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Structure and seasonal dynamics of Orthoptera assemblages living in a fragmented habitat in North Hungary

G. SZÖVÉNYI*

Abstract. Seasonal dynamics and community structure of Orthoptera assemblages were studied in 2000 by a non-destructive sampling method in a chain of steppe meadow-covered nearby forest clearings. The similarity and temporal changes of the local assemblages were analysed by multivariate statistical methods. The phenological characters of species occurring in the assemblages and the significant phenological differences between sexes of two dominant species were also demonstrated.

The Orthoptera fauna of Hungary is fairly well known, especially that of national parks and other protected areas (e.g. Nagy & Nagy, 2000; Nagy & Rácz, 1996; Nagy, Rácz & Varga, 1999; Nagy & Szövényi, 1997, 2001; Szövényi & Nagy, 1999 a). The structure (e.g. Nagy, 1949/50; Nagy, Šušlik & Krištin 1998; Nagy & Szövényi, 1998; Szőnyi & Kincsek, 1986) and especially the seasonal dynamics of the orthopteran assemblages (e.g. Szövényi & Nagy, 1999 b) are, however, much less investigated.

The aim of this study was to describe and analyse the structure, seasonal dynamics and phenological characteristics of an orthopteran meta-assemblage existing as a group of local assemblages interconnected by migration of individuals (Szövényi, 2001).

MATERIAL AND METHODS

The field investigations were carried out in 2000, on a hilly woodland area of the Buda Hills Landscape Conservation Area near Budapest (northern Hungary, 47° 33' N, 18° 54' E, ca. 480 metres above sea-level). There was a group of six nearby clearings selected having steppe-meadow vegetation (see details on Fig. 1 and Table 1) surrounded by an oak forest matrix with other more remote clearings. For sampling the local Orthoptera assemblages, a non-destructive sampling procedure, the mark-recapture method was applied by group marking the adult orthopterans. The sampling efforts were similar in all clearings (collecting specimens by net sweeping during ca. 1/2 to 3 hours on a clearing depending on its area). In Hungary, the main time for most orthopterans is summer and the first half of autumn. The sampling regime covered this period. Following the first marking on 19-20th of June, marks and recaptures were made every two weeks (altogether 8 sampling periods) until the end of September (27th Sept.) by which time the size of Orthoptera populations already strongly decreased. Individual insects captured at any time got a new, time- and clearing-specific mark and were released. The marks were coloured paint marker dots on the pronotum.

To classify the local assemblages and demonstrate phenological changes of the meta-assemblage, multivariate statistical analyses such as cluster analysis (CA) and non-metric multidimensional scaling (NMDS) were applied. To show significant correlation the Spearman rank-order correlation analysis was applied. For the statistical analyses Statistica 5.0 (StatSoft Inc., 1994) and SYN-TAX 2000 (Podani, 1997) programs were used.

*Gergely Szövényi, ELTE Állatrendszertani és Ökológiai Tanszék (Department of Systematic Zoology and Ecology of the Eötvös Loránd University), 1117 Budapest, Pázmány Péter sétány 1/C, Hungary.

