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DIPLOMARBEIT

Titel der Diplomarbeit

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

angestrebter akademischer Grad

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Wien, am	2. Oktober 2008

NESTING DYNAMICS OF THE SOLITARY DIGGER WASP *BEMBECINUS HUNGARICUS* (HYMENOPTERA: APOIDEA: CRABRONIDAE) AT THE NATURE RESERVE "IN DEN SANDBERGEN" NEAR DRÖSING A. D. MARCH, LOWER AUSTRIA

1. 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 with 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 specialized 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 (WIESBAUER 2002) and again, this time only on some parts, in May 2003.

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 wasps in the most endangered categories 0-2 on the Red List of Endangered Species (DOLLFUSS 1994), including *Bembecinus hungaricus* (Frivaldsky), 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 the microclimatic factors on nest density of *Bembecinus hungaricus* by comparing three habitats.

2. Materials and Methods

2.1. 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). As grazing is a maintaining action for the LIFE-project, this area was monitored during the grazing period.

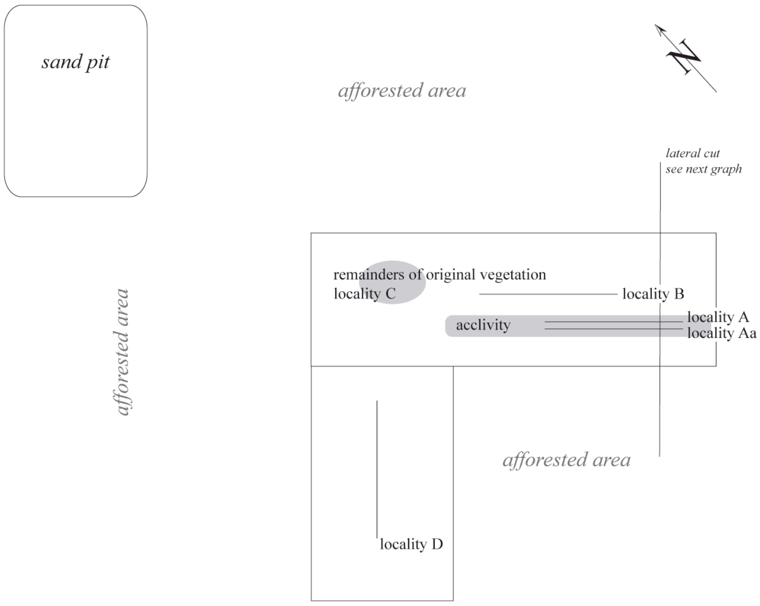

Fig. 1 Sketch of investigation area.

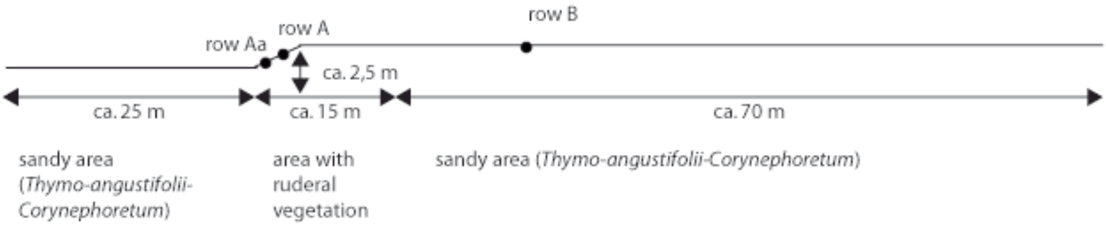

Fig. 2 Lateral cut through the investigation area.

2.2. Data collection

Three transects of 5 x 2 meters, subdivided in squares of 50 x 50 cm^2 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 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 (see KUGLER 2006) and Hymenoptera (this study) was recorded by so-called Barber 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 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** (*B*), and finally another line in the grazed area termed *D*.

Supplementary, the following abiotic factors were collected: Near each transect the air humidity, the radiation on surface, and the temperature at -10 cm, -5 cm and on surface was 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 buried 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.

