Fauna and Ecology of Grasshoppers (Orthoptera) in the Coastal Dune Habitats in Ziemupe Nature Reserve, Latvia

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SPUŅĢIS V. 2007. FAUNA AND ECOLOGY OF GRASSHOPPERS (ORTHOPTERA) IN THE COASTAL DUNE HABITATS IN ZIEMUPE NATURE RESERVE, LATVIA. – *Latvijas entomologs*, 44: 58-68.

Abstract: Grasshoppers (Orthoptera) were studied in dunes of the Baltic Sea at the Latvian western coast in 2001 and 2003-2006. Direct collection and pitfall trapping of individuals were used. In total 12 species of grasshoppers were identified, seven of them can be regarded as characteristic for dunes. Number of species and population density increased significantly along white dune – grey dune – dry grassland habitat gradient. Dominating species *Myrmeleotettix maculatus* had maximum of population density in the typical grey dune habitat. Significant correlation among population density of grasshoppers and plant species diversity and vegetation cover was stated. These correlations can be explained both by feeding and sheltering requirements of the grasshoppers.

Key words: Orthoptera, fauna, ecology, dune habitats, Latvia.

Introduction

Grasshoppers in the coastal dunes have been investigated in Europe rather extensively (Decleer, Devriese 1992, Bonte, De Knijf 1998, Folger, Handelmann 1999). Particular attention was paid to habitat preference, to distribution of species and to the influence of anthropogenic pressure on species diversity.

Grasshoppers in Latvia have been studied in different habitats, including dunes (Princis 1932, 1939, 1943, Spungis 2003). Regardless these studies knowledge on fauna and ecology of Orthoptera in the dune habitats are scarce. Princis (1943) reported numerous species from 25 localities at the seacoast, but did not specify which species live in what dune habitat. Dunes are also reported as characteristic habitat for several endangered in Latvia species, namely, *Oedipoda coerulescens*, *Sphingonotus caerulans*, *Psophus stridulus* (Spuris 1998). *Podisma pedestris* is a single protected grasshopper species in Latvia now (The Regulations … 2000). This species is very rare and is also known to live in the dunes (personal observation in Ovīši particularly protected nature territory). Little is known about present distribution and ecology of these species.

The aim of the current study is to identify the fauna of grasshoppers in dune habitats, to study spatial distribution of species and limiting biotic factors in the model coastal territory.

Methods

Epigeic arthropods, including grasshoppers were investigated in the coastal dune habitats in Ziemupe Nature Reserve near Akmensrags in 2001 and 2003-2006. The dunes covered a narrow, up to 100 m wide zone. The white dune bordering the sea was narrow and low, gradually transforming to the grey dune. This habitat covered about 20 m wide zone. The width of typical grey dune was about 50 m. Inlands the grey dune is bordered by dry grassland near Scotch pine plantings.

For faunistic purpose the grasshoppers were collected by sweep net or by hands in 2001 and 2003-2004. Additional faunistic data were obtained also by use of pitfall traps in 2005-2006.

The pitfall traps (plastic glasses, opening diameter 7 cm, filled with 4% solution of formaldehyde with addition of ethylenglycole and few drops of detergent) were used to study epigeic arthropods. Preliminary study was performed in 2005. Pitfall traps were arranged on three transects parallel in-between (interval between them was 7-8 m) and perpendicular to the coast. Every of three 60 m a long transect started at white dune then crossed typical grey dune and ended at dry coastal meadow. The distance between traps was 2 m. The exposition period lasted two weeks – 10.08-24.08.2005. 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. Since pitfall trapping was efficient for Orthoptera the detailed study was continued in 2006. One transect was selected for studies during the whole non-freeze period of the year – from April to November. 40 pitfall traps were arranged on 80 m long transect. Transect started on white dune then crossed typical grey dune and ended at dry coastal meadow. The distance between traps was 2 m. The traps were emptied and refilled every two weeks from 02.04.2006 to 12.11.2006. Accumulated number of grasshoppers in every trap was used to characterise spatial distribution and to calculate correlations. Juveniles were counted and identified to families, adults counted and identified to species in accordance with Holst (1986). One transect in both study years largely coincided giving possibility to compare data.

Species dominance was evaluated in accordance with the classification of Engelmann (1978). Correlation among variables characterising grasshopper populations, plant species and cover was calculated using MS Excel. All data were log transformed.

