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Ant biodiversity conservation in Belgian calcareous grasslands: active management is vital

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ABSTRACT. A list of ant species collected in eight calcareous grasslands in the Viroin valley (Viroinval, Belgium) is presented. Thirty species were identified, including *Temnothorax albipennis*, for the first time recorded in Belgium. Ant community composition and chorology of some ant species are discussed. Recommendations on how to use ant community composition and nest densities of several ant species to evaluate management in calcareous grasslands are given. It appears that in locations with encroachment of tall grasses (especially *Brachypodium pinnatum*) and spontaneous afforestation, due to a complete lack of or to inadequate management, most of the often rare xerophilic ant species are replaced by mesophilic, rather common species.

KEY WORDS : ant biodiversity conservation, calcareous grassland, nature management, Belgium

ABSTRACT. Un inventaire des fourmis collectées à l'aide de pièges d'activité dans huit pelouses calcicoles de la vallée du Viroin (Viroinval, Belgique) est présenté. Trente espèces ont été identifiées dont une, *Temnothorax albipennis*, est signalée pour la première fois de Belgique. Des remarques sont données sur les communautés de fourmis et leur composition spécifique, ainsi que sur la chorologie de certaines espèces. Des suggestions sont émises à propos de la prise en compte des communautés de certaines espèces de fourmis et des densités de leurs nids dans le cadre de l'évaluation des effets de la gestion des pelouses calcicoles. A cet égard, nous pensons que dans les sites où le tapis graminéen (comme le *Brachypodium pinnatum*) se densifie ou que la recolonisation préforestière s'amorce, la plupart des espèces xérothermophiles, souvent rares et très localisées, seront remplacées par des éléments plus mésophiles, largement plus répandus et communs.

INTRODUCTION

The calcareous grasslands of northwestern Europe comprise the dry grasslands on limestone and chalk as well as those on calcareous loess. These grasslands originated after felling of primordial forest, which had already started in prehistoric times. Since these habitats are semi-natural, they require some form of management by grazing or mowing to prevent afforestation. They were once widespread in the hilly calcareous regions of Europe, but because of changes in agricultural practice their extent has decreased dramatically. Since World War II urbanisation, abandonment of grazing practice and fertilisation resulted in a dramatic decrease of these grasslands in Belgium. Everywhere in Europe this habitat type is severely pressured by threats that impinge upon several ecological communities. A shift in land use is one of the most important among these. Moreover the remaining areas are often strongly fragmented. This poses threats of extinction and inbreeding for the remaining characteristic arthropod populations (WALLISDEVRIES et al., 2002; VANDEWOESTIJNE et al., 2005).

Calcareous grasslands, especially the ones on dry slopes and plateaus, are known as being rich in plant diversity and they often contain many rare species (MITCHLEY & XOFIS, 2005). Regions which have this rich floristic diversity are often biodiversity hot spots for a wide variety of invertebrates. In Belgium the calcareous grasslands of the Viroin valley are such habitats (ADAM et al., 1991; HONNAY et al., 2004; BUTAYE et al., 2005a,b). They are catalogued as a Belgian hot spot for several groups, i.e. Heteroptera (DELESCAILLE et al., 1991), Saltatoria (DECLEER et al., 2000), butterflies (GOFFART & DE BAST, 2000; VANDEWOESTIJNE et al., 2005), bees and wasps (CLAESSENS, 1992; LONGO et al., 1992) and spiders (BARA, 1991).

In Belgium the ant fauna of these habitats is rather poorly investigated. Elsewhere in Europe calcareous grasslands and other similar thermophilic grasslands are known to have a rich ant fauna often including very rare species (MABELIS, 1983; GALLÉ, 1986; SEIFERT, 1996; MEYER-HOZAK, 2000; BRASCHLER & BAUR, 2003; 2005; OTTONETTI et al., 2006). In the northern part of the country (Flanders), calcareous grasslands are scarce and the one that was recently well studied at the Sint-Pietersberg, was indeed a hot spot of ant biodiversity (more than 25 species) in Flanders (DEKONINCK et al., 2003; 2005). In the southern part of Belgium (Wallonia), calcareous grasslands are more widespread but their ant fauna is poorly known. Gaspar (1965; 1971) investigated the habitat type in the Famenne region, whilst the Viroin valley has been studied by Lemal (1978) and later by Delescaille et al. (1991). But others have never been sampled for their ant fauna. Recently, two localities in the Viroin valley, respectively at Treignes and Vaucelles, were studied by Baugnée (2004). He recorded *Camponotus piceus* (Leach, 1825) for the first time in Belgium and suggested that this interesting region still has a lot of entomological "secrets" to reveal. Hence, when a new pitfall sampling campaign on xeromorphic and rocky soils (*Xerobromion*=XB and *Mesobromion*=MB) in the Viroin valley was started, rare, extinct or new species for the Belgian ant fauna were expected. As different nature management types, microhabitats and vegetations were sampled, this study also enables us to evaluate the influence of the type or the lack of management in these grasslands on the occurring ant communities.

