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Nesting Dynamics of the Digger Wasp *Bembecinus hungaricus* (Hymenoptera: Apoidea: Crabronidae) at the Nature Reserve "in den Sandbergen" near Drösing a. d. March, Lower Austria

Andrea LARNHOF

From April to October 2004 activity of the females of the digger wasp *Bembecinus hungaricus* FRIVALDSKY, 1877 was investigated at the Nature Reserve „in den Sandbergen" near Drösing a. d. March, Lower Austria. After extensive restoration management to restore the original condition in 2003 a total of over 1000 burrows on 10 m^2 open sand surface was registrated. We could show a relation between the temperature in burrow-depth to the numbers of burrows.

Additional, the fauna of Hymenoptera: Aculeata (excluding Formicidae) was recorded. 37 species could be trapped; 50 percent are endangered species. Most of them were found at the open sand areas indicating the importance of such rare habitats for specialised psammophilous species.

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Von April bis Oktober 2004 wurde im Naturschutzgebiet „In den Sandbergen" bei Drösing a. d. March, NÖ. die Aktivität von Weibchen der Grabwespe *Bembecinus hungaricus* (FRIVALDSKY 1877) analysiert. Nach Renaturierungsmaßnahmen zur Wiederherstellung der ehemals offenen Sandflächen im Jahr 2003 wurden über 1000 Nester auf 10m^2 vegetationsfreier Bodenfläche gezählt. Ein Zusammenhang zwischen der Temperatur in Nestkammer-Tiefe und der Anzahl an Nestern konnte nachgewiesen werden.

Zusätzlich wurde die Zusammensetzung der aculeaten Hymenopteren-Fauna (mit Ausnahme der Ameisen) untersucht. 37 Arten konnten nachgewiesen werden, etwa die Hälfte davon gilt als gefährdet. Die meisten Tiere wurden auf der freien Fläche gefunden, was die dringende Notwendigkeit des Schutzes solch seltener Lebensräume für spezialisierte psammophile Arten aufzeigt.

Keywords: Hymenoptera, Crabronidae, digger wasps, *Bembecinus hungaricus*, sand habitats, nesting dynamics, nature reserve, Drösing.

Introduction

Until the 18th century sand areas – aeolian sand of postglacial age (35,000 to 10,000 years old) (KÜSTER 1995) – were common in Eastern Lower Austria, especially between Oberweiden and Weikendorf and near Drösing. Field names like "in den Sandbergen" are reminiscent of such landscapes. At the end of the 18th century huge areas of drifting sand were stabilised by men through forestation with Scots Pine (*Pinus sylvatica*) (WIESBAUER 2002). Since these days these particular landscapes became rare and endangered habitats for a highly specialised community of psammophilous plants and arthropods (WIESBAUER & MAZZUCCO 1997).

The investigation area is located about 2.5 kilometres southeast of Drösing/ March in Lower Austria (48° 31'N, 16° 54'O) and is called "in den Sandbergen". The sands were once freighted by wind from potamic sand banks of the nearby river March (WIESBAUER & MAZZUCCO 1999). The main grain size is between 0.63 and 0.2 mm; the ph-value 4.7 (WIESBAUER & MAZZUCCO 1999).

The area has been afforested presumably in the 1920ies. The topsoil was first removed in 1993 and again, this time only on some parts, in May 2003 (WIESBAUER 2002).

This re-established dry sand habitat with only sparse vegetation cover is inhabited by huge accumulations of hundreds of individuals of the digger wasp *B. hungaricus* (Crabronidae) (ZOLDA 2001, ZOLDA, ORTEL & WAITZBAUER 2001).

The males of *B. hungaricus* emerge at the mid of June, females about 5 weeks later. After mating, the female digs a nest, tossing away the loose substrate under their bodies. This takes about 1 to 2 hours when warm weather, but can last up to 6 hours under cooler conditions. The completed nest is closed from inside and the female lays a single egg. Before leaving to capture prey the females close the nest from outside (ZOLDA, ORTEL & WAITZBAUER 2001).

A few days later the larva hatches and is provisioned with small leafhoppers (Cicadellidae) (ZOLDA 2001). The late summer, autumn and winter are outlived as prepupa. In early summer of the next year the wasp pupates, turns into an imago and emerges (LÜPS 1969).

