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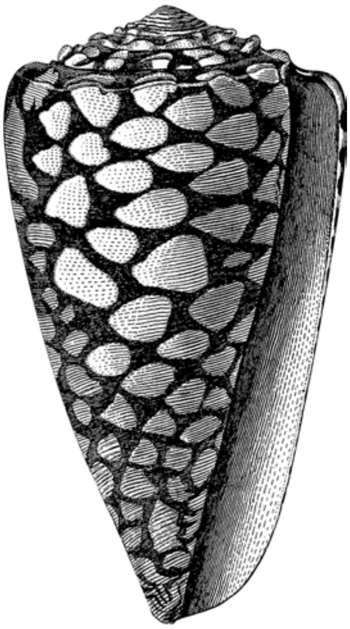

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Dietary preferences of two species of *Meridolum* (Camaenidae : Eupulmonata : Mollusca) in southeastern Australia

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Abstract.

Non-marine molluscs have extinction rates that rival the major vertebrate groups. Australia has about 800 described land snails, mostly endemic, yet virtually nothing is known of their biology, severely limiting effective conservation planning. In this study, a simple experiment was conducted to determine the feeding preferences of two native New South Wales species of camaenid snails, both with restricted distributions. Feeding experiments were conducted offering *Meridolum gulosum* (a rainforest species) and *Meridolum* sp. (a littoral rainforest species) several different types of living and senescent vegetation found in their natural habitat, as well as two species of commercially grown fungi. These experiments demonstrate that the camaenid snails studied show a preference for fungi over plant tissue but further experimental work is needed to examine feeding preferences for these and other land snails using an even greater range of potential food types.

Introduction

Non-marine molluscs, particularly land snails, are highly vulnerable: approximately 300 species world wide have been documented by the IUCN as becoming extinct over the last 300 years, an extinction rate that rivals that of vertebrates (Hadfield 1986; Cowie 1992; Yen and Butcher 1992; Baillie and Groombridge 1996; Ponder 1997; Seddon 1998). Land snails are an important component of Australia's biodiversity, comprising about 800 described, mostly endemic, species.

While it is often stated that invertebrates, including terrestrial molluscs, play a crucial role in ecosystem maintenance and function (e.g. Wilson 1987; Yen and Butcher 1992; Hadfield 1993), the details of the role of land snails in litter degradation in Australian ecosystems is unknown, as are virtually all other aspects of the biology of this diverse group.

One of the biological factors that govern the distribution of land snails is food type and availability (Little 1998). Pomeroy (1969) showed that by removing food from field plots, snails migrated to other areas where the food source was more readily available. Food availability can clearly influence distribution, abundance and habitat selection in land snails (Dillon 1980; Bishop 1981; Little 1998) and understanding the feeding biology of these animals is important if conservation management is to be successful. Diet also affects growth rates and some species of land snails have been observed to show increased growth when consuming their preferred food (Baur *et al*. 1994).

There is little information or literature that relates to the feeding habits and dietary preference of Australian pulmonates. Most species are referred to as detritivores and fungivores, which consume a variety of decaying plant material, algae and fungi, and there is often speculation that ground dwelling taxa are primarily fungal feeders (McLauchlan 1951; Colman and Burch 1977; Bishop 1981; Solem 1985; Smith and Stanisic 1998). However, these findings are generally the result of casual observation rather than critical study or experimentation.

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The aim of this study was to examine feeding preferences of two land snail species endemic to the Illawarra area, south of Sydney, NSW, with the main objective to test whether these two species were preferential fungal feeders.

Materials and methods

Species studied

This study focused on two native land snail species endemic to southeastern Australia, *Meridolum gulosum* (Gould, 1864) and *Meridolum* sp. (unnamed species). These species are members of one of Australia's largest land snail families, the Camaenidae, and both are ground-dwelling snails found in rainforest remnants in the Illawarra region (Puslednik 1998).

Meridolum gulosum is large with a uniformly chestnut-coloured shell reaching an adult size of about 35 mm in diameter (Puslednik 1998). The head–foot is dark grey and the mantle, orange flecked with white. The umbilicus is generally closed to half closed. *Meridolum gulosum* ranges along the coast of NSW from Bulli to Batemans Bay, extending 40 km inland from the coast, with most records being centred around the Illawarra Region (Australian Museum collection; Allan 1950; Puslednik 1998).