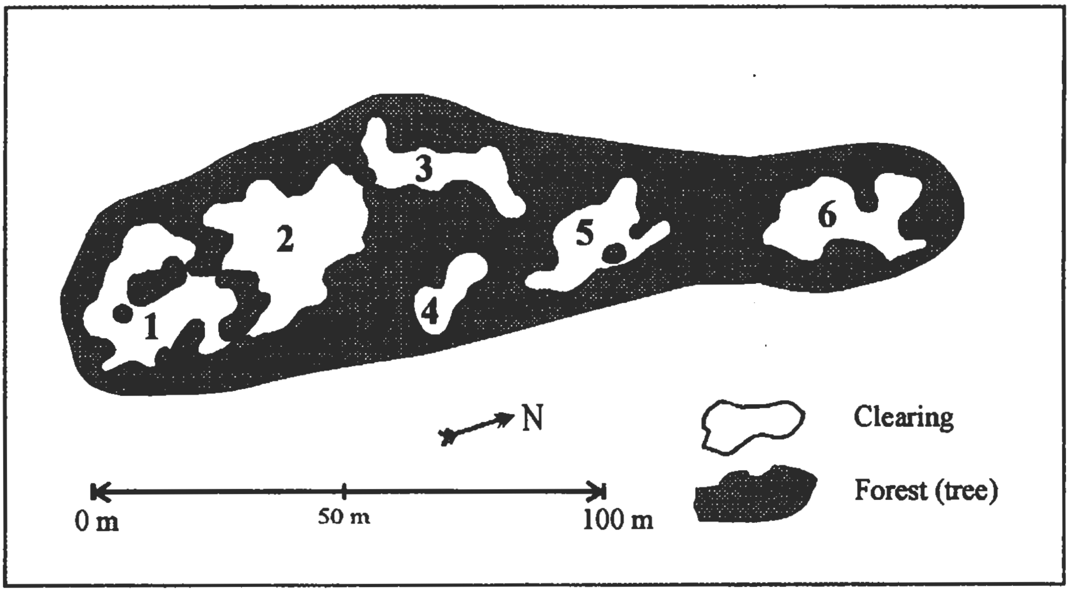

Figure 1. The ground plan of investigated clearings. Clearings 1-2-3 are interconnected by corridors, however, clearings 4, 5 and 6 are isolated by forest each others

Table 1. Specifications of the investigated clearings

Clearing No.	Area (m^2)	Exposition and degree of slope	Vegetation
1	510	S-SE, ca. 5-10°	Meso-xeric steppe grassland dominated by *Festuca* and *Arrhenatherum*
2	670	S-SE, ca. 5°	Rocky meso-xeric steppe grassland dominated by *Festuca* and *Arrhenatherum*
3	280	E-SE, ca. 3-5°	Xero-mesic steppe grassland dominated by *Arrhenatherum*
4	140	E-SE, ca. 5°	Small, shady clearing dominated by *Arrhenatherum* and *Melica*
5	320	E, ca. 5°	Rocky xero-mesic steppe grassland dominated by *Arrhenatherum* and *Festuca*
6	400	NE, ca. 5-8°	Xero-mesic steppe grassland dominated by *Arrhenatherum, Agropyron pallens* and *Festuca*

Table 2. *List of Orthoptera species occurring on the clearings investigated in order of their total dominance in the assemblage, percentage dominance values and presence (+) in local assemblages of clearings. Thick lines separate three types, such as dominant, constant and rare species of assemblage (downwards from top). Dom. means dominance*

Species	Total dom. (%)	Occurrence on clearing No.					
		1	2	3	4	5	6
Euthystira brachyptera (Ocskay, 1836)	48.9	+	+	+	+	+	+
Stenobothrus lineatus (Panzer, 1796)	22.7	+	+	+	+	+	+
Gomphocerus rufus (Linnaeus, 1758)	6.3	+	+	+	+	+	+
Pholidoptera griseoaptera (De Geer, 1773)	5.5	+	+	+	+	+	+
Chorthippus apricarius (Linnaeus, 1758)	3.5	+	+	+	+	+	+
Metrioptera bicolor (Philippi, 1830)	3.3	+	+	+		+	+
Chorthippus parallelus (Zetterstedt, 1821)	3.0	+	+	+	+	+	+
Pholidoptera fallax (Fischer, 1853)	2.6	+	+	+	+	+	+
Chorthippus brunneus (Thunberg, 1815)	1.3	+	+	+		+	+
Leptophyes albovittata (Koller, 1873)	1.1	+	+	+		+	+
Isophya kraussii (Brunner, 1878)	0.6	+	+	+	+	+	+
Chorthippus mollis (Charpentier, 1825)	0.2	+	+	+			
Chrysochraon dispar (Germar, 1834)	0.2		+	+	+		+
Platycleis albopunctata grisea (Fabricius, 1781)	0.2		+	+		+	+
Pholidoptera aptera (Fabricius, 1781)	0.2			+	+	+	+
Calliptamus italicus (Linnaeus, 1758)	0.1			+		+	+
Tetrix bipunctata (Linnaeus, 1758)	0.1						+
Euchorthippus pulvinatus (Fischer-Waldheim, 1846)	0.1		+				+
Pachytrachis gracilis (Brunner, 1861)	0.03						+
Ephippiger ephippiger (Fiebig, 1784)	0.03		+				
Stenobothrus nigromaculatus (Herrich-Schäffer, 1840)	0.03					+	
Omocestus haemorrhoidalis (Charpentier, 1825)	0.03					+	
Myrmeleotettix maculatus (Thunberg, 1815)	0.03	+					
Species richness:	**23**	**13**	**16**	**16**	**10**	**15**	**18**