Vegetation was described by B.Laime, L.Liepiņa and I.Cera, and these data are referred here partly. The plant species and vegetation cover were described in one square meter around every pitfall trap in accordance with Braun-Blanquet method. Vegetation height was measured by use of light foam plastic plate mounted on graduated handle. Three measures were done around every trap and mean height was calculated. Abiotic factors were not considered in this study.

A collection of grasshoppers is deposited in the Faculty of Biology, University of Latvia.

Results

Species composition

1. *Metrioptera brachyptera* (L., 1761)

Material: 24.07.2001, 1 ind., 30.08.2001, 2 ind.

2. *Metrioptera roeselii* (HAGENBACH, 1822)

Material: 30.08.2001, 1 ind.

3. *Decticus verrucivorus* (L., 1758)

Material: 24.07.2001, 1 ind., 10.08-24.08.2005, 3 ind., pitfall traps, 09.07-03.09.2006, 6 ind., pitfall traps.

4. *Tettigonia viridissima* (L., 1758)

Material: 30.08.2001, 1 ind., at the boarder of grey dune and dry meadow.

5. *Tetrix subulata* (L., 1758)

Material: 21.05-18.06.2003, 1 ind., 22.05-19.06.2004, 1 ind., pitfall traps, 01.05-14.05.2006, 5 ind., pitfall traps.

6. *Psophus stridulus* (L., 1758)

Material: 30.08.2001, 1 ind., at the boarder of grey dune and dry meadow. At the same time numerous individuals were observed in the habitats behind dunes – in dry meadows and Scotch pine forest clearings.

7. *Oedipoda coerulescens* (L., 1758)

Material: 24.07.2001, 8 ind., 10.08-24.08.2005, 1 ind., pitfall traps, 09.07-23.07.2006, 1 ind., pitfall traps.

8. *Omocestus haemorrhoidalis* (CHARPENTIER, 1825)

Material: 24.07.2001, 1 ind., 10.08-24.08.2005, 30 ind. pitfall traps, 17.09-15.10.2006, 3 ind., pitfall traps.

9. *Chorthippus albomarginatus* (DEGEER, 1773)

Material: 24.07.2001, 1 ind.

10. *Chorthippus brunneus* (THUNBERG, 1815)

Material: 24.07.2001, 10 ind., 10.08-24.08.2005, 12 ind., pitfall traps, 09.07-01.10.2006, 21 ind., pitfall traps.

11. *Chorthippus vagans* EVERSMANN, 1848

Material: 10.08-24.08.2005, 4 ind., pitfall traps, 23.07-29.10.2006, 16 ind., pitfall traps.

12. *Myrmeleotettix maculatus* (THUNBERG, 1815)

Material: 24.07.2001, 32 ind., 22.05-19.06.2004, 17 ind., 10.08-24.08.2005, 106 ind., pitfall traps, 11.06- 01.10.2006, 868 ind., pitfall traps.

Community structure

Seven grasshopper species were collected by use of pitfall traps in 2005 and 2006 (Table 1). *Myrmeleotettix maculatus* was the most common species – eudominant in both years.

Other species were dominant to subrecedent depending of sample size and observation period.

The population relative density of *Myrmeleotettix maculatus* was compared in similar periods and on the same stretch of transect in both years. Significant difference were observed (Figure 1), however, the population density was higher in the grey dune (middle of the transects) in both years. The data of 2005 are not analysed in detail because of shorter trapping period and smaller number of trapped individuals than in 2006.

Spatial distribution of grasshoppers

In 2006, the number of Orthoptera species increased significantly along white dune – grey dune – dry meadow habitat gradient (Figure 2A). A significantly higher population density of grasshoppers was observed in the middle of transect – in the typical grey dune habitat, the minimum – in the transition zones from white dune to grey dune and from grey dune to dry meadow (Figure 2B). Spatial distribution of grasshoppers was actually dominated by *Myrmeleotettix maculatus* (Figure 2C). The other grasshopper species had low population densities. They were captured mainly at the end of transects – in the area of grey dune and in the transition zone from grey dune to dry meadow.

Vegetation factors limiting spatial distribution of grasshoppers

The cover of flowering plants and number of species increased significantly from white dune to grey dune and dry meadow (Figure 2D, E). *Hieracium umbellatum*, *Festuca sabulosa*, *Thymus serphyllum*, *Galium mollugo*, *Carex arenaria*, *Sedum acre*, *Artemisia campestris*, *Leymus arenarius* and *Calamagrostis epigeios* dominated among flowering plant species.

The cover of mosses-lichens significantly increased in the same way (Figure 2F). The cover of lichens alone was very low (mean cover per sample was 2.7%). *Hypnum cupressiforme*, *Brachythecium albicans*, *Tortula ruralis* and *Ceratodon purpureus* dominated among moss species.

