Prey analysis of the spider *Achaeearanea riparia* (Blackw.) (Araneae, Theridiidae), a generalist predator in winter wheat fields

Journal Article**Author(s):**

Nyffeler, Martin; Benz, Georg

Publication date:

1988

Permanent link:

<https://doi.org/10.3929/ethz-a-005802288>

Rights / license:

[In Copyright - Non-Commercial Use Permitted](#)

Originally published in:

Journal of Applied Entomology 106(1-5), <https://doi.org/10.1111/j.1439-0418.1988.tb00615.x>

Department of Entomology, Swiss Federal Institute of Technology, ETH-Zentrum,
Zurich, Switzerland

Prey analysis of the spider *Achaearanea riparia* (Blackw.) (Araneae, Theridiidae), a generalist predator in winter wheat fields¹

By M. NYFFELER and G. BENZ

Abstract

In winter wheat fields of eastern Switzerland, the foraging of the comb-footed spider *Achaearanea riparia* (Blackw.) was studied. This spider – occurring in the winter wheat ecosystem in estimated numbers of ca. 0.6 ind./m² – was observed to be a generalist predator of small- to medium-sized arthropods. With its irregular webs – which *A. riparia* spins in the lowest 15 % of the foliage – this spider captured a variety of arthropods, primarily of the orders Hymenoptera (36 % by numbers, mostly apterous ants), Coleoptera (19 %, mostly Staphylinidae, and Carabidae of the genus *Amara*), Homoptera (14 %, mostly aphids), Diptera (6 %), and Araneae and Acari (6 %, Micryphantidae and Oribatidae). – The prey data of *A. riparia* assessed in this study are compared with data on its feeding habits in nonagricultural habitats, indicating that it has a narrower “feeding niche” in nonagricultural habitats (tending there towards a monophagous predator of ants) than in winter wheat fields where it was found to be a nonspecific predator. – A comparison of *A. riparia* with other spiders inhabiting the winter wheat fields showed that, though all spiders studied are generalist predators, the “feeding niche” of *A. riparia* differed significantly from the others, characterizing *A. riparia* as a unique forager within the spider community of the winter wheat ecosystem.

1 Introduction

Spiders have been observed to be abundant insectivorous predators in European cereal fields (BASEDOW 1973; BRASSE 1975; DE CLERCQ and PIETRASZKO 1983; SUNDERLAND et al. 1986a, b). The predatory role of the various spider species inhabiting cereal fields, however, has been little known up to the present (see NYFFELER and BENZ 1979, 1987). In the course of a study on spiders as natural control agents in agricultural habitats, the comb-footed spider *Achaearanea riparia* (Blackw.) was found to occur in Swiss winter wheat fields (NYFFELER 1982). This spider species had also been recorded in cereal fields in Finland (RAATIKAINEN and HUHTA 1968) and Poland (LUCZAK 1975). As its preferred habitats places amongst grass and roots under overhanging banks, on the sides of road cuttings, and at the bases of walls of rock are mentioned in literature (WIEHLE 1937; LOCKET and MILLIDGE 1951/53; NØRGAARD 1956; BENZ 1969). *A. riparia* (*Achaearanea riparia* [Blackw.] = *Theridion saxatile* C. L. Koch) is adult in late May and June, with a body length of ca. 3.5 mm in the female and of ca. 3 mm in the male. The females build a peculiar species-specific tubular retreat, which is covered with pieces of stone, earth, prey carcasses, and other small particles found in the environment. *A. riparia* traps its prey with tangled webs, which are designed for the capture primarily of prey organisms walking on the ground surface such as apterous ants and others. NØRGAARD (1956) described the web of *A. riparia* as follows: “The snare is a more or less densely meshed three-dimensional web, a so-called space-web . . . The threads run more closely to each other in a horizontal

¹ This research was supported by the Swiss National Science Foundation, grant 3.0020.76.

zone in level with the lower edge of the nest. From this denser part of the web vertical or slightly oblique threads are stretched to the ground where they are fixed to the soil surface. The basal portions of the vertical threads are viscid, the lower 5 to 10 mm being provided with small globular drops made of a sticky substance..." When a prey organism crawling on the ground touches one of the adhesive threads, it sticks to it, and by the victim's struggling movements the thread becomes detached from the ground, the prey being lifted into the web where it is killed by the spider. – In this study the prey spectrum of *A. riparia* in winter wheat fields is analysed. Studies on the feeding ecology of other spider species in the same habitat are presented by NYFFELER and BENZ (1979, 1988a, b).

