MITES IN BALTIC SEA COASTAL HABITATS (AKMENSRAGS, LATVIA) WITH SPECIAL REFERENCE TO MESOSTIGMATA

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ACARIFORMES
ORIBATIDA
MESOSTIGMATA
SPECIES COMPOSITION
SPATIAL DISTRIBUTION
COASTAL HABITATS

SUMMARY: Mites of grey dune soil were studied near Akmensrags in Latvia, the eastern Baltic Sea coast. Thirty-three Mesostigmata species were recorded. About half of them belonged to the Phytoseiidae. *Asca bicornis, Zercon carpathicus* and *Amblyseius meridionalis* were the most abundant. *Protodinychus punctatus* and *Amblyseius nemorivagus* were new to the fauna of Latvia. A spatial distribution of Oribatida and other Acariformes, and Mesostigmata along the coastal dune habitats was analysed. Mites had taxa-specific distribution along the dune habitat gradient.

INTRODUCTION

Dunes in Latvia are among the most northerly situated in Europe. The vegetal cover in Latvia differs significantly from that in similar habitats along the southerly-situated coasts. The dunes are sensitive to disturbances, particularly trampling, and hence they can serve as a model for study of anthropogenic influence on coastal ecosystems: KOEHLER *et al.* (1996) investigated effects of trampling on dune microarthropods in Denmark.

Dunes are subdivided in embryonic dunes and foredunes (or white dunes) and grey dunes. The vegetation on white dunes is sparse or scattered with species of sandy habitats. Grey dunes are the next stage of development after fore-dunes. Grey dunes are covered with stable and permanent plant cover. The grey dunes are the most sensitive among the coastal ecosystems because of dryness and vegetation.

Various mite taxa are present in coastal habitats. Together with springtails (Collembola), Acari are the main litter decomposers and many species participate to the organic matter turnover in the ecosystems (ANDRÉ *et al.* 1994; KOEHLER *et al.* 1995; KRANTZ, 1978; PURVIS, 1982).

Soil inhabiting Acariformes mites are particularly investigated (EVANS *et al.* 1961). These mites are common in variety of habitats and many species are cosmopolite in distribution. They have been stated in the diverse soil (from forests, grasslands and agricultural habitats), and in the decaying organic matter, mosses, lichens, fungi, higher plants etc. (COLEMAN & CROSSLEY, 1996; EGLITIS, 1954; EVANS *et al.* 1961). Acariformes include saprophagous, mycetophagous mites and predators. Feeding habitats for many species are still unknown (WALTER & PROCTOR, 2000).

Oribatida mites are probably the best-known group of Acariformes (KRIVOLUTSKY, 1995). They are primarily fungal feeders or panphytophagous mites, but also feed on algae, yeasts, flowering plants, dead wood etc. (KRIVOLUTSKY, 1976, 1995; COLEMAN & CROSSLEY, 1996; 1975; LUXTON, 1972; WALTER & PROCTOR, 2000). Fauna of Oribatida mites is rich

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in the natural habitats in comparison to the human affected ones. These mites are a very important group in the decomposition processes of dead organic matter.

Soil and plant inhabiting Mesostigmatid mites are relatively well-investigated, however ecology and biology of many species are still unknown (Coleman & Crossley, 1996; Koehler, 1999; Walter & Proctor, 2000). Mesostigmata are mainly predators, with the exception of Ameroseiidae, some Aceosejidae and Rhodacaridae species (Coleman & Crossley, 1996; Eglitis, 1954; Evans *et al.* 1961; Koehler, 1999). Cosmopolite, they are able to live in the various habitats.

Data on mite fauna in the dunes in Europe are limited to few works (e.g. Eitminaviciute, 2003; Kohler *et al.* 1992, 1995). Halbert (1920), Pugh & King (1988) and Purvis (1982) studied diverse mite faunas from the intertidal zone and coastal dunes. Several authors (Eitminavicute, 1976; Salmane, 1996, 2000, 2001b; Salmane & Heldt, 2001) investigated mites of the coastal habitats of Latvia. However, knowledge on mite fauna of coastal habitats, particularly on grey dunes, is incomplete. Partly this is due to the restricted distribution and limited area of grey dunes along the Latvian seacoast (Kabucis, 2000). Eitminaviciute (2003) mentioned 31 mite species (Oribatida and Mesostigmata) from the grey dunes of the Baltic Sea coast in Lithuania. About 150 Mesostigmata species were recorded from the various coastal habitats (except grey dunes) in Latvia until now (Salmane, 1996, 2000, 2001b; Salmane & Heldt, 2001).

