Mediterranean by *Parastichopus regalis*. This species is mainly distributed in the northwest of the Mediterranean Sea and in the eastern Atlantic Ocean (Ramón et al. 2010). In the Mediterranean Sea, *P. regalis* is caught as bycatch by trawlers and is marketed for human consumption in Europe (Spain, Turkey and Greece) (Ramón et al. 2010). In Catalonia (Spain), it is currently the most expensive seafood product, reaching EUR 130/kg fresh weight (Ramón et al. 2010). Few biological data are available on *P. regalis* (Santos et al. 2015; Galimany et al. 2018; Ramón et al. 2019). This is probably because this species expels its organs when the nets are hauled in, making it difficult to collect and monitor them (González-Wangüemert et al. 2018; several personal observations during the collection of this species).

Methods

This study was carried out in the Sidi-Medjdoub region, which is located in the west of the Algerian coast (Fig. 1). An indirect method of recovering bycatch (not targeted by

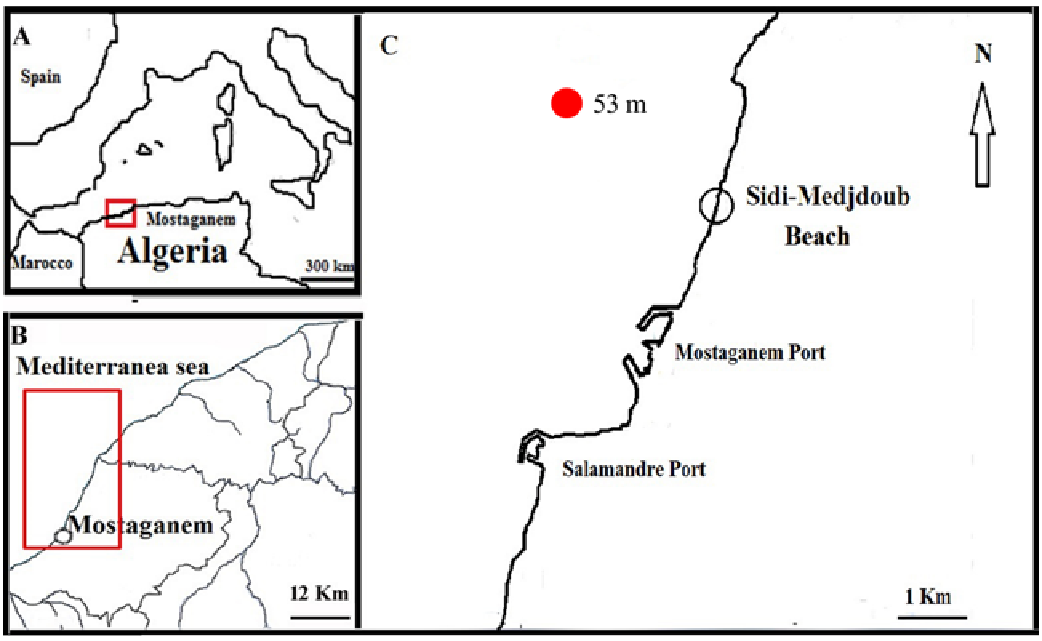

Figure 1. Geographical location of the Sidi-Medjdoub station (indicated by a red dot on the right-hand map).

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professional fishing) of demersal gill nets was used. Three individuals of *Parastichopus regalis* were collected by small-scale fishers in February 2019 at a depth of 53 m (N 36°0.032, E 0°1.456, Fig. 1).

The individuals of *Parastichopus regalis* (Fig. 2) were identified on the basis of morphological, anatomical and endoskeletal criteria (the form of sclerites of the ventral and dorsal faces and tentacles). The preparation of sclerites was carried out according to the protocol of Samyn et al. (2006). Photographs were taken on the different types of ossicles using Optika View Lite software.

The three individuals of *P. regalis* were measured (relaxed total body length) and weighed (wet body weight with viscera and digestive system, which represents only a very small part of the total weight of the animal) (Mezali1998).

Results and discussion

The *Parastichopus regalis* individuals that were examined had a fairly depressed soft body with a sharp lateral fold bearing large papillae and separating the dorsal and ventral sides (Fig. 2A, B and C). The length of the three individuals was between 9 cm and 20 cm, with an average length of nearly 14.0 cm and a wet weight between 35.6 and 89.7 g, with an average weight of 59. 9 g. The anatomical examination revealed the presence of five pairs of longitudinal muscles (Fig. 2D). The defense organs (Cuvierian tubules) were absent. Observation of the dorsal (Fig.3A) and ventral (Fig.3B) integument revealed three types of ossicles: 1) tables (Fig. 3 A-a,c,d; B-e), perforated plates (Fig.3 A-b; B-f) and terminal plates (Fig. 3B). The tables observed corresponded to that of the genus *Stichopus* described by Clark (1922).

The ossicles of the ventral side differ from those of the dorsal side. The rods that exist only in tentacles (Fig. 3C) are elongated (Fig. 3C-h), arched (Fig. 3C-i), thorny, and some are branched and perforated (Fig.3 C-g).

Acknowledgements

The first author thanks the fishermen of the beach Sidi Medjdoub, particularly Mr Khalifa Abdelillah and Mr Khalifa Mouhssine for authorising us to use their boat and helping to collect the specimens during the survey at sea. The first author also thanks Mr Benbernou Babi for making the navigation software available.

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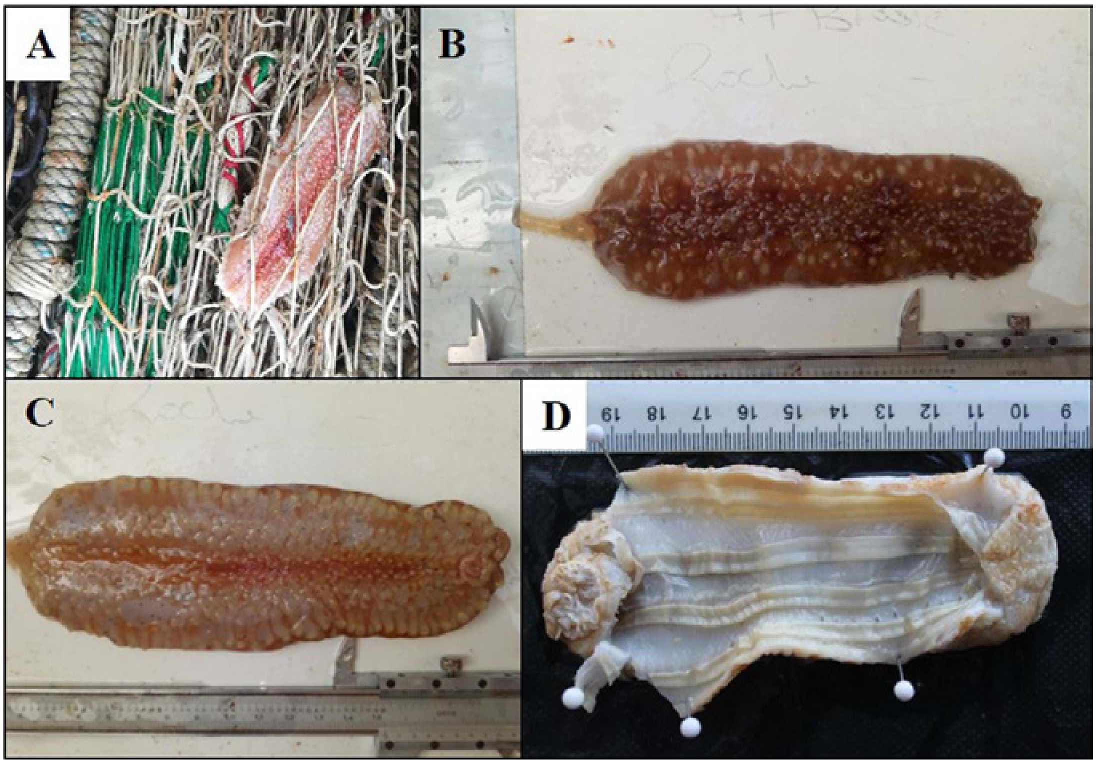

Figure 2. A: An individual of *Parastichopus regalis* caught in a net; B: Dorsal face of *P. regalis*; C: Ventral face of *P. regalis*, showing a ventral mouth; D: Anatomical section showing the various internal organs of *P. regalis*.

