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Habitat preferences of selected Central European centipedes

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Abstract

In the eastern German states of Saxony-Anhalt, Thuringia and Saxony the centipede fauna of 217 sites belonging to 12 biotope types was studied by pitfall trapping. The following ecological categories of the species can be distinguished: 1. Inhabitants of wet to humid habitats with high vegetation cover, 2. Inhabitants of habitats with high vegetation cover, 3. Inhabitants of dry to very dry habitats with low vegetation cover and without relation to humidity, 4. Inhabitants of dry to very dry habitats without relation to vegetation cover, 5. Inhabitants of wet to humid habitats with low vegetation cover and 6. Species without clear habitat preference. The results are discussed in relation to literature data.

1. Introduction

Since 1998, legal requirements in Germany necessitate the provision of comprehensive protection for the structure and function of soil biocoenoses. Therefore diagnosis and assessment of biological soil quality has become a matter of increasing interest.

Centipedes are essential components of the predatory arthropod fauna. Because of their considerable suitability as indicators of ecological site conditions, they attract a great deal of attention. The use of a species as a biological indicator is based on knowledge of its ecological behaviour, phenology and bionomical strategy. Laboratory investigations of centipede autecology are almost completely lacking. Hence the ecological preferences of species are analysed using their occurrence in different habitats.

This study investigates the distribution of centipede species at a large number of sites. The results should allow better characterisation of the habitat preferences of frequent species.

2. Materials and methods

2.1. Material

Since more than 40 years the State Museum of Natural History Görlitz has continuously brought together material from different sites in eastern parts of Germany, Saxony, Saxony-Anhalt and Thuringia (Dunger 2005).

The material was collected by pitfall trapping. Only large series were used (70 to 360 trap contents per site and a collecting period over one year at least). Only species found at more than 10 sites were included in the analysis of habitat preference. 26 species with a total of approximately 8000 individuals were investigated.

Tab. 1 Site description.

Habitat	Abbreviation	Plant association	Federal state	Number of sites	Site characters
Bogs and swamps	B/S	*Sphagnetalia magellanici*, *Scheuchzerietalia palustris*	Saxony-Anhalt Saxony	16	very wet, low vegetation cover
Flood plains and swamp forests	F/S	*Alnetum*, *Betuletum*, *Salicetum*, *Ledo palustris-Pinetum*	Saxony-Anhalt	25	very wet, high vegetation cover
Stream- or riversides	B/R	*Alnus*- or *Alnus-Fraxinus*- and *Salix*- populations *Urtico dioicae-Aegopodietum*	Saxony-Anhalt Thuringia	8	wet to very humid, high vegetation cover
Moist meadows and pastures	M/P	*Molinio-Arrhenatheretea*, *Dauco-Arrhenatheretum* (fresh formation), *Onobrychido-Brometum* (fresh formation)	Thuringia Saxony-Anhalt Saxony	35	fresh to humid, low vegetation cover
Deciduous and deciduous mixed forests	DF	*Fagetalia*, *Querco-Carpinetum*	Thuringia Saxony-Anhalt Saxony	35	fresh to humid, high vegetation cover
Coniferous forests	CF	*Piceetum*, *Pinetum*	Thuringia Saxony-Anhalt Saxony	18	dry, high vegetation cover
Thermophilic woods	TW	*Quercetalia pubescenti-petraeae*, *Tilio-Carpinetum* on sandy-loamy soils	Saxony-Anhalt	3	dry, high vegetation cover

Habitat	Abbreviation	Plant association	Federal state	Number of sites	Site characters
Special structures	SS	semi-natural and anthropogenic vegetation-poor sites (clear cutting, granite debris)	Saxony-Anhalt	5	dry, low vegetation cover
Fields and fallows on different soils	F/F		Saxony-Anhalt	7	dry, low vegetation cover
Xeric shrub societies	XSS	*Berberidion* with the association *Ligustro-Prunetum spinosae* and pioneer forests tending towards the association *Potentillo albae-Quercetum petraeae* on loamy-marly soils	Saxony-Anhalt	8	dry, middle vegetation cover
Xeric and mesoxeric meadows	XM	– pioneer sandy xeric meadows – *Corynephorion canescentis* with the association *Spergulo morisonii-Corynephoretum canescentris* on dry and warm, nutrient-poor inland dunes with loose Pleistocene sand – persistent sandy xeric meadows – *Armerion elongatae* on sandy, dry soils with a more or less dense sod – submediterranean mesoxeric sites with *Mesobromion erecti* on limestone (»Muschelkalk«) and loess sites with continental mesoxeric meadows (*Cirsio-Brachypodion*)	Saxony-Anhalt Thuringia	46	very dry, low vegetation cover
Dwarf-shrub heaths	DSH	– subatlantical DSH (*Genisto pilosae-Callunetum*) on nutrient-poor, sandy soil (podsol) – sub-alpine DSH (*Pulsatillo-Nardetum*) on granite gravel at the hilltop of the Brocken, 1110 m NN	Saxony-Anhalt	10	very dry, low vegetation cover