According to LÜPS 1969 the duration of larval development as well as the provisioning should depend on the temperature and lasts about 2 weeks (ZOLDA, ORTEL & WAITZBAUER 2001). As females only dig a new nest and lay a new egg when the larva reached a certain stage of development they can only bring up few offspring (LÜPS 1969).

Aeolian sand areas are rare in Austria and important habitats for many species of sand inhabiting Hymenoptera: About 80 % of the digger wasp in the most endangered categories 0–2 on the Red List of Endangered Species (DOLLFUSS 1994) nest in sand (WIESBAUER & MAZZUCCO 1999). Nevertheless, only the pannonic inland dunes and sand steppes are protected within the Continental Biogeographic Region of the NATURA 2000-project of the European Union.

This study shows the influence of soil temperature at different depths and of other microclimatic factors on nest density of the solitary digger wasp *Bembecinus hungaricus* (Hymenoptera: Crabronidae) by comparing three habitats.

Methods

Study area

The examined area exhibits four miscellaneous habitats: a large area with only sparse, but typical *Thymo-angustifolii-Corynephoretum* vegetation (termed *B*); a slope, partly consisting of the removed topsoil, abundantly covered with rural vegetation located at the south-west (*A* and *Aa*); a spot with remainders of special vegetation – an area, only scanty covered by bush grass (*C*), and an area grazed by sheep since mid of June until the 26th of October (*D*) (Fig. 1, 2). As grazing is a maintaining action for the LIFE-project, this area was monitored during the grazing period.

Data collection

Faunistics

Three transects of 5 × 2 meters, subdivided in squares of 50 × 50 cm, were located in each of the areas *A* – *C*. In each square the number of current open burrows of *B. hungaricus* was counted and marked with wooden spits. As the burrows form an average

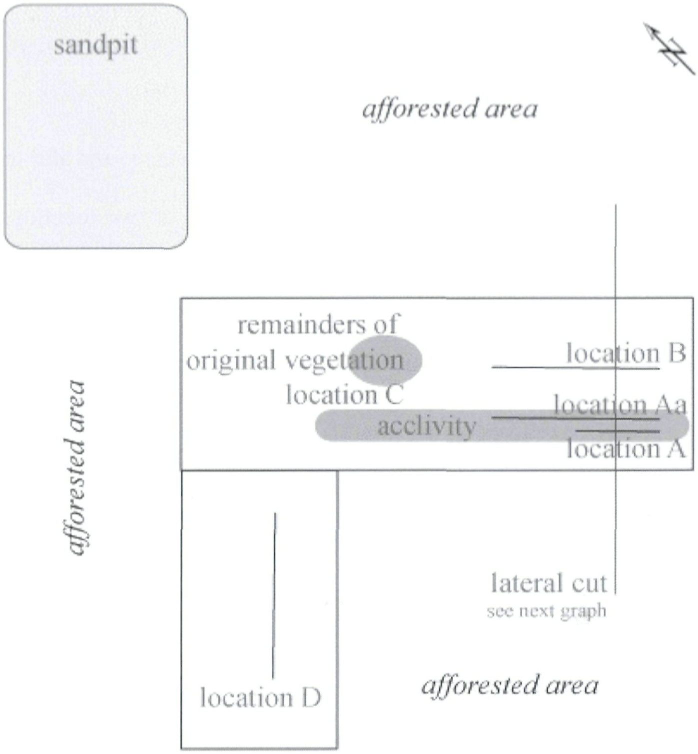

Fig. 1: Sketch of the investigation area. – Abb. 1: Skizze des Untersuchungsgebietes.

angle of 24° with the surface (ZOLDA, ORTEL & WAITZBAUER 2001) the oval holes can easily distinguished from other constructions. As burrows are only open during digging or provisioning the number of burrows refers to the female activity.

Proportional vegetation cover was estimated for each square as it is an important factor for nesting behaviour as *B. hungaricus* only nests on sites with a maximum cover of 25% (ZOLDA 2001).

