Food preferences of four aspidochirotid holothurians species (Holothuroidea: Echinodermata) inhabiting the *Posidonia oceanica* meadow of Mostaganem area (Algeria)

Nor-Eddine Belbachir[1,2] and Karim Mezali[2]

Abstract

Analysis of the digestive contents of four aspidochirotid holothurians species (*Holothuria poli, H. tubulosa, H. forskali* and *H. sanctori*) sampled in two localities in the Mostaganem area (Stidia, Salamandre) were carried out in order to overview the different food sources appreciated by these animals.

Our results show that holothurians feeds on diatoms, cyanophytes, macrophytes algae, *Posidonia oceanica* leaves (alive and dead), foraminifera, crustaceans, molluscs bivalve shells, sponge ossicles and nematodes. Diatoms were mostly consumed by holothurians at both sites. The greatest rates of ingested diatoms are recorded for *H. poli* (38.66% and 34.44% respectively at Stidia and Salamandre). The *Posidonia oceanica* leaves (alive and dead) are also consumed, but with low rates. *Holothuria forskali* feeds in a preferential way on the *Posidonia oceanica* leaves (3.33% dead leaves, 14% live leaves at Stidia and 9% live leaves at Salamandre). Foraminifera are consumed mostly by *H. forskali* (13.33% and 15% respectively at Stidia and Salamandre), even if that food source is not appreciated very much (Ivlev index: -0.3 and -0.06 respectively at Stidia and Salamandre). At both sites, most holothurian species consume large amounts of sponge ossicles and this is their preference. Crustaceans and nematodes are less consumed, regardless of their significant electivity index (Ivlev index = 1 for nematodes, in most holothurians species of Stidia area).

Introduction

The 'deposit feeders' aspidochirotid holothurians species represent the major component of the *Posidonia oceanica* ecosystem in the Mediterranean Sea. They play an important role in the detritus food web by recycling of organic matter (Zupo and Fressi 1984). The sediments ingested by holothurians are mainly composed of 1) inorganic material (coral scraps, coralline, skeletons and inorganic remnants of the benthos); 2) organic detritus matter (fragments of algae and marine phanerogams, decaying dead animals); and 3) microorganisms (bacteria, diatoms, protozoa and cyanophytes) (Massin 1982; Moriarity 1982).

In Algeria, several research works have been carried out on systematics, biology, ecology, population dynamics and valorisation of holothurians (Mezali 2004, 2008; Mezali et al. 2003, 2006, 2014, 2016). The sediment particle size selectivity and the assimilation of organic matter by these animals were also discussed (Mezali and Soualili 2013; Belbachir et al. 2014). Nevertheless, their diet strategy is still not well known.

Materials and methods

Sampling was carried out during winter 2015 by scuba diving at 3 m depth, at two sites (Stidia and Salamandre) on the Mostaganem coastline (Algeria) (Figure 1). Ten individuals of each of the following species (*Holothuria poli, H. tubulosa, H. forskali* and *H. sanctori*) were collected. The first millimetres of the sediment (biotope) on which these animals feed were also sampled.

Figure 1. Geographical sites of the sampling areas (red circles).

[1] Departement of Biology, Faculty of Natural Sciences and Life, Abedelhamid Ibn Badis University, Mostaganem, P.O. Box 300, 27000 Algeria

Each sample (containing an individual of each holothurians species and the sediment originating from its biota) was isolated separately in a plastic bag containing seawater for its laboratory investigation. The 'contact method' described by Jones (1968) and Nédélec (1982), was used for the analysis of digestive contents. For that, a sub-sample of 1 g of the digestive content was added to 10 mL of formalin-fixed seawater. Then 1 mL of the preparation was observed under a light microscope objective (using a lens with magnification of 40x). The preparation on the slide was moved randomly. At each position, the food item, which is located exactly in the centre of the visual field, was identified; this constitutes a contact. Ten contacts were made for ten microscope slides (100 contacts were analysed for all the digestive content). The sum of the contacts for a given food item established the percentage of its presence in the digestive content. This method was also used for the sediment of the biota. The selectivity in the choice of food item was studied by calculating the Ivlev electivity index (E'): $E' = (ri - pi) / (ri + pi)$ [ri: % of food item in the digestive content, pi: % of food item biota sediment. $E' = 0$ indicates no selectivity; $-1 < E' < 0$, indicates avoidance; $0 < E < 1$, indicates preference] (Ivlev 1961; Whitlatch 1974 in Stamhuis et al. 1998).

