ARTICULATA 2010 25 (1): 59–72 **FAUNISTIK**

The Orthoptera communities of sub-Mediterranean dry grasslands (*Aphyllanthion* alliance) in the western Spanish Pyrenees

Benjamin Krämer, Dominik Poniatowski, Luis Villar & Thomas Fartmann

Abstract

Sub-Mediterranean dry grasslands (*Aphyllanthion* alliance) are habitats with high biodiversity that have recently become threatened by abandonment of traditional management activities. Orthoptera communities are highly influenced by the spatial structure and thus indicate the quality of a habitat. The communities can be classified by the occurrence of characteristic Orthoptera species (regional "character species" and/or "differential species" according to PONIATOWSKI & FARTMANN 2008). We studied the composition of these communities in 21 plots along an elevation gradient from 750 to 1150 m a.s.l. in the Aísa Valley, western Aragonese Pyrenees (Spain). We defined three Orthoptera communities: (i) a community of herb- and grass-rich grasslands (type 1) with the character species *Tessellana tessellata*, (ii) a community of shrub-rich grasslands (type 2) with the character species *Thyreonotus corsicus* and *Chorthippus binotatus binotatus* and the differential species *Stenobothrus lineatus* and (iii) a community of rocky grasslands (type 3) with the character species *Chorthippus b. binotatus* and the differential species *Oedipoda coerulea*. Moreover, we analysed the ecological traits of the character and differential species: *Tessellana tessellata* prefers homogenous, high and dense vegetation, while the occurrence of *Thyreonotus corsicus* and *Stenobothrus lineatus* depends on heterogeneous, vertically well-structured habitats with herbs and bushes. In contrast, optimal habitats of *Oedipoda coerulea* are characterized by a high proportion of bare ground, and the occurrence of *Chorthippus b. binotatus* is restricted to sites with a high dwarf-shrub cover.

Zusammenfassung

Submediterrane Trockenrasen (Verband *Aphyllanthion*) sind Lebensräume mit einer hohen Biodiversität, die heutzutage durch die Aufgabe traditioneller Landnutzung gefährdet sind. Heuschreckengemeinschaften werden hauptsächlich von der Raumstruktur beeinflusst und sind deshalb gute Indikatoren für die Habitatqualität. Die Gemeinschaften können durch das Vorkommen charakteristischer Heuschreckenarten klassifiziert werden (regionale "Leitarten" und/oder "Differentialarten" nach PONIATOWSKI & FARTMANN 2008). Als Untersuchungsgebiet diente das Aísatal in den westlichen aragonesischen Pyrenäen (Spanien). Entlang eines Höhengradienten (750–1150 m NN) wurden hier 21 Flächen untersucht. Drei Heuschreckengemeinschaften ließen sich abgrenzen: (i) die Gemeinschaft der kraut- und grasreichen Trockenrasen (Typ 1) mit der Leitart *Tessellana tessellata*, (ii) die Gemeinschaft der strauchreichen Trockenrasen

(Typ 2) mit den Leitarten *Thyreonotus corsicus* und *Chorthippus binotatus binotatus* und der Differentialart *Stenobothrus lineatus* und (iii) die Gemeinschaft der steinigen Trockenrasen (Typ 3) mit der Leitart *Chorthippus b. binotatus* und der Differentialart *Oedipoda coerulea*. Außerdem wurden die Habitatansprüche der Leit- und Differentialarten analysiert: *Tessellana tessellata* bevorzugt homogene, hohe und dichte Vegetation, während das Vorkommen von *Thyreonotus corsicus* und *Stenobothrus lineatus* von einem heterogenen, vertikal gut strukturierten Habitat mit Kräutern und Sträuchern abhängt. Im Gegensatz dazu sind die Optimallebensräume von *Oedipoda coerulea* durch hohe Rohbodenanteile gekennzeichnet und das Vorkommen von *Chorthippus b. binotatus* beschränkt sich auf Standorte mit einer hohen Zwergstrauchdeckung.

Resumen

Los pastos mesomediterráneos (alianza *Aphyllanthion*) constituyen hábitats de una gran biodiversidad, ahora amenazados por el abandono de las técnicas tradicionales de explotación. Las comunidades de ortópteros se encuentran muy influenciadas por la estructura de la vegetación y por ello pueden ser indicadoras de sus características. Estas comunidades pueden ser clasificadas por la presencia de "especies características" o de "especies diferenciales", siguiendo a PONIATOWSKI & FARTMANN (2008). Estudiamos aquí la composición de estas comunidades en 21 parcelas situadas a lo largo de un gradiente altitudinal, de 750 a 1150 msnm en el Valle de Aísa, Pirineo Aragonés occidental (España). Definimos tres comunidades de ortópteros: (i) una comunidad de pastos densos rica en gramíneas y otras hierbas (tipo 1) con la especie característica *Tessellana tessellata*, (ii) una comunidad de pastos ricos en caméfitos (tipo 2) con las especies características *Thyreonotus corsicus* y *Chorthippus binotatus binotatus* más la especie diferencial *Stenobothrus lineatus*, y (iii) una comunidad de pastos pedregosos (tipo 3) con la especie característica *Chorthippus b. binotatus* y la especie diferencial *Oedipoda coerulea*. Además, analizamos las preferencias ecológicas de las especies características y diferenciales: *Tessellana tessellata* prefiere una vegetación densa, alta y homogénea, mientras que *Thyreonotus corsicus* y *Stenobothrus lineatus* se presenta en un hábitat heterogéneo, bien estructurado verticalmente con herbáceas y caméfitos. Por el contrario, los hábitats óptimos para *Oedipoda coerulea* muestran una gran proporción de terreno sin vegetación y *Chorthippus b. binotatus* queda restringida a lugares con una alta cobertura de caméfitos.

