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Response of Orthoptera assemblage composition to land-use in the southern Alps of Italy

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The effects of land-use systems and thermal heterogeneity on the composition of Orthoptera assemblages in secondary grasslands were investigated on a site in the Southern Alps of Italy. Orthoptera species were sampled on seven plots with different management regimes, and different aspects. Species were classified on the basis of their distribution, in an effort to identify groups of species with particular responses to human disturbance. Stepwise multiple-regression analysis revealed that heterogeneity in thermal conditions as expressed by irradiation played a key role in determining species distribution across the study site. A group of thermophilous species related to South-facing plots was distinguished from more generalist species that also colonize East-facing plots. It was also possible to distinguish species that appeared to receive benefits from abandonment from species occurring mainly on managed (mown) meadows. Differences in group densities among plots reflected differences in ground level temperature and vegetation structure.

Keywords: Orthoptera, land-use change, assemblage composition, temperature, vegetation structure, Italy, Alps.

INTRODUCTION

In the last decades, changes in agricultural production methods have led to substantial changes in land-use systems (TURNER II & MEYER, 1994), including intensification in productive landscapes and abandonment of less productive mountain soils. Intensification and abandonment have led to the disappearance of many traditionally managed grassland areas throughout the entire Alpine region (SURBER *et al.*, 1973; PENZ, 1978; BÄTZING, 1990).

Land-use systems affect the vegetation structure and diversity (TAPPEINER & CERNUSCA, 1993; CERNUSCA *et al.*, 1992), and so the fauna (MORRIS, 1978; SOUTHWOOD *et al.*, 1979; ERHARDT & THOMAS, 1991; review in TSCHARNTKE & GREILER, 1995). In the mountains, an important role in determining the local occurrence of species is also played by climate heterogeneity resulting from topographical complexity.

Orthoptera are important primary consumers of alpine grasslands (BLUMER & DIEMER, 1996) and are effective bioindicators due to their differentiated reaction to habitat disturbances (KÖHLER, 1990). The choice of habitat by species depends mainly on microclimate conditions (VAN WINGERDEN *et al.*, 1991a; COXWELL & BOCK, 1995; review in INGRISCH & KÖHLER, 1998) and vegetation patterns (KEMP *et al.*, 1990; QUINN *et al.*, 1991; FIELDING & BRUSVEN, 1995). Therefore, land-use practices that imply a change in the structure of vegetation and microclimate must

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significantly affect Orthoptera assemblages (VAN WINGERDEN *et al.*, 1991b; FRICKE & VON NORDHEIM, 1992; THORENS, 1993; ANTOGNOLI & ZETTEL, 1996; review in INGRISCH & KÖHLER, 1998).

This study deals with the effects of climate heterogeneity and land-use systems on the composition of Orthoptera assemblages from secondary grasslands in the Southern Alps. Species distribution was analyszed in relation to selected environmental variables in order to characterize the different groups and to distinguish the impact of different land-use systems from the effect of thermal heterogeneity resulting from topographical aspect. This study also aims to integrate the results of a paper that assessed the effects of land-use changes on Orthoptera abundance and diversity (GUIDO *et al.*, 1998), and it is part of a larger research project (EC project ECOMONT) carried out along a N-S transect from the Austrian to the Italian Alps.

MATERIALS AND METHODS

Study site

The study site was located on the Viote plateau (46°01'20"N, 11°02'30"E) on Mount Bondone, at an altitude of 1550 m. Mount Bondone range is part of the Southern Alps and is located on the west side of the River Adige near the city of Trento.