2.3. Data analysis

2.3.1. 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 and -5 cm as well as on the surface.

2.3.2. Pitfalls

The specimens from the pitfalls were first sorted to families. Thereafter most of the digger wasps (Sphecidae, Crabronidae) were identified by using WITT, 1998, DOLLFUSS, 1991 and BERLAND, 1925, 1928, 1938. Dr. Herbert Zettel (Natural

History Museum Vienna) revised them and determined the Chrysididae, Pompilidae, and Apidae (some specimens sent to other experts for review).

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 curves of location B was plotted.

3. Results and Discussion

3.1. Abiotic factors

3.1.1. Precipitation

Precipitation was measured only at location C. The plot (Fig. 4) 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).

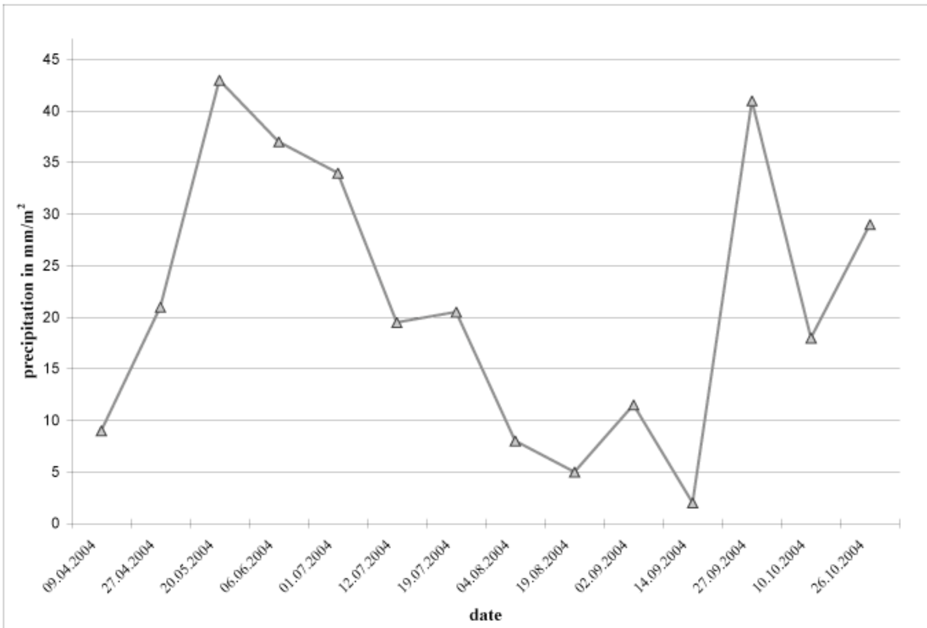

Fig. 3 Precipitation in mm/ m2 during the investigation period

3.1.2. 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.