Results

The main types of food items found in the digestive content are divided into two large fractions: 1) a plant fraction composed of diatom (Dt), cyanophytes (Cy), macrophytes algae (Al), and live (Pv) and dead (Pm) *Posidonia* leaves; 2) an animal fraction, represented by foraminifera (Fo), crustaceans (Cr), sponge ossicles (Sp), nematodes (Nm) and shells of bivalve molluscs (Cq) (Figures 2 and 3). Organic particles that couldn't be identified due to their advanced degradation are referred to as organic debris (Do) (Figures 2 and 3). The contribution of each food source is different for each species.

At both study sites, diatoms (Dt) were the most consumed food of almost all holothurians species. The highest rates were recorded for *H. poli* (38.66% and 34.44% respectively at Stidia and Salamandre) (Figure 2). The preference for this food was observed only for holothurians collected at Stidia site (E': 0.11, 0.07 and 0.07 respectively for *H. poli*; *H. forskali* and *H. sanctori*) (Figure 4). Sponge ossicles (Sp) were the second most widely consumed food item in all holothurians of both studied sites. In fact, the highest rates were obtained in the Salamandre site for *H. forskali* and *H. sanctori* [with 25% and 23.33% respectively (Figures 2 and 3)]. *Holothuria forskali* selected the most sponge ossicles (Sp), as shown by the important electivity index for this food [E': 0.22 and E': 0.23 respectively at Stidia and Salamandre] (Figures 4 and 5)]. The contribution of cyanophytes (Cy) in the food bowl of holothurians at both sites was relatively large. The highest rates were obtained for *H. forskali* [12.33% and 12% respectively at the sites of Stidia and Salamandre (Figures 2 and 3)] and *H. sanctori* [17.66% and 11.66% respectively at Stidia and Salamandre] (Figures 2 and 3)]. In addition,

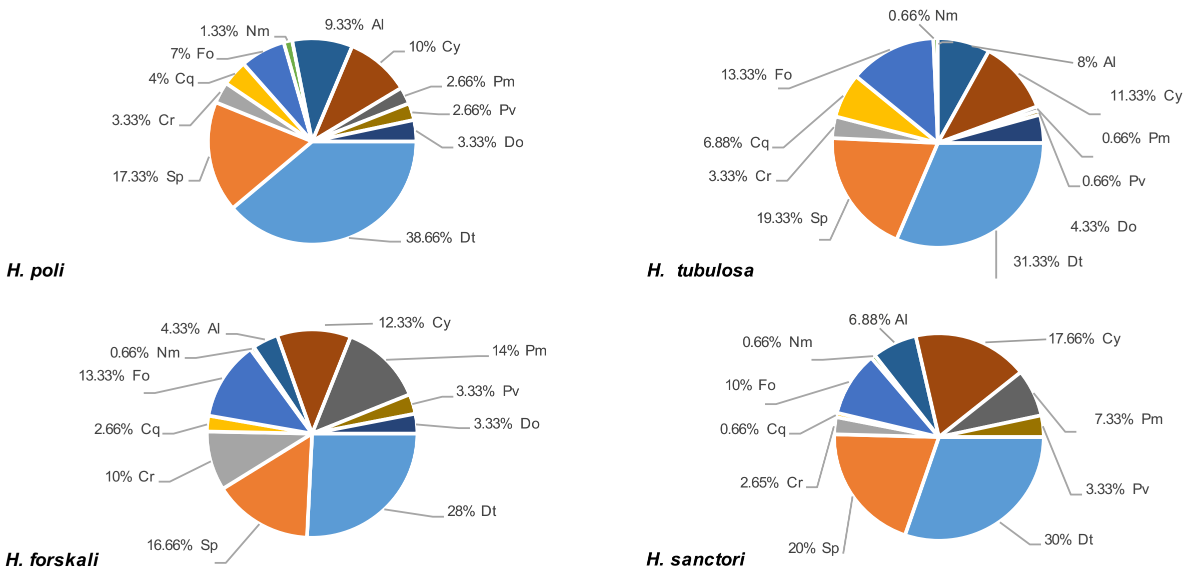

Figure 2. Contribution (in percentage) of the different types of food items in the diet of holothurians originating from the site of Stidia. Sp = sponge ossicles; Cr = crustaceans; Cq = shells of bivalve molluscs; Fo = foraminifera; Nm = nematodes; Al = macrophytes algae; Cy = cyanophytes; Pm = dead *Posidonia* leaves; Pv = live *Posidonia* leaves; Do = organic debris; Dt = diatom.

