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Short Contribution

Odour tracking to a food source by the gastropod *Meridolum gulosum* (Gould, 1864) from New South Wales, Australia (Camaenidae : Eupulmonata : Mollusca)

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Abstract

Some gastropods are able to find food sources by following airborne chemical plumes using both tropotaxis and anemotaxis. This study examined odour tracking to food odours with a species of terrestrial gastropod, *Meridolum gulosum* (Gould, 1864), a native to rainforests in coastal south-eastern New South Wales, Australia. It was demonstrated that *M. gulosum* moves towards food odours (fungus) in still air, and holds its tentacles at characteristic angles when moving towards an odour source. This snail can detect odours at least 12 cm away from the source in air.

Additional keywords: behaviour, chemoreception, Gastropoda, kinematics, orientation, snail, tentacle.

Introduction

Animals use cues from their environment to find mates and food. Gastropods sense many features about their environment and some can follow mucus trails and chemical odours in freshwater, marine and terrestrial systems (Chase *et al*. 1978; Chase 1986; Tankersley 1989; Levri 1998; Davies and Knowles 2001). Gastropods can track odours in air using both tropotaxis and anemotaxis (Chase and Croll 1981; Lemaire and Chase 1998). In this study, an Australian land snail from New South Wales was tested for odour tracking abilities and tentacle kinematics both when tracking and not tracking odours.

Understanding how gastropods track food odours and the speed at which they do so may assist in calculating dispersal rates of gastropods when moving to a new food source. This is important because many gastropods are narrow-range taxa and may live in threatened habitats (Ponder and Colgan 2002). No previous studies on odour tracking with gastropods have dealt with endemic Australian fauna, but studies have been carried out on the European garden snail *Cantareus aspersus* (Müller, 1774) (Farkas and Shorey 1976; Lemaire and Chase 1998), which occurs natively in Europe and is present also in parts of the USA and Australia. In addition, the natural history of the Australian rainforest snails of New South Wales is not well understood (Kay *et al*. 1998; Lemaire and Chase 1998; Puslednik 2002). This species, *Meridolum gulosum*, is endemic to the rainforest south of Sydney and has been shown previously to prefer fungus in a dietary preference study (Puslednik 2002).

Materials and methods

The gastropod *Meridolum gulosum* used in these experiments is a member of the Camaenidae. The specimens ($n = 3$) were collected on 25 February 2003 in the rainforest on Mt Kiera in Wollongong, New South Wales, Australia and the experiment was conducted within 24 h of collection. After the experiment, identification was confirmed by L. Puslednik and all specimens were returned to the rainforest.

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The food source chosen for this study was based on information from the literature. *Meridolum* spp. are fungivores and have been shown to readily consume commercial fungi, such as white button mushrooms (Solem 1998; Puslednik 2002); this habit also being suspected for many other camaenids (Solem 1998). *Meridolum gulosum* has not previously been shown to track odours.

All snails were kept in a group container for at least 4 h before being used in experiments. After being removed from the container, they were placed on plastic and sprinkled with water. They were only placed in the experimental arena after they began to crawl. Snails were not fed before experiments (8–24 h). Temperature ranged from 23 to 31°C with a mean of 25°C.

To test odour tracking abilities, an individual snail was placed at the centre of a square arena (25.4 cm long) that was divided into four equal quadrants with a cotton ball in each corner and allowed to crawl freely (Fig. 1). One of the four cotton balls was soaked in a solution of water and food to make an odour ball; the others were soaked in water alone. The surface of the testing arena was covered with clean plastic film (Saran Wrap, Indianapolis, IN, USA) for each trial, presenting each snail with a similar substrate and preventing any confounding orientation to pre-existing mucus trails. The orientation of the snail and odour ball placement were both chosen randomly. There was at least a 2-min break between trials to allow odours to dissipate.