Biodiversity of Coleoptera (Carabidae) (see KUGLER 2006) and Hymenoptera (this study) was recorded by pitfall traps. As killing agent ethylene glycol diluted with water at a ratio 1:1 was used, which is known to be non-attractive for insects and non-polluting. Traps were positioned in lines, each consisting in ten pitfalls (line *D* in 5) in intervals of

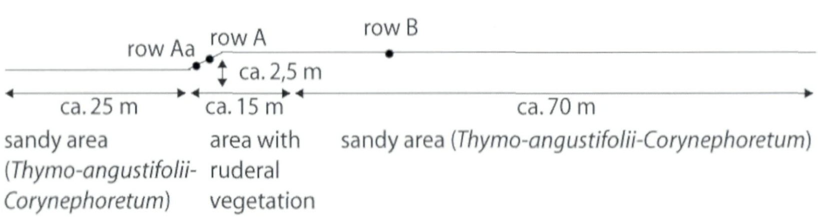

Fig. 2: Lateral cut through the investigation area. – Abb. 2: Lateraler Schnitt durch das Untersuchungsgebiet.

5 metres each. Two parallel lines were located near transect *A* at the slope, called *A* (near the top) and *Aa* (near the bottom), one line near transect *B*, and finally another line in the grazed area termed *D*.

Abiotic factors

Near each transect the air humidity, the radiation on surface, and the temperature at –10 cm, –5 cm and on the soil surface were measured with a temperature sensor (Testo 635). Two anemometers (Lambrecht 1440) were installed at two locations (near *A* and above *C* on the top of the slope). Furthermore minimum-maximum thermometers were placed close to the anemometers. At area *A* one of the thermometers was left exposed to the sun, another one shaded, and a third one was burried at –20 cm. At site *C* two shaded thermometers were placed on the soil surface. As a last parameter precipitation was measured with an ombrometer (after Hellmann) in area *C*, presuming this parameter wouldn't change all over the whole area.

From 31st of March to 26th of October 2004 data collecting was carried out including depleting the pitfalls every 10 to 14 days.

The specimens from the pitfalls were first sorted to families. Thereafter most of the digger wasps (Sphecidae, Crabronidae) were identified by using BERLAND, (1925, 1928, 1938), WITT, (1998) and DOLLFUSS (1991). Dr. Herbert Zettel (Natural History Museum Vienna) revised them and determined the *Chrysididae, Pompilidae*, and *Apidae* (some specimens were sent to other experts for review).

Data analysis

Nesting activity

A correlation matrix was computed to display dependencies between the quantity of burrows and environmental parameters. It compares the number of burrows at a distinct date with the actual environmental factors during the same date.

Also a multilinear regression was calculated. It shows the estimated count of burrows in consideration of the parameters most strongly influencing the wasps in digging their nests: relative air humidity and temperatures at –10 cm and –5 cm as well as on the surface.

Statistical methods

To compare the species communities of different localities, various analyses were made. The Shannon-Wiener-Index as well as Evenness and Species Diversity were computed. Additionally a cluster analysis was assessed, the program EstimateS was used to calculate a rarefaction. The species abundance curve of location B was plotted.

Results and discussion

Abiotic factors

Precipitation

Precipitation was measured only at location *C*. The plot shows two peaks, one in spring to early summer and another one in autumn, but a dry summer, as it is normal for the temperate zonobiome (GRABHERR 1997).

As an over-all sum nearly 300 mm/m^2 could be recorded, which is distinctly below the average for eastern Austria/Vienna, i.e. 600mm/m^2. According to the Central Institute for Meteorology and Geodynamics, in 2004 a slightly higher amount of precipitation was recorded than the long-time average for the region (ZAMG 2005) (Fig. 3).

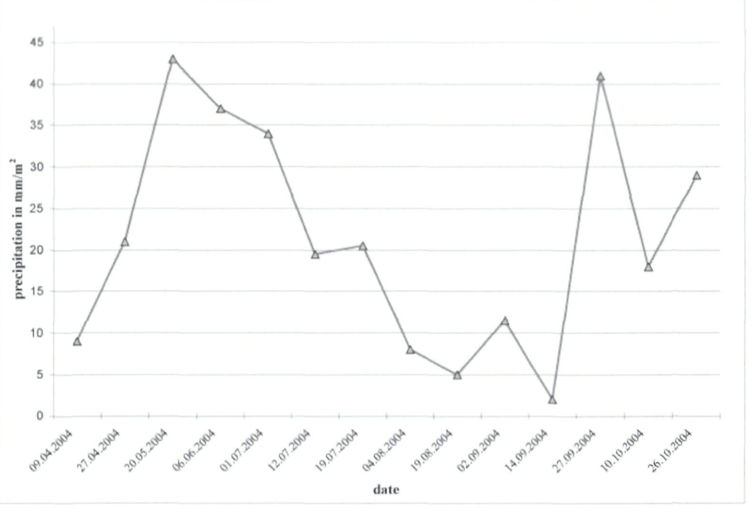

Fig. 3: Precipitation in mm/m² during the investigation period. – Abb. 3: Niederschlag in mm/m² im Untersuchungszeitraum.