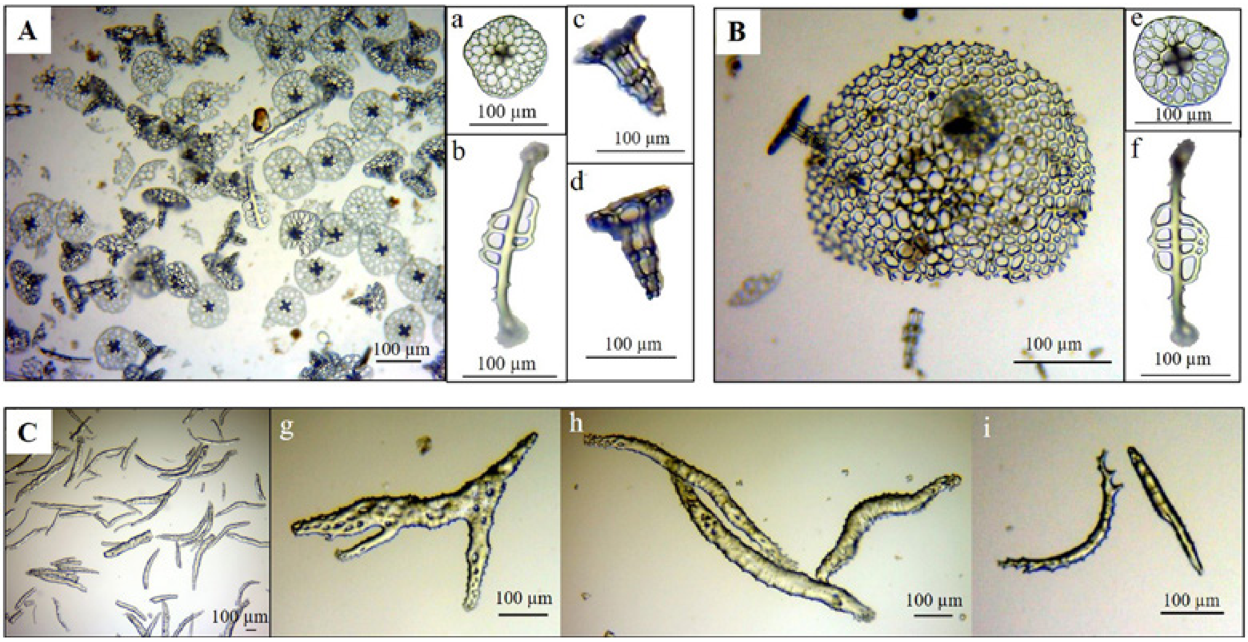

Figure 3. Endoskeletal characteristics of *Parastichopus regalis* individuals from the Sidi Medjdoub region (A: General view of sclerites of the dorsal integument – a: Top view of dorsal integument's table, b: perforated plates of dorsal integument, c,d: side view of dorsal integument's tables; B: General view of sclerites of the ventral integument, showing the perforated plate – e: Top view of ventral integument's table, f: perforated plates of ventral integument; C: Different rod shapes observed at the tentacles – g: branched and perforated rods, h: elongated rods, i: arched rods) (Magnification:C: X4; A,B,c,d,g,h,i: X10; a,b,e,f: X40).

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First occurrence of the species *Holothuria coronopertusa* in Mayotte, in the Indian Ocean

Thierry Mulochau,[1] Clément Delamarre[2] and Chantal Conand[3]

Introduction

Holothuria (Stichothuria) coronopertusa (Cherbonnier, 1980) has been described from collections made by divers from ORSTOM[4] in Noumea, New Caledonia. This species was described in a publication on holothurians from New Caledonia (Cherbonnier 1980) , a description later included in the guide to sea stars, urchins and other echinoderms of New Caledonia (Guille et al. 1986). The species is long and cylindrical and has a thin tegument. Its description is detailed and mostly based on the spicules. The subgenus *Stichothuria* had been created for this species, as the spicules are quite different from the other 17 subgenera under the genus *Holothuria*. *Stichothuria* shares with eight other subgenera, the presence of a collar of papillae at the base of the tentacles. To our knowledge, this species has never been observed in the Indian Ocean.

A programme currently underway, named MesoMay, aims to carry out a first non-exhaustive faunal inventory of certain sites located in mesophotic zones on the slopes of some Mayotte reefs between 50-m and 150-m depth (Mulochau et al. 2019). This programme is based on participatory science, and two associations of divers with gas mixtures and recyclers are involved (Service Plongée Scientifique and Deep Blue Exploration). Individuals of *Holothuria coronopertusa* have been observed during several scuba dives at different sites in Mayotte.

Figure 1. Sampling an individual of *Holothuria coronopertusa* in Mayotte in November 2018 – on the Iris Bank at a depth of 78 m – to collect surface integument to prepare spicules.
(Images: Association Service de Plongée Scientifique)

Methods

Dives with gas mixtures and rebreathers were necessary to inventory mesophotic fauna on the outer slopes of Mayotte's reefs. At each site, divers photographed and sampled (for 30 minutes) some organisms to determine their species. For holothurians, if the species is difficult to identify from photos, a specimen can be collected and its tegument sampled on site, to prepare spicules (Fig. 1). The specimen is then released back into the water.

From the sample collected, spicules were prepared, following the method described by Samyn et al. (2006).

Results

The external morphology of the *Holothuria coronopertusa* specimen that was collected – at a depth of 78 m on Iris Bank north of Mayotte – was typical, in that it had no Cuvierian tubules (Fig. 1). It was photographed and integument samples were taken. It was then released on site.

Three other specimens of *Holothuria coronopertusa* were observed and photographed at an average depth of 80 m (Table 1).

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[2] Association de Service de Plongée Scientifique
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[4] ORSTROM stands for Office de la recherche scientifique et technique outre-mer. The organisation is now called Institut de Recherche pour le Développement
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Table 1. Observations of *Holothuria coronopertusa* in Mayotte.

Location	Depth	Date	Latitude	Longitude
Bouéni	70–90 m	24 November 2018	12.931583°S	44.964250°E
Iris Bank west	78.6 m	26 November 2018	12.626944°S	44.927789°E
Iris Bank west	70–90 m	17 January 2019	12.626944°S	44.927789°E

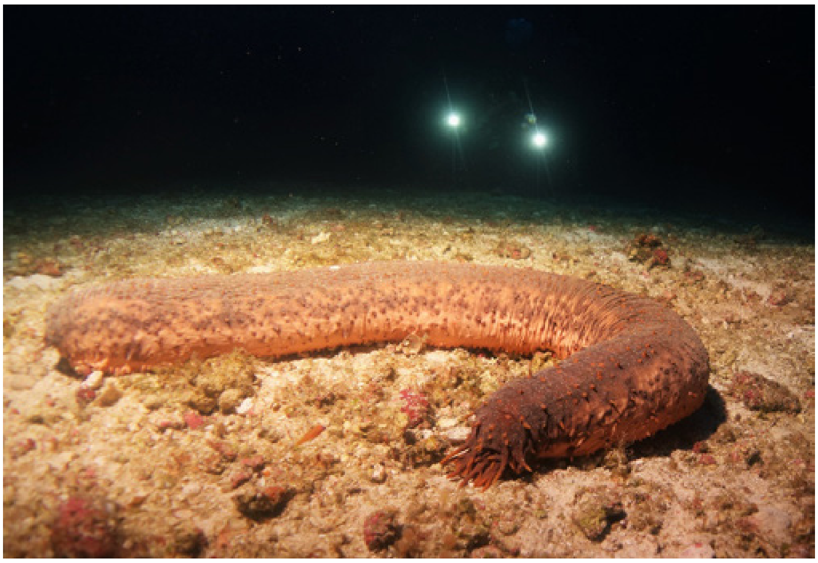

Figure 2. *Holothuria coronopertusa* observed on the Iris Bank north of Mayotte at a depth of 80 m (length ~80 cm). (Images: Association Service de Plongée Scientifique)

Figure 3. *Holothuria coronopertusa* observed at a depth of 80 m at Bouéni in southwestern Mayotte. (Images: Association Deep Blue Exploration)

A carapid fish was observed protruding from the cloaca of an individual of *H. coronopertusa*. The species could be *Carapus* aff. *boraborensis* (Fig. 4), although a sample is still necessary to confirm this species .

Figure 4. Observation of a carapid (*Carapus* aff. *boraborensis*) protruding from the cloaca of a *Holothuria coronopertusa*. (Image: Association Service de Plongée Scientifique)

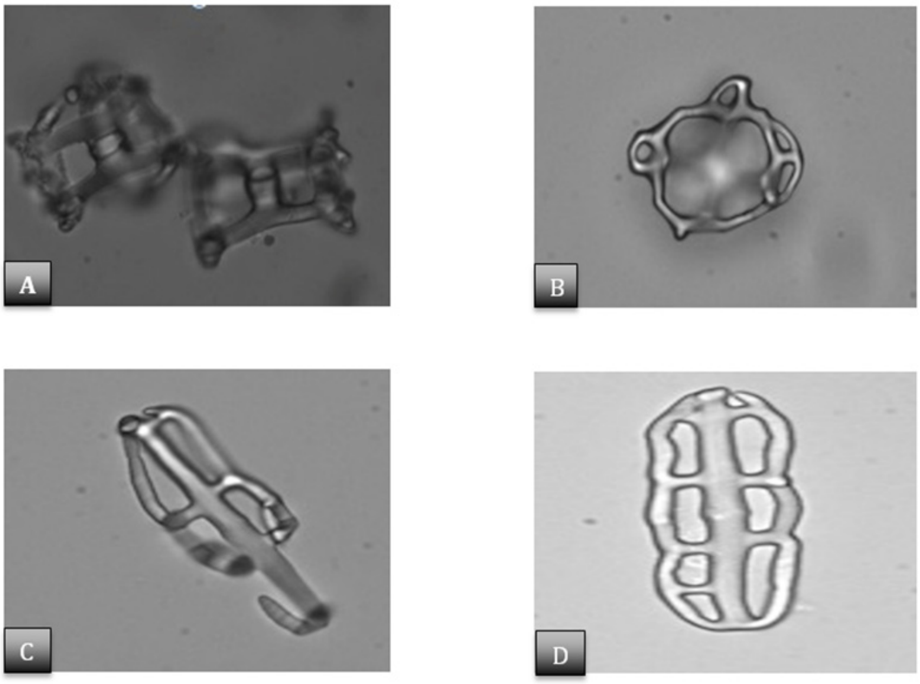

Figure 5. Spicules from the tegument of *Holoturia coronopertusa*. A: Tables in lateral view; B: Table; C: Pseudo-button; D: Button.

