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Psammobiontic Actinedida in southwest Germany and new findings from coastal dunes in Denmark and Norway

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Abstract

Microarthropods were sampled in various sandy habitats in northwest Europe. The actinedid mites represented the most abundant microarthropod group found. In those areas that were quantitatively sampled (Germany), microarthropod densities increased with successional development of the sampling site. Also with increasing succession, the relative dominance of the different microarthropod groups within the communities changed, with endeostigmatid mites dominating in open sands, prostigmatid mites in short-grass sites, and balanced communities - with increasing densities of Oribatida and Collembola - in the most developed sites. Psammophilous taxa dominated in the open and short-grass sites. The most important psammobiontic actinedid taxa are briefly presented and discussed in relation to the literature on microarthropods of sandy habitats.

Introduction

Especially since the publications of Coineau and colleagues (i.e., COINEAU & MASSOUD 1977; COINEAU et al. 1978; COINEAU & SEELY 1983), soil zoologists have become increasingly interested in the microarthropod fauna of sandy habitats. Studies in many disparate sites around the world have shown that Actinedida are the most important soil mite group occurring in xerotherm, sandy areas (WALLWORK 1972; SANTOS et al. 1978; STEINBERGER & WHITFORD 1985; CEPADA-PIZARRO & WHITFORD 1989; STEINBERGER et al. 1990; KINNEAR 1991; CEPADA-PIZARRO et al. 1996; NOBLE et al. 1996). Many new species have been described from such sites (COINEAU et al. 1967; THERON et al. 1970; SCHUBART 1973; ANDRÉ 1996) as well as strong morphological adaptations to the environment (COINEAU et al. 1978; HAUPT & COINEAU 1999). However, no studies have been published comparing the Acari of sandy habitats at a more regional scale. The lack of determination keys and autecological data make it difficult to study Actinedida comparatively and/or at a community level. The results presented here are part of ongoing studies of these habitats in Europe and present some of the most important, apparently psammophilous-actinedid taxa found there.

Study sites and methods

The data presented here originated from four different sand sites: two continental dune areas in southwest Germany (Sandhausen and Lampertheim near Heidelberg) and sporadic samples from coastal dunes in Farsund, Norway and Bornholm, Denmark (material provided by A. Fjellberg, Tjome). These represent, of course, only a very small proportion of such habitats in Europe. Only one of the study areas was studied quantitatively: Sandhausen, sampled regularly between 1993 and 1998. Here, various sites (representing a successional gradient from open sands, grasslands, to wooded areas; see Fig. 1 and Tab. 1) were sampled three times per year (with 3–5 samples, to a depth of 5 cm), the microarthropods extracted in a high-gradient extraction device, and the animals thus obtained sorted under the dissecting microscope into Collembola, the major acarological groups, and remaining arthropods (»Other Groups«). The other sites have only been sampled qualitatively as of yet. Collembola and Actinedida were determined to the specific level, where possible; only major aspects of the Actinedida results are presented here. Actinedida determination was performed using, i.e., KETHLEY (1990, unpublished manuscript 1986); ZACHARDA (1980); STRANDTMANN (e.g., 1971); ANDRÉ (1980); as well as original descriptions. The only other published reports of Actinedida in sand habitats in Europe are the descriptions of species found in coastal dunes in Southern France (COINEAU et al. 1967; COINEAU & THERON 1983), which, however, provided no quantitative data or little information on community composition.

Results and Discussion

Community composition

In all sites, the Actinedida (here divided into Endeostigmata and Prostigmata including Heterostigmata) represented the most frequently registered mite group. Only the microarthropod groups found in the Sandhausen sites can be put in relation to one another. A general tendency for increasing individual densities and number of identified taxa with increasing vegetative cover (= increasing soil eutrophication) was found here. There was also an obvious relationship between group composition and successional development of the sampling sites (Fig. 1). In the open sites, the microarthropod communities were dominated by Endeostigmata, mostly Nanorchestidae. This family has often been described, from all continents, as being dominant in sandy and xerotherm habitats (SHIBA 1976; SANTOS et al. 1978; SANTOS & WHITFORD 1983; CEPEDA-PIZARRO & WHITFORD 1989; KINNEAR 1991; CEPEDA-PIZARRO et al. 1996). In the more heavily vegetated grassland sites, the Endeostigmata occurred in far lower densities, and prostigmatid species became dominant. Soil Prostigmata are indeed important microarthropods in grassland soils (KETHLEY 1990). In the biotically most developed sites, the Oribatida were found equally abundant, and, finally, in the woodland site, the Collembola also played an important role and the microarthropod communities were fairly balanced.