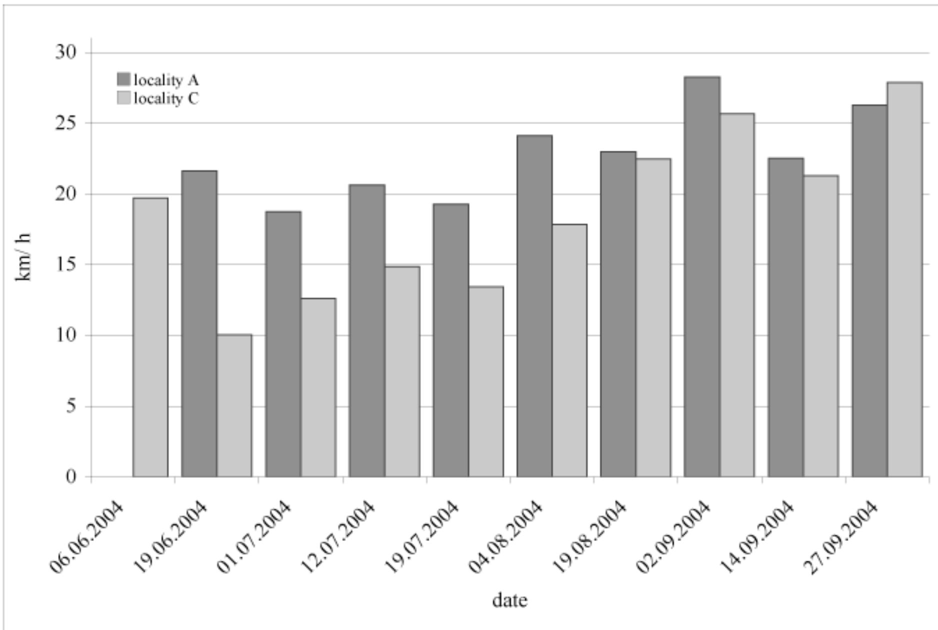

Fig. 4 Wind velocity of both anemometers during the investigation period/ days of investigation

3.1.3. 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 (as an example see 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.

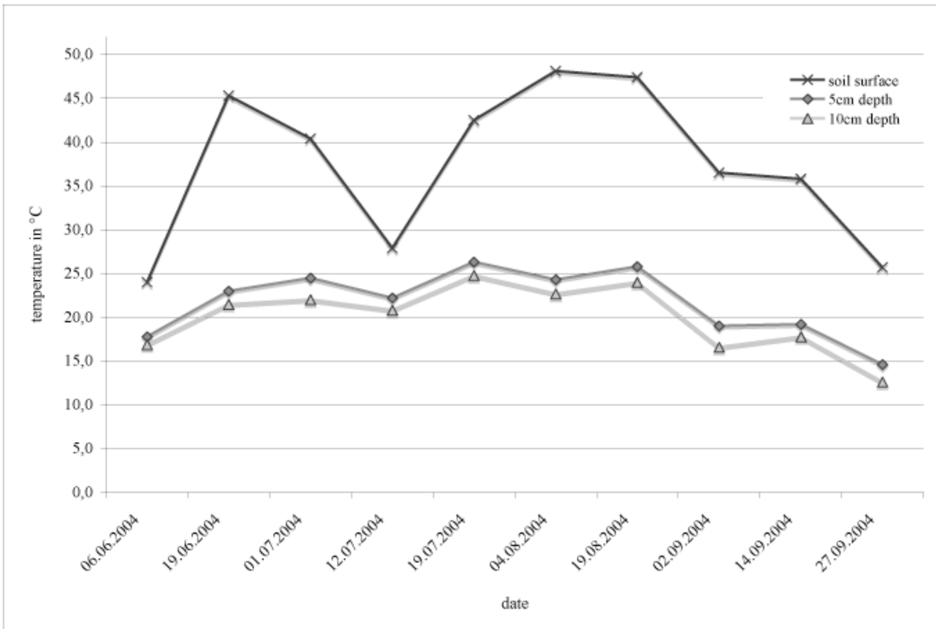

Fig. 5 Comparison of temperatures on the soil surface, -5 cm, and -10 cm on locality B.