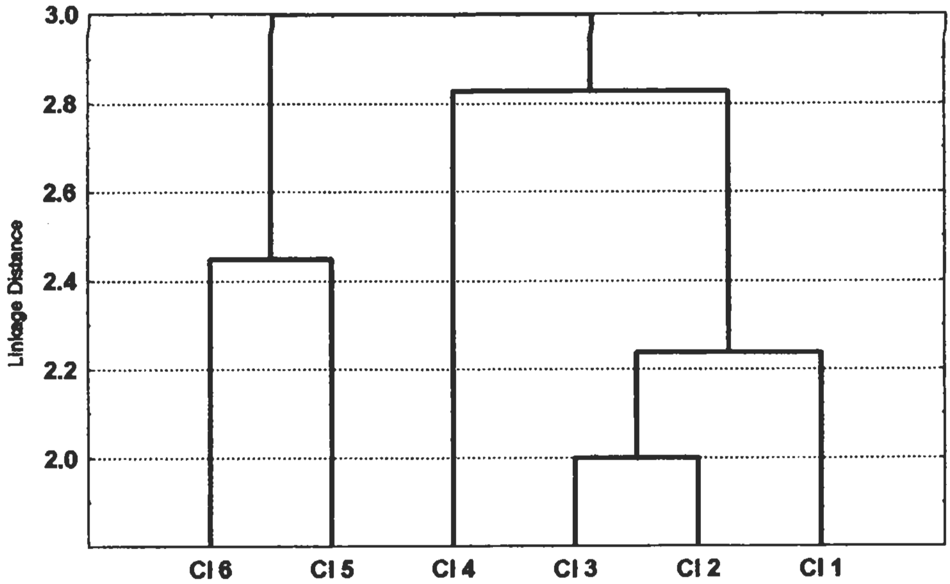

Figure 2. Result of cluster analysis of local Orthoptera assemblages of clearing No. 1-6 based on species composition

RESULTS

During three months altogether 23 Orthoptera species (3054 adult specimens of 9 Tettigonioidea, 13 Acridoidea and 1 Tetrigoidea species) were captured on one or more clearings showing varying dominance (Table 2). According to the type of habitat, most species are xero- and mesophilous grassland inhabitants (e.g. the dominant *Euthystira brachyptera* and *Stenobothrus lineatus*). However, *Chrysochraon dispar* which was represented only by a very low population size (0.2 % of total dominance) is known to be a hygrophilous species. Several others (e.g. *Pholidoptera griseoaptera, Ph. aptera, Gomphocerus rufus*) are typical forest and forest edge inhabitants. Categories of dominance were established on the basis of greater changes between neighbouring dominance values of dominance ranks (Table 2). For instance, the change from dominant to constant was 22.7/6.3 = 3.6 and from constant to rare 0.6/0.2 = 3. In addition to dominant species that occurred on all habitats patches sampled, constant ones were absent at most but one. However, rare species with very low population size (or as one specimen) were present only on few clearings.

The cluster analysis of the local assemblages (using Euclidean distance and complete linkage methods) separated three groups of local assemblages of clearings (Fig. 2). The first contains clearings 1, 2, 3 and the second contains clearings 5 and 6. Clearing No. 4 is separated from the rest at a relative high level.