Wind velocity

Wind velocity was measured at localities A and C. The two values differ significantly from each other (f-value: 0,0518). The afforested area near the anemometer of locality A may act as windbreak and cause lower wind velocities than at the more exposed locality C on the top of the slope (Fig. 4).

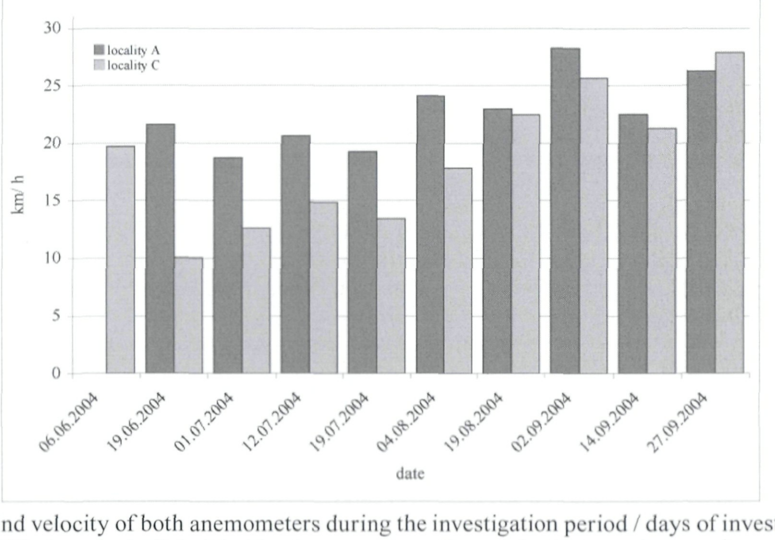

Fig. 4: Wind velocity of both anemometers during the investigation period / days of investigation. – Abb. 4: Windgeschwindigkeit beider Anemometer während des Untersuchungszeitraumes.

Temperature

Every 10 to 14 days the temperature of the minimum-maximum thermometers was read off at each location.

At all habitats, values for –10 cm and –5 cm were more similar to each other than to the other temperature values (Fig. 5). The temperatures of the soil-surface and in –10 cm varied significantly between the four locations.

Further, the temperatures in –20 cm and that underneath a small pine tree differed significantly from those values measured with the unshadowed thermometer and the temperatures on the surface (e.g. see Fig. 6). As expected, temperature patterns in the depth are smoother than those from the surface.

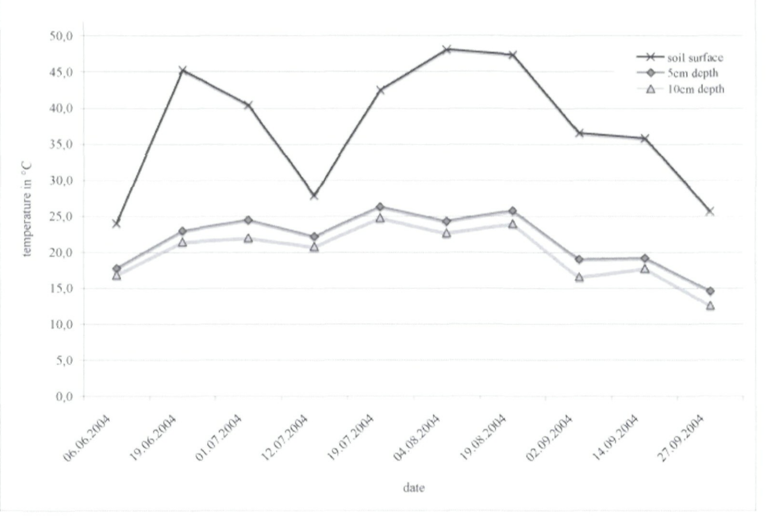

Fig. 5: Comparison of temperatures on the soil surface, –5 cm, and –10 cm on locality B. – Abb. 5: Vergleich der Temperaturen der Bodenoberfläche, in 5 und 10 cm Tiefe am Standort B.