Tab. 2 Distribution of centipede species along a »humidity- and vegetation-gradient« of 217 sites in East Germany using P_{rel}.

	Humidity		Vegetation cover		
	wet	dry	high	middle	low
1. Inhabitants of wet to humid habitats with high vegetation cover					
Geophilus insculptus Attems, 1895	95.4	4.6	95.4	0	4.6
Lithobius curtipes C. L. Koch, 1847	88.7	11.3	100	0	0
Lithobius tenebrosus Meinert, 1872	85.2	14.8	83.3	0	16.7
Lithobius pelidnus Haase, 1880	76.4	23.6	73.4	0	26.6
2. Inhabitants of habitats with high vegetation cover					
Strigamia acuminata (Leach, 1814)	58.3	41.7	72.0	4.2	23.8
Lithobius nodulipes Latzel, 1880	52.9	47.1	62.9	0	37.1
3. Inhabitants of dry to very dry habitats with low vegetation cover without relation to humidity					
Cryptops hortensis Leach, 1814	3.1	96.9	3.1	0	96.9
Lithobius calcaratus C. L. Koch, 1844	6.2	93.8	18.8	6.5	74.7
Schendyla nemorensis (C. L. Koch, 1837)	6.7	93.3	24.7	17.5	57.8
Strigamia crassipes (C. L. Koch, 1835)	12.6	87.4	7.0	15.2	77.8
Cryptops parisi Brölemann, 1920	17.1	82.9	0	37.4	62.6
Lithobius microps Meinert, 1868	20.8	79.2	24.2	21.1	54.7
Geophilus flavus (De Geer, 1778)	21.5	78.5	21.5	24.2	54.3

	Humidity		Vegetation cover		
	wet	dry	high	middle	low
4. Inhabitants of dry to very dry habitats without relation to vegetation cover					
Lithobius austriacus Verhoeff, 1937	24.4	75.6	68.4	0	31.6
Lithobius melanops Newport, 1845	0	100	18.2	20.5	61.3
Lithobius erythrocephalus C. L. Koch, 1847	3.1	94.1	56.4	0	43.6
Lithobius muticus C. L. Koch, 1847	10.4	89.6	50.7	11.5	37.8
Geophilus electricus (Linné, 1758)	19.8	80.2	45.0	20.6	34.4
Lithobius forficatus (Linné, 1758)	29.7	70.3	42.4	13.3	44.3
5. Inhabitant of wet to humid habitats with low vegetation cover					
Lamyctes emarginatus (Newport, 1844)	68.2	31.8	23.3	0	76.7
6. Species without clear habitat preference					
Lithobius agilis C. L. Koch, 1847	50	50	52.8	0	47.2
Lithobius crassipes L. Koch, 1862	38.8	61.2	54.2	13.5	32.3
Lithobius dentatus C. L. Koch, 1844	51.8	48.2	54.6	4.8	40.6
Lithobius macilentus L. Koch, 1862	36.3	63.7	57.0	16.2	26.8
Lithobius piceus L. Koch, 1862	47.8	52.2	59.7	26.5	13.8
Lithobius mutabilis L. Koch, 1862	57.8	42.2	68.0	6.1	25.9

Much of the material was collected by the author. For this, complete site descriptions exist. Further material was collected from other institutions or private individuals and was given to the museum with the request for determination. In these cases, the habitat descriptions were often deficient, which reduced the value of the data of these habitat descriptions.

2.2. Sites

Altogether 217 sites were considered.

Humidity and vegetation cover were chosen as the most important characters of the sites as habitats for centipedes. Only very approximate degrees of humidity – wet, humid, dry and very dry – were distinguished; correspondingly, the different groups for vegetation were limited to high, middle and low vegetation cover (Tab. 1). These characters could be deduced from the plant associations, which were known in each case from the site itself or from documented site descriptions.