The aim of the study is to investigate fauna and spatial distribution of mites in dune habitats, with particular reference to Mesostigmata.

Methods

Investigation site was situated at the Baltic Sea east coast near Akmensrags in the Ziemupe Nature Reserve (56°49′21′′N/21°03′13′′E).

The sampling site was selected in the dune area with slightly elevated white dune (about 2m), nearly flat grey dune, without trees and bushes. Three 60m long transects (parallel to each other and perpendicular to the seacoast) were selected. Transects were oriented in the West-East direction with 8m interval between them. The whole dunes cover narrow zone, up to 100m. The white dune and transition zone between white and grey dune covers about 20m wide zone of transects. These two habitats had moving sand. The width of typical grey dune was about 30m and about 10m zone was covered with grey dune, influenced by dune meadow bordering Scots Pine forest (*P. sylvestris)*. At the beginning of transects, humus layer absent and pure sand presented. In the middle of transects and towards inland, the soil was sandy with thin organic layer (ca. 1-4cm). Anthropogenic influence on dunes was weak.

Upper 10cm of the soil was collected by use of soil core (area 0.01m^2). Thirty soil samples with 2m interval along each transect were collected. In total, 90 soil samples were collected. An extraction of arthropods from soil samples was performed on the Berlese-Tullgren type funnels for 10-day period. Afterwards mites were sorted by taxa, and permanent slides were made only for Mesostigmata. Data of the corresponding samples of three transects at the same distances from white dune were pooled to give one replicate for every distance. So, 30 replicates were obtained and used in further calculations.

The plant species and vegetation cover were described in one square meter around sampling sites in accordance with Braun-Blanquet method. Abiotic factors were not considered in this study.

Collected mites were divided in three groups: Oribatida (Acariformes), other Acariformes and Mesostigmata (Parasitiformes). Only Mesostigmata were determined to species using identification keys of Arutunjan (1977), Begljarov (1981), Bregetova (1977), Hutu & Calugar (2002), Karg (1989, 1993), Kuznetzov & Petrov (1984). All mite specimens are deposited at the Institute of Biology, University of Latvia.

Species dominance was evaluated in accordance with Engelmann (1978) classification. Pearson correlation quotients were calculated between mite and vegetation data using MS Excel. The density of Mesostigmata was estimated by the number of mites in the particular dune habitat divided by the number of samples in this habitat.

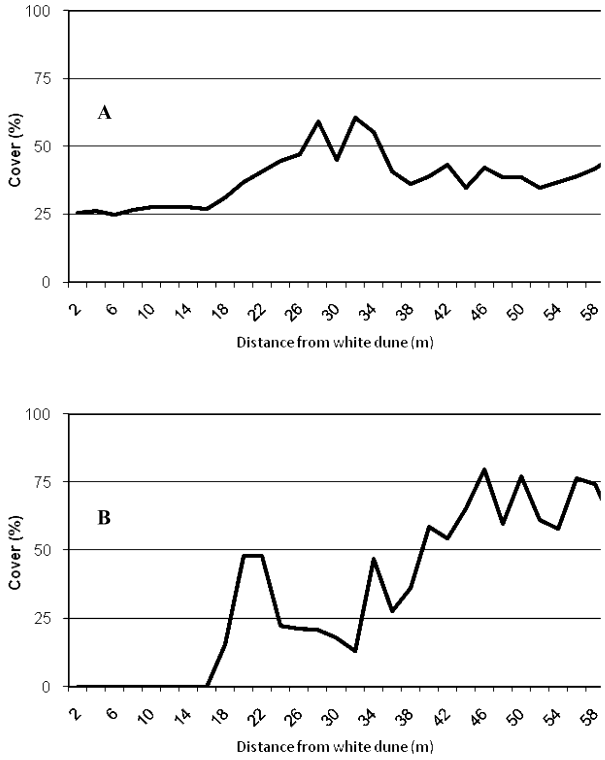

FIG. 1. — Mean cover (%) of plants (pooled data from three transects) at different distances from the white dune near Akmensrags in 2006. A. — Cover of flowering plants; B. — Cover of mosses and lichens (B. LAIME and L. LIEPINA, unpublished data).