Psammophilous Actinedida were concentrated in the open sands and short-grass vegetation in Sandhausen (Table 1). These were especially represented by endeostigmatid taxa (i.e., *Neonanorchestes*, *Micropsammus*) as well as prostigmatid taxa such as *Linotetranus* and some apparently specialised Microtydeids (i.e., *Coccotydeolus*, see below). In the more heavily vegetated sites, mostly prostigmatid taxa, such as other Tydeidae (mostly species from the subfamily Tydeolinae), Eupodidae, and Stigmaeidae were found, whereby endostigmatid and psammophilous taxa were less represented. A similar tendency was also observed in the Lampertheim sites.

Tab. 1 Dominance of selected groups of Actinedida within the entire actinedid communities found in the various sampling sites in the Sandhausen area (only). The Group »Psammophile« includes the taxa presented in this report as well as *Poecilophysis arena*, which only occurred in Sandhausen as sporadic individuals. Not all Actinedida recorded in Sandhausen are listed in this table; the last line thus shows the proportion (in %) of the listed groups within the Actinedida found in the various sampling sites. Conventions and information regarding the sites as in Fig. 1.

Group	Open Sands				Short-grass sites				Long-grass sites			Forest
	Sand	Sand II (93)	Sand II (94)	Sand II (96)	<i>Corynephorus</i>	<i>Koeleria</i> I	<i>Koeleria</i> II	"De-matted"	<i>Festuca</i> I	<i>Festuca</i> II	<i>Festuca</i> III	<i>Pinus</i>
Claveupodes	-	-	8.6%	3.3%	1.0%	0.2%	4.3%	0.3%	0.8%	0.8%	26.6%	1.1%
Other Eupodidae	0.7%	-	1.2%	0.1%	3.0%	2.0%	2.5%	0.7%	19.2%	9.0%	3.2%	28.1%
Stigmaeidae	-	-	-	-	0.2%	-	7.1%	1.4%	18.6%	0.7%	11.5%	0.2%
Rhagidiidae	2.1%	-	-	-	0.7%	-	-	0.1%	0.3%	2.2%	0.8%	1.7%
Coccotydaeus	2.8%	5.3%	0.4%	2.7%	0.8%	7.4%	0.9%	14.8%	1.4%	6.6%	0.8%	0.2%
Other Tydaeidae	1.7%	7.7%	8.6%	7.3%	6.7%	18.0%	41.5%	51.3%	33.8%	57.9%	30.7%	13.3%
Psammophile	83.2%	8.7%	31.0%	17.2%	83.9%	72.2%	26.0%	31.7%	9.3%	6.9%	2.3%	1.3%
Total of all Actinedida	91%	22%	50%	31%	96%	100%	82%	100%	83%	84%	76%	46%

