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Impact of trampling on sandy beach macrofauna

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Abstract. The effects of varying intensities of human trampling on sandy beach macrofauna were investigated at an exposed beach on the Eastern Cape coast. An experimental approach investigated the survival rates of four macrofaunal species which were subjected to human trampling at different intensities in a holiday-activity simulation. It was found that the clam *Donax serra* was slightly impacted at all trampling intensities while *Donax sordidus* and the isopod *Eurydice longicornis* were affected only at high trampling intensities. Vigorous beach games, such as volleyball, may have a damaging effect on *D. serra*. In a second experiment, the severe effects of human trampling on *D. serra* and the benthic mysid *Gastrosaccus psammodytes* were investigated using numbered animals in enclosures. The results indicated that few members of the macrofauna were damaged at low trampling intensities but substantial damage occurred under intense trampling.

Keywords: Bivalve; Eastern Cape; Isopod; Recreation.

Introduction

Recreational activities are increasing dramatically in developed countries as people enjoy more leisure time and experience higher standards of living. Demands for public outdoor recreation have increased over the last few decades and, as a result, many studies have been undertaken on the effects of such activities on coastal environments (e.g. Burden & Randerson 1972; Liddle 1991).

A considerable amount of effort has focused on the impacts of off-road vehicles on coastal flora and fauna, and most research on the effects of human trampling has been directed towards the response of coastal dune vegetation (Liddle 1975). Little is known of the effects of human trampling on intertidal beach animals, however, and although such effects are expected to be negligible (Brown & McLachlan 1990), the potential for disturbance to intertidal macrofauna as a result of human trampling from recreation is unknown (Underwood & Kennelly 1990). The aim of this study was to determine the effect of human trampling on intertidal sandy beach macrofauna.

Study area

The Eastern Cape coast is characterized by extensive sandy beaches fringed by dynamic surf zones and large dune fields. Maximum spring tide range is 2.1 m and the intertidal zones average 50-80m in width. Sands are fine to medium quartz with high calcium carbonate contents. This area has a warm temperate climate with a maximum sea temperature range of 12-25¡C. The macrofauna consists of two trophic groups: filter feeders and scavengers/predators. Of the filter feeders, two bivalves of the genus *Donax*, *D. serra* and *D. sordidus*, contribute more than 95 % of the biomass (McLachlan 1977).

McLachlan (1980) identified two zones on high-energy sandy beaches in the Eastern Cape: a lower zone dominated by the whelk *Bullia rhodostoma*, *D. sordidus* and the mysid *Gastrosaccus psammodytes*; and a mid-littoral zone dominated by *D. serra*, with the isopods *Pontogeloides latipes* and *Eurydice longicornis*, also present.

Methods

Simulated recreational impact

The study was conducted at the Van Stadens River Mouth beach west of Port Elizabeth during May 1994 and consisted of a simulation of typical holiday activities.

Impact was assessed by subjecting transects to different trampling intensities and monitoring areas marked out and used as volleyball courts. Four transects were established perpendicular to the shoreline from just below the drift line to the swash/waterline. Each transect had 14 equally spaced sampling stations marked at 2 m intervals. Two transects were trampled at 50 × intensity (TA50× and TB50×; Fig.1), i.e. 50 human passages along the transect, and two of them at 500× trampling

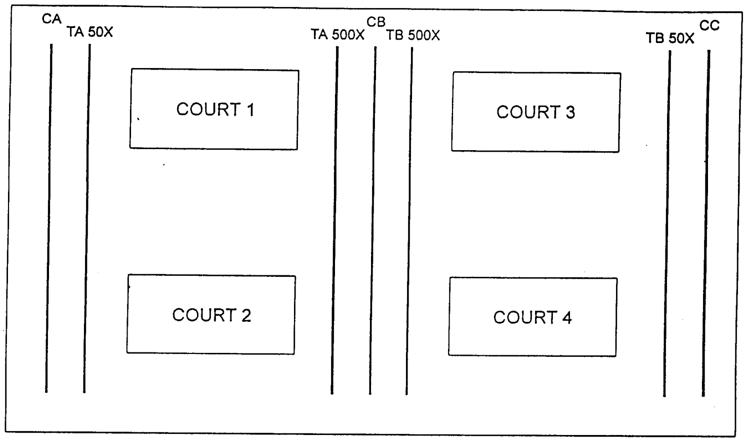

Fig. 1. Layout of the study site for the simulated recreational impact experiment on an Eastern Cape beach at Van StandenÕs River Mouth, South Africa, with transects and volleyball courts.