RESULTS

Vegetation characteristics

Flowering plants grow over all dunes with the highest cover in the middle of transects, respectively in the typical grey dune (FIG. 1A). Mosses and lichens were absent in the white dune and in the transition zone from white dune to the grey dune, and then gradually increased inland (FIG. 1B).

Distribution of mites in dunes

Oribatid mites showed maxima of population density in the white dune and grey dune and minimum observed in the transition zone from white to grey dune (FIG. 2A). The other Acariformes were more abundant in the grey dune (FIG. 2B). Mesostigmata mites had higher population density and higher number of species at the end of transects (FIGS. 2C, D). The total number of collected individuals per taxa was nearly equal.

The number of Oribatid mites significantly positively correlated with the mean moss-lichen cover ($R=0.395$, $p<0.05$, $N=30$) and had no significant correlation with the mean flowering plant cover. The number of the rest of Acariformes had significant correlation both with mean flowering plant cover ($r=0{,}489$, $p<0.01$, $N=30$) and mean moss-lichen cover ($r=0{,}541$, $p<0.01$, $N=30$). The number of Mesostigmata significantly positively correlated with the mean flowering plant cover ($r=0.377$, $p<0.05$, $N=30$) and with the mean moss-lichen cover ($r=0.558$, $p<0.01$, $N=30$).

Fauna and domination of Mesostigmata species

In total 33 Mesostigmata species were identified (TABLE 1). Sixteen of them belonged to the family Phytoseiidae — plant inhabiting predatory mites. *Asca bicornis* (Aceosejidae) formed 32.8% (dominant), *Zercon carpathicus* (Zerconidae) 26.5% (dominant) and *Amblyseius meridionalis* (Phytoseiidae) 10.8% (subdominant) of the total number of Mesostigmata. The rest of species were recedent or subrecedent. *Asca bicornis* and *Amblyseius meridionalis* dominated both in grey dunes and at the end of transects, *Asca bicornis*, *Zercon carpathicus* at the end of transects (TABLE 1). Major part of the species were small body sized, while few specimens of large body sized species, surface dwelling mites like *Veigaia nemorensis* or *Hypoaspis aculeifer* were found.

DISCUSSION

Distribution of mites in dunes

Oribatid mites were collected in 96% of the samples. These mites are known to be common inhabitants of forest litter, moss, soil organic layer and lichens, in wet and rich in organics habitats (VIKSNE, 1959; GILJAROV, 1975; COLEMAN, CROSSLEY, 1996; EGLITIS, 1954; EVANS *et al.* 1961). Relatively low density of Oribatida was recorded in the grassland habitats. Only several taxa of oribatids are well adapted to the dry and poor environmental conditions (Prof. R.A. NORTON, pers. comm.).