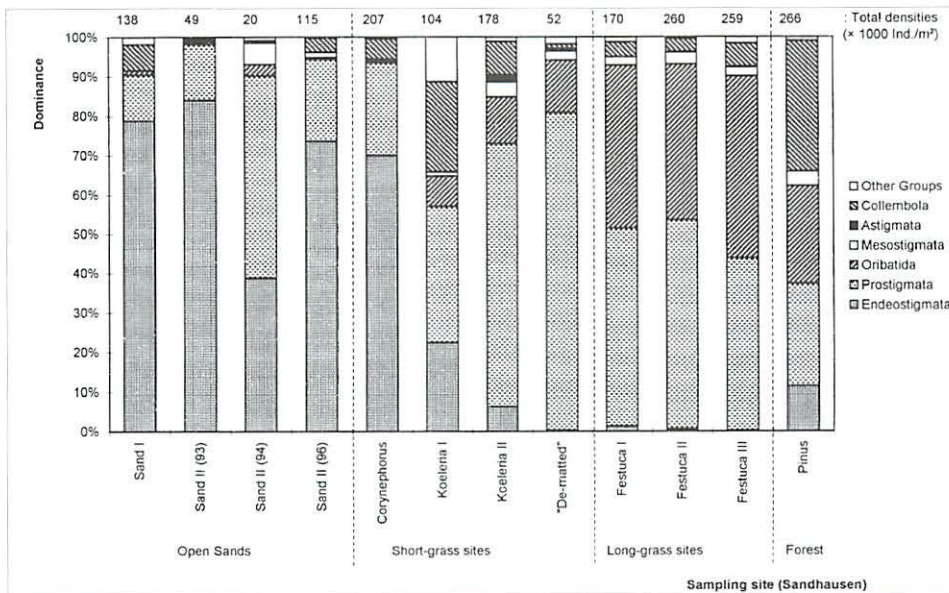


Fig. 1 Total densities and group dominances of the major groups of microarthropoda found in the various sites in the Sandhausen area (only) in southwest Germany. »I«, »II«, and »III« refer to separate sampling sites with the same successional status, soil characteristics, and vegetation. »Sand-II« and »De-matted« (a former *Festuca* meadow) were set back to the successional status shown here by landscape-management practices at least two years before sampling. »Sand-II« was sampled in three separate years, and the results are shown here to exemplify the variability.

Psammobiontic taxa

Stigmalychus Theron, Meyer & Ryke 1970 spec. nov. (Alicorhagiidae, Endeostigmata)

Although no record other than that of the only described species, *S. veretrum* (THERON et al. 1970) has been published for this taxon, it is known to occur in various sandy sites in North America, Hawaii, Africa, and elsewhere (unpublished data; KETHLEY, pers. comm.; THERON et al. 1970). In the present study, an apparently undescribed species of this genus was found in the dunes in Sandhausen and in samples from coastal areas in Farsund, Norway. This genus is therefore probably exclusively psammobiontic. It appears that, when specimen of this genus occur, they are most often found in relatively low individual numbers. In the present sites, this species occurred in somewhat more vegetated sites.

Micropsammus littoralis Coineau & Theron 1983 (Micropsammidae, Endeostigmata)

The genus *Micropsammus* is probably distributed world-wide (KETHLEY, pers. comm.). To date, however, the genus has been found exclusively in xerotherm sand habitats, albeit very disjunctly (COINEAU & SEELY 1983; COINEAU & THERON 1983; ESTRADA et al. 1988; KETHLEY 1990; CEPEDA-PIZARRO et al. 1996; NOBLE et al. 1996). The genus is, thus, most likely psammobiontic and can be considered to be typical of actinedid sand communities. Although the species found in the sites reported here was indeed the only described species, *M. littoralis*, other species are probably represented in the other continents of occurrence (KETHLEY, pers. comm.). In Sandhausen, *M. littoralis* occurred in high individual numbers in the open and sparsely vegetated sites, where it - together with *Neonanorchestes* - comprised up to 80% of the actinedid community.

Neonanorchestes ammolitoreus McDaniel & Bolen 1981 (Nanorchestidae, Endeostigmata)

