ACTIVE DISGUISE IN LAND SNAILS: *NAPAEUS BADIOSUS* (GASTROPODA, PULMONATA, ENIDAE) FROM THE CANARY ISLANDS

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Abstract *Some snails disguise the shell with a covering of soil or other material. Among species in the Canarian enid genus* Napaeus*, some rock-dwelling species cover the shell with lichens; in one of these,* N. barquini*, the process is known to be active. In some ground-dwelling species the muddy covering may be acquired passively, as for example in* N. variatus*.* Napaeus badiosus *is a snail with an almost smooth shell which is not disguised in the field. It normally rests out of sight of predators. Four specimens of* N. badiosus *were transferred to a glass terrarium with a layer of loose, humid soil without stones and vegetation. The snails acquired a soil layer with prominent protuberances that covered the whole shell, reducing the risk of attack by visual predators. The appearance of the disguised* N. badiosus *shell is compared with those of* N. barquini *and of* N. variatus*. The disguise of* N. badiosus *is similar to that of* N. barquini*. This active disguise thus appears to be facultative, adopted when hiding places are not available. Mechanisms of disguise are briefly discussed; the behaviour of other disguised species should be investigated.*

Key words *active disguise, predation, land snail,* Napaeus*, Canary Islands*

INTRODUCTION

The fitness of many organisms depends on minimising the risk of predation (Palma and Steneck, 2001; Ruxton *et al*., 2004). In land snails, an important anti-predator adaptation is the cryptic colouration of the shell and/or body colouration (Allen, 2004), which decreases the chances of the animal being seen against its background. This crypsis is usually achieved through the colouration of the organism itself. However, some animals increase their crypsis by actively decorating themselves with inanimate or animate components of their habitat. This strategy is well known among insects and marine crustaceans and molluscs but is unusual among land snails and slugs, perhaps because these are typically nocturnal and thus less liable to attack by visually-hunting predators (Runham & Hunter, 1970). In some land snail species, however, the shell often has an additional external layer, usually consisting of dust or soil. There are an increasing number of studies showing such external disguise in snails, especially enids, in natural settings (Fechter & Falkner, 1990; Falkner, 1992; Gittenberger & Menkhorst, 1993; Gittenberger, 1996; Herbert and Kilburn, 2004; Allgaier, 2007). In many cases the process by which this layer is positioned on the shell remains unknown. It may be acquired passively by passage through a sticky substrate, or by adherence to ribs, hairs or spines on the shell, as in the Canarian hygromiid *Monilearia tubaeformis* Alonso & Groh 2006, which inhabits dry areas of Fuerteventura Island. This species has a shell with sharp, densely-packed ribs (Ibáñez *et al*., 2006) and is covered with an additional thin and relatively uniform layer of soil.

Among Canarian enids, there are many species which acquire this external covering. Passive disguise seems likely in the case of *Napaeus variatus* (Webb & Berthelot 1833), which lives in the northern coastal zone of Tenerife (Fig. 1). These snails are ground dwellers and usually have the shell (height: 11–15 mm) covered with a relatively uniform, almost tubular, layer of wet soil (Alonso *et al*., 1995; Fig. 2 A), which can easily stick to their shells; the disguise probably is acquired during the snail movement in the muddy soil. Similar disguised appearances have been found in *N. tenoensis* Henríquez 1993 (Henríquez *et al*., 1993) and *N. helvolus* (Webb & Berthelot 1833) (personal observation, 2008), two species also from the northern coastal zone of Tenerife.

However, the case of six rock-dwelling *Napaeus* species endemic to the Canary Islands is different. All six have glossy, weakly ornamented