Introduction

As a part of the Mediterranean Basin, the southern slopes of the Pyrenees are one of the global biodiversity hotspots (CINCOTTA et al. 2000). Not only montane species but also a multitude of Atlantic, central European and Mediterranean species inhabit this area (e.g. ISERN-VALLVERDÚ 1990, DEFAUT 1994, SCHMIDT 2000).

Reasons for the high biodiversity are the close proximity of ice-free parts of the Iberian Peninsula to the Pyrenees as one of the most important glacial refugia

during the last ice age (HEWITT 1999) as well as geological heterogeneity (calcareous and acid rocks), high land use diversity and strong climatic differences within the extent of the mountain range (LOBO et al. 2001). In addition, the traditional grazing systems that have taken place for centuries favoured high species numbers (e.g. FILLAT 2008, SEBASTIÀ et al. 2008). However, livestock has been decreasing for decades in the Pyrenees (GARCÍA-RUIZ & LASANTA-MARTÍNEZ 1990). Nowadays, pastures are restricted to nutrient-rich sites in the vicinity of villages; the other sites were abandoned or afforested (BURGA 2004, LASANTA et al. 2006). This development has had adverse effects on a variety of species, including on many orthopterans, which benefit from low-intensity grazing (e.g. FARTMANN & MATTES 1997).

There are already several studies about the orthopteran fauna of the western Spanish Pyrenees and adjacent regions (e.g. KÜHNELT 1960, CLEMENTE et al. 1990, ISERN-VALLVERDÚ 1990, ISERN-VALLVERDÚ & PARDO GONZÁLEZ 1990, SCHMIDT 2000, BARRANCO VEGA & LLUCIÀ POMARES 2001). However, although their successful protection can only be assured by the knowledge of their ecological demands (e.g. SAMWAYS 2005; HEIN et al. 2007), information on the ecology of the species is rare (e.g. FUSEK 2005, GÖHLER 2005).

The habitat selection of Orthoptera is, beside land use (e.g. FARTMANN & MATTES 1997), mainly caused by vegetation structure and the interlinked microclimate (e.g. SZÖVÉNYI 2002; PONIATOWSKI & FARTMANN 2008). Hence, it is possible to distinguish characteristic orthopteran communities for different structural types (e.g. FARTMANN 1997, BEHRENS & FARTMANN 2004a, PONIATOWSKI & FARTMANN 2008). The classification of communities again is a powerful tool for nature protection, because the survey of community completeness allows drawing useful conclusions about possible changes in the environment (e.g. PONIATOWSKI & FARTMANN 2008).

The aim of this study is to make a contribution to the knowledge of orthopteran species in the sub-Mediterranean dry grasslands of the Spanish Pyrenees and to define characteristic orthopteran communities for certain structural types.

Material and Methods

Study area

The study area (42°35'N, 0°39'W and 42°40'N, 0°36'W) is located in the western Spanish Pyrenees, about 10 km northwest of Jaca (province Huesca) (Fig. 1). It comprises the 12 km long lower part of the southwards directed Valle de Aísa, through which the *Río Estarrún* is flowing. The study area is in the transition zone between sub-Cantabrian and sub-Mediterranean climates, with an annual precipitation of 835 mm and a mean annual temperature of 9.8 °C (Jaca-Ordolés, 1040 m a.s.l.; VILLAR et al. 1997). The bedrock consists, as in most parts of the western Pyrenees, mainly of limestone (GARCÍA-RUIZ & LASANTA-MARTÍNEZ 1990).

The study area is situated in the montane zone. Naturally, this area is dominated by downy oak forests (*Quercion pubescenti-petraeae*) with *Quercus cerrioides* agg. and *Buxus sempervirens* (VILLAR et al. 1997). The investigations were carried out in sub-Mediterranean dry grasslands (*Aphyllanthion*), which developed

through grazing and burning. Predominant plant species in these habitats are *Aphyllanthes monspeliensis*, *Brachypodium phoenicoides*, *B. retusum*, *Lavandula angustifolia subsp. pyrenaica, Dorycnium pentaphyllum* and *Genista scorpius*.

Fig. 1: Study area (Valle de Aísa) in the western Spanish Pyrenees.

Study plots

In the end of July 2008 we sampled 21 study plots once along an elevation gradient of 750–1150 m a.s.l. The plots differed in vegetation structure and land use in order to reflect the whole habitat variety of the study area. Following SÄNGER (1977) we only selected plots with a homogeneous vegetation structure. To avoid edge effects the size of the area was at least 500 m^2 (e.g. BEHRENS & FARTMANN 2004a, PONIATOWSKI & FARTMANN 2008). The sampling took place between 10 am and 5 pm.