2 Materials and methods

The investigations were conducted in winter wheat fields of the Swiss Agricultural Experiment Station at Zurich-Reckenholz, eastern Switzerland. In three successive years (1 field of 2 ha being studied each year) the fields were thoroughly searched for *A. riparia* webs, which were easy to discover by the conspicuous species-specific retreats. A total of 131 webs of *A. riparia* were examined for prey. Evidence of predation was obtained by removing the remains of previously killed arthropods from the spiders' webs. All carcasses of arthropods found in webs were considered prey, regardless of the spiders being observed feeding on them or not. Most arthropod groups found dead in the spider webs are known to be eaten by theridiid spiders in the field (see NØRGAARD 1956; NYFFELER et al. 1986, 1988, and unpubl.), suggesting that the prey items presented in this paper can be considered *A. riparia*'s food. Prey items were collected from the webs with forceps and preserved in 70% ETOH. They were later identified and counted under a dissecting microscope. In late May the population density of *A. riparia* was assessed by counting the numbers of this species within squares of $0.4 \text{ m} \times 0.4 \text{ m}$ in 100 randomly selected sites within one field.

3 Results

The observed *A. riparia* spun their tangled webs close to the ground in the lowest 15% of the field layer between neighbouring wheat plants. At the very beginning of June the webs were still small (retreat 5 cm above ground, avg. retreat length 0.6 cm) (table 1). About one week later larger webs were found (retreat ca. 11 cm above ground, avg. retreat length 0.8 cm) (table 1). From then the webs steadily increased in size, reaching a maximum on July 9 (retreat ca. 16 cm above ground, avg. retreat length 2.4 cm) (table 1). Females guarding egg-sacs were found in the second half of June and in July. Spiderlings evidently hatched in summer, since in the second half of July we found immatures having built small webs (retreat 9.5 cm above ground, avg. retreat length 0.4 cm). A web count conducted in one winter wheat field in late May showed this spider to occur then in estimated numbers of 0.6 ind./m^2 ($0.09 \pm 0.03 \text{ ind./0.16 m}^2$, $\bar{x} \pm \text{SE}$, $n = 100$).

Table 1. Seasonal change of web parameters (height of retreat above ground and retreat length) of the spider *Achaearanea riparia* in a winter wheat field near Zurich

Date	No. observed spiders	Retreat above ground (cm) $\bar{x} \pm \text{SE}$	Retreat length (cm) $\bar{x} \pm \text{SE}$
1 June	5	5.0 ± 1.2	0.6 ± 0.1
9 June	18	10.9 ± 1.4	0.8 ± 0.1
21 June	20	13.7 ± 1.2	1.5 ± 0.1
6 July	10	14.8 ± 1.9	2.0 ± 0.1
9 July	19	15.8 ± 1.3	2.4 ± 0.2
21 July	8 ^a	10.2 ± 1.1	2.2 ± 0.5

^a Including 3 immature stages

The prey spectrum of *A. riparia* in three winter wheat fields is shown in table 2. Our prey analysis is based on a total of 312 arthropod carcasses collected from its webs. Forty-nine prey items were in an unidentifiable condition. A certain variation of the prey composition in the three investigated fields can be noticed. The arthropod groups most frequently killed in *A. riparia* webs were Hymenoptera, Coleoptera, Homoptera, Diptera, and Arachnida. Overall (pooled data of 3 fields), the most dominant components in the

Table 2. Prey spectrum of the spider *Achaearanea riparia* in winter wheat fields near Zurich

Prey taxa	Field 1	Field 2	Field 3	Total
HYMENOPTERA				
Apterous ants	17	22	24	63 (20.2 %)
Winged Hymenoptera	1	34	13	48 (15.4 %)
COLEOPTERA				
Carabidae				
<i>Loricera pilicornis</i>	3	0	1	4 (1.3 %)
<i>Clivina fossor</i>	1	0	1	2 (0.6 %)
<i>Acupalpus teutonius</i>	1	0	0	1 (0.3 %)
<i>Agonum dorsale</i>	1	0	0	1 (0.3 %)
<i>Agonum muelleri</i>	0	0	1	1 (0.3 %)
<i>Amara</i> spec.	11	0	0	11 (3.5 %)
<i>Amara</i> spec. ^a	2	0	0	2 (0.6 %)
Unident. Carabidae ^a	3	2	0	5 (1.6 %)
Staphylinidae	10	3	7	20 (6.4 %)
Other Coleoptera	6	1	5	12 (3.9 %)
HOMOPTERA				
Aphidina	0	3	38	41 (13.1 %)
Cicadina	0	1	1	2 (0.6 %)
DIPTERA				
	2	8	10	20 (6.4 %)
ARACHNIDA				
Micryphantidae				
<i>Erigone atra</i>	0	3	0	3 (1.0 %)
<i>Erigone dentipalpis</i>	0	1	0	1 (0.3 %)
<i>Erigone</i> sp. ^a	0	0	1	1 (0.3 %)
Unident. Araneae	0	1	0	1 (0.3 %)
Oribatidae	0	7	6	13 (4.2 %)
HETEROPTERA				
	0	0	3	3 (1.0 %)
DERMAPTERA				
	0	2	0	2 (0.6 %)
ORTHOPTERA				
	1	0	0	1 (0.3 %)
Unident. prey ^a	17	7	25	49 (15.7 %)
Total prey	76	95	141	312 (100 %)
No of spiders observed	22	18	91	131