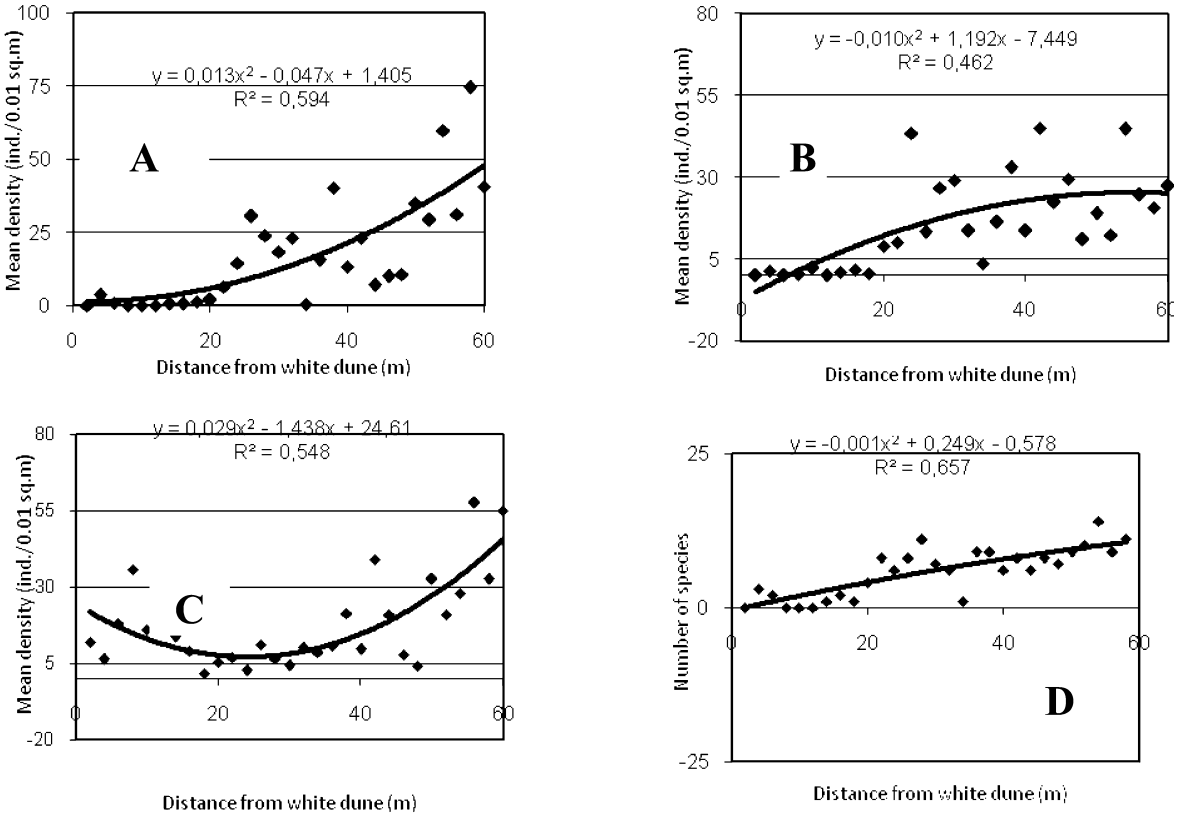

FIG. 2. — Changes in mean population density (ind./0.01m^2) of mites belonging to different taxa and changes in number of Mesostigmata species at different distances from the white dune near Akmensrags in 22.10.2005. A. — Oribatida; B. — Other Acariformes; C. — Mesostigmata; D. — Number of Mesostigmata species; polynomial trend—line added to the charts.

Occurrence of oribatids in diverse dune habitats in Europe was documented in several publications (Mallow, 1984; Søchting, Gjelstrup, 1985). Data on Oribatida distribution in the grey dunes of Baltic region is limited. EITMINAVICIUTE (2003) registered 114 species from various dune habitats in Lithuania, nine of them were found in the grey dunes.

In our investigation, Oribatida significantly positively correlated with the mean moss cover, but not with flowering plants. Moss cover better accumulate moisture and there is a higher amount of organic matter than the flowering plant roots have in sandy soil (Prof. R.A. NORTON, pers. comm.). Obviously, such conditions are favourable for saprophagous Oribatida mites.

The rest of Acariformes presented in 75% of samples. Single specimens of them were registered at the beginning of transects (FIG. 1C). The population density of Acariformes increased gradually to the middle of transects, where reached its maximum. Many free-living Acariformes mites are known to prefer moist and rich in organic matter habitats (WALTER & PROCTOR, 2000). Very few mites were found in the sandy soil of white dunes. It should be considered that upper 10 cm of soil were taken in our samples, but numerous individuals could live in deeper soil horizons. ANDRÉ *et al.* (1994) found high density of Acariformes mites in the grey dunes. The authors stated that density of Acariformes can reach 175000-1378161 ind./m^2. Mainly this was due to the deep soil sampling (up to 70 cm) and the use of flotation method for extraction of mites. KOEHLER *et al.* (1996) also found a high density (about 54 000 ind./m^2) of Acariformes mites in the undisturbed grey dunes of Denmark. Most probably, BERLESE-TULLGREN funnel method is less efficient for