Orthoptera sampling

Orthoptera densities were sampled using transect counts. Transect counts are a quick and fairly accurate sampling technique (GARDINER et al. 2005) in all of the studied sub-Mediterranean dry grasslands. However, transect counts are not as accurate as e.g. box quadrats (GARDINER & HILL 2006), which are not applicable in dense and tall vegetation.

In the centre of each study plot all orthopteran individuals (except Gryllidae) were detected in an area of 100 m^2. The visual and acoustical survey was done systematically, i.e. the whole area was scanned for orthopterans in sinuous lines. If necessary for the species determination, the individuals were captured and iden-

tified using PONIATOWSKI et al. (2009). In one plot, the abundance was so high that the number of individuals for three dominant species (-groups) (*Euchorthippus elegantulus/chopardi*, *Calliptamus barbarus/italicus*, *Tessellana tessellata*) was estimated. Due to the difficulty of distinction between *Calliptamus barbarus* and *C. italicus* (DETZEL 1998), particularly the nymphs of these two species were subsumed. For the nymphs of the genus *Euchorthippus* the situation was similar. Although adults of *E. chopardi*, in contrast to *E. elegantulus*, were only found at the lowest plot in 760 m a.s.l., occurrence in higher altitudes is possible (cf. FUSEK 2005). Hence, both species were merged, too. Scientific nomenclature followed mainly HELLER et al. (1998) and the revisions of *Euchorthippus* (ORCI et al. 2002), *Ephippiger* (BAUR & CORAY 2004), *Oedipoda* (DEFAUT 2006) and *Tessellana* (STOROZHENKO 2004).

Habitat

After the orthopteran sampling we recorded the vegetation structure in an undisturbed section of the plot. According to PONIATOWSKI & FARTMANN (2008), the total vegetation cover, the cover of shrubs, field layer, litter, as well as bare ground, gravel, stones and rocks were determined in 5% steps. We measured the average vegetation height and the horizontal vegetation density (SUNDERMEIER 1998). For the estimation of the vegetation density, we used a box 50 cm wide and 30 cm deep (MÜHLENBERG 1993) which was open on all sites except the back. Horizontal wires in the front divided the box into six layers (0–5, 5–10, etc. up to 25–30 cm). For each layer the cover of vegetation was estimated in 5% steps against the bright back.

The land use was ascertained by traces of grazing or mowing as well as the amount of bushes. Additionally, altitude, aspect and slope were recorded using GPS and a compass with an inclinometer.

Data analysis

Each plot was allocated to one structural type. The classification of the structural types was carried out by a cluster analysis using the statistical program SPSS 16. Ward's method based on Euclidean distance was used as the measure of distance. All values were z-transformed prior to analysis. The variables total vegetation cover, cover of shrubs, field layer, litter, bare ground, gravel, stones and rocks as well as the vegetation height and the horizontal vegetation cover from 0–5 cm to 25–30 cm were used for the classification.

Afterwards, medians were calculated for the structural parameters within the structural types and constancy and dominance (cf. ENGELMANN 1978) for the Orthoptera. The classification of orthopterans into character, differential and attendant species followed the "character and differential species model" from PONIATOWSKI & FARTMANN (2008).

We tested the orthopteran density and species number for significant differences between the structural types using ANOVA. The density had to be Ln-transformed prior to analysis to obtain Gaussian distribution and homogeneity of variance. The ANOVA was performed with a Tukey-HSD-test in SPSS 16.

Results

Orthopteran communities and structural types

During the study we sampled 1,318 Orthoptera individuals (adults and nymphs) belonging to 20 species. Six species belong to the order Ensifera and 14 to the order Caelifera.

The 21 study plots were grouped into three structural types, which differ clearly in vertical and horizontal structure (Table 1). The arrangement of the structural types corresponds to an ecological gradient: while the cover and height of the field layer decreases from type 1 to type 3, the proportion of bare ground and stony surface increases in the same direction (Table 1). The highest cover of the shrub layer was measured in type 2 (median: 35%).

The density of orthopterans increased with vegetation density. The herb- and grass-rich type 1 significantly differed from the types 2 ($P < 0.05$) and 3 ($P < 0.01$) (Fig. 2a). Species number is highest in the shrub-rich type 2 (mean: 6), which varies significantly ($P < 0.05$) from the species-poor type 3 (mean: 4.5) (Fig. 2b).

