PARASITES AND PREDATORS IN *ALBINARIA* (GASTROPODA PULMONATA: CLAUSILIIDAE)

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Abstract

Data are given on a number of predators and parasites of the Mediterranean clausiliid genus *Albinaria*. Direct observations of parasitism or predation by *Brachylaima* spp. (Digenea: Trematoda), *Drilus* spp. (Insecta: Coleoptera), *Eopolita protensa* (Gastropoda: Pulmonata) and *Poiretia compressa* (Gastropoda: Pulmonata) are described. On the basis of circumstantial evidence, small mammals or birds, a large carabid species (Insecta: Coleoptera, possibly *Carabus banoni*), *Poiretia dilatata marginata* (Gastropoda: Pulmonata) may also be considered natural enemies of *Albinaria*. The maker of small (0.3 mm diameter), circular holes in albinarian shells remains unknown.

Key words: clausiliidae, Albinaria, parasites, gastropoda

Περίληψη

Δίνονται στοιχεία σχετικά με έναν αριθμό θηρευτών και παρασίτων του Μεσογειακού γένους *Albinaria* των Clausiliidae σαλιγκαριών. Περιγράφονται άμεσες παρατηρήσεις παρασιτισμού ή θήρευσης από τα *Bracvhylaima* spp. (Digenea: Trematoda), *Drilus* spp. (Insecta: Coleoptera), *Eopolita protensa* (Gastropoda: Pulmonata) και *Poiretia compressa* (Gastropoda: Pulmonata). Σύμφωνα με τις ενδείξεις, μικρά θηλαστικά ή πουλιά, ένα μεγάλο είδος σκαραβαίου (Insecta: Coleoptera, πιθανόν το *Carabus banoni*), το *Poiretia dilatata marginata* (Gastropoda: Pulmonata) μπορούν επίσης να θεωρηθούν ως φυσικοί εχθροί του *Albinaria*. Το ζώο που κάνει μικρές (0.3 mm διάμετρος) κυκλικές τρύπες στα κελύφη του *Albinaria* παραμένει άγνωστο.

Introduction

The terrestrial snails of the clausiliid genus *Albinaria* Vest occur on limestone rocks almost everywhere in Greece, Cyprus, the Lebanon and western and southern coastal Turkey. The genus is extremely speciose; at present, more than 70 species have been described, most of these showing a considerable degree of polytypy.

During research on the systematics and the evolutionary biology of these snails, the conchology and anatomy of hundreds of specimens have been studied (see Gittenberger, 1992 and Kemperman, 1992). As a by-product, these investigations have yielded information on the hitherto largely unknown predators and parasites of these snails.

In this paper, data are presented that provide some basic insight into some aspects of the life history of *Albinaria* species. These data may help in determining the selective pressures that are relevant in the evolution of *Albinaria*.

Materials and methods

During field-work, snails were collected in the islands of Kephallonia, Ithaka and Crete. The animals were transported alive and, on arrival in the laboratory, were checked for the presence of parasites and predators. If any were discovered, they were preserved in alcohol 70% or, in the

case of adult Drilidae (Coleoptera), were mounted on insect pins and dried. The snails themselves were then either killed and dried or killed and preserved in 70% ethanol. The dry shells were inspected for any traces of predation. The shells of the snails that were preserved in alcohol were carefully peeled off and dissected. Trematode parasites discovered during this stage were stained with haematoxylin and eosin and mounted in Euparal.