The odour solution was a puree of the commercial fungus *Agaricus bisporus* (white button mushroom) and water. Trials were conducted indoors under artificial light, except for two trials conducted in the dark because those snails would not move in the lighted arena. Each snail was used only once. The air flow within

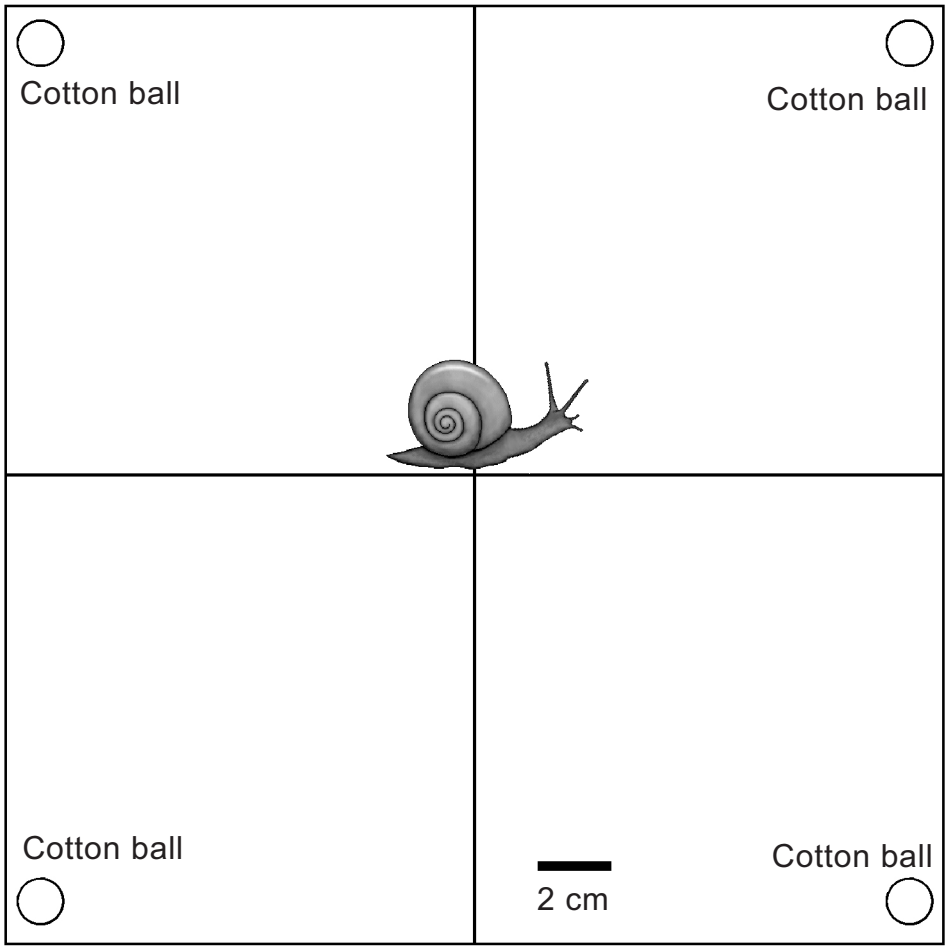

Fig. 1. Diagram of arena used to test odour tracking.

the room was relatively stationary and was not controlled. Trials were concluded when the snail exited the arena or reached a cotton ball. If a snail stopped moving for more than 20 min, its position was recorded and the trial was ended.

Trials were videotaped using a Sony PC101 camcorder (Sony, Tokyo, Japan) on Mini-Digital videotape. Observations on snails' behaviours were made during trials. The length and width of each specimen was measured before each trial. Snail shells ranged in size from 24 mm length × 27 mm width to 29 mm length × 33 mm width. The paths and tentacle positions were digitised using Motus digitising software (version 4; Peak Performance Technologies, Centennial, CO, USA). For the paths, three points were digitised: the most anterior part of the head (not including the tentacles), the anterior margin of the shell aperture and the most posterior part of the foot. These points were digitised every 5 s during the trial. For the angle between the tentacles, three points were digitised: the distal tip of each optic tentacle and the point where the mid-lines of the tentacles would intersect (tentacles were straight). Trials were analysed for: time in each quadrant, path of snail at 5-s intervals and tentacle positions every 60 s during the trial. The angle between the tentacles was averaged for each snail and across all snails. Also, the time of trial and final location of the snail were recorded. Average velocity of each snail was calculated at 20-s intervals.

Results and discussion

All snails moved for the duration of their trial and went directly to the odour source. Two of the trials in which the snails went directly to the odour source were conducted in the dark and at night (Trials 2 and 3), while the other trial (Trial 1) was conducted in light and before sundown. All snails spent the majority, if not all, of their time in the quadrant with the odour source and their paths were analysed for direction and to observe head movements (Fig. 2). The overall average angle between tentacles was 102° with a standard deviation of 22° (n = 37, range 63°–165°, where n is the number of measurements used to calculate the mean). The three snails differed in tentacle angle with mean ± s.d. of 89° ± 8° (n = 5), 101° ± 15° (n = 15) and 107° ± 28° (n = 17). The average velocity of the snails was plotted against distance to the odour source (Fig. 3).