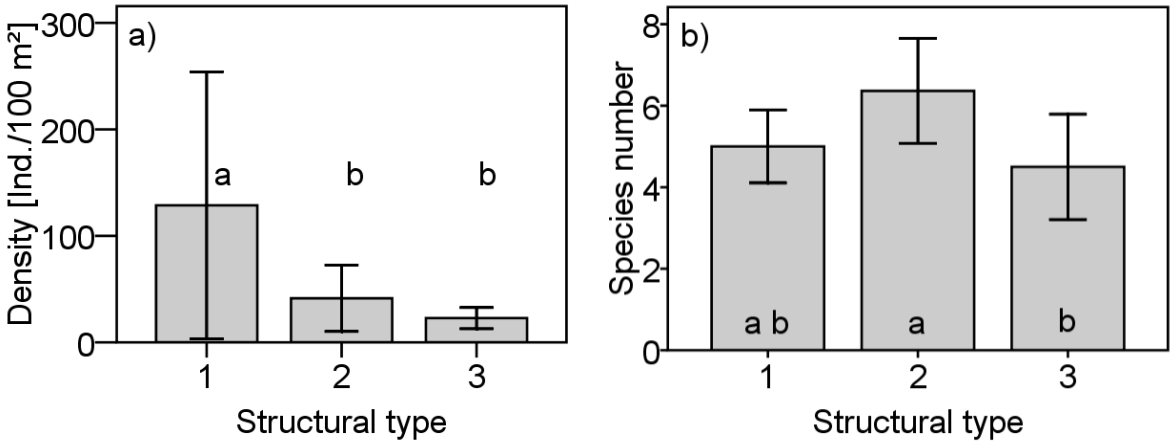

Fig. 2: Mean (± SD) orthopteran density (a) and species number (b) in the three structural types (type 1: $n_{plots} = 6$, type 2: $n_{plots} = 11$, type 3: $n_{plots} = 4$). Distinct letters indicate significant differences at the $P < 0.05$ level. For further information concerning the structural types see Table 1 and text.

Type 2 is the most heterogeneous one because it is composed of bare ground (median: 15%), a high cover of shrubs (median: 35%) and ground vegetation (median: 50%, Table 1). Type 3 has the highest cover of bare ground (median: 65%) and the lowest total vegetation cover, although the shrub cover is with a median of 18% comparatively high. All plots in type 2 and 3 were abandoned while just 33% of the plots in type 1 were not grazed. This type had a very low amount of shrubs and bare ground, but a very high field-layer cover with a median of 95%.

Each structural type has a distinct orthopteran community, i.e. a typical combination of character and/or differential species as well as several attendant species.

Following the "character and differential species model" of PONIATOWSKI & FARTMANN (2008), *Euchorthippus elegantulus/chopardi* can be classified as regional character species of the sub-Mediterranean dry grasslands without differential capacity, while *Tessellana tessellata*, *Thyreonotus corsicus* and *Chorthippus binotatus binotatus* can be appointed as regional character species with differential capacity. In contrast, *Stenobothrus lineatus* and *Oedipoda coerulea* are classified as differential species. Typical attendant species of the sub-Mediterranean dry grasslands are *Calliptamus barbarus/italicus* and *Platycleis albopunctata*, which occur with high constancy in all structural types (Table 1).

Structural type 1: Community of herb- and grass-rich grasslands
Regional character species: *Tessellana tessellata*

The community of herb- and grass-rich grasslands is characterized by the occurrence of *T. tessellata*. This species is dominant (Table 1) and can reach densities up to 50 individuals/100 m^2. Additionally, *Euchorthippus elegantulus/chopardi* is typical and often occurs in high densities (eudominant). *Calliptamus barbarus/italicus* and *Platycleis albopunctata* are attendant species with high constancy. However, *Calliptamus barbarus/italicus* is much more abundant than *Platycleis albopunctata*.

Structural type 2: Community of shrub-rich grasslands
Regional character species: *Thyreonotus corsicus*, *Chorthippus binotatus binotatus*

Differential species: *Stenobothrus lineatus*

Character species of this community are *T. corsicus* and *C. b. binotatus*. While the occurrence of *T. corsicus* is restricted to shrub-rich grasslands, *C. b. binotatus* inhabits also rocky grasslands (Table 1). *S. lineatus* is classified as a differential species of this community. The attendant species *Ephippiger diurnus* and *Phaneroptera nana* have a clearly higher constancy in this shrub-rich structural type than in the herb- and grass-rich grasslands. Species with high constancy are again *Euchorthippus elegantulus/chopardi* (character species without differential capacity, see above) and the attendant species *Calliptamus barbarus/italicus* and *Platycleis albopunctata*.

Structural type 3: Community of rocky grasslands
Regional character species: *Chorthippus binotatus binotatus*

Differential species: *Oedipoda coerulea*

C. b. binotatus characterizes the rocky grasslands and *O. coerulea* is a differential species of this structural type. Moreover, *Euchorthippus elegantulus/chopardi* is typical for rocky grasslands (Table 1). However, in contrast to the other two structural types, its dominance is much lower. Typical attendant species are again *Calliptamus barbarus/italicus* and *Platycleis albopunctata*: While *C. barbarus/italicus* is eudominant in the rocky grasslands, *P. albopunctata* reaches only low densities in this structural type. This community is species-poor; apart from the previously mentioned species, only four other species occur with low densities.

Table 1: The Orthoptera communities of sub-Mediterranean dry grasslands (*Aphyllanthion*) of the Aísa Valley. Values of vegetation structure are medians with interquartile range as superscript; classification of character species (CS) and differential species (DS) based on the differential species criterion following PONIATOWSKI & FARTMANN (2008); percentage constancy values are given for the sum of adults and nymphs with percentage dominance values as superscript; 0 = 1–3 individuals with a constancy value < 0.5%; for further information see text.