Family	Species	Mean density (ind./0.01m^2)			Total
		WG	GT	GM	
Veigaiaidae	*Veigaia nemorensis* (C.L.Koch, 1839)	0.10	0.07	2.20	13
Aceosejidae	*Leioseius bicolor* (Berlese, 1918)	—	3.20	6.00	78
	L. insignis Hirschmann, 1963	0.10	0.60	0.40	12
	L. semiscissus (Berlese, 1892)	—	0.07	—	1
Phytoseiidae	*Amblyseius andersoni* (Chant, 1957)	—	0.07	—	1
	A. begljarovi Abbasova, 1970	—	0.20	—	3
	A. bicaudus Wainstein, 1962	—	0.27	—	4
	A. cucumeris (Oudemans, 1930)	0.20	2.33	0.20	38
	A. graminis Chant, 1956	0.20	1.40	5.80	52
	A. herbarius (Wainstein, 1960)	—	0.07	0.20	2
	A. levis Wainstein, 1960	—	0.07	—	1
	A. marginatus (Wainstein, 1961)	—	0.53	—	8
	A. meridionalis (Berlese, 1914)	—	7.20	11.40	165
	A. messor Wainstein, 1960	—	0.87	1.20	19
	A. nemorivagus Athias—Henriot, 1961	—	0.40	—	6
	A. obtusus (C.L.Koch, 1839)	—	0.27	2.00	14
	A. rademacheri Dosse, 1958	—	0.20	—	3
	A. reductus Wainstein, 1962	—	0.07	5.00	26
	A. umbraticus (Chant, 1956)	—	0.07	—	1
	A. zwoelferi (Dosse, 1957)	1.00	—	—	10
Antennoseiidae	*Antennoseius bacatosimilis* Karg, 1965	—	—	0.20	1
Rhodacaridae	*Asca bicornis* (Canestrini et Fanzago, 1877)	0.80	18.13	43.80	499
	Dendrolaelaps foveolatus (Leitner, 1949)	0.10	0.27	0.20	6
	Rhodacarellus silesiacus Willmann, 1935	—	—	0.20	1
	Rh. mandibularis Berlese, 1921	—	1.53	3.40	40
Laelaptidae	*Hypoaspis aculeifer* (Canestrini, 1883)	—	0.80	0.80	16
	H. lusisi Lapina, 1976	0.10	0.13	—	3
	H. praesternalis Willmann, 1949	—	1.33	5.20	46
	H. rigensis Lapina, 1976	0.20	0.40	0.20	9
	H. vacua (Michael, 1891)	—	0.13	0.20	3
	Laelaspis austriacus (Sellnick, 1935)	—	0.20	6.60	36
Zerconidae	*Zercon carpathicus* Sellnick, 1958	—	12.60	42.80	403
Protodinychidae	*Protodinychus punctatus* Evans, 1957	—	—	0.40	2
	Total mean density	0,14	1,78	13,84	1522

Table 1. — Mesostigmata distribution in dune habitats: species, mean population density (ind./0.01m^2) and total number of collected individuals at Akmensrags in 22.10.2005. Explanations: WG – white dune and transition zone to grey dune; GT – typical grey dune; GM – grey dune with influence of dune meadow and pine forest.

extraction of mites from the sandy dune soils in comparison with the other methods. That is true especially for small and tiny arthropods, like many Acariformes mites are.

Significant correlation between Acariformes and plant cover was stated. The cover of flowering plants and mosses had importance for these species for feeding and sheltering.

Detailed analyses of Acariformes mites cannot be done without identification of species, because taxon includes diverse morphological, ecological and trophic groups.

Data on occurrence of Acariformes mites in the coastal habitats, especially in the grey dunes in the Baltic countries are limited. Lazauskene (after Eitminaviciute, 1976) found some Tarsonemini species in various coastal habitats of the Baltic Sea coast in Lithuania. Eitminaviciute (2003) mentioned 18 Acariformes species from the dunes of Lithuania, but none was recorded in the grey dunes.

Mesostigmatid mites (Gamasina and Uropodina) were collected in 67% of samples. They were nearly absent in the first 20m of the transects (white dune and transition zone to the grey dune) (Fig. 2C). The Mesostigmata abundance was found low in white dunes (Salmane, 1996; Salmane & Heldt, 2001). The density increased gradually inlands following the increase of vegetation cover and reached maximum at the end of transects (Figs. 2C). Mesostigmata are adapted to the wide range of soil habitats, but they reach the highest population density in the moist organic soils (Wallwork, 1982).

