Lichen specificity of Oribatid mites (Acari; Oribatida) on limestone walls in the Great Alvar of Öland, Sweden

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Oribatid mites, springtails and other invertebrates inhabiting calcicolous lichens were collected on stone walls in the grassland Great Alvar on the Baltic island of Öland, Sweden. Three foliose and two crustose (squamulose) lichen species were examined. Eight taxa of oribatid mites were found. *Trichoribates trimaculatus* (47% of all mite individuals collected) and *Phauloppia lucorum* (27%) were the most abundant species. *Trimalaconothrus saxosus* and *Scheloribates ascendens* were recorded for the first time in the Nordic countries. Mites tended to be associated more frequently with foliose lichens than with crustose lichens. Most mite species showed a preference for certain lichen species. Three springtail species were found. *Xenylla maritima* (80% of all springtails) was the most abundant species. Springtails were exclusively found on foliose lichens, no specimens were found on crustose lichens. On the level of lichen species, the species richness of springtails was positively correlated with species richness of oribatid mites.

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Introduction

A variety of invertebrates are associated - at least during a certain stage of their life cycle - with lichens (Seaward 1988). For numerous oribatid mite species lichens serve as habitat and food resource (Seyd & Seaward 1984). However, the mites' specificity to certain lichens is largely unknown. In a pilot study, five oribatid mite taxa were found to be associated with the foliose lichens *Xanthoria parietina* and *Physcia adscendens* and the crustose (squamulose) lichen *Lobothallia radiosa* on limestone walls in the grassland Great Alvar on Öland, Sweden (Fröberg et al. 1996). The aim of the present study was to investigate whether mite taxa show any specificity towards foliose or crustose lichens on stone walls in the Great Alvar. We determined the number of individuals for all mite species found in samples of five lichen species. We also examined the occurrence of other potential lichen grazers (springtails and other invertebrates) in these lichen samples and assessed the density of terrestrial gastropods, which are the most important lichen herbivores on the stone walls.

Material and methods

Twenty-four lichen samples were collected on the top layer of limestone walls at four localities (2 or 4 samples of each species at each locality) in the grassland Great Alvar on the Baltic island of Öland, Sweden, on 26-27 March 1997. The localities were: (1) 1.3 km SSW of Vickleby

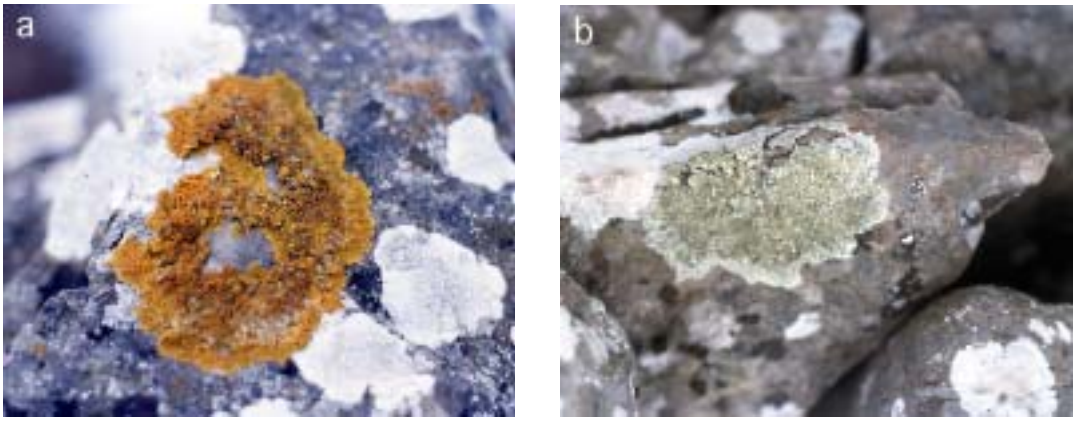

*Figure 1. Foliose lichen species, such as **Xanthoria parietina** (a) had more orbatids and springtails than crustose lichens such as **Lecanora muralis** (b).*

*Bladlavar, som t.ex. a) vägglav (**Xanthoria parietina**) hade fler arter och individer av orbatidkvalster och hoppstjärtar än skorplavar, som t.ex. b) kvartslav (**Lecanora muralis**).*

church; (2) 1.7 km E of 'södra baspunkten' (Bårby källa); (3) 400 m S of the southernmost tip of Möckelmossen; and (4) 300 m S of the Ecological Research Station (ERS), Torslunda. Two additional lichen samples were collected at locality 4 on 11 March 2000. We sampled the most abundant foliose (*Collema polycarpon*, *Physcia adscendens* and *Xanthoria parietina*; Figure 1a) and crustose (*Lecanora muralis* and *Tephromela atra*; Figure 1b) lichen species growing on limestone walls. These lichens are assumed to be potential habitats for mites. Lichen samples were carefully removed from the horizontal stone surface using a knife. The area covered by lichen individuals removed was determined to the nearest cm^2. Lichen removal was done as carefully as possible. However, a few animals may have been lost. Characteristics of the stone