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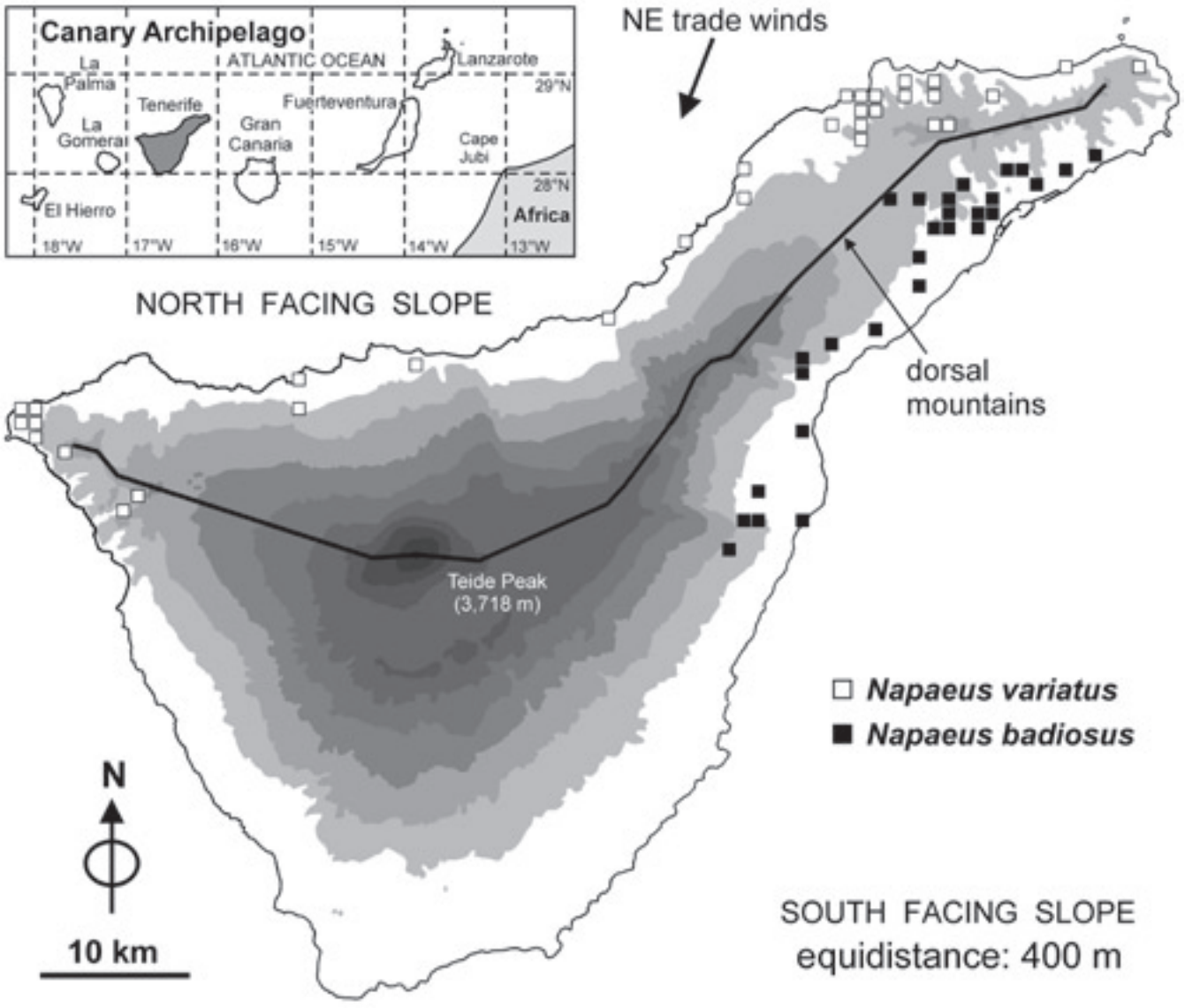

Figure 1 Geographic distribution of *Napaeus variatus* and *N. badiosus*; symbols represent 1×1 km UTM squares.