Spicules from the integument are shown in Figure 5. They correspond to the original description by Cherbonier (1980). The tables are similar on both the dorsal and ventral sides, a characteristic of this species. Numerous spicules are either C- or O-shaped.

Discussion and conclusion

The exploration of mesophobic coral reef ecosystems in the Indo-Pacific region is relatively recent. No faunal inventory in the mesophotic zone of Mayotte had been done before. To our knowledge, *Holothuria coronopertusa* – a species never before observed in Mayotte, and recorded at two sites about 40 km away from each other (Banc de l'Iris and Bouéni Pass) – has never been observed in the Indian Ocean. This species has not yet been observed at other sites. The depth of observation is around 80 m. This species has been sampled in New Caledonia and the western Pacific at depths of 100 m (Michonneau et al. 2013). A better knowledge of the biodiversity of the mesophotic coral ecosystems of the southwest Indian Ocean and Pacific could explain the distributions and connectivity of the species.

Acknowledgements

We thank the Service Plongée Scientifique association for collecting a specimen of *Holothuria coronopertusa* and several samples of integument that confirmed the species. We also thank Eric Parmentier from the University of Liège, and Ron Fricke from the Stuttgart Museum of Natural History, for their help in trying to identify the carapid.

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Observations of asexual reproduction of *Holothuria* (*Platyperona*) *parvula* (Selenka, 1867) in the Caribbean Sea

Giomar H. Borrero-Pérez[1]*

Holothuria (Platyperona) parvula is one of the nine species of sea cucumbers belonging to the family Holothuriidae reported by Dolmatov (2014) as being capable of asexual reproduction. The fission process in this species was first recorded by Crozier (1917, as *H. captiva*) in Bermuda. Later, Kille (1942) studied the development of the reproductive system after fission using specimens from the Dry Tortugas and, for comparison, some from Bermuda, the only location for which this information was available for *H. (P.) parvula* (Dolmatov 2014). Emson and Mladenov (1987), also based on specimens from Bermuda, described the fission process and its frequency throughout the year (from August 1984 to September 1985). These authors concluded that during fission, *Holothuria parvula* split into roughly equal parts across the middle of the body, and that there was little difference in survival between the oral and anal ends. The authors found that regeneration of a new gut is a priority and that feeding was possible within two months of fission. They also found many individuals fully regenerated within a year, so fission is possibly an annual event. In 2017, individuals obviously regenerating new anterior and posterior ends were observed in two localities of Colombia, and this is the first record of asexual reproduction of *H. parvula* in the Caribbean Sea.

Location: Bahía Concha, Parque Nacional Natural Tayrona, Magdalena, Colombia (Caribbean Sea) at 11°18'6.64" N 74° 8'50.94" W

Date: 29 July 2017

Depth: 3 m

Bottom: Mixed bottom with sand, rocks and algae

Four specimens collected and deposited at the Museo de Historia Natural Marina de Colombia and catlogued as INV EQU4566: One apparently whole specimen (37 mm long); one posterior fission halve showed no regeneration of the anterior end (26 mm long); one anterior fission halve (30 mm long) with no regeneration of the anus; only the scar of the fission is apparent (Fig. 1A, C); and one posterior fission halve (27 mm long) with some very small tentacles in the new anterior end (Fig. 1A, B). These last specimens were found under the same rock. Length shown is for preserved specimens.

Notes: Specimens were observed adhered to the underside of small- to medium-size rocks, no more than 50 cm diameter. They were in pairs, with two to six on the same rock, including posterior fission halves (which were obviously regenerating new anterior ends) and anterior fission halves. Some apparently whole specimens were also observed. Two specimens of *H. (P.) parvula* were collected previously from Bahia Chengue (11 October 2016), also located at the Parque Nacional Natural Tayrona, although no evidence of asexual reproduction in those specimens was observed.

Location: Isla cayo Serranilla, SeaFlower Biosphere Reserve, Colombia (Caribbean Sea) at 15° 47' 53.2638" N 79° 50' 56.076" W

Date: 24 September 2017

Depth: 3 m

Bottom: Mixed bottom with coral reefs, rocks and algae

Three specimens collected and catalogued as INV EQU4545: Two apparently whole specimens (20 and 27 mm long) and one posterior fission half, with an obviously regenerating new anterior end (23 mm long) (Fig. 1D). Length shown is for preserved specimens.

Notes: Specimens were observed adhered under small- to medium-size rocks, no more than 70 cm in diameter. No pairs were observed, but at least one specimen with a new portion of the body and tentacles was collected. Samples were collected as part of a project developed by INVEMAR (Instituto de Investigaciones Marinas y Costeras) during the SeaFlower Expedition in 2017 (Colombia BIO-Colciencias project).

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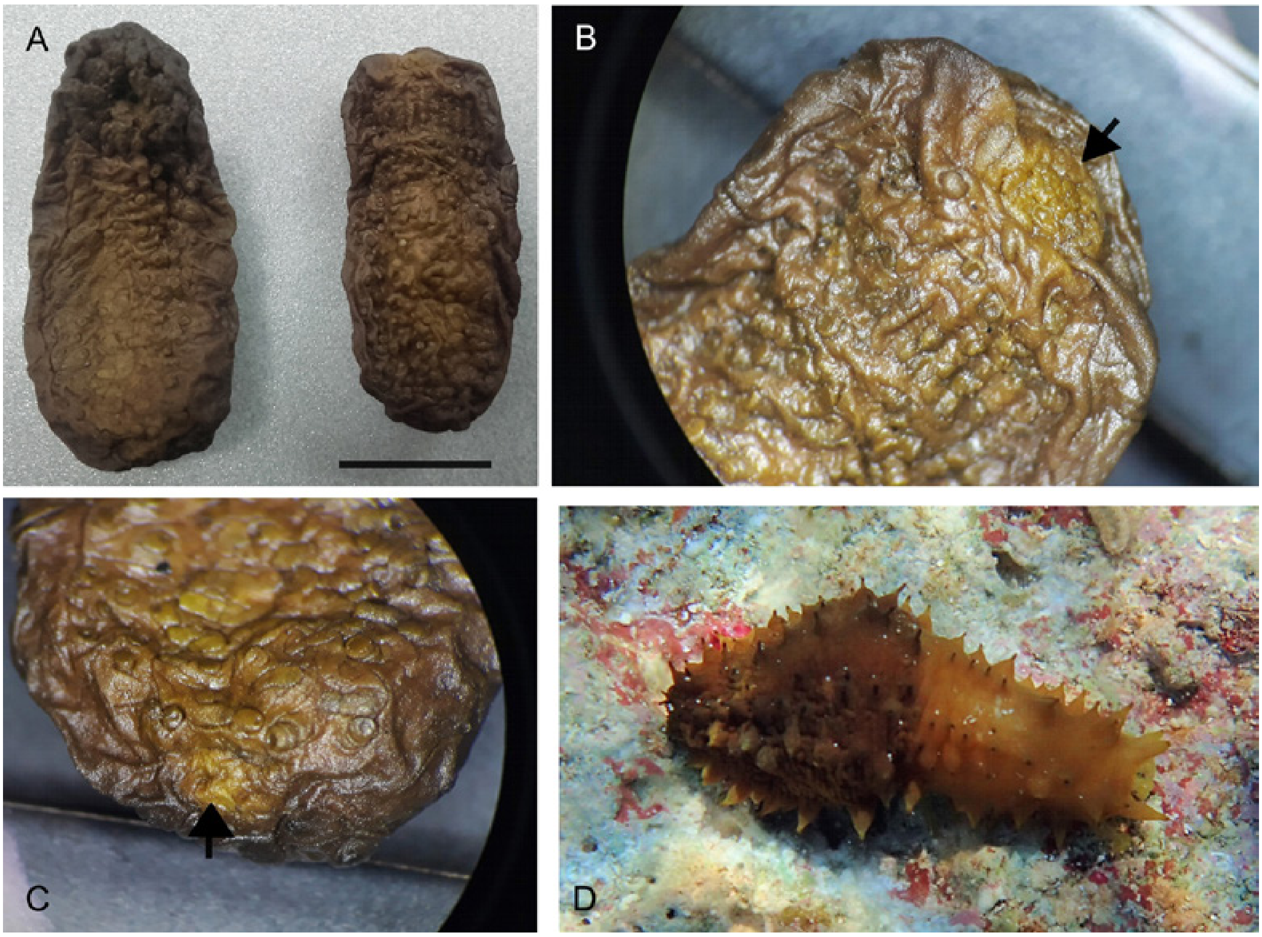

Figure 1. Specimens of *Holothuria parvula* collected in the Colombian Caribbean Sea. A–C: Specimens from Bahia Concha, Parque Nacional Natural Tayrona (catalogued as INV EQU4566) – A: Ventral side of anterior (left side) and posterior (right side) halves; B: Anterior part in regeneration, showing the small tentacles; C: Posterior part showing the scar of fission in the posterior part; D: Specimen from Isla Cayo Serranilla, SeaFlower Biosphere Reserve (INV EQU4545), general view of a live specimen.