Results and discussion

***a.* Platyhelminthes: Trematoda: Digenea: Brachylaimidae: *Brachylaima* (Dujardin 1845).**

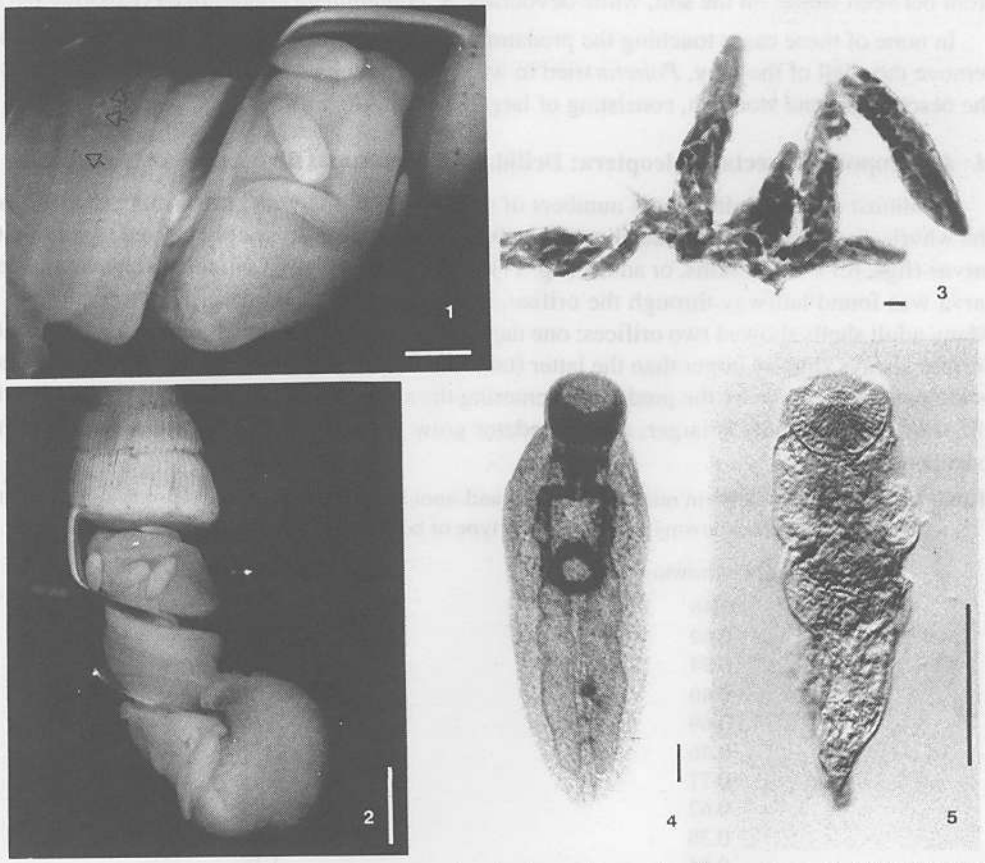
In an adult specimen of *Albinaria senilis flavescens* (Boettger), collected in May 1987 near Chavdata on the West Kephallinian peninsula of Paliki, metacercariae of digenean trematodes were found between the epidermis of the snail and the shell (figs. 1,2). In total, 20 worms were observed, scattered over the surface of the animal from just behind the clausilium up to the 4th whorl, with a tendency to aggregate. All were found positioned with mouth and sucker in contact with the snail's mantle, and were embedded in relatively abundant mucus. At places where the parasites were removed, the snail's epidermis was cratered and showed small perforations with somewhat thickened, callous edges (fig. 1). The shell itself was completely undamaged. The snail was dissected, but no additional parasites were found.

Among the other ten preserved conspecific snails from the same locality, only one more specimen was found to contain trematodes. In this case, however, the worms were not found between the shell and the mantle, but inside the visceral mass. The life-stage present in this second individual was not metacercariae, but sporocysts, completely filled with numerous immature larvae, obviously cercariae (figs. 3,5). These cercariae resemble closely the metacercariae that were found in the first snail, except for their much smaller size and less elongated caudal region. Brief descriptions of both cercariae and metacercariae follow below:

Cercariae (fig. 5): Small, measuring 0.26 x 0.09 mm. Both oral and ventral sucker are 0.54 mm in diameter. The ventral sucker is positioned at 3/5 of the total length from the head. The caudal region is somewhat narrowed. The excretory ducts are probably not ending into the urine bladder but into separate pores. Metacercariae (fig. 4): Slender worms, measuring approximately 1.3 x 0.4 mm, with side margins almost parallellic. The oral sucker is large, 0.2 mm across, and the pharynx is 0.1 mm long. The ventral sucker has a diameter of 0.15 mm and is positioned at 2/5 of the total length from the head. The two gut-arms are initially directed laterally, but shortly after that are bent caudally. Near the ventral sucker, they become broader and less irregular, although the overall shape remains simple and straight. Excretory ducts (unified near the caudal ends of the gut into the urine bladder) and the excretory pore are clearly visible.

Two metacercariae, very similar to the ones described above, were also found in a specimen of *Albinaria hippolyti hippolyti* (Boettger), collected near Tilissos, some 10 km W of Iraklion, in Crete. The parasites were only discovered after most of the snail had been dissected. Their original position, therefore, could not be established. The Kephallinian specimens were identified by Dr. Yolanda Manga (León, Spain) as belonging to the genus *Brachylaima* Dujardin, 1845 (Brachylaimidae). The species of this genus are known for having snails as intermediate hosts and small mammals and birds as their definitive hosts. The infection of the definitive host takes place when the snails containing metacercariae are eaten. The observation of metacercariae on the ouside of the snails' epidermis is unusual (the above based on personal communications by Manga); however, since metacercariae of this genus are normally found in the kidney (Hardambidis

et al., 1965), it does not seem likely that the metacercariae had migrated from the kidney into the space between the shell and the snail's epidermis, so possibly this species of *Brachylaima* is an exception to the rule.



Figs. 1-5 *Brachylaima* spp. 1, some metacercariae *in situ* on the mantle of a specimen of *Albinaria senilis flavescens:* scars are indicated with arrows; Scale line: 1 mm. 2, *Albinaria ibidem:* scale line: 2 mm. 3, sporocysts from the visceral mass of *Albinaria senilis flavescens:* Scale line: 0.1 mm. 4, metacercaria, habitus; Scale line: 0.1 mm. 5, cercaria, habitus; Scale line: 0.1 mm.

The presence of brachylaimid cercariae and metacercariae in *Albinaria* suggests that the snails are preyed on by one or more (yet unidentified) vertebrate predators.

b. **Mollusca: Gastropoda: Pulmonata: Zonitidae: *Eopolita protensa* (Férussac)**

On 6.10.1991, at a locality near the village of Marathos, Crete, a pulmonate snail, *Eopolita protensa* (Férussac), was found eating a juvenile *Albinaria hippolyti hippolyti* (Boettger). Riedel (1980) mentions that the representatives of the zonitid tribe Oxychilini, to which this species belongs, are mainly carnivores, preying on small invertebrates, such as other snails. *E. protensa* is by far the most common zonitid gastropod species in Crete (personal observations, third author).

c. Mollusca: Gastropoda: Pulmonata: Oleacinidae: *Poiretia compressa* (Mousson)

At three different localities on Kephallonia, *Poiretia compressa* was collected, while attacking *Albinaria*. At Markópoulon (21.3.1988), a *Poiretia* was removed from a small crevice in a rock. The snail was almost completely enveloping an adult *Albinaria contaminata periporon* Kemperman & Gittenberger. At both Laknthra (22.4.1987) and Troïnata (25.4.1987), *Poiretia* was collected from between stones on the soil, while devouring *A. contaminata contaminata* (Rossmässler).

In none of these cases touching the predator caused it to release its prey. During attempts to remove the shell of the prey, *Poiretia* tried to withdraw, which caused the release of contents of the oesophagus and stomach, consisting of large parts of *Albinaria* tissue.