^a Only fragments found

spiders' prey were apterous ants (20.2 % by numbers), winged Hymenoptera (15.4 %), aphids (13.1 %), carabid beetles (8.5 %, mostly genus *Amara*), staphylinid beetles (6.4 %), Diptera (6.4 %), and mites (4.2 %). The Arachnida in the prey of *A. riparia* were mites of the family Oribatidae and small spiders of the family Micryphantidae (*Erigone* spp. ♂♂), which both are typical inhabitants of the soil surface in winter wheat fields. Hence it follows that a considerable portion of *A. riparia*'s prey are ground surface-dwellers (apterous ants, Carabidae, Staphylinidae, Oribatidae, and Micryphantidae).

4 Discussion

In the past *A. riparia* was described to tend towards a specialized predator of ants (WHELE 1937; BRISTOWE 1941; NØRGAARD 1956), whereby all previous reports based on observations from nonagricultural habitats (sides of road cuttings etc.). Likewise *A. riparia* was observed capturing ants most frequently (>90 % of spiders' prey by numbers) in a nonagricultural habitat in the environs of Zurich (table 3). – In contrast to this, *A. riparia*'s prey spectrum in winter wheat fields was diverse, comprising by numbers >75 % "non-ant prey" of various arthropod orders, and only ca. 20 % ants.

A. riparia's trophic diversity (H' , a measure of feeding specialization) was found to be ca. 3–5 times higher in winter wheat fields ($H' = 1.99$) than in nonagricultural habitats ($H' = 0.39$ and 0.55) (table 3), the difference being statistically highly significant ($p < 0.001$, t-test after POOLE 1974). Thus, *A. riparia* tends towards a monophagous predator of ants in nonagricultural habitats but appears to be a generalist predator in winter wheat fields. The difference in the width of *A. riparia*'s "feeding niches" (sensu KREBS 1985) in the two habitats studied obviously reflects differing composition and diversity of potential prey. In the habitat where NØRGAARD (1956) conducted his study, ants were by far the most numerous potential prey of *A. riparia*, which explains why ants were captured much more frequently than other potential prey groups. On the ground of winter wheat fields to the

Table 3. Prey diversity of *Achaearanea riparia* in agricultural habitats and in nonagricultural habitats (comparison based on prey records)

N = numbers of prey items collected from spider webs

Prey component	Winter wheat fields	Nonagricultural habitats	
	Switzerland (this paper) N = 312	Switzerland (this paper) ^a N = 101	Denmark (Nørgaard 1956) N = 181
	%	%	%
Apterous ants	20.2	92.0	88.4
Other Hymenoptera	15.4		.6
Coleoptera	18.8		5.0
Aphidina	13.1		
Cicadina	.6	3.0	
Heteroptera	1.0		1.1
Diptera	6.4		2.8
Orthoptera	.3		1.1
Dermaptera	.6	2.0	
Isopoda			.6
Araneae	1.9		
Opiliones			.6
Acari	4.2		
Unident. prey	15.7	4.0	
Total	100	100	100
Trophic diversity (H') ^b	1.99	0.39	0.55
Statistical significance			
of diversity difference ^c	p < 0.001 p > 0.05		
	p < 0.001		

^a Wayside, under overhanging grass. – ^b Trophic diversity (sensu HURTUBIA 1973) calculated with SHANNON-WEAVER's information theory formula $H' = -\sum_{i=1}^s p_i \ln p_i$, where p_i is the proportion of the i^{th} prey category used. – ^c Comparison of H' -values with t-test after POOLE (1974)

contrary, beside ants several other arthropod groups being potential prey occur in high numbers, as evidenced by pitfall trap studies (BRASSE 1975; NYFFELER and BENZ, unpubl.). For instance, harmful cereal aphids occurred in the investigated winter wheat fields in numbers of up to 5000 ind./m², many of them dropping to the ground and being partly intercepted in spider webs (see NYFFELER and BENZ 1988a). Likewise, Arachnida and Coleoptera (Staphylinidae, Carabidae) occurred in the investigated winter wheat fields in high numbers and constituted a large potential of prey biomass for insectivorous predators capable of killing and eating arachnids and beetles.

Among the Coleoptera killed by *A. riparia* in winter wheat fields there are several Carabidae-species which represent a rather typical selection of medium-sized Carabidae living in cereal fields of Central Europe (THIEHLE 1977). In this study, the beetles found as prey of *A. riparia* never exceeded 10 mm in length, but it is known from literature that *A. riparia* is capable of killing even large-sized carabid beetles up to the size of *Pterostichus niger* Schall. (NØRGAARD 1956), which has a length of 16 mm or more.

Similar foraging patterns were observed also in other spiders of the family Theridiidae using the same type of tangled webs and very similar predatory behaviours to trap and kill prey. For instance, the American black widow spider, *Latrodectus mactans* (F.) – which also spins webs in the lowest branