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Biogeography, diversity, and vertical distribution of ants (Hymenoptera: Formicidae) in Vorarlberg, Austria

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Abstract

Information on biogeographical composition and vertical distribution patterns of regional ant faunas in the Alps is relatively scarce. In this study I investigated species number, vertical distribution and zoogeographical composition of the ant fauna of Vorarlberg (Austria). A total number of 68 species and 4 subfamilies of ants were recorded in the region. Using information from literature these ant species were related to biogeographical elements and classes. The major part of the ant fauna is associated with the mixed and deciduous forest zone (58 %) and the coniferous forest zone (31 %). A few ant species belong to the Mediterranean zone (10 %). Regarding the biogeographical composition the regional ant fauna is dominated by North-Transpalaearctic (13 spp., 19 %), Boreomontane (7 spp., 10 %), Euro-Siberian (13 spp., 19 %) and South-Palaearctic elements (7 spp., 10 %). Total species number and species numbers of biogeographical classes and elements were analysed relative to altitude. Total species number and species numbers of the class of mixed and deciduous forest and Mediterranean zone as well as the biogeographical elements of these classes decrease significantly with altitude. In the class of the coniferous forest zone, North-Transpalaearctic and Montane elements decrease at higher elevations, while Alpine-Endemic and Boreomontane elements increase with altitude.

Key words: Formicidae, elevation, zoogeography, ants, Eastern Alps, Europe.

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Introduction

Information on the vertical distribution of ants in the Alps is relatively scarce, and can often be considered as by-product of faunistic and / or conservation studies (KUTTER 1977, GLASER 2001, 2005, SCHLICK-STEINER & al. 2003). I know of no studies dealing with the biogeographical composition of the Alpine ant fauna. However there are biogeographical analyses of the North-European (BARONI-URBANI & COLLINGWOOD 1977) and Polish ant fauna (CZECHOWSKI & al. 2002).

Furthermore I detected no studies dealing with patterns of species richness of ants in relation to altitude from the Alps, but some studies demonstrate lower species richness of ants at higher elevations for several tropical regions (WEBER 1943, BROWN 1973, JANZEN 1973, JANZEN & al. 1976, COLLINS 1980, ATKIN & PROCTOR 1988, OLSON 1994, FISHER 1996, BRÜHL & al. 1999, cited in SANDERS 2002). Some authors detected distinct mid-elevation-peaks of ant species richness in Madagascar (FISHER 1998) and the Philippines (SAMSON & al. 1997). Also, SANDERS (2002) described a peak of species richness at mid elevations in Utah, Colorado, and Nevada and discussed the influence of available area on species richness. GOTELLI & ELLISON (2002) determined latitude as main predictor for species density of ant communities in New England bogs and forests. However, species density of forest ants was negatively correlated with elevation. In contrast, SANDERS & al. (2003) observed a significant increase of species richness of ants in arid canyons of Nevada at higher elevations. They argued that lower temperatures and higher precipitations at higher elevations in arid ecosystems favour higher rates of primary production and species richness of ants.

In this paper I present a biogeographical analysis of the relatively well studied ant fauna of Vorarlberg, the westernmost federal country of Austria and at the same time the westernmost part of the Eastern Alps. The ant species were related to biogeographical elements and classes using information from literature (see below). I summarized the known vertical distribution of this regional ant fauna and described its biogeographical composition in relation to altitude.

In addition the following hypotheses were tested:

1) Total species richness should decrease with altitude. Most Central European ant species prefer rather warm habitats. Highest species numbers are observed in xerothermic habitats, whereas cool habitats show a relatively poor ant fauna.

2) Species number of ants associated with the class of the coniferous forest (taiga) zone and its biogeographical elements (Alpine-Endemic, Boreomontane, Montane, North-Transpalaearctic) should increase with altitude or at least not decrease with altitude. These species are expected to be well adapted to the cool and harsh conditions of higher altitudes.

3) Species numbers of ants associated with the class of mixed and deciduous forest zone and its elements (Amphipalaearctic, Central-European, European, Euro-Caucasian, Euro-Siberian, South-European, South-Palaearctic) should decrease with altitude. These species are expected to show less adaptations to "mountain" climates, their habitats are often lacking at high altitudes.