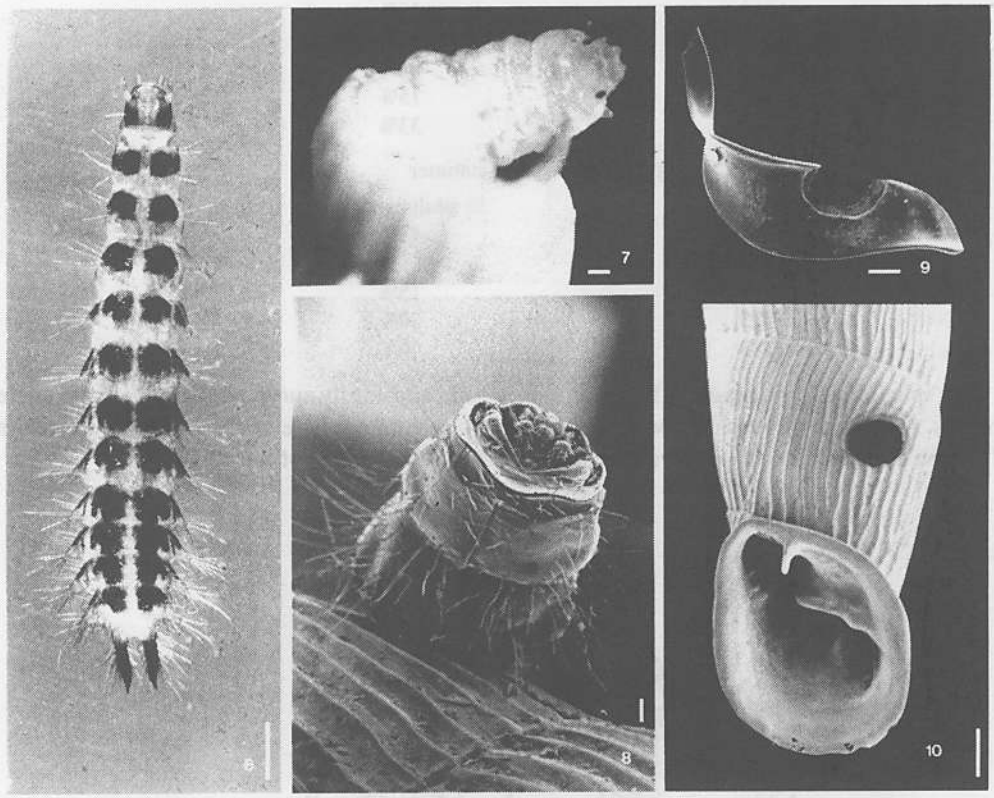
d. Arthropoda: Insecta: Coleoptera: Drilidae: *Drilus* spp. Olivier

At almost every locality, large numbers of shells were found with one or more oval holes in the whorls, the cervix, or the clausilium (figs. 9,10). Such shells invariably proved to contain the larvae (figs. 6,7), larval skins, or adults (fig. 11) of the beetle-family Drilidae. In one case, a dead larva was found halfway through the orifice, apparently having died while emerging (fig. 8). Many adult shells showed two orifices: one narrowing outward, the other narrowing inward, the former always slightly larger than the latter (table 1). Apparently, the outwardly narrowing hole is the one that is made by the predator on entering the shell, the other one is made while leaving the shell. The exit-hole is larger, as the predator grew after having devoured the shell's former occupant.

Table 1 Largest diameters (in mm) of inwardly and outwardly narrowing drilid holes in a number of *Albinaria* shells, showing that the former type of hole is always smaller than the latter.

inwardly narrowing hole	outwardly narrowing hole
0.46	1.31
0.69	1.23
0.54	1.38
0.46	1.08
0.69	1.15
0.46	1.15
0.77	0.92
0.62	1.00
0.38	1.08
0.85	1.15
0.77	1.23
0.54	0.92

Drilidae are well-known for their molluscivorous way of life (Plate, 1951). The larvae of the Western European species *Drilus flavescens* (Geoffroy) attack helicid snails by entering through the aperture. They then devour the living snail. Until their metamorphosis they will kill several snails in this manner. However, none of the authors reporting on the biology of this and other drilid species (Crawshay, 1903; Plate, 1951), mention their ability to perforate shells. This habit is known, however, for a related family, the Lampyridae (Mienis, 1975).