The Nanorchestidae were, with almost 33% and 43%, respectively, of all Actinedida, one of most common actinedid families in Sandhausen and Lampertheim. As described above, Nanorchestidae are commonly abundant in xerotherm habitats, often with the genus *Speleorchestes* (FRANCO et al. 1979; WALLWORK 1972; SANTOS & WHITFORD 1983; CEPEDA-PIZARRO & WHITFORD 1989; STEINBERGER et al. 1990; KINNEAR 1991; CEPEDA-PIZARRO et al. 1996; NOBLE et al. 1996). *Speleorchestes* was indeed found as the dominant Actinedid and was widely distributed in the Lampertheim area. In Sandhausen, however, *Nanorchestes* spp. were dominant. In the open sands and short-grass sites, *Neonanorchestes ammolitoreus* was found, sometimes comprising up to 70% of all actinedid individuals, especially in *Corynephorus* and *Koeleria* grasses. The distribution of this species was similar to that of *Micropsammus*. In the Norwegian samples, a second, as of yet undescribed *Neonanorchestes* species was found from shoreline foredunes. To date, the species of this genus have been reported from littoral sand habitats in southern North America and Mexican desert areas (MCDANIEL & BOLEN 1981; SANCHEZ-ROCHA & PALACIOS-VARGAS 1997). Thus, the species reported here are the first records of European *Neonanorchestes*.

Cunliffea (Cunliffe 1956) spec. nov. (Nematalycidae, Endeostigmata)

Cunliffea is a member of the aberrant endeostigmatid family, Nematalycidae, the genera

of which have all been exclusively found in sandy soils and which show strong adaptations to mesopsammal life (SCHUBART 1973; COINEAU et al. 1978; HAUPT & COINEAU 1999). The only nematalycid taxon found here was *Cunliffea* in Sandhausen, which occurred in extremely low densities in the open sands as well as in the more vegetated, organically richer soils. The genera of this family appear to occur widely, yet very disjunctly in various parts of the world (SCHUBART 1973; HAUPT & COINEAU 1999; NORTON & KINNEAR 1999).

Other Acari

Other actinedid taxa were found in these sites, which - although perhaps not as rare and extremely psammobiontic as the species presented above - appear to be important members of the psammophilous actinedid community:

Linotetranus cylindricus Berlese 1910 (Linotetranidae, Prostigmata). One of four known species of this genus (ANDRÉ 1996), *L. cylindricus* was found in almost all sampling sites in Sandhausen, sometimes eudominant, especially in disturbed short-grass sites. The genus *Linotetranus* has, to date, been found exclusively in sandy biotopes (ATHIAS-HENRIOT 1961; ESTRADA et al. 1988; ARGANÁRAZ et al. 1991; KINNEAR 1991; ANDRÉ 1996; CEPEDO-PIZARRO et al. 1996; NOBLE et al. 1996; SANCHEZ-ROCHA & PALACIOS-VARGAS 1996) and, thus, is probably psammobiontic.

Neognathus Willman 1955 spec. (Calligonellidae, Prostigmata). Although very little is known about the distribution and occurrence of the species of this genus, Kethley (unpubl. manuscript) lists them as occurring in »sandy soils with grass«. Indeed, in both Sandhausen and Lampertsheim, the genus was found in sun-exposed, short-grass sites, sometimes in comparatively large individual numbers.

Coccytydeolus Baker 1965 spp. (Tydeidae, Prostigmata). In Sandhausen, members of this genus (which were found as two separate, as of yet unidentified species) were found in all sampling sites (=successional stages), with, however, the largest densities in the short-grass sites (Table 1). This genus has often been found in xerotherm sand communities (ESTRADA et al. 1988; CEPEDO-PIZARRO & WHITFORD 1989; SANCHEZ-ROCHA & PALACIOS-VARGAS 1996) and, thus, is very likely psammophilous.

Concluding comments

Most of the species mentioned here appear to be highly adapted to sandy soil habitats. Without further soil studies on Actinedid community composition, however, the distribution and autecology of these taxa will remain widely unknown and interpretations thus somewhat speculative. Their known localities of occurrence are highly disjunct, yet show a worldwide distribution at least at the generic level. Their occurrence appears to be exclusively in sandy habitats. With *Cunliffea*, *Micropsammus*, *Neonanorchestes*, *Stigmalychus*, and *Linotetranus*, an extremely rare psammobiontic actinedid community was registered in Sandhausen. Many of these species are reported here for the first time in Central Europe and, indeed, for Europe altogether. How widely distributed these taxa truly are can only be determined with more thorough sampling of such habitats and taxonomic investigation of this poorly known mite group.

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