4) Similarly, species numbers of ants associated with the class of the Mediterranean zone and its elements should decrease with altitude.

5) Transition zones of different communities along elevation gradients should cause intermediary peaks of species numbers (e.g., LOMOLINO 2001). If this is the case it can be

interesting at which elevations such intermediary peaks will be detected.

Material and methods

A data base of 6283 single records of ants collected in the federal country of Vorarlberg (Austria) was analysed. Vorarlberg is the westernmost and smallest federal country of Austria (area: 2601 km²). The region extends between 400 m (Lake Konstanz) and 3312 m a.s.l. (Piz Buin). Only 12 % of the area is situated below 500 m, but 65 % above 1000 m and 25 % above 2000 m.

The biogeographical information for single species is mainly based on the following sources: CZECHOWSKI & al. (2002), SEIFERT (2002: *Formica selysi* BONDROIT, 1918 and *F. fuscocinerea* FOREL, 1874), SEIFERT (1988a: *Lasius sabularum* (BONDROIT, 1918)), SEIFERT (1988b: *Myrmica vandeli* BONDROIT, 1920), SEIFERT 1996: *Formica paralugubris* SEIFERT, 1996), B. Seifert (pers. com.: *Lasius flavus* (FABRICIUS, 1782), *L. platythorax* SEIFERT, 1992, *Formica picea* NYLANDER, 1846, *F. polyctena* FÖRSTER, 1850, *F. sanguinea* LATREILLE, 1798, *Myrmica hellenica* FINZI, 1926, *M. specioides* BONDROIT, 1918, *Leptothorax gredleri* MAYR, 1855, *L. acervorum* (FABRICIUS, 1793), *Temnothorax nigriceps* (MAYR, 1855), *T. albipennis* (CURTIS, 1854), *T. nylanderi* (FÖRSTER, 1850) and *Tetramorium* spp.), and KUTTER (1977: *Camponotus truncatus* (SPINOLA, 1808)). The occurrence of ants in altitude steps of 100 m was arranged in a presence / absence table. Only records of workers or colonies were included in the analyses (4488 records). The total number of species and the number of species belonging to biogeographical classes and elements were tested for correlation with altitude. Non parametric statistics were selected because of zero values in the data tables. All correlations were tested using non-parametric Spearman Correlations in the program Statistica for Windows (Release 5.0, 1984 - 1995). The taxonomically problematic genus *Tetramorium* (SCHLICK-STEINER & al. 2006) was pooled as *Tetramorium* spp. *Tetramorium* cf. *impurum* FÖRSTER, 1850 and *T.* cf. *caespitum* LINNAEUS, 1758 are listed for Vorarlberg by GLASER (2005). The material of *Myrmica lobicornis* NYLANDER, 1857 from Vorarlberg was not checked for the occurrence of *M. lobulicornis* NYLANDER, 1857, rank elevated by SEIFERT (2005).

Results

Sixty-eight ant species are recorded in Vorarlberg belonging to four subfamilies (Ponerinae, Myrmicinae, Dolichoderinae, Formicinae) (see Tab. 1). The discrepancy with the data from GLASER (2005) listing 69 species for this country, arises because one species, *Myrmica microrubra* SEIFERT, 1993 has been synonymised with *Myrmica rubra* (LINNAEUS, 1758) by STEINER & al. (2005) in the meantime.

Biogeographical composition: More than the half of the ant fauna of Vorarlberg is associated with the mixed and deciduous forest zone (39 spp., 58 %). One third (21 spp., 31 %) belongs to the coniferous forest zone. Few species are assigned to the Mediterranean zone (sensu lato) (7 spp., 10 %).

Table 2 shows the biogeographical composition of the ant fauna of Vorarlberg. The quantitatively most important biogeographical elements are North-Transpalaearctic (12 spp., 17 %), Euro-Siberian (13 spp., 19 %), South-Pa-

Tab. 1: List and biogeographical classification of the ants (Hymenoptera: Formicidae) recorded in Vorarlberg (Austria). Biogeographical classes (BC) and elements (BE) according to CZECHOWSKI & al. (2002). Abbreviations: 1 = coniferous forest (taiga) zone, 2 = mixed and deciduous forest zone, 3 = Mediterranean zone (s.l.), AE = Alpine-Endemic, BM = Boreomontane, M = Montane, NP = North-Transpalaearctic, AP = Amphipalaearctic, E = European, EC = Euro-Caucasian, ES = Euro-Siberian, SE = South-European, SP = South-Palaearctic, MD = Mediterranean; ? = biogeographical classification questionable.

Species	BC	BE
Aphaenogaster subterranea (LATREILLE, 1798)	3	MD
Camponotus fallax (NYLANDER, 1856)	2	ES
Camponotus herculeanus (LINNAEUS, 1758)	1	BM
Camponotus ligniperda (LATREILLE, 1802)	2	E
Camponotus truncatus (SPINOLA, 1808)	3	MD?
Camponotus vagus (SCOPOLI, 1763)	2	ES
Dolichoderus quadripunctatus (LINNAEUS, 1771)	2	ES
Formica aquilonia YARROW, 1955	1	BM
Formica cunicularia LATREILLE, 1798	2	EC
Formica exsecta NYLANDER, 1846	1	NP
Formica fusca LINNAEUS, 1758	1	NP
Formica fuscocinerea FOREL, 1874	3	MD?
Formica lemani BONDROIT, 1917	1	BM
Formica lugubris ZETTERSTEDT, 1838	1	BM
Formica paralugubris SEIFERT, 1996	1	AE?
Formica picea NYLANDER, 1846	2	ES
Formica polyctena FÖRSTER, 1850	2	ES
Formica pratensis RETZIUS, 1783	2	SP
Formica pressilabris NYLANDER, 1846	1	NP
Formica rufa LINNAEUS, 1761	1	NP
Formica rufibarbis FABRICIUS, 1793	2	ES
Formica sanguinea LATREILLE, 1798	1	NP
Formica selysi BONDROIT, 1918	3	MD?
Formica truncorum FABRICIUS, 1804	1	NP
Formicoxenus nitidulus (NYLANDER, 1846)	1	NP
Harpagoxenus sublaevis (NYLANDER, 1849)	1	BM
Lasius brunneus (LATREILLE, 1798)	2	EC
Lasius distinguendus (EMERY, 1916)	2	SP
Lasius emarginatus (OLIVIER, 1792)	2	SE
Lasius flavus (FABRICIUS, 1782)	1	NP
Lasius fuliginosus (LATREILLE, 1798)	2	AP
Lasius mixtus (NYLANDER, 1846)	2	SP
Lasius niger (LINNAEUS, 1758)	1	NP?
Lasius paralienus SEIFERT, 1992	2	E
Lasius platythorax SEIFERT, 1991	2	ES
Lasius sabularum (BONDROIT, 1918)	2	SP?
Lasius umbratus (NYLANDER, 1846)	2	SP
Leptothorax acervorum (FABRICIUS, 1793)	1	NP
Leptothorax gredleri MAYR, 1855	2	EC
Manica rubida (LATREILLE, 1802)	1	M
Myrmecina graminicola (LATREILLE, 1802)	2	AP

Myrmica gallienii Bondroit, 1920	2	ES
Myrmica hellenica Finzi, 1926	2	E
Myrmica lobicornis Nylander, 1846	1	BM
Myrmica lonae Finzi, 1926	2	ES
Myrmica rubra (Linnaeus, 1758)	1	NP
Myrmica ruginodis Nylander, 1846	1	NP
Myrmica rugulosa Nylander, 1849	2	ES
Myrmica sabuleti Meinert, 1861	2	ES
Myrmica scabrinodis Nylander, 1846	2	ES
Myrmica schencki Viereck, 1903	2	SP
Myrmica specioides Bondroit, 1918	2	E
Myrmica sulcinodis Nylander, 1846	1	BM
Myrmica vandeli Bondroit, 1920	2	E?
Ponera coarctata (Latreille, 1802)	3	MD
Solenopsis fugax (Latreille, 1798)	3	MD
Stenamma debile (Förster, 1850)	2	EC
Tapinoma ambiguum Emery, 1925	2	SE
Tapinoma erraticum (Latreille, 1798)	3	MD
Temnothorax affinis Mayr, 1855	2	EC
Temnothorax albipennis (Curtis, 1854)	2	E
Temnothorax corticalis (Schenck, 1852)	2	EC
Temnothorax nigriceps (Mayr, 1855)	2	E
Temnothorax nylanderi (Förster, 1850)	2	E
Temnothorax tuberum (Fabricius, 1775)	2	ES
Temnothorax unifasciatus (Latreille, 1798)	2	EC
Tetramorium spp.	2	SP