A much finer differentiation of habitat characters would certainly be desirable, but for a preliminary analysis of the problems it should not be more complex.

2.3. Calculation

The preference of centipede species for special site types was determined on the basis of »presence«. The term presence signifies at how many different sites of the same biotope-type (within a greater area) a certain species occurs; according to the formula:

$P = 100 \frac{S_i}{X_i}$ where P is the presence (in %),

S_i the total number of sites and

X_i the number of sites in which a special species occur.

However different numbers of each biotope type were investigated, so a weighting had to be included according to the formula:

$$P_{rel} = \widetilde{X}_i = \frac{\frac{S_i}{X_i}}{\Sigma \frac{S_i}{X_i}}$$

3. Results

Tab. 2 shows the distribution of 26 centipede species along an artificial »humidity- and vegetation-gradient« of 217 investigated sites in East Germany. 6 groups of possibilities as to how the species will prefer the different habitat characters could be established. The detailed occurrence of species that will be discussed in the following account is shown in Figs 1 to 7.

4. Discussion

4.1. Inhabitants of wet and humid habitats with high vegetation cover

Only 4 species (*L. curtipes*, *L. pelidnus*, *L. tenebrosus* and *G. insculptus*) show a clear preference for a combination of wet and humid habitats with high vegetation cover.

This type of preference of these species in many parts of Europe is known from literature data. As a well documented example *G. insculptus* is discussed in the following.

Geophilus insculptus Attems, 1895 (Fig. 1)

(= *G. alpinus* Meinert, 1870)

Habitats: B/R, DF, XM

This species belongs to the group of species that inhabit humid or wet habitats with a high vegetation cover site group 1. These are mostly humus-rich ravine forests and wet wooded river- and brook sides. A very small percentage occurs in xeric and mesoxeric meadows. This preference is known from many other parts of Europe (Czech Republic: Folkmanová 1954, Tuf 2003, Austria: Franz et al. 1959, Koren 1986, Germany: Albert 1982, Spelda 1999, Italy: Minelli & Iovane 1987). Northwards the species becomes increasingly synanthropic (Meidell 1969, 1979, Enghoff 1971). The decisive factor for habitat selection seems to be more the humidity than temperature because *G. insculptus* also occurs in thermophilic deciduous woods (Voigtländer et al. 1994) – presumed they are wet enough.

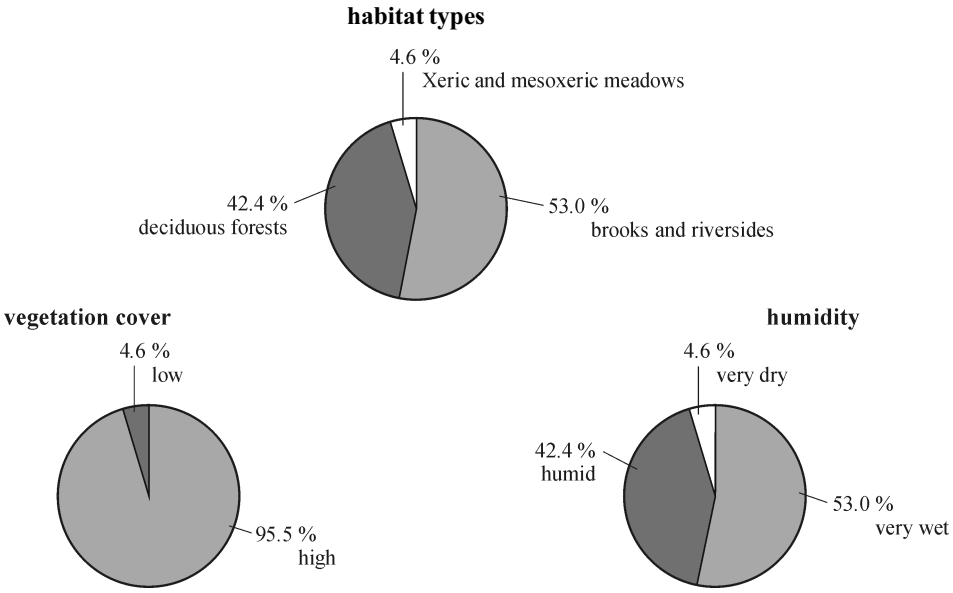

Fig. 1 Distribution of *Geophilus insculptus* in different habitat types. Inhabitant of wet and humid habitats with high vegetation cover.