The distribution of the species along transects was different (Table 1):

– Seven of them were recorded all along the whole transects: *L. insignis, A. graminis, A. cucumeris, D. foveolatus, H. rigensis, V. nemorensis, A. bicornis*.

– *Amblyseius zwoelferi* was found only in the first 20 meters at the beginning of transects in white dunes. Vegetation was scarce there, and mainly represented by *Hieracium umbellatum, Leymus arenarius* and *Festuca sabulosa*.

– In turn, *A. meridionalis*, *A. messor* and *Hypoaspis rigensis* were more numerous in the typical grey dune at the middle of the transects, where the plant cover was the highest.

– The major part of Phytoseiid mites were typically found in samples with the denser vegetation cover.

– *Laelaspis austriacus* was found only at the end of transects. This species is known to inhabit decomposing organic materials, forest litter, inland meadows (Bregetova, 1977; Karg, 1993; Salmane, 2001a). Hence it was found in samples closer to the dune meadow.

The other species were found in more or less equal densities at the middle and end of transects (e.g. *Asca bicornis*) or had the highest density at the end of the transects (e.g. *Hypoaspis aculeifer, Zercon carpathicus*). Mites of the families Phytoseiidae and Zerconidae are known to be abundant in the grasslands (Clapperton *et al.* 2002). *Asca bicornis* also is common inhabitant of grasslands (Bregetova, 1977).

The main response of microarthropods in the coastal dunes is to the sea/land gradient (McLachlan, 1991), and it was confirmed in our investigation. Only 28 specimens of 9 species were found in the transition zone from white to grey dune. The number of species and individuals increased and reached the maxima closer to the end of transects (Figs. 2C, D).

Fauna and domination of Mesostigmata species

Obviously, the vegetation reflects gradual change of habitats from white dune to grey dune and inland habitats. In turn, species richness responds to the changes in the vegetation and habitat complexity primarily along the gradient perpendicular to the seacoast (McLachlan, 1991).

Typical fauna of the dune habitats was observed in our investigation. Though some influence of species from dune meadow and coastal pine forest was presented. *Leioseius* spp. and Rhodacaridae were typical for the grey dune soils. Kohler *et al.* (1992) made similar observations in the grey dunes in Denmark. Most phytoseiid species belonged to the plant inhabiting predatory mites. Eight species stated by us (*Amblyseius graminis, A. meridionalis, A. nemorivagus, A. obtusus, A. messor, A. bicaudus, A. cucumeris, A. zwoelferi*) are distributed also in soil, humus, litter and mosses (Kolodochka, 2006; Kuznetzov & Petrov, 1984). *A. meridionalis* was the dominant species of Phytoseiidae. The distribution of these mites was closely associated with the cover of flowering plants ($r=0.427$, $p<0.01$, $N=30$), but no association with moss-lichen cover was stated. Previously 39 Phytoseiidae species were recorded from the various habitats in Latvia (Kuznetzov & Petrov, 1984; Salmane & Petrova, 2002). Nineteen of them were recorded from the various seacoast habitats (except grey dunes).

No species of the family Parasitidae, usually widely distributed in various habitats in Latvia (Lapina, 1988; Salmane, 2001a), and also found in the grey dunes of Denmark and Germany (Kohler *et al.* 1992, 1995), was recorded in the grey dune at Akmensrags. The vegetation of grey dunes and dry meadows has some similarity, and typical meadow species like *Asca bicornis* was found in grey dunes at Akmensrags. This species was more abundant in grey dune and grey dune influenced by dune meadow, nevertheless no significant correlation with the cover of flowering plants or mosses was stated. The other numerous species *Zercon carpathicus* is typical for litter, humus and mosses (Bregetova, 1977). The species was found in the samples with higher moss-lichen cover ($r=0.339$, $p<0.05$, $N=30$), but was indifferent to the cover of flowering plants.

