SHORT COMMUNICATION

Alarm reaction and absence of alarm reaction to simulated predation on conspecifics in two temperate sea urchin species

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INTRODUCTION

Body fluids released by prey can signal the presence of a nearby predator. Numerous aquatic organisms show alarm responses to body fluids of conspecifics (reviewed by Chivers & Smith 1998, and by Ferrari et al. 2010). For nine sea urchin species, an alarm response to the smell of crushed conspecifics or the smell of extracts of conspecifics has been shown (Snyder & Snyder 1970, Mann et al. 1984, Parker & Shulman 1986, Campbell et al. 2001, Hagen et al. 2002, Vadas & Elner 2003). Two sea urchin species also responded to extracts from other species of the same genus (Parker & Shulman 1986). The sea urchins either moved to nearby shelter or moved away from the direction of the extract. We tested the two common, temperate eastern Atlantic sea urchins *Arbacia lixula* and *Sphaerechinus granularis* for the presence of such alarm reactions to simulated predation on conspecifics.

MATERIAL & METHODS

The experiments were performed during daytime at the inner wall of Ponta Delgada harbour, São Miguel Island, Azores, at the outer wall of Horta harbour, Faial Island, Azores, and in the sheltered bay of Reis Magos, Madeira Island. There were no directed water currents at the time and place of the experiments.

EXPERIMENT 1

The experiment had a stepwise design. First, a group of three to eight *Arbacia lixula* in shallow water (0.2 - 2 m water depth) was selected and the position of each animal was recorded by a drawing on a plastic slate or by underwater photography. After an interval of three to five minutes, the position of the animals was recorded again. Thus, this first part of the experiment controlled for spontaneous movements of the sea urchins (without experimental stimulation).

The experimenter next gently waved a hand over the sea urchins at a distance of a few centimetres, providing weak mechanical stimulation. After another three to five minutes, the position of the animals was recorded again. Thus, this part of the experiment controlled for reactions to waving a hand over the urchins (without the chemical stimulation in the final step of the experiment).

Finally, an *Arbacia* was crushed nearby and the crushed parts were gently waved over the group of sea urchins at a distance of a few centimetres. After another five minutes, the position of the animals was recorded again. The distance moved by the sea urchins was not quantified (some animals were still moving at the end of the final 5 minute period and some had completely disappeared from sight). This experiment was performed 20 times.

EXPERIMENT 2

A crushed sea urchin of another species common in the same area, *Sphaerechinus granularis*, was used as a stimulus for a group of *Arbacia lixula* (instead of a conspecific animal) in the final step of the experiment. This experiment was performed six times.

EXPERIMENT 3

A group of *Sphaerechinus granularis* was treated in the same way as described above, using a crushed *Sphaerechinus* as stimulus in the final step of the experiment. This experiment was performed eight times.

RESULTS

In only one case, some *Arbacia lixula* had moved slightly at the end of the first interval (without experimental stimulation) and the trial was discontinued at this point. In all other 34 cases, neither the *Arbacia lixula* nor the *Sphaerechinus granularis* observed showed spontaneous locomotion (both species are nocturnal).

In none of the 34 replicates did the *A. lixula* or *S. granularis* show any signs of movement after the experimenter waved a hand over them. Thus, any response to waving a crushed sea urchin over them (see below) is likely to be due to chemical stimulation and not to the weak mechanical stimulation provided at the same time.

In all of the 20 experiments, *Arbacia lixula* showed a response to the exposure to the smell of a crushed conspecific. There were two types of responses: (1) animals formed a dense group with interlocking spines and (2) animals moved away from the place where the stimulation occurred.

Animals that were already forming a dense group of individuals touching each other would sometimes simply move closer together when exposed to the smell of a crushed conspecific, consequently forming a close-knit group of individuals with interlocking spines (Fig. 1).