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First record of asexual reproduction of *Holothuria* (*Mertensiothuria*) *hilla* (Lesson, 1830) in the tropical eastern Pacific Ocean

Giomar H. Borrero-Pérez,[1]* and Maria Juliana Vanegas[1]

Asexual reproduction in *Holothuria (Mertensiothuria) hilla* has been reported from Reunion Island in the western Indian Ocean (Hoareau et al. 2008), the Great Barrier Reef in Australia, and Hawaii (Lee et al. 2008). This is one of the nine species belonging to the family Holothuriidae reported by Dolmatov (2014) as being capable of asexual reproduction. Hoareau et al. (2008) considered *H. (M.) hilla* as a relatively rare species at Reunion Island, and reporting evidence of natural fissiparity (anterior and posterior part specimen regenerating) in one specimen in June 2001 and two specimens in January 2008. Lee et al. (2008) monitored asexual reproduction of a population of *H. hilla* at One Tree Island on the Great Barrier Reef, where the species has shown densities of 82–220 ind./ha on midshelf reefs, and lower numbers on outer shelf reefs (Hammond et al. 1985). The authors reported that fission occurs through the year, although it appears to be more prevalent in the cooler months (May–August). The presence of gonads was investigated by these authors in five specimens in November 2006, although the stage of maturation of the gametes could not be determined, so further studies would be required in order to understand the complete reproductive cycle of *H. hilla*. Lee et al. (2008) also reported asexual reproduction in *H. hilla* in aquaria where it is a popular species. During 2016, evidence of natural asexual reproduction was observed in several individuals collected from rocky reefs of northern Chocó, Colombia. This is the first record of fissiparity of *H. hilla* in the tropical eastern Pacific.

Location: Piedra de Rodrigo rocky reef, northern Chocó, Colombia, tropical eastern Pacific Ocean, at 6°47'2.076" N 77°41'36.887" W

Depth*:* 19 m

Bottom*:* Mixed bottom with middle-size rocks on sand

Specimens collected and deposited at Museo de Historia Natural Marina de Colombia. One specimen catalogued as INV EQU4245: total length 75 mm (Fig. 1A), collected by J. Vanegas on 25 April 2016; four specimens catalogued as INV EQU4310: one complete specimen (110 mm length); two posterior fission halves with obvious new anterior end, total length 69 mm (10 mm new anterior end) and 90 mm (20 mm new anterior end) (Fig. 1B), and one posterior fission half without a mouth and no visible sign of regeneration (75 mm total length) (Fig. 1B), collected by G. Borrero on 26 October 2016; one whole specimen catalogued as INV EQU4311: total length 65 mm, collected by G. Borrero on 26 October 2016.

Notes: The specimens were collected as part of a project seeking to characterise the biodiversity of the rocky reefs (locally called *riscales* and *morros*) at northern Chocó in the Colombian Pacific Ocean ("Riscales" project developed by INVEMAR, www.invemar.org.co). The specimens were collected only in one of the 22 localities during samplings made in April and October 2016. During both samplings, several specimens were observed under several rocks that were examined, however, only six specimens were collected (Fig. 1). As was mentioned by Lee et al. (2008), and as happens in other *Holothuria*, regeneration in specimens of *H. hilla* is easily distinguished because the new part of the body is lighter in colour and smaller in diameter than the original body (Fig. 1B). Although it was easy to observe that the anterior part was regenerating, it was not very clear for the posterior part. Nugroho et al. (2012) observed that the posterior part grew faster than other parts of *Holothuria impatiens*, which could be similar in *H. hilla.* This note reports evidence of natural asexual reproduction of *H. hilla*, completing this information for the entire distribution area of the species.

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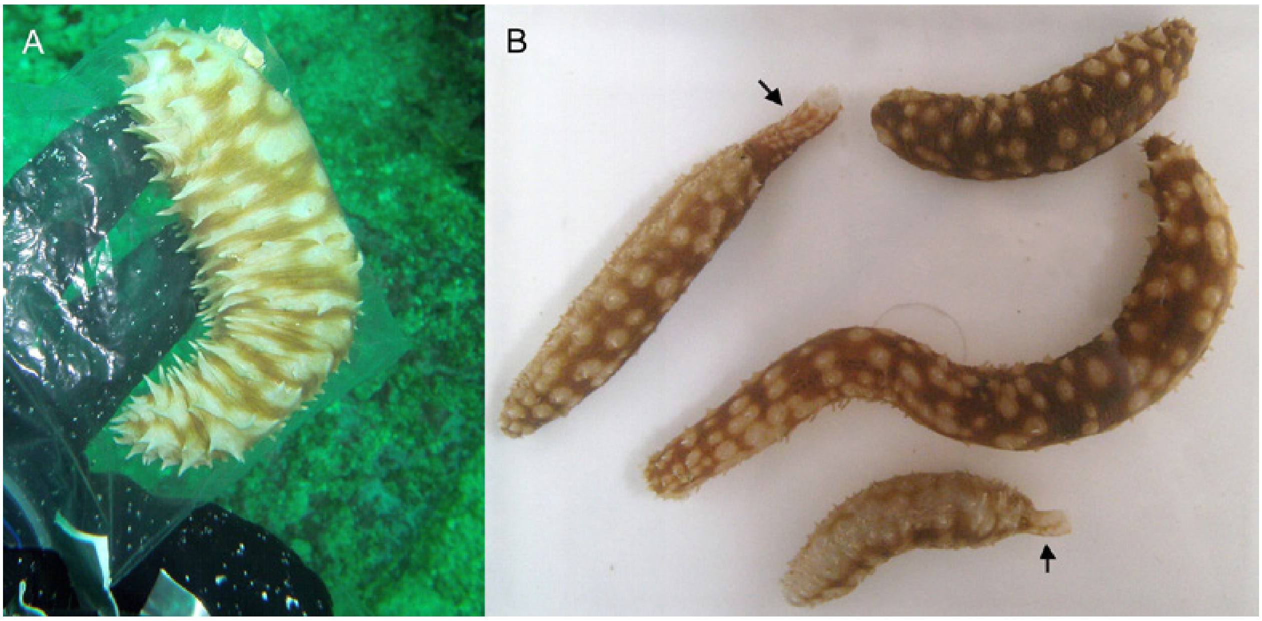

Figure 1. Specimens of *Holothuria* (*Mertensiothuria*) *hilla* collected at the northern Chocó, Colombia, in the tropical eastern Pacific. A: Whole specimens (INV EQU4225) collected on 25 April 2016; B: Four specimens (INV EQU4310) collected on 26 October 2016 two posterior fission halves with obvious new anterior end (indicated with black arrows), and two anterior fission halves with the anus already developed.

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Observations of juvenile *Stichopus* sp. on a coral reef in Palau

Amelia Desbiens[1] and Kennedy Wolfe[1*]

Information on the supply-side ecology[2] of tropical sea cucumbers is poor because juveniles are rarely observed in nature, especially newly settled or early-stage juveniles (i.e. < 1 cm) (Conand 1988; Shiell 2004; Bourjon and Conand 2015). In the case of commercially important sea cucumber species, this hinders our ability to develop fisheries management strategies that adequately incorporate data on spawning windows (e.g. Balogh et al. 2019), larval recruitment, and juvenile nursey sites (e.g. Eriksson et al. 2010; Palazzo et al. 2016; Wolfe and Byrne 2017).

During field surveys of cryptic fauna inhabiting reef rubble in Palau, western Micronesia (Fig. 1), we found six, early-stage juvenile stichopodids. These surveys were part of a larger study aimed at characterising cryptofauna communities in degraded reef structures and quantifying their roles in coral reef trophodynamics. The rubble habitat was shallow (1–2 m depth) and on the back reef of a common research and dive site known as Lighthouse Reef (Fig. 1a). The back-reef habitat varied from large dead coral and rubble pieces (including coral bommies ~1 m) to rubble beds comprising smaller fragments (Fig. 1b), on which juvenile stichopodids were found. Two juveniles were found within our broader sampling protocol, while the remainder were found during haphazard searches in the same environment.

The juvenile stichopodids observed, presumably belong to the *Stichopus* genus. They ranged from 7 mm to 12 mm in length (Table 1), and were bright yellow. The trivium had three rows of podia and the bivium had a number of papillae with dark tips (Fig. 2a). Larger individuals were observed to have 10 ramified feeding tentacles at the anterior end (Fig. 2b), which were suppressed in the smallest individual (Table 1).

The first four juveniles found were kept in controlled aquarium conditions for subsequent weeks to monitor their growth. Natural rubble from the collection site was provided but no additional food was supplied. Within six days, the smallest individual (7 mm) had grown 1 mm and its tentacles became ramified. All other individuals (≥ 9 mm) had ramified tentacles when found, with the exception of the posterior end of a recently split individual (Table 1). Interestingly, Hu et al. (2010) documented 8 mm as the size threshold for ramification of the tentacles for (a likely different) *Stichopus* sp. reared in a laboratory. Growth rates were approximately 1 mm/week (Table 1). This is slower than that reported by Hu et al (2010) (1 mm/day), although notably, they provided enriched food throughout the juveniles' development.