*) Nesting activity

Transects of 5 × 2 m were established at the localities *A*, *B* and *C*, but only in transect *B* burrows of *B. hungaricus* were found and counted.

These counts, the data about temperature at different depths and radiation were compared in a correlation matrix. It was found a correlation of surface temperature with the number of burrows. Further, a strong positive correlation to the temperature in –5 cm and –10cm was found as shown in Fig. 6.

The latter corresponds to data of ZOLDA & HOLZINGER (2002) that females of *B. hungaricus* construct their nests at a median depth of 5.5 cm where the temperature is more constant.

In contrary correlation of air humidity with the number of burrows is negative (Fig. 7). This is supported by a study of ZOLDA (2001), showing that females depress their body to the surface absorbing the heat from the warm sand during cloudy weather periods.

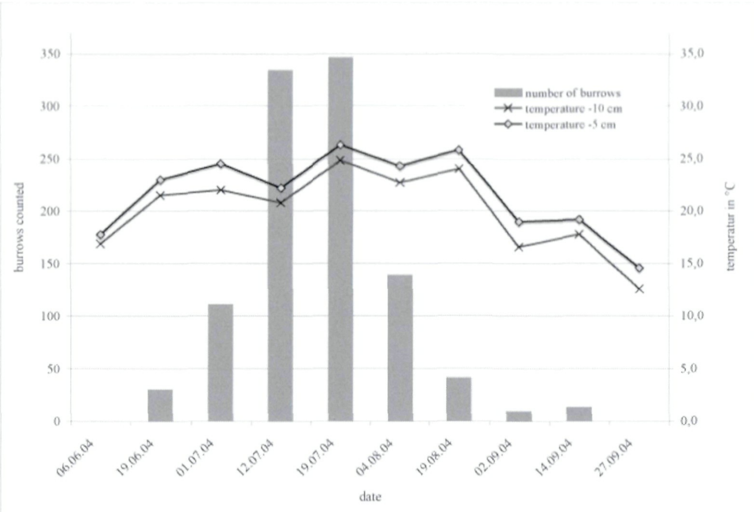

Fig. 6: Strong positive correlation between temperature in the depth to the number of burrows. – Abb. 6: Starke positive Korrelation zwischen der Temperatur in der Tiefe und der Anzahl der gezählten Nester.

In addition a multilinear regression was calculated associating the number of counted burrows to the influencing parameters (see above). The resulting formula is the following:

$$y = -394.87 - 2.30918 * e^{0.14} x_1 - 2.8685 x_2 + 53.877 x_3 - 14.119 x_4$$

y:	number of counted burrows
x_1:	relative air humidity
x_2:	temperature at –10 cm
x_3:	temperature at –5 cm
x_4:	Temperature on the soil surface

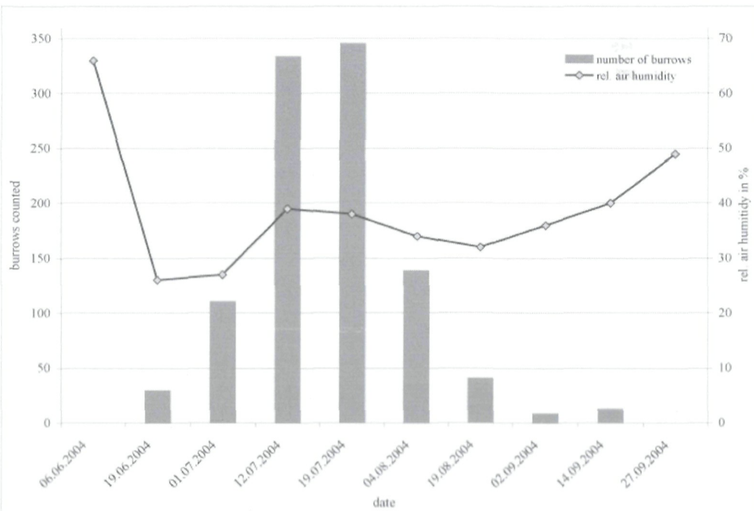

Fig. 7: Negative correlation of the number of counted burrows with relative air humidity. – Abb. 7: Negative Korrelation zwischen der Anzahl der gezählten Nester und der relativen Luftfeuchte.

The graph (Fig. 8) deriving from this formula nearly fits the one from true values (f-value: 0.9866).