Tab. 2: Biogeographical composition of the ant fauna of Vorarlberg, based on the literature (for references see text). n = number of species.

Biogeographical class	**Biogeographical element**	**n**	**%**
Coniferous forest (taiga) zone 21 spp., 31 %	Alpine-Endemic	1	1.4
	Boreomontane	7	10.1
	Montane	1	1.4
	North-Transpalaearctic	12	17.4
Mixed and deciduous forest zone 39 spp., 58 %	Amphipalaearctic	2	2.9
	European	8	11.6
	Euro-Caucasian	7	10.1
	Euro-Siberian	13	18.8
	South-European	2	2.9
	South-Palaearctic	7	10.1
Mediterranean zone (s.l.)	Mediterranean	7	10.1

laearctic species (7 spp., 10 %) and European species (8 spp., 12 %). Boreomontane (7 spp., 10 %), Mediterranean (7 spp., 10 %) and Euro-Caucasian (7 spp., 10 %) ant species play a minor role. All other elements (Alpine-Endemic, Montane, Amphipalaearctic, European, South-European) are represented only by a few species.

Vertical distribution of species: Vertical distribution patterns of ant species in Vorarlberg have been published in Glaser (2005). Table 3 summarizes the known vertical

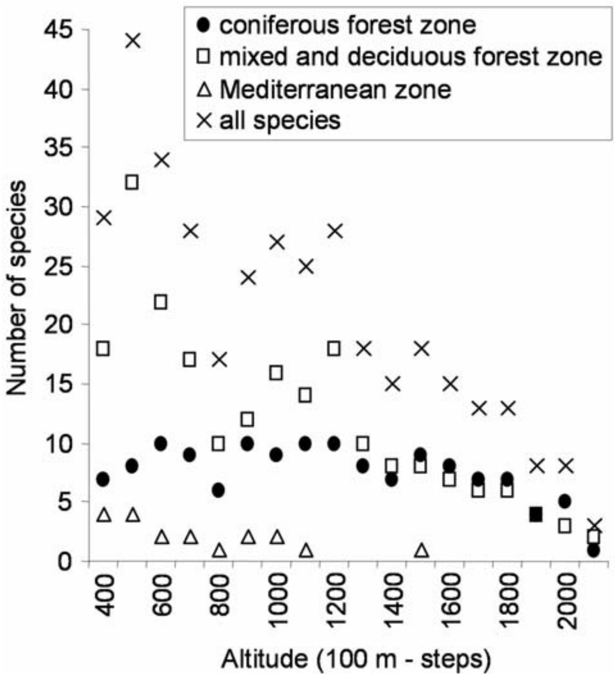

Fig. 1: Patterns of total species number and species numbers of biogeographical classes in relation to altitude steps. For statistical parameters see Tab. 4.

range of all ant species recorded in Vorarlberg updated by new faunistic data (F. Glaser, unpubl.)

Vertical patterns of species richness, biogeographical classes and elements: Statistical parameters and graphs are shown in Figs. 1 - 2 and Tab. 4. Total species richness is negatively correlated with altitude. This decrease is not linear, but there is an intermediate peak between 900 and 1200 m a.s.l. At a similar altitude North-Transpalaearctic and Euro-Siberian species show a slight mid elevation peak, whereas Boreomontane species richness is characterized by an intermediate peak between 1000 and 1800 m a.s.l.