Table 1. Characteristics of limestone walls and area sampled for each lichen species at the four localities investigated. Height and width of each wall are given as means of 6 measures with standard deviations in parentheses. Sample size is expressed as the area covered by the lichens collected.

Beskrivning av stenmurarna samt storleken av lavproverna på de fyra lokalerna. Höjd och bredd av respektive mur anges som medelvärde av 6 mätningar med standardavvikelse inom parentes. Storleken av proverna motsvarar en uppskattning av underlagets yta som täcktes av laven.

Locality *Lokal*	Direction *Riktning*	Height *Höjd* (cm)	Width *Bredd* (cm)	Area sampled (cm^2) for each lichen species *Storlek av lavprover (cm^2)*				
				Collema polycarpon	*Lecanora muralis*	*Physcia adscendens*	*Tephromela atra*	*Xanthoria parietina*
1. Vickleby church	SSW-NNE	79 (6)	42 (4)	10	-	17	-	32
2. Bårby källa	SSW-NNE	106 (6)	44 (2)	-	12	-	12	15
3. Möckelmossen	SSW-NNE	113 (5)	55 (3)	-	11	-	14	-
4. ERS*	ESE-WNW	100 (12)	48 (7)	8	-	19	-	-

* = Ecological Research Station *Ekologiska forskningsstationen*

Table 2. Invertebrate fauna on the limestone walls investigated. The total number of living and dead (in parentheses) individuals of oribatid mites (adults, nymphs and larvae combined) and springtails collected from lichens at the four localities is given. Gastropod density is indicated by the number of adult and juvenile snails collected within 3 minutes (mean values of 5 replicates are shown).

Evertebratfaunan på de undersökta stenmurarna. Siffrorna anger det totala antalet levande och döda (inom parentes) individ av oribatidkvalster (adulta, nymfer och larver) och hoppstjärtar insamlade i lavar på de fyra lokalerna. Tätheten av snäckor anges som antalet adulta och juvenila individ som insamlades under en tre-minuters period (medelvärde baserat på fem replikat).

Invertebrate species / *Arter av evertebrater*	Locality/ Lokal 1	2	3	4
Oribatid mites/ *Oribatidkvalster*:				
Camisia invenusta	0	26(29)	0	0
Camisia sp.	1 (1)	0	0 (5)	14
Eupelops sp.	0	0	0	0 (2)
Phauloppia lucorum	13(34)	60(54)	15(62)	7 (2)
Scheloribates ascendens	0	0	0	6 (1)
Tectocepheus velatus	0	0	0	0 (1)
Trichoribates trimaculatus	41 (26)	0	0	126(30)
Trimalaconothrus saxosus	41 (7)	0	0	2
Springtails/ *Hoppstjärtar*:				
Anurophorus laricis	0	0	0	14
Entomobrya nivalis	0	0	0	3
Xenylla maritima	24	1	0	44
Gastropod density/ *Täthet av snäckor*:				
Chondrina clienta	0	6.4	0	6.8
Balea perversa	46.6	0	89.0	58.0

walls and area covered by the lichen species are given in Table 1.

Lichen samples together with the mites and other invertebrates were put into tubes with 70% ethanol. All invertebrates were subsequently removed from the lichen thalli and identified. In the two most abundant mite species adults, nymphs and larvae were counted.

Gastropod density on limestone walls was estimated by turning the upper layer of stones and counting the number of juvenile and adult snails picked up with a pair of tweezers within 3 min. Density estimates were based on five replicate

Figure 2. SEM-image (scanning electron microscope image) of ***Phauloppia lucorum****; scale = 100 µm.*

SEM-foto (svepelektronmikroskop-foto) av orbatidkvalstret ***Phauloppia lucorum*** *– en av de vanligaste och mest generalistiska arterna i undersökningen. Skalstrecket = 100 µm.*

counts conducted in March 2000. This method reveals reliable density estimates for rock-dwelling land snail species (Baur et al. 1995). *Balea perversa* and *Chondrina clienta* have an adult life span of 5-10 years and show relatively constant densities over long periods (B. Baur & A. Baur, unpublished data).

Nomenclature of oribatid mites follows Lundqvist (1987), that of springtails Fjellberg (1980) and that of lichens Santesson (1993). Data analysis was performed using the StatView program package (Version 5.0, SAS Institute 1998).

Results

Eight taxa of oribatid mites were found (Table 2). The most abundant species were *Trichoribates trimaculatus* (47% of all living oribatid mite individuals collected) and *Phauloppia lucorum* (27%; Figure 2). The percentage of living individuals of *T. trimaculatus* was 75%. Those of different life stages of living *T. trimaculatus* were 32% adults, 59% nymphs, 9% larvae. The percentage of living individuals of *P. lucorum* was 38%. Those of different life stages of living *P. lucorum* were 73% adults, 24% nymphs, 3% larva. Less common were *Camisia invenusta* (7%), *Camisia* sp. (4%) and *Trimalaconothrus*

Table 3. Oribatid mites and springtails found on five lichen species. In both mites and springtails, the number and density of living individuals and species richness are given for each lichen species.

Oribatidkvalster och hoppstjärtar som observerades på de fem undersökta lavarterna. För både oribatidkvalster och hoppstjärtar anges antalet och tätheten av levande individ, samt antalet arter i varje lavart.

Type of lichen *Typ av lav*	Lichen species *Lavart*	Lichen area examined *Undersökt lavyta* (cm^2)	No. of mites *Antal kvalster*	No. of mites per cm^2 lichen *Antal kvalster/ lavyta*	No. of mite species *Antal arter av kvalster*	No. of springtails *Antal hoppstj.*	No springtails per cm^2 lichen *Antal hoppstj./ lavyta*	No. of springtail species *Antal arter av hoppstjärtar*
Foliose	*Collema polycarpon*	18	64	3.56	4	37	2.1	2
bladlav	*Physcia adscendens*	36	164	4.56	5	48	1.3	3
	Xanthoria parietina	47	77	1.64	4	1	0.02	1
Crustose	*Lecanora muralis*	23	36	1.57	2	0	0	0
skorplav	*Tephromela atra*	26	11	0.42	1	0	0	0

Table 4. Number of living individuals of the various oribatid mite and springtail species found on different lichen species.

Antal levande individ av olika arter av oribatidkvalster och hoppstjärtar associerade med olika lavarter.

	Oribatid mite species *Arter av oribatidkvalster*						Species of springtails *Arter av hoppstjärtar*		
Lichen species/ *Lavart*	*Camisia invenusta*	*Camisia* sp.	*Phaulop. lucorum*	*Scelorib. ascend.*	*Trichorib. trimacul.*	*Trimalac. saxosus*	*Anuroph. laricis*	*Entomob. nivalis*	*Xenylla maritima*
Collema polycarpon	0	0	5	3	15	41	2	0	35
Physcia adscendens	0	14	8	3	137	2	12	3	33
Xanthoria parietina	25	1	36	0	15	0	0	0	1
Lecanora muralis	1	0	35	0	0	0	0	0	0
Tephromela atra	0	0	11	0	0	0	0	0	0

saxosus (12%). Only one or a few specimens were found of *Eupelops* sp. (only dead individuals encountered on *P. adscendens*), *Scheloribates ascendens* and *Tectocepheus velatus* (only one dead individual encountered on *C. polycarpon*). *Scheloribates ascendens* and *T. saxosus* are new to the Nordic countries.

Table 3 gives the number of oribatid mite individuals and species found on each lichen species. Foliose lichens tended to contain both more individuals and more species of mites than crustose lichens. Considering individual lichen species, five mite species were associated with *Physcia adscendens* and each four with *Collema polycarpon* and *Xanthoria parietina* (Tables 3 and 4). In contrast, only two and one mite species were associated with the crustose lichens *Lecanora muralis* and *Tephromela atra*, respectively. Different mite species appeared to have a preference for certain lichen species (Table 4). *Phauloppia lucorum* was an exception, occurring on all lichen species examined (Table 4).

Two gastropod species (*Balea perversa* and *Chondrina clienta*) were recorded on the stone walls examined (Table 2). The snails occurred at rather high densities. However, both species coexisted at only one locality. No relationships between gastropod density and mite density (number of mites collected per cm^2 lichen area) or gastropod density and mite species richness were found on the locality level ($p > 0.8$ in both cases).