4.2. Inhabitants of dry and very dry habitats with low vegetation cover

This group encompasses *C. hortensis*, *C. parisi*, *L. calcaratus*, *L. microps*, *Sch. nemorensis*, *Str. crassipes* and *G. flavus*. *Str. crassipes* and *Sch. nemorensis* are discussed as examples.

Strigamia crassipes (C. L. Koch, 1835) (Fig. 2)

Habitats: F/F, XM, XSS, DF, B/S, M/P

S. crassipes was found predominantly in fields and fallows as well as on xeric and mesoxeric meadows and xeric shrubs.

The species shows a clear preference to open-warm sites in its European distribution area as a whole (Becker 1982, Voigtländer 1987, 1988, Lock & Dekoninck 2001). In especially warm areas such as Rhineland-Palatinate, Baden-Wuerttemberg or Slovenia, *Str. crassipes* often inhabits deciduous or mesophilic woodland associations also (Karafiat 1970, Spelda 1999, Grgič & Kos 2003). Because the species was also recorded from montane areas, an increased drought resistance rather than thermophily is to be assumed. Occurrences in other habitats, such as flood plains (Tuf 2003), are very unusual.

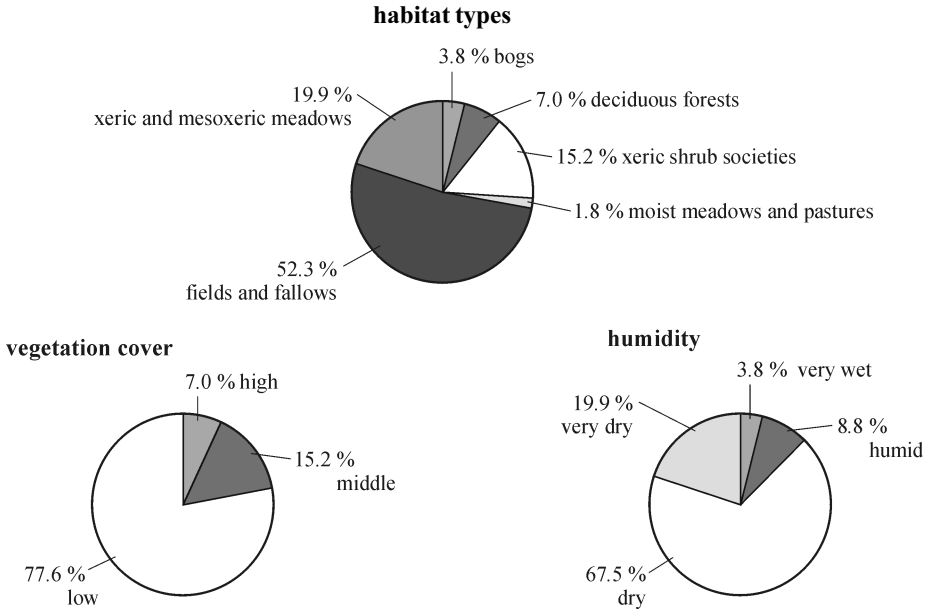

Fig. 2 Distribution of *Strigamia crassipes* in different habitat types. Inhabitant of dry and very dry habitats with low vegetation cover.

Schendyla nemorensis (C.L. Koch, 1837) (Fig. 3)

Habitats: DSH, XSS, XM, F/F, TW, SS, CF, DF, M/P

In the area investigated *Sch. nemorensis* prefers dry habitats. The vegetation cover seems to play a secondary role.

From a lot of ecofaunistical information it may be concluded that *Sch. nemorensis* is a very eurytopic species, which inhabits very different habitats, from flood-plain and swamp forests up to xeric meadows and suburban areas (Enghoff 1973, Albert 1978, Becker 1982, Schulte et al. 1989, Wytwer 1990). This conclusion has to be revised according to the investigations presented here of more than 200 sites. Some authors categorise the species as thermo-and mesophilic. Thus it should prefer open habitats, but in the present study it shows only minor tendencies towards these habitats. This allows the conclusion that the drought factor of a site is the most important character for habitat selection by *Sch. nemorensis*.