Structural type	**1**	**2**	**3**
N study plots	6	11	4
Sum of individuals	771	454	91
Total species number	11	16	9
Cover (%)			
Total vegetation	95 $^{95–95}$	85 $^{80–88}$	40 $^{38–43}$
Shrub layer	4 $^{1–5}$	35 $^{30–43}$	18 $^{5–30}$
Field layer	95 $^{91–95}$	50 $^{50–60}$	20 $^{15–25}$
Litter layer	5 $^{5–5}$	5 $^{5–5}$	5 $^{5–5}$
Bare ground and stony surface	8 $^{6–10}$	15 $^{10–20}$	65 $^{58–70}$
Vegetation height (cm)	50 $^{40–60}$	20 $^{12–34}$	17 $^{12–23}$
Horizontal vegetation density (%)			
25–30 cm	1 $^{0–2}$	0 $^{0–0}$	0 $^{0–0}$
20–25 cm	5 $^{1–5}$	0 $^{0–0}$	0 $^{0–0}$
15–20 cm	15 $^{8–19}$	1 $^{0–4}$	0 $^{0–0}$
10–15 cm	38 $^{26–49}$	5 $^{0–18}$	1 $^{0–2}$
5–10 cm	70 $^{54–79}$	30 $^{18–48}$	7 $^{3–14}$
0–5 cm	95 $^{95–99}$	70 $^{45–85}$	35 $^{25–43}$
Species without differential capacity			
CS of sub-Mediterranean dry grassland			
Euchorthippus elegantulus/chopardi	100 ^{53}	91 ^{53}	75 ^{13}
Species with differential capacity			
CS of herb- and grass-rich grasslands			
Tessellana tessellata	67 ^{14}	9 ^{0}	.
CS of shrub-rich grasslands			
Thyreonotus corsicus		73 ^{4}	.
DS of shrub-rich grasslands			
Stenobothrus lineatus	17 ^{0}	55 ^{3}	.
CS of dwarf-shrub-rich grasslands			
Chorthippus binotatus binotatus	.	55 ^{3}	75 ^{14}
DS of rocky grasslands			
Oedipoda coerulea	17 ^{0}	.	50 ^{6}
Attendant species			
Calliptamus barbarus/italicus	100 ^{29}	91 ^{25}	75 ^{57}
Platycleis albopunctata	83 ^{1}	82 ^{6}	50 ^{4}
Ephippiger diurnus	17 ^{0}	36 ^{2}	25 ^{1}
Phaneroptera nana	17 ^{0}	27 ^{2}	25 ^{2}
Dociostaurus jagoi	17 ^{1}	18 ^{1}	25 ^{1}
Chorthippus vagans	.	18 ^{1}	25 ^{1}
Omocestus panteli	17 ^{0}	.	.
Stenobothrus stigmaticus	17 ^{0}	.	.

Continuation of Table 1.

Structural type	1	2	3
Chorthippus parallelus	.	9 [1]	.
Omocestus rufipes	.	9 [0]	.
Stenobothrus festivus	.	9 [0]	.
Tettigonia viridissima	.	9 [0]	.

Discussion

Species inventory

In the Valle de Aísa, it is possible to find more than 50 orthopteran species between 750 and 2000 m a.s.l. (pers. obs.). With 20 species in total, the sub-Mediterranean dry grasslands cover about 40% of the known species of the Valley. Due to the short study period, it is likely that some species with low abundance were not found. One example is *Oedipoda caerulescens*, which is rare in the study area compared to its sibling species *Oedipoda coerulea* (pers. obs.). Moreover, the occurrence of some bivoltine species later in the season is possible. SCHMIDT (2000) for instance recorded two specimens of the 2nd generation of *Acrotylus insubricus* and *A. fischeri* in late August and early September, respectively, at the floodplain of the adjacent *Río Aragón*. Furthermore, the occurrence of the late-summer species *Uromenus catalaunicus* in the sub-Mediterranean dry grassland is likely (cf. FUSEK 2005).

Orthopteran communities and structural types

The vegetation structure is crucial for the habitat selection of the orthopterans (Table 1, SZÖVÉNYI 2002, PONIATOWSKI & FARTMANN 2008). Structural type 1 is inhabited only by species such as *Tessellana tessellata* that particularly depend on a dense herb and grass layer. The low-intensity land use there results in the highest number of individuals (VAN WINGERDEN et al. 1991, FARTMANN & MATTES 1997). If these areas are not in use over a longer period, woody plants establish and the area develops to structural type 2 (shrub-rich grasslands). In comparison to structural type 1, the abundances are considerably lower in structural type 2 (Fig. 2). The main reason for the low densities seems to be the lack of land use. FARTMANN & MATTES (1997) mention unfavourable microclimatic conditions (cool-moist) that are caused by accumulation of litter and the encroachment of woody plants. However, shrub inhabitants like *Thyreonotus corsicus*, *Ephippiger diurnus* and *Phaneroptera nana* benefit from this and reach their highest constancy and dominance values. The high species numbers of the shrub-rich grasslands are remarkable. They are caused by a high structural diversity (ISERN-VALLERDÚ & PEDROCCHI 1994), i.e. a mosaic of bare ground, grass, herbs and woody plants. However, with proceeding unification by shrub growth, a decline in species is likely (cf. FARTMANN & MATTES 1997). The sites with many gaps, where bedrock is exposed, were grouped into structural type 3 (rocky grasslands). It is a typical habitat for the geophilic species *Oedipoda coerulea*, which can cope with low food supply and high temperatures.