Species numbers of ants associated to the deciduous and mixed forest zone and to the Mediterranean zone (s.l.) also decline with altitude. However there is no evidence for a positive correlation between species number of ants associated with the coniferous (taiga) zone and altitude. Within the class of the coniferous forest zone the species number of Boreomontane elements and the occurrence of the single Alpine-Endemic species *Formica paralugubris* is positively correlated with altitude. On the other hand the North-Transpalaearctic elements and the single Montane species *Manica rubida* (Latreille, 1802) show a significant decrease with altitude. Most North-Transpalaearctic ants (exception *Formica rufa* Linnaeus, 1761) and *Manica rubida* occur above 1500 m a.s.l. The North-Transpalaearctic elements *Formica fusca* Linnaeus, 1758, *Formicoxenus nitidulus* (Nylander, 1846), and *Myrmica ruginodis* Nylander, 1846 were found at 2000 m a.s.l.

In the class of the deciduous and mixed forest zone the species numbers of all elements decrease with altitude. But some Euro-Caucasian (*Formica cunicularia* Latreille, 1798), Euro-Siberian (*M. sabuleti* Meinert, 1861) and South-Palaearctic elements (*Tetramorium* spp.) can be found at elevations above 1500 m. The Euro-Siberian element *M. scabrinodis* Nylander, 1846 reaches the subalpine zone, whereas no Amphipalaearctic and Central-European ele-

Tab. 3: Vertical distribution of the ants of Vorarlberg, only records of workers or colonies evaluated. Grey shadowed rectangles show altitude steps (in metres) with records. Last row: number of species per altitude step. Species arranged according to biogeographical classification (column 1).

	Species	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100
Alpine-Endemic	*F. paralugubris*								■			■	■	■	■	■	■	■	
Boreomontane	*C. herculaneus*		■	■	■			■		■	■	■	■	■	■	■			
	F. aquilonia					■			■					■					
	F. lemani		■			■		■	■	■	■	■	■	■	■	■	■	■	■
	F. lugubris				■		■	■	■	■	■	■	■	■	■	■	■	■	■
	H. sublaevis									■									
	M. lobicornis								■	■	■		■		■	■	■		
	M. sulcinodis											■	■	■		■		■	
Montane	*Ma. rubida*	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
North-Transpalaearctic	*F. exsecta*			■			■			■			■	■		■			
	F. fusca	■	■	■	■		■	■	■	■	■		■		■			■	
	F. pressilabris												■		■	■			
	F. rufa		■	■	■			■	■	■									
	F. sanguinea			■		■	■	■	■	■				■					
	F. truncorum						■						■			■			
	Fo. nitidulus				■						■			■	■			■	
	L. flavus	■	■	■	■		■	■	■	■	■	■		■					
	L. niger	■	■	■	■	■	■	■	■	■	■	■					■		
	Le. acervorum	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■
	M. rubra	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
	M. ruginodis	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Amphipalaearctic	*L. fuliginosus*	■	■	■	■		■												
	My. graminicola	■	■	■	■	■													
European	*C. ligniperda*		■	■	■		■	■		■	■								
	L. paralienus		■	■	■					■									
	M. hellenica	■	■		■	■		■											
	M. specioides		■						■										
	M. vandeli		■																
	Te. albipennis						■												
	Te. nigriceps		■																
	Te. nylanderi	■	■	■	■	■	■												
Euro-Caucasian	*F. cunicularia*	■	■	■	■		■	■	■	■	■		■						
	L. brunneus	■	■	■	■	■	■	■	■	■									
	Le. gredleri		■																
	St. debile	■	■	■															
	Te. affinis	■	■	■	■														
	Te. corticalis	■																	
	Te. unifasciatus		■		■														
Euro-Siberian	*C. fallax*		■																
	C. vagus			■															
	D. quadripunctatus	■	■	■				■											
	F. picea	■	■	■		■		■		■									
	F. polyctena		■	■	■		■	■		■									
	F. rufibarbis		■	■	■														
	L. platythorax	■	■	■	■	■	■	■	■	■	■	■		■					
	M. lonae							■	■	■									
	M. gallienii	■																	
	M. rugulosa	■	■																
	M. sabuleti	■	■	■	■	■	■	■	■	■	■	■	■						
	M. scabrinodis	■	■	■		■	■	■	■	■	■			■	■	■	■		
	Te. tuberum		■				■		■	■		■							