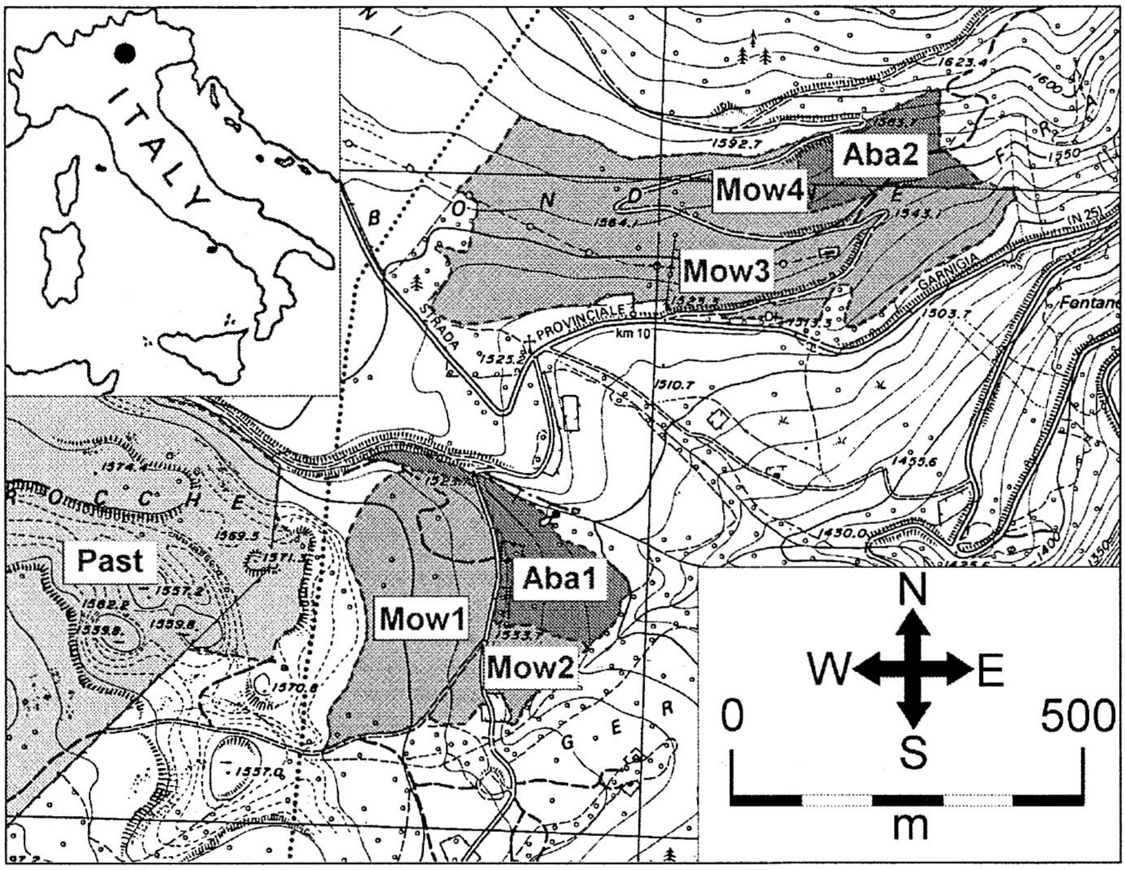

Fig. 1 - Location of the plot study sites at Monte Bondone. The location of sampled areas within each plot is also given by rectangles including the name of the plot. Plots characterized by different land-use are indicated with different scales of grey. Abandoned meadows: dark grey; mown meadows: mid grey; pasture: light grey.

The mean annual temperature is 5.5 °C, with mean monthly temperatures ranging from -2.7 °C in January to 14.4 °C in July. Precipitation is abundant through the year (mean annual rainfall 1189 mm), with two peaks in June and October, and a minimum in January.

At present, the most common land-use system is extensive mowing, as meadows are cut once a year and lightly fertilized (30 kg N ha^{-1}). The vegetation of these meadows is dominated by golden oats field (*Geranio-Trisetetum flavescentis*) and nard field (*Sieverso-Nardetum strictae*) (TASSER *et al.*, 1999). The beech forest represents the climax vegetation. Detailed information about the study site is given in CESCATTI *et al.* (1999).

Sampling methods

Sampling of adult Orthoptera was carried out on seven plots from 1 July to 15 September 1997 (Tab. 1 and Fig. 1). Plots were selected in relation to aspect (southern or eastern) and types of land-use system. Pasture plots were available only on E-facing slopes. Within each plot, abundance of adult Orthoptera was assessed by sweep netting. Four replicate patches of 5 m^2 per plot were sampled. A modified sweep net with a plastic bag attached was used. Sweeping was repeated eight times on the same replicate patch, to make sure that all insects were caught. Each sweeping consisted of 10 strokes per m^2. This number of strokes was found to allow of a complete coverage of the patch surface in all the different investigated types of vegetation. After each sweeping, the plastic bag was changed. Therefore, abundance

Tab. 1 - Description of the sampling plots; Al = altitude (m), S = slope (°), As = Aspect, I = Irradiation (nh). Vegetation types according to TASSER *et al.* (1999).

Plot	Description	Al	S	As	Vegetation type	Management system	I
Aba1	Abandoned grassland	1530	10	E	Sieversio-Nardetum strictae with *Calluna vulgaris*	none since 30 years	1991
Mow1	Hay meadow	1550	10	E	Sieversio-Nardetum strictae	mown once a year and fertilised (30kgN ha^{-1})	1991
Mow2	Hay meadow	1530	10	E	Geranio-Trisetetum flavescens	mown once a year and fertilised (30kgN ha^{-1}	1967
Past	Pasture	1560	15	E	Sieversio-Nardetum strictae	grazing by cattle and horses (1.5 animals ha^{-1})	1926
Aba2	Abandoned grassland	1565	15	S	Geranio-Trisetetum flavescens	none since 10 years	2339
Mow3	Hay meadow	1540	15	S	Sieversio-Nardetum strictae trifolietosum	mown once a year and fertilised (30kgN ha^{-1})	2337
Mow4	Hay meadow	1570	15	S	Arrhenatheretum elatioris	mown once a year and fertilised (30kgN ha^{-1})	2339

data were calculated per 5 m^2. Sampling was only carried out under fair weather conditions. Quantitative samplings were repeated every 15 days (i.e. six samples). On managed meadows, mowing occurred between the 2nd and 3rd sampling.

Heterogeneity in thermal conditions among plots resulting from topographical aspect was expressed by irradiation. Irradiation was estimated for each plot according to BARTORELLI (1965), who proposed an algorithm for the calculation of the amount of solar radiation hitting the ground as a function of latitude, slope and aspect. Irradiation is measured in normal hours (nh), which give the lap of time (measured in hours) during which the sun should stay directly perpendicular to a place in order to give the same amount of radiation that it gives under normal conditions to the same place during a year.

Above-ground phytomass was estimated by clipping all growth of the current year on four patches per plot. The size of each harvested patch was 0.25 m^2. All clipped material was divided into grasses, herbs (including dwarf shrubs), and dead standing plant matter (necromass). Samples were obtained every 15 days during the vegetative season from June to September (i.e. eight samples; TELLINI, pers. comm.).

Ground level temperatures were measured by thermocouples connected to a portable data acquisition system that provided temperature data for each hour (TAPPEINER *et al.*, 1999). We considered the mean daily temperature and maximum daily temperature of eight periods of seven days, with Orthoptera and phytomass sampling date as the central day of each period.