The main aim of the present inventory is to investigate if there is a specific ant fauna in the typical xeromorphic, rocky and calcareous grasslands of the Viroin valley and to give a complete list of all known ant species of this region. We also want to essay the possibilities to use ant community composition and the occurrence and abundance of several typical ant species to evaluate the effects of management and to make some remarks on the importance of active management for ant community composition of calcareous grasslands in general.

MATERIALS AND METHODS

Study area

The Viroin valley is located in southwestern Belgium, mainly in the municipality of Viroinval (province of Namur). The Viroin, a river of medium size (about 25km long and 5-10m width) flows between a succession of hills and joins with the Meuse near Givet in the French Ardennes. The geological formation dates from the Devonian period and occurs as limestone hills ('Tiennes' in French) in the landscape. In the Viroin valley two major types of calcareous grasslands are present: mesomorphic calcareous grasslands with five different plant communities, and xeromorphic grassland with three different plant communities (see Honnay et al., 2004; Butaye et al., 2005a,b). The mesomorphic calcareous grasslands in the Viroin valley belong to the *Mesobromion* and show an intermediate position between the Central European and Atlantic calcareous grassland communities (Butaye et al., 2005a). The xeromorphic calcareous grassland communities on the other hand show strong affinities with the calcareous vegetation of Central Europe and southern Europe. The Viroin valley is a favourite region for entomologists and other naturalists because some of the most notable Belgian calcareous grasslands occur there (Duvigneaud et al., 1990).

TABLE 1

Codes, locality, description, management, exposition, distance to other habitat and area of the sampled localities (with temperature: +=cold, ++=warm, +++=hot sites)

Code	Locatity (city)	Vegetation and description site	Temperature	Management	Exposition	Distance to other habitat	Area
TdL(WO)	Tienne du Lion (Frasnes)	Open woodland: *Pinus nigra nigra*, *Brachypodium pinnatum*, *Teucrium chamaedrys*, mosses on NW slope.	+	None	South-East	20m open grassland	10.000m²
Cha(XB)	Chalaine (Nismes)	*Xerobromion*: xeromorphic site with a lot of stones and bare ground; vegetation: *Teucrium chamaedrys*, *Galium pumilum*, *Anthyllis vulneraria*, *Thymus praecox*, *Helianthemum nummularium* and *Ononis repens*.	+++	Short intensive summer grazing	South	40m forest and arable field	2.500m²
FdC(XB)	Fondry des Chiens (Nismes)	*Xerobromion*: south-exposed slope with stones and a scarce vegetation, a sharp slope, with vegetation similar to Cha(XB).	+++	None	South	100m forest	4.500m²
RTr(MB-XB)	Roche Trouée (Nismes)	*Meso-Xerobromion*: south-exposed slope with grasses (*Brachypodium pinnatum* and *Festuca ovina*) but also other typical calcareous herbs.	++	Short intensive summer grazing	South	20-25m forest	2.500m²
TaP(XB)	Tienne aux Pauquis (Dourbes)	*Xerobromion*: a lot of stones, short grassland on a sharp slope, *Origanum vulgare*, *Sedum* sp., *Teucrium chamaedrys* and *Prunella lanciniata*.	+++	None	South-West	25m forest	2.000m²
TaP(MB)	Tienne aux Pauquis (Dourbes)	*Mesobromion*: uniform grass layer (80%) surrounded by *Buxus-Carpinus betulus* forest, regularly chopped.	+	None (regularly chopping)	South-West	5-10m forest	6.000m²
TdR(MB-XB)	Tienne des Rivelottes (Treignes)	*Meso- Xerobromion*: straight, south-exposed slope, with *Gymnadenia conopsea*, *Sanguisorba minor*, *Cirsium acaule*, *Potentilla neumanniana*, *Helleborus foetidus* and *Scabiosa columbaria*.	+++	Mowing in September	South	25m forest	8.750m²
Aba(MB)	Les Abannets (Nismes)	*Mesobromion* with well developed *Brachypodium pinnatum* layer.	++	None	South	20m forest	7.500m²

TABLE 2

Vegetation characteristics at each site (given in percentage ground cover or height in cm) (TdL=Tienne du Lion; Cha=Chalaine; FdC=Fondry des Chiens; RTr=Roche Trouée; TaP=Tienne aux Pauquis; TdR=Tienne des Rivelottes and Aba=Les Abannets).

Code site	Stones %	Trees %	Shrubs %	Herbs %	Grasses %	Mosses %	Veg Height (cm)	Bare ground %	*Brachypodium pinnatum* %	*Festuca ovina*
TdL(WO)	5	15	15	10-15	80	50	30-40	0	75	0
Chat(XB)	20	0	0	80	15	20	15-20	10	5	10
FdC(XB)	40	0	15	75	20	30	15	5	0	20
RTr(MB-XB)	5	0	5	30	60	40	30	5	20	20
TaP(XB)	45	0	10	20	40	20	20	25	5	40
TaP(MB)	0	0	10	35	80	5	35	5	70	5
TdR(MB-XB)	10-15	0	10	30	40	5	30	5	20	20
Aba(MB)	0	0	20	45	90	5	45	0	80	0

In this study, eight localities were sampled for ants (see Table 1 and 2). They are all included in part of the nature reserve of the Viroin (for details, see http: //mrw.wallonie.be/dgrne/sibw).

Sampling and identification of ants

In all investigated grasslands three pitfall traps were installed. Pitfalls with a diameter of 9,5cm were placed in a row, spaced 3-5m apart. A 3,5% formaldehyde solution was used as a fixative and detergent was added to lower surface tension. Pitfalls were emptied monthly. Sampling lasted from September 2002 until October 2003.

Although the use of pitfall trapping to collect ants has been questioned by some (e.g. Seifert, 1990), in many investigations capture rates are used to estimate the relative abundance of particular species in simultaneously sampled sites, i.o.w. to assess the habitat preference of these species (Retana & Cerdá, 2000; Schlick-Steiner et al., 2005; Steiner et al., 2005; Botes et al., 2006; Ottonetti et al., 2006).

All species were morphometrically investigated and identified using Seifert (1996). Some specimens were inspected by B. Seifert and two gynes of *Lasius jensi* were deposited in the collection at the Staatliches Museum für Naturkunde of Görlitz. All other voucher specimens were deposited in the personal collection of the first author.

Implications and possibilities of pitfall sampling for ant community studies

Capture rates of pitfall traps not only depend on population densities (abundance) of the species caught, but also on intra- and interspecific differences in bottom surface activity levels and in trapping efficiency as influenced by habitat structure (Greenslade, 1964, Maelfait & Baert, 1975, Baars, 1979, Halsall & Wratten, 1988; Antvogel & Bonn, 2001; Bonte et al., 2003). Therefore, they are not suited to compare different species in their abundance. If, however, resulting from a long enough sampling period in not too structurally different sampling sites, they give good estimates of the relative abundance of each particular species over the sampling sites (Maelfait & Baert, 1975; Baars, 1979; Desender & Maelfait, 1986; Maelfait, 1996). When used for ordinations capture rates therefore have to be transformed giving each species equal weight, what we did hereafter in the program PC-ORD (Mc Cune & Mefford, 1999; Mc Cune & Grace, 2002). An indirect gradient analysis, Detrended Correspondence Analysis (DCA) was carried out. Only the most abundantly caught species were used here. DCA-ordinations are interpreted against the background of the available dataset of environmental variables, yielding a biplot, based on the ‘a posteriori’-obtained significant correlation values between DCA axes and environmental variables.

Indicator Species Analysis

Characteristic species for different types of calcareous grasslands or different management regimes were explored by Indicator Species Analysis (Dufrêne & Legendre, 1997). An Indicator Species Analysis is a useful method to find indicator species and/or species assemblages characterising groups of samples. This analysis gives information on the concentration of species abundance in a particular group of samples and on the faithfulness of occurrence of a species in this particular group. Indicator values are tested on their statistical significance using a randomization (Monte Carlo) technique. *A posteriori* groups that were tested here are the ones obtained by DCA analysis and the groups of pitfalls with the same management regime. Species with a significant IndVal higher than 50% are considered as ‘indicators’ i.e. characteristic and/or typical for a group of pitfalls.

Characterisation of the environmental variables

At each of the eight sampling sites the most abundant plant species were noted and the habitat structure determining variables such as dominant grasses (percentage ground cover of *Festuca ovina* and *Brachypodium pinnatum*), cover of other vegetation layers (herbs, trees, mosses, bare ground, the amount of stones and rocks and vegetation height were estimated (see Table 2). High abundance of *B. pinnatum* is often used as an indicator of calcareous grassland habitat deterioration and is a negative indicator of habitat quality and condition (Bobbink & Willems, 1987; 1988; 1991; Bobbink et al., 1988; Butaye et al., 2005a,b; Mitchley & Xofis, 2005). Also temperature conditions, exposition, total habitat area and distance to other habitat were noted (see Table 1).