South-European	*L. emarginatus*			■															
	Ta. ambiguum	■	■	■															
South-Palaearctic	*F. pratensis*	■	■		■			■	■	■									
	L. mixtus		■		■														
	L. umbratus		■																
	M. schencki		■	■															
	T. spp.	■	■	■	■	■	■	■	■	■	■	■	■		■				
Mediterranean	*A. subterranea*						■												
	C. truncatus	■																	
	F. selysi				■			■											
	F. fuscocinerea	■	■	■	■	■	■	■	■				■						
	P. coarctata	■	■																
	So. fugax	■	■																
	Ta. erraticum		■	■															
	Total number of species	30	45	34	31	19	25	27	25	29	19	14	18	15	13	13	8	8	3
	Records per altitude step	474	1747	348	491	223	88	174	124	188	98	84	77	108	70	128	38	12	4

Tab. 4: Statistical parameters and significance levels (Spearman-Correlations) for the relations between total species numbers and species numbers of biogeographical classes and elements in relation to altitude steps (n = 18).

	Spearman R	t(N-2)	p-level
All species	-0.94	-11.01	< 0.001
Classes			
Coniferous forest (taiga) zone	-0.02	-0.07	n.s.
Mixed and deciduous forest zone	-0.96	-13.65	< 0.001
Mediterranean resp. Mediterranean zone (s.l.)	-0.87	-7.13	< 0.001
Elements			
Boreomontane	0.55	2.67	<0.05
Alpine-Endemic	0.65	3.39	< 0.01
Montane	-0.65	-3.39	< 0.01
North-Transpalaearctic	-0.67	-3.61	< 0.01
Amphipalaearctic	-0.83	-6.02	< 0.001
European	-0.90	-8.17	< 0.001
Euro-Caucasian	-0.92	-9.37	< 0.001
Euro-Siberian	-0.90	-8.52	< 0.001
South-European	-0.64	-3.32	< 0.01
South-Palaearctic	-0.89	-7.84	< 0.001

ment occurs higher than 1000 m. Mediterranean elements seem also to be restricted to elevations below 1100 m a.s.l., but the riparian species *F. fuscocinerea* can climb up to 1500 m along alpine rivers.

Discussion

Hypotheses 1, 3, and 4, suggesting a decline of the species number of all ants, respectively, the ants associated with the class of mixed and deciduous forest zone, and with the class of the Mediterranean zone, with altitude, could be verified. Contrary to my expectations the species number of North-Transpalaearctic elements decrease with altitude. Also, the single Montane *Manica rubida* occurs in all altitude steps below 1900 m and does not lack in the valley bottoms.

However, the Alpine-Endemic *Formica paralugubris* can only be found at altitudes below 1000 m and the species number of Boreomontane elements increases with altitude, which corresponds with hypothesis 2.

The biogeographical composition of the ant fauna in Vorarlberg is heterogenous and reflects different postglacial recolonization paths. The spatial vicinity of the Western Alps is documented by the occurrence of *F. pressilabris* NYLANDER, 1846, showing a distribution centre in the Western Alps, or the (Western) Alpine-Endemic *F. paralugubris* (GLASER 2005). *Formica pressilabris* seems to lack in the other parts of the Eastern Alps (GLASER 1999, GLASER & MÜLLER 2003). *Formica paralugubris* only reaches the Western part of North Tyrol (GLASER 2001). Some species restricted to deciduous lowland forests (*Aphaneogaster subterranea* (LATREILLE, 1798), *Temnothorax corticalis* (SCHENCK, 1852), *T. nylanderi* (FÖRSTER, 1850), *Camponotus truncatus, C. fallax* (NYLANDER, 1856)) are regionally distributed in Vorarlberg. Their recolonization paths after glaciation probably led through the valleys of Rhine and Ill. They do not occur in North Tyrol (GLASER 2001) and were thus unable to colonize North Tyrol from the South or through the Inn valley from the North. The westerly distributed *T. nylanderi* is replaced in North Tyrol by its Eastern sibling species *Temnothorax crassispinus* (KARAVAJEW, 1926) (GLASER 2000).