Data analysis

An analysis of variance (ANOVA) was used to test differences between plots and periods in measured environmental variables. As homogeneity of variances was not achieved even by data transformation, non-parametric Kruskall-Wallis ANOVA by ranks was applied to the data, and the effects of plot, aspect (S vs. E), and land-use were tested separately. To assess the effects of aspect on temperature and vegetation biomass, the pasture plot was not considered due to the absence of a S-facing replicate. Effects of land-use systems were analyzed considering E-facing and S-facing plots separately. To test differences between means, non-parametric multiple comparisons using rank sums from the Kruskall-Wallis test (ZAR, 1984) were performed.

Species occurrence in the different plots was analyzed by cluster analysis (CA) in order to obtain groups of species. For CA, abundance data were treated using 1-Pearson r as the distance index, and weighted pair-group method using arithmetic averages (WPGMA) as the clustering strategy. The density of each group of species was calculated by summing the densities of individual member species. To test the differences in abundance of CA groups, data were then submitted to a Kruskall-Wallis ANOVA followed by non-parametric multiple comparisons, using plot, aspect (not considering the pasture plot), and land-use (considering S- and E-facing plots separately) as independent variables. Densities of groups were also correlated to the environmental variables by forward stepwise regression analysis. Although sweep netting is not a particularly adequate method for catching Tetrigid species, abundance data of *Tetratetrix bipunctata kraussi* were included into the statistical analyses, since the distribution among plots of this species as obtained by sweep netting reflected the distribution as estimated in the field by qualitative observations. All statistical analyses were performed using the software package STATSOFT Statistica, version 5.

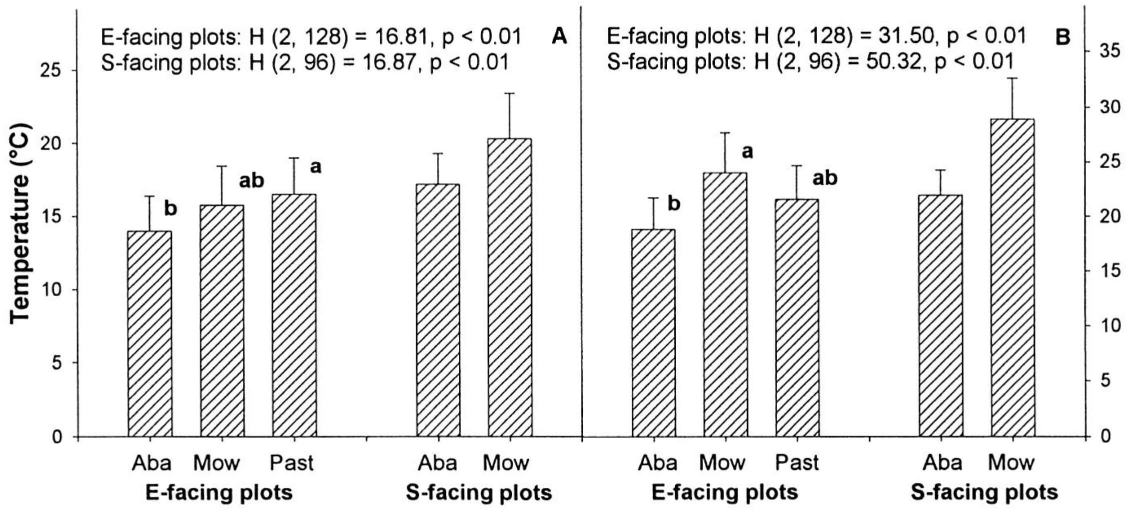

Fig. 2 - Distribution of mean (A) and maximum (B) ground level temperature for plots with different land-uses. The mean (+ SD) temperature values corresponding to the different land-use systems separated by aspect are given; Aba = abandoned meadow, Mow = mown meadow, Past = pasture. Results of Kruskall-Wallis test performed separately for E-facing and S-facing plots using land-use as independent variable are also given. Different letters imply significant differences in pairwise comparison among land-uses under similar aspect as revealed by non-parametric Tukey-type test.

RESULTS

Environmental variables

Irradiation (Tab. 1) and ground level temperature (both mean and maximum) were higher on the S-facing plots ($H_{1,\ 192} = 59.13$, $p < 0.01$, and $H_{1,192} = 31.49$, $p < 0.01$, respectively). The mean and maximum temperatures (under similar irradiation) were significantly higher on managed plots (Fig. 2A). In particular, temperature maxima were clearly greater on mown meadows (Fig. 2B).

Above-ground phytomass was highly affected by thermal heterogeneity and by land-use (Fig. 3). Necromass was significantly higher on E-facing plots ($H_{1,\ 190} = 4.43$, $p < 0.05$), where necromass was higher on the pasture. The first result can be explained as due to the relatively lower irradiation and temperature, that led to a slower decomposition process of litter on E-facing plots. The second one can be explained by the fact that the investigated pasture plot was covered by a high percentage of perennial grasses, which accumulated dead matter into their tufts. On S-facing plots, necromass was significantly higher on abandoned plots (Fig. 3A). The grass biomass was higher on S-facing plots ($H_{1,\ 192} = 14.30$, $p < 0.01$). No significant differences in grass biomass were revealed between managed and abandoned plots (Fig. 3B). Herb biomass had no differences due to aspect ($H_{1,\ 185} = 1.93$, $p > 0.05$); under similar irradiation, herb biomass was higher on abandoned plots (Fig. 3C).

