The Central Mediterranean Naturalist	3(3): 97 - 100	Malta, December 2001

POLYXENID MILLIPEDE (DIPLOPODA, POLYXENIDA) ASSOCIATED WITH EMPTY SNAIL SHELLS

Karl A. Ebejer[1] and Patrick J. Schembri[1]

ABSTRACT

A polyxenid millipede found singly and in groups of up to nine individuals or their exuviae in dead empty snail shells from Qrejten Point, northeastern coast of Malta, was identified as *Polyxenus macedonicus* Verhoeff, 1952. Other organisms were also collected from the same shells, but there was no evidence to suggest a parasitic or predatory relationship of any of these with the millipedes. We conclude that the polyxenids were exploiting the shells as shelters with a relatively benign microclimate in an otherwise arid environment.

INTRODUCTION

Polyxenid millipedes are minute (<4mm) diplopods characterised by a soft body wall lacking impregnation with calcium and covered with tufts of hair-like setae. Two polyxenid species are known from the Maltese Islands: *Polyxenus lapidicola* Silvestri was collected twice from leaf-litter under large shrubs, and *Lophoproctus jeanneli* Brölemann, collected once from the same habitat (Enghoff & Schembri, 1989). Enghoff & Schembri (1989) did not exclude the possibility that polyxenids are more widespread in the Maltese Islands than their records suggest, since their small size precludes easy observation.

The present paper reports findings of aggregations of polyxenid millipedes in empty (in the sense of lacking the original gastropod soft tissues) snail shells at one site on the east coast of Malta during a study on the resource value of empty terrestrial snail shells in the Maltese Islands (Ebejer, 2001).

METHODS

The study area, Qrejten Point, is a peninsula on the east coast of Malta with a high exposure to wind and sea spray. The flat Coralline Limestone terrain supports a maritime garigue dominated by Golden Samphire (*Inula crithmoides*), Boar Thistle (*Galactites tomentosa*), Clustered Carline-thistle (*Carlina involucrate*), Mediterranean Thyme (*Thymbra capitata*), Maltese Sea-chamomile (*Anthemis urvilleana*), Rock Crosswort (*Crucianella rupestris*), Edible Birdsfoot Trefoil (*Lotus edulis*), and various Graminae. The entire area is strewn with rubble.

Sampling was carried out between September and October 2000. Three shore-normal transects were established approximately 20m apart. Sampling stations were located at 10-20m intervals along these transects up to a distance of about 90m from the sea. At each station empty snail shells were collected by searching the surface of the terrain, ignoring any partially buried shells that did not have an exposed aperture or visible breakage. Each collected shell was immediately placed individually in a sealed plastic container until processed. In the laboratory, shells were identified, measured and carefully broken and searched and any animal contents (or parts thereof) were preserved and identified to the fullest extent possible.

RESULTS

Among the contents of the snail shells were polyxenid millipedes and/or their exuviae (Table 1). None of the polyxenids appeared to be alive. The number of polyxenids found in occupied shells varied from one to nine individuals per shell. In some shells, large masses of exuviae were found in silken nests, which the animals had presumably spun themselves. Of the 61 shells that contained a polyxenid (or exuviae), 59% also had other occupants, or remnants thereof (Table 2). In many cases, shells contained a variety of occupants sharing the shell with the millipedes.

DISCUSSION

Enghoff & Schembri (1989) identified two polyxenids from the Maltese Islands: *Polyxenus lapidicola* Silvestri and *Lophoproctus jeanneli* Brölemann. However, the taxonomic status of *P. lapidicola* is uncertain and the leading authority on polyxenids, M. Nguyen Duy-Jacquemin, who was sent specimens of the polyxenids collected for examination, prefers to refer to the Maltese specimens from Qrejten Point as *Polyxenus macedonicus* Verhoeff, 1952 (H. Enghoff, personal communication).

In addition to Malta, *Polyxenus macedonicus* is known from Macedonia (F.Y.R.O.M.) as well as southern France and Corsica (Henrik Enghoff, personal communication, 2001).