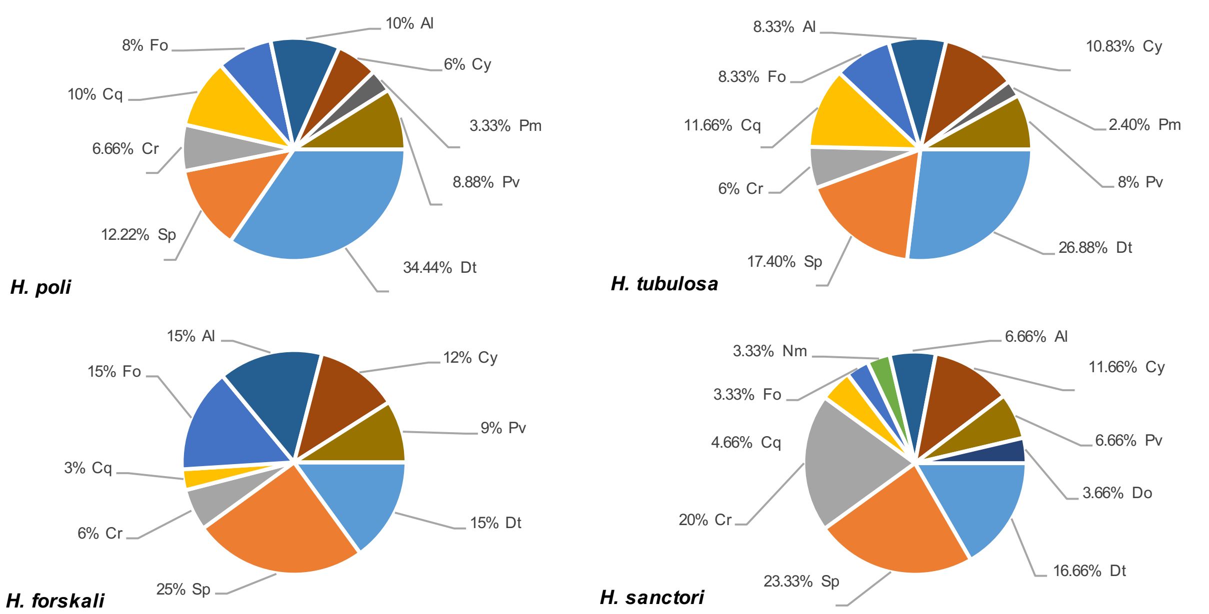

Figure 3. Contribution (in percentage) of the different types of food items in the diet of holothurians originating from the site of Salamandre. Sp = sponge ossicles; Cr = crustaceans; Cq = shells of bivalve molluscs; Fo = foraminifera; Nm = nematodes; Al = macrophytes algae; Cy = cyanophytes; Pm = dead *Posidonia* leaves; Pv = live *Posidonia* leaves; Do = organic debris; Dt = diatom.

cyanophytes (Cy) were preferred by holothurians that originated from Salamandre site (Figure 5). At both sites, all the studied holothurians consumed relatively small amounts of dead (Pm) and live (Pv) *Posidonia* leaves. Among the considered species, it was *H. forskali* that mostly consumed them [3.33% for live leaves (Pv); 14% for dead leaves (Pm) at Stidia and 9% for live leaves (Pv) at Salamandre (Figures 2 and 3)] and in a preferential manner [*E′*: 0.69, 1 respectively for dead leaves (Pm) and live leaves (Pv) at Stidia; *E′*: 0.2, 1 for dead leaves (Pm) and live leaves (Pv) respectively for Salamandre (Figures 4 and 5)]. The macrophytes (Al) algae were hardly consumed (Figures 4 and 5).