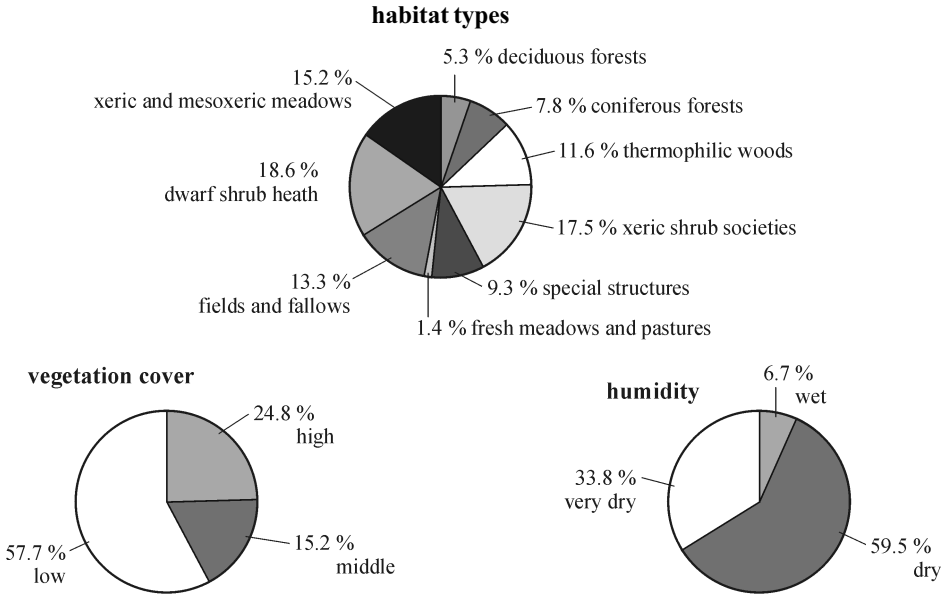

Fig. 3 Distribution of *Schendyla nemorensis* in different habitat types. Inhabitant of dry and very dry habitats with low vegetation cover.

4.3. Inhabitants of habitats with high vegetation cover but without influence of humidity on habitat preference

Inhabitants of such habitats are *Str. acuminata* and *L. nodulipes*.

These species are known from and characteristic of woods with a high litter layer. *L. nodulipes* is distributed montanous to subalpine. This species is mostly found in spruce forests, whereas *Str. acuminata* also occurs in deciduous woods (Franz 1975, Albert 1982, Spelda 1999, Voigtländer 1999, Leśniewska 2000). The present results correspond to this experience.

4.4. Inhabitants of dry and very dry habitats

L. melanops, *L. erythrocephalus*, *L. forficatus*, *L. muticus*, *L. austriacus* and *G. electricus* are inhabitants of dry and very dry habitats. Vegetation cover has no influence on habitat preference. From this habitat group *L. muticus*, *L. austriacus* and *G. electricus* are discussed in the following, because they show different habitat selection behaviour according to literature data.

Lithobius muticus C. L. Koch, 1847 (Fig. 4)

Habitats: CF, TW, SS, XM, XSS, M/P, DF

As yet, clarity about the true preferences of this species has not been attained (Fründ et al. 1997). Literature data indicate an eurytopy, as *L. muticus* occurs both in (mostly mesophilic) woods and dry, open and thermophilic sites as well as in agrocoenoses. Suburban occurrences are also known. According to Spelda (1999) *L. muticus* inhabits the edge of woods, but not the interior.

In the investigations presented here *L. muticus* was also found in many and in very different biotope types (the species occurs in 7 to 12 biotope types – from moist meadows and woods up to xeric and mesoxeric meadows). The species was especially common in dry *Pinus*-afforestations and thermophilic woods (*Quercus*). The present calculations definitely characterise *L. muticus* as an inhabitant of dry habitats whereas the influence of vegetation cover plays a secondary role.

Lithobius austriacus Verhoeff, 1937 (Fig. 5)

