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Spider fauna of semi-dry grasslands on a military training base in Northwest Germany (Münster)

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Abstract: The spider fauna of semi-dry grasslands on the military training area of Dorbaum near Münster (North Rhine-Westphalia) was investigated. From 2002 to 2003 a total of 11,194 mature spiders from 141 species and 20 families was caught by pitfall trapping and hand sampling. Among them are 18 species listed in the Red Data Book of North Rhine-Westphalia, four species are rare or previously rarely recorded. Most of the spiders are habitat generalists that extend their occurrence into all types of habitats, while the number of species which are stenotopic to sand habitats is noticeably low (n = 13). The spider data were analysed with Principal Component Analysis (PCA). It is possible to distinguish spider communities of neighbouring forested habitats from species groups of open habitats, but there is no uniform spider community which is characteristic for semi-dry grassland.

Keywords: Araneae, inland dunes, sand habitat, spider community, Westphalian Bay

In northwestern Germany sand habitats are rare and restricted to small areas (VERBÜCHELN & JÖBGES 2000, PARDEY 2004). Many habitats like dry grassland, heathland and inland dunes are endangered (VERBÜCHELN et al. 1999) and contain a large number of specialised and rare animal species (BELLMANN 1997, STEVEN 2004). Spiders play an important role in ecological surveys – they are abundant, occupy a wide array of spatial and temporal niches, have high within-habitat taxonomic diversity, respond immediately to habitat change and are useful indicators of the overall species richness and ecological status of biotic communities (KIECHLE 1992, KREMEN et al. 1993, WISE 1993, SCHULTZ & FINCH 1996, NORRIS 1999). Nevertheless, information about the ecology of spiders in sand habitats of Northwest Germany is still very poor (Lower Saxony: RABELER 1951, LADEMANN 1995, FINCH 1997, MERKENS 2002; North Rhine-Westphalia: JÄGER 1996, GRIGO 1997). Further work seems imperative for successful conservation and habitat management. This study about the epigeic spiders of the semi-dry grasslands on the military training area of Dorbaum near Münster is part of a detailed investigation of the ecology of spiders in sand habitats of the Westphalian Bay.

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Study area

The study was carried out at a military training area which is located northeast of Münster near the districts Handorf and Dorbaum at an elevation of 50 m a.s.l. covering about 400 ha (Abb. 1). In the north the Ems river forms the boundary of the area. The study area is glacially formed and the ice-age top layers are fluviatile and aeolic sands with dry soil conditions. The climate is sub-Atlantic with a mean annual temperature of 9.5 to 10 °C and mean annual precipitation of 700 to 750 mm (MEYNEN & SCHMITHÜSEN 1959, MURL NRW 1989). According to MEYNEN & SCHMITHÜSEN (1959) the potential natural vegetation is the Fago-Quercetum typicum. STARKMANN et al. (1993) and GROSSE (1995) describe the actual vegetation which consists of several endangered plant species. Beyond pine (*Pinus sylvestris*) and oak forests (*Quercus robur*), mainly at the edge of the area, small patches of dry grasslands with dry soil conditions and a sparse herbal layer (Thero-Airion: Airo-Festucetum ovinae, Filagini-Vulpietum), dominated by *Vulpia myuros* and *Aira caryophyllea*, are distributed in parts of the training area. Furthermore the Airetum praecocis and the Spergulo-Corynephoretum are also present. All over the study area former dry grassland sites are overgrown by semi-dry grassland (*Agrostis capillaris*-grassland, *Holcus lanatus*-grassland) (Beulting pers. comm.). For a further detailed description of the grassland vegetation types see GROSSE (1995). The military training area was established in the second

Tab. 1: Site characteristics (hum = humidity: hum1 = very dry, hum2 = dry, hum3 = fresh, hum4 = humid; sha = shading: sha1 = open, sha3 = partially shaded, sha4 = shaded; dist = disturbance).

site	habitat	vegetation structure	humidity	shade	disturbance
D1	heathland	mosaic of bare sand and *Calluna* shrubs	hum2	sha1	habitat management (once a year)
D2	rough grazing	dense herbal-layer with a low height of vegetation (about 10 cm)	hum2	sha1	grazing, training (periodical)
D3	dry grassland	sparse herbal-layer in places bare sand and mosses	hum1	sha1	animals (e. g. rabbits) (periodical)
D4	rough meadow	dense herbal-layer (about 20-30 cm) overgrown with shrubs	hum3	sha1	-
D5	rough meadow	dense herbal-layer (about 30-40 cm) overgrown with shrubs	hum3-4	sha1	-
D6	edge of a pine-forest (*Pinus silvestris*)	mosaic tussocks and shrubs in places bare sand	hum2	sha3	training (periodical)
D7	edge of a oak-forest (*Quercus robur*)	dense and high-growing herbal-layer (about 50 cm)	hum4	sha4	-

half of the 19th century and is under British control today. It is periodically used for training (tanks, track vehicles) with different intensities from site to site (STARKMANN et al. 1993, GROSSE 1995).

Site descriptions

Seven sites (D1-D7) were studied at the military training area (Tab. 1). Five sites (D1-D5) were located in open habitats whereas D6 and D7 were situated on woodland edges.

Methods

Pitfall traps were used to monitor the active densities of the ground-dwelling spiders for one year (08.04.2002 to 18.04.2003). In five sites (D1-D5) five traps (glass jars, diameter 9 cm) were installed with a distance of 5–10 m, arranged as a cross. In two sites (D6, D7) three traps were placed in line, about 5 m apart. A 3% formalin solution with detergent was used as the killing agent and preservative. The traps were emptied fortnightly during the warm seasons and once a month during the winter. In addition to pitfall trapping, one hand sampling session was carried out in June 2002.

Statistical methods

Dominances [D %] were calculated according to ENGELMANN (1978). Measurements of diversity were reported for each site. For alpha-diversity (diversity in individual sample units) the Brillouin index was calculated using $H_B = (\ln N! - \sum \ln n_x!)/N$ (N = total number of individuals; n_x = specimens of species x). For an approximation of factorial Stirling's formula ($\ln n! \approx n * \ln n$) was used. Furthermore the Brillouin-Evenness E_B was calculated as follows: $E_B = H_B / H_{Bmax}$ (H_B = Brillouin index; $H_{Bmax} = \ln S$ where S is the total number of species) (KRATOCHWIL & SCHWABE 2001).

Comparison of the epigeic spider communities was made by Principal Component Analysis (PCA) using Canoco 4.5. To compare the sites, data were standardized (individual sums x 100/number of sampling days/number of pitfall traps). For PCA the abundances of each species were log transformed. Only species with a dominance of >1% per site were included in the analyses.

Results

Altogether, 11194 mature spiders from 141 species and 20 families were caught by pitfall trapping and hand sampling (Tab. 2). The most abundant families were Linyphiidae, Lycosidae and Gnaphosidae. Dominant species were *Pardosa monticola* and *Pardosa palustris*. *Alopecosa cuneata*, *A. pulverulenta*, *Drassyllus pusillus*, *Hahnia nava*, *Pardosa hortensis*, *P. lugubris* s. str. and *Trochosa terricola* were also numerous. Rare or previously rarely recorded species were *Micaria subopaca*, *Panamomops mengei*, *Parapelecopsis nemoralis* and *Pelecopsis mengei*. A status of endangerment for North Rhine-Westphalia is given for 18 species: Five species are endangered (category 3) and one, *Euophrys herbigrada*, is highly endangered (category 2). For 11 species an endangerment can be assumed (category V). *Meioneta simplicitarsis* is considered extinct (category 0).

Tab. 2: Species list (nomenclature follows Platnick 2007). Abbreviations: RL = status of endangerment (according to Kreuels & Buchholz 2006): * = not endangered, V = endangerment can be assumed, R = extremely rare, not declining species, 3 = endangered, 2 = highly endangered, 0 = extinct; HB = habitat bindings : e = eurytopic, s = stenotopic (1 = dry non-forested habitats, 2 = wet non-forested habitats, 3 = forests, 4 = fringes); A = abundance; D = Dominance [%]; M = method: hs = hand-sampling, pt = pitfall-trapping.

family/species	RL	HB	D1	D2	D3	D4	D5	D6	D7	A	D	M
Segestriidae												
Segestria senoculata	*	e	2	.	.	.	.	.	.	2	0,02	hs
Mimetidae												
Ero cambridgei	*	s2	.	.	.	.	.	.	1	1	0,01	pt
Theridiidae												
Anelosimus vittatus	*	e	.	.	.	1	.	.	.	1	0,01	hs
Enoplognatha latimana	3	s1	.	.	.	.	1	1	.	2	0,02	pt
Enoplognatha thoracica	*	e	6	3	10	20	72	4	6	121	1,08	pt
Euryopis flavomaculata	*	e	.	.	.	.	.	4	.	4	0,04	pt
Neottiura bimaculata	*	e	1	.	.	4	1	.	.	6	0,05	pt, hs
Robertus arundineti	*	e	1	.	.	6	2	.	.	9	0,08	pt
Robertus lividus	*	e	11	.	2	2	.	.	.	15	0,13	pt
Steatoda phalerata	*	e	4	2	10	1	11	2	.	30	0,27	pt
Linyphiidae												
Agyneta subtilis	*	e	.	.	1	.	.	.	.	1	0,01	pt
Araeoncus humilis	*	e	5	5	2	4	4	.	.	20	0,18	pt
Bathyphantes gracilis	*	e	1	4	.	1	1	3	2	12	0,11	pt
Centromerita bicolor	*	e	.	2	.	.	2	1	3	8	0,07	pt
Centromerita concinna	*	e	4	3	13	.	.	.	.	20	0,18	pt
Centromerus sylvaticus	*	e	.	.	.	1	1	.	.	2	0,02	pt
Ceratinella brevipes	*	e	1	.	.	.	.	.	.	1	0,01	pt
Ceratinella brevis	*	e	.	.	.	1	.	5	.	6	0,05	pt
Cnephalocotes obscurus	*	e	5	4	.	16	19	.	.	44	0,39	pt
Dicymbium nigrum	V	e	1	1	.	1	.	2	83	88	0,79	pt
Dicymbium tibiale	*	e	4	.	.	.	.	.	.	4	0,04	pt
Diplocephalus latifrons	*	e	.	.	.	.	.	.	3	3	0,03	pt
Diplostyla concolor	*	e	.	.	.	2	.	7	.	9	0,08	pt
Dismodicus bifrons	*	e	.	.	.	1	.	.	.	1	0,01	hs
Erigone atra	*	e	16	22	2	6	35	.	.	81	0,72	pt
Erigone dentipalpis	*	e	11	16	3	8	72	1	17	128	1,14	pt
Erigone longipalpis	*	e	.	.	1	.	.	.	.	1	0,01	pt
Floronia bucculenta	*	e	.	.	.	.	.	1	.	1	0,01	pt
Gnathonarium dentatum	V	e	.	.	.	.	3	.	.	3	0,03	pt
Gongylidiellum latebricola	*	e	1	.	.	.	.	.	.	1	0,01	pt
Gongylidiellum vivum	*	e	3	3	2	5	41	2	6	62	0,55	pt
Lepthyphantes minutus	*	e	.	.	1	.	.	.	.	1	0,01	pt
Linyphia hortensis	*	e	.	.	.	.	.	1	.	1	0,01	hs
Linyphia triangularis	*	e	.	.	.	.	.	2	1	3	0,03	pt
Macrargus rufus	*	e	.	.	.	.	.	.	1	1	0,01	pt
Maso sundevalli	*	e	1	1	.	.	.	.	11	13	0,12	pt
Meioneta mollis	*	e	.	.	.	2	.	.	.	2	0,02	pt
Meioneta rurestris	*	e	4	7	3	.	2	.	.	16	0,14	pt
Meioneta saxatilis	*	e	.	.	.	.	2	1	.	3	0,03	pt
Meioneta simplicitarsis	0	s2	.	.	.	7	.	.	.	7	0,06	pt
Micrargus apertus	*	e	.	.	.	1	.	.	.	1	0,01	pt
Micrargus herbigradus	*	e	1	.	1	2	7	6	10	27	0,24	pt
Micrargus subaequalis	*	e	.	1	.	5	1	.	.	7	0,06	pt
Microlinyphia pusilla	*	e	9	1	2	3	2	.	.	17	0,15	pt
Microneta viaria	*	e	1	.	2	2	.	.	.	5	0,04	pt
Minyriolus pusillus	*	e	.	.	.	.	2	.	.	2	0,02	pt
Oedothorax apicatus	*	e	.	.	.	.	3	.	3	6	0,05	pt
Oedothorax fuscus	*	e	.	.	3	.	.	.	.	3	0,03	pt
Palliduphantes pallidus	*	e	.	.	1	.	.	2	1	4	0,04	pt
Panamomops mengei	R	e	.	.	.	.	.	.	1	1	0,01	pt
Parapelecopsis nemoralis	R	s3	.	.	.	2	.	.	.	2	0,02	pt
Pelecopsis mengei	R	s2	1	.	.	.	.	1	.	2	0,02	pt
Pelecopsis parallela	*	e	5	17	7	13	13	1	.	56	0,50	pt
Pocadicnemis juncea	V	e	.	.	.	.	.	4	.	4	0,04	pt
Pocadicnemis pumila	*	e	2	.	.	.	.	.	2	4	0,04	pt
Stemonyphantes lineatus	*	e	.	2	8	1	.	.	5	16	0,14	pt

family/species	RL	HB	D1	D2	D3	D4	D5	D6	D7	A	D	M
Tapinocyba insecta	*	e	.	.	.	.	.	1	.	1	0,01	pt
Tapinocyba praecox	V	e	7	8	7	3	3	4	.	32	0,29	pt
Tenuiphantes flavipes	*	e	.	.	.	.	.	1	.	1	0,01	pt
Tenuiphantes mengei	*	e	.	.	1	.	.	.	.	1	0,01	pt
Tenuiphantes tenuis	*	e	5	2	13	9	14	55	75	173	1,55	pt
Tenuiphantes zimmermanni	*	e	.	.	1	1	1	1	.	4	0,04	pt
Tiso vagans	*	e	3	3	.	28	91	2	40	167	1,49	pt
Walckenaeria acuminata	*	e	1	.	.	.	.	.	.	1	0,01	pt
Walckenaeria alticeps	*	e	1	.	.	1	.	.	2	4	0,04	pt
Walckenaeria antica	*	e	10	.	1	1	.	.	.	12	0,11	pt
Walckenaeria atrotibialis	*	e	6	.	.	.	.	.	.	6	0,05	pt
Walckenaeria dysderoides	*	e	2	.	.	9	1	3	.	15	0,13	pt
Walckenaeria nudipalpis	*	e	.	.	1	.		.	.	1	0,01	pt
Tetragnathidae												
Metellina mengei	*	e	.	1	.	1	.	.	.	2	0,02	hs
Pachygnatha clercki	*	e	.	.	1	.	2	.	.	3	0,03	pt
Pachygnatha degeeri	*	e	79	35	6	5	6	13	14	158	1,41	pt
Tetragnatha pinicola	*	e	.	.	.	1	.	.	.	1	0,01	hs
Araneidae												
Agalenatea redii	3	s1	1	.	.	1	.	1	.	3	0,03	hs
Araneus diadematus	*	e	1	.	.	.	.	.	.	1	0,01	pt
Araniella opisthographa	*	e	.	.	.	1	.	.	.	1	0,01	hs
Cercidia prominens	*	e	12	2	2	6	.	1	.	23	0,21	pt
Hypsosinga pygmaea	*	s2	.	3	7	4	3	.	.	17	0,15	pt, hs
Larinioides cornutus	*	e	1	.	.	.	.	.	.	1	0,01	hs
Mangora acalypha	*	e	.	.	.	12	.	.	.	12	0,11	hs
Lycosidae												
Alopecosa accentuata	V	e	.	.	15	1	.	.	.	16	0,14	pt
Alopecosa cuneata	*	e	143	128	288	168	71	8	8	814	7,27	pt
Alopecosa pulverulenta	*	e	153	28	70	20	37	36	17	361	3,22	pt
Arctosa leopardus	*	e	.	1	.	.	.	1	.	2	0,02	pt, hs
Pardosa agrestis	*	e	4	13	157	.	.	.	1	175	1,56	pt, hs
Pardosa amentata	*	e	5	3	.	.	1	.	.	9	0,08	pt
Pardosa hortensis	3	e	270	4	2	6	1	151	14	448	4,00	pt
Pardosa lugubris	*	e	146	1	1	1	.	59	156	364	3,25	pt
Pardosa monticola	*	e	403	839	1836	204	63	2	8	3355	29,97	pt
Pardosa palustris	*	e	270	1148	238	6	13	21	13	1709	15,27	pt, hs
Pardosa prativaga	*	e	17	33	3	16	.	18	4	91	0,81	pt, hs
Pardosa pullata	*	e	60	19	26	33	34	.	2	174	1,55	pt
Pirata hygrophilus	*	e	1	.	.	.	.	1	1	3	0,03	pt
Pirata piraticus	*	e	1	.	.	.	.	.	.	1	0,01	hs
Trochosa ruricola	*	e	27	119	43	.	7	10	4	210	1,88	pt
Trochosa terricola	*	e	95	15	39	67	47	47	10	320	2,86	pt
Xerolycosa miniata	V	e	147	69	3	.	.	1	.	220	1,97	pt, hs
Pisauridae												
Pisaura mirabilis	*	e	2	.	3	1	.	5	1	12	0,11	pt, hs
Agelenidae												
Malthonica silvestris	*	e	.	.	.	.	1	.	.	1	0,01	pt
Tegenaria agrestis	*	e	.	.	1	1	.	1	.	3	0,03	pt
Tegenaria atrica	*	e	.	.	.	.	.	1	.	1	0,01	hs
Hahniidae												
Hahnia montana	*	e	.	.	.	.	.	.	4	4	0,04	pt
Hahnia nava	*	e	6	50	221	87	14	14	3	395	3,53	pt
Hahnia ononidum	*	e	.	.	.	.	49	.	.	49	0,44	pt
Hahnia pusilla	*	e	.	2	1	.	.	.	1	4	0,04	pt
Dictynidae												
Dictyna pusilla	*	e	1	.	.	.	.	.	.	1	0,01	hs
Amaurobiidae												
Amaurobius fenestralis	*	e	1	.	.	.	.	.	.	1	0,01	hs
Miturgidae												
Cheiracanthium virescens	3	s1	1	.	2	3	.	.	.	6	0,05	pt, hs
Liocranidae												
Agroeca brunnea	*	e	1	.	.	.	1	1	.	3	0,03	pt, hs
Clubionidae												
Clubiona comta	*	e	2	1	.	.	.	.	.	3	0,03	pt
Clubiona neglecta	*	e	2	.	1	1	2	.	.	6	0,05	pt

family/species	RL	HB	D1	D2	D3	D4	D5	D6	D7	A	D	M
Clubiona pallidula	*	e	.	.	.	.	1	.	.	1	0,01	pt
Clubiona reclusa	*	e	1	.	.	.	1	.	.	2	0,02	pt
Clubiona terrestris	*	e	.	.	.	.	.	.	2	2	0,02	pt
Corinnidae												
Phrurolithus festivus	*	e	15	1	1	2	2	2	.	23	0,21	pt
Gnaphosidae												
Drassodes pubescens	*	e	9	5	9	6	10	4	1	44	0,39	pt
Drassyllus lutetianus	*	e	1	.	16	.	.	.	.	17	0,15	pt
Drassyllus pusillus	*	e	42	39	75	62	78	3	7	306	2,73	pt
Haplodrassus signifer	*	e	38	30	49	17	15	6	17	172	1,54	pt
Haplodrassus umbratilis	*	e	2	.	.	.	.	.	.	2	0,02	pt
Micaria pulicaria	V	e	2	.	.	.	1	.	.	3	0,03	pt
Micaria subopaca	R	s3	.	.	.	.	.	1	.	1	0,01	pt
Zelotes electus	V	e	2	.	2	30	7	.	1	42	0,38	pt
Zelotes latreillei	*	e	8	.	12	25	23	3	.	71	0,63	pt, hs
Zelotes longipes	V	s1	.	.	2	.	.	.	.	2	0,02	pt
Zelotes petrensis	*	e	16	.	3	3	13	.	.	35	0,31	pt
Zelotes subterraneus	*	e	1	.	.	.	.	4	.	5	0,04	pt
Zoridae												
Zora silvestris	*	s4	3	.	.	.	.	.	.	3	0,03	pt
Zora spinimana	*	e	1	.	.	.	.	1	1	3	0,03	pt
Philodromidae												
Philodromus cespitum	*	e	.	.	.	1	.	1	.	2	0,02	pt, hs
Philodromus praedatus	*	s3	.	.	.	.	.	.	1	1	0,01	pt
Thomisidae												
Xysticus acerbus	3	s1	3	5	6	.	1	.	.	15	0,13	pt
Xysticus audax	*	e	2	.	.	.	.	.	.	2	0,02	hs
Xysticus cristatus	*	e	15	11	25	10	6	3	13	83	0,74	pt, hs
Xysticus kochi	*	e	7	12	8	3	2	2	6	40	0,36	pt, hs
Salticidae												
Euophrys herbigrada	2	e	.	.	.	2	.	1	.	3	0,03	pt
Evarcha falcata	*	e	1	.	.	.	.	.	.	1	0,01	pt
Heliophanus flavipes	*	e	.	.	.	7	.	1	.	8	0,07	hs
Phlegra fasciata	V	e	4	1	2	2	3	.	.	12	0,11	pt, hs
Talavera aequipes	V	e	1	.	1	.	.	.	.	2	0,02	pt
		Σ	**2162**	**2725**	**3275**	**986**	**922**	**542**	**583**	**11195**		
			82	**49**	**62**	**70**	**58**	**60**	**46**			

Most of the species are eurytopic, only 13 are stenotopic. Of these, *Agalenatea redii*, *Cheiracanthium virescens*, *Enoplognatha latimana*, *Xysticus acerbus* and *Zelotes longipes* are stenotopic to dry grassland and sandy habitats. *Hypsosinga pygmaea* is stenotopic to heathlands. All stenotopic species occur only with a low number of specimens (Tab. 2).

Considering the number of investigation days and traps the largest number of specimens could be caught at sites D2 and D3, followed by D1, while the number of specimens of sites D4 – D7 is low (Tab. 3). The highest number of species is given at D1 followed by D4 in contrast to D2 and D7 with the lowest number of species. Regarding the Brillouin-Index D5 and D4 show the highest diversity whereas the values for D2 and D3 are noticeable low. Thus in comparison with all other sites (E_B = 0.66 – 0.72), the Brillouin-Eveness of site D2 (E_B = 0.48) and D3 (E_B = 0.46) is also low while the largest value for Brillouin-Eveness could be calculated for D5 (E_B = 0.79).

On the basis of the PCA it is possible to separate four species groups (Fig. 2). In the plot the species composition of the sites D1, D2 and D3 [A] is clearly distinguished from that of the sites D4 and D5 [B] and D6 and D7 [C]. The first axis may reflect a humidity gradient with dry habitats on the left and humid sites on the right. Along the second axis probably a vegetation cover gradient is given.

The PCA shows an overlap between the sites D1, D2 and D3. Thus the first group of spiders occur on sites which show typical conditions of dry grassland, rough meadows and grazing: sparse and low-growing vegetation with places of bare sand. The community comprises 22 species. Some of them are exclusively found at these sites (e.g. *Centromerita concinna*, *Drassyllus lutetianus*), others seem to prefer these structures (e.g. *Alopecosa accentuata*, *Pardosa agrestis*, *P. palustris*, *Xerolycosa miniata*). Only one species, *Xysticus acerbus*, is stenotopic to this habitat. Most of the species seem to be able to cope with a wide ecological amplitude and thus

Tab. 3: Diversity measures for investigated sites (n ind. = total number of individual, n spec. = number of species, ind/day = ratio individuals per day, ind/day/trap = ratio individuals per day and trap, HB = Brillouin-Index, EB = Brillouin-Evenness).

site	n ind.	n spec.	ind/day	ind/day/trap	HB	EB
D1	2162	82	7,5	1,5	2,90	0,66
D2	2725	49	12,9	2,6	1,88	0,48
D3	3275	62	11,3	2,3	1,88	0,46
D4	986	70	4,7	0,9	3,03	0,71
D5	922	58	4,3	0,9	3,22	0,79
D6	542	60	2,6	0,9	2,85	0,70
D7	583	46	2,8	0,9	2,75	0,72

also occur on other habitat types (e.g. *Alopecosa pulverulenta*, *Pardosa prativaga*, *Tapinocyba praecox*, *Xysticus cristatus*).

Group A/B comprises 13 species which occur in habitats of group A as well as on sites of group B and thus probably need dry conditions.

The species of the second group prefer sites with a dense herbal layer and high vegetation. This group has hardly any species of its own, apart from *Hahnia ononidum* and *Mangora acalypha* which are exclusively found at sites D4 and D5. *Zelotes electus* seems to be the only spider which clearly prefers this habitat, but all other species show only poor habitat bindings.

The PCA shows a clear difference between Group C which combines sites D6 and D7 and all other communities. Apart from *Dicymbium nigrum* s. str. and *Maso sundevalli* all other species extend into various other habitats. For example, *Pardosa hortensis* and *P. lugubris* were also found to be numerous at site D1 (group A) while *Micrargus herbigradus* and *Tenuiphantes tenuis* were caught at sites D4 and D5 (group B).

Discussion

Frequent species like *Alopecosa pulverulenta*, *Pardosa palustris* and *Trochosa terricola* are eurytopic and occur in a wide array of habitats all over North Rhine-Westphalia. *Alopecosa cuneata*, *Hahnia nava*, *Pardosa hortensis* and *Pardosa monticola* are widespread too, but they show a preference for dry habitats (Kreuels & Buchholz 2006). Interesting faunistic records from this study are the linyphiid spiders *Meioneta simplicitarsis* and *Panamomops mengei*. Both species are very rare, *M. simplicitaris* had hitherto been found in eastern Germany (e. g. Moritz 1973, Sacher & Breinl 1999) and by Casemir (1982) in North Rhine-Westphalia. *P. mengei* is mainly distributed in the central and eastern parts of Germany but has also been recorded in a few areas of Saarland and Rhineland-Palatinate (Staudt 2007). *Meioneta simplicitarsis* seems to prefer dry grassland (Braun 1969, Casemir 1982, Sacher & Breinl 1999, Buchar & Ruzicka 2002) but also occur in damp and wet meadows and pastures (Heimer & Nentwig 1991, Kreuels & Buchholz 2006). *Panamomops mengei* was found in different habitats like dry grassland (Perner 1997, Schnitter et al. 2003), marshes and bogs (Hiebsch 1985, Kreuels & Buchholz subm.), shores of waters (Buchsbaum 1995) and among detritus in various forests (Rabeler 1969, Beyer 1972, Heimer & Nentwig 1991, Platen 1995,

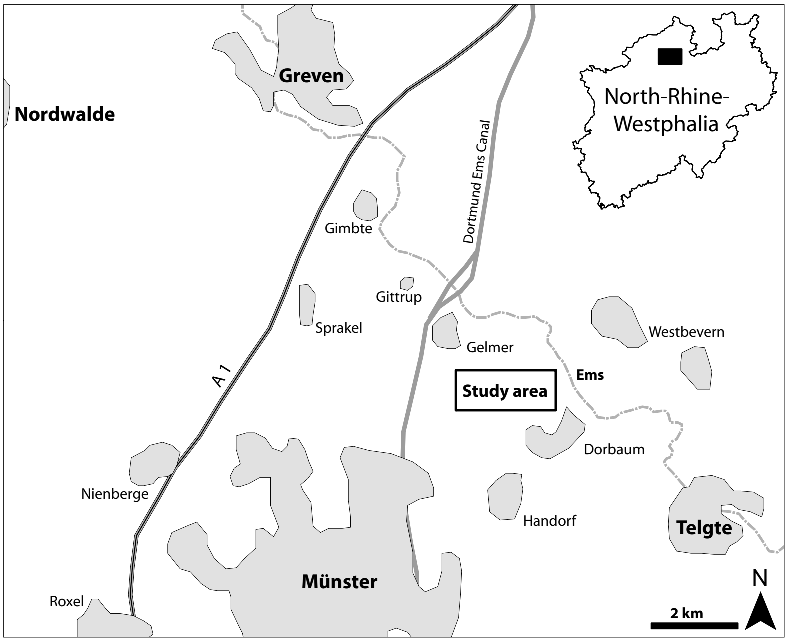

Fig. 1: Map of study area (TK25 3912-3).

SCHIKORA & SACHER 1998, MUSTER 1999, BUCHAR & RUZICKA 2002).

Most of the spiders seem to be habitat generalists that extend into all types of habitats of the study area. In contrast to this, the number of species which are stenotopic to sand habitats is noticeably low. Thus expected species like *Agroeca lusatica*, *Arctosa perita*, *Sitticus saltator* and *Steatoda albomaculata*, as recorded by LADEMANN (1995) on dry grasslands of north-western Germany, or *Clubiona frutetorum*, *Pellenes tripunctatus* and *Sitticus distinguendus*, found by FINCH (1997) in similar habitats, are missing. The absence of *Arctosa perita* is especially surprising, because this species usually occurs in all types of sandy habitats (BRAUN 1969, BAUCHHENSS 1990, 1995, LEIST 1994, MERKENS 2002, SCHNITTER et al. 2003). Probably this fact can be explained by the low number and size of patches with open sand and sparse vegetation in the study area. According to MERKENS (2002) the Atlantic climate seems to accelerate the succession of inland dunes and to reduce the extreme character of the habitat. Several common species of other habitat types can be found regularly in dunes or dry grassland while in the east of Germany these species stay in their 'typical' habitats, probably because the eastern sandy sites are drier and hotter than those in the west.

The largest number of specimens could be caught at sites D2 and D3 which can be explained by the very frequent occurrence of the lycosid spiders *Pardosa monticola* and *Pardosa palustris*. As mentioned above, *Pardosa palustris* is able to cope with a wide spectrum of ecological conditions and a high level of disturbance. *Pardosa monticola* is common and frequent in grassland fragments, often inhabiting short dune grasslands (BONTE & MAELFAIT 2001, BONTE et al. 2003, KREUELS & BUCHHOLZ 2006). Both species show high locomotory activity and

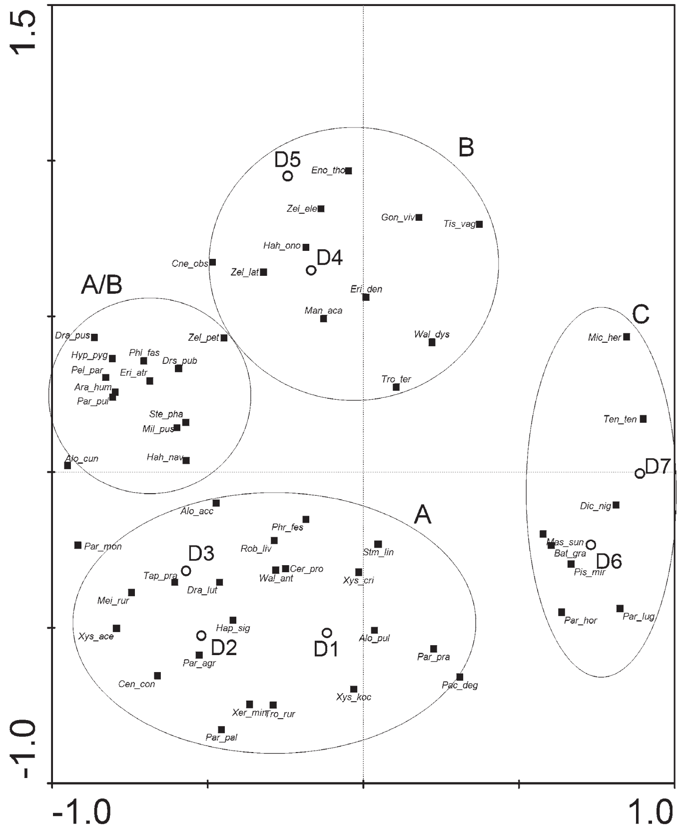

Fig. 2: Principal Component Analysis of spider communities from the military training area of Dorbaum – species plot (eigenvalue first axis = 0.714, second axis = 0.222; cumulative percentage variance of species data first axis = 71.4, second axis = 93.6). D1 – D7 = sites, A, A/B, B, C = species groups. Abbreviated species names: Alo_acc = *Alopecosa accentuata*, Alo_cun = *Alopecosa cuneata*, Alo_pul = *Alopecosa pulverulenta*, Ara_hum = *Araeoncus humilis*, Bat_gra = *Bathyphantes gracilis*, Cen_con = *Centromerita concinna*, Cer_pro = *Cercidia prominens*, Cne_obs = *Cnephalocotes obscurus*, Dic_nig = *Dicymbium nigrum*, Drs_pub = *Drassodes pubescens*, Dra_lut = *Drassyllus lutetianus*, Dra_pus = *Drassyllus pusillus*, Eno_tho = *Enoplognatha thoracica*, Eri_atr = *Erigone atra*, Eri_den = *Erigone dentipalpis*, Gon_viv = *Gongylidiellum vivum*, Hah_nav = *Hahnia nava*, Hah_ono = *Hahnia ononidum*, Hap_sig = *Haplodrassus signifer*, Hyp_pyg = *Hypsosinga pygmaea*, Man_aca = *Mangora acalypha*, Mas_sun = *Maso sundevalli*, Mei_rur = *Meioneta rurestris*, Mic_her = *Micrargus herbigradus*, Mil_pus = *Microlinyphia pusilla*, Pac_deg = *Pachygnatha degeeri*, Par_agr = *Pardosa agrestis*, Par_hor = *Pardosa hortensis*, Par_lug = *Pardosa lugubris*, Par_mon = *Pardosa monticola*, Par_pal = *Pardosa palustris*, Par_pra = *Pardosa prativaga*, Par_pul = *Pardosa pullata*, Pel_par = *Pelecopsis parallela*, Phl_fas = *Phlegra fasciata*, Phr_fes = *Phrurolithus festivus*, Pis_mir = *Pisaura mirabilis*, Rob_liv = *Robertus lividus*, Ste_pha = *Steatoda phalerata*, Stm_lin = *Stemonyphantes lineatus*, Tap_pra = *Tapinocyba praecox*, Ten_ten = *Tenuiphantes tenuis*, Tis_vag = *Tiso vagans*, Tro_rur = *Trochosa ruricola*, Tro_ter = *Trochosa terricola*, Wal_ant = *Walckenaeria antica*, Wal_dys = *Walckenaeria dysderoides*, Xer_min = *Xerolycosa miniata*, Xys_ace = *Xysticus acerbus*, Xys_cri = *Xysticus cristatus*, Xys_koc = *Xysticus kochi*, Zel_ele = *Zelotes electus*, Zel_lat = *Zelotes latreillei*, Zel_pet = *Zelotes petrensis*. For species representation values see Tab. 4.

Tab. 4: Representation values for all species which were included in the PCA.

group A		group B		group C	
species	R [%]	species	R [%]	species	R [%]
Cen_con	100	Hah_ono	100	Mic_her	59
Dra_lut	100	Man_aca	100	Ten_ten	75
Par_agr	99	Zel_ele	88	Mas_sun	85
Xer_min	99	Cne_obs	79	Dic_nig	97
Par_pal	97	Eno_tho	76	Bat_gra	42
Alo_acc	94	Gon_viv	74	Pis_mir	50
Wal_ant	92	Tis_vag	71	Par_hor	36
Par_mon	91	Zel_lat	67	Par_lug	59
Tro_rur	90	Wal_dys	66		
Mei_rur	88	Eri_den	63		
Rob_liv	87	Tro_ter	35		
Pac_deg	76				
Phr_fes	74				
Xys_ace	73				
Cer_pro	70				
Alo_pul	69				
Tap_pra	69				
Hap_sig	68				
Xys_koc	68				
Stm_lin	63				
Xys_cri	62				
Par_pra	48				

according to BONTE et al. (2003) *Pardosa monticola* in particular can easily be recorded during sunny days, when females and males are very active. The high number of species at D1 and D4 is caused by the diverse habitat structure being a varied mosaic of open ground, dense vegetation, tall plants, shrubs and in the case of D1 the vicinity to a forest edge (HEUBLEIN 1982, 1983, SCHEIDLER 1990, HART & HORWITZ 1991). Low values for diversity and evenness indicate higher dynamics and disturbance in species groups (KRATOCHWIL & SCHWABE 2001) and so reflect the conditions at D2 and D3: the first one is situated on the training area and thus disturbed by the military while D3 is outside the training area, but nevertheless disturbed by mammals (e.g. rabbits, sheep). The sites D4 and D5 as well as D6 and D7 have higher evenness values because of their location outside the training area where human impact does not exist. During the investigation period the soil surface of site D1 was removed for habitat management which entailed short-time changes of the habitat structure.

Conclusions

On the basis of this study we can conclude that it is possible to distinguish spider communities of forested habitats from species groups of open habitats, but there is no uniform spider community which is characteristic for semi-dry grassland. One reason may be that exclusive species are almost missing or rare while eurytopic generalists dominate. Furthermore in many parts of the study area the herbal layer of former dry and sandy grasslands is now too dense, probably because dynamics caused by human impact (e.g. military training) or natural disturbances (e.g. wind, erosion) are missing. Thus they almost show ecological conditions of meadows or tall-forb vegetation (e.g. D5). In contrast to this on some patches a very high level of disturbance causes a low diversity and a dominance of pioneer species (e.g. D2). In some places habitat characteristics of semi-dry and dry grassland exist but these patches are often very small (e.g. D3). The small size of the different habitat types seems to be a general problem. Because of the high locomotory activity of spiders many species move from site to site and hence can be found in all habitats of the study area.

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