In 2006, total number of species and total number of individuals of the most abundant grasshopper taxa positively correlated with the number of plant species and the cover of the majority of flowering plant species, but negatively – with *Hieracium umbellatum* and *Leymus arenarius* during the whole period of trapping of grasshoppers (Table 2). Similar correlations were found also with cover of mosses-lichens. Grasshoppers were indifferent to cover of *Festuca sabulosa*.

Relative population density of *Myrmeleotettix maculatus* positively correlated with the height of vegetation ($r=0{,}573$, $\alpha<0.01$, $N=40$) in 2006. Average vegetation height on transect was 12.3 cm.

Eudominating *Myrmeleotettix maculatus* was selected for correlation analysis during the sampling periods with higher population density (Table 3). *M. maculatus* correlated positively with the cover of majority of plant species and number of species, butt negatively with *Festuca sabulosa* and *Leymus arenarius*. The significance of correlation changed during the trapping period for some parameters, e.g. significance of *Festuca sabulosa* and *Thymus serphyllum* was significant for the species at the beginning of a season, but later significance decreased.

Age and sex structure of *Myrmeleotettix maculatus* population

Juvenile locusts (Acrididae) cannot be identified to species and thus are treated here as a whole. Presumably, the majority of them belonged to eudominant *Myrmeleotettix maculatus*. The juveniles appeared at the beginning of May, until middle of July they have passed last instars and moulted to adults (Figure3A). The first adults appeared format the beginning of June and died until the middle of September. Very few individuals lived longer. Population density of juveniles was significantly lower than density of adults.

An analysis of sex structure showed predominance of males at the beginning of the season and slight predominance of females at the end of the season (Figure 3B).

Discussion
Species composition

In total, 12 grasshopper species were collected in the dune habitats at Ziemupe. This is less than 30% of the species known in Latvia. 42 species are known for the territory in accordance with recent evaluation (Matisons 2005). The study area was rather homogenous with no depressions, dune slacks, and young dunes or otherwise complicated meso-relief. That explains rather low species diversity. Similar habitats in the coastal dunes at Atlantic had 10-23 species (Decleer, Devriese 1992, Bonte, Knijf 1998, Folger, Handelmann 1999). Species composition was also different, thus representing different climatic and vegetation regions. So, our investigations indicate that species composition in the dunes, particularly grey dunes, of Latvia is more or less known completely.

An analysis of habitat preference was used to identify characteristic dune species. *Metrioptera brachyptera* requires warm and humid habitats (Holst 1986) and is not characteristic for dunes. *Metrioptera roeselii* lives in variety of habitats, including also dunes and prefers habitats with denser vegetation (Holst 1986). Our observations indicate that these species are not characteristic for dunes. *Tettigonia viridissima* lives in bushes and taller herbs (Holst 1986) and is not characteristic for dunes. *Decticus verrucivorus* needs dry or damp habitats with low vegetation (Holst 1986). The species is characteristic for dunes, but population density is low. *Tetrix subulata* prefers damp habitats (Holst 1986) and is not characteristic for dunes. Some observed specimens could be immigrants from moister places. *Psophus stridulus* is demanding high temperatures and lives in warm, sunny habitats – dry meadows, clearings in forests, heath land (Holst 1986). The species is characteristic for open dry habitats with sparse vegetation, including coastal dunes and is widely distributed along the Baltic Sea coast (Spuris 1998). Regardless the presence of these requirements in the dunes, the species cannot be considered characteristic for this habitat, probably, because of lack of some unknown specific requirements. *Oedipoda coerulescens* lives in dunes, heath land and sandy places (Spuris 1998), prefers habitats on sandy soils (Holst 1986) and coastal meadows with low vegetation (Spungis, 2003). The species is characteristic for dunes, but population density was low and populations can be restricted to very small area. One such area covered about 900 m^2 around a group of *Juniperus communis* (Spungis 2003). *Sphingonotus coerulans* lives in dunes and similar dry places with low vegetation (Holst 1986). The species is known to inhabit coastal areas – dunes, heath land, sandy places (Spuris, 1998), but it was found neither during this study nor during last decades. *Chorthippus albomarginatus* lives in dunes and permanent stands of grass, especially near coasts (Holst 1986). Bonte and De Knijf (1998) reported species from sandy dunes, dry and wet grasslands. The species is rare in dunes. *Omocestus haemorrhoidalis* prefers dry graminetae or moorlands. It is common on sandy and dry habitats, frequently found with *Myrmeleotettix maculatus* and *Chorthippus brunneus* (Holst 1986). Species is characteristic for dunes. *Chorthippus brunneus* lives in wide variety of habitats, including dunes except the driest or the wettest ones (Holst 1986) and is characteristic for dunes. *Chorthippus vagans* lives on sandy soil of the dunes and other similar habitats in association with *Myrmeleotettix maculatus* (Holst 1986) and is characteristic for dunes. *Myrmeleotettix maculatus* lives in sandy and dry habitats (Holst 1986) and is characteristic for dunes.