Character and differential species following PONIATOWSKI & FARTMANN (2008)
In the Valle de Aísa the occurrence of *Tessellana tessellata*, *Thyreonotus corsicus* and *Chorthippus binotatus binotatus* is (mainly) restricted to the sub-Mediterranean dry grasslands (pers. obs.). Hence, following the "character and differential species model" of PONIATOWSKI & FARTMANN (2008), they can be classified as regional character species. Moreover, *Tessellana tessellata*, *Thyreonotus corsicus* and *Chorthippus b. binotatus* show preferences for certain structural types. Therefore, they are character species with differential capacity (Table 1), i.e. each of them acts as an indicator for a certain habitat quality (see below). *Stenobothrus lineatus* and *Oedipoda coerulea* were classified as differential species because they occur not only in sub-Mediterranean dry grasslands: *S. lineatus* is also typical for the common pastures above the timberline in the province Huesca (ISERN-VALLVERDÚ 1990, pers. obs.) and *O. coerulea* reaches high constancy on gravel banks of the *Río Estarrún* (Poniatowski, unpubl. data).

In addition, *Euchorthippus elegantulus/chopardi* can be classified as a character species without differential capacity for the sub-Mediterranean dry grassland. The occurrence of both *Euchorthippus* species is restricted to this habitat type (pers. obs.). *Calliptamus barbarus/italicus* and *Platycleis albopunctata* in contrast, have a similar constancy in the three structural types as *E*. *elegantulus/chopardi*, but they also colonise other habitats: *Calliptamus barbarus* and *C. italicus* e.g. occurr on gravel banks of the *Río Estarrún* (Poniatowski, unpubl. data) and *Platycleis albopunctata* e.g. in common pastures below and above the timberline (pers. obs.).

Indicating function of the character and differential species (only species with differential capacity are considered)

Tessellana tessellata
Habitat quality: herb- and grass-rich grasslands with little bare ground

In Central Europe *T*. *tessellata* prefers warm and very dry sites (DETZEL 1998). Moreover, HEITZ & HERMANN (1993) highlight the importance of a high sward in combination with bare ground. In contrast to Central Europe, in Southern Europe *T*. *tessellata* avoids very dry and warm habitats (DEFAUT 1999). In the study area the species prefers sub-Mediterranean dry grasslands with a dense and high sward that are mostly free of shrubs and bare ground (FUSEK 2005, this study).

Thyreonotus corsicus
Habitat quality: shrub-rich grasslands

The habitat choice of *T*. *corsicus* depends to a great extent on the preferred inhabitancy of the species: small, very dense bushes, according to BELLMANN (2006). Hence, this species occurs only in shrub-rich grasslands (type 2).

Stenobothrus lineatus
Habitat quality: shrub-rich grasslands

Although *S*. *lineatus* is a typical species of warm and dry sites in Central Europe (DETZEL 1998; BEHRENS & FARTMANN 2004b), in the Spanish Pyrenees – i.e. at the southern range limit – the species can be classified as mesophilous: within the sub-Mediterranean dry grasslands the occurrence of *S*. *lineatus* is mainly

restricted to dense, shrub-rich areas (type 2), which have a cooler and moister microclimate than the sites of structural type 1 and 3. Moreover, in the Spanish Pyrenees *S. lineatus* is typical for high altitudes with high precipitation (e.g. ISERN-VALLVERDÚ 1990; ISERN-VALLVERDÚ & PARDO GONZÁLEZ 1990; FUSEK 2005, GÖHLER 2005).

Chorthippus binotatus binotatus
Habitat quality: dwarf-shrub-rich grasslands

Chorthippus binotatus binotatus is the only known species of this genus which is not graminivorous. Instead, *C. b. binotatus* feeds preferably on some dwarf-shrubs (Genistaceae) (PICAUD et al. 2002). As in Provence (France) (MOSSOT & PETIT 2000), the dominant *Genista scorpius* is probably preferred in Valle de Aísa, too. Hence, *C. b. binotatus* occurs only in the shrub-rich structural types 2 and 3. In addition, the high constancy and dominance in the rocky grasslands (type 3) indicate high thermal requirements.

Oedipoda coerulea
Habitat quality: rocky grasslands

Like its sibling species *O. caerulescens*, *O. coerulea* is ethologically and morphologically adapted to poorly vegetated habitats (cf. DETZEL 1998). Hence, in sub-Mediterranean dry grasslands the occurrence of *O. coerulea* is primarily restricted to the rocky grasslands (type 3).

Acknowledgements

We would like to thank David Llucià Pomares for constructive comments on an earlier version of the manuscript; moreover, we are very grateful to him for the determination of some critical individuals.

Authors:
Benjamin Krämer, Dominik Poniatowski and PD Dr. Thomas Fartmann
Department of Community Ecology
Institute of Landscape Ecology
University of Münster
Robert-Koch-Straße 26
D-48149 Münster, Germany
E-mail: benjamin.kraemer@uni-muenster.de
E-mail: poni@uni-muenster.de
E-mail: fartmann@uni-muenster.de

Dr. Luis Villar Pérez
Instituto Pirenaico de Ecología, IPE-CSIC
Apdo. 64
E-22700 Jaca (Huesca), Spain
E-mail: lvillar@ipe.csic.es

References

BARRANCO VEGA, P. & LLUCIÀ-POMARES, D. (2001): Catálogo de los Caelifera no Acrididae (Insecta: Orthoptera) de Aragón. – Cat. Entomofauna aragon. 23: 15–18.

