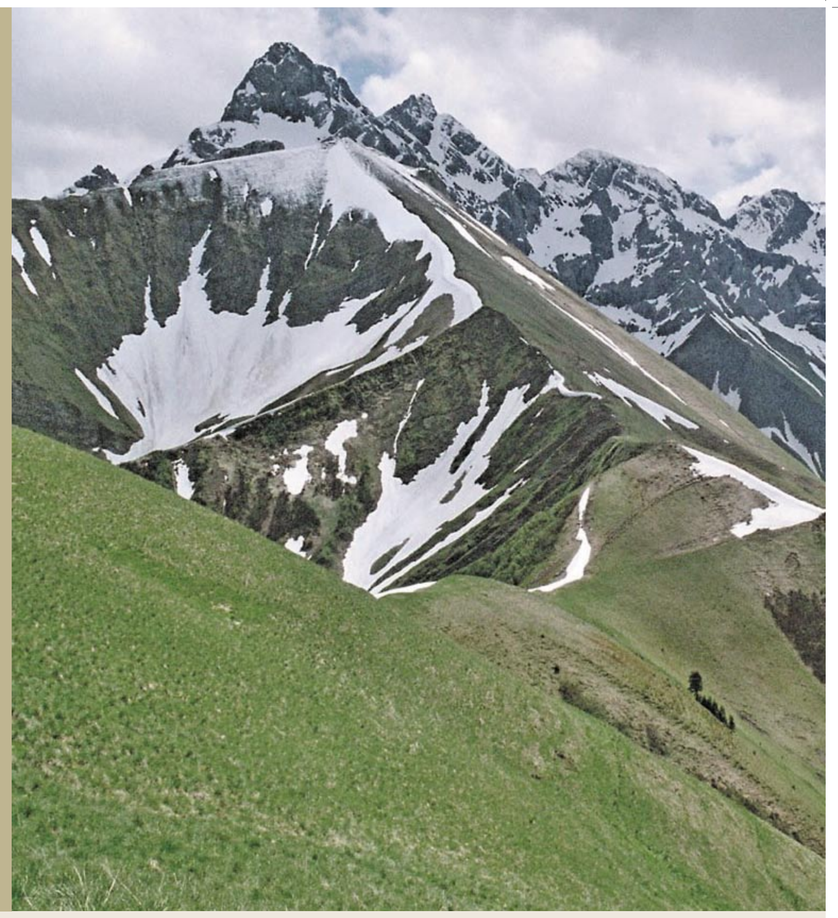
Sampling and estimating spider diversity in an alpine environment

HUBERT HÖFER[1], THEO BLICK[2], CHRISTOPH MUSTER[3] & DETLEV PAULSCH[1]

[1]State Museum of Natural History Karlsruhe, [2]Hummeltal, [3]Putbus

contact: hubert.hoefer@smnk.de



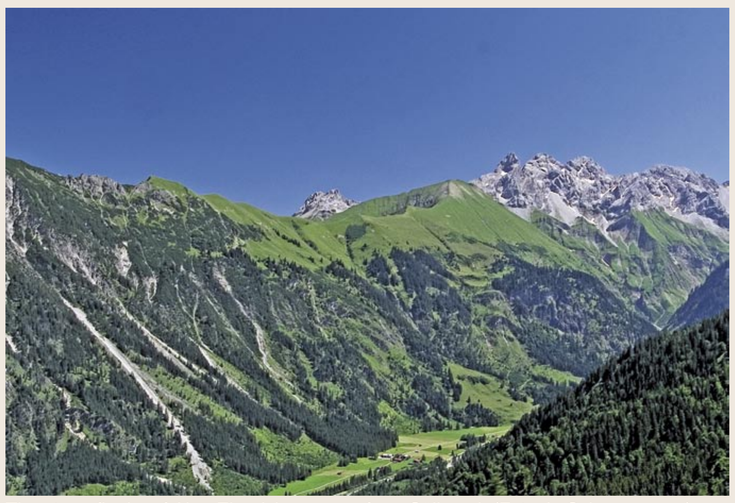
Staatliches Museum für Naturkunde Karlsruhe

Financial support was granted by Bayerischer Naturschutzfonds, Landesbund für Vogelschutz e.V. in Bayern (LBV) and State Museum of Natural History Karlsruhe

HUMBOLDT-RING Verbund deutscher Forschungsmuseen Berlin Bonn Karlsruhe München Stuttgart

Introduction

We studied the spider diversity in an alpine meadow during six years (2003-2008). 'Alpe Einödsberg' (1430-2000 m a.s.l.) belongs to the Allgäu Alps in Bavaria, Germany. The extraordinary botanical diversity of the region originates a.o. from the edaphic conditions: deep humid non-calcareous soils on laminated jurassic marl. These mountains attract people's attention due to a flower-rich mat-grass vegetation on steep flanks reaching up to the summits. However, vegetation in the area had suffered considerable alteration by intense sheep grazing during at least 20 years. The ridge was predominantly used by the sheep to lair and became strongly eutrophic by their excrement and consequently dominated by the grass *Deschampsia cespitosa*. Sheep grazing ended in 1999 and in 2001 a controlled cattle grazing was started with the aim to regenerate the species-rich alpine mat-grass (*Nardus stricta*) vegetation.



The steep flanks of Alpe Einödsberg seen from Söllereck (Foto: L. Scheuermann).

The main intention of our study was to assess the species richness and diversity of spiders in an alpine meadow and to measure effects of the intense grazing in the past and the actual extensive pasturing on the spider diversity.
Spiders were sampled with pitfall traps opened during three two-week periods within the vegetation periods of 2003, 2004, 2006, 2007, 2008 and during the whole vegetation period from early June to late September in 2005 (emptied every two weeks). Always six traps were installed in each of 16 permanent plots in the grazed Nardetalia grassland and in further 22 plots in other vegetation types (e.g. spruce forest, green alder shrubbery and calcareous grassland) in selected years.
Here we analyze the completeness of the species richness assessment and the sampling effort necessary to assess and monitor the species richness of a spider assemblage in alpine grassland.

Cattle grazing on an alpine meadow at Alpe Einödsberg.

We used the nonparametric species estimators ICE, Chao 2 and Jackknife 2 and the Michaelis-Menten equation (see Magurran 2004; calculated with EstimateS 8.0) to compare observed and estimated species richness for all and several subsets of samples.

Results

In total we captured 81,700 spiders of which 85% were adult and 83% of these were males. 158 species were identified belonging to 17 families with Linyphiidae as the most species rich (86 species), followed by Lycosidae (22 species), Gnaphosidae (12 species) and Thomisidae (9 species). 32 species are mentioned in the Red List of threatened spiders of Bavaria. Remarkable are the discovery of the lycosid *Pardosa giebeli*, which was listed as disappeared in Germany and of the critically endangered *Gnaphosa nigerrima*.

Protected pitfall trap.

One dominant lycosid: *Pardosa amentata*.

We observed an extreme dominance (85%) of four lycosid species originating from the extremely high activity density of their males during the first two weeks after snow melt. Species richness at single plots varied between 11 and 36 species in one year (mean 19) and pooled over 6 years between 22 and 54 species. The most species-rich plots were in the lower calcareous grassland with dwarf pine, in ungrazed (and thermally favored) flower-rich grassland, but also in the strongly altered ridge area.
The Chao 2 and ICE estimators are very close to the observed numbers, whereas Jackknife 2 seemed to overestimate and Michaelis-Menten underestimate species richness (Table 1).

Table 1. Estimation of species richness and completeness of sampling of the spider fauna at 'Alpe Einödsberg'
(Sobs – observed species; ICE – incidence-based coverage estimator; sdev. – Standard deviation of Chao 2 estimator; compl. - completeness = Sobs/Chao 2 estimator in %; Jack 2 – Jackknife 2 estimator; M-M – Michaelis-Menten extrapolation; percentage values are always related to numbers of observed species (Sobs)).