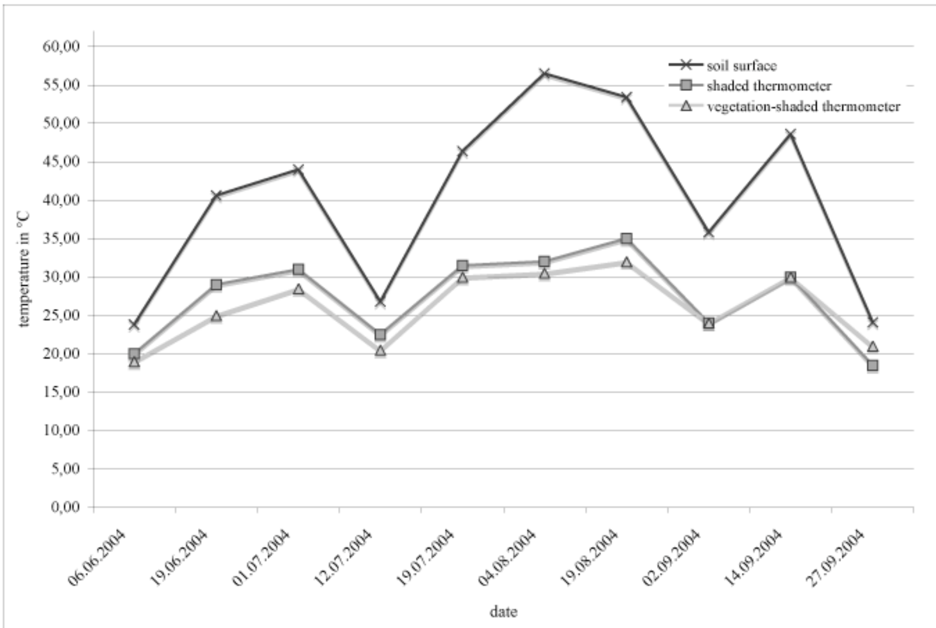

Fig. 6 Temperature patterns of location C, indicating the difference between the temperatures on the soil surface and under the shade of a small pine tree.

3.2. Nesting activity

Transects of 5 x 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 and -10 cm was found as shown in Fig. 7.

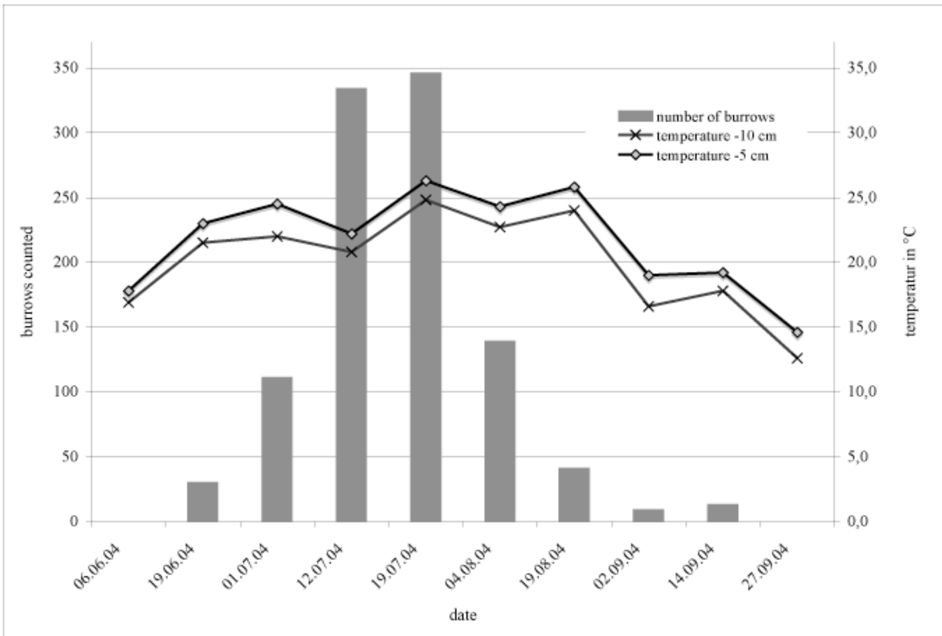

Fig. 7 Strong positive correlation between temperature in the depth to the number of burrows.

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. 8). 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.