We found one individual that exhibited traverse fission (i.e. splitting in half), with distinct and partially healed anterior

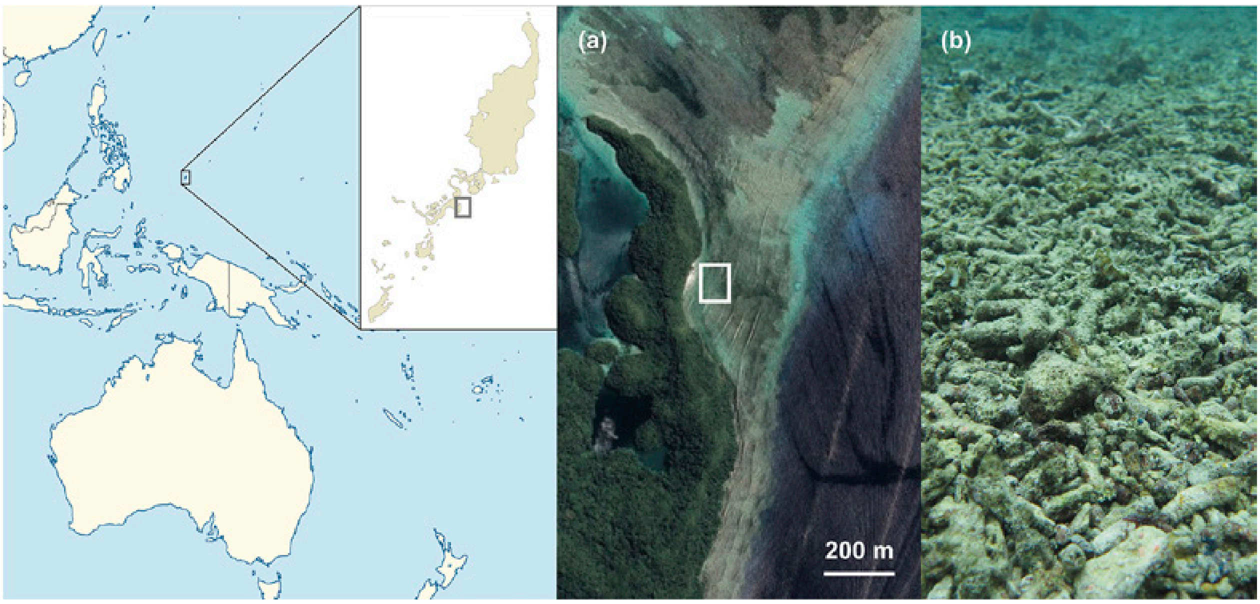

Figure 1. Palau, western Micronesia, indicating the location of Lighthouse Reef (7°16'06" N and 134°27'08" E) and the back-reef rubble site (a), and rubble habitat where juvenile stichopodids were found (b).

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[2] "Supply-side" ecology looks at the mechanisms that control the settlement and recruitment of marine organisms, and the conditions under which recruitment variation affects the distribution and abundance of adults.

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Table 1. Information on juvenile *Stichopus* sp., including date found, initial and final size (mm), growth rate (mm/week) and the presence of ramified tentacles at the time of collection. Note: individual no. 4 had undergone fission, with separate measurements taken for the anterior (an) and posterior (po) segments.

ID no.	Date found	Days in aquaria	Initial size (mm)	Final size (mm)	Growth rate (mm/week)	Tentacles ramified
1	15-11-2019	25	7	12	1.40	No
2	18-11-2019	22	9	13	1.27	Yes
3	20-11-2019	20	12	16	1.40	Yes
4 (an)	28-11-2019	12	9	11.5	1.46	Yes
4 (po)	28-11-2019	12	5	8	1.75	No
5	06-12-2019	0	10	-	-	Yes
6	06-12-2019	0	11	-	-	Yes

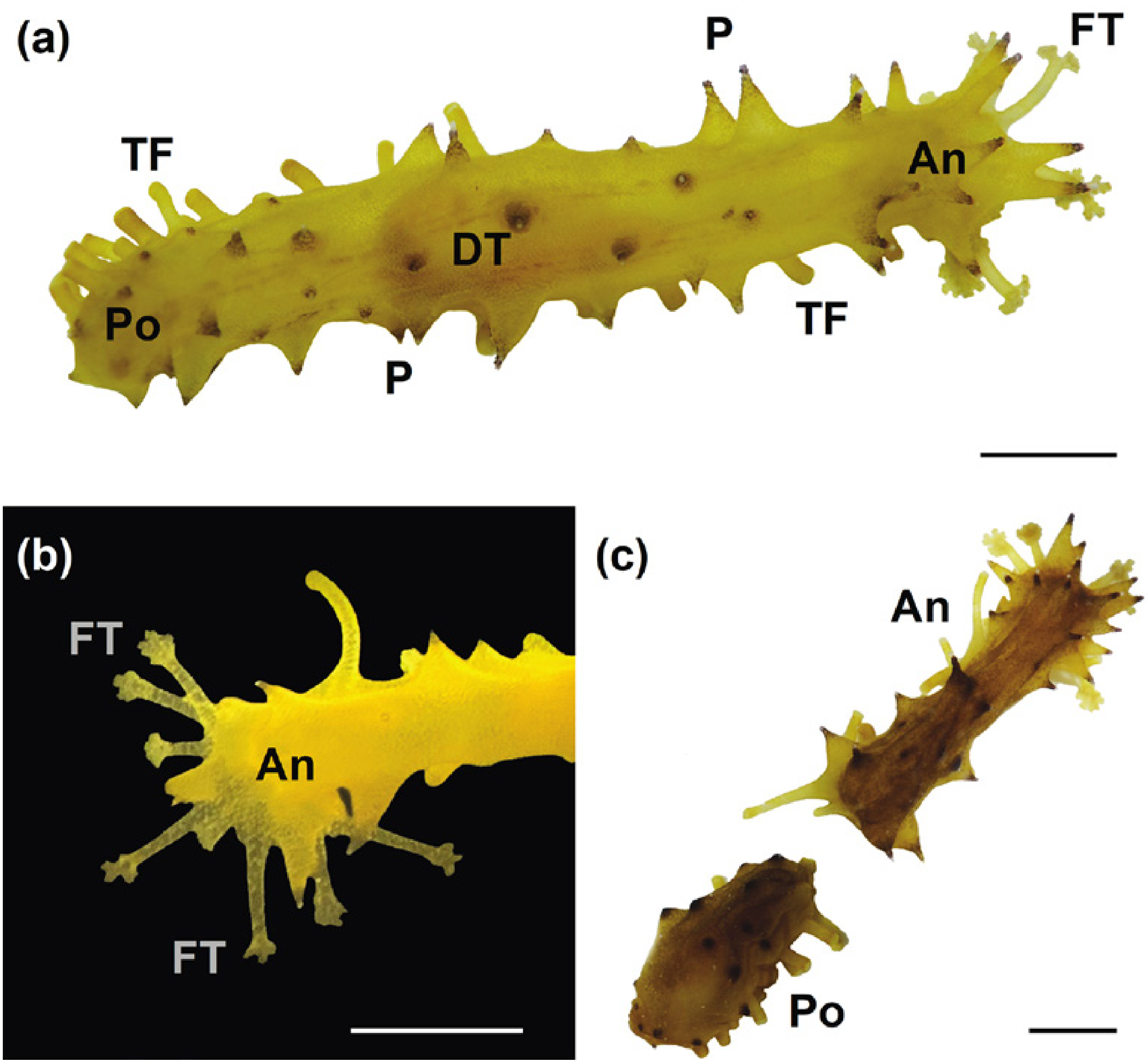

Figure 2. Images depicting: a) a juvenile *Stichopus* sp. found in reef rubble habitat in Palau, including b) the anterior end with ramified feeding tentacles, and c) the individual that had undergone fission. Letters indicate: TF = tube feet; P = papillae, FT = feeding tentacles; DT = digestive tract; An = anterior end, and Po = posterior end (scale bars = 2 mm).

and posterior parts (Fig. 2c). It remains unknown when this fission occurred but both halves were found on the same piece of rubble *in situ*. The cause of fission also remains unknown, but was possibly due to attempted predation or physical abrasion. Both halves persisted in aquaria with regeneration of ramified tentacles identified on the posterior segment approximately one week after discovery. This is consistent with previous observations of successful posterior-end regeneration in *Stichopus* spp., although persistence of the anterior segment, as observed here, is less common (Reichenbach and Holloway 1995; Dolmatov 2014). This may reflect the tendency for smaller (and younger) *Stichopus* individuals to show higher survivorship and shorter regeneration times relative to later life stages (Reichenbach et al. 1996).

To our knowledge, these are the smallest reported *Stichopus* spp. juveniles found in nature. There are several previous reports of juvenile *S. herrmanni* ≥ 9 cm (nearing the subadult stage) on the Great Barrier Reef, and in New Caledonia and the Indian Ocean (see Conand 1993; Shiell 2004; James 2005; Eriksson et al. 2010; Palazzo et al. 2016; Wolfe and Byrne 2017). Bourjon and Conand (2015) found one, 2.5-cm-sized *Stichopus* juvenile *in situ* in La Réunion, which was likely a different species to that found here. Our observations confirm predictions that rubble and similar consolidated reef matrices are important recruitment habitats for tropical sea cucumbers (Eriksson et al. 2013; Wolfe and Byrne 2017).

Observations around the shallow back-reef rubble site suggest that adult *Stichopus* spp. were rare, with infrequent observations of *Holothuria atra* and *Bohadschia argus*. Observations along the deeper reef slope (5–8 m depth) of Lighthouse Reef (Fig. 1a) suggest that *Thelenota anax* and *Holothuria atra* were the two most abundant holothuroids at this site, with less frequent observations of *S. herrmanni*, *T. ananas*, *H. edulis*, *H. scabra*, *H. whitmaei*, *B. argus* and *Pearsonothuria graeffei* (1–2 individuals per species during one 60-minute dive). Despite the sparsity of *Stichopus* spp. at this site, they are fairly common at other sites in Palau, particularly in the northwestern reef regions. Links between adult, larval and juvenile populations have yet to be characterised for most tropical sea cucumbers, and this remains a critical consideration for future research, particularly regarding commercially important aspidochirotoids such as *Stichopus*.