[1] Department of Biology, University of Malta, Msida MSD06, Malta

Table 1 – Frequency of polyxenid occupancy of different snail shells from Qrejten Point.

Snail species[1]	No. shells collected	No. shells Occupied[2]	% occupied
Trochoidea spratti	103	24	23.30
Sphincterochila candidissima	73	3	4.11
Eobania vermiculata	52	4	7.69
Pomatias sulcatus	52	14	26.92
Cochlicella acuta	21	3	14.29
Muticaria macrostoma	20	1	5.00
Rumina decollata	15	0	0.00
Chondrula pupa	13	5	38.46
Cantareus aspersus	10	1	10.00
Xerotricha sp.	8	3	37.50
Caracollina lenticula	5	1	20.00
Theba pisana	3	2	66.67
Cantareus aperta	2	0	0.00
Cernuella caruanae	1	0	0.00
Ferussacia folliculus	1	0	0.00
TOTALS	**379**	**61**	**16.09**

[1] Nomenclature follows Giusti *et al.* (1995) [2] Shells listed as occupied contained at least one polyxenid or polyxenid exuvium.

Aggregations of polyxenids in snail shells, but not in other microhabitats, at Qrejten Point indicate that empty snail shells are an important resource for this species. It has been suggested that *Polyxenus macedonicus* may have selected the snail shells if they had any algal growth (H. Enghoff, personal communication). The shells at Qrejten were normally free of such growth except in the case of *Sphincterochila candidissima* and *Pomatias sulcatus*, older specimens of which were sometimes very eroded and showed signs of algal or lichen growth. However, this was not confirmed at the time of collection and no records were made of whether such shells also contained polyxenids. Shells that contained polyxenids but which did not bear any algae may have already been stripped of such growth if there had been any.

There is no literature describing any relationship of polyxenid millipedes with snails or snail shells, although some millipede species have been reported to feed on dead animal remains, including snails (Srivastava & Srivastava, 1967). Their presence in snail shells at Qrejten may not be related to any interaction with the living or recently dead gastropod, but to the microclimatic conditions afforded by the empty shells. In Britain, *Polyxenus lagurus* is found under the bark of dead trees, in leaf litter and under stones (Blower, 1985). All of these places are typically dark, damp and sheltered. However, *Polyxenus lagurus* is extremely successful at colonising dry habitats. In coastal regions they have been found at the roots of halophilic plants and beneath lichens and mosses growing on boulders (Blower, 1985). It therefore appears that *Polyxenus lagurus* can survive in a range of environments, whether moist or dry, if suitable microhabitats are available.

Crawford (1979) describes a number of behavioural and physiological mechanisms employed by millipedes to reduce water loss. These include walking to a wet area and minimisation of cuticular, respiratory and other forms of water loss. The hot, dry summers experienced by *Polyxenus macedonicus* in Malta may be survived through utilisation of such mechanisms. The polyxenids may seek the relative shelter and humidity of discarded snail shells in otherwise exposed areas. The presence of more than one individual in these shells suggests that the shells are preferred 'roosts' in which polyxenids aggregate after feeding.

Empty snail shells were very abundant at Qrejten Point. The tendency for the millipedes to be found in aggregations rather than singly in a greater number of shells may result from the animals following the same environmental cues in seeking shelter but may also be the result of some form of social behaviour. It is also possible that the aggregations may be associated with reproductive or moulting behaviour.

The preference of *Polyxenus macedonicus* for certain shells may be a chance observation resulting from a small sample size. Given the number of shells of all snail species that were found to be empty of any occupants, it is unlikely that the polyxenids were competitively excluded from the shelter offered by any shell.

The occurrence of other organisms in the same shells occupied by polyxenids maybe completely fortuitous but the possibility of predatory or parasitic associations cannot be excluded. There is very little literature on this aspect of polyxenid biology, but predatory and parasitic associations of

Table 2 – Occupants sharing empty snail shells with polyxenids at Qrejten Point.