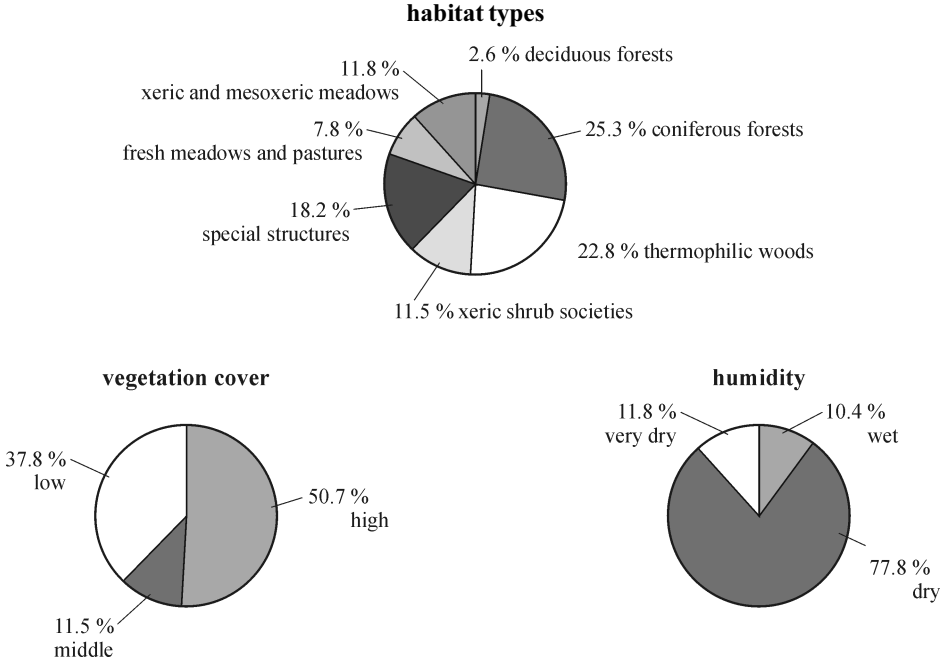

Fig. 4 Distribution of *L. muticus* in different habitat types. Inhabitant of dry and very dry habitats.

L. austriacus occurs in very different habitats. On the one hand the species is recorded from ravine woodland with well-developed herb layer on permanently cool and moist grounds of slopes (Folkmanová 1945, 1947, Voigtländer 1994), but on the other hand in relatively dry habitats such as *Picea*-forests in Bohemia and Slovakia (Lellaková-Dusková 1959, Stašiov & Maršalek 1999), coal-mining areas with low vegetation (Dunger 1967) or a dry selection forest both nearby Görlitz/Upper Lusatia. In this forest, the most humid areas at a brook side were avoided. In Hungary the species prefers closed woodland associations rather than shrubs (Loksa 1966). The species seems to be quite euryoecious without special requirements.

In the investigations presented here the species prefers clearly dry habitats, but an exiguous vegetation cover seems to be necessary. Unfortunately, the relatively low number of records complicates the assessment of its ecology.

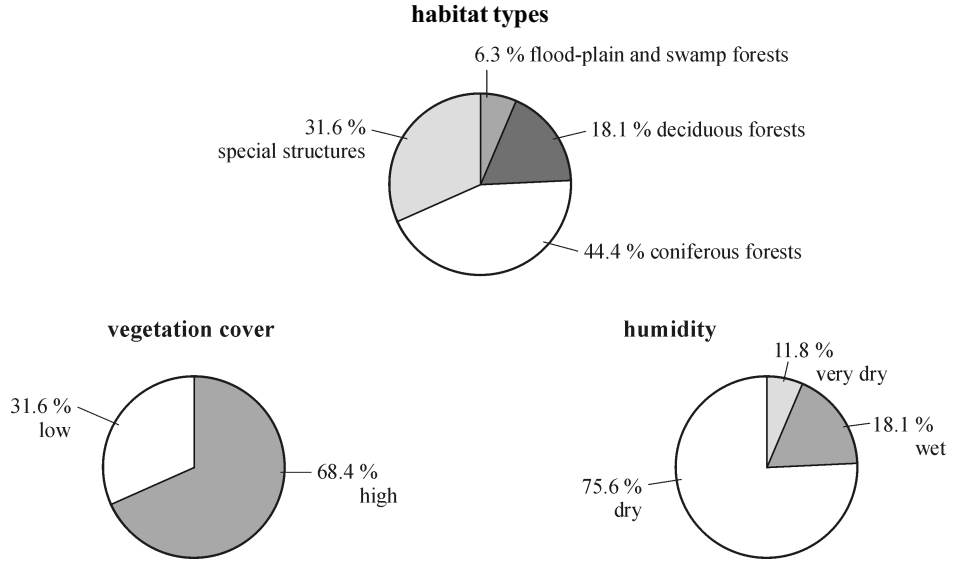

Fig. 5 Distribution of *L. austriacus* in different habitat types. Inhabitant of dry and very dry habitats.