The NMDS ordination of the whole assemblage (based on dominance data, using Euclidean distance) sampled at different points of time during the season throw light to a general trend of change in the structure of the assemblage from sampling period 1 to 8 along the axis 1 (Fig. 3).

The size and species number changes of local assemblages, as well as the entire assemblage through the sampling season are shown on Figs. 4 and 5. The size of assemblage and the number of species on clearing No. 4 differ from those of other clearings. Clearings No. 1, 2, 3, 5 and 6 are similar

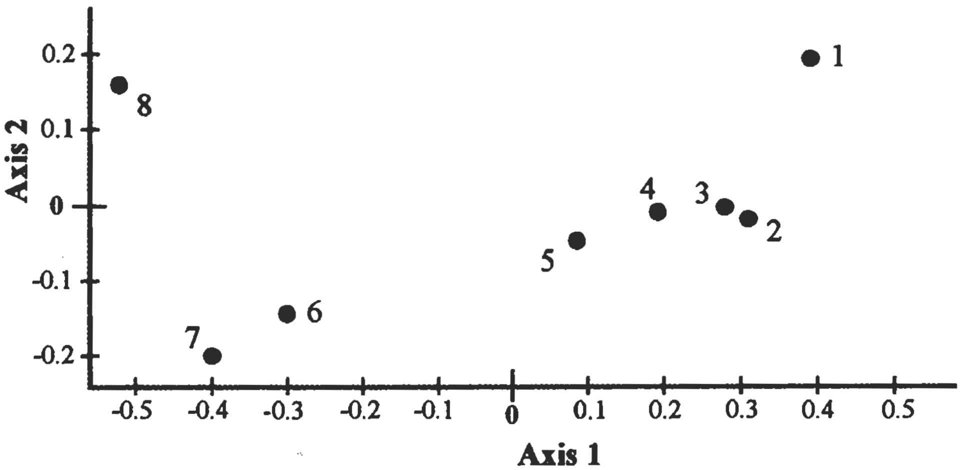

Figure 8. NMDS ordination of samples of the whole assemblage collected at different time periods. Numbers 1-8 mean the serial number of two weeks sampling periods from 19-20th of June (1) to 27th of September (8)

to the whole assemblage (on figures "total") showing an increasing and following a peak, a decreasing phase in time in both cases. On the contrary, the local assemblage of clearing No. 4 demonstrates only a fluctuating phase between weak increasing and decreasing phases.

The phenological patterns of assemblages investigated are shown in Fig. 6. Species represented in samples by more than 5 specimens could be characterised by the time of appearance and fading out and by a "peak" population size in the season. In case of two dominant species, a phenological asynchrony between males and females could be demonstrated (Fig. 7). Rank-order correlation in both species showed a significant decrease of male/female ratios through the sampling season (*E. brachyptera*: $Rs = -0.93$, $p = 0.0009$; *St. lineatus*: $Rs = -0.97$, $p = 0.00003$).

DISCUSSION

The species richness detected on the study area is high; about 20 % of all orthopterans known in Hungary. One of the reasons of high species richness of the Orthoptera assemblage on such a small area (ca. 2300 m^2 total area of clearings investigated) could be the relatively high diversity of habitats and microhabitats (see in Table 1). The xerophilous *Chorthippus mollis* occurred only on the south-faced sunny clearings No. 1, 2 and 3, while the north-faced No. 6 clearing and also the shady edges of others (No. 2, 3, 4) were suitable for the hygrophilous *Chrysochraon dispar*, too. Another reason could be the possible connection with more remote clearings through migration. Species appearing as wandering specimens without resident populations on investigated clearings (e.g. *Myrmeleotettix maculatus, Omocestus haemorrhoidalis, Stenobothrus nigromaculatus*) belong to the group of "rare" species (Table 2).