Only 7 of 12 species known from dunes in Latvia can be considered as characteristic for this habitat. Four species – *Myrmeleotettix maculatus*, *Omocestus haemorrhoidalis*, *Chorthippus brunneus*, and *Chorthippus vagans* can be considered as the most typical for dunes. These graminivorous (Joern 1979, Picaud et al. 2003) species need similar habitat requirements and frequently are found together (Holst 1986, Bonte, De Knijf 1998, Folger, Handelmann 1999). Largegrasshoppers as *Decticus verrucivorus* had a low population density, small ones, particularly *Myrmeleotettix maculatus*a high population density.

Community structure

The results may indicate that pitfall trapping is an efficient method and can give good data on population relative density of grasshoppers. However, only about half of the species known from the area were captured in traps and the selectivity of the method was not tested. At the same time population density of grasshoppers cannot be compared with the other investigations in dunes, because of uniqueness of used collecting method.

Myrmeleotettix maculatus was eudominant species with the maximum population density in the grey dunes. Our results agree in general with findings of Folger and Handelmann (1999). In 2005, the grasshopper community structure was different in comparison with 2006. The population density in the comparably short (2 weeks) period differed significantly, so reflecting the differences in the climatic conditions. Mean air temperature and sum of precipitations in 2005 was close to average, but in 2006 the temperature exceeded average by +1.4^{o}C and precipitations consisted 81% of average (the data of Latvian Environment, Geology and Meteorology agency). Thus, the climatic conditions were more favourable to grasshoppers in 2006 than in 2005.

Vegetation factors limiting spatial distribution of grasshoppers

The data of 2005 covered only short period of time, the three selected transects were shorter (n=30), but at the same time possessed the higher diversity of vegetation. The correlations (not shown in the results) with the plant species and vegetation data, however, were essentially the same as in 2006. In 2006 the transect was longer (N=40) and observations covered the whole vegetation season, and more data on the role of vegetation during the whole season were obtained. Plant species diversity on one transect was lower in 2006.

Insect species diversity in general increases with the increase of plant diversity and vegetation cover in dune habitats (Hodge 1999). This is supported by a positive significant correlation between number of plant and grasshopper species. This relationship may be explained not only by an increased variety of food, but also by diversity of suitable microhabitats. Vegetation serves both as a food source and also as a shelter for grasshoppers. The majority of grasshopper species are not specialised in food plants and constantly feed on variety of grasses (Poaceae) (Joern 1979, Picaud et al. 2003). They may differ however, in their preference for different grass species (Ingrisch, Köhler 1998). Characteristic and dominating grey dune grass species *Festuca sabulosa* did not contribute to Orthoptera species diversity and population density as no significant correlation was stated (Table 2). Even more, at the beginning of summer *Festuca sabulosa* had significant negative correlation with dominating *Myrmeleotettix maculatus*. Thus, plant food availability obviously was not the main limiting factor for this eudominating species.

The population relative density of grasshoppers was high in the dune areas covered by flowering plant and mosses-lichens cover. The average vegetation height in dunes was low. Grasshoppers avoided areas overgrown by *Hieracium umbellatum* and *Leymus arenarius*. The latter plant species are characteristic for white dune, transition zone to grey dune and areas with bare sand. These plants formed sparse cover and did not give enough shelter for grasshoppers. Grasshoppers selected also dune areas covered by non-edible plants as *Sedum acre* and *Thymus serphyllum*. They feed mostly upon graminetae (Holst 1986). The most obvious that sheltering requirements can explain these correlations, but not demands for food.

Mosses-lichens cover increased along white dune – grey dune – dry meadow gradient. Significant positive correlation among cover of some dominating moss species (*Hypnum cupressiforme* and *Brachythecium albicans*) and density of all grasshoppers or particular species (Table 3) cannot be explained by feeding requirements. Most obviously, mosses can be important for oviposition, movement or sheltering of grasshoppers. These statements were not clearly proved, as not all significant correlations always have causal relationships.