Orthoptera assemblages

A total of 3520 individuals belonging to 15 species were collected on the seven study plots (Tab. 2). Cluster analysis (CA) separated the species by their local occurrence. A first separation into two clusters can be observed at a distance of about 1 (Fig. 4A). In the cluster (a) are species which were exclusively found (*Leptophyes*

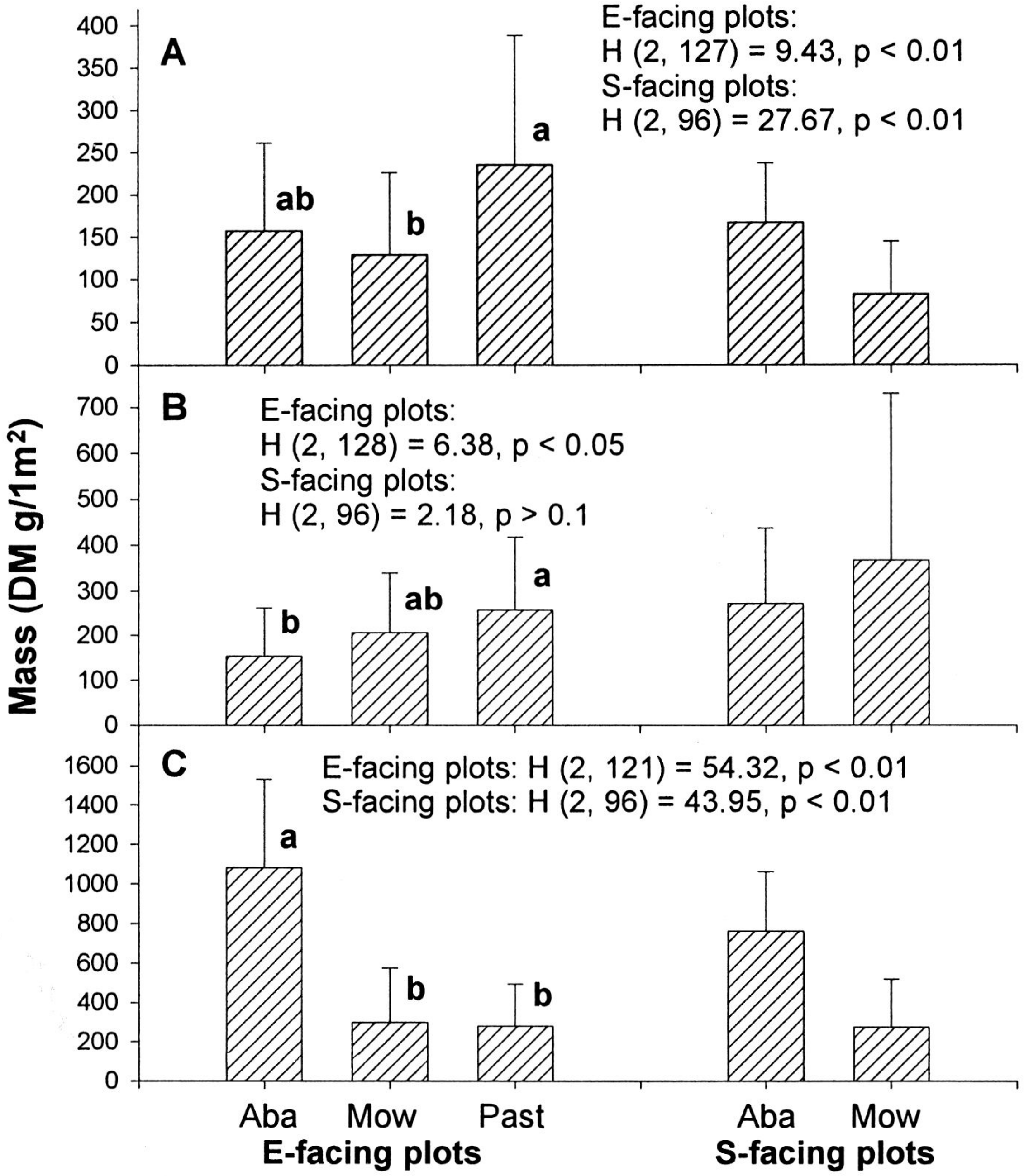

Fig. 3 - Distribution of necromass (A), grass biomass (B), and herb/dwarf shrub biomass (C) for different land-uses. The mean (+ SD) dry weight values per m^2 corresponding to different land-use systems separated by aspect are given; Aba = abandoned meadow, Mow = mown meadow, Past = pasture. Results of Kruskall-Wallis tests performed separately for E-facing and S-facing plots using land-use as the independent variable are also given. Different letters imply significant differences in pairwise comparison among land-uses under similar aspect as revealed by non-parametric Tukey-type test.

bosci, Gomphocerus rufus, Chorthippus dorsatus) or with higher densities (*Tettigonia caudata, Arcyptera fusca, Euthystira brachyptera, Omocestus viridulus, Stenobothrus lineatus, Stauroderus scalaris, Glyptobothrus biguttulus*) on the S-facing areas (Aba2, Mow3, Mow4) (Tab. 2). This cluster was significantly and positively correlated to irradiation, herb biomass and mean temperature (Tab. 3). In the cluster (b), there are 5 species with a significant negative statistical relationship with irradiation and necromass (Tab. 3). These two clusters seem to be separated on the basis of the distribution of species in relation to thermal heterogeneity, and thus on the thermal requirements of species. In particular, Orthoptera from the group (a) are linked to warmer sites, while the species grouped in cluster (b) do not show precise thermal requirements, being found with similar densities on both E- and S-facing plots (Tab. 4).

A further classification can be operated at a distance level of about 0.8 (Fig. 4A). Each of the two main clusters (a) and (b) splits into two branches.