Occupant	No. of occurrences
Spiders (Araneae)	13
Mites and ticks (Acari)	10
Ants (Formicidae)	9
Beetles (Coleoptera)	6
Unidentified arthropods	5
Pseudoscorpions (Pseudoscorpiones)	4
Snails (Gastropoda)	4
Springtails (Collembola)	2
Bugs (Hemiptera)	2
Woodlice (Isopoda)	1

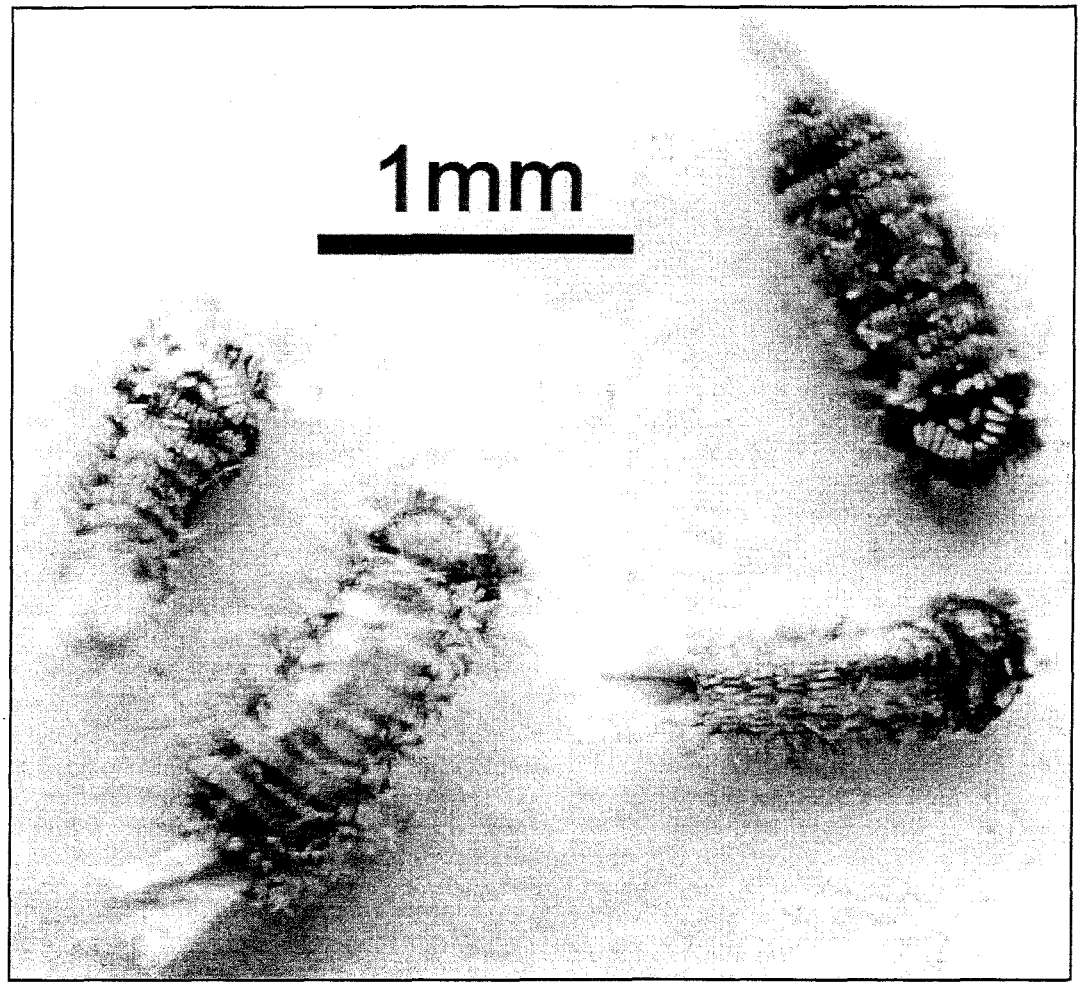

Fig. 1 *Polyxenus macedonicus* Verhoeff, 1952

polyxenids with ants and gall midges respectively have been recorded. Ants of the Neotropical genus *Thaumatomyrmex* are specialised predators on polyxenids that strip the millipedes of their setae before eating most of the prey tissues (Brandão *et al.*, 1991). This or related genera do not occur in the Maltese Islands (Stephen Schembri, *personal communication*) and while remains of ants were found in shells occupied by polyxenids at Qrejten Point, there is no evidence to suggest ant predation or any association between ants and the millipedes.