Two new species to the fauna of Latvia were recorded. *Amblyseius nemorivagus* is widely distributed species living on herbaceous plants, trees, shrubs, in soil and rodent nests in Europe and Africa (Begljarov, 1981; Kolodochka, 2006). *Protodinychus punctatus* is relatively rare species collected from the washed ashore material of seacoast, riverside habitats and from the organic materials in North and Middle Europe (Bregetova, 1977; Karg, 1989).

Eitminaviciute (2003) has found 66 species of Mesostigmata from the diverse coastal habitats of Lithuania. Of them, 22 species were recorded in the grey dunes. In our study, only four of these 66 species were found: *Rhodacarellus silesiacus*, *Dendrolaelaps foveolatus*, *Asca bicornis* and *Hypoaspis praesternalis*. Twenty-two Mesostigmata species were found in the grey dunes of Denmark and Germany (Kohler *et al.* 1995). Eight of them were found in grey dune at Akmensrags: *Leioseius bicolor*, *Asca bicornis*, *Hypoaspis vacua*, *Hypoaspis aculeifer*, *Amblyseius obtusus*, *A. umbraticus*, *Rhodacarellus silesiacus* and *Veigaia nemorensis*. Such low similarity could be explained by differences in grey dune ecological characteristics in Latvia and West Europe, and by the short study period in Latvia.

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REFERENCES

André (H. M.), Noti (M. I.), Lebrun (F.), 1994. — The soil fauna: the other last biological frontier. – Biodiversity and Conservation, 3: 45-56.

Arutunjan (E. S.), 1977. — [Identification keys for Phytoseiidae mites of agricultural plants in Armenian SSR]. — Erevan, Pub. House Acad. Sc. Armenian SSR, 47 pp.

Begljarov (G. A.), 1981. — [Identification keys for predatory Phytoseiidae mites (Parasitiformes, Phytoseiidae) of the fauna of USSR]. — Leningrad, Nauka, 97 pp.

Bregetova (N. G.), 1977. — [Identification key for soil inhabiting mites. Mesostigmata]. — Leningrad, Nauka, 717 pp.

Clapperton (M. J.), Kanashiro (D. A.), Behan-Pelletier (V. M.), 2002. — Changes in abundance and diversity of microarthropods associated with Fescue Prairie grazing regimes. – Pedobiologia, 46: 196-511.

Coleman (D. C.), Crossley (Jr. D. A.), 1996. — Fundamentals of soil ecology. — San Diego, New York, Boston, London, Sydney, Tokyo, Toronto, Academic Press, 205 pp.

Eglitis (V.), 1954. — [Soil fauna of the Latvian SSR]. — Riga, Publ. House Acad. Sc. Latv. SSR, 263 pp.

Eitminaviciute (I.), 1976. — [Soil invertebrate fauna of the coastal area in the Eastern Baltic region]. — Vilnius, Mokslas, 172 pp.

Eitminaviciute (I.), 2003. — [Soil mites of Lithuania. Catalogue]. — Vilnius, VU Ekologijos instituto leidykla, 167 pp.

Engelmann (H. D.), 1978. — Zur Dominanzklassifizierung von Bodenarthropoden. — Pedobiologia, 18: 378-380.

Evans (G. O.), Sheals (J. G.), Macfarlane (D.) 1961. — The Terrestrial Acari of the British Isles. An Introduction to their Morphology, Biology and Classification. 1. Introduction and Biology. — London, Trustees of the British Museum, 219 pp.

Halbert (J. N.), 1920. — The Acarina of the seashore. — Proc. Roy. Irish Ac., 35: 106-155.

Hutu (M.), Calugar (A.), 2002. — Zwei neue *Protodinychus*-Arten (Anactinotrichida: Uropodina: Protodinychidae). — Abh. Ber. Naturkundemus. Görlitz, 74(2): 219-236.

Kabucis (I.), 2000. — [Habitat handbook. European Union protected habitats in Latvia]. — Riga, Latvijas Dabas fonds, 160 pp.

Karg (W.), 1989. — Acari (Acarina), Milben Unterordnung Parasitiformes (Anactinochaeta) Uropodina Kramer, Schildkrötenmilben. — VEB Gustav Fischer Verlag, Leipzig, Jena, 67, 203.