Cluster (a) (S preferring species) splits into a first group (1), which includes species that reached significantly higher densities on S-facing mown meadows (Figs 4B, 5). This cluster groups two species which showed a clear preference for S-facing mown meadows (*G. biguttulus* and *S. lineatus*), and two other species which occurred with relatively higher densities on such plots, although not showing such a strong preference for a particular land-use (*S. scalaris* and *C. dorsatus*) (Tab. 2). The relatively less clear preference shown by *S. scalaris* might be due to its high mobility by flying across the plots. The group was positively related to mean temperature and irradiation, and negatively related to necromass (Tab. 3). The other group (2) is characterized by species that preferred abandoned meadows (Fig. 5). This cluster includes species with a clear preference for abandoned habitats (*E. brachyptera, L. bosci, G. rufus*) as well as species that occurred only with a

Tab. 2 - Total captures per plot (20 m^2) of the species of Orthoptera found in the surveyed areas. Species are named according to FAILLA *et al.* (1995).

Species	Plot						
	Aba1	**Mow1**	**Mow2**	**Past**	**Aba2**	**Mow3**	**Mow4**
Fam. Tettigoniidae							
Poecilimon ornatus (Schmidt)	4	1	4	2	2	1	1
Leptophyes bosci Brunner					2		
Tettigonia caudata (Charpentier)			2		3	1	1
Decticus verrucivorus (Linnaeus)	34	42	103	2	27	22	25
Pholidoptera griseoaptera (De Geer)	22	3	1		4		1
Fam. Tetrigidae							
Tetratetrix bipunctata kraussi (Saulcy)	3	4			2		4
Fam. Acrididae							
Arcyptera fusca (Pallas)	21	5	6		49	11	48
Euthystira brachyptera (Ocskay)	197	49	18	46	309	103	82
Omocestus viridulus (Linnaeus)	20	33	14	30	137	56	138
Stenobothrus lineatus (Panzer)		2				9	4
Gomphocerus rufus (Linnaeus)					4		
Stauroderus scalaris (Fischer Waldheim)	43	27	26	5	56	83	72
Chorthippus d. dorsatus (Zetterstedt)					3	7	3
Chorthippus p. parallelus (Zetterstedt)	248	195	220	139	131	196	286
Glyptobothrus biguttulus (Linnaeus)		1			4	35	26

Tab. 3 - Results of forward stepwise regression analysis performed on groups obtained by classification of Orthoptera species. Environmental variables with significant effect on each group distribution and their contribution to change in R-square are given.

Group	Resume of Regression	Independent variables entered ($p < 0.05$)	Beta	R-square change
Cluster a	$R^2 = 0.66$, $F(4,163) = 77.97$, $p = 0.000$	**Irradiation**	0.40	0.38
		Herb & shrub biomass	0.35	0.13
		Mean temperature	0.81	0.09
		Maximum temperature	-0.56	0.06
				S = 0.66
Cluster 1	$R^2 = 0.38$, $F(3,164) = 32.96$, $p = 0.000$	**Mean temperature**	0.35	0.30
		Irradiation	0.24	0.05
		Necromass	-0.15	0.02
				S = 0.38
Cluster 2	$R^2 = 0.60$, $F(4,163) = 61.60$, $p = 0.000$	**Irradiation**	0.38	0.28
		Herb & shrub biomass	0.40	0.21
		Mean temperature	0.73	0.05
		Maximum temperature	-0.58	0.06
				S = 0.60
Cluster b	$R^2 = 0.31$, $F(4,163) = 18.04$, $p = 0.000$	**Necromass**	-0.45	0.07
		Irradiation	-0.57	0.03
		Mean temperature	0.59	0.09
		Herb & shrub biomass	0.41	0.11
				S = 0.31
Cluster 3	$R^2 = 0.28$, $F(4,163) = 16.05$, $p = 0.000$	**Mean temperature**	0.60	0.10
		Irradiation	-0.48	0.03
		Necromass	-0.39	0.05
		Herb & shrub biomass	0.38	0.10
				S = 0.28
Cluster 4	$R^2 = 0.16$, $F(4,163) = 7.57$, $p < 0.001$	**Irradiation**	-0.50	0.04
		Necromass	-0.36	0.06
		Herb & shrub biomass	0.26	0.02
		Mean temperature	0.26	0.03
				S = 0.16

slight preference for the S-facing abandoned meadow (*A. fusca, O. viridulus, T. caudata*). In particular, *A. fusca* and *O. viridulus* reached similar high density values on both Aba 2 and Mow 4 (Tab. 2), although the results of classification seemed to be mostly affected by low density values recorded on Mow 3. In addition, some of the sampled patches of Mow 4 were close to the abandoned area (less than 10 m, Fig. 1), thus a migration process from the nearby abandoned meadow might have been involved in determining the high densities of these two species recorded on Mow 4. Stepwise regression analysis showed a significant positive relationship between this group and irradiation, herb biomass, and mean temperature. Maximum

Tab. 4 - Mean densities and SD of the groups of orthopteran species obtained by classification among areas at a distance of 1. Mean densities are referred to 5 m^2. Results of Kruskall-Wallis tests using plot as main effect are also given. Different letters imply significant differences in pairwise comparisons among plots as revealed by non-parametric Tukey-type tests.

		Plot						
Cluster		**Aba1**	**Mow1**	**Mow2**	**Past**	**Aba2**	**Mow3**	**Mow4**
a	Kruskall-Wallis test: H (6,168) = 103.10, p < 0.01							
	Mean	11.71	5.00	2.79	3.37	23.58	12.71	15.58
	S.D.	5.77	4.90	2.65	3.24	9.89	8.17	8.38
		b	c	c	c	a	ab	ab
b	Kruskall-Wallis test: H (6,168) = 30.55, p < 0.01							
	Mean	13.08	10.17	13.67	5.96	7.04	9.12	13.37
	S.D.	6.41	6.37	9.51	3.86	4.76	6.37	7.41
		a	ab	a	b	b	ab	a

temperature, higher on mown meadows, was negatively related to this group (Tab. 3).