A parasitoid gall midge (Diptera, Cecidomyiidae), *Chiliodiplosis vasta* Möhn is known to specialise on individuals of *Polyxenus lagurus* in Scandinavia (Möhn, 1955; Enghoff, 1976). In the present study, Cecidomyiidae, including one larva, were found in shells at Qrejten Point, but never in the same shells as *Polyxenus macedonicus*. The Cecidomyiidae also have some members whose larvae are predators (Skuhravá, 1997). Other potential predators that occur in association with polyxenids in snail shells at Qrejten point include spiders, pseudoscorpions and beetles. As no literature on the interaction of polyxenids with such species seems to exist, further study is required before any assessment of the significance of these co-occurrences can be made.

ACKNOWLEDGEMENTS

We are grateful to Edwin Lanfranco (University of Malta) for identification of plants, Stephen Schembri (University of Malta) for information on ants, Professor Henrik Enghoff (Zoologisk Museum, Copenhagen, Denmark) for information on polyxenids and for arranging for the identification of the polyxenid, and to Professor Monique Nguyen Duy-Jacquemin (Museum National d'Histoire Naturelle, Paris, France) for her identification of the *Polyxenus* species from Qrejten Point. PJS thanks the University of Malta Research Committee for the award of a research grant.

(Accepted 20th September 2001)

REFERENCES

Blower, J.G. (1985). *Millipedes*. [Synopsis of the British Fauna (New Series) No.35]. E.J. Brill/Dr. W. Backhuys, London, England. vii + 242pp.

Brandão, C.R.F., Diniz, J.L.M. & Tomotake, E.M. (1991). *Thaumatomyrmex* strips millipedes for prey: a novel predatory behaviour in ants, and the first case of sympatry in the genus (Hymenoptera: Formicidae). *Insectes Sociaux* **38**: 335-344.

Crawford, C.S. (1979). Desert millipedes: a rationale for their distribution. In: Camatini, M. [ed.] *Myriapod biology*, Academic Press, London; pp.171-181.

Ebejer, K.A. (2001). *A study on the use of empty terrestrial snail shells (Gastropoda) as a resource.* Unpublished BSc (Hons) dissertation, Department of Biology, University of Malta; v + 112pp.

Enghoff, H. (1976). Morphological comparison of bisexual and parthenogenetic *Polyxenus lagurus* (Linné, 1758) (Diplopoda, Polyxenidae) in Denmark and southern Sweden, with notes on taxonomy, distribution, and ecology. *Entomologiske Meddelelser* **44**: 161-182.

Enghoff, H. & Schembri, P.J. (1989). The millipedes of the Maltese Islands (Central Mediterranean). *Bolletino della Societá Entomologica Italiana, Genova* **120** (3): 164-173.

Giusti, F., Manganelli, G. & Schembri, P.J. (1995). *The non-marine molluscs of the Maltese Islands.* [Museo Regionale di Scienze Naturali, Torino, Monografie 15] Torino, Italy: Museo Regionale di Scienze Naturali; 607pp.

Möhn, E. (1955). Neue zoophage Gallmücken-Gattungen (Diptera: Itonididae). *Beiträge zur Entomologie* **5**: 415-425.

Skuhravá, M. (1997). Family Cecidomyiidae. In: Papp, L. & Darvas, B. [eds] *Contributions to a manual of Palaearctic Diptera. 2: Nematocera and Lower Brachycera.* Science Herald, Budapest; pp 71-204.

Srivastava, P.D. & Srivastava, Y.N. (1967). *Orthomorpha* sp., a new predatory millipede on *Achatenia fulica* in Andamans. *Experentia* **23**: 776.