intensity (TA500×, TB500×, Fig. 1), *i.e.* 500 human passages. Four volleyball courts (14m ×16 m) were erected and each court had 12 sampling stations, also at 2-m intervals in a grid. Volleyball games were played in these courts for ca. one hour by rotating teams of six players. Three control transects were also established (CA, CB and CC, Fig.1). After the trampling and volleyball games, a single 0.1-m^2 quadrat was excavated to a depth of 30 cm at each of the 104 sampling stations and the sediment passed through 1-mm mesh sieves. The residue in the sieves was preserved in 5% formalin and the animals were sorted from the sediments in the laboratory, identified, counted and categorized as damaged or whole. The size of whole and damaged *D. serra* in the three treatments was measured to determine whether smaller animals were more susceptible to trampling damage. Results were evaluated by ANOVA and *t*-tests (Zar 1984) were used for size effects.

Controlled experimental impact

In the second phase of this study at the same location during October 1994, predetermined numbers of juvenile *D. serra* and adults of the benthic mysid *Gastrosaccus psammodytes* were put in enclosures and subjected to different trampling intensities. Wooden frames (500 mm × 500 mm, 200 mm high) with stainless steel mesh bottoms (2mm aperture) were buried in areas where the experimental animals were most likely to occur, and filled with sand from the adjacent beach area. All the sand used in the containers was sifted through a 2-mm mesh to remove the fauna. The sand surface was kept moist with sea water.

Experimental animals were collected as follows: *D. serra* by digging by hand to prevent injury to animals, and *G. psammodytes* using a sled. 30 animals of each species were counted out, placed in each enclosure and allowed to settle before trampling took place. Only smaller (mean size ca. 20 mm) *D. serra* were used in this experiment, to determine whether these animals were vulnerable to trampling and whether there was a corresponding increase in impact with increased trampling intensity.

After allowing the specified number of *G. psammodytes* individuals to settle, any floating (injured) or dead animals were removed and replaced with living animals. This was not necessary with *D. serra* which all burrowed below the sand after a brief settling period. Impacting was carried out by volunteer adults stepping into each box with one foot. Experiments were repeated for each species at different impacting intensities, i.e. 20× and 200× impact. Two replicates of each treatment and two controls were conducted per species. The total duration of an experiment never exceeded 30 minutes from collection of animals to completion of a treatment. After the trampling exercise was completed, the number of dead, injured and healthy animals was recorded and specimens preserved in 5% formalin for further analyses. A Friedman Two Way Analysis by Ranks (Zar 1984) was used to test for significant differences in numbers of damaged individuals with and without trampling.

Results

Simulated recreational impact

In this experiment the following species were identified - the bivalves *D. serra* and *D. sordidus*, the whelk *B. rhodostoma*, the isopods *E. longicornis*, *Pontogeloides latipes* and *Excirolana natalensis* and the polychaetes *Lumbrinereis tetraura*, *Sigalion capensis* and *Glycera benguellana*. Due to their low numbers, *P. latipes, E. natalensis* and the polychaete species were excluded from further analyses and only the four most abundant species were used to determine the effects of human trampling.

Table 1. Mean percentage of intertidal macrofauna damaged at varying intensities of experimental human trampling at Van StadenÕs River Mouth beach, South Africa.

Species	Trampling frequency	Mean% damaged	Sample size
D. serra	Control	0	42
	T50×	6	28
	T500×	3	28
	Volleyball court	18	48
D. sordidus	Control	0	42
	T50×	0	28
	T500×	4	28
	Volleyball court	0	48
B. rhodostoma	Control	0	42
	T50×	0	28
	T500×	0	28
	Volleyball court	0	48
E. longicornis	Control	0	42
	T50×	0	28
	T500×	9	28
	Volleyball court	0	48

Also due to these low numbers, analysis of variance revealed no significant differences in the numbers of animals damaged at different trampling intensities (p = 0.85). At the low intensity treatment (50×) 6% of *D. serra* were damaged, whereas the higher intensity (500×) produced damage in only 3% of this species (Table 1). In the volleyball courts 18% of *D. serra* were damaged. The higher trampling intensity also damaged 4% of *D. sordidus* and 9% of *E. longicornis*.