Management

In most calcareous grasslands in the Viroin valley, management measures for biodiversity conservation are of recent date. Only in three sites a continuous management is carried out (Table 1). In Roche Trouée and Chalaine both situated in Nismes, short intensive summer grazing is used to control tall grass encroachment and consists of 20-25 sheep that are put in a 25 x 25m mobile raster "as long as needed". In Tienne de Rivelottes the management regime during the last years was mowing in September.

RESULTS

Faunistics and general results

During the study 30 different species were found (37.5% of the Belgian Formicidae (DEKONINCK et al., 2006)). *Temnothorax albipennis* was recorded for the first time in Belgium. The ant fauna composition of the different sites is presented in Table 3. *Lasius niger* (Linnaeus, 1758) the most common Belgian ant, was not found during the project. Two species were found in each of the

TABLE 3

Species composition at the different sites (x=only found in isolated specimen or very small numbers, xx=abundant, xxx=very abundant) with Belgian status (CO=common ant species, RA=rare and VR=very rare ant species) and between () their habitat preference (Ca=calcareous grasslands and rocky habitats, Xe=xeromorphic grasslands and other hot habitats, Wo=woodlands, Bo=bogs, He=heathlands), (TdL=Tienne du Lion; Cha=Chalaine; FdC=Fondry des Chiens; RTr=Roche Trouée; TaP=Tienne aux Pauquis; TdR=Tienne des Rivelottes and Aba=Les Abannets).

Species	Used codes	Status (habitat preference)	Location							
			TdL (WO)	Cha (XB)	FdC (XB)	RTr (MB-XB)	TaP (XB)	TaP (MB)	TdR (MB-XB)	Aba (MB)
Aphaenogaster subterranea (Latreille, 1798)	APHASUBT	RA (Ca)			xxx				x	
Formica cunicularia (Latreille, 1802)	FORCCUNI	CO		x	x	x	xx		x	
Formica fusca Linnaeus, 1758	FORCFUSC	CO	x			x	xx	x		
Formica lusatica Seifert, 1997	FORCLUSA	RA (Xe)				x				
Formica pratensis Retzius, 1783	FORCPRAT	RA (Xe)	x							x
Formica rufibarbis Fabricius, 1798	FORCRUFI	RA (Xe)		x		x	x			
Formica sanguinea Latreille, 1798	FORCSANG	CO (Xe, He)		x						
Lasius alienus Förster, 1850	LASIALIE	CO (Ca)	x	xxx	xxx	xxx	xxx	x	xxx	xx
Lasius flavus (Fabricius, 1781)	LASIFLAV	CO		xx	x	x	x	x	x	x
Lasius fuliginosus (Latreille, 1798)	LASIFULI	CO	x	x						x
Lasius jensi Seifert, 1986	LASIJENS	VR (Ca)			x				x	
Lasius mixtus (Nylander, 1846)	LASIMIXT	CO	x	x	x	x	x		x	
Lasius platythorax Seifert, 1991	LASIPLAT	CO (Wo, Bo)	xxx			xx	x	x		xxx
Lasius sabularum (Bondroit, 1918)	LASISABU	RA				x				
Lasius umbratus (Nylander, 1846)	LASIUMBR	CO							x	
Leptothorax acervorum (Fabricius, 1793)	LEPTACER	CO	x							
Temnothorax albipennis (Curtis, 1854)	TEMNALBI	RA (Ca)				x				
Temnothorax interruptus (Schenck, 1852)	TEMNINTE	RA (Ca)		xx	x		x		x	
Temnothorax nylanderi (Förster, 1850)	TEMNNYLA	CO (Wo)					x		x	
Temnothorax unifasciatus (Latreille, 1798)	TEMNUNIF	RA (Ca)					x			
Myrmica rubra Linnaeus, 1758	MYMIRUBR	CO	x	x						
Myrmica ruginodis Nylander, 1846	MYMIRUGI	CO (Wo)	xx							x
Myrmica sabuleti Meinert, 1860	MYMISABU	CO	xx	x	xxx	xxx	xxx	xxx	x	x
Myrmica scabrinodis Nylander, 1846	MYMISCAB	CO	x	x	x	x	xx		x	x
Myrmica schencki Emery, 1894	MYMISCHE	RA (Xe)	x	xxx			x			
Myrmecina graminicola (Latreille, 1802)	MYRMGRAM	(RA) under recorded		x	x	xxx	x		x	x
Ponera coarctata (Latreille, 1802)	PONECOAR	RA (Xe)		x		x				
Stenamma debile (Förster, 1850)	STENDEBI	CO (Wo)	x						x	
Tapinoma erraticum (Latreille, 1798)	TAPIERRA	CO (Ca)	xx	x	xxx	xx	x	xx	xx	xx
Tetramorium impurum (Förster, 1850)	TETRIMPU	CO		x	x		xx	xx		
number of species			**14**	**16**	**12**	**15**	**16**	**7**	**14**	**10**

eight sites in high abundances: *Lasius alienus* and *Tapinoma erraticum*. The ant species richness per site is not significantly correlated with any of the habitat variables, although there is a nearly significant negative correlation with *Brachypodium pinnatum* cover (r=-0.6486, p=0.082).

Status of the collected species

On the basis of conservation status (common, rare, very rare) and habitat choice in Belgium, several groups can be discerned in our species list (Table 3). First we have common Belgian ant species with no preference for any type of habitat (CO in Table 3). We can consider them as additional species in calcareous grasslands. We found 18 of these common ant species (58% of the total).

We also found 12 rare and very rare species (marked with RA and VR in Table 3) restricted in their occurrence to one habitat type (Table 3). Almost all of them have a preference for xeromorphic or rocky habitats in calcareous grasslands. They can be considered as typical species for these grasslands as they are only very exceptionally observed outside these xeromorphic habitats. The observations of *Lasius jensi* are the 3rd and 4th record of this species in Belgium (Dekoninck & Vankerkhoven, 2001). This species, strictly bound to this particular habitat (Seifert, 1996), is very rare and threatened in our country. In general the number of rare and very rare species per site is positively correlated with percentage ground cover of *Festuca ovina* (r=0.71 p<0.05) and negatively with *Brachypodium pinnatum* cover (r=-0.86 p<0.05).

Community analysis and correlations with environmental variables

For the indirect gradient analysis only the 14 most abundantly caught species were used. The DCA diagram (Axis 1 and 2) is shown in Fig. 1. Ordination of the sites reveals three groups (Fig. 1). Tienne du Lion and Les Abannets belong to Group 1. The latter is a dense grassland, the other an open woodland with a dense undergrowth, both lacking patches of bare ground and surfacing rocks i.e. they can be characterised as open woodland and as a degraded *Mesobromion* (Table 1). The *Brachypodium pinnatum* cover of these sites is more than 75%. They show a typical ant fauna for woodlands and woodland edges with few thermophilic species. All sites of Group 2 and 3 are *Meso-* and/or *Xerobromions* (MB or XB) with surfacing rocks and stony debris, patches of bare ground and high insolation. The small patches of dense vegetation occurring there are composed of calcareous herbs, not grasses. The sites from Group 2 and 3 (on the left of Fig. 1) have higher average species richness (13.4±3.4) than the sites from Group 1 (12.0±1.0).