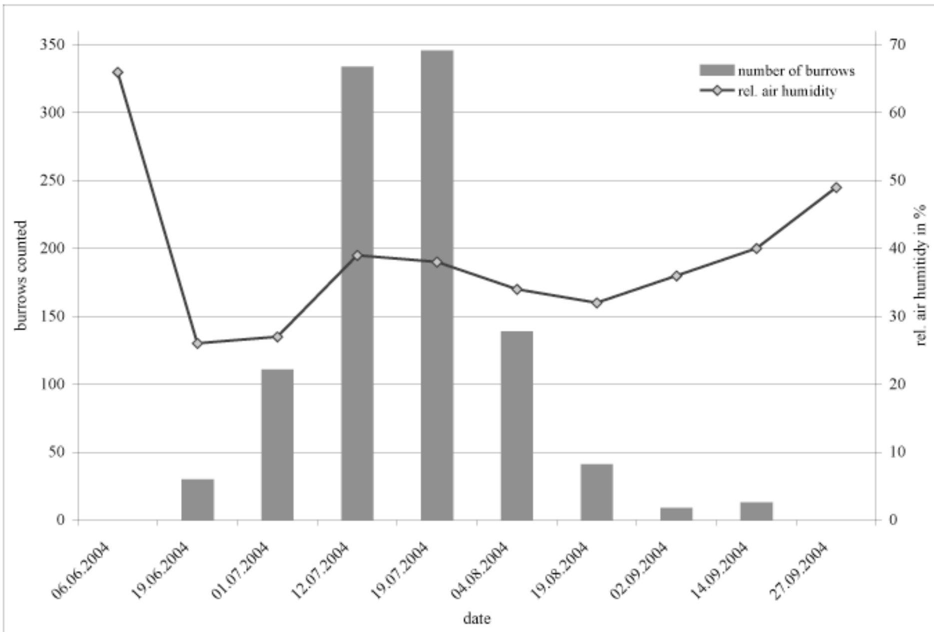

Fig. 8 Negative correlation of the number of counted burrows with relative air humidity.

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

$y = -394.87 - 2.30918{*}e0.14\ x_1 - 2.8685\ x_2 + 53.877\ x_3 - 14.119\ x_4$

where

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

The graph (Fig. 9) deriving from this formula nearly fits the one from true values (f-value: 0.9866).

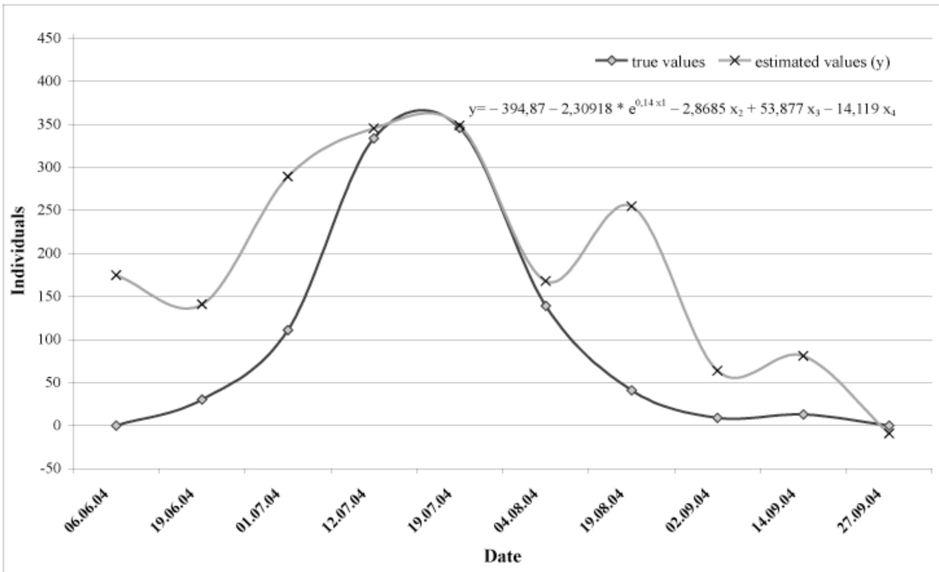

Fig. 9 Plotted multilinear regression.

3.3. Pitfalls

In total 282 individuals in 37 species of Aculeata (excluding Formicidae) were trapped, nine 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 of saving such habitats.

Nonetheless the rarefaction curve (Fig. 10) shows that not enough data were required 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.