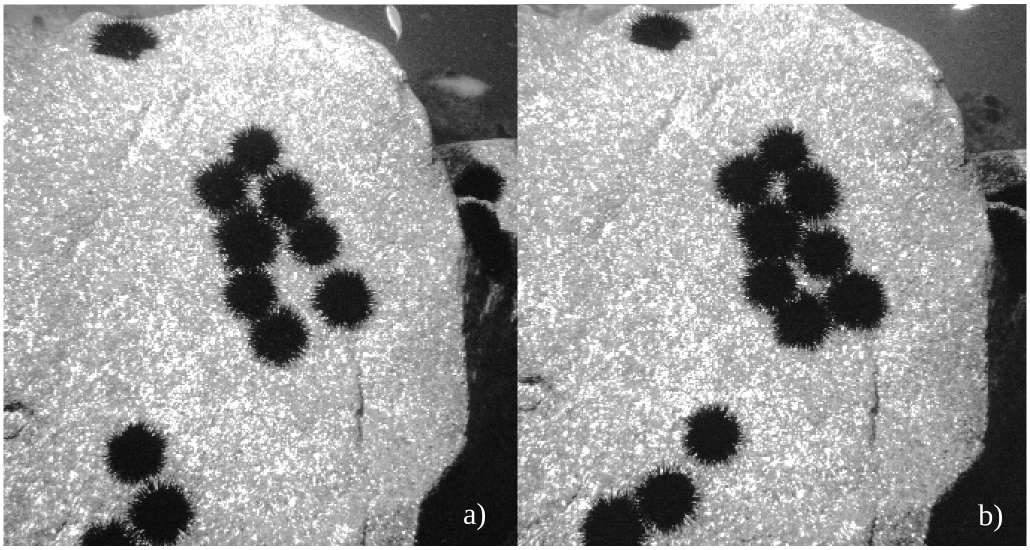

Fig. 1. A group of *Arbacia lixula* (a) before and (b) after stimulation with the smell of a crushed conspecific.

Animals not close together started to move in various directions on exposure to the smell of a crushed conspecific. The reaction started within a few seconds of exposure and sea urchins moved up to 60 cm away in the following five minutes (distance moved was measured only in this one extreme case). Such movement frequently resulted in the sea urchins disappearing from view, as they had passed the edge of a boulder**.**

The six groups of *Arbacia lixula* tested with a crushed *Spaerechinus granularis* showed no visible response. The eight groups of *S. granularis* tested with crushed *S. granularis* showed no visible response.

DISCUSSION

The sea urchin *Arbacia lixula* showed a clear alarm response to the smell of crushed conspecifics, either aggregating or moving to a different place. Such a response is likely to have evolved in response to predation on the species by a predator that has the habit to break up more than one sea urchin per meal. Of the common shallow water species of the Azores and Madeira, the triggerfish *Balistes carolinensis* is the most likely such predator. The sea urchin eating starfish *Marthasterias glacialis* is also common in the study area but probably does not kill more than one sea urchin at a time.

While the species *Arbacia lixula* showed a clear alarm response to the smell of crushed conspecifics, *Sphaerechinus granularis* did not. The two species differ not only in size (*Sphaerechinus* being more than twice as large) but also in the thickness of the shell. The shell of *Sphaerechinus granularis* is much thicker and stronger and, even with a knife, these urchins were difficult to crush. The species apparently relies on the strength of its shell and perhaps is preyed on so rarely as an adult that it did not evolve an alarm response to the smell of crushed conspecifics. This would also explain why *Arbacia* did not react to the smell of crushed *Sphaerechinus*. An alternative explanation for the recorded difference in behaviour of the two sea urchin species is the following: *Arbacia lixula* occurs in locally high densities in a narrow band of water depth (0-3 m), whereas *Sphaerechinus granularis* occurs at much lower population densities in a much larger depth range (1 to more than 40 m depth). Thus, even when a *S. granularis* is preyed on, the smell of the crushed animal probably only rarely (in relation to total population size) reaches another animal of the same species.

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