Overall, foraminifera (Fo) were less consumed by holothurians of the Salamandre site compared with the Stidia site (Figures 2 and 3); This food was preferred only by *H. poli* and *H. tubulosa* (Figures 4 and 5). Crustaceans (Cr) took an important place (20%) in the diet of *H. sanctori* from the Salamandre site, unlike other species (Figures 2 and 3). However, this food item had a very important electivity index in the majority of species (Figures 4 and 5). Nematodes (Nm) were the preferred food for holothurians of the Stidia site [*E′*: 1 for *H. poli*; *H. tubulosa* and *H. sanctori* (Figure 4)], even if their contribution to the digestive contents was very low (Figure 2).

Discussion

The food sources of holothurian species are very diverse at both sites. The plant fraction prevails over the animal fraction for all studied holothurian species. This indicates that the plant fraction plays a very important role in the feeding process of these benthic animals. This allows us to conclude that holothurians have a significant impact on the transfer of primary production from the areas where they live. The high rates of diatoms (Dt) and macrophytes algae (Al) found in the digestive tracts of all the studied holothurians, was also reported by Sonnenholzner (2003) for the aspidochirotid holothurians *Holothuria theeli* of the central coast of Ecuador. Consumption of dead *Posidonia* leaves (Pm) by holothurians has already been reported in literature; this could have a positive impact on the transfer of organic matter produced by the *Posidonia oceanica* meadow. In fact, the 'litière' biota (composed mainly of dead *Posidonia* leaves) (Mezali 2004) appears to be an important source of organic matter for the 'deposit feeder' communities living in the *Posidonia oceanica* meadow (Walker et al. 2001). It has even been suggested that this is the main pathway for the transfer of organic matter from the *Posidonia oceanica* meadows (Cebrián et al. 1997). The fact that live *Posidonia* leaves (Pv) are a preferential food

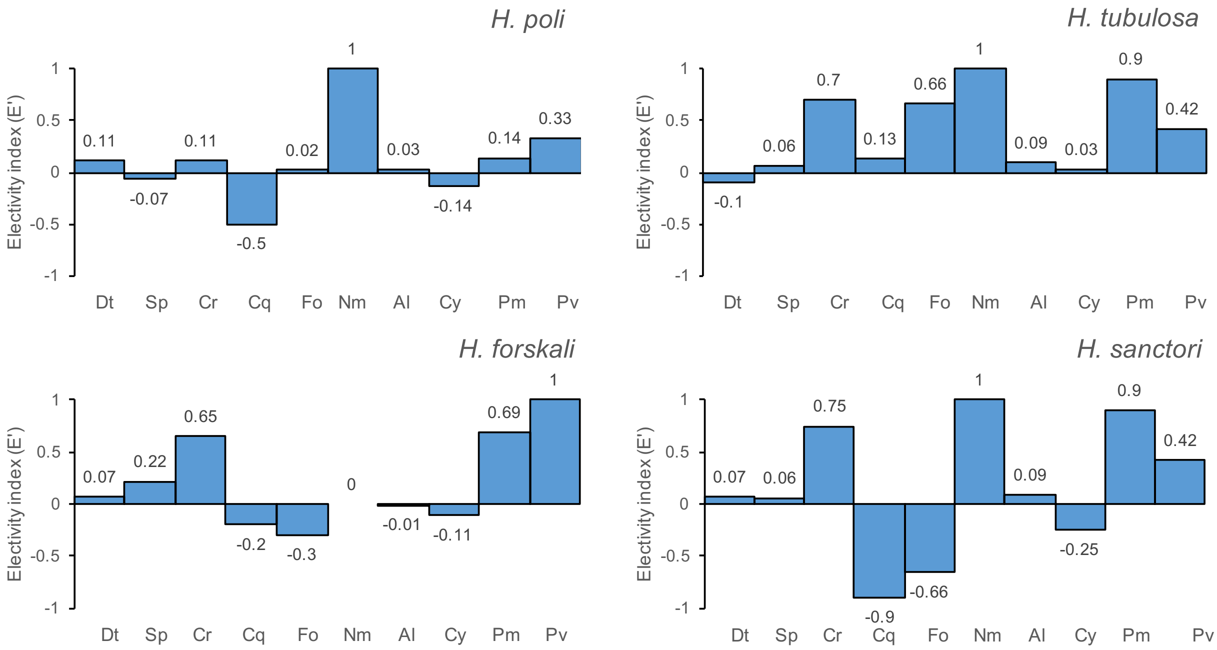

Figure 4. Ivlev electivity index indicating the preference or rejection of food item in the diet of holothurians originating from Stidia site. Dt = diatom; Sp = sponge ossicles; Cr = crustaceans; Cq = shells of bivalve molluscs; Fo = foraminifera; Nm = nematodes; Al = macrophytes algae; Cy = cyanophytes; Pm = dead *Posidonia* leaves; Pv = live *Posidonia* leaves.