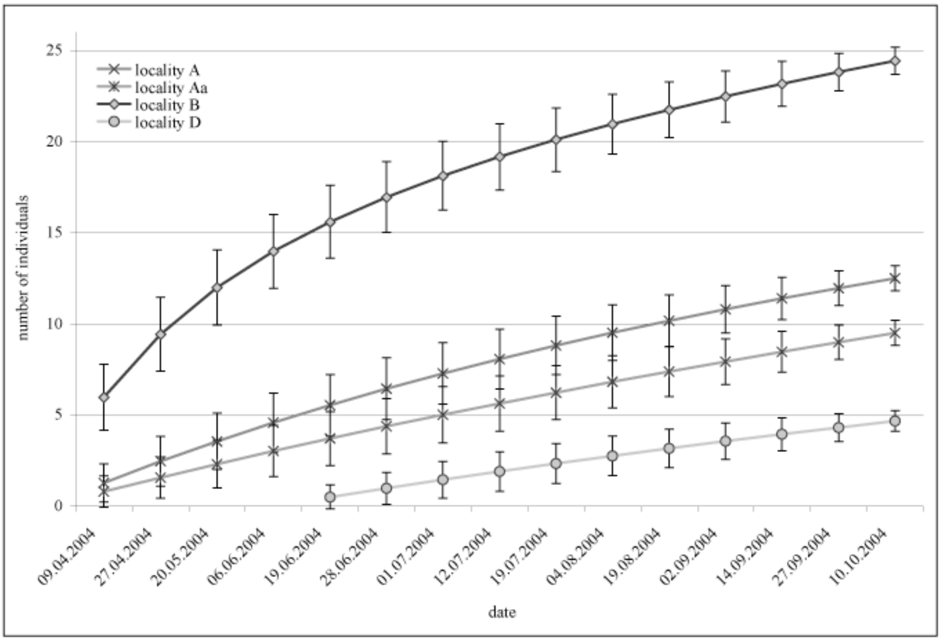

Fig. 10 Rarefaction-plot comparing all four localities.

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).

	Number of species	Shannon-Index (H'=-∑[pi * ln pi])	Evenness (E = H'/ ln S)	Dominance (D = ∑ [ni/ 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

Tab. 1 Diversity indices for the four locations.

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, *B. hungaricus* dominated, a species most characteristic for the Sandberge near Drösing.