Cluster (b) is also divided into two groups. These groups are composed of few species (2 and 3 respectively) and the autoecology and abundance of individual species play a substantial role. The first cluster (3) grouped two species, *Chorthippus parallelus* and *T. bipunctata*, and the local distribution of this group reflected the distribution of the dominant and eurytopic *C. parallelus*. It occurred with significantly different densities among plots, but without any significant relationship with thermal heterogeneity and land-use system (Figs 4B, 5; Tab. 3). The second branch (4) reached significantly higher densities on E-facing plots and was negatively correlated to irradiation (Fig. 4B; Tab. 3). The local occurrence of the group results from the distribution pattern of *Decticus verrucivorus*, and that of *Pholidoptera griseoaptera* and *Poecilimon ornatus*. The first species reached a higher density on mown meadows, whereas *P. griseoaptera* was more abundant on abandoned meadows and *P. ornatus* occurred with similar density on both managed and abandoned meadows (Tab. 2).

DISCUSSION

Both thermal heterogeneity and land-use systems affect the species composition and especially the local occurrence of Orthoptera on Mount Bondone.

The role of solar radiation and general thermal conditions on Orthoptera was underscored by SAMWAYS (1990) and COXWELL & BOCK (1995), and a relatively

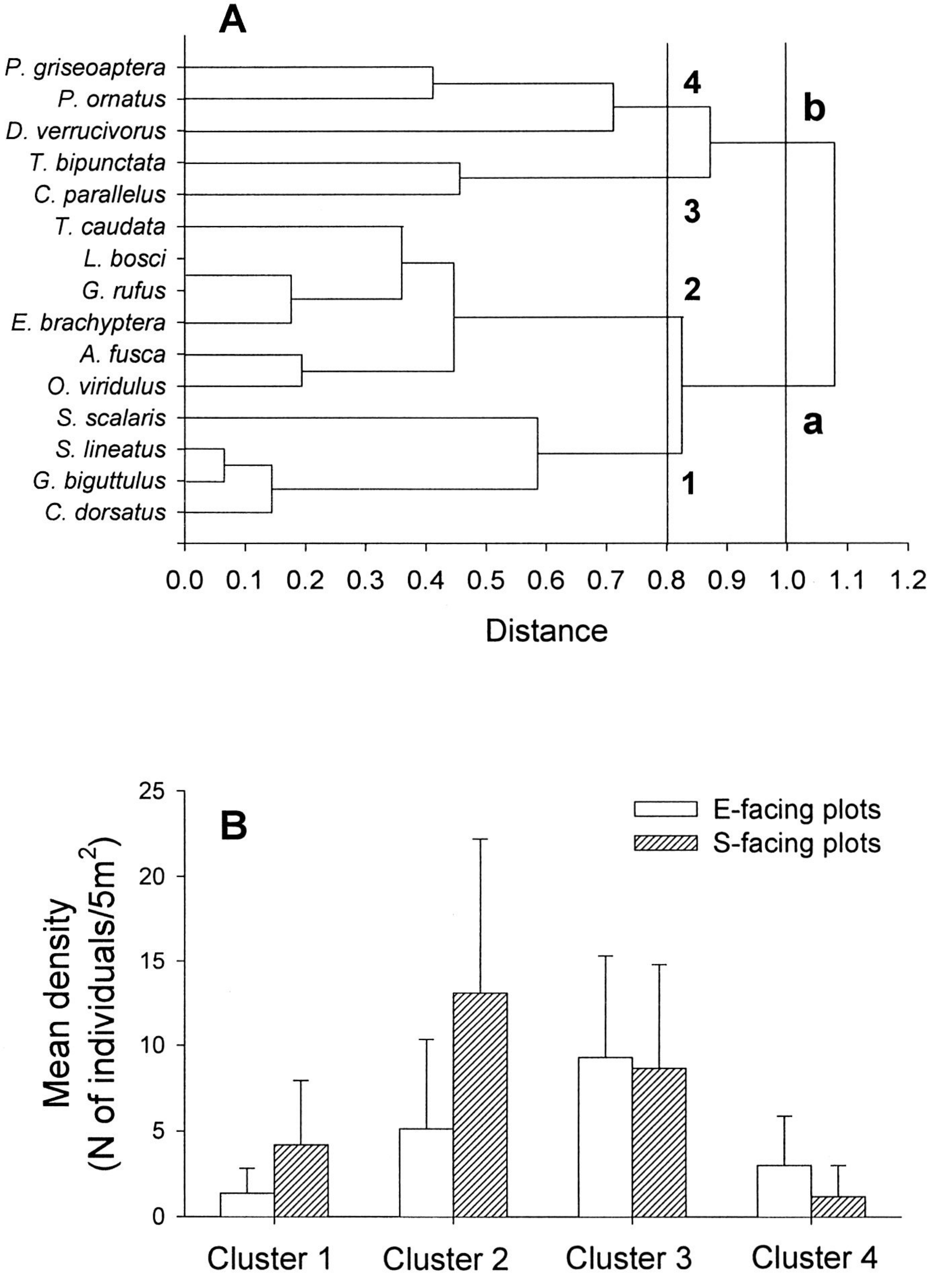

Fig. 4 - Classification of orthopteran species. (A) WPGMA dendrogram of the 15 orthopteran species found across the seven sampling plots obtained by cluster analysis. (B) Distribution of the four species groups obtained by classification at a distance of 0.8 according to aspect. The mean (+ SD) density values per 5 m^2 for E-facing and S-facing plots are given. Kruskall-Wallis ANOVA revealed that groups (1) and (2) reached significantly higher densities on S-facing plots (respectively $H_{1,144} = 36.48$, $p < 0.01$, and $H_{1,144} = 37.25$, $p < 0.01$). However, no significant differences in group (3) density due to aspect occurred ($H_{1,144} = 0.80$, $p > 0.05$), whereas group (4) was significantly more abundant on E-facing plots ($H_{1,144} = 18.29$, $p < 0.01$).