The highest number of species of grasshoppers at the end of transects showed influence of neighbouring habitat – dry coastal meadow. The latter enriches grey dunes with species, but these species were recedent and probably are temporary visitors in dunes. Folger and Handelmann (1999) and Hodge (2003) also pointed out the influence of neighbouring habitats.

At the beginning of transect with dominating white dune vegetation grasshoppers were extremely rare. White dune with sparse vegetation was unsuitable for grasshoppers. This contradicts to the statements of Folger and Handelmann (1999) who described rather high diversity of grasshoppers on white dune (foredune). The most obviously these are regional differences as dunes near the North Sea are wide, while at Latvian coast –narrow.

Importance of definite plant species for grasshoppers may have changed during the season. For instance, moss cover was important at the beginning of the period of appearance of adult *Myrmeleotettix maculatus*, and later the significance gradually decreased (Table 3). It is hardly explained by feeding or sheltering requirements. Presumably, this could be explained by changes in selection of microhabitats by newly hatched grasshoppers at the beginning of season, adult individuals – at middle, and ovipositing females - at the end of the season. Unfortunately data were too insufficient to prove definitely these assumptions.

Age and sex proportions of *Myrmeleotettix maculatus*

Normally juveniles must have higher population densities than adults, because of natural mortality. In our investigation this basic assumption was not observed (Figure 3A). Even more, juveniles had much lower population density than adults. This has to be explained by unknown behavioural specificities. The most obvious may be that wingless juveniles have less possibility for active movement in comparison with the winged adults, and that pitfall traps could not show the real population density during juvenile development period.

Males dominated over females at the beginning of the season of emerging of adults, and both sexes were more or less in equilibrium until the end of the season. These results indicated that males emerged earlier than females and males predominate during the vegetation season. This, probably, can be also explained by higher moving activity of males in comparison with females. Slight predominance of females was observed only at the end of the season.

Need for further research

Further investigations are needed to study influence of temperature at soil surface, extent of plant associations, meso- and micro-relief. Possible seasonal migrations of juveniles and adults, oviposition requirements and distribution of species along the Baltic Sea coast also need to be investigated.

Acknowledgements

I would like to thank everybody of the project team, particularly B. Laime and L. Liepina for providing floral and vegetation data, I. Cera for assistance in sampling and sample processing in 2006. This research was supported by project No 01.0488 “The elaboration of the biodiversity indication system for terrestrial ecosystems” and project No 04.1301 “An elaboration of the bioindication system for assessment of naturalness and anthropogenic influence to coastal biotopes” of the Latvian Council of Science.

Kopsavilkums
Taisnspārņu (Orthoptera) fauna un ekoloģija kāpu biotopos Ziemupes dabas liegumā

Taisnspārņi (Orthoptera) tika pētīti Ziemupes dabas liegumā Latvijas Baltijas jūras rietumu piekrastes kāpās 2001. un no 2003. līdz 2005. gadam. Pētījumā tika izmantoti entomoloģiskais tīkliņš, tiešie novērojumi un augsnes lamatas. Kopā konstatētas 12 taisnspārņu sugas, no kurām septiņas var uzskatīt par kāpām raksturīgām. Sugu skaits un populācijas blīvums būtiski pieauga gar biotopu gradientu: priekškāpa – pelēkā kāpa – sausa pļava. Dominējošajai sugai *Myrmeleotettix maculatus* visaugstākais populācijas blīvums bija tipiskajā pelēkajā kāpā. Konstatēta statistiski būtiska korelācija starp taisnspārņu populācijas blīvumu un augu sugu skaitu un

projektīvo segumu. Korelācija izskaidro taisnspārņu prasības pēc barības un slēptuves.

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Received: March 28, 2007.

Table 1. A number of collected individuals and dominance structure of grasshopper community in 2005 and 2006.

Species	**10.08-24.08.2005**		**02.04-12.11.2006**	
	Number of individuals	Dominance (%)	Number of individuals	Dominance (%)
Myrmeleotettix maculatus	106	67.95	868	94.35
Omocestus haemorrhoidalis	30	19.23	3	0.33
Chorthippus brunneus	12	7.69	21	2.28
Chorthippus vagans	4	2.56	16	1.74
Decticus verrucivorus	3	1.92	6	0.65
Oedipoda coerulescens	1	0.64	1	0.11
Tetrix subulata	0	0	5	0.54
In total	**156**	**100**	**920**	**100**

