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Trophical relations of selected web-building spiders (Araneae) in xerophil grasslands

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RIASSUNTO

Nelle praterie xerofile della riserva naturale "Leutratal" vicino Jena (Thuringia) sono stati studiati nel corso di tre anni i rapporti trofici delle seguenti specie di ragni costruttori di tele: *Argiope bruennichi* (Scopoli), *Araneus diadematus* Clerck, *Araneus quadratus* Clerck, *Linyphia triangularis* (Clerck) e *Theridion impressum* Koch. La ripartizione delle nicchie è stata indagata sotto il profilo spaziale, strutturale e trofico. Gli aspetti fondamentali dei rapporti prede-predatori e della ripartizione delle nicchie sono stati analizzati mediante metodi statistici multivariati (Canonical Correspondence Analysis, Discriminant Analysis). Viene evidenziato che le differenze tra le specie indagate riguardo alla preferenza del tipo di preda sono il risultato di interazioni multiple tra le prede potenziali, la struttura e la localizzazione della tela e le caratteristiche del predatore.

Parole chiave: Ragni costruttori di tele, Relazioni trofiche, Praterie xerofile, Canonical Correspondence Analysis, Discriminant Analysis, Parametri di predazione.

ABSTRACT

Trophical relations of the following web-building spider guilt were studied in a 3year open beds investigation in xerophil grasslands of the nature reserve "Leutratal" near Jena (Thuringia): *Argiope bruennichi* (Scopoli), *Araneus diadematus* Clerck, *Araneus quadratus* Clerck, *Linyphia triangularis* (Clerck) and *Theridion impressum* Koch. Spatial, structural and trophical niche-partitioning of the selected spiders are investigated. Multivariate statistical methods (Canonical Correspondence Analysis, Discriminant Analysis) are used to analyze fundamental aspects of the predator-prey relations and niche partitioning. Prey type preferences of the investigated web-building spiders as result of multitude interactions between potential prey, structural and web parameters as well as the predator itself are the main emphasis of this study.

Key words: Web-building spiders, Trophical relations, Xerophil grasslands, Canonical Correspondence Analysis, Discriminant Analysis, Foraging parameters.

Material and Methods

1. *Registration of web and web-site parameters*
   - fastening structures of the web in vegetation

E	=	Exposition of the web (estimated value of the hidden effective catching area through vegetation)
Vegd	=	height of the dense vegetation
VegS	=	height of the vegetation tops
HN	=	height of the hub, sheet or retrait of the web
DH or **DV**	=	horizontal or vertical web diameter
FBo	=	height of the upper boundary from catching area
FBu	=	height of the lower boundary from catching area
I	=	web inclination (only orb-webs)

   - direction of web exposition (only orb-weds)

2. *Registration of body length of the spiders*
   KL = lenghts of prosoma and opisthosoma

3. *Registration of prey*
   - separate removal of all prey items of 10-40 webs per spider species and month decade
   - assignment of each prey item to:
     A) a prey type (taxon)
     B) a size class (**GK1-GK6** in 2 mm-steps)
     C) a mobility type (**Drifter** = drifting, more passive fliers;
     Flieger = prey with good active flying capacity;
     Spring./Flug. = prey with flying and jumping capacity;
     Springer = prey with jumping capacity and reduced or without flying capacity;
     Läufer = prey without flying and jumping capacity.

4. *Multivariate statistical data analysis*
   - Discriminant analysis - SPSS 2 +
   - Canonical Correspondence Analysis - CANOCO 2.2 (method description see TER BRAAK, 1986)

Results

Tab. 1 - Comparison of the prey spectrum with regard to dominance of prey types (taxa) size class and mobility type distribution.