Geophilus electricus (Linné, 1758) (Fig. 6)

Habitats: F/F, XSS, TW, XM, B/R, DF, CF

Within its distribution area this west-Palaearctic species varies in its habitat preference. In the climatically favoured south-western parts of Germany (Baden-Wuerttemberg, Rhineland-Palatinate) *G. electricus* occurs in (deciduous) woods and shrub formations (e.g. Becker 1982, Spelda 1991, 1999). In East Germany (the present study), the species predominantly inhabits fields and fallows and dry thermophilic woods and shrub succession stages but seldom more humid sites. Only a few synanthropic records are

known (Schulte et al. 1989). The tendency to live in gardens, parks, greenhouses or indoors clearly increases in areas north- and eastwards of Germany (e.g. Palmén 1948, Enghoff 1973, Andersson 1985, Leśniewska 1996, Wytwer 1996).

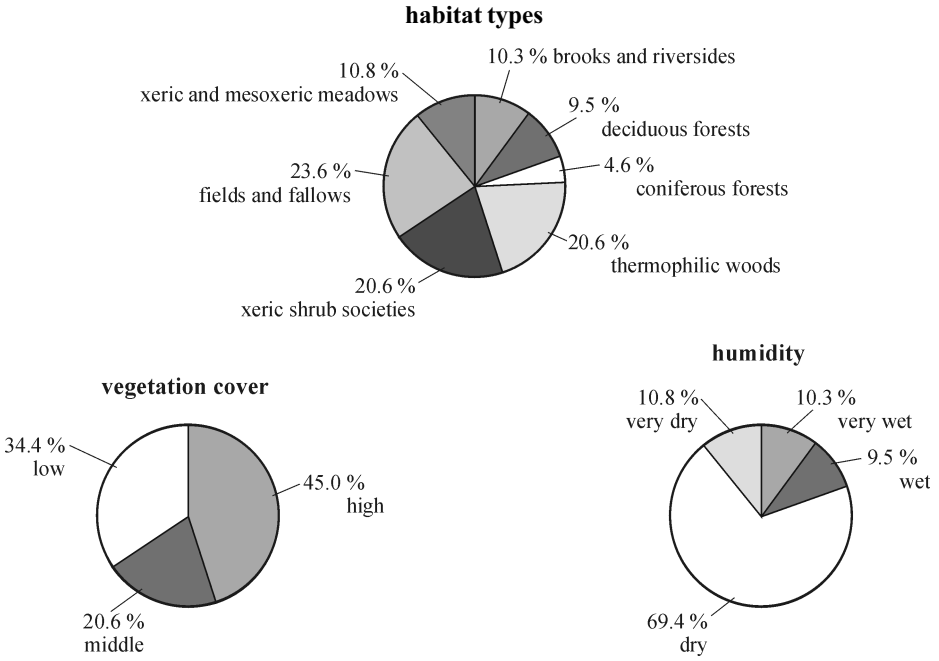

Fig. 6 Distribution of *G. electricus* in different habitat types. Inhabitant of dry and very dry habitats.

4.5. Inhabitants of humid to very wet habitats with low vegetation cover

This group is only represented by *Lamyctes emarginatus*.

Lamyctes emarginatus (Newport, 1844) (= *L. fulvicornis* Meinert, 1868) (Fig. 7)

Habitats: M/P, F/F, F/S, B/S, B/R, DF, XM

In the present investigations, *L. emarginatus* shows a clear preference for wet (68.2 %) but open sites (76.7 %). This is in accordance with many other records known from the literature (e.g. Seidel et al. 1992, Spelda & Rahmann 1995, Lock & Dekoninck 2001).

However the species can also live in very dry open land. The species enters spoil dumps of lignite mining very rapidly (Dunger & Voigtländer 1990, 2004). *L. emarginatus* is the most important pioneer species colonising sites with extreme site conditions regardless of humic degree, such as flood plains (Zulka 1991, Zerm 1997a, b, 1999) or reclaimed land. It develops stabile populations very rapidly because of its parthenogenesis and very short life span of only one year. Nevertheless, the populations break down with increasing competition from other species.