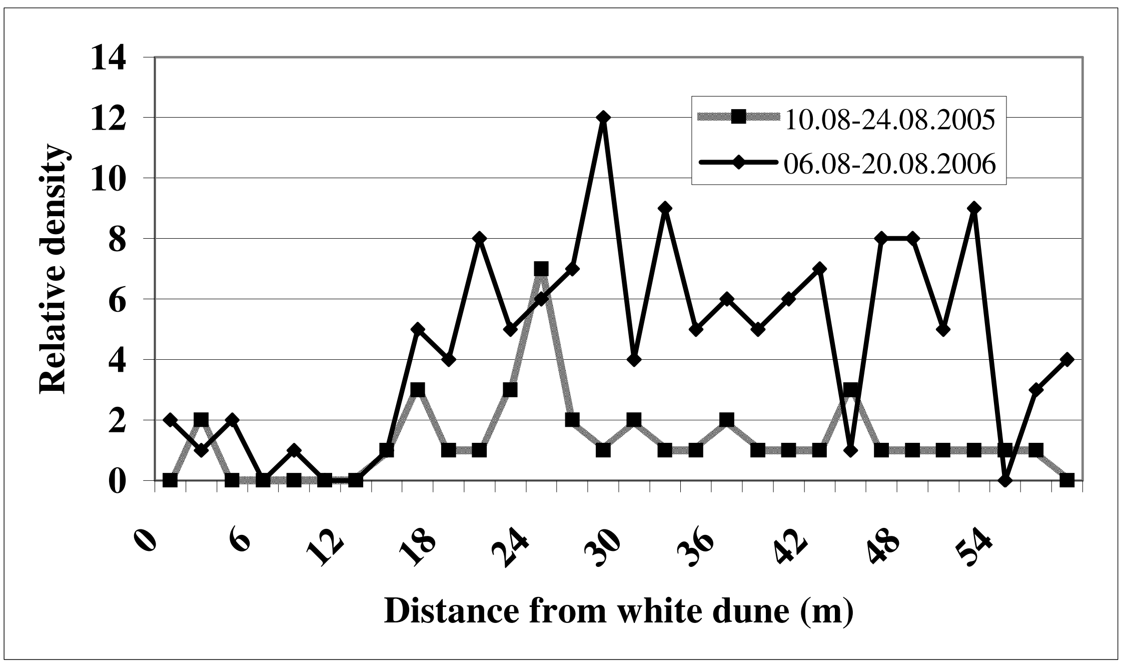

Figure 1. Changes in relative population density (ind./trap per 14 days) of *Myrmeleotettix maculatus* at different distances from white dune in similar sampling periods and the same stretch of transect in 2005 and in 2006.