Meridolum sp. is an undescribed species restricted to the littoral rainforest of Bass Point and two other locations around Lake Illawarra (Australian Museum collection). In this study, two shell morphs of this species were identified but were considered to be variants of a single species. *Meridolum* sp. is smaller than *M. gulosum*, with an average adult shell diameter of 23 mm. One morph of *Meridolum* sp. had similar shell and head–foot colouring to *M. gulosum*, while the other had a pale brown (almost yellow) shell and a light brown head–foot. Both morphs had an orange mantle flecked with white and an umbilicus that was half open to closed (Puslednik 1998).

Feeding trials: *Meridolum gulosum*

Ten individuals of *Meridolum gulosum* were collected from Bulli Pass (34°18′S 150°52′E), near Wollongong, NSW. Only adult snails were used in the trials. Each snail was housed separately in an empty, clean, sealed, 4-litre plastic container and was kept without food for 24 hours. After this period of starvation, faeces were removed and containers washed with water. Each snail was offered six different food types during the experiment, most collected from Bulli Pass subtropical rainforest within the area where the snails were found (food species used listed in Table 1). Plant species were selected on the basis of their abundance within the area. Living sapling leaves and dead mature leaves were offered as food in the trials as it was presumed that these items were accessible to this ground dwelling species. Native fungi proved too difficult to obtain in sufficient quantity, so two types of commercially grown fungi (*Agaricus bisporus* and *Pleurostus ostreatus*) were substituted.

Food samples were given to the snails as discs, cut into circles with a diameter of 21.5 mm (area = 363.1 mm²). Each food disc was positioned in a circle around the perimeter of the container, and a snail was placed into the middle of the container, equidistant from each food type. Containers were sprayed with water to prevent dehydration and small holes were punched into the lids of the containers to provide snails with air. After 24 hours, each snail was removed and the uneaten remains of food discs were collected. The amount of the different food types each individual consumed was recorded as a percentage, by measuring the area remaining and subtracting it from the initial area.

Feeding trials: *Meridolum sp.*

Slight modifications were made to the methods employed for *Meridolum gulosum*. Smaller plastic containers (2 litre) and smaller diameter food discs (diameter 14.5 mm, area = 165.1 mm²) were used. Two experiments were conducted with this species, each using ten different adult snails collected from Bass Point (34°34′S 150°53′E) on two separate occasions. The first was carried out as a pilot study to test the methods employed.

The first experiment offered six different living food types to *Meridolum* sp. (food species used listed in Table 1), while the second experiment was performed using six food types, a combination of both dead and living material (food species used listed in Table 1). Again the plant food types used were those found living within the habitat of the species and likely to be encountered by this snail species. Commercial fungi were again used because of the difficulty of obtaining native fungi. After 24 hours, each snail was removed, and the amount each individual consumed of the different food types was estimated and recorded as a percentage, as with the *Meridolum gulosum* experiment.

Data analysis

Data for each trial were analysed using a top-down concordance test (Zar 1999). Within each replicate, the food types offered were assigned a rank (a Savage score), according to the relative amount of each food type consumed within that replicate. This savage score was then used to calculate the concordance test statistic. The significance of this statistic was then assessed by comparison with the chi-squared distribution with *n*–1 degrees of freedom.

Results

Meridolum gulosum

Meridolum gulosum demonstrated a significant preference for fungi ($\chi_T^2 = 32.05$, d.f. = 5, $P > 0.001$). Of the six different food types offered to *M. gulosum* only the two species of fungi were consumed. Every snail consumed all of the *Agaricus bisporus* offered and between 5 to 57% of the other fungus, *Pleurotus ostreatus* (Table 1). None of the other food types offered showed evidence of grazing (Table 1).

Meridolum sp.

Meridolum sp. demonstrated a significant preference for fungi in the first feeding trial ($\chi_T^2 = 50.07$, d.f. = 5, $P > 0.001$). Of the six food types offered in this trial, only two were consumed: *Agaricus bisporus* (the only fungus offered in this trial) and *Tylophora barbata* (a sapling leaf). Every snail consumed all of the fungus and *Tylophora barbata* was consumed by only three of the ten individuals, with the amount consumed ranging from 8% to 63% (Table 1). None of the other food types offered showed evidence of grazing (Table 1).

In the second feeding trail, *Meridolum* sp. again showed a significant preference for fungi ($\chi_T^2 = 29.67$, d.f. = 5, $P > 0.001$). In this trial four out of the six different food types were consumed, the two fungi (*Agaricus bisporus* and *Pleurotus ostreatus*), the sapling leaf of *Tylophora barbata* and the dead leaf of *Eucalyptus sieberi* (Table 1). Every snail consumed all of the *Agaricus bisporus* offered and between 10% to 100% of *Pleurotus ostreatus* (Table 1). *Tylophora barbata* was consumed by three individuals, the amounts consumed ranging from 11% to 100% (Table 1). Only one individual consumed the dead *Eucalyptus* sp., removing 21% of the amount offered (Table 1).