and smooth shells, with no hairs, and a similar, small size (shell height: 8–13 mm): *N. gruereanus* (Grasset 1857), from El Hierro, *N. barquini* Alonso & Ibáñez 2006, and *N. beguirae* Henríquez 1995, from La Gomera, *N. roccellicola* (Webb & Berthelot 1833), from Tenerife, *N. lichenicola* Alonso & Ibáñez 2007, from Fuerteventura and *N. rufobrunneus* (Wollaston 1878), from Lanzarote. By day, all these species usually rest in a quiescent state on open, lichen-covered rock faces exposed to the humid trade winds. All six species normally have shells disguised by an additional layer made from surrounding lichens, including *Roccella* sp. (the orchill, a fruticose lichen) in *N. roccellicola*, and crustose lichens in all other five *Napaeus* species (Wollaston, 1878; Alonso *et al*., 1995, 2006; Allgaier, 2007; Ibáñez *et al*., 2007). Since all six of these *Napaeus* species have relatively smooth shells, passive disguise with lichens of the rock faces seems unlikely. In one case, *Napaeus barquini*, the active process of acquiring disguise has been observed. It grazes lichen and/or soil material from the substrate and sticks it to the surface of its shell with the mouth, forming protuberances and altering the appearance of the shell considerably (Allgaier, 2007: a visual demonstration of the process is available at http://home.arcor.de/christoph.allgaier/videofile.htm). It is most probable that the other species also pursue an "active disguise" strategy. Two species, *N. gruereanus* and *N. roccellicola*, have been found without disguise in other habitats such as the hollows of stone walls and *Euphorbia* sp. scrublands, respectively.

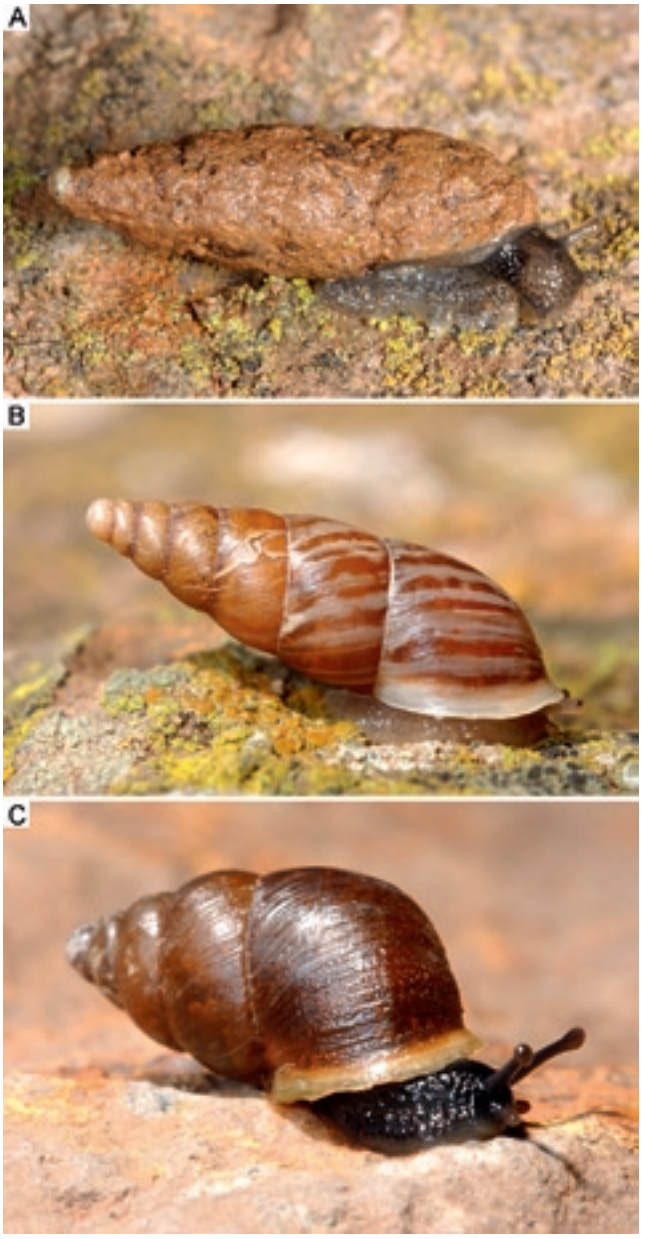

Figure 2 A, *Napaeus variatus* from Los Realejos, north of Tenerife Island. The specimen was placed on a stone to easier visualization. B, a *N. variatus* specimen with the shell cleaned. C, *Napaeus badiosus* from Mirador de San Martín (Güímar, south of Tenerife Island).