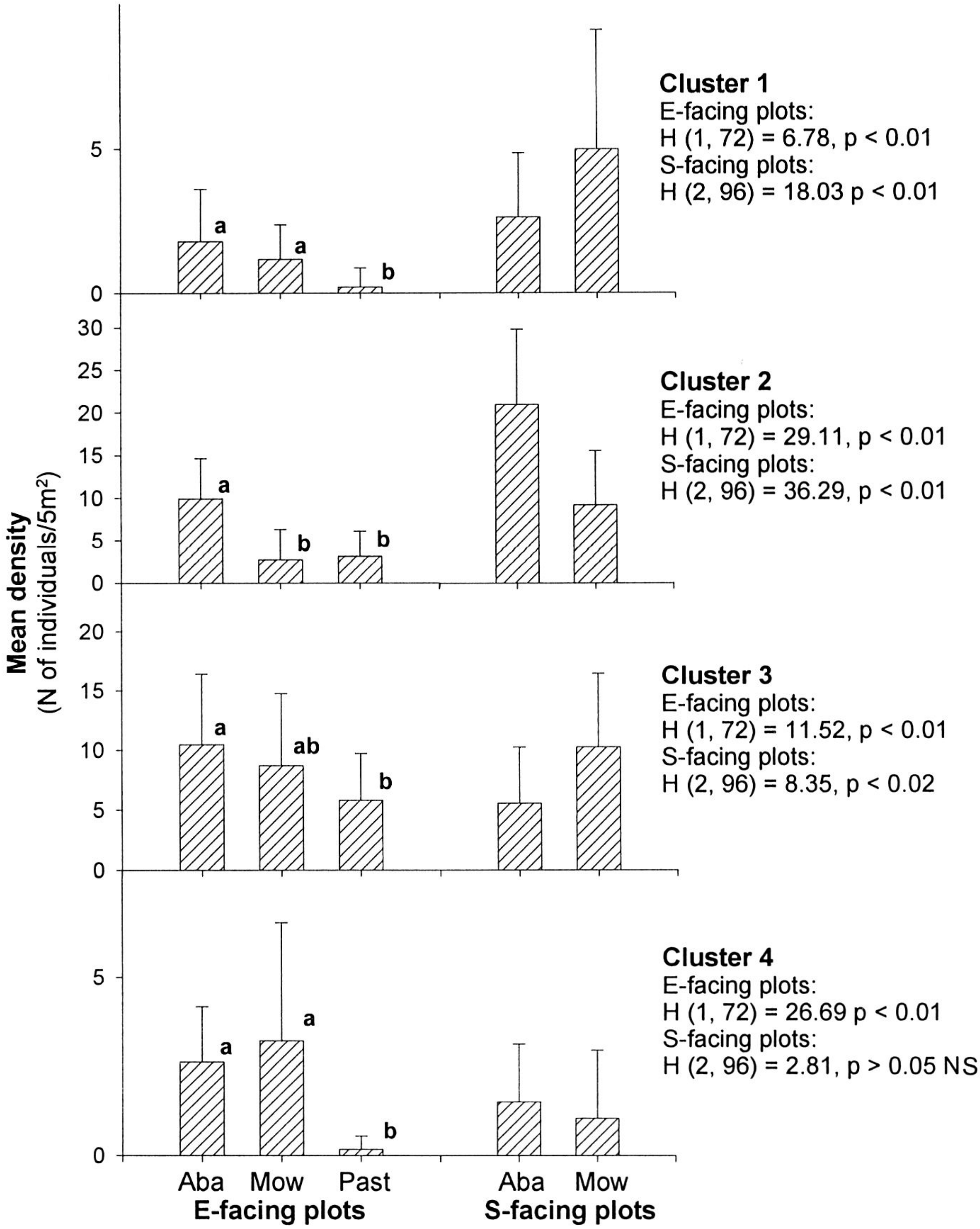

Fig. 5 - Distribution of the four species groups obtained by classification at a distance of 0.8 according to land-use. The mean (+ SD) density values per 5 m^2 corresponding to different land-use systems separated by aspect are given; Aba = abandoned meadow, Mow = mown meadow, Past = pasture. Results of Kruskall-Wallis tests performed separately for E-facing and S-facing plots using land-use as the independent variable are also given. Different letters imply significant differences in pairwise comparison among land-uses under similar aspect as revealed by non-parametric Tukey-type test.

small difference in mean temperatures can play a key role in the regulation of population density (REMMERT, 1985). A key factor determining Orthoptera distribution is the temperature during egg development, and particularly during post diapause egg development (PDD) (VAN WINGERDEN *et al.*, 1991a). Some species that reached higher densities on S-facing plots are known to have relatively long PDD, as *G. biguttulus* and *S. lineatus* (VAN WINGERDEN *et al.*, 1991a). On the opposite side, *C. parallelus* is a short PDD eurytopic species that can be found on warm as well as cold places (OSCHMANN, 1973; VAN WINGERDEN *et al.*, 1991a). Thermoregulation requirements are also of importance for completing the nymphal development (CARRUTHERS *et al.*, 1992). *Omocestus viridulus* has a short PDD duration (VAN WINGERDEN *et al.*, 1991a), but its larval development is stopped by lower temperatures (WILLOTT, 1997; WILLOTT & HASSAL, 1998) and thus its higher densities are restricted to relatively warmer study grasslands (Tab. 2).