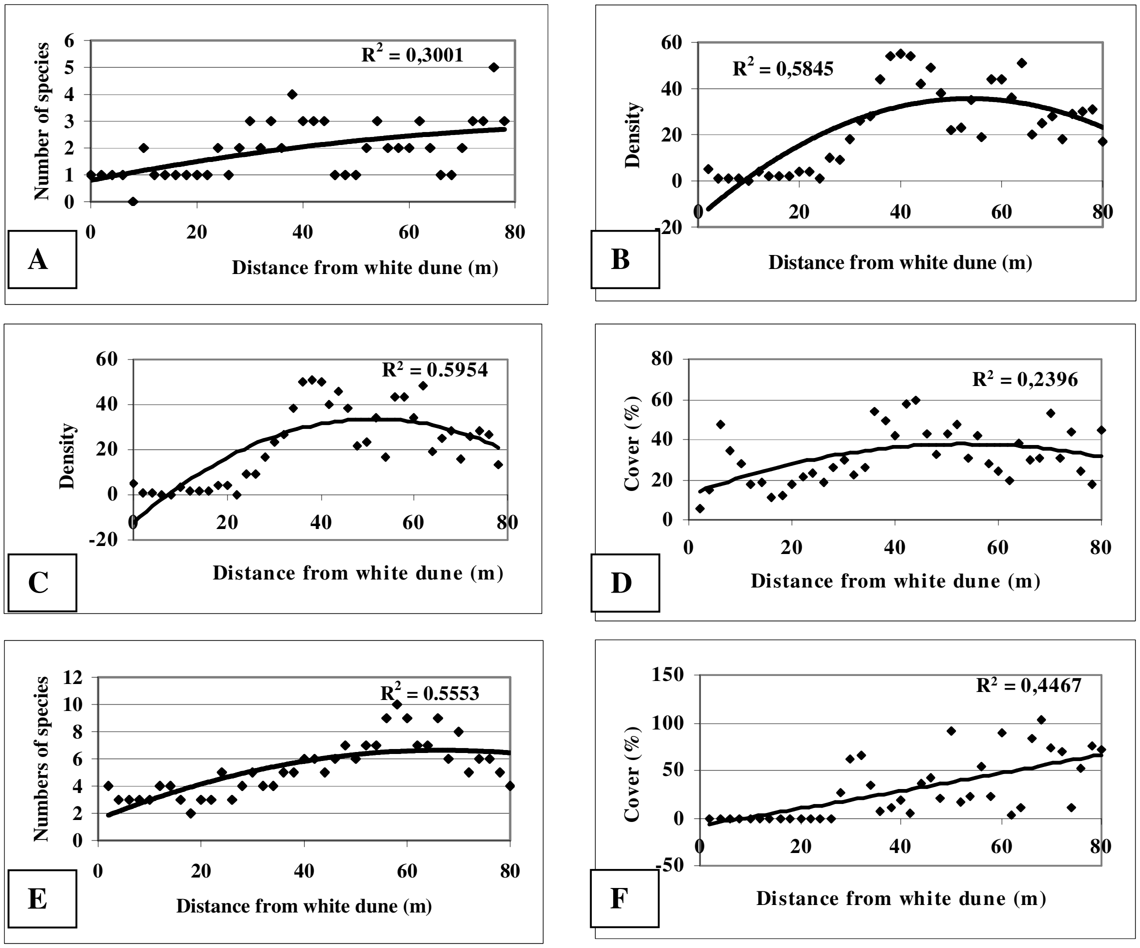

Figure 2. Changes in number of grasshopper species (A), relative population density (ind./40 traps per year) of all individuals (B) and *Myrmeleotettix maculatus* (C); changes in flowering plant cover (D) and number of species (E) and cover of mosses-lichens (F) along transect crossing dune habitats in 2006. Polynomial trend lines and R^2 are added to the charts.

Table 2. Correlation among number of species and individuals, and individuals of the most abundant Orthoptera taxa and cover of dominating plant species and number of plant species in the dune habitats in 2006. Remarks: * – significance at α<0.05, N=40; ** – significance at α<0.01, N=40.

Cover (%) / number of species	Number of Orthoptera species	Number of Orthoptera individuals	**Number of collected grasshopper individuals of different taxa**		
			Acrididae juv.	*Chorthippus* spp.	*Myrmeleotettix maculatus*
Flowering plants	0,291	0,506**	0,485**	0,362*	0,484**
Mosses-lichens	0,554**	0,860**	0,375*	0,432**	0,852**
Festuca sabulosa	0,024	0,085	0,243	0,253	0,056
Hieracium umbellatum	-0,237	-0,435**	0,212	-0,238	-0,434**
Carex arenaria	0,412**	0,572**	0,445**	0,391*	0,549**
Leymus arenarius	-0,288	-0,500**	-0,211	-0,241	-0,475**
Thymus serphyllum	0,294	0,509**	0,128	0,149	0,504**
Calamagrostis arenarius	0,037	0,437**	0,105	0,016	0,443**
Gallium mollugo	0,486**	0,694**	0,145	0,402*	0,684**
Sedum acre	0,239	0,553**	0,143	0,122	0,557**
Artemisia campestris	0,238	0,464**	0,209	0,262	0,465**
Number of plant species	0,433**	0,839**	0,226	0,321	0,838**

Table 3. Correlation among relative population density (ind./trap per 14 days) of *Myrmeleotettix maculatus* at the maximum population density periods and number of plant species and total cover, and cover of dominating plant species in dune habitats in 2006. Remarks: * – significance at α<0.05, N=40; ** – significance at α<0.01, N=40.

Plant / species cover (%)	**Relative population density in the sampling period**					
	11.06-25.06	25.06-09.07	09.07-23.07	23.07-06.08	06.08-20.08	20.08-03.09
Flowering plants	0.431**	0.402*	0.456**	0.397*	0.561**	0.492**
Number of plant species	0.792**	0.869**	0.743**	0.664**	0.612**	0.343*
Festuca sabulosa	-0.462**	-0.623**	-0.284	-0.249	-0.318*	-0.037
Hieracium umbellatum	-0.018	0.086	0.018	0.043	0.439**	0.261
Carex arenaria	0.414**	0.574**	0.445**	0.375*	0.234	0.387*
Leymus arenarius	-0.334*	-0.443**	-0.488**	-0.390*	-0.350*	-0.233
Thymus serphyllum	0.448**	0.478**	0.493**	0.394*	0.226	0.047
Calamagrostis arenarius	0.287	0.441**	0.492**	0.386*	0.402*	-0.048
Gallium mollugo	0.653**	0.779**	0.580**	0.408**	0.525**	0.290
Sedum acre	0.560**	0.585**	0.519**	0.433**	0.507**	0.236
Artemisia campestris	0.353*	0.442**	0.384*	0.413**	0.583**	0.419**
Mosses-lichens total	0.713**	0.866**	0.719**	0.687**	0.524**	0.356*
Hypnum cupressiforme	0.552**	0.596**	0.235	0.149	0.116	-0.05
Brachythecium albicans	0.160	0.435**	0.517**	0.487**	0.499**	0.460**
Tortula ruralis	0.086	0.022	0.234	0.337*	0.044	0.129
Ceratodon purpureus	0.239	0.280	0.405*	0.549**	0.337*	0.542**

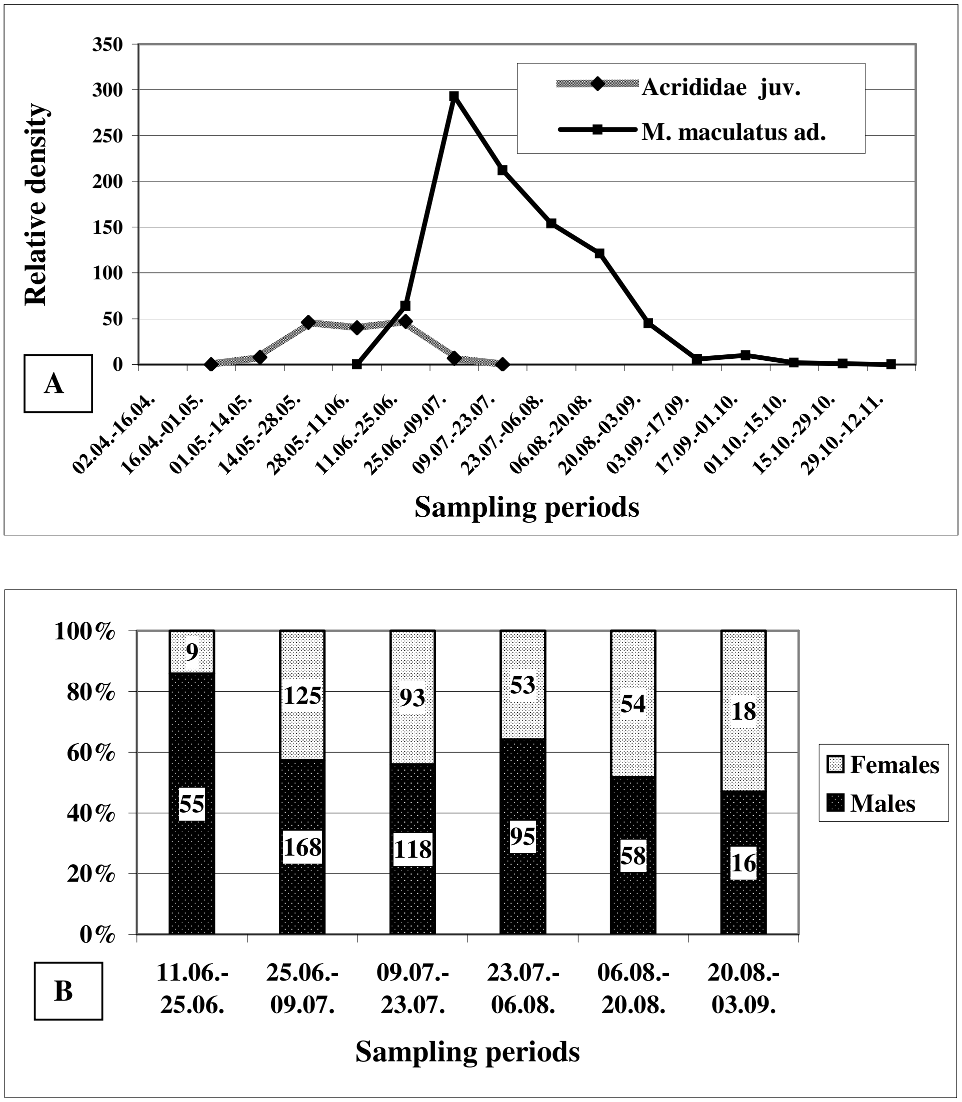

Figure 3. Seasonal dynamics of relative population density of juveniles (Acrididae) and adults of *Myrmeleotettix maculatus* (ind./trap per 14 days) (A) and sex structure (B) in 2006.