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SHORT COMMUNICATION

Retreats of orb web spiders (Araneae, Araneidae) as hibernation sites for terrestrial arthropods

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Abstract. Retreats of orb weaving spiders (Araneidae) were collected during the winter of 2004/2005 in northwestern Germany in order to determine the importance of these animal-made structures as hibernation sites for terrestrial arthropods. Retreats were clipped out of the vegetation, stored, and searched in the laboratory for their inhabitants. Overall, there was a high occupation of retreats by spiders, whereas only a few other arthropods were recorded. For Central Europe, there is no evidence that retreats made by orb weavers support the hibernation of a large spectrum of arthropods other than spiders. Only for spiders that may also occur as secondary occupants, retreats play an important role as hibernation sites.

Keywords: Animal constructions, animal remains as habitat, ecosystem engineering, hibernation strategy, shelter

The existence of different types of shelters may positively influence arthropod colonization of plants (Lill & Marquis 2004). Animal-made leaf shelters are created by binding, tying, rolling, or webbing leaves together with silk. Besides other arthropods like caterpillars, sawflies, ants, and beetles, various spider families construct shelters on plants (Wagner & Raffa 1993; Berenbaum 1999; Anderson & McShea 2001; Fukui 2001). Such spider retreats vary in terms of size, structural complexity, and location. The function of these constructions also varies among different spider families. For example, Clubionidae and Salticidae predominantly use woven shelters as hiding sites during day or night and for construction of egg sacs within these shelters, whereas most Agelenidae and Araneidae seek shelter while they are waiting for prey. Secondary use of such animal-made shelters by a variety of arthropods that use them as feeding sites or refuges has been observed (Carroll & Kearby 1978; Cappuccino 1993; Cappuccino & Martin 1994; Martinsen et al. 2000; Lill & Marquis 2003). From an ecological viewpoint, arthropods building such shelters act as physical ecosystem engineers: organisms that influence the resource availability for other organisms by modifying the abiotic or biotic environment (Jones et al. 1994, 1997). So far, only a few studies explicitly focus on the colonization of animal-made shelters, including spider retreats, by secondary occupants (Auten 1925; Jackson & Griswold 1979; Austin 1993; Cappuccino 1993; Lill & Marquis 2004).

We have been interested in orb web spiders as ecosystem engineers and the effects of their constructions on other terrestrial arthropods throughout Central Europe. Many orb web spiders build silken retreats where they sit and wait for prey and where they protect themselves from extreme weather conditions and from predators (e.g., Jackson & Griswold 1979; Austin 1993). We predicted that these shelters that remain in the vegetation, especially during winter, might play an important role as hibernation sites for arthropods of higher strata. Thus, a high abundance and a large species diversity of secondary retreat colonizers were expected to occur in these constructions. As far as we know, the importance of such spider-made structures for the hibernation of arthropods has not been investigated in any previous study. Other animal-made structures are also seldom considered as hibernation sites for spiders (e.g., bird nests and snail shells) (Otzen & Schaefer 1980; Klüppel et al. 1984; Bauchhenss 1995).

The study was conducted in the vicinity of Oldenburg (NW Germany). Retreats were collected haphazardly and irrespectively of plant species by sight in nine rural grasslands during two winter months (February and March) of 2005 (mean temperature: 1.2° C (Feb.), 4.0° C (Mar.)). All retreats were clipped out of the vegetation in the field and individually stored in Petri dishes. In the laboratory, all retreats were searched, and the abundance and taxa of all arthropod inhabitants recorded. Only arthropods within the retreat were collected, not those partially or completely outside. Furthermore, all retreats were stored for at least 14 days after harvesting and controlled every 2–3 days in the laboratory in order to record hatchlings or well hidden individuals. Specimens were preserved in glass tubes containing 70% ethanol. They were stored at the University of Oldenburg, Terrestrial Ecology Working Group. Retreats were primarily constructed of spider silk and small fragments of plants. Parts of prey (insect remains) were often included as secondary elements in the retreats. The retreats themselves were normally attached to infructescences of grasses or canes or to ramifications of herbaceous plants.

For the investigation of the community of hibernating arthropods in retreats of orb weaving spiders, a total of 1,004 retreats were examined (Table 1). Of these, 429 retreats (42.7%) were not colonized by any arthropods. The 575 colonized retreats yielded 605 individuals of spiders and only 15 individual insects. Thus on average, 0.6 arthropods were found per retreat. Insects were found predominantly alone in the retreats. However, four retreats were occupied by insects and spiders together. Furthermore, several retreats were inhabited by more than one individual spider.