The results of cluster analysis (Fig. 2) show a topology- and habitat type-based distinction of assemblages; the latter being known in orthpterans (e.g. Kemp et al., 1990). The most closely related local assemblages belong to clearings No. 1, 2, and 3 (first group) which have similar type of vegetation and - it could be more important - are physically interconnected by grassland-covered corridors (Fig. 1). Members of local assemblages can easily transmigrate between the neighbour-

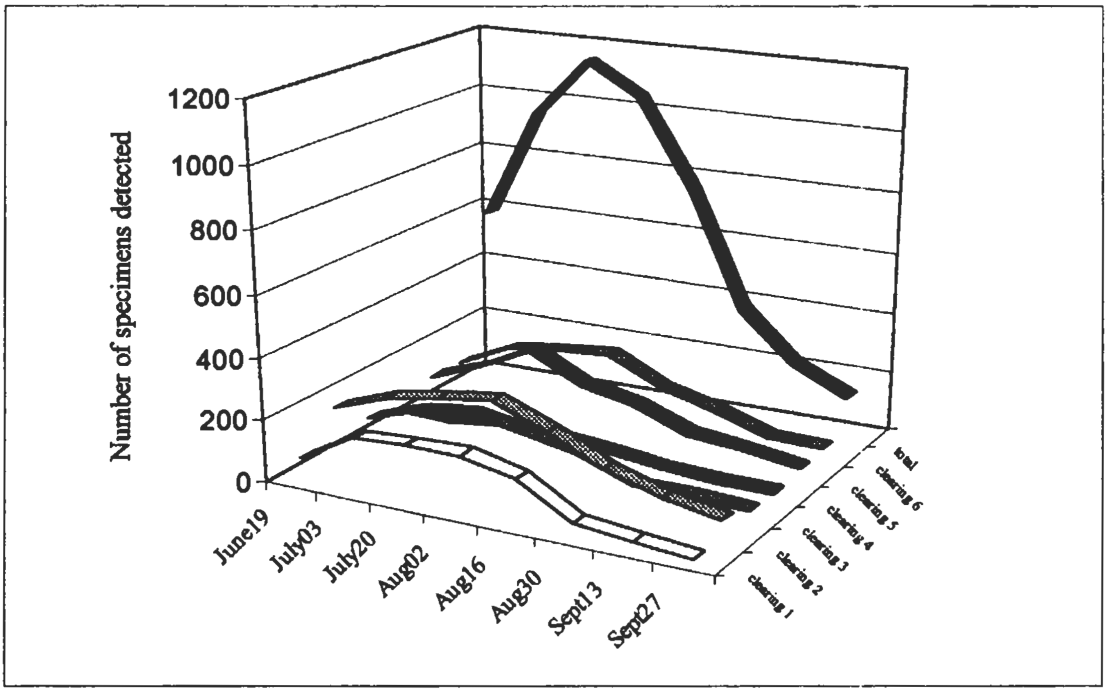

Figure 4. The number and sum of individuals collected on clearings at different sampling dates