The t-tests revealed no significant differences in size between whole and damaged animals at the low trampling intensity (50×; p = 0.99) or in the volleyball courts (p = 0.35). At the higher trampling intensity (500×), however, the average size of damaged animals was smaller than that of intact animals (p = 0.025).

Table 2. Percentage of *Gastrosaccus psammodytes* and *Donax serra* impacted by humans during controlled experimental trampling at Van StadenÕs River Mouth beach, South Africa.

Species	Treatment	Mean % damaged
G. psammodytes	0 (control)	0
(n = 60)	20×	38
	200×	70
D. serra	0 (control)	3
(n = 60)	20×	5
	200×	63

Controlled experimental impact

Of the *D. serra*, 3% were damaged in the control treatment, possibly due to experimental handling of the animals. For the 20× and 200× treatments, the numbers of damaged *G. psammodytes* and *D. serra* animals increased with increased trampling intensity (Table 2). Friedman analyses revealed no significant difference in trampling damage (p = 0.66) between species. However, there was a significant difference (p = 0.04) in trampling damage between treatments (regardless of species) - while the low intensity treatment did not differ significantly from the control, the high intensity treatment caused significantly more damage than the control or the low intensity treatment.

Discussion

Though not fragile ecosystems, sandy beaches require specific management practices to avoid degradation, while they continue to serve a recreational function. Although it can be argued that human impacts, such as those caused by off-road vehicles, are unimportant, particularly when compared to storm-generated beach erosion, small-scale modifications to the beach profile could have a significant effect on an incremental basis. There is thus an urgent need to examine and understand whole coastal systems both from physical and biological viewpoints, and to design restoration and management policies to fit specific site factors (Wilcock & Carter 1977). Essential to this is an understanding of human impacts and this study represents a first attempt at investigating the effects of human trampling on the intertidal macrofauna of a sandy beach.

In the first experiment at Van Stadens River Mouth beach, *D. serra* was affected at the low as well as at the high intensity treatments, but in low numbers. This may be because a minimum number of *D. serra* were impacted initially, regardless of trampling intensity, and that after this initial impact, the surviving animals moved to a depth where they were not influenced by trampling. Other species, i.e. *D. sordidus* and *E. longicornis*, were impacted at the high trampling intensity only, but also in low numbers. In the volleyball courts, *D. serra* was affected to a greater extent, suggesting that such vigorous beach games may have a damaging effect on this species. Increasing trampling intensity did not lead to a significant increase in the number of damaged *D. serra*, the average percentage of animals damaged in the low impact treatment being twice that in the higher impact treatment. This result may, however, be a sampling artefact due to variation in animal numbers (which were very low), the low number (two) of replicates or the patchy distribution of this species, as noted (Ansell 1983; Bally 1981; Donn et al. 1986).

Size did not appear to influence whether *D. serra* was damaged at low trampling intensities or in the volleyball courts. However, in the high intensity treatment smaller *D. serra* were more susceptible to trampling, probably because they lie closer to the surface and have more delicate shells than adults.

In the second approach, the results were more conclusive regarding the impact human trampling may have on the macrofauna. For both species examined there was an increase in the number of animals damaged with increasing trampling intensity. A large percentage (38%) of *G. psammodytes* was affected at the low trampling intensity, whereas for *D. serra* only 5% of the animals were affected at this intensity. The number of damaged *D. serra* at the 200× intensity was higher (63%) than in the first experimental approach where a 500× trampling intensity was used.

This may be due to the fact that smaller *D. serra* were selected for this experiment and that it was carried out under more controlled conditions. The increase in the numbers damaged at higher trampling intensities appears to support this observation.

Results from these experiments have demonstrated that certain species survive trampling better than others, e.g. *B. rhodostoma* was not impacted at all by human trampling, whereas *G. psammodytes* was more susceptible to trampling than any of the other species examined. The impact of the volleyball games indicates that most games played by holidaymakers on beaches may have only a minor impact on the macrofauna. The low abundance of many of the species prevented a more meaningful understanding of the effects of human trampling on intertidal macrofauna. However, this is relevant since most species on sandy beaches occur in low abundance. Damage was related to the intensity of impact only in the more controlled second experiment, where the numbers and sizes of animals were predetermined and the sampling area uniform. It is therefore concluded that trampling has some impact on sandy beach macrofauna, but this is limited to areas of very high impact and delicate, shallow burrowing species (such as mysids and juvenile bivalves).

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