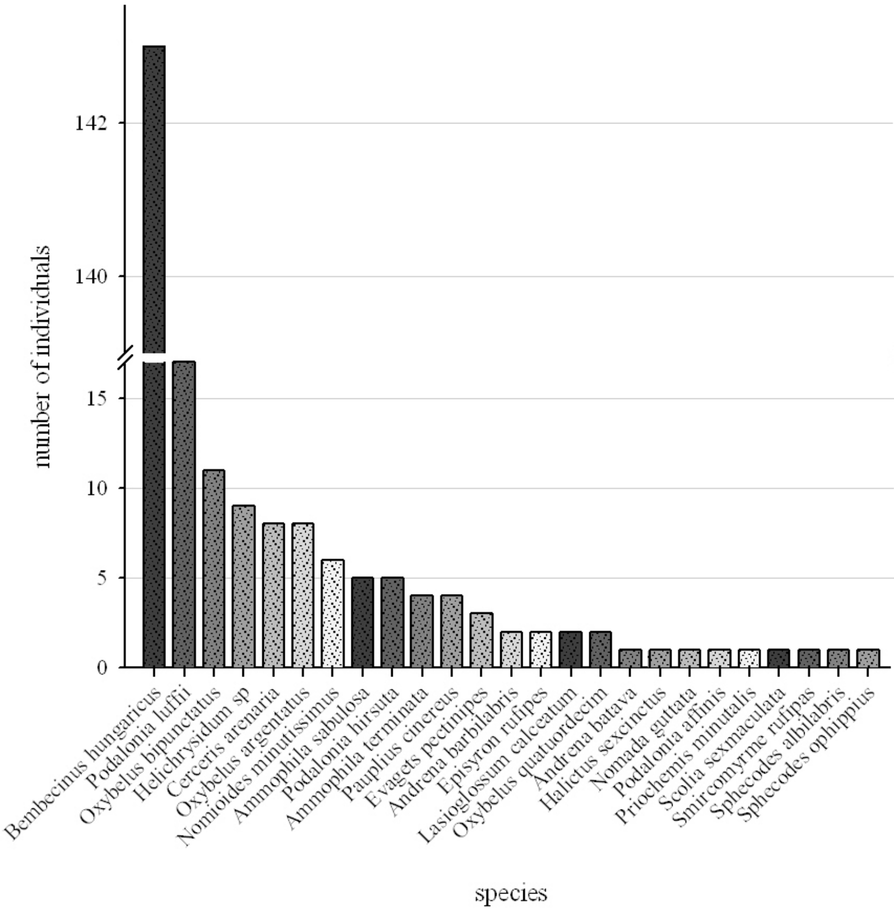

Fig. 11 Rank abundance plot of locality B.

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*.

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. 12).

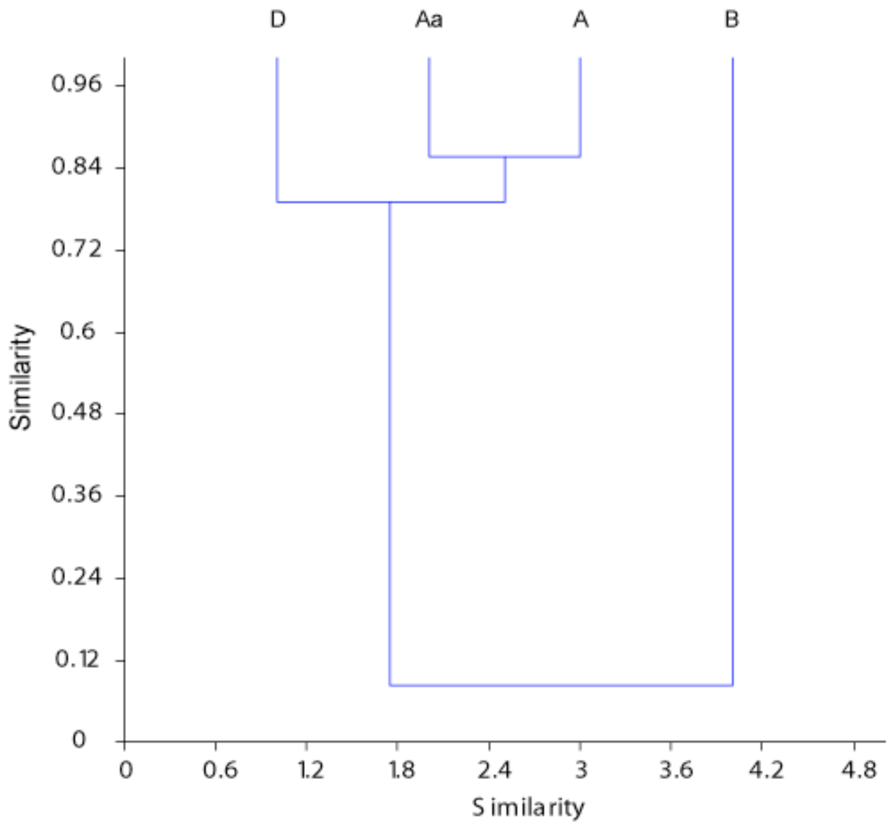

Fig. 12 Cluster analysis

4. Acknowledgements

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Thanks to my dear friend and colleague Mag. Kristina Kugler for her help – not only in the field, and also to Mr. Bernd Gabriel for his advice with statistics. I also want to thank Ing. Horst Rebernik (Nikon Instruments), who took the pictures of both one male and one female of *B. hungaricus*.

Last but no least I want to thank my partner and friend Gerd, who encouraged me to study Biology, for his patience and assistance, and of course my parents, who always supported my decision.