	Arg. bruenn.			**A. quad.**			**A. diad.**			**Lin. triang.**		**The. impr.**	
webs [n]	(775)	(464)	(566)	(41)	(45)	(82)	(59)	(64)	(78)	(91)	(99)	(111)	(89)
	1988 [%]	1989 [%]	1990 [%]	1988 [%]	1989 [%]	1990 [%]	1988 [%]	1989 [%]	1990 [%]	1989 [%]	1990 [%]	1989 [%]	1990 [%]
prey types													
Diptera	30,7	36,7	48,7	51,9	59,7	72,5	25,8	39,8	62,3	14,4	12,5	6,5	11,5
Homoptera	27,0	19,5	14,3	7,9	5,5	7,0	32,9	23,5	12,2	39,7	54,6	68,7	60,7
Auchenorrh.	(17,1)	(6,0)	(6,6)	(3,1)	(0,4)	(1,6)	(3,0)	(1,2)	(0,2)	(24,7)	(7,3)	(0,7)	(0,5)
Aphidina	(9,7)	(13,4)	(6,9)	(4,7)	(5,2)	(5,2)	(29,9)	(22,1)	(11,7)	(14,4)	(46,1)	(67,9)	(59,9)
Hymenoptera	25,4	19,0	17,8	27,0	18,7	11,7	17,5	22,5	12,9	26,8	23,6	10,8	11,1
Apoidea	(11,7)	(6,9)	(5,7)	(2,8)	(3,6)	(1,5)	(4,0)	(5,2)	(0,8)	(1,0)	-	(0,3)	(0,5)
Saltatoria	7,2	6,5	7,6	-	0,4	0,9	-	0,2	0,6	0,5	-	-	0,1
Thysanoptera	2,0	6,3	3,0	3,5	7,8	3,9	3,5	2,1	1,2	0,5	2,4	7,3	10,0
Coleoptera	1,9	5,1	2,4	2,8	3,6	1,3	2,8	5,4	4,1	3,1	0,7	2,6	2,8
Strepsiptera	1,2	-	-	0,9	-	-	0,3	-	-	-	-	-	-
Lepidoptera	0,9	1,4	1,6	0,3	0,8	0,5	1,7	0,4	0,8	4,6	3,6	1,0	1,9
Heteroptera	0,8	1,6	2,5	-	1,0	0,6	1,7	0,8	1,8	4,1	1,1	2,5	1,3
Psocoptera	0,8	2,1	0,6	2,5	1,5	0,4	5,4	2,7	3,0	0,5	-	0,2	0,1
Collembola	0,8	0,4	0,5	-	-	1,0	-	-	-	-	-	0,1	0,0
Arachnida	0,8	0,9	0,3	2,8	0,8	0,1	0,4	1,0	0,5	-	1,1	0,2	0,1
Diplopoda	0,1	0,1	0,1	-	-	-	-	-	-	-	-	-	-
Dermaptera	0,0	0,0	-	-	-	-	-	-	-	-	-	-	-
Blattodea	0,0	-	-	-	-	-	-	-	-	-	-	-	-
Planipennia	-	-	-	-	-	-	0,3	-	-	4,1	-	0,0	0,1
Isopoda	-	-	-	-	-	-	0,3	-	-	-	-	-	-
prey items [n]	2756	2753	1869	318	524	788	298	480	666	194	449	4116	2433
prey size													
GK1	29,7	66,3	69,2	39,6	84,4	90,2	48,3	79,4	87,8	25,8	63,9	86,5	83,7
GK2	27,4	9,8	11,3	30,8	6,5	4,8	22,8	9,0	6,3	38,1	29,0	7,0	8,4
GK3	19,0	7,2	2,7	18,9	3,4	1,4	17,4	5,2	3,0	19,6	4,9	5,1	3,9
GK4	2,8	1,4	2,2	1,9	0,8	0,8	5,7	1,9	1,2	12,9	1,3	1,0	2,9
GK5	0,8	1,2	1,0	-	0,2	0,5	0,7	0,4	0,2	3,1	0,4	0,2	0,7
GK6	20,2	14,1	13,6	8,8	4,8	2,3	5,0	4,2	1,5	0,5	0,4	0,1	0,3
prey mobility													
Drifter	56,4	65,2	68,2	81,4	85,3	89,2	76,5	79,8	88,1	29,9	74,8	84,6	83,8
Flieger	18,2	18,9	14,7	12,3	13,0	7,6	18,8	16,0	9,9	42,8	13,6	10,6	11,3
Spring./Flug.	18,6	10,4	11,1	3,1	1,0	1,4	3,0	1,2	0,8	24,7	8,7	0,7	0,7
Springer	6,7	2,5	4,1	0,3	-	1,3	0,4	0,2	-	0,5	-	0,1	0,1
Läufer	0,1	3,1	1,9	2,8	0,8	0,5	1,3	2,7	1,2	2,1	2,9	4,0	4,1

Fig. 1 - Web-site preferences and vertical stratification of the investigated spider guilt in xerophil grasslands.

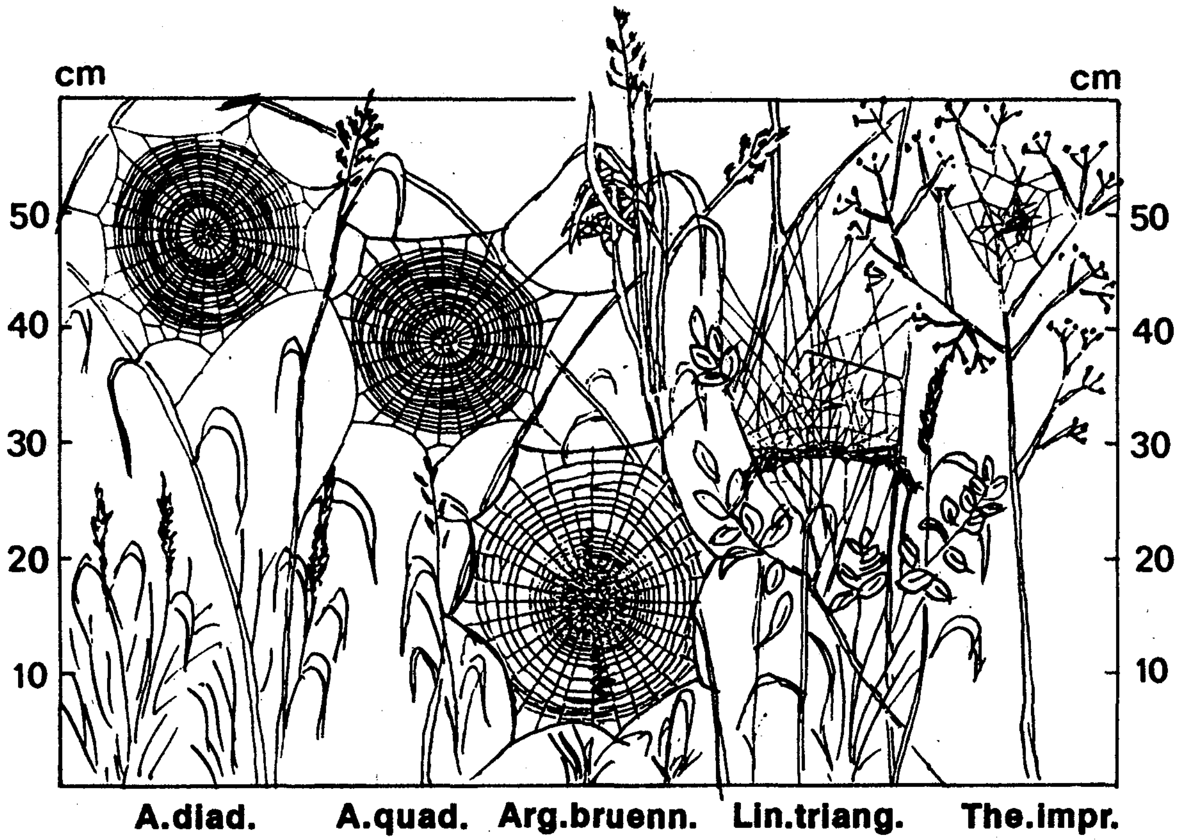
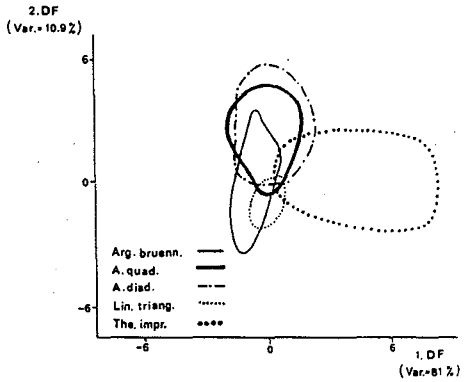


Fig. 2 - Discriminant analysis to trophical niche partitioning (the area of each scatterplot contains all sample points of one species).

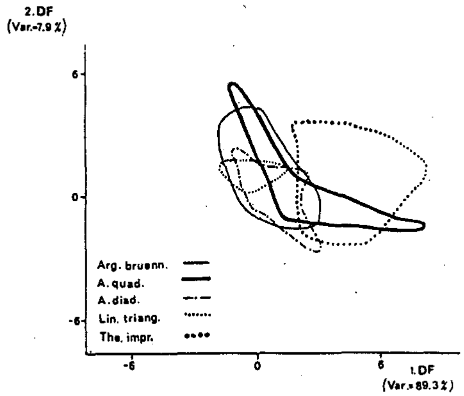
Coefficient discriminant functions
1. prey types (taxa)

	1. DF	2. DF
Eigenvalue	1,5	0,2
prey types		
Nematocera	0,10	0,39
Brachycera	-0,09	0,46
Auchenorrhyncha	-0,08	-0,44
Aphidina	0,71	-0,07
Apoidea	-0,03	-0,08
Formicoidea	0,31	-0,02
Hymenoptera Rest	0,01	0,12
Saltatoria	-0,12	-0,31
Thysanoptera	0,30	-0,16
Coleoptera	0,32	0,12
Lepidoptera	-0,02	-0,05
Heteroptera	-0,09	-0,05
Psocoptera	-0,09	0,46



Coefficients discriminant functions
2. prey size

	1. DF	2. DF
Eigenvalue	0,96	0,07
prey size		
GK 1	0,53	-0,10
GK 2	0,28	-0,17
GK 3	0,51	0,07
GK 4	0,40	0,42
GK 5	0,13	0,20
GK 6	-0,26	0,87



Coefficients discriminant functions
3. prey mobility

	1. DF	2. DF
Eigenvalue	0,81	0,07
prey mobility		
Drifter	0,66	-0,44
Flieger	0,45	0,53
Spring./Flug.	-0,31	0,65
Springer	-0,09	0,49
Läufer	0,36	0,34

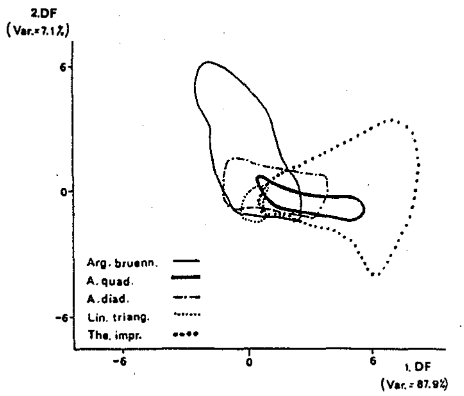
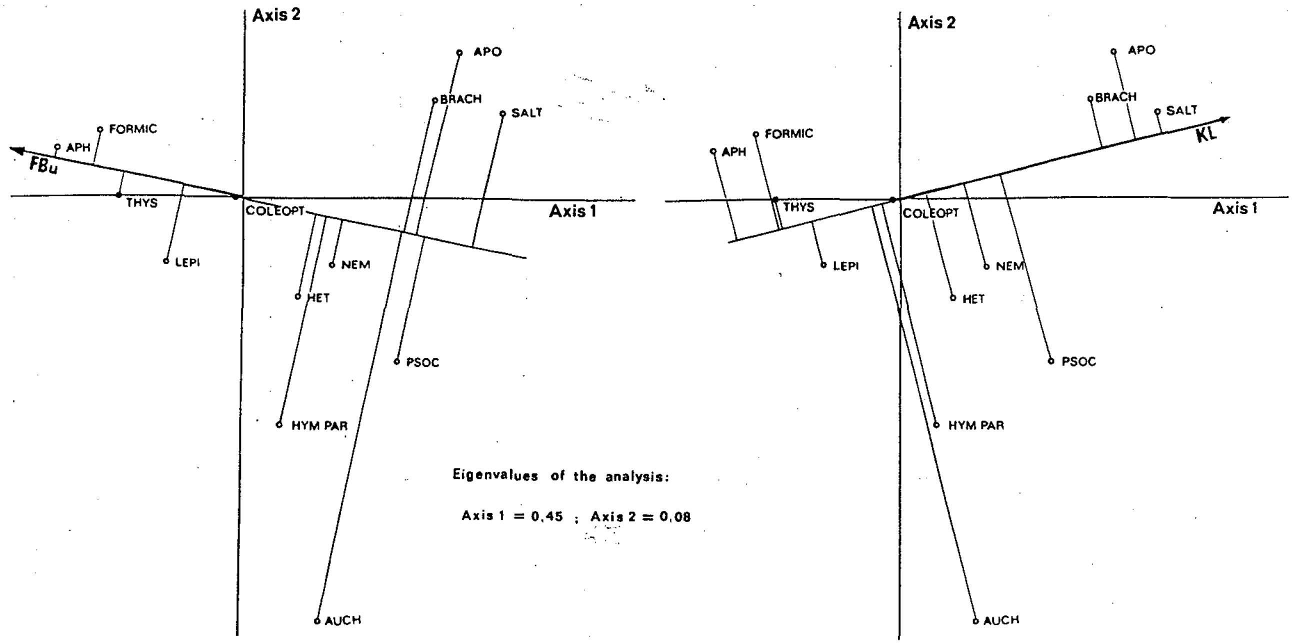


Fig. 3 - Canonical Correspondence Analysis (CCA) to prey type spectrum and foraging parameters.

Biplot: catch area-vector (web) **FBu** and prey type spectrum

Biplot: body length-vector (spider) **KL** and prey type spectrum

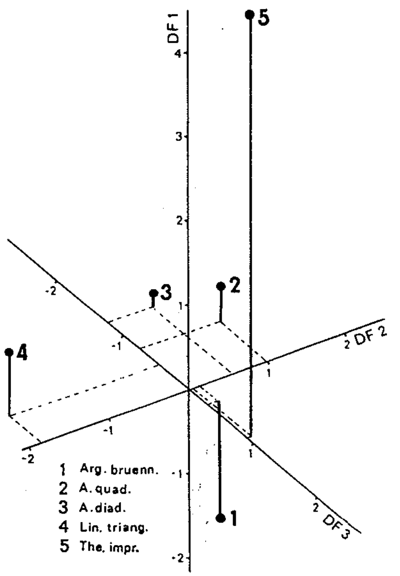


The ordination diagram (biplot) reflects weighted averaging values of the prey types in relation to corresponding foraging parameters. Each foraging parameter is plotted as vector with positive or negative correlation to the main axis of the CCA, along which the distribution of the prey types are maximally separated. Orthogonal projection of prey type-rank values to the gradient of the foraging parameters shows the prey type-foraging parameter relation.

Fig. 4 -Separation of the population centroids in a three dimensional space determined by discriminant function axes (DF1, DF2, DF3) to be based on spatial, functional and trophical niche parameters.

Coefficients discriminant functions
Separation population centroids

	DF 1	DF 2	DF 3
% Var.	78,8	12,0	7,9
Eigenvalue	3,9	0,6	0,4
Parameter			
GK 1	0,49	1,24	1,85
GK 2	0,18	0,08	0,48
GK 3	0,19	0,07	0,40
GK 4	0,19	0,07	0,48
GK 5	0,04	0,02	0,25
GK 6	-0,04	0,13	0,47
Drifter	-0,14	-0,99	-1,66
Flieger	0,01	-0,20	-0,11
Spring./Flug.	-0,05	-0,32	-0,14
Springer	-0,01	0,08	0,01
Läufer	0,19	-0,07	0,08
FBo	-0,35	-0,43	0,47
FBu	-0,46	2,83	1,93
Vegd	-0,43	-0,02	0,29
VegS	-0,28	0,18	-0,04
HN	1,79	-2,14	-2,80
KL	-0,61	1,60	0,18



Discussion

Canonical Correspondence Analysis of foraging parameters (web height, foraging stratum, web inclination, direction of web exposition, spider size, vegetation closeness) and prey type spectrum indicated, that foraging stratum (FBu), effective catching areae of the web and body size of the spider (KL) are principal components of selective predation with regard to abundance, size or mobility of certain prey types (see Fig. 3).

Greater individual (or spider species) are able to overcome larger, more mobil or more resistible prey with the aid of their web, foraging behaviour or morphological adaptations.

Spider species with web site preferences in the upper, more sparse vegetation layer of the xerophil grasslands (*The. impr.*, *A. diad.*, partly *A. quad.*) capture more flying or drifting prey types and the highest share of smallest and medium-sized insects. In contrast to these, web-building spiders which are prefer the medium or lower, more thick stratum in the vegetation (*Arg. bruenn.*, *Lin. triang.*) capture plainly recognizable more jumping or jumping/flying prey types.

The highest share of prey items with a body length > 10 mm captures *Arg. bruenn.*, which are the only one species of the investigated spider guilt foraging in the lowest stratum of the grasslands. Adult individual of these species capture so agile and heavy or resistible insects like Saltatoria or Apoidea in considerable magnitudes.

Despite the use of the same macrohabitat and partly considerable overlap of parameters concerning prey or predation the niches of the investigated spider species are spatial and/or functional separated (see Fig. 1, Fig. 2 and Fig. 4).

Specialization for certain microhabitats (strata) and/or for certain prey types (also size, mobility) make possible the coexistence of web-building spiders in grassland ecosystems (ENDERS, 1974). Vertical stratification of the web sites, use of different habitat structures and changes of the vertical stratum of several developmental stages are decisive factors (niche parameters) facilitating coexistence. This in turn affects besides phenology, morphology and size of the predator (spider) the selective predation of certain prey types.

Selective predation are the result of:

1. the spider web, site (height and exposition) in the vegetation, web size and web structure (mesh width and so on)

2. the spider itself, foraging strategy, predation behaviour and morphological constitution (chelicera, leg length and so on) and general body length

3. the potential prey, their phenology, morphological constitution, size (weight), active and/or passive capture avoidance mechanisms.

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