Karg (W.), 1993. — Acari (Acarina), Milben Parasitiformes (Anactinochaeta) Cohors Gamasina Leach. Raubmilben. — Jena, Stuttgart, New York, Gustav Fischer Verlage, 524.

Koehler (H. H.), 1999. — Predatory mites (Gamasina, Mesostigmata). — Agriculture, Ecosystems and Environment, 74: 395-410.

Koehler (H. H.), Harder (H.), Meyerdirkd (J.), Voigt (A.), 1995. — The Effect of Trampling on the Microarthropod Fauna of Dune Sediments. A Case Study from Jutland, Denmark. – Pp. 221-231, In P. S. Jones, M. G. Healy, & A. T. Williams (eds.), Studies in European Coastal Management: 221-231. Cardigan, Samara Publishing Limited.

Koehler (H. H.), Hofmann (S.), Munderloh (E.), 1992. — The soil mesofauna of white-, grey- and brown-dune sites in Jutland (Denmark) with special reference to the Gamasina (Acari, Parasitiformes). – Pp. 273-281, In R. W. G. Carter, T. G. F. Curtis, & M. J. Sheehy-Skeffington (eds.), Coastal Dunes: 273-281. Rotterdam, Balkema.

Kohler (H. H.), Munderloh (E.), Hofmann (S.), 1995. — The terrestrial mites of sand dunes from two sites of the North-Sea coast, with special reference to the Gamasina. – Pp. 217-229, In D. Kropczynska, J. Boczek, & A. Tomczyk (eds.), The Acari. Physiological and Ecological Aspects of Acari-Host Relationships: 217-229. Warszawa, Oficyna Dabor.

Kolodochka (L. A.), 2006. — A Phytoseiid Mites of Palaearctic region (Parasitiformes, Phytoseiidae): faunistics, ecomophology, evolution. — Vestnik zoologii, 21: 250 pp.

Krantz (G. W.), 1978. — Manual of Acarology. — Oregon, Corvallis, 508 pp.

Kuznetzov (N. N.), Petrov (V. M.), 1984. — [Predatory mites of the Baltic Region (Parasitiformes: Phytoseiidae, Acariformes: Prostigmata)]. — Rīga, Zinātne, 144 pp.

Lapiņa (I. M.), 1988. — [Gamasina mites of Latvia]. — Rīga, Zinātne, 200 pp.

McLachlan (A.), 1991. — Ecology of coastal dune fauna. — J. Arid Environ., 21: 229-243.

Pugh (P. J. A.), King (P. E.), 1988. — Acari of the British supralitoral. — J. Nat. History, 22: 107-122.

Purvis (G.), 1982. — The soil arthropod fauna (Acari and Collembola) of a coastal locality in Southeast Ireland. — J. Life Sc. Roy. Dublin Soc., 3: 379-396.

Salmane (I.), 1996. — Gamasin mites (Acari, Gamasina) of the Kurzeme coast of the Baltic Sea. — Latv. Entomol., 35: 28-34.

Salmane (I.), 2000. — Fauna of soil dwelling predatory Gamasina mites (Acari, Mesostigmata) in seashore habitats of Kurzeme coast in Latvia. – Ekológia (Bratislava), 19(4): 87-96.

Salmane (I.), 2001a. — A check-list of Latvian Gamasina mites (Acari, Mesostigmata) with short notes to their ecology. – Latv. Entomol., 38: 27-39.

Salmane (I.), 2001b. — Fauna of soil Gamasina mites (Acari, Mesostigmata) along the Latvian seacoast and their relation to the respective habitats. – Norw. J. Entomol., 48(1): 223-230.

Salmane (I.), Heldt (S.), 2001. — Soil predatory mites (Acari, Mesostigmata, Gamasina) of the Western Baltic Coast of Latvia. – Acarologia, 41(3): 295-301.

Salmane (I.), Petrova (V.), 2002. — Overview on Phytoseiidae mites (Acari, Mesostigmata, Gamasina) of Latvia. – Latv. Entomol., 39: 48-54.

Walter (D.E.) & Proctor (H.C.) 1999. — Mites. Ecology, Evolution and Behaviour. — University of New South Wales Press, Sydney. 322 pp.

Wallwork (J. A.), 1982. — Desert soil fauna. — New York, Praegar, 296 pp.