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6. Appendix

6.1. species list

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	
Evagets pectinipes (L.)				x	
Nomada alboguttata (Schäfer)				x	
Nomioides minutissimus (Rossi)	••			x	
Smicromyrme rufipas (Fabricius)				x	
CHRYSIDIDAE					
Hedychridium sp.			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	
SCOLIIDA					
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			
Mellinus arvensis (L.)		x	x		
Oxybelus argentatus (Curtis)	••			x	

Species	Red List Status	Localities			
		A	Aa	B	D
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:
1: extinct	•• highly endangered
2: threatened	• endangered
4: potentially threatened	

6.2. Abstract

Von April bis Oktober 2004 wurde die Aktivität von Weibchen der Grabwespe *Bembecinus hungaricus* Frivaldsky, 1877 analysiert. Nach der Wiederherstellung der offenen Fläche 2003 wurden über 1000 Nester auf 10 m^2 gezählt.

Ein Zusammenhang zwischen der Temperatur in Nestkammer-Tiefe und der Anzahl an Nester konnte nachgewiesen werden.

Auch wurde die Zusammensetzung der aculeaten Hymenopteren-Fauna (mit Ausnahme der Ameisen) untersucht. 37 Arten konnten nachgewiesen werden, etwa die Hälfte davon gefährdet. Die meisten Tiere wurden auf der freien Fläche gefunden, was die Notwendigkeit des Schutzes solcher Lebensräume aufzeigt.

From April to October 2004 activity of the females of the digger wasp *Bembecinus hungaricus* Frivaldsky, 1877 was investigated. After extensive restoration management to restore the original condition in 2003 a total of over 1000 burrows on 10 m^2 was counted.

We could show a relation between the temperature in burrow-depth and numbers of burrows.

Additional, the Aculeata fauna (excluding Formicidae) was recorded. 37 species could be trapped; the half hereof endangered species. Most of them were found at the open sand areas indicating the importance of such areas.

Hymenoptera: Crabronidae: *Bembecinus hungaricus*; sand habitat; temperature; Drösing; Lower Austria

Zusammenfassung

Auf einer restaurierten Sandfläche nahe Drösing an der March, Niederösterreich wurde von April bis Oktober 2004 die Aktivität von Weibchen der Grabwespe Bembecinus hungaricus Frivaldsky, 1877 analysiert.
Entstanden aus aeolischen Sanden der Nacheiszeit wurden offene Sandflächen im 18. Jahrhundert durch Aufforstungen befestigt und sind seither seltene und schützenswerte Lebensräume für psammophile Arthropoden.
Schon nach einer Wiederherstellung der offenen Fläche 2003 eine Aktivitätsstudie durchgeführt.

In der vorliegenden Arbeit wird nicht nur die Abhängigkeit der Aktivität von verschiedenen Umweltparametern, wie zB relative Luftfeuchtigkeit und Temperatur, aufgezeigt, sondern auch eine Artenliste dieses speziellen Lebensraumes erstellt.
Dazu wurde die Fläche an vier verschiedenen Standorten mittels Barber-Fallen beprobt und verschiedene abiotische Faktoren ermittelt.

Insgesamt konnten 37 aculeate Hymenoptera-Arten nachgewiesen werden, etwa die Hälfte davon gefährdet.
Mithilfe von Diversitätsindices konnte nachgewiesen werden, welch wichtigen Lebensraum freie Sandflächen für psammophile Arten wie *Bembecinus hungaricus* darstellen.
Eine Korrelationsmatrix zeigte deutlich den Zusammenhang zwischen der Temperatur in Nestkammer-Tiefe und der Aktivität der Grabwespen-Weibchen.

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Sept 1986 - June 1990: Elementary School at Eisenstadt

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since Oct. 2005: Natural History Museum, Department of Botany, Herbarium W:

employed via (L)API Project: establishing a virtual herbarium by databasing and scanning type material from Latin America and Africa; training of volunteers

Dec. 2004 - Sept. 2005: Natural History Museum, Department of Botany, Herbarium W:

employed via SYNTHESYS-Project: administrativ work; department's and publisher's secretary

summer 1998 & 1999: internship at the Austrian Research Centers Seibersdorf, Austria

Vienna, October 2nd 2008