BAUR, H. & CORAY, A. (2004): A revision of the Blattodea, Ensifera and Caelifera described by H. Fruhstorfer. – Revue suisse de Zoologie 111: 611–630.

BEHRENS, M. & FARTMANN, T. (2004a): Die Heuschreckengemeinschaften isolierter Schieferkuppen der Medebacher Bucht (Südwestfalen/Nordhessen). – Tuexenia 24: 303–327.

BEHRENS, M. & FARTMANN, T. (2004b): Habitatpräferenzen und Phänologie der Heidegrashüpfer *Stenobothrus lineatus*, *Stenobothrus nigromaculatus* und *Stenobothrus stigmaticus* in der Medebacher Bucht (Südwestfalen/Nordhessen). – Articulata 19: 141–165.

BELLMANN, H. (2006): Der Kosmos Heuschreckenführer – Die Arten Mitteleuropas sicher bestimmen. – Kosmos, Stuttgart; 350 S.

BURGA, C.A. (2004): Pyrenäen (vorwiegend Frankreich). – In: BURGA, C.A., KLÖTZI, F. & GRABHERR, G. (Hrsg.): Gebirge der Erde. – Ulmer, Stuttgart: 46–54.

CINCOTTA, R.P., WISNEWSKI, J. & ENGELMAN, R. (2000): Human population in the biodiversity hotspots. – Nature 404: 990–992.

CLEMENTE, M.E., GARCÍA, M.D. & PRESA, J.J. (1990): Nuevos datos sobre los Acridoidea (Insecta: Orthoptera) del Pirineo y Prepirineo catalano-aragonés. – Butll. Inst. Cat. Hist. Nat. (Sec. Zool. 8) 58: 37–44.

DEFAUT, B. (1994): Les synusiens orthoptériques en région paléarctique eccidentale. – A.N.A., La Bastide de Sérou, 275 S.

DEFAUT, B. (1999): Synopsis des Orthopteres de France. – Matériaux Entomocénotiques, n° hors série, deuxième édition, révisée et augmentée; 87 pages.

DEFAUT, B. (2006): Révision préliminaire des *Oedipoda* ouest-paléarctiques (Caelifera, Acrididae, Oedipodinae). – Matériaux Orthoptéres et Entomocénotiques 11: 23–48.

DETZEL, P. (1998): Die Heuschrecken Baden-Württembergs. – Ulmer, Stuttgart; 580 S.

ENGELMANN, H.D. (1978): Zur Dominanzklassifizierung von Bodenarthropoden. – Pedobiologia 18: 378–380.

FARTMANN, T. (1997): Biozönologische Untersuchungen zur Heuschreckenfauna auf Magerrasen im Naturpark Märkische Schweiz (Ostbrandenburg). – In: MATTES, H. (Hrsg.): Ökologische Untersuchungen zur Heuschreckenfauna in Brandenburg und Westfalen. – Arb. Inst. Landschaftsökol. 3: 1–62.

FARTMANN, T. & MATTES, H. (1997): Heuschreckenfauna und Grünland – Bewirtschaftungsmaßnahmen und Biotopmanagement. – In: MATTES, H. (Hrsg.): Ökologische Untersuchungen zur Heuschreckenfauna in Brandenburg und Westfalen. – Arb. Inst. Landschaftsökol. 3: 179–188.

FILLAT, F., (2008): Bosquejo histórico de la actividad pastoril en el Pirineo. – In: FILLAT, F., GÓMEZ, D., REINÉ, R. & GARCÍA, R. (eds.) Pastos del Pirineo. – CSIC, Madrid: 25–35.

FUSEK, A. (2005): Der Einfluss unterschiedlicher Strukturen auf die Heuschreckenfauna entlang eines Höhengradienten in den spanischen Pyrenäen. – Unveröff. Diplomarbeit, Münster; 49 S.

GARCÍA-RUIZ, J. M. & LASANTA-MARTÍNEZ, T. (1990): Land-use-changes of the Spanish Pyrenees. – Mountain Research and Development 10 (3): 241–255.

GARDINER, T. & HILL, J. (2006): A comparison of three sampling techniques used to estimate the population density and assemblage diversity of Orthoptera. – J. Orthoptera Res. 15: 45–51.

GARDINER, T., HILL, J. & CHESMORE, D. (2005): Review of the methods frequently used to estimate the abundance of Orthoptera in grassland ecosystems. – J. Insect Conserv. 9: 151–173.

GÖHLER, U. (2005): Habitatpräferenzen der Keulenschrecken *Gomphocerus sibiricus* und *Myrmeleotettix maculatus* auf Allmendweiden der spanischen Pyrenäen. – Unveröff. Diplomarbeit, Münster; 58 S.

HEIN, S., BINZHÖFER, B., POETHKE, H.-J., BIEDERMANN, R., SETTELE, J. & SCHRÖDER, B. (2007): The generality of habitat suitability models: A practical test with two insect groups. – Basic Appl. Ecol. 8: 310–320.

HEITZ, S. & HERMANN, G. (1993): Wiederfund der Braunfleckigen Beißschrecke (*Platycleis tessellata* Charpentier 1829) in der Bundesrepublik Deutschland. – Articulata 8: 83–87.