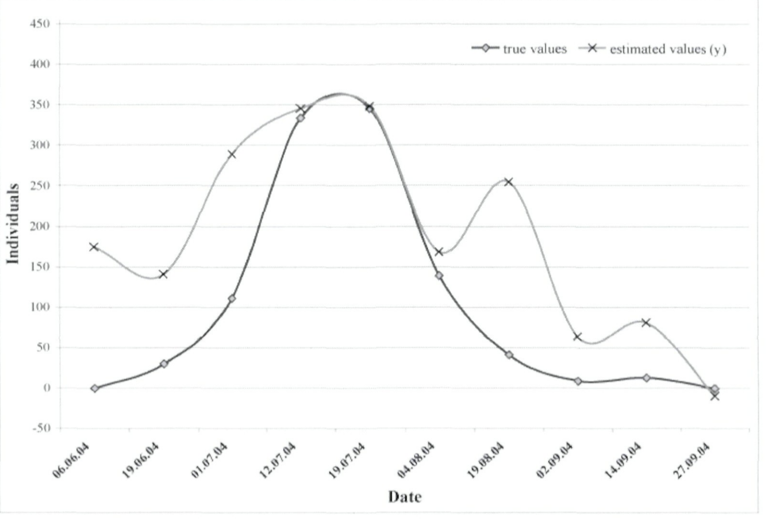

Fig. 8: Plotted multilinear regression of individuals during time of investigation. – Abb. 8: Multilineare Regression der Individuen während des Untersuchungszeitraumes.

*) Pitfalls

In total 282 individuals in 37 species of *Aculeata* (excluding Formicidae) were trapped, five hereof registered on the Red List of endangered species of Austria (DOLLFUSS 1994; see species list in the appendix). Most of these endangered species were found at the open sand area *B*. This proves the importance of conservation or restoration such habitats.

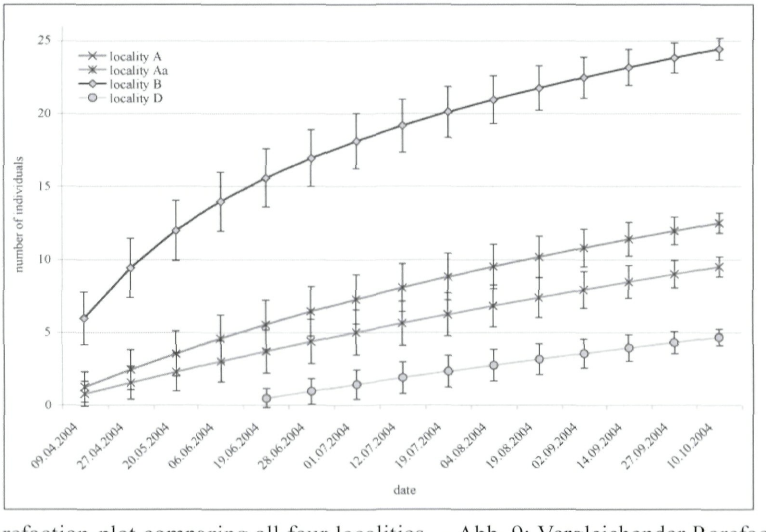

Fig. 9: Rarefaction-plot comparing all four localities. – Abb. 9: Vergleichender Rarefaction-Plot aller vier Standorte.

Nonetheless the rarefaction curve (Fig. 9) shows that not enough data were acquired and that the *Aculeata* community is not yet fully known. Especially at *A* and *Aa* more species can be expected. Locality *D* was not sampled before mid of June, so data are insufficient. Thus much more species should occur in this area.

As the rarefaction calculation standardises samples one can see that at *B* much more species were found than in the other areas. This may be caused by the ruderal and high vegetation on the slope, which is not attractive to those digger wasps and bees, which prefer loose substrate (Zolda 2001). Locality *D* was eventually too much disturbed by sheep, but insufficiency of data also plays an important role.

The diversity indices show differences between the four locations (Tab. 1).