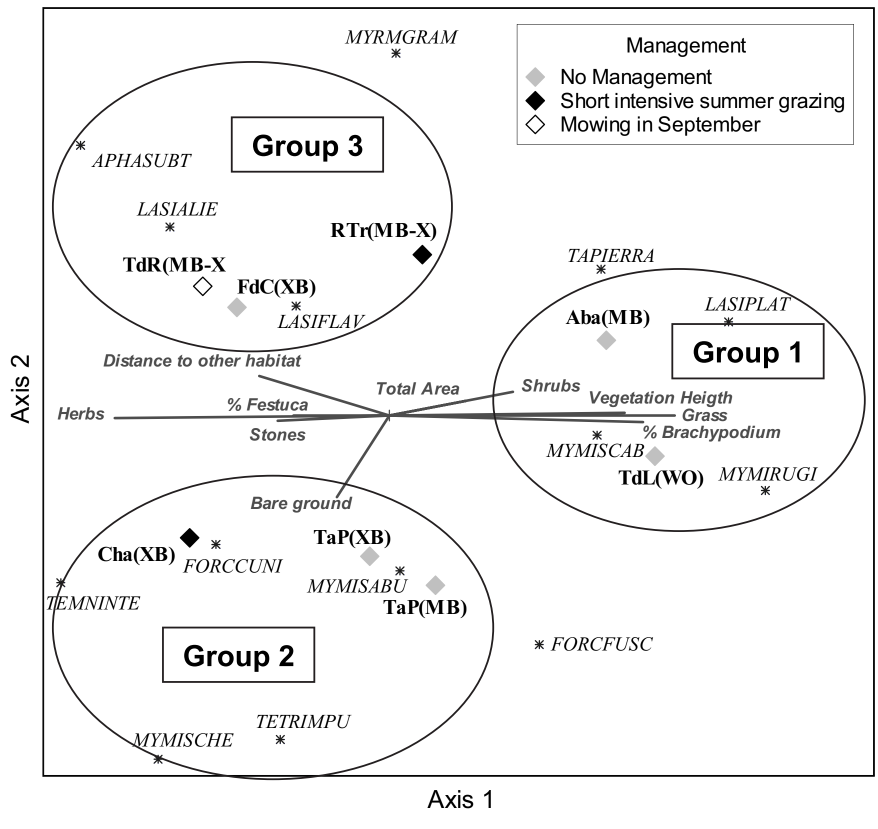

Fig. 1. – Detrended Correspondence Analysis (DCA) diagram (Axis 1 and 2) with 14 most dominant species (percentages explained on Axis 1=58% and on Axis 2=22%). Species are presented with * and their codes (see Table 3) and the sites presented with ◆ in a different colour according to their management (TdL=Tienne du Lion; Cha=Chalaine; FdC=Fondry des Chiens; RTr=Roche Trouée; TaP=Tienne aux Pauquis; TdR=Tienne des Rivelottes and Aba=Les Abannets and WO=woodland, MB=*Mesobromion* and XB=*Xerobromion*).

The abundances of two species are significantly positively correlated with the first axis: *Lasius platythorax* (r=0.882, p<0.01) and *Myrmica ruginodis* (r=0.748 p<0.05). This axis is also positively correlated with the cover of grasses (r=0.901, p<0.01), cover of *Brachypodium pinnatum* (r=0.848 p<0.01) and with average vegetation height (r=0.817, p<0.05). Axis 1 is significantly negatively correlated with the cover of herbs (r=-0.883, p<0.01) and the abundance of *Lasius alienus* (r=-0.813, p<0.05). No species or environmental variable is significantly correlated with the second axis. We can conclude that the main differences in species composition are explained by the gradient going from xeromorphic towards mesomorphic environmental characteristics as was also found by Butaye et al., 2005a for plants.

Indicator species

Indicator species with a significant (p<0.05) IndVal higher than 50, were searched for in *a posteriori* groups of pitfalls. Indicator species for a group of pitfalls with the same management regime (3 regimes: No management, Short intensive summer grazing and mowing in September) and for the groups obtained by DCA (Group 1, 2 and 3) are presented in Table 4. For Group 1 from the DCA, five common less thermophilic ant species typical for forest, have a significant IndVal higher than 50: *Formica pratensis*, *Myrmica ruginodis*, *Lasius platythorax*, *Lasius fuliginosis* and *Leptothorax acervorum*. For the *Xerobromiums* and *Mesobromiums* we can distinguish a group (Group 2) with two common (*Myrmica sabuleti* and *Tetramorium impurum*) and one rare xeromorphic species (*Myrmica schencki*) as indicator species and a second group indicator species (for Group 3) with mostly rare and very rare xeromorphic ant species as *Aphaenogaster subterannea*, *Lasius jensi* and *Myrmecina graminicola* and the common ant *Lasius mixtus*.

For groups of pitfalls with the same management regime we also found indicator species. *Lasius platythorax*, an indicator for the less thermophilic ant species group, seems also an indicator for no management activity. Seven rare and xeromorphic species also appear to react positively to short intensive summer grazing management. *Lasius jensi*, *Lasius umbratus*, *Aphaenogaster subterranea*, *Stenamme debile* and *Temnothorax nylanderi* have a significant IndVal higher than 50 for the management regime mowing in September. However as this management regime was only present in one site, these results have to be interpreted with caution.

DISCUSSION

The Viroin valley: a hot spot for ant biodiversity in Belgium?

During this study 30 ant species were recorded. If some other neighbouring and not calcareous grassland localities (for example anthropogenic localities, dense forests, …) would have been sampled too, this list would have even been longer, e.g. *Lasius brunneus* (Latreille, 1798) and *Lasius niger* are very common and widespread species in their typical habitats in this region. *Temnothorax nigriceps* Mayr, 1855; *Solenopsis fugax* (Latreille, 1798); *Camponotus ligniperda* (Latreille, 1802) and *Lasius emarginatus* (Olivier, 1792) are also known for the region, but their colonies are only locally found (Lemal, 1978; Delescaille et al. 1991). Some other ant species were only recently found in the Viroin region (Baugnée, 2002; 2004): *Plagiolepis vindobonensis* Lomnicki, 1925; *Camponotus piceus* and *Temnothorax parvulus* (Schenck, 1852). Until now, a total of 40 ant species is known from the region. This is almost half of the Belgian ant fauna (Dekoninck et al., 2006). Hence, the region can be considered as a hot spot for ant biodiversity in Belgium.