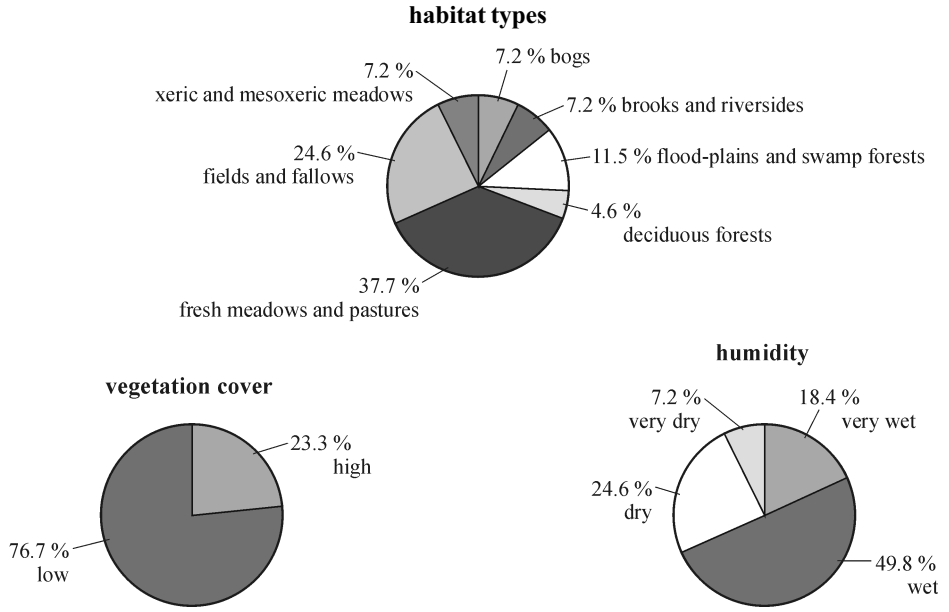

Fig. 7 Distribution of *Lamyctes emarginatus* in different habitat types. Inhabitant of wet and humid habitats with low vegetation cover.

4.6. Species without clear habitat preferences

Very provisionally, we assign to this group: *L. agilis*, *L. crassipes*, *L. dentatus*, *L. macilentus*, *L. mutabilis* and *L. piceus*.

L. crassipes is generally considered as one of the most eurytopic species.

5. Conclusions

The assessment of species of chilopods on the basis of environmental factors and resources, often combined as »habitat preference«, varies – as known from the literature – from author to author depending on interest and scope of experience. Even laboratory experiments (e.g. measurements of preferences to humidity or temperature; Weil 1958, Rossolimo & Rybalov 1979, Fründ 1987) or theoretical derivations from habitat overlap (Schatzmann 1990) do not bring significant improvement because within the real habitats other factors (e.g. competition, space-contact) are able to play an important role at least for certain periods (e.g. in the year's dynamics). The present paper does not offer a new method to solve the problem but deals again with the presence of a species at a typical type of habitat. Nevertheless, it differs from other studies in being based on a very large number of observations (about 8000 individuals of 26 species from 217 sites) brought about with the same method and nearly the same intensity of sampling. The restrictions of pitfall trapping limit the relevance of the results especially in relation to some species of the order Geophilomorpha.

The sites have intentionally been arranged in a very coarse pattern of vegetation and humidity with only three or four gradations. This will allow a later test whether more exact results can be obtained by using a finer pattern. In all, 12 types of habitats could be differentiated by this method. The allocation of each individual species to these 12 types of habitats has been determined on the basis of weighted presence, which assesses in how many different sites of a particular type of habitat the species was present.

To assess the present results, influence of the climatic region on the ecological behaviour of the species should be taken into consideration. Some species (e.g. *Cryptops anomalans*) show divergent preferences for habitats depending on the geographical type of climate in northern and southern parts of Russia (Gilarov & Folkmanová 1957, Gilarov 1964). Such a regional change of preference (under constancy of ecological potency of the species) seems to occur even in Germany: The present paper documents for *Strigamia crassipes* and *Geophilus electricus* a preference for open, dry habitats (in Eastern Germany) whereas other authors (e.g. Spelda 1999) found these species in Rhineland and southern parts of Germany as inhabitants of (mesophilic) woodlands. In this connection, it should be remembered that woodland ecotones are of great importance because they allow the species to hunt in the more open parts and to reproduce in the better-sheltered more woody parts.

Further results of the present paper indicate that the knowledge of habitat preference of some species (e.g. *Sch. nemorensis*, *L. muticus*) can be understood more clearly. Other species (e.g. *L. crassipes*, *L. mutabilis*), described as »eurytopic« in the literature, cannot be better assessed even after the present analysis.

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