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Spawning of *Australostichopus mollis* at its northernmost subtropical locality

Simon L. Hartley,*[1] Steven W. Purcell[2] and Frank W.E. Rowe[3]

Species: *Australostichopus mollis* (Hutton, 1872), confirmed by F.W.E. Rowe from photographic comparisons (e.g. Coleman 2007)

Location: Elizabeth Reef, eastern Australia at 29°57'S, 159°04'E. The reef is 160 km north of Lord Howe Island and 555 km from the New South Wales coast of Australia. It is the southernmost coral atoll in the world. The site where spawning was observed is on the seaward side of the main lagoon, in a bay on the northwest corner of Elizabeth Reef.

Date and time: 19 February 2007

Moon phase: Waxing crescent (one day after the new moon)

Tide: At or just after low tide

Observer/photographer: Simon L. Hartley

Spawning

The photographs (Fig. 1) clearly shows that spawning animals were in close proximity, with individuals about 3–5 m apart. Many of these spawning pairs and trios were observed during the day of 19 February 2007. The close proximity would favour reproduction success, since the rates of fertilisation of oocytes in echinoderms is known to be highly dependent on distance between mates (Bell et al. 2008).

Individuals were also observed and photographed at elevated locations on the reef where sperm and oocytes could easily be taken by water currents to other spawning individuals and would be carried away from the reef benthos. Some authors have observed small fish (e.g. damselfishes) feeding on the sperm or oocytes of sea cucumbers (Moosleitner 2006; Desurmont 2008), so an erect body pose in elevated positions on the reef would serve to ensure that

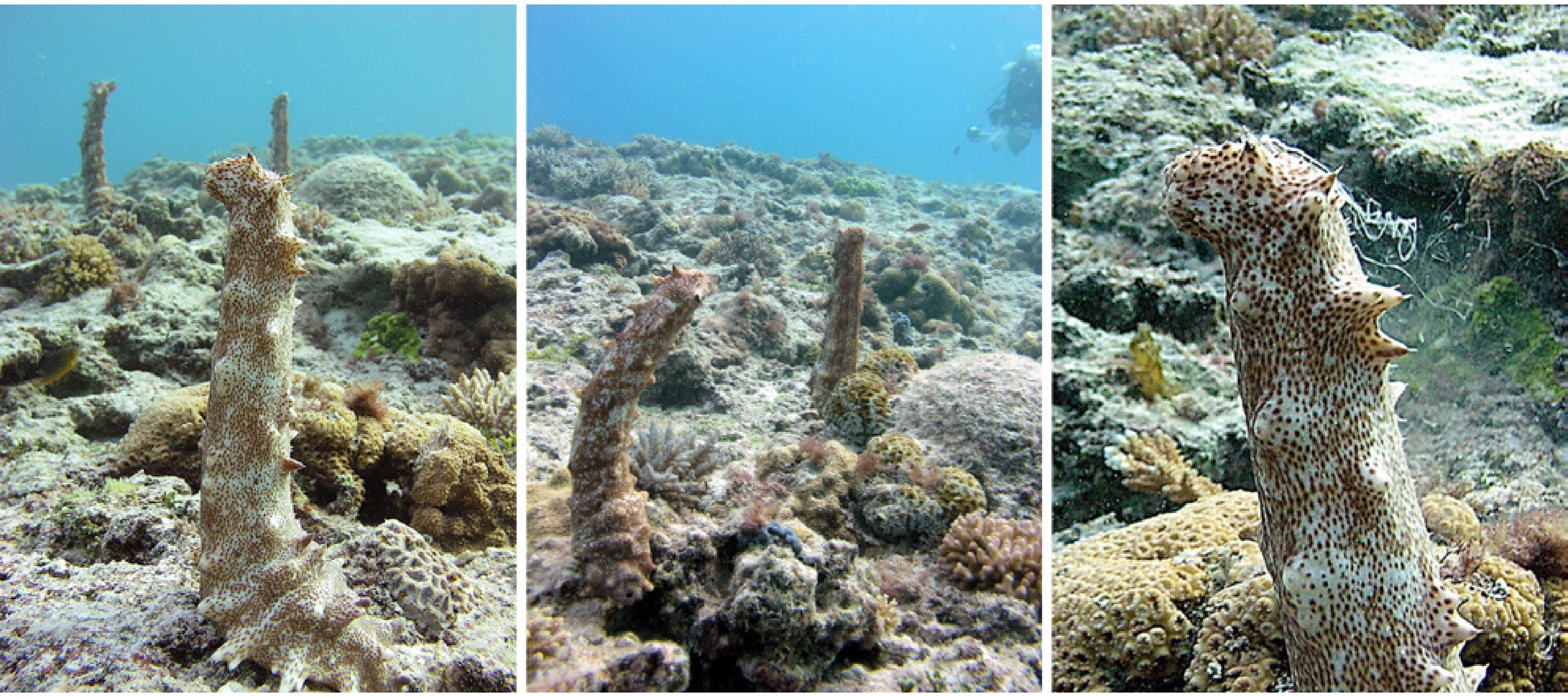

Figure 1. Pairs and trios of *Australostichopus mollis* spawning during the daytime at Elizabeth Reef, off the east coast of Australia (left and middle). A male *A. mollis* releasing sperm from its gonopore at the anterior end of the animal while in the erect spawning pose (right). (Images: S.L. Hartley)

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Figure 2. *Australostichopus mollis* observed moving on the reef surface at night at Elizabeth Reef, Australia. (Images: S.L. Hartley)

oocytes are swept away from the benthos where they could otherwise be eaten.

The observations reported here for *Australostichopus mollis* conform to a general model of individuals spawning in small groups in relatively close proximity and at elevated positions on the reef. Similar observations have been made for other reef-dwelling holothuroids (Muthiga 2008; Desurmont 2008; Byrne and Wolfe 2018; Byrne 2019; Huertas and Byrne 2019).

The spawning event occurred on the day just after the new moon, when the tidal range was 1.93 m (a "spring" tide). Many other observations of coral reef holothuroids spawning in the wild have also occurred around a new moon (Desurmont 2008; Muthiga 2008; Oki et al. 2011; Bédier et al. 2013; Hair et al. 2016; Byrne and Wolfe 2018; Byrne 2019), although some authors have reported spawnings during other lunar phases (e.g. Gaudron 2006; Olavides et al. 2011; Tessier and Letouze 2014; Huertas and Byrne 2019). Many reports of spawning also occurred in the late afternoon, as observed here. The animals were also observed exposed and moving around the reef at night, so are perhaps mainly nocturnally active at this locality (Fig. 2).

Distribution

This is a new and extended record for *Australostichopus mollis* into subtropical waters, and adds to the three stichopodid species previous reported for Elizabeth Reef (Rowe and Filmer-Sankey 1992). We also note that the animals depicted in the photographs appear relatively large, and likely to be greater than the 20 cm maximum length recorded for this species. The species is otherwise distributed in cooler, more southerly localities in the Tasman Sea, including the east coast of New South Wales, as far north as Broken Bay (33°33'S; slightly north of Sydney); south to the east coast of Tasmania; and around New Zealand (Rowe and Gates 1995). Records of *A. mollis* from Bass Strait, southern Australia, west to Fremantle and the Abrolhos Islands in Western Australia (see Rowe and Gates 1995) refer to a second species (*A. victoriae* Bell, 1887) closely related to *A. mollis* (see Rowe et al. 2017).

The present record from Elizabeth Reef, therefore, extends the previous known geographic distribution of the species by 3½ degrees of latitude (about 390 km). Elizabeth Reef is herewith reported as the northernmost locality for the species. The reef, located more than 160 km north of Lord Howe Island, is a subtropical coral reef, and the animals can clearly be seen among hard corals (Fig. 1). The locality (and likely neighbouring Middleton Reef) might represent a stepping stone to provide some genetic connectivity between populations on the east coast of Australia with those in New Zealand.

Acknowledgements

F.W.E. Rowe acknowledges, with thanks, support for the taxonomic study of Australian stichopodid holothurians (Echinodermata) from the Geddes Visiting Collection Fellowship (2011–2012 Australian Museum, Sydney). S.L. Hartley acknowledges Dr Annika Noreen for providing the opportunity to join this trip, facilitated by Paul Anderson (Department of the Environment, Water, Heritage and the Arts). The authors also gratefully acknowledge Prof Maria Byrne for email correspondence regarding the identification of this species.

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COMMUNICATIONS

Workshop on sea cucumber identification at La Réunion

Pierrat J., Dedeken M., Fari C., Frouin P., Mulochau T., Quod C., Sancelme T., Trentin F., Viramoutou B. and Conand C.

Recent discussions on biodiversity loss in the Anthropocene, and the influence of global warming, have stimulated an increased interest in biodiversity. Many expeditions and programmes have recently collected specimens of marine fauna, including holothurians, and taxonomy skills are required to identify them at different levels, down to species.

A working group gathered on 23 November 2019 at La Réunion University, with participants from different laboratories and non-governmental organisations.

Several species of sea cucumbers from the families Holothuriidae and Stichopodidae were collected to prepare the ossicles following the classical method (Samyn et al. 2006) and FAO books (Purcell et al. 2012) were distributed to participants to help them for further work.