Figs. 6-10 *Drilus* spp. 6. last-instar larva from a shell of *Albinaria cretensis:* Scale line: 1 mm (photo by A. 't Hooft). 7. first-instar larva in the apical whorls of a shell of *A. spratti:* Scale line: 0.2 mm. 8. last-instar larva emerging from a hole in the shell of *A. spratti:* Scale line: 0.2 mm (SEM-photo by J. Goud). 9. clausilium from a shell of *Albinaria amalthea*, showing a drilid perforation: Scale line: 0.5 mm. 10. ultimate whorls of *Albinaria amalthea*, showing a drilid entrance-hole: Scale line: 1 mm.

The Drilidae found to prey on *Albinaria* seem particularly well adapted to their prey. Levels of predation are generally quite high, as table 2 indicates. At some sites, more than half the juvenile shells found during late summer contained first-instar larvae (fig. 7). Last- instar larvae and adults, however, were usually found in adult shells during early summer. This suggests that the beetles reproduce during summer, when the snails are aestivating. During this period, the snails glue their shells to the rocks by means of tough, plug- like epiphragms. This may explain why the beetle larvae are forced to perforate the shells of their prey. The presence of holes in the clausilium (fig. 9) however, indicates that the predator may also enter via the aperture, apparently not hindered by the clausilium.

Table 2 Fractions of Cretan *Albinaria* populations attacked by Drilus spec. at a number of localities.

a. juvenile predation in late summer

locality	% juveniles attacked
1413	16%
1643	51%
1414	28%
1415	15%
1394	33%

b. adult predation in early summer

locality	% adults attacked
1244	47%
1129	7%
1018	15%
1025	39%
1183	20%

In spite of their predators' efficiency, some snails apparently survived their attack by unclear means. A number of live snails were found in which an entrance hole of *Drilus* had been repaired. In some cases, the dried-up larva was still sticking to the outside of the shell.