Discussion

Meridolum marshalli was observed to be a generalist omnivore by McLauchlan (1951), and captive animals were observed feeding on vegetable matter, plant tissue, decaying vegetation, fungus, and animal matter, although no choice experiments were conducted. Similarly, observations on captive *M. gulosum* indicated that this species will feed on various foods including vegetables, paper, leaves, soil and even commercial fish food (Puslednik 1998). However, the results of this study suggest that *M. gulosum* will feed on fungi in preference to living and dead leaves.

Among the northern Western Australian camaenids there is observational evidence of different feeding habits, *Ampliragada* species are generalist feeders of dead plant material and *Westraltrachia* species are also general plant feeders (Solem 1985). However, when species in these two genera are in sympatry, species of *Westraltrachia* apparently graze on algal–fungal blooms. *Meridolum gulosum* and *Meridolum* sp. do consume leaves. However, with only a single observation in this study of *Meridolum*. sp. consuming dead vegetation and none for *M. gulosum*, it seems reasonable to assume that these taxa are not consumers of dead vegetation by preference. It appears that there may be significant differences in the

Table 1. Food types offered to *Meridolum gulosum* and *Meridolum* sp. during feeding trials, showing the mean percentage (± standard deviation, s.d.) consumed of each food type during each trial

Meridolum gulosum feeding trial 1 ($n = 10$)			*Meridolum* sp. feeding trial 1 ($n = 10$)			*Meridolum* sp. feeding trial 2 ($n = 10$)		
Name	Food type	Mean % consumed ± s.d.	Name	Food type	Mean % consumed ± s.d.	Name	Food type	Mean % consumed ± s.d.
Agaricus bisporus	Fungus	100	*Agaricus bisporus*	Fungus	100	*Agaricus bisporus*	Fungus	100
Pleurotus ostreatus	Fungus	55 ± 41	*Tylophora barbata*	Living sapling leaf	17 ± 33	*Pleurotus ostreatus*	Fungus	77 ± 37
Acmena smithii	Living sapling leaf	0	*Notolea ovata*	Living sapling leaf	0	*Acmena smithii*	Living sapling leaf	0
Livistona australis	Living sapling leaf	0	*Scopia braunii*	Living sapling leaf	0	*Tylophora barbata*	Living sapling leaf	12 ± 31
Acmena smithii	Dead mature leaf	0	*Cissus antarctica*	Living mature leaf	0	*Acmena smithii*	Dead mature leaf	0
Eucalyptus sp.	Dead mature leaf	0	*Eucalyptus sieberi*	Living mature leaf	0	*Eucalyptus sieberi*	Dead mature leaf	2 ± 7

feeding habits of camaenids, with some differences even seen between the two *Meridolum* species examined in this study. Experimental work is needed to verify observations of food preferences in other taxa. Other, non-camaenid, land snails have been shown to exhibit species-specific food preferences, even though they are capable of being generalists (Lawrey 1983; Baur *et al*. 1994; Heller and Dolev 1994; Desbuquois and Daguzan 1995; Gervais *et al*. 1997).

The strong dietary preference for fungi over plant tissue displayed by *Meridolum gulosum* and *Meridolum* sp. is important when considering fungus–invertebrate associations. Mammals have been identified as important in controlling and maintaining mycorrhizal relationships (see Johnson 1996 review) and it is possible that land snails may also play an important role. Fungus-feeding invertebrates with fungal associations have the ability to alter fungal species diversity, which may in turn affect the rate of leaf litter decomposition (Visser 1985). Invertebrates with strong preferences for particular fungi could alter fungal diversity by dispersing fungal spores (on the body or following passage through the gut) and selectively grazing fungus (Visser 1985).

The snails of this study showed preference for one of the two commercial fungi presented suggesting that selective grazing may be important. Ideally, experiments conducted using native fungi found in the habitat occupied by the snails need to be carried out. However, this will have considerable logistical difficulties given the rudimentary knowledge of native fungi and the presence of a large number of minute (such as moulds) or microscopic taxa. The trials in this study used only large fruiting bodies and it is not known whether the hyphae are consumed, or even accessible as a food source. In addition, future studies should examine other food types, including animal tissue, as observations of *Meridolum marshalli* feeding on animal tissue led McLauchlan (1951) to identify this species as an omnivore.

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