TABLE 4

Indicatorspecies with a significant IndVal (IV) 50 (p<0.05), considered as ‘indicators’ typical for a group of pitfalls with the same management regime (3 regimes: No management, Short intensive summer grazing and mowing in September) and for the groups obtained by DCA (Group 1, 2 and 3)

Species	IV	p	Management
Lasius platythorax	64	0.03	No management
Formcica lusatica	50	0.03	Intensive summer grazing
Lasius sabularum	50	0.03	Intensive summer grazing
Temnothorax albipennis	50	0.03	Intensive summer grazing
Lasius flavus	65	0.02	Intensive summer grazing
Myrmecina graminicola	87	0.01	Intensive summer grazing
Formica rufibarbis	89	0.01	Intensive summer grazing
Ponera coarctata	100	0.01	Intensive summer grazing
Aphaenogaster subterranea	58	0.03	Mowing September
Lasius jensi	82	0.02	Mowing September
Stenamma debile	83	0.01	Mowing September
Temnothorax nylanderi	83	0.02	Mowing September
Lasius umbratus	100	0.02	Mowing September
Species	**IV**	**p**	**Group DCA**
Leptothorax acervorum	50	0.02	1
Lasius fuliginosis	75	0.01	1
Lasius platythorax	91	0.01	1
Formica pratensis	100	0.01	1
Myrmica ruginodis	100	0.01	1
Myrmica schencki	57	0.05	2
Myrmica sabuleti	66	0.03	2
Tetramorium impurum	94	0.01	2
Lasius mixtus	55	0.01	3
Aphaenogaster subterranea	67	0.01	3
Lasius jensi	67	0.01	3
Myrmecina graminicola	72	0.01	3

Ant communities in calcareous grasslands in the Viroin valley

Lasius niger, one of the most common Belgian ants, was not found during the sampling campaign. In the xero- and mesomorphic grassland sites studied here, this eurytopic ant species is replaced by another, less common *Lasius* s. str. species: *Lasius alienus*. Like *L. alienus*, also *Tapinoma erraticum* is found on each of the sites in high abundance. Both species can be considered as common for the region. They are typical for calcareous and other rocky habitats in Wallonia and are almost not present in Flanders (Boer et al., 2003; Dekoninck et al., 2003; 2005).

In calcareous habitats as the ones studied here, a lot of *Formica* species are found. The *Serviformica* species, *Formica lusatica*; *Formica cunicularia* and *Formica rufibarbis* are found in the open xeromorphic vegetations and are probably frequently used as slaves by *Formica sanguinea*. In less thermophilic sites the *Serviformica* species *Formica fusca* is probably often used to start the nests of the wood ant *Formica pratensis* (a *Formica* s. str. species). Although most *Formica* and *Serviformica* species have a rather wide foraging range and are sometimes found far from their nesting sites (BRASCHLER & BAUR, 2003), we suggest, as their occurrence on a particular site can rapidly be assessed by visual inspection, they can be used in evaluation and monitoring campaigns as indicators for a good management regime. Especially when a rapid evaluation of a site is needed the presence of one or several of these species is indicative for special micro-climatological conditions and high conservation value of the site.

Also within the genera *Myrmica*, *Temnothorax* and *Leptothorax* with small-sized species and the other *Myrmecinae* species we can clearly distinguish ant groups preferring specific temperature conditions (see Fig. 1; Table 3 and 4). Sites can be dominated by indifferent, less thermophilic ant species from woodlands and closed grassland vegetations, occurring here on places with a high ground cover of trees and of the grass *Brachypodium pinnatum*: *Myrmica ruginodis*, *Myrmica rubra*, *Myrmica scabrinodis, Stenamma debile* and *Leptothorax acervorum*. When tree and tall grass cover decrease and the site becomes a more thermophilic habitat, species from this group are replaced by *Tetramorium impurum*, *Myrmica sabuleti* and *Myrmica schencki* and with further decrease (as in the well-developed *Xerobromion* grasslands) by species as *Myrmecina graminicola*, *Aphaenogaster subterranea* and *Temnothorax interruptus*.

To detect changes in ant communities caused by changing management regime, pitfall trapping will be needed, because most of these species cannot be identified with certainty in the field (SEIFERT, 1988a; 1996). Moreover, the chance to detect their presence (small nests usually in low densities) by visual inspection in the field is very low. We recommend a monitoring by three to six pitfall traps (during 6 months May-October) in these sites where management regimes are changed or will be implemented.

The occurrence and abundance of *Lasius* s.str., and especially of a lot of *Chthonolasius* species can also be a good measure for the special temperature and vegetation conditions of well developed calcareous grassland and hence the nature value of particular sites. Their identification in the field is even more difficult (SEIFERT, 1988b; 1992; 1996) than the identification of most *Myrmecinae* species but in contrast to the latter, *Lasius* s. str. and even *Chthonolasius* spec. can be more easily collected in the field and their nest densities can be determined after identification of nest samples in the laboratory. Special attention should be given to the exact nest localities and local conditions of some of the rare *Chthonolasius* species. Also mixed nests could help us to reveal the host preference of these parasites (DEKONINCK et al., 2004; LEHOUCK et al., 2004). As is the case for the *Myrmecinae* species, also *Lasius* s.str. and *Chthonolasius* have characteristic species for different types of calcareous grasslands. Changes in their nest species composition, foraging abundance (to be detected with pitfall traps) and nest density (field observation and hand collecting) can be used in the evaluation of management measures.