Data set	S_{obs}	ICE	Chao 2	sdev.	compl.	Jack 2	M-M
Complete: all plots and years	166	209.8	214.7	19.8	77.3 %	232.5	160.4
Only plots in grassland (all years)	136	167.8	172.3	16.8	78.9	186.6	131.3
Percentage of complete S_{obs} (166)	82 %	101 %	104 %			112 %	79 %
Only permanent plots (all years)	116	142.7	137.8	10.8	84.2	153.7	113
Percentage of S_{obs} (136) in grassland	85 %	105 %	101 %			113 %	83 %

For the further considerations we assume to have sampled the spider assemblage of the Nardetalia grassland near to complete. This opinion is based on the fact that we had sampled within this vegetation type, covering about 80% of 120 ha, with 108 pitfall traps during six years, and on expert knowledge of literature and species occurrences in the Bavarian Alps. We are conscious that some winter-active species may not have been collected, but expect the number of these species to be below 10.
As we did not intend to assess the spider assemblages of the spruce forest, alder shrubbery or neighboring calcareous grassland completely, the lower completeness (77%) of the dataset including these other habitat types is not surprising (Table 1).
Considering all samples from all plots in grassland we sampled 136 species and estimated a potential species number of 172 ± 17 (Chao 2) resulting in a completeness of 79% (Table 1).
In the permanent plots 116 spider species were observed during the whole investigation and 138 species estimated (Chao 2) for the vegetation type mat-grass sward. Sample completeness is high (84%), which is expected in a long-term study with many samples.

We think it can shed light on the quality of the estimators to compare the estimated species richness of a subset of the samples with the observed species number in a dataset which includes further habitat types within the meadow area, because these neighboring habitats serve as a source of species. Especially the occurrence of rare species in an assemblage, which is the basis for the nonparametric estimators may at least in part be explained by intrusion of non-autochthonous species in a certain habitat type.
The Chao 2-estimated 172 species from all grassland samples are close to the species number observed in the whole area (166) and the 138 species estimated from the samples of the permanent plots are very close to the species number observed in the whole open grassland (136) (Fig. 1, left column). 82% of the species observed in the whole area were sampled in the (dominating) grassland and 85% of the species observed in grassland were sampled in the permanent plots (Table 1). These second measurements of completeness are close to the statistically produced ones.

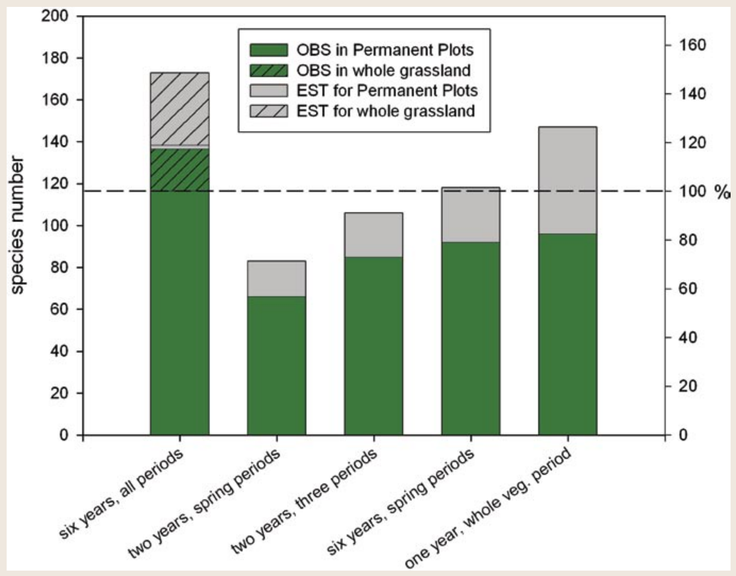


Figure 1. Observed and estimated (Chao 2) species richness in different sampling subsets and relations to the complete observed species number in permanent plots (OBS - observed species numbers; EST - estimated species numbers).

We further wanted to get an idea of how much the sampling effort could be reduced while still getting a good estimate of the richness of the spider assemblage of the alpine meadow and plotted the observed and estimated species numbers of reduced data sets in relation to the large sampling effort of six year sampling in the permanent plots (Fig. 1).
Considering only two spring periods 57% of the overall observed species were captured and 72% (Chao 2) estimated (second bar in Fig. 1). Considering samples of three two-week-periods from two consecutive years resulted in an estimate of 91% (Chao 2) of the observed species (third bar). Considering the samples of the two-week spring periods from 6 years 92 species or 79% of all species observed in permanent plots were sampled and 118 (102%) estimated (fourth bar). This value is very close to the observed species richness at the core plots for all years (116) (see Table 1).
Sampling one year during the whole vegetation period from early June to end of September resulted in 96 species (83%) and an estimate of 147 species or 108% of all species observed in the grassland and 127% of all species observed in all permanent plots (fifth bar in Fig. 1).