HELLER, K.-G., KORSUNOVSKAYA, O., RAGGE, D.R., VEDENINA, V., WILLEMSE, F., ZHANTIEV, R.D. & FRANTSEVICH, L. (1998): Check-List of European Orthoptera. – Articulata, Beiheft 7: 1–61.

HEWITT, G.M. (1999): Post-glacial re-colonization of European biota. – Biol. J. Linn. Soc. 68: 87–112.

ISERN-VALLVERDÚ, J. (1990): A quantitative ecology of orthopteran communities on Pyrenean grasslands above timberline (Huesca, Spain). – Bol. San. Veg. Plagas (Fuera de serie) 20: 311–320.

ISERN-VALLVERDÚ, J. & PARDO GONZÁLEZ, J.E. (1990): Contribución al estudio de los orthópteros (Insecta: Orthoptera) del Parque National de Ordesa y Monte Perdido. – Lucas Mallada 2: 145–160.

ISERN-VALLVERDÚ, J. & PEDROCCHI, C. (1994): Effect of the abandonment of mountain pastures on the Orthoptera populations in the northwest of Spain. – Articulata 9 (2): 15–23.

KÜHNELT, W. (1960): Verbreitung und Lebensweise der Orthopteren der Pyrenäen. – Zool. Beitr., N.F. 5: 557–580.

LASANTA, T., GONZÁLEZ-HIDALGO, J., VICENTE-SERRANO, S.M. & SFERI, E. (2006): Using landscape ecology to evaluate an alternative management scenario in abandoned Mediterranean mountain areas. – Landscape and Urban Planning 78: 101–114.

LOBO, J.M., CASTRO, I. & MORENO, J.C. (2001): Spatial and environmental determinants of vascular plant species richness distribution in the Iberian Peninsula and Balearic Islands. – Biol. J. Linn. Soc. 73: 233–253.

MOSSOT, M. & PETIT, D. (2000): Présence de *Chorthippus binotatus binotatus* (Charpentier, 1825) dans le Vaucluse (Orth., Acrididae). – Bull. Soc. Entomol. Fr. 105: 251–252.

MÜHLENBERG, M. (1993): Freilandökologie. 3. Aufl. – Quelle & Meyer, Heidelberg, Wiesbaden; 430 S.

ORCI, K.M., RAGGE, D.R. & REYNOLDS, W.J. (2002): A re-examination of the taxonomy of *Euchorthippus pulvinatus* and related species on the basis of morphology and song (Orthoptera: Acrididae). – J. Natural History 36: 585–600.

PICAUD F., GLOAGUEN, V. & PETIT, D. (2002): Mechanistic aspects to feeding preferences in *Chorthippus binotatus* (Acrididae, Gomphocerinae). – J. Insect Behav. 15: 513–525.

PONIATOWSKI, D. & FARTMANN, T. (2008): The classification of insect communities: Lessons from Orthoptera assemblages of semi-dry calcareous grasslands in central Germany. – Eur. J. Entomol. 105: 659–671.

PONIATOWSKI, D., DEFAUT, B., LLUCIÀ-POMARES, D. & FARTMANN, T. (2009): The Orthoptera fauna of the Pyrenean region – a field guide. – Articulata, Beiheft 14: 1–143.

SAMWAYS, M.J. (2005): Insect Diversity Conservation. – Cambridge University Press, Cambridge; 342 pp.

SÄNGER, K. (1977): Über die Beziehungen zwischen Heuschrecken (Orthoptera: Saltatoria) und der Raumstruktur ihrer Habitate. – Zool. Jb. Syst. 104: 433–488.

SEBASTIÀ, M.T., DE BELLO, F., PUIG, L. & TAULL, M. (2008): Grazing as a factor structuring grasslands in the Pyrenees. – Appl. Veg. Sci. 11: 215–222.

SCHMIDT, G.H. (2000): Ein Beitrag zur Orthopterenfauna der spanischen Pyrenäen. – Articulata 15 (2): 131–162.

STOROZHENKO, S.Yu. (2004): Long-horned orthopterans (Orthoptera: Ensifera) of the Asiatic part of Russia. – Dalnauka, Vladivostok, 280 S. (In Russian)

SUNDERMEIER, A. (1998): Methoden zur Analyse der Vegetationsstruktur. – In: TRAXLER, A. (Hrsg.): Handbuch des vegetationsökologischen Monitorings. Teil A: Methoden. – Umweltbundesamt Wien: 123–158.

SZÖVÉNYI, G. (2002): Qualification of grassland habitats based on their Orthoptera assemblages in the Közeg Mountains (W-Hungary). – Entomol. Exp. Appl. 104: 159–163.

VAN WINGERDEN, W.K.R.E, MUSTERS, J.C.M., KLEUKERS, R.M.J.C., BONGERS, W. & VAN BIEZEN, J.B. (1991): The influence of cattle grazing intensity on grasshopper abundance (Orthoptera: Acrididae). – Proc. Exp. & Appl. Entomol., N.E.V. 2: 28–34.

VILLAR, L., SESÉ, J.A. & FERRÁNDEZ, J.V. (1997): Atlas de la Flora del Pirineo Aragonés. Vol. I. – Instituto de Estudios Altoaragoneses y Consejo de Protección de la Naturaleza de Aragón, Huesca; XCI + 648 S.