All snails used in this experiment moved directly to the odour source. This shows strong preliminary evidence that *M. gulosum* is able to track food odours accurately in air and

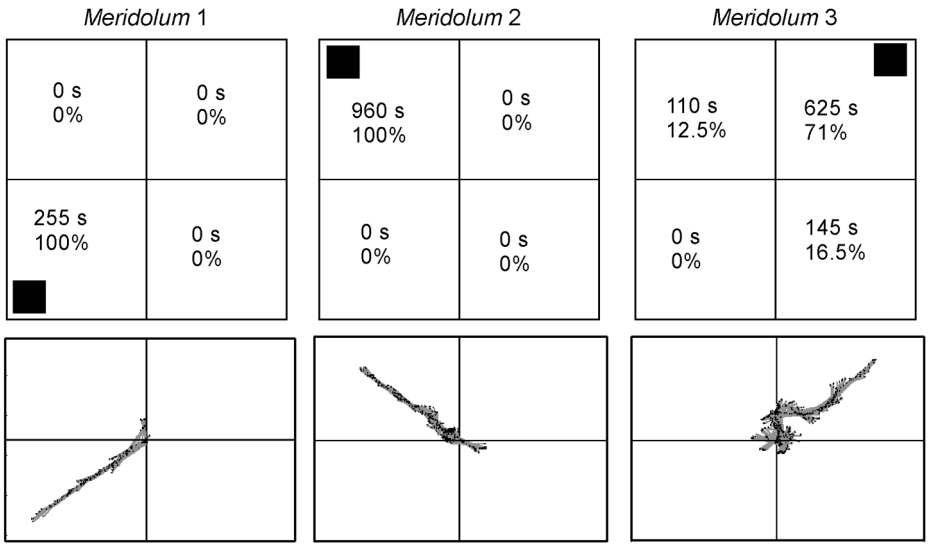

Fig. 2. Results of time in quadrant test (top arenas) and path analysis (bottom arenas) for *Meridolum gulosum*. The solid black box indicates location of the odour source. Snails were started at the centre of the arena. Paths (below) show snail positions every 5 s of head, middle and foot (black dots) connected by a line.

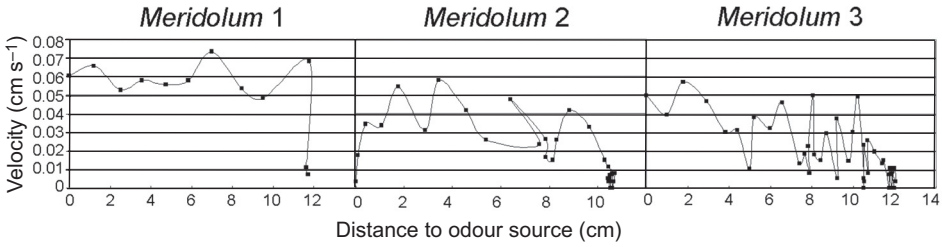

Fig. 3. Average velocity at 20-s intervals against distance to odour source.

probably uses chemoreception to find food sources. In each trial, the snail started moving slowly but showed an increase in velocity when within 10 cm of the odour source. This implies that *M. gulosum* can detect odours from at least 10 cm away (Fig. 3).

It has been shown by Chase and Croll (1981) that the optic tentacles of stylommatophoran pulmonates are capable of detecting airborne odours. The optic tentacles of *M. gulosum* were held at a characteristic angle, which may be helpful in comparing a gradient of odour between the right and left optic tentacles. The oral tentacles of *M. gulosum* were tapped alternately whenever the snail was crawling, although they were not visible on the video and could not be analysed. Further studies of the movements of the tentacles while odour tracking would increase our understanding of how gastropods track chemical plumes in air.

The odour tracking abilities of gastropods also enable them to be agricultural pests; snails like the European garden snail *Cantareus aspersus* can find plant food through chemoreception (Farkas and Shorey 1976). The movements of the tentacles while tracking plant odours were characterised in *Cantareus aspersus*, showing the average angle between the tentacles was 115° (n = 5) (calculated from Lemaire and Chase 1998). A better understanding of the mechanisms used in long-distance chemoreception could assist in the control of such gastropods.

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