Araneids (76.8%) clearly dominated the spectrum of inhabitants in the retreats. Theridiids (7.4%) and clubionids (5.8%) were less common. Other spider families (Linyphiidae, Philodromidae, Dictynidae, Tetragnathidae, and Thomisidae) were scarce (altogether 7.1%). In total, 412 (66.5%) of the araneids were *Larinioides* sp. (mostly juveniles and subadults; presumably all *L. cornutus* (Clerck 1757)).

Among the remaining terrestrial arthropods (3%), Coleoptera (6 species) were the most abundant secondary users (8 ind.; 1.3%). Heteroptera (3 ind.), Hymenoptera-Parasitica (2 ind.) as well as Diptera (1 ind.) and larvae of Lepidoptera (1 ind.) were extremely rare colonizers of the retreats.

Overall, our results for the Central European region implicitly show that retreats of orb web spiders in higher vegetation do not support a distinct increase of the abundance and species diversity of terrestrial insects during winter. Retreats of araneids in higher strata do not play a significant role for hibernation of arthropods other than spiders. Consultation of relevant ecological literature reveals, for example, for

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Table 1.—Identification of arthropods that had colonized 575 out of 1004 retreats of orb web spider collected during two winter months (February and March) of 2005.

Taxon	Total
ARANEIDA	605
Araneidae	476
Araneidae indet.	22
Agelenatea sp.	42
Larinioides (total)	412
Larinioides cornutus adults	132
Larinioides juveniles + subadults	280
Theridiidae (juveniles)	49
Paidiscura pallens (Blackwall 1834)	1
Theridiidae (juveniles)	48
Clubionidae	36
Clubiona stagnatilis Kulczyn'ski 1897 adults	4
Clubionidae (juveniles + subadults)	32
Linyphiidae indet.	21
Philodromidae indet.	8
Dictynidae indet.	7
Tetragnathidae indet.	6
Tetragnathidae	1
Metellina mengei (Blackwall 1870)	1
Thomisidae indet.	1
INSECTA	15
Coleoptera	8
Apionidae	
(*Perapion curtirostre*)	1
Coccinellidae	
(*Adalia bipunctata*)	1
(*Aphidecta obliteratata*)	1
(*Coccidula rufa*)	2
Carabidae	
(*Pterostichus diligens*)	2
Chrysomelidae	
(*Prasocuris marginella*)	1
Diptera	1
Nematocera	1
Heteroptera	3
Hymenoptera	2
Chalcidoidea	2
Lepidoptera	
(caterpillars)	1
ARTHROPODS (total)	620

the recorded Coleoptera, that all 6 species are eurytopic and showed no feeding preferences for spiders or insect remains. Insect remains that were included as secondary structures in some of the retreats don't seem to be an important food resource for scavengers. In conclusion, all recorded insects can be regarded as opportunistic refuge seekers (Jackson & Griswold 1979). Thus, the importance of orb web spiders as physical ecosystem engineers in the construction of retreats is low for other hibernating terrestrial arthropods.

The function of the retreats as shelter during winter is restricted predominantly to spiders, which occur in more than half of our collected retreats. They seem to find hospitable microclimatic conditions in the retreats. Furthermore, they may be protected from natural enemies like birds (*Parus* sp. and others; Gunnarsson 2007).

Spiders hibernating in retreats may have constructed these shelters themselves or they may be secondary users. During our study, the retreats used as shelters by all of the recorded theridiids (48 ind.) had been classified by us as primary constructions of araneids. Furthermore, although most of the individuals of *Larinioides* sp. collected by us seemed to hibernate in retreats of their own species and other structures have already been shown to be important hibernating sites for this species (Kirchner 1965), several individuals were found during our study in retreats that showed typical attributes of a retreat primarily constructed by an *Araneus* species (e.g., form, color of silk). Thus, secondary use of retreats as hibernation sites seems to be quite common among spiders. In addition, it can be assumed, that some species of theridiids, actively sought pre-existing shelters of other species. They adopt the retreats of other species as a refuge or substitute for constructing their own nests (Jackson & Griswold 1979; Austin 1993).

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