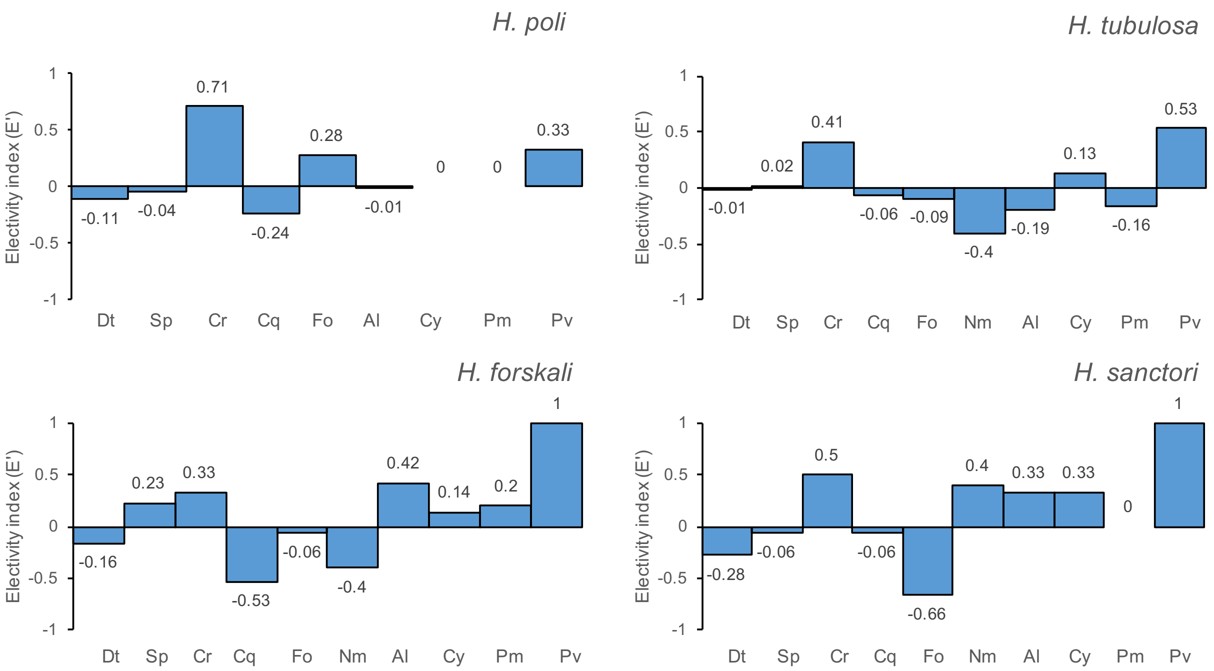

Figure 5. Ivlev electivity index indicating the preference or rejection of a food item in the diet of holothurians originating from Salamandre site. Dt = diatom; Sp = sponge ossicles; Cr = crustaceans; Cq = shells of bivalve molluscs; Fo = foraminifera; Nm = nematodes; Al = macrophytes algae; Cy = cyanophytes; Pm = dead *Posidonia* leaves; Pv = live *Posidonia* leaves.

source, especially for *H. forskali*, is very interesting as few marine animals consume them. The majority of food items of animal origin can be consumed and holothurians sometimes prefer these items more than other food sources – if we refer to the obtained Ivlev electivity index (*E′*). This selectivity that is exercised on certain food items can only be beneficial in terms of energy intake.

References

Belbachir N., Mezali K., and Soualili D.L. 2014. Selective feeding behaviour in some aspidochirotid holothurians (Echinodermata: Holothuroidea) at Stidia, Mostaganem Province, Algeria. SPC Beche-de-mer Information Bulletin 34:34–37.