Generally, a decrease of species richness of ants in relation to altitude is not a very surprising result. Intermediate peaks of species richness in elevation gradients situated in transition zones of different communities are predicted by LOMOLINO (2001), here referred to as hypothesis 5. The presence of an intermediate peak at elevations between 900 and 1200 m may reflect a transition zone of lowland and mountain ant communities. Such intermediate

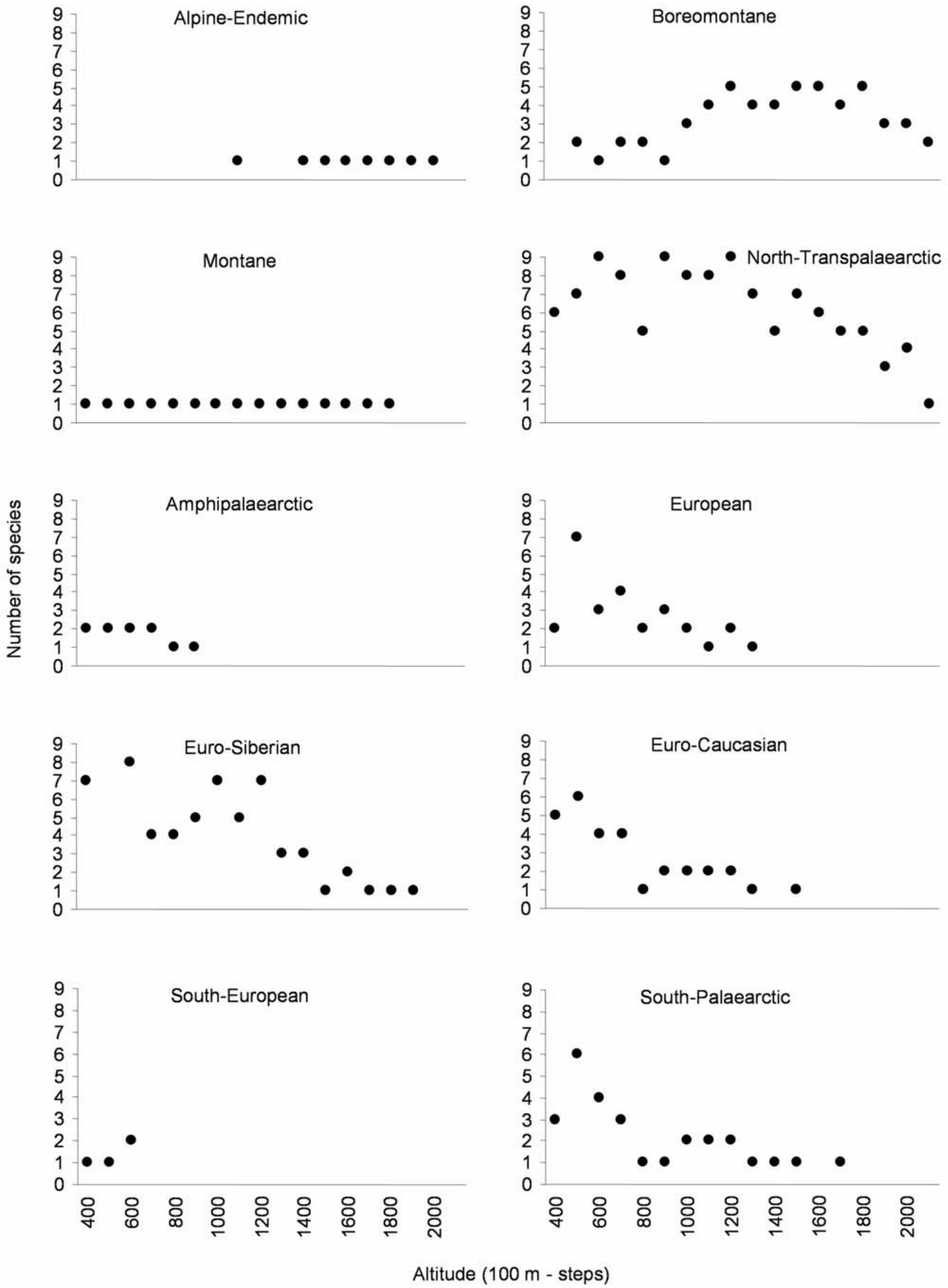

Fig. 2: Patterns of species numbers of biogeographical elements in relation to altitude steps. For statistical parameters see Table 4.