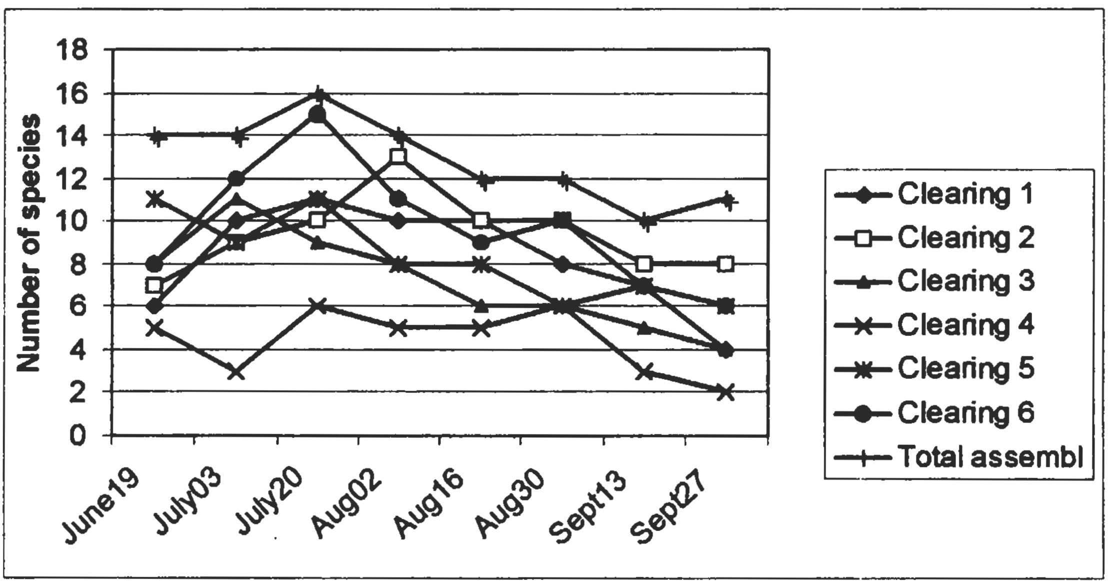

Figure 5. The number and sum of species found on clearings on sampling dates

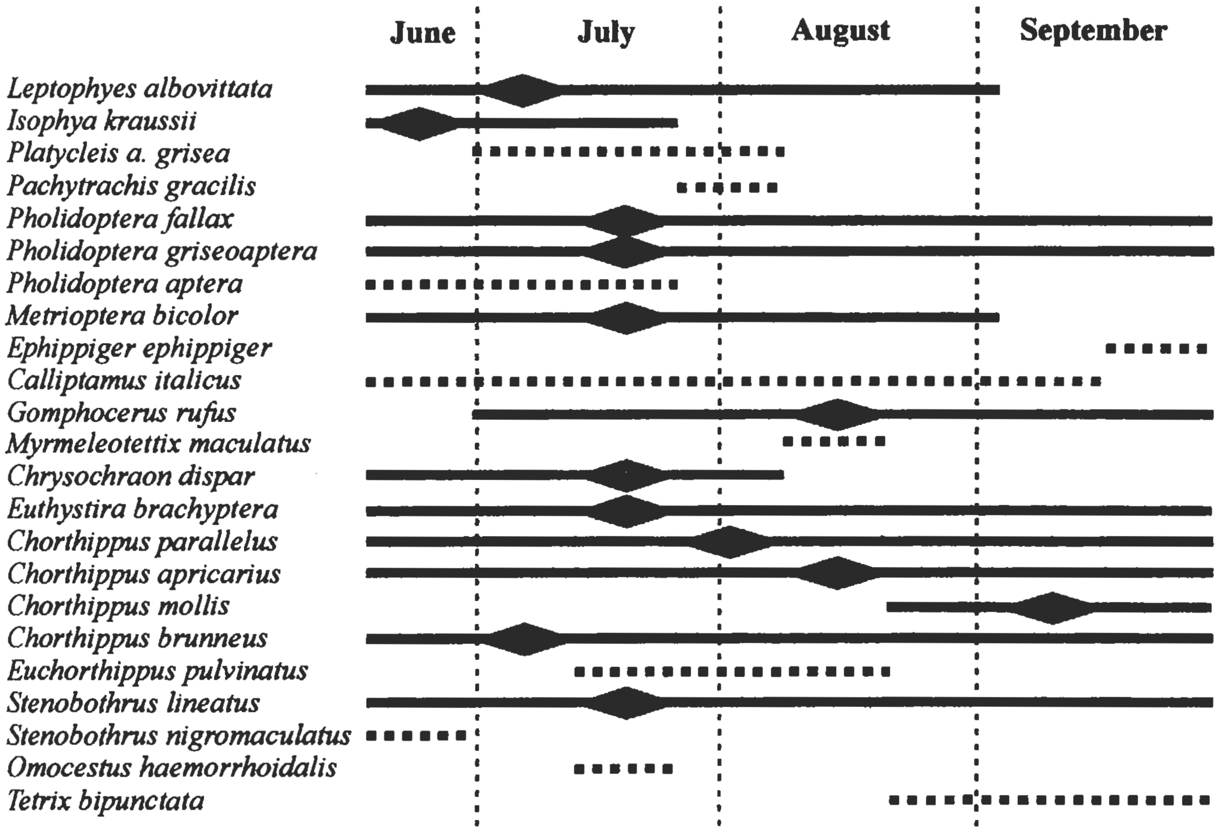

Figure 6. Phenological characteristics of species occurring in the assemblage based on the number of specimens detected. Black line denotes the occurrence of the adult population, dotted lines denote the scattered occurrence of 1-5 adults of species. The thickenings of black lines mark the period when species occurred at their highest abundances during the sampling season

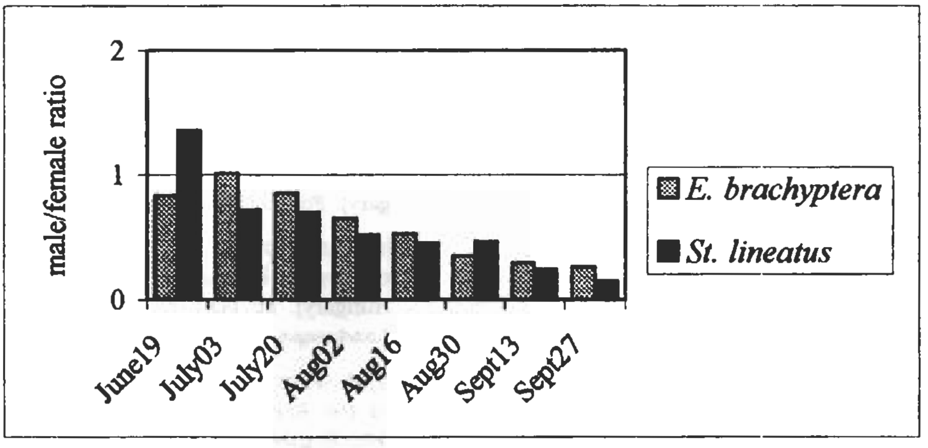

Figure 7. Change of sex ratio (number of males/number of females) of two dominant species of the assemblage studied from middle June to the end of September, 2000

ing and similar habitat patches by these corridors (Szővényi, 2001) that results in very similar assemblages. Local assemblages of clearings No. 5 and 6 are not similar, therefore, they form another group. Although these clearings have similar vegetation, they are isolated by forest from each other. The separation of no. 4 clearing's assemblage can be explained primarily by its extremely small size, which produces a microclimate and, by this way a vegetation different from others (see Table 1). In addition, because of small size, it can support only very small or transient populations. This effect results in a low species richness (Fig. 5) and a small number of specimens (Fig. 4) of this local assemblage.

Most Central European species of Orthoptera overwinter as egg, hatch in late spring, become adults in summer and die in autumn (except e.g. the family Tetrigidae; Ingrisch & Köhler, 1998). The number of adults of these species increases at the beginning of summer and then decreases in late summer and in autumn. Within this type of life cycle there are characteristic phenological differences between species (Fig. 6). The first one at about the end of spring among the early species is *Isophya kraussii* in the assemblage studied. Its population was already in a decreasing phase when I started samplings and disappeared in July. Other early species (e.g. *Leptophyes albovittata, Chorthippus brunneus*) survived until September. Most species reached the highest population size in July, while some typical late species peaked in August (*Gomphocerus rufus, Chorthippus apricarius*) or in September (*Chorthippus mollis*). The appearance of one or few wandering specimens of rare species seems to be independent of its phenological characters.

The result of NMDA (Fig. 3) also correctly demonstrates these seasonal changes. The distinct jump from stage 5 to 6 is parallel with the strongest decrease in the number of specimens shown on the cumulative curve of assemblage in the same period (curve "total" on Fig. 4).

The marked phenological difference between adult males and females is known for some Central European orthopteran species (Janssen & Reich, 1998; Wagner, 2000). Our study detected an asynchrony of males and females with both dominant species of the investigated assemblage (Fig. 7). Similarly to other studies, it was found that the males appeared earlier than females in the mating season and the decreasing ratio of males/females through the season was significant in both cases.

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