In general, where encroachment of dominant grasses (*Brachypodium pinnatum*) and litter accumulation have already taken place in calcareous grasslands in the Viroin valley, the abundance of xerophilic, typical calcareous grassland species is lower than the abundance of less thermophilic, more common species. Species from more nutrient-rich grasslands can be expected to invade these neglected calcareous grasslands. When nests of thermophilic ant species decrease in number and are replaced by nests of species from the indifferent group, part of the very valuable ant fauna, characteristic for the region, will be lost.

Monitoring ant communities in calcareous grasslands?

Some of the studied calcareous grasslands in the Viroin region probably contain the richest ant faunas in Belgium and house a lot of very rare species. So management and monitoring is needed to conserve these very important ant communities. Calcareous grasslands are predominantly semi-natural habitats and they require some form of management by grazing or mowing. Here, different species or species groups can have conflicting demands as long-term experiments on the management of calcareous grasslands have clearly shown that very often different taxonomic groups react in a different way on the respective management treatments (BRAUCKMANN et al., 1997; WALLISDEVRIES et al., 2002). Habitat quality is often diminished by the encroachment of dominant grasses (*Brachypodium pinnatum*) and litter accumulation (BUTAYE et al., 2005a) due to a lack of active management, too low intensity management and probably also by eutrophication through aerial deposition (WALLISDEVRIES et al., 2002).

At present two sites lack management and continue evolving towards shrub and tree vegetations with high abundances of *B. pinnatum*. As we saw, two species are significantly positively correlated with that type of vegetation change: *Lasius platythorax* and *Myrmica ruginodis* Monitoring by pitfall traps and mapping nests of these two ant species could be an early warning system to assess the effects of management or of the lack of it. High abundance of the very competitive grass *B. pinnatum* is mostly caused by insufficient management (BOBBINK & WILLEMS, 1987; 1991; BUTAYE et al., 2005a,b) and increasing nutrient deposition (BOBBINK & WILLEMS, 1988) it leads to a dramatic decrease of the nature value of calcareous grassland (BOBBINK & WILLEMS, 1987; 1991; MITCHLEY & XOFIS, 2005).

Sometimes very contradictory views can be found in literature on the effects of grazing management in general or particular forms of it on the biodiversity of grasslands (BESTELMEYER & WIENS, 2001; BOULTON et al., 2005), and calcareous grasslands in particular (FISCHER et al., 1996; DUTOIT & ALARD, 1997; BARBARO et al., 2001; DAUBER & WOLTERS, 2005; MITCHLEY & XOFIS, 2005). Here only short intensive summer grazing with sheep and no grazing management can be evaluated. Under sheep grazing conditions the vegetation in *Mesobromions* occurs as a short, tight turf with an extremely high plant species richness and diversity turnover at a strikingly small scale (Butaye et al., 2005a). In such situations, grazing can indeed favour ant communities from the thermophilic group. When mesomorphic calcareous grasslands are abandoned or management is lacking, their stability is disrupted and *B. pinnatum* starts to dominate resulting in higher vegetation and large amounts of litter. Both processes cause a reduction of the light penetration to the ground, resulting in a decrease in the competitive ability and finally to local extinction of typically xerophilic plant species (Butaye et al., 2005a) and, as we see here, the ant species bound to that kind of vegetation. In *Xerobromions* the regional climate is often modified on a local scale by the influence of topography. Inclination and exposition determine the openness of the vegetation, but when shifting towards more mesomorphic environments, grazing by sheep or rabbits becomes increasingly important.

Not only in this particular region, but also elsewhere in Belgium and Europe, it is likely that in calcareous grasslands with an increasingly dense and high grass layer due to a lack of or an inadequate management, endangered xerophilic ant species will be replaced be mesophilic, rather common species. As management to restore the former open xeromorphic grasslands sites by mowing, grazing and selective clearing started only recently in the Viroin valley, two types of ant monitoring can be very useful. Regularly mapping the nests of *Formica* species and typical xerophilic ant species that can be recognised in the field as *Aphaenogaster subterranean* and *Temnothorax interruptus* and also monitoring by pitfall trapping (3-6 pitfalls during 6 months May-October) for all xeromorphic and rare species that can not be recognized in the field, can be good instruments to evaluate management effects (Braschler & Baur, 2003; 2005; Englisch et al., 2005). This may also give us more insights in the habitat preferences of the many rare ant species occurring there. We therefore recommend starting an ant monitoring of these grasslands of European importance.

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