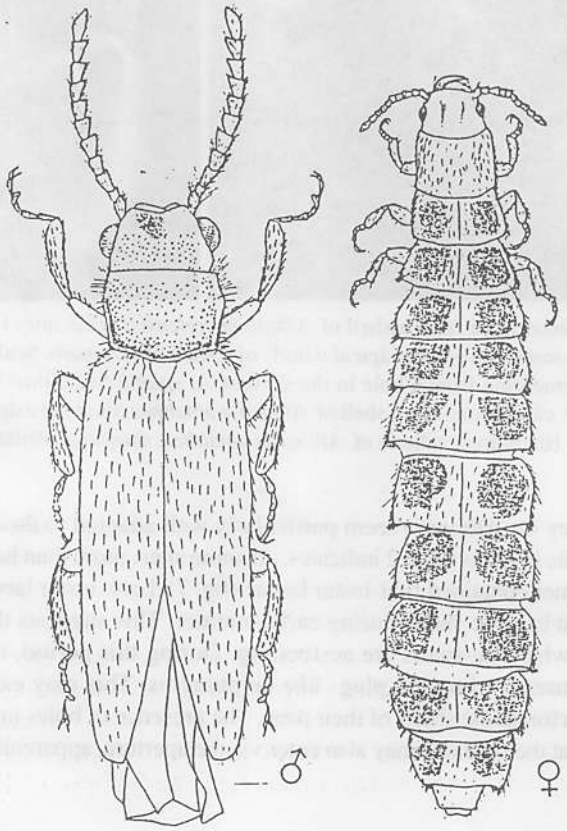


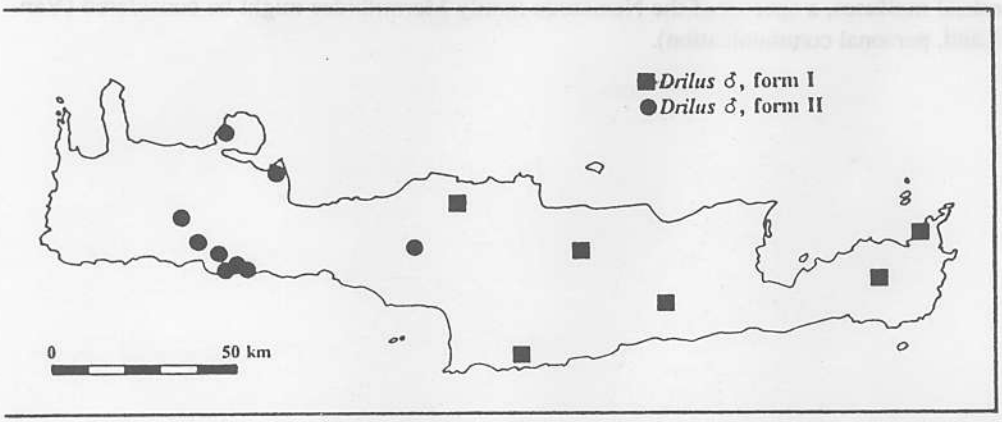
Fig. 11 *Drilus* spp., habitus of male form I (left) and female (right).

Live Drilidae were only found in Crete, during field-work by the first and third authors. In tal, 20 adult males, 9 adult females and hundreds of larvae were found. The females were of e well-known larviform appearance, lacking wings and elytra (fig. 11). The males came in two rms, one uniformly black (below referred to as form I), the other with a brightly orange thorax elow referred to as form II). In fig. 12, the distribution of both forms in Crete is given, indicating at they may be geographic races or vicariant species. A brief description of the larval and adult sects is given below.

Last-instar larva (fig. 6): Approximately 10 mm long, flattened. The head and the appendages e reddish brown, the rest of the body is black. The surface is shiny. The head carries two ocelli, ort, triarticulate antennae and slightly upturned, sickle-shaped mandibulae. The pronotum has ew long, brownish bristles along its margins. Similar bristles are present all over the abdominal gments, especially on tubercles that are situated on the posterolateral angles of each sternite. ıe last abdominal segment carries two thick, sharp cerci.

Female (fig. 11): 6.2-9.2 mm long. Larviform. Light-brown, with darker lateral spots on each dominal tergite. The surface is covered with short, brownish hairs. The head is square, with ort antennae.

Male (form I, fig. 11): 6.2-8.5 mm long. Black, legs dark-brown. The surface is shiny, in spite a coarse, but not very dense, punctation. The body is covered with short, dark hairs. The frontal ge of the clypeus, between the antennal bases, is concave. The eyes are hemispherical. The tennae are slightly serrated. The sides and base of the pronotum are distinctly marginate; its solateral angles are slightly turned upward.



g. 12 Map of Crete, showing localities at which adult male drilids were found.

Male (form II): 5.0-7.3 mm long. Black, the femora dark-brown, the ventral side of the head onsisting of gula, postgenal areas and mouth-parts), a spot on the clypeus, the thorax (scutellum cluded), the last abdominal segment, the tibiae and tarsi orange. The body is covered with short ıirs that are yellow on the orange parts of the body, but dark elsewhere. Not only the basolateral ırners, but also the lateral margins of the pronotum are distinctly turned upward. For the rest, rm II is similar to form I.

