



Contrasting displacement of the sea cucumber *Holothuria arguinensis* between adjacent nearshore habitats



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ARTICLE INFO

Article history:

Received 28 December 2013

Received in revised form 12 January 2014

Accepted 13 January 2014

Available online 4 February 2014

Keywords:

Abundance

Behavior

Canary Islands

Feeding

Movement

Sea cucumber

ABSTRACT

Many sea cucumber species are subjected to exponentially increasing fisheries worldwide; management of their populations should take into account their behavior. Yet, studies relating feeding rates and displacement of sea cucumbers are, to date, scarce. The abundance, particulate organic matter (POM) consumption and displacement of the sea cucumber *Holothuria arguinensis* were compared between two adjacent, vegetated, habitats: a macroalgal dominated bed and a seagrass meadow formed by *Cymodocea nodosa*, at the island of Gran Canaria (eastern Atlantic). Abundances of *H. arguinensis* did not differ between the macroalgal bed and the seagrass meadow. No differences were found neither in POM consumption nor POM content between habitats. Movement of *H. arguinensis* occurred continuously during the day and nighttime, i.e. without resting periods. No sheltering behavior was observed. Faster and longer displacements were detected on the seagrass meadow than in the macroalgal bed, probably as a result of the different topography between habitats, independently of the daily period (day vs. night) and the moon phase. As a result, differences in locomotion of *H. arguinensis* between the two habitats are not connected with differences in POM consumption rates between habitats. These results could be useful for managing current and future fisheries of this species in the Mediterranean Sea and the Atlantic Ocean.

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1. Introduction

Despite the importance of sea cucumbers for marine ecosystems (Anderson et al., 2011; Uthicke, 2001; Wheeling et al., 2007), and the exponential increase of their fisheries worldwide (Conand, 2004; Purcell et al., 2012; Toral-Granda et al., 2008), behavioral studies relating feeding rates and displacement on these organisms are still scarce. The behavior of holothurians has been traditionally studied separately; for example, through multiple-choice selection feeding indoor experiments (Uthicke and Karez, 1999; Zamora and Jeffs, 2011), by measuring total displacements of individuals on the field (Graham and Battaglene, 2004; Shiell and Knott, 2008), or by observing punctual spawning events (Mercier et al., 2007; Morgan, 2009). Although some studies have been conducted on the movements of tropical species in the Pacific (Graham and Battaglene, 2004; Mercier et al., 2000b; Purcell and Kirby, 2006), little is known about this behavior of Atlantic species.

Deposit-feeding sea cucumbers process large volumes of benthic sediments, from which they assimilate bacterial, fungal and detrital organic matter (OM) (Kitano et al., 2003; Navarro et al., 2013a; Slater et al., 2011; Yokoyama, 2013). According to the OM availability, sea cucumbers have developed two main different feeding strategies:

i) continuous search for food (Mercier et al., 1999; Slater, 2010; Uthicke and Karez, 1999), or ii) selection of organically rich particles (Hammond, 1983; Paltzat et al., 2008; Rainer and Herndl, 1991). In this sense, Yamanouchi (1956) suggested that aspidochirote holothurians could be classified into those that feed continuously (e.g. *Holothuria mexicana*, *Holothuria atra*, *Holothuria edulis*, *Holothuria flavomaculata* and *Isostichopus badionotus*) (Hammond, 1982b), and those that shelter during periods of reduced feeding activity (e.g. *Holothuria thomasi*, *Actinopyga agassizi*, *Euapta lappa* and *Stichopus chloronotus*).

Coastal landscapes typically encompass a range of habitats with different composition and abundance of organisms (Tuya et al., 2008), that may influence the way OM is distributed (Alongi, 1997; Sauchyn et al., 2011). As sea cucumbers tend to concentrate in areas with high content of OM (Sibuet, 1984; Slater et al., 2011; Yingst, 1982), differences in spatial distribution patterns of animals are also expected (Mercier et al., 2000a).

Displacements of holothurians can also be influenced by other factors like light intensity, that can alter ecological functions of aquatic animals such as daily activity rhythm, migrations, aggregation behavior, etc. (Dong et al., 2010; Mercier et al., 2000a; Shiell and Knott, 2010). Many holothurians exhibit a marked photophobic behavior (Navarro et al., 2012, 2013a; Purcell et al., 2012), which is considered by some authors a response to predation (Dance et al., 2003; Eckert, 2007; Francour, 1997; Mercier et al., 1999). Light intensity, however, does not only vary during day and night periods, but also during nighttime

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as a result of the different moon phases throughout a lunar cycle. Some echinoderms are known to alter their behavior (e.g. spawning events) according to this lunar cycle (Coppard and Campbell, 2005; Hereu et al., 2004; Muthiga, 2005; Muthiga and Jaccarini, 2005). However whether displacements of sea cucumbers can also be affected by these lunar cycles, or not, is still unknown. Previous studies on the effects of light intensity on the behavior of tropical sea cucumbers have been reported (Mercier et al., 1999, 2000a; Purcell, 2010); however, studies concerning temperate species are still scarce.

Management of commercial sea cucumber stocks is, in part, based on estimations of population densities, which, in turn, depend on knowledge of habitat preferences (Shiell and Knott, 2008). Studying the behavior of sea cucumbers is important to: i) design of no-take zones, by sizing them accordingly to the usual and maximum displacements of target species (Purcell and Kirby, 2006); ii) establishment of diurnal or nocturnal fishing periods, by determining whether target species move continuously throughout the day and night periods or show a resting period during the day or night (Shiell and Knott, 2008); and iii) to avoid underestimations of population abundances due to sheltering, if a certain species remains sheltered during a period of the day (Graham and Battaglene, 2004; Purcell, 2010).