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Figure 1. Participants to the workshop at La Réunion University

PhD thesis

Sea cucumbers of the Holothuroiida order from the Ain Franine region (west coast of Algeria): biology, ecology and exploitation

Farah Slimane-Tamacha

Presented on 8 December 2019, Department of Marine Sciences and Aquaculture, Faculty of Natural Sciences and Life, University Abdelhamid Ibn Badis, Mostaganem, Algeria.[1]

Abstract

Our study focuses on the reproductive biology and population dynamics of sea cucumbers on the western Algerian coast. During the sampling period (October 2016 to September 2017) it was noted that only *Holothuria (R.) poli* (Delle Chiaje, 1823) and *Holothuria (P.) sanctori* (Delle Chiaje, 1823) are represented consistently. The other two species, *Holothuria (H.) tubulosa* (Gmelin, 1790) and *Holothuria (R) arguinensis* (Koehler andVaney, 1907), were much less abundant. It is for this reason that we focused especially in our study on the first two aforementioned species.

The study of reproduction considered only for *Holothuria (R.) poli* showed that sex ratio is in favour of females throughout the year. The survey of the monthly evolution of the two parameters (RGS and K) showed a single spawning period with a peak in July. The average size at first sexual maturity is 150 mm. Microscopic analyses of gonadal structures have shown that the sexual cycle of *Holothuria (R.) poli* is composed of five stages: stage I recovery; Stage II growth; stage III near-mature; stage IV mature; and stage V spawning.

The size structures established for the four studied holothurians species generally have a normal distribution. Total anaesthetised lengths range from: 100 to 290 mm for *Holothuria. (R.) poli*; 140 to 325 mm for *Holothuria (P.) sanctori*; 100 to 360 mm for *Holothuria (H.) tubulosa*, and 95 to 290 mm for *Holothuria (R.) arguinensis*. The b parameter of the weight-size relation is less than 3 for the two holothuroids (*Holothuria (R.) poli* and *Holothuria (P.) sanctori*), reflecting a lower allometry which means that the size grows faster than the weight. The growth parameters (L_∞) of the Von Bertalanffy equation are similar for the two holothurids: *H.(R.) poli* (364.5mm) and *H.(P.) sanctori* (364.5mm). The growth coefficient (K) of these two species – 0.25 mm/year for *Holothuria (R.) poli* and K= 0.35/year for *Holothuria (P.) sanctori* – are closest.

The values of total mortality (Z = 0.83), natural mortality (M = 0.27) and fishing mortality (F = 0.56) obtained for *H.(R.) poli* appear to match with individuals ranging between 100mm and 290 mm. The values obtained for *H. (P.) sanctori* (M = 0.32, Z =0.90 and F= 0.58) seem to match with individuals ranging between 140 mm and 325 mm. The recruitment model consists of a single peak in March for *Holothuria (R.) poli* and another peak in April for *Holothuria (P.) sanctori*.

Through the questionnaire carried out during this study we noted the existence of illegal fishing of sea cucumbers along the entire Algerian coast, which requires urgent regulation.

Keywords: *Holothuria (R.) poli*, *Holothuria (P.) sanctori*, reproduction, growth, exploitation, illegal fishing, Oran Bay

[1] http://lpvrmlsm.univ-mosta.dz/index.php/soutenance-de-these/soutenances-doctorat-systeme-classique/oulhiz-aicha

Publications related to holothurians, published in 2019

By Chantal Conand

A Google Alert, using the word "holothurian", was set up for the period from January to December 2019. The same method had first been used in 2015 to produce the article "Bibliography on holothurians: Access to modern tools to follow new publications", which was published in the SPC *Beche-de-mer Information Bulletin* #36, and yearly since then.

Table 1. Number of publications on sea cucumbers found in 2019 by month, using a Google Alert with the word "holothurian".

	Category					
Month	General, ecology, biology	Biochemistry, microbiology	Genetics	Aquaculture	Fishery, socioeconomics	Total/month
January	10	7	1	1	3	22
February	12	5	2	1	4	24
March	8	6	2	0	1	17
April	11	10	2	1	5	29
May	6	6	2	2	1	17
June	6	4	1	0	6	17
July	8	6	2	3	3	22
August	9	11	1	5	3	29
September	4	8	1	1	2	16
October	13	13	1	4	6	37
November	22	12	1	5	1	41
Decemmber (partial)	9	7	4	3	6	29
Total	118	95	20	26	41	300
%	39,3%	31,7%	6,7%	8,7%	13,7%	100%

The steady decrease in articles devoted to holothurians (from over 400 in 2015 to 300 in 2019) prompts us to look at a longer period, and to verify, among other things, whether the decrease in articles on fisheries and socioeconomic issues (Fig. 1) is a consequence of the disappearance of these fisheries in several parts of the world due to overfishing.

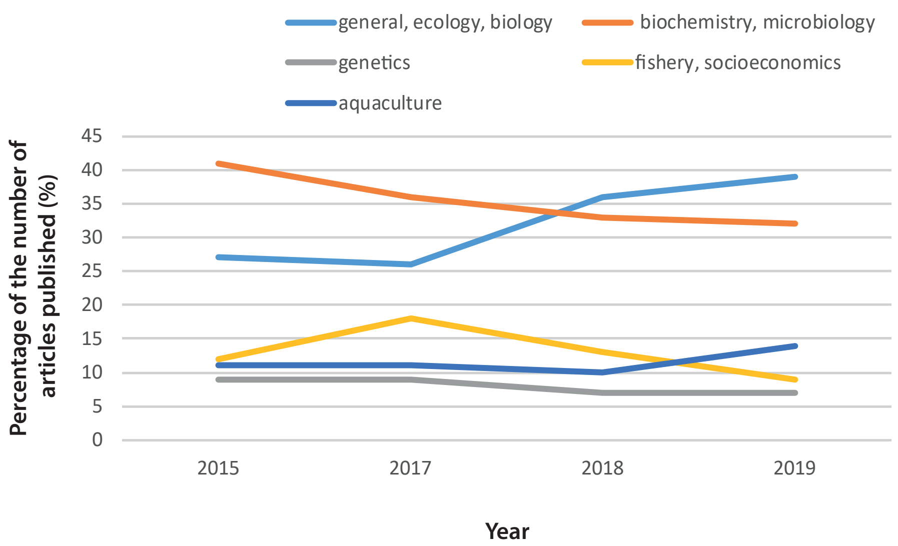

Figure 1. Evolution of the yearly ratio of articles published from 2015 to 2019.

Tribute to Professor Patrice Francour

From the research team of the Protection and Valorization of Littoral Marine Resources and Molecular Systematic Laboratory, Department of Marine Science and Aquaculture, Faculty of Natural Sciences and Life, Abdelhamid Ibn Badis University, Mostaganem, Algeria.

It is with immense sadness that we received the announcement of the premature loss of a seasoned scientist, Professor Patrice Francour, who was committed to the conservation of the marine environment in the Mediterranean. He passed away on Sunday, 13 October 2019 after a long fight against an incurable disease.

Doctor of Aix-Marseille University, Patrice Francour was appointed Senior Lecturer in Nice in 1998, then Professor in 2002. He directed the ECOMERS[1] laboratory for 10 years, before its transition to a Research Federation in 2016 and a Joint Research Unit in 2019.

He was thus one of the architects of the development of the ECOMERS laboratory, which has now become ECOSEAS[2] and is accredited by the CNRS[3].

Patrice was passionate about marine biodiversity and coastal ichthyofauna, in particular. He developed many approaches – based on *in situ* observations – to better identify, understand and qualify the ecological state of coastal ecosystems, and to promote their preservation; for example, the FAST methodology and the monitoring of artificial reefs, a theme for which Patrice never hesitated to receive young researchers in order to introduce them to his method.

He was among the pioneers who studied holothurians (sea cucumbers) in the Mediterranean Sea ecologically and especially the standardisation of measures of *Holothuria* that many researchers were unaware of at the time. He reviewed predation on these species in 1997, and studied in detail the microdistribution of holothurians within the Mediterranean seagrass (*Posidonia oceanica*) ecosystem.

His erudition and scientific expertise, as well as his plethora of bibliographic backgrounds, have enabled many researchers to restructure their research and find solutions to more current problems. From the beginning, Patrice committed himself to the protection of the marine environment and to marine protected areas in the Mediterranean. With his academic commitment, Patrice extended his work to many organisations and associations, including the International Union for Conservation of Nature.

This scuba diving enthusiast will be missed by lovers of our dear Mediterranean, and it goes without saying that his memory will be honoured by our scientific contributions, a loyal return for his humility and his bonhomie.

Rest in peace Patrice.

Professor Patrice Francour.

1 Écosystèmes Côtiers Marins et Réponses aux Stress (Marine Coastal Ecosystems and Stress Responses)
2 Ecology and Conservation Science for Sustainable Seas
3 Centre National de la Recherche Scientifique (National Center for Scientific Research)

Sea cucumber trade in the Taiwan International Fisheries and Seafood Show

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The Taiwan International Fisheries Seafood Show (TIFSS) is held annually at the Kaoshiung Exhibition Center in Chinese Taipei, and is one of the most popular seafood-related events, attracting researchers, academics, farmers, vendors and buyers of seafood products from all over the world. TIFSS 2019, held from 26 to 28 September 2019, attracted 180 exhibitors from 16 countries and an estimated 7000 visitors. People attending the seafood tradeshow had the opportunity to network and update themselves on the latest technology available in the field of aquaculture and fisheries. Buyers were able to discover new products and cutting-edge equipment, while vendors were able to display their products and innovation.