Cebrian J., Duarte C.M., Marba N. and Enriquez S. 1997. The magnitude and fate of the production of four co-occurring Western Mediterranean seagrass species. Marine Ecology Progress Series 155:29–44.

Ivlev V.S. 1961. Experimental ecology of the feeding of fishes. . New Haven, CT: Yale University Press.

Jones R.S. 1968. A suggested method for quantifying gut content in herbivorous fishes. Micronesica 4(2):369–71.

Massin C. 1982. Effect of feeding on the environment: Holothuroidea. p. 493–97. In: Jangoux M. and Lawrence J.M. (eds). Echinoderm nutrition. Balkema: Rotterdam.

Mezali K. 2004. Micro-répartition des holothuries aspidochirotes au sein de l'herbier de Posidonies de la presqu'île de Sidi-Fredj – Algérie. Rapports P.V. Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, Monaco, Vol. 37. 534 p.

Mezali K. 2008. Phylogénie, systématique, dynamique des populations et nutrition de quelques espèces d'holothuries aspidochirotes (Holothuroidea: Echinodermata) inféodées aux herbiers de Posidonies de la côte algéroise. Thèse de Doctorat d'état. Alger, Algérie: USTHB. 208 p.

Mezali K., Caulier G., Soualili D. L., Decroo C., Demeyer M., Eeckhaut I., Gerbaux P. and Flammang P. 2016. Chemical characterization of saponins contained in the body wall and the Cuvierian tubules of the sea cucumber *Holothuria (Platyperona) sanctori* (Delle Chiaje, 1823). Biochemical Systematics and Ecology 68:119–27.

Mezali K., Chekaba B., Zupo V. and Asslah B. 2003. Comportement alimentaire de cinq espèces d'holothuries aspidochirotes (Holothuroidea: Echinodermata) de la presqu'île de Sidi-Fredj (Algérie). Bulletin de la Société Zoologique de France 128(1):1–14.

Mezali K. and Soualili D.L. 2013. The ability of holothurians to select sediment particles and organic matter. SPC Beche-de-mer Information Bulletin 33:38–43.

Mezali K., Soualili D. L., Neghli L. and Conand C. 2014. Reproductive cycle of the sea cucumber *Holothuria (Platyperona) sanctori* (Holothuroidea: Echinodermata) in the southwestern Mediterranean Sea: Interpopulation variability. Invertebrate reproduction and development 58(3):179–89.

Mezali K., Zupo V. and Francour P. 2006. Population dynamics of *Holothuria (Holothuria) tubulosa* and *Holothuria (Lessonothuria) polii* of an Algerian *Posidonia oceanica* meadow. Biologia Marina Mediterranea 13(4):158–61.

Moriarty D.J.W. 1982. Feeding of *Holothuria atra* and *Stichopus chloronotus* on bacteria, organic carbon and organic nitrogen in sediments of the Great Barrier Reef. Australian Journal of Marine and Freshwater Resources 33:255–63.

Nédélec H. 1982. Ethologie alimentaire de *Paracentrotus lividus* dans la baie de Galeria (Corse) et son impact sur les peuplement phytobenthiques. Thèse de Doctorat 3[eme] cycle. Paris, France: Université Pierre et Marie Curie. 175 p.

Sonnenholzner J. 2003. Seasonal variation in the food composition of *Holothuria theeli* (Holothuroidea: Aspidochirotida) with observations on density and distribution patterns at the central coast of Ecuador. Bulletin of Marine Science 73(3):527–43.

Stamhuis E.J., Videler J.J. and de Wilde P.A.W.J. 1998. Optimal foraging in the thalassinidean shrimp *Callianassa subterranean*. Improving food quality by grain size selection. Journal of Experimental Marine Biology and Ecology 228:197–208.

Walker D.I., Pergent G. and Fazi S. 2001. Seagrass decomposition. pp. 313–24. In: Short F.T. and Cole R.G. (eds). Global Seagrass Research Methods. Amsterdam: Elsevier Scientific Publishers B.V.

Zupo V. and Fresi E. 1984. A study of the food web of the *Posidonia oceanica* ecosystem: analysis of the gut contents of Echinoderms. International Workshop on *Posidonia oceanica* beds, Boudouresque C.F., Jeudy de Grissac A., Olivier J. (eds). GIS Posidonie publication France 1:373–79.