Holothuria arguinensis Koehler and Vaney, 1906 is a sea cucumber geographically distributed in the north-east Atlantic, from the Berlengas Islands (Portugal) (Rodrigues, 2012) to Morocco and Mauritania, including the Canary Islands and the transition zone to the Mediterranean Sea (the Alborán Sea). Recently, this sea cucumber has been also registered in the eastern Mediterranean coast of Spain (Gonzalez-Wangüemert and Borrero-Perez, 2012). This species is frequently found on macroalgal-dominated beds and seagrass meadows of the Canarian Archipelago, where individuals are often covered with seagrass leaves and algae as camouflage (Navarro, 2012). Recently, this species has become a target species in some sea cucumber fisheries of the Mediterranean Sea (González-Wangüemert and Borrero-Pérez, 2012) and Mauritania (pers. comm. S. Purcell).

The aim of this study was to evaluate differences in the feeding and movement patterns of *H. arguinensis* between two coastal, vegetated, habitats at Gran Canaria Island. Specifically, the following hypotheses were set out: (i) the abundance of *H. arguinensis* varies between

habitats (a macroalgal bed vs. a 'seagrass' meadow); (ii) there is no difference in POM consumption between habitats; and (iii) the movement of *H. arguinensis* (here quantified through traveled distances and speeds) varies between habitats, day vs. night periods and moon phases.

2. Material & methods

2.1. Abundance patterns

This study was carried out in Gran Canaria Island (28° N, eastern Atlantic) at the location of Playa del Cabrón (PC, 27°52'16" N; 15°23'08" W; Fig. 1). This location encompasses rocky substrates covered by brown macroalgae (mainly seaweeds of the genera *Cystoseira*, *Sargassum*, *Lobophora* and *Dictyota*) and sandy substrates covered by extensive patches of the seagrass *Cymodocea nodosa*. These habitats are at ca. 3–8 m depth. To determine differences in *H. arguinensis* abundances between these two habitats, 4 haphazardly (6 × 20 m) underwater transects were placed using a plastic metric tape on each habitat. On each transect, the total number of adult individuals of *H. arguinensis* was annotated on a slate by one observer using SCUBA. The 6-m width of transects was estimated by observers. Underwater visibility in the area remained stable during all sampling, typically ranging between 20 and 30 m. These transects were repeated at 3 different days on April 11th, 18th and 26th 2013 to determine whether abundance patterns were temporally consistent at random times. All the observations were made at the same time of the day (08:00 h); both habitats were sampled consecutively in the same dive, with a difference of 15 min approximately. The level of replication was established to optimize the cost/benefit of sampling, particularly taking into account previous observations in the study area (Navarro et al., 2012, 2013b). To test for differences in abundances of *H. arguinensis* between habitats and days, a 2-way, permutation-based, ANOVA was carried out. The analysis included the factors: (1) 'Habitat' (fixed factor with two levels: macroalgal bed vs. seagrass meadow) and (2) 'Day' (random factor with three levels). Data were square root-transformed to achieve homogeneous variances.

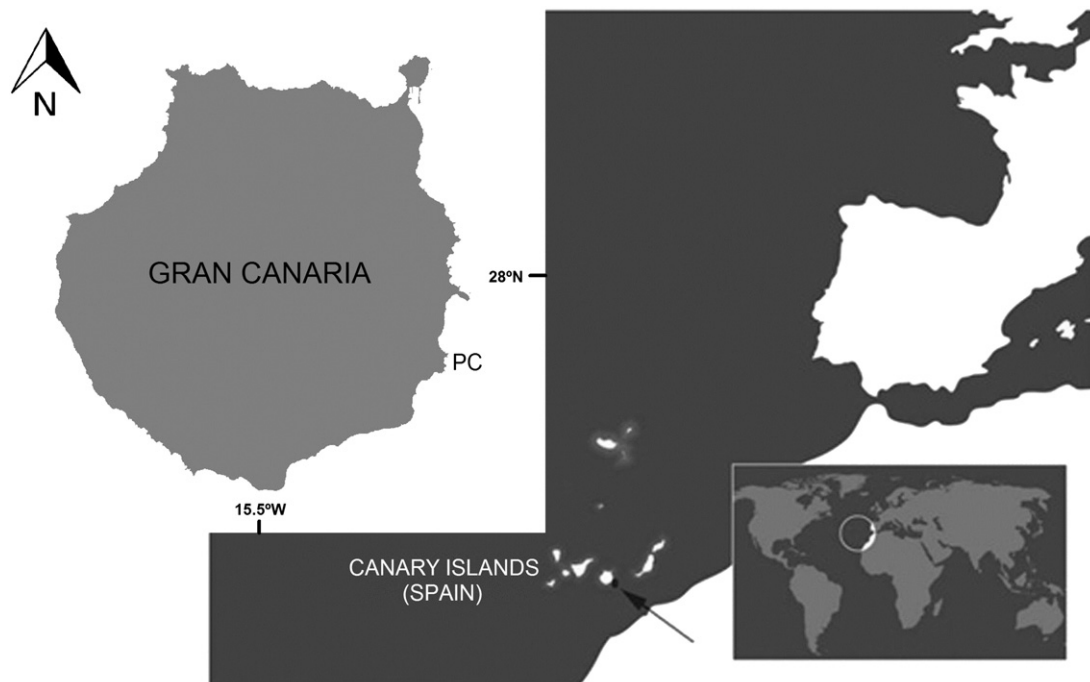


Fig. 1. Location of the study area in the eastern Atlantic (right) and the study site at Gran Canaria Island (left), PC: Playa del Cabrón.

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