Disguised snails are easily overlooked in the field. However, the nine disguised species above mentioned represent the 16% of the 56 known *Napaeus* species (Yanes *et al*., 2009) and it is possible that other *Napaeus* species can also disguise. Here we report a new case of active disguise with soil material in a tenth *Napaeus* species, *N. badiosus* (Webb and Berthelot 1833), contrasted with the possibly passive disguise of *N. variatus* (Webb & Berthelot 1833). Both species have a small shell weakly ornamented and relatively smooth (Figs 2 B, C).

MATERIAL EXAMINED

N. badiosus (shell height: 12–13 mm), occurs between 15–550 m altitude in a dry, lowland vegetation area of the southern slopes of central and eastern Tenerife mountains (Fig. 1). The snails are mostly active at night or during wet weather, resting the remaining time under stones or in rock crevices, with the shell aperture tightly adhered to a stone or a rock crevice wall via an epiphragm of dried mucus. In contrast to the other six active-disguised *Napaeus* species above mentioned, *N. badiosus* did not show disguise at any locality (Fig. 1). This is not surprising given that the species usually lives in an arid environment which would presumably makes passive disguise more difficult, and where there are plenty of hiding places.

Four living, undisguised *N. badiosus* specimens were captured in a rock crevice at Mirador de San Martín (Güímar, leeward slope of Tenerife Island). They were transferred in the laboratory to a glass terrarium (20×12×10 cm) layered with a loose, moist, standard greenhouse soil, free of stones and vegetation.

RESULTS AND DISCUESSION

Each *N. badiosus* specimen actively used the soil to cover the surface of their shell during the night of their transfer to the terrarium, working from the apex to the aperture. Later, they all adhered to the terrarium walls by means of an epiphragm of dried mucus (Figs 3 A, B). The shell-cover was incomplete; a tiny area of about 3 mm^2 remained soil-free at the base of the body whorl close to the shell aperture (Figs 3 A, B, arrow and asterisks), making easier a tight seal between the shell aperture and the underlying surface through the epiphragm. A similar uncovered shell area in *N. barquini* was named "gap area" by Allgaier (2007). The four specimens had an extraneous layer arranged in the form of prominent soil protuberances altering greatly the appearance of the shell, making it virtually unrecognisable to the human eye (Fig. 3 D), and therefore presumably reducing

Figure 3 A–C, Three views of the disguised shell of *Napaeus badiosus*. A, lateral view. B, almost ventral view. C, dorsal view. The dashed line in "A" represents the joining plane, parallel to the snail shell aperture and nearly perpendicular to the photograph plane. The arrow and asterisks in "A" and "B" represent the uncovered "gap area". D, View of the terrarium base, with three disguised specimens of *Napaeus badiosus* on the humid soil; the fourth specimen, with a cleaned shell, was added for comparison.

the risk of visual predation. The snails are part of the diet of the omnivorous lizard *Gallotia atlantica* (Peters & Doria 1882), endemic to the eastern islands (Valido & Nogales, 2003), and the other species of *Gallotia*, which as a genus is present in all the islands of the Archipelago, probably also consume snails in their regular diet. Birds are potential predators as well, especially the songthrush, *Turdus philomelos* Brehm 1831 (Turdidae), a winter visitor to the eastern Fuerteventura and Lanzarote Islands.

The general appearance of the *N. badiosus* shells (Fig 3 A–C) is different from that of *N. variatus*, but similar to that of *N. barquini* (Allgaier, 2007, figs 3D, 4 A, D). It appears that N. *badiosus* and *N. barquini* display a similar active disguise strategy. The active disguise observed exclusively under laboratory conditions may be explained by the absence of alternative hiding places such as plants, stones or rock crevices in the terrarium. The absence of active disguise in *N. badiosus* in the wild raises an interesting question: will such behaviour be induced when the snail is placed in a "hostile" environment devoid of hiding places? Plasticity in this apparently innate, adaptive behaviour may be important for snail survival, for example during prolonged periods of wet weather when the snail may be more active and exposed and thus, more vulnerable to predation. Disguised snails are easily overlooked in the field, and it is possible that other species can also disguise.

This very simple observation, together with the remarkable study of Allgaier (2007), suggests that more experiments on species observed to have external disguise are needed. In particular, evidence for active disguise is *a priori* evidence that the disguise is indeed adaptive. This is even more the case when presence or absence of disguise in the wild varies with the habits and habitat of the snails.

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