Three springtail species were found in the lichens collected (Table 2). The most common species was *Xenylla maritima* (80% of all springtail individuals collected). Springtails

were only found on foliose lichens (Table 3). Most interestingly, on the level of lichen species, the number of springtail species was positively correlated with the number of oribatid mite species ($r = 0.91$, $n = 5$, $p = 0.031$). On the locality level, no relationships between gastropod density and springtail density (number of springtails collected per cm^2 lichen area) and species richness were found ($p > 0.8$ in both cases).

Other invertebrates found belonged to Mesostigmata (several specimens), Prostigmata (several specimens), Thysanoptera (a few specimens), Coleoptera (*Enicmus* sp.), Diptera (larva) and Lepidoptera (larva), Araneae, Nematocera (larva) and Nematoda. All specimens, except some of the Thysanoptera, were exclusively found on foliose lichens.

Discussion

The present study showed that foliose lichens contained more individuals and species of oribatid mites than crustose lichens. Furthermore, springtails only occurred on foliose lichens, as did most of the other invertebrates. This corresponds with the results of Søchting & Gjelstrup (1985), who investigated the invertebrate fauna on seashore rocks on the Baltic island of Bornholm, Denmark. They found most springtails on foliose lichens and bryophytes and only a few on crustose and fruticose lichens. Foliose lichens are not as firmly attached to the rock surface as crustose (squamulose) lichens are and may therefore provide a microhabitat with a higher structural complexity. Thus, in foliose lichens more niches are available to tiny invertebrates than in squamulose lichens. This idea is also supported by the correlation between mite species richness and springtail species richness on the lichen level. Different herbivore species feeding on the same lichen may compete for this resource. For example, lichen feeding gastropods may compete for food, both within and between species (Baur 1988, Baur & Baur 1990). However, we did not find any negative relationship between the density of the gastropods *Balea perversa* and *Chondrina clienta* (two major herbivores on lichens in the area studied; Fröberg et al. 1993, Baur et al. 1994), and those of mites and springtails. This indicates that there is no strong competition for food between gastropods and mites and springtails.

Most of the oribatid mite and springtail species were recorded in more than one lichen species, and different mite species showed different preferences for lichen species. However, *Phauloppia lucorum* seems to be a generalist species (Seyd & Seaward 1984). In the present study, *P. lucorum* was associated with all five lichen species examined. Similarly, *P. lucorum* occurred on 7 of 11 lichen species examined by Gjelstrup & Søchting (1984). Previous studies on oribatid mite communities inhabiting *Ramalina*, *Umbilicaria* and *Xanthoria* species suggest that there is little dispersal of mites among lichen individuals during any season or as a response to adverse climatic conditions (Solhøy 1975, Søchting & Gelstrup 1985, Tilrem 1994, Manazza 1995).

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Sammanfattning.

Material av fem lavarter insamlades på kalkstensmurar på Stora Alvaret, Öland, för en studie av deras evertebratfauna. Syftet var att undersöka oribatidernas specificitet för lavar med bladformig och fjällig bål. Tre bladlavar, nämligen rikfruktig gelélav (*Collema polycarpon*), hjälmrosettlav (*Physcia adscendens*) och vägglav (*Xanthoria parietina*), samt två fjälliga skorplavar, nämligen kvartslav (*Lecanora muralis*) och svart kantlav (*Tephromela atra*) ingick i studien. Lavarna lades i 70% etanol, och därefter blev oribatidkvalster, hoppstjärtar och andra evertebrater som hittades vid en nogrann observation utplockade.

Allt som allt hittades åtta arter av oribatidkvalster. Av dessa var *Trichoribates trimaculatus* (47% av alla oribatider) och *Phauloppia lucorum* (27%) vanligast. Av övriga oribatider var *Trimalaconothrus saxosus* och *Scheloribates ascendens* nya för Norden. De flesta arterna hade preferenser för bladlavar, med undantag av *P. lucorum* som återfanns hos alla lavarter. Tre arter av hoppstjärtar hittades; *Xenylla maritima* (80% av alla hoppstjärtar) var den vanligaste. Hoppstjärtarna förekom uteslutande hos bladlavar. Övriga evertebrater (insekter, spindeldjur och rundmaskar) förekom även de främst hos bladlavar. Antalet arter av oribatider och hoppstjärtar hos respektive lavart var korrelerade. Frekvensen av två landsnäckor, klippspolsnäcka (*Balea perversa*) och hällsnäcka (*Chondrina clienta*), som är vanliga i området och äter lavar, var inte korrelerad med frekvensen av oribatider eller hoppstjärtar. Dominansen av evertebrater hos bladlavar, beror sannolikt på den högre komplexiteten i byggnaden av dessa jämfört med fjälliga skorplavar, vilket medför att de erbjuder fler mikrohabitat för djuren.