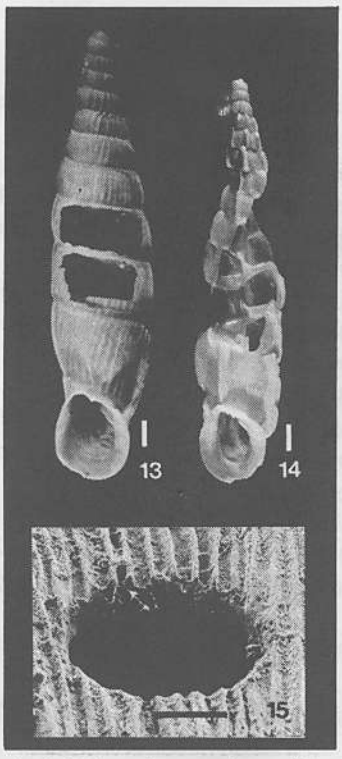
It proved to be practically impossible to identify the species involved. Wittmer (1944) lists 23 species of Drilidae from the Mediterranean, including several from Crete. The species in question probably belongs to *Drilus* Olivier. However, the differences between this genus and *Malacogaster* Bassi appear insufficiently defined (Zurcher, 1911). Comparison with type-specimens from the Muséum National d'Histoire Naturelle (Paris) eliminated *D. creticus* Pic, *D. funebris* Reitter, *D. latithorax* Pic and *D. longulus* Kiesenwetter as names for the *Albinaria* predators. The original descriptions of the remaining candidate species are too brief and superficial to make a safe identification possible. For this reason any tentative identification is refrained from and the species is referred to as *Drilus* spp.

Traces of other predators

The observations above are restricted to direct records of predation and parasitism of *Albinaria*. In addition, at many localities, dead shells were found with damage, obviously caused by some predator or parasite. These traces are discussed below.

i. Small, circular perforations

At many localities, dead shells were found with small (approximately 0.3 mm diameter), circular perforations (fig. 15). Their size, circularity and lack of any inwardly or outwardly narrowing distinguish these holes from the ones produced by *Drilus* spp. It remains unclear to which organism this type of damage may be attributed; the appearance of the holes suggests some type of worm. Van der Land (personal communication) is unaware of any worm known to produce such holes. However, because of their epigean mode of life and their known association with terrestrial molluscs, a species of the Nematode family Mermithidae might be considered (Van der Land, personal communication).



Figs. 13-15 Damage done to *Albinaria* shells by various predators. 13, a shell of *Albinaria cretensis*, probably damaged by *Poiretia dilatata marginata;* Scale line: 1 mm (photo by A 't Hooft). 14, a shell of *Albinaria praeclara praeclara*, possibly damaged by carabid beetle; Scale line: 1 mm (photo by A 't Hooft). 15, small circular perforation in the shell of *Albinaria adrianae adrianae*, made by a yet unidentified predator; Scale line: 0.1 mm.

ii. Shell crushed across several whorls

In Crete, some *Albinaria* species with thin-walled shells, notably *A. praeclara* (Pfeiffer), *A. hippolyti* (Boettger) and *A. maltzani* (Boettger), are often preyed on by an organism that forcifully breaks away the shell across several whorls (fig. 14). Mienis (1985) reports on such behaviour by the Carabid beetle *Scarites eurytes*, preying on helicids. Possibly, also here the predator is a Carabid beetle. A likely candidate is the largest, and quite common, Cretan Carabid species, *Carabus banoni* Dejean.

iii. Shell scraped away on one side

In Kephallinia, Ithaca and western Crete, empty *Albinaria* shells are often found, which have been scraped away at one side (fig. 13). This kind of damage might be caused by a predatory pulmonate of the genus *Poiretia* Fischer (Falkner, 1990: 168, 169, fig. 11). In Crete, this is quite likely, as damaged *Albinaria* shells are found only on the western part of the island, which matches exactly the distribution of the Cretan representative of this genus, *P. dilatata marginata* (Westerlund) (Maassen, 1991). Direct observations (see above) confirm *Poiretia* as a predator of Kephallinian *Albinaria*, although any scraping behaviour was not observed.

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