TIFSS 2018 had new cosmetic and food products made from sea cucumber on display. Shinhan ECO Co. Ltd., a South Korean company (Fig. 1) with a branch in Qingdao, Shandong Province, China, promoted cosmetic (under the brand name *Chunsulbi*) and food products made from extracts of the red sea cucumber (*Stichopus japonicus*) found in Jeju Island, South Korea. These cosmetic products included moisturising creams, sheet masks, soaps, whitening creams, sun blocks and cleansing foam (Fig. 2). Food products included red sea cucumber gel, granules, and bottled beverages and capsules that were sold as health supplements (Fig. 3).

Figure 1. Shinhan Eco. Co. Ltd. booth in South Korea (at TIFSS 2018), promoting products made from extracts of the red sea cucumber (*Stichopus japonicus*).

Figure 2. Cosmetics produced by Shinhan Eco. Co. Ltd. and made from extracts of the red sea cucumber (*Stichopus japonicus*).

Figure 3. Health supplements produced by Shinhan Eco. Co. Ltd. and made from extracts of the red sea cucumber (*Stichopus japonicus*).

Vlazar Coasta Caribe, a company from Nicaragua (Fig. 4) promoted dried sea cucumbers. Species available included: Molongo black sea cucumber, also known as donkey dung sea cucumber (*Holothuria mexicana*), pikachu (scientific name unavailable), pepino lapiz (*Holothuria floridana*), pepino ballena (*Isostichopus badionotus*) and toalla (scientific name unavailable). Figure 5 shows pictures of the different sea cucumber species promoted by the company.

Figure 4. The booth of the com panyVlazar Costa Caribe from Nicaragua (at TIFSS 2019), promoting dried sea cucumbers.

Figure 5. Sea cucumber brochure distributed by the Nicaraguan company Vlazar Costa Caribe.
Top row, from L. to R.: Molongo (*Holothuria mexicana*); Molongo dried; Picachu (scientific name unknown) Middle row, from L. to R.: Picachu dried; Lariz (*Holothuria floridana*); Toalla (scientific name unavailable) Bottom row, L.: Café (*Isostichopus badionotus*)

Conferences and symposiums

List prepared by Chantal Conand

Symposiums held in 2018

International Echinoderms Conference (Nagoya, 2018)

21 October 2019 communication from: Tatsuo Oji, Toshihiko Fujita, Tatsuo Motokawa, Miéko Komatsu, Yukio Agatsuma and Ken'ichi Kanazawa

We are happy to announce that the proceedings of the 16th International Echinoderms Conference held in Nagoya, Japan last year have been published online at: https://mapress.com/j/zs/issue/view/zoosymposia.15.1

All papers from the proceedings are open access. We thank the volunteer reviewers of the papers that were submitted to the proceedings.

Symposiums held in 2019

11th Western Indian Ocean Marine Science Association International Symposium – University of Mauritius, 1–6 July 2019

The symposium has been an important event for marine science in the Indian Ocean. Around 600 scientists, managers and students were able to exchange information during the week on many topics and multi-disciplinary fields. Plenaries by well-known scientists, selected oral communications, numerous posters, mini-symposia and other activities have made it memorable. More information on the symposium is available from: www.wiomsa.org

Holothurians were the subject of:

Oral communications

- Kuehnhold H., N. Steinmann N., Huang Y., Meyer A. and Kunzmann A. Temperature-dependent aerobic scope and Hsp70 expression in the sea cucumber *Holothuria scabra*.
- Conand C., Claereboudt M., Dissayanake C., Fernando S., Fouad A., Govinden R., Hart A., Lavitra T., Leopold M., Mmbaga T., Mulochau T., Shea S., Vaitilingon D., Yahya S. and Friedman K. Fisheries and management of sea cucumbers in the Indian Ocean: An update.
- Léopold M., Govinden R., Caquelard J., Ebrahim A. and Bach P. Estimating sea cucumber resource abundance in Seychelles using fishery-dependent data.

Posters

- Di Simone M., Horellou A. and Conand C. Towards a CITES listing of sea cucumbers: teatfish *Holothuria (Microthele)* spp.
- Randrianandrasana J., Behivoke F., Razakandrainy A. and Todinanahary G. Towards sustainable octopus and sea cucumber fishing: Use of half-sphere artificial reefs for habitat restoration.
- Yussuf Y. and Yahya S. Setting baselines for large scale hatchery production of high value tropical sea cucumber *Holothuria scabra* (Jaeger, 1833) in Zanzibar, Tanzania.
- Zafinirina D. and Rakotovao J. Study of the diversity and effect the vibrios on *Holothuria scabra* raised at the IOT in Toliara (Madagascar).
- Hery Lova Tiana Charlot R. and Kluckow T. Community-based sea cucumber aquaculture in the Velondriake locally managed marine area: A community centric approach to governance.
- Maka O., Pascal B. and Todinanahary G. Wild holothurian fishery in the southwest Madagascar.
- Issangya P. Particle size and patch selectivity in *Holothuria atra* and *Holothuria leucospilota*.
- Steinmann N. We are family: High geneflow in sandfish (*Holothuria scabra)* in Zanzibar, Tanzania.
- Lavitra T., Pascal F., Pascal B., Razanakoto I., Eeckhaut I. and Todinanahary G. Towards development of a promising community-based polyaquaculture involving sea cucumber (*Holothuria scabra*) seaweed (*Kappaphycus alvarezii)* and corals in Madagascar.

4th Congress of Latino-American Echinoderms – La Paz, Mexico, 10–15 November 2019

More information at: http://rediberoamericanaequinodermos.com/programa

2020 symposiums and calls for proposals

Global Summit on Climate Change (GSCC-2020) London, UK, 15–16 June 2020

On behalf of the board members, we are pleased to write and invite you to join our congress as a speaker. For more details, see: https://www.climatechangecongress.com/

6th International EcoSummit, Gold Coast, Australia, 21–25 June 2020

EcoSummit 2020 co-chairs are:

- Jan-Olaf Meynecke, Griffith University, Australia
- Robert Costanza, Crawford School of Public Policy at Australian National University, Australia
- B. Larry Li, University of California, Riverside, USA

Visit the EcoSummit 2020 website: http://www.ecosummitcongress.com/

ECSA 58 & EMECS 13 Conference – Hull, United Kingdom, 7–11 September 2020

Estuarine and coastal seas in the Anthropocene – Structure, functions, services and management

During the 12th International Conference on the Environmental Management of Enclosed Coastal Seas (EMECS 12) in Pattaya, Thailand, representatives from ECSA and the EMECS Science and Policy Committees approved a joint ECSA 58-EMECS 13 Conference to be held in Hull, UK in 2020.

More information at: https://ecsa.international/event/2020/joint-ecsa-58-emecs-13-conference-hull-september-2020

9th North American Echinoderm Conference – Charleston, Oregon, 13–18 June 2020

I am pleased to announce that the 9th North American Echinoderm Conference will be held at the Oregon Institute of Marine Biology in Charleston, Oregon from 13 to 18 June 2020. You can find information about registration, presenting, lodging, travel, and other details on our website at: https://www.echinoderm.org

If you have any questions please do not hesitate to contact us through the website, on Facebook (https://www.facebook.com/echinoconf/), or me directly. We began accepting abstract submissions on 1 September 2019.

Julie Schram – Postdoctoral Researcher, University of Oregon, Oregon Institute of Marine Biology. Email: jschram@uoregon.edu

Echinoderm Session at NSA Meeting in March April 2020

A session on echinoderms will be organised at the next National Shellfisheries Association meeting, which will be held in Baltimore, Maryland, USA from 29 March to 2 April 2020.

More information at: https://www.shellfish.org/annual-meeting

5th World Conference on Marine Biodiversity – Auckland, New Zealand, 13–16 December 2020

This is the premier world conference on all aspects of marine biodiversity, having being held previously in Valencia Spain, Aberdeen Scotland, Qingdao China, and Montreal Canada. It is led by the over five-year old academic body, the International Association of Biological Oceanography.

More information at: https://www.wcmb2020.org/

ICRS 2020 Bremen, Germany – 14th International Coral Reef Symposium, 5–10 July 2020

We invite all who are interested in contributing phylogenetic and biodiversity insights on reef organisms to submit abstracts for the International Coral Reef Symposium 2020. This session in Theme 2, Species and their populations, asks the question: How can we use phylogenetic tools to better understand biodiversity, evolutionary patterns, and processes?

More information at: http://www.icrs2020.de/program/session-program/#c234

IUCN World Conservation Congress 2020 – Marseille, France, 10–12 June 2020

More information at: https://www.iucncongress2020.org/

NWO Caribbean Research programme

The new call for the NWO Caribbean Research programme is open for applications. This call has a total budget of EUR 7.18 million, and comprises a special approach. NWO is seeking two programme chairs who will each set up a multidisciplinary research programme: one with a focus on sociocultural issues and based in the Leeward Islands, and one focusing on natural science issues and based in the Windward Islands.

The call for proposals can be downloaded from:

https://www.nwo.nl/en/funding/our-funding-instruments/enw/caribisch-research-call-for-programme-chairs/caribisch-research.html

Other information on sea cucumbers

How sea cucumbers can help the ocean

Sea cucumbers are a prized aphrodisiac in China. However, like many coastal species, they have been chronically overfished. One remote community in Madagascar has started a pioneering coastal-farming project with astonishing results. Watch the excellent video produced by The Economist at: https://www.woi.economist.com/how-sea-cucumbers-can-help-the-ocean/

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