Tab. 1: Diversity indices at the four reserach locations. – Tab. 1: Diversitätsindizes aller vier Standorte.

research area	number of species	Shannon-Index ($H' = -\sum[p_i * \ln p_i]$)	Evenness ($E = H' / \ln S$)	Dominance ($D = \sum [n_i / n]^2$)
locality *A*	13	2.40	0.93	0.10
locality *Aa*	11	2.32	0.97	0.11
locality *B*	25	1.80	0.56	0.37
locality *D*	6	1.75	0.98	0.18

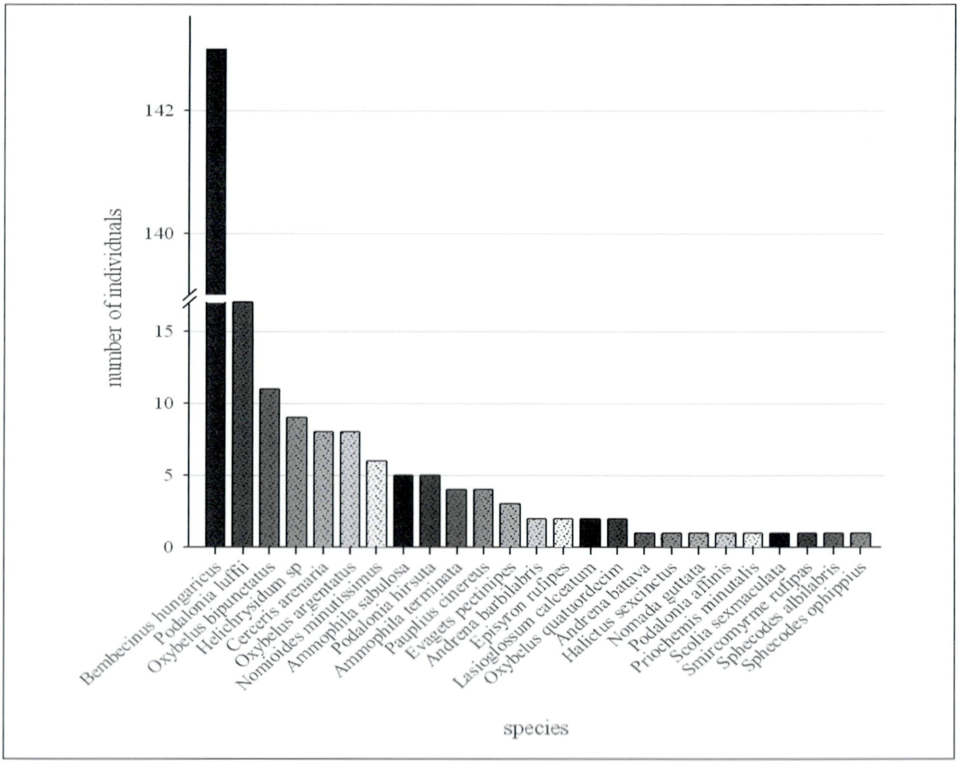

Fig. 10: Rank abundance plot of registrated species at locality *B*. – Abb. 10: Abundanz-Kurve aller registrierten Arten des Standortes *B*.

At locality *D* only few, but some very interesting species, such as ***Bembix rostrata*** *or* ***Scolia sexmaculata***, were found in very low numbers caused by the short period of investigation. Although the diversity indices could be calculated they are of little significance.

Most species were found at locality *B*. This area was the most natural one, sandy with sparse vegetation cover. There, ***Bembecinus hungaricus*** dominated, a species most characteristic for the Sandberge near Drösing. The community there shows only little diversity, but is uneven distributed, due to the dominance of a few species, especially ***B. hungaricus*** and the equally endangered species ***Podalonia luffii*** (Fig. 10, see also Appendix).

At the slope *A* and *Aa* not only the species numbers equal but also the Shannon-Wiener-Index match. Both communities show a similar evenness (E = 0.93 at *A*; E = 0.97 at *Aa*). For further analysis too few species in too few numbers were collected.

The similarity between *A* and *Aa* and the difference to *B* can be seen from the cluster analysis after Raup-Crick, using the Monte-Carlo-Randomisation (Fig. 11).

