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Effects of recreational activity on Acorn Barnacle (*Tetraclita squamosa rufotincta*) in the Red Sea

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ABSTRACT

Environmental recreation is a fast growing industry. However, in many cases the consequences for the environment are ignored. Eilat is just such a case wherein tourism is the mainstay of the city and the Red Sea is the main attraction. Most areas are developed specifically for enhancing tourism and one of the most benign of creatures, that sits permanently on rocks and seashores, is trodden upon regularly is the Acorn Barnacle (*Tetraclita squamosa rufotincta)*. We surveyed 10 sites with the same area for the number of barnacles that were live, dead or deserted. We compared between areas frequented by recreationists, and from which, they were denied access. We found a significantly greater number of individuals, live barnacles, and fewer deserted barnacles in the restricted areas. We conclude that the Acorn Barnacles in the undisturbed areas had significantly greater probability of survival and longevity compared to those exposed to anthropogenic activity.

KEYWORDS

Acorn barnacles; Eilat, Red Sea; *Tetraclita squamosa rufotincta*; tourism

INTRODUCTION

Mullins (1991, 1992) was one of the first who described tourism-urbanization as a process whereby urban areas, particularly large cities, are specially developed for the production, sale and consumption of goods and services providing pleasure. Weaver (2011) found that tourism-urbanization is also synonymous with terms such as leisureopolis, entertainment city, fantasy city, tourist metropolis and resort city. However, tourism focused urbanization is very specific and resource-consumption is with little consideration for the environment in which it is built (for review see Huijbers et al., 2013). An example of such disregard of sustainable mass tourism (SMT), even though at the time public and scientific awareness was not very high, is Las Vegas in the USA and the Gold Coast in Australia, wherein large areas considered as 'wasteland' were 'developed' for recreational purposes and are today celebrated as heritage sites (cf. Weaver, 2011). The synergism of habitat structure and population-suppressing factors in urban areas creates prime habitat for only a few species and usually leads to homogenization (e.g., Beissinger and Osborne, 1982). Subsequently, these synanthropic species dominate the urban communities and are often considered undesirable species or pests, that is, synurbic (but see Francis and Chadwick, 2011).

The repercussions of tourism-urbanization have been demonstrated in a variety of terrestrial (e.g., Gregg et al., 2003) and aquatic habitats (e.g., Davenport and Davenport, 2006). It has been shown to be especially acute in marine areas and can range from pollution and run-off from human activities on shore (Booth and Jackson, 1997; Wang et al., 2001), to altering the processing of marine carrion on sandy beaches (Huijbers et al., 2013), to changes in fish assemblages (Ilarri et al., 2008), damage to coral reefs (Zakai and Chadwick-Furman, 2002), to benthic fauna (Cole, 1994) and others.

In spite of the research conducted on the subject, there appears to be a dearth of knowledge in how the 3S tourism (sun, sea, sand) affects the benthic fauna, especially in the

intertidal zone. Hence, we wished to understand how anthropogenic activity at the shoreline of rocky beaches affects the survival of sessile organisms; an example of this is the crustacean Acorn Barnacle (*Tetraclita squamosa rufotincta*), and on which most people that access the sea must step upon to get to the water.

One of the most benign of creatures, that sits permanently on rocks and seashores and is trodden upon regularly by recreationists, is the crustacean the Acorn Barnacle. This sessile, inter-tidal organism is ignored by most, including those in charge of conserving biodiversity in the region. Typical acorn barnacles, upon settling at a site as nauplii, develop six hard calcareous plates that surround and protect their bodies. For the rest of their lives, they are cemented to the substrate. The only opening to its environs is through the operculum that allows the individual to communicate and reproduce with its neighbours, to collect food during the tidal hours and with the water trapped inside the calcareous fortification also as a buffer against excess heat (see Stanley and Newman, 1980).

1. METHODS

The study was conducted along the southernmost shores of Eilat (29°32'N; 34°57') where rocky shores and human constructions in the form of overhang bridges for swimmers to cross the reef shelf are available and acorn barnacle are present. We evaluated barnacle clusters during the summer months of May–August 2017. We surveyed ten sites with the same area from which five were frequented by recreationists and five where they were denied access. We controlled a total of linear space of 31.0 m^2 of the sea shore edge – per 15.5 m^2 in each of the compared habitats. We checked each individual barnacle to verify the occurrence of the resident barnacle by the presence of the operculum. In each of the sampled sites, we counted the number of live, dead or deserted individuals. The diameter of the operculum of each live barnacle was measured at its widest in order to understand the habitat persistence. We assumed that the larger the operculum opening, the greater the longevity. Mean values were presented with standard deviation (±SD).

2. RESULTS

In a total linear area of 31.0 m^2 (15.5 m^2 in each of the two habitats), we recorded a total of 3,938 barnacles. Significantly more individuals were found in the undisturbed than in the disturbed areas (2132 individuals – 54.1% vs. 1806 – 45.9%; Chi-square = 26.99, df = 1 $p < 0.001$, Fig 1). Furthermore, the contribution of live barnacles in relation to all the recorded individuals was higher on undisturbed than on disturbed areas (Chi-square = 624.48, df = 1 $p < 0.001$, Fig. 1). Similarly, there were fewer deserted barnacles at the restricted than disturbed areas (Chi-square = 14.69, df = 1, $p < 0.001$, Fig. 1). However, in the limited access areas, the operculum of the living individuals was larger than those found in the tourism zones (11.3 ± 4.2 mm *vs*. 8.1 ± 3.3 mm; Student's t-test, t = 26.39, df = 3937, $p < 0.001$).

3. DISCUSSION

Similar to Eilat, on the shores of the Red Sea, many of the seaside communities rely on the 3S (sun, sea, sand) tourism for their livelihood, and those that succeed continue to enlarge the related facilities (e.g., Ilarri et al., 2008). The tourism-urbanization that results in these cases requires large areas to be developed as support zones for the recreational needs of the tourism industry (Davenport and Davenport, 2006; Jovanic and Ilic, 2016).

In many a case, the development disregards the needs of the indigenous organisms that inhabit the areas being 'developed' for recreational purposes (e.g., Chemini and Rizzoli, 2003). The economic systems are intrinsically interlinked with the environment and its diversity and the wide-spread assumption that society must choose between jobs and environment is incorrect; the real choice is between short-term gain and long-term sustained prosperity and development (Lubchenco, 1998; Chemini and Rizzoli, 2003).

In our study, we were able to show that a sessile organism that most recreationists consider to be a bother because of their hard, calcareous shells, are disadvantaged by anthropogenic development and activity. On the one hand, human structures that protrude into the sea are settled by the study species, but on the other hand are abused by human activity. Although these sessile, benign animals are ignored by most of the tourists, they too play an important role in the environment as filter-feeders and are important bioindicators of pollution levels (da Silva et al., 2009; Reis et al., 2011).

Our study has shown that the Acorn Barnacles in the undisturbed areas had significantly greater probability of survival, and longevity as suggested by radius of the opercu-

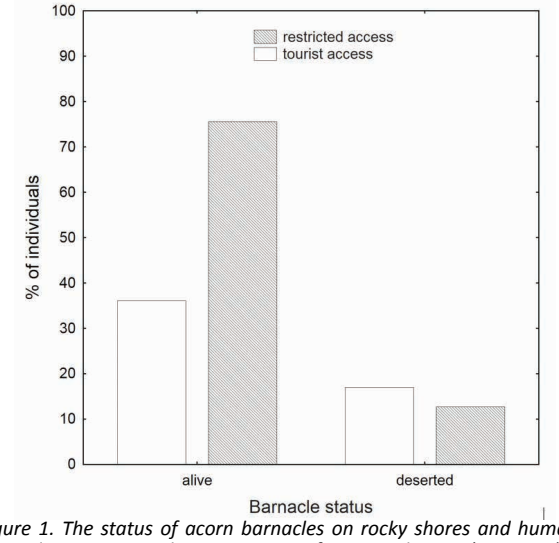

Figure 1. The status of acorn barnacles on rocky shores and human-erected structures in the sea in tourist frequented areas (N = 1806) as compared to areas where access was limited (N = 2132)

lum, compared to those exposed to anthropogenic activity. We conclude that authorities encouraging development through urbanization must take into account the most benign of creatures in order to ensure the biodiversity of any given region.

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