peaks are even featured by the species numbers of North-Transpalaearctic, Euro-Siberian and Boreomontane elements. Obviously, such peaks can also be caused by varying investigation intensity in single elevation steps. To exclude such sampling errors further studies have to be conducted.

The increase in species numbers of Alpine-Endemic and Boreomontane elements with elevation can be explained by their good adaptations to cold and harsh conditions in mountain habitats. But also some Euro-Siberian, Euro-Caucasian, South-Palaearctic and even Mediterranean ant species can be found at remarkable altitudes.

The biogeographical classification by CZECHOWSKI & al. (2002) used in this study is based primarily on present distribution patterns from an ecological point of view and does not reflect historical colonization. More historical aspects have to be involved to explain biogeographical patterns.

The biogeographical interpretation of distributions of ants or other biota depends on the correctness of biogeographical classification. A relatively high uncertainty even for widespread and quantitatively important ant species like *Lasius niger* (LINNAEUS, 1758) and *L. platythorax* still represents an obstacle for biogeographical studies and interpretations. This emphasizes the importance of intensive faunistic research to get realistic distribution maps.

Global climate change resulting in shifts of vertical distributions of species cannot be studied easily in most animal groups, whereas plants are considered as well established indicator organisms for studying changing vertical patterns (DIRNBÖCK & al. 2003, PAULI & al. 2003, GRABHERR & al. 2003). The rather stationary colonies of ants offer methodological advantages in this respect. Rising temperatures could influence the upper distribution limits of ant species which are frequent at higher elevations in the Alps like *Formica lemani* BONDROIT, 1917 and *Leptothorax acervorum*. Successful colonization of formerly almost ant free habitats like alpine grass heaths are possible. On the other hand subalpine habitats may be invaded by species like *Lasius* (s.str.) spp. (*Lasius niger*, *L. platythorax*), *Myrmica scabrinodis* or *M. rubra* which actually show their upper limit in the upper Montane zone.

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Zusammenfassung

Informationen über biogeographische Zusammensetzung und vertikale Verbreitungsmuster regionaler Ameisenfaunen im Alpenraum sind relativ lückenhaft. Im Rahmen dieser Studie wurden Artenzahl, Vertikalverbreitung und biogeographische Zusammensetzung der Ameisenfauna Vorarlbergs (Österreich) untersucht. Eine Gesamtzahl von 68 Arten aus 4 Unterfamilien ist aus der Region bekannt. Der Großteil der Arten ist mit der Klasse der Misch- und Laubwälder (57 %) sowie der Nadelwälder (31 %) assoziiert. Wenige Ameisenarten gehören der Mediterranen Zone an (10 %). Boreomontane (7 spp., 10 %), Euro-Sibirische (13 spp., 19 %) und Süd-Paläarktische Arten (7 spp., 10 %) dominieren die regionale Ameisenfauna. Gesamtartenzahl und Artenzahlen biogeographischer Klassen und Elemente wurden auf Korrelationen mit der Seehöhe untersucht. Gesamtartenzahl und Artenzahlen der Klasse der Misch- und Laubwälder sowie der Mediterranen Zone und deren Elemente nehmen mit der Seehöhe signifikant ab. Innerhalb der Klasse der Nadelwälder nehmen Artenzahlen Nord-Transpaläarktischer und Montaner Elemente mit der Seehöhe ab und Artenzahlen Alpin-Endemischer und Boreomontaner Elemente zu. Biogeographische Besonderheiten in der Ameisenfauna Vorarlbergs werden diskutiert.

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