The land-use (under similar irradiation) affects the local occurrence of Orthoptera both directly, through the disturbance caused by haymaking and grazing, and indirectly by modifying microclimate and grassland vegetation structure (Figs 2-3). Stepwise multiple regression highlighted a predominant role played by microclimate (ground level temperature) in determining habitat selection by species from mown meadows (group 1 on Fig. 4.A plus *D. verrucivorus*), while species from abandoned areas (group 2) were chiefly correlated with herb and dwarf shrub biomass, suggesting a more direct relationship with vegetation structure.

Species chiefly related to mown meadows (Fig. 4A; Tab. 2) lay their eggs just above or beneath the soil surface and thus are favoured by the light and thermal climate of mown meadows. The temperature of oviposition sites is strongly influenced by radiation extinction by vegetation (STOUTJESDIJK & BARKMAN, 1992). On mown meadows light absorption is evenly distributed throughout all layers (CERNUSCA *et al.*, 1992), and there is a higher temperature in the egg environment (Fig. 2). Light absorption on the abandoned grasslands takes place chiefly in the upper layer (61-70%) because of the accumulation of dead matter and the lignified stems of dwarf shrubs (CERNUSCA *et al.*, 1992); this layer insulates the ground from extreme irradiation leading to significantly lower temperatures at the soil surface (Fig. 2). Therefore, egg development of species that lay their eggs into the soil, as *D. verrucivorus* (INGRISCH, 1979, HARZ, 1964), *G. biguttulus* (THORENS, 1989), and *S. lineatus* (WALOFF, 1950; LOHER, 1959), is hindered, with a consequent delay in hatching (VAN WINGERDEN *et al.*, 1991a; 1991b).

Species linked to abandoned grasslands lay eggs on the soil surface, e.g. *O. viridulus* (group 2) (WALOFF, 1950; LOHER, 1959), or on vegetation, e.g. *E. brachyptera* (group 2) (SÄNGER, 1977), and *P. griseoaptera* (RAGGE, 1965) (upper branch of group 4). They are less damaged by soil insulation from radiation resulting in lower temperatures in the soil. On the other hand, they could clearly be damaged by land-use systems that cause the removal of vegetation and prevent the development of shrubs (such as mowing and grazing).

Not all species with similar egg laying preferences reacted in the same way to land-use, and *C. parallelus*, probably due to its short PDD duration, occurred with high density on differently managed plots, in accordance to the results obtained by VOISIN (1990) and FRICKE & VON NORDHEIM (1992). As observed by ANDERSON *et al.* (1979), CHAPPEL (1983), WHITMAN (1987), and WILLOTT (1997) the thermoregulatory ability during larval development contributes to habitat partitioning in Orthoptera.

Classification results partly agree with SÄNGER (1977), who considered *G. biguttulus*, *S. lineatus* and *C. dorsatus* as species linked with short grass meadows (e.g. mown meadows), and *E. brachyptera*, *P. griseoaptera*, *L. bosci*, and *G. rufus* as species more linked with tall grass ecosystems, as abandoned meadows.

No species were linked exclusively with pasture, where the most generalist species occurred, together with a few more sensitive species as occasional guests. This is in accordance with the results of previous studies (BONAVITA *et al.*, 1999; GUIDO *et al.*, 1999), which suggested that the examined pasture plot is over-exploited in relation to the environmental sustainability of the site.

Mown meadows of Mount Bondone are interesting habitats for the local conservation of several species of Orthoptera. Other orthopteran species receive short-term benefit from abandonment. In fact, abandoned grassland areas are transitory habitats. In the long-term, the beech forest would re-colonise the grasslands, causing the almost complete disappearance of the recorded species (GUIDO *et al.*, 1998). The maintenance of the current extensive management system of meadows is of particular importance for the conservation of orthopteran assemblages from the Viote plateau. Unmanaged areas of high and dense vegetation should be left as shelter on the borders of meadows, as suggested by ERHARDT & THOMAS (1991), THORENS (1993), and LÖRTSCHER *et al.* (1994), contributing to a diverse habitat structure and satisfying the requirements of the species linked with abandoned grasslands.

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RÉSUMÉ

Réponse de la composition des groupements d'Orthoptères aux types d'utilisation des prairies dans le sud des Alpes italiennes – Les effets des systèmes de gestion agricole et de l'hétérogénéité des conditions thermiques sur la composition des groupes d'Orthoptères des prairies secondaires d'un site du sud des Alpes italiennes sont analysés. Les Orthoptères ont été échantillonnés dans sept parcelles gérées de façon différente et selon différentes expositions. Les espèces ont été classées sur la base de leur distribution , dans le but d'identifier des groupes présentant des réactions communes face aux pertubations humaines. Une analyse par régression multiple pas à pas a révélé que l'hétérogénéité des conditions thermiques, exprimée par l'insolation potentielle, joue un rôle clé dans la distribution des espèces. Un groupe d'espèces thermophiles lié aux parcelles exposées au sud a été séparé d'un groupe d'espèces plus généralistes qui colonise également les zones exposées à l'est. On distingue également les espèces qui bénéficient d'un abandon de celles liées principalement aux prairies encore gérées (fauchées). Les différences de densité des groupes selon les parcelles dépendent de la température au niveau du sol et de la structure de la végétation.

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