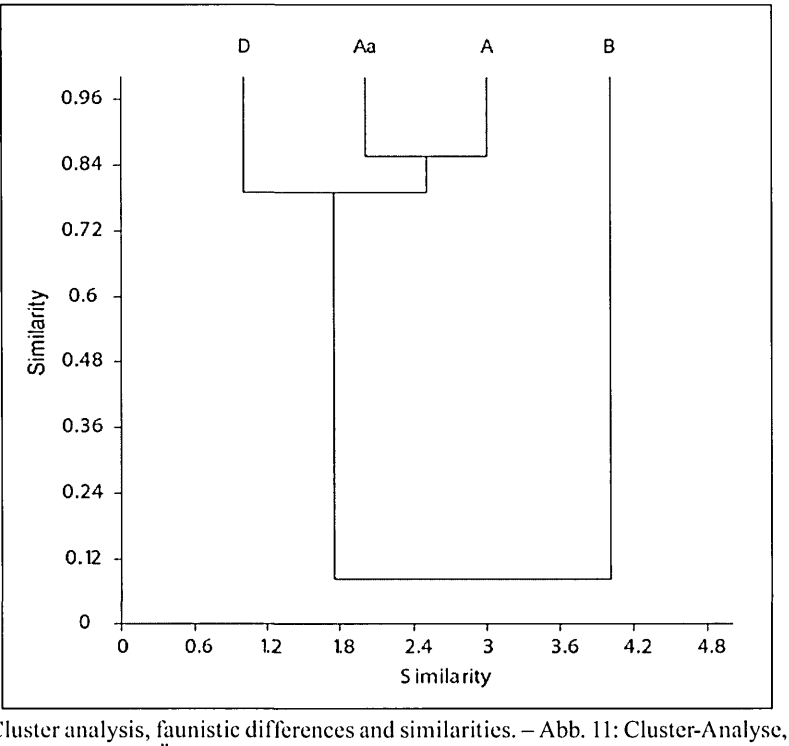

Fig. 11: Cluster analysis, faunistic differences and similarities. – Abb. 11: Cluster-Analyse, faunistische Unterschiede und Ähnlichkeiten.

Appendix

Appendix: Hymenoptera species which have been recorded for the research area. – Anhang: Hymneopteren-Arten im Untersuchungsgebiet.

Species	Red List Status	Localities			
		A	*Aa*	*B*	*D*
APIDAE					
Andrena barbilabris (Fabricius)		x		x	
Andrena batava (Pérez)	**			x	
Andrena nigroaenea (Kirby)		x			
Anoplius viaticus paganus (Dahlbom)	*	x			
Anthophora bimaculata (Panzer)	*		x		
Episyron rufipes (L.)				x	
Evagetes pectinipes (L.)				x	
Nomada alboguttata (Schäfer)				x	
Nomioides minutissimus (Rossi)	**			x	
Smicromyrme rufipes (Fabricius)				x	
CHRYSIDIDAE					
Hedychridium spec.			x	x	
HALICTIDAE					
Halictus leucaheneus (Ebmer)					x
Halictus sexcinctus (Fabricius)				x	
Lasioglossum calceatum (Scopoli)		x		x	
Lasioglossum zonulum (Smith)					x
Sphecodes albilabris (Fabricius)				x	
Sphecodes ephippius (L.)				x	
POMPILIDAE					
Pompilus cinereus (Fabricius)	**			x	
Priocnemis minutalis (Wahis)				x	
SCOLIIDAE					
Scolia hirta (Schrank)		x			
Scolia sexmaculata (Müller)	*	x	x	x	x
SPHECIDAE					
Ammophila sabulosa (L.)		x	x	x	
Ammophila terminata (F. Smith)	1			x	
Bembecinus hungaricus (Frivaldsky)	**			x	
Bembecinus tridens (Fabricius)	1	x			
Bembix rostrata (L.)	1				x
Cerceris arenaria (L.)		x	x	x	x
Colletes cunicularius (L.)		x	x		
Dinetus pictus (Fabricius)				x	
Dryudella stigma (Panzer)	*	x			

Species	Red List Status	Localities			
		A	*Aa*	*B*	*D*
Mellinus arvensis (L.)		x	x		
Oxybelus argentatus (Curtis)	**			x	
Oxybelus bipunctatus (Olivier)				x	
Oxybelus quatuordecimnotatus (Jurine)		x		x	
Philanthus triangulum (Fabricius)	2			x	
Podalonia affinis (Kirby)	*			x	
Podalonia hirsuta (Scopoli)			x	x	x
Podalonia luffii (Saunders)	4			x	
Tachytes panzeri (Dufour)	*		x		
Tiphia femorata (Fabricius)			x		

after Dollfuss 1994	after Dr. H. Zettel 2006
1 extinct	** highly endangered
2 threatened	* endangered
4 potentially threatened	

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Anschrift: Andrea LARNHOF, Clemens-Hofbauer-Platz 2–3/17, 1170 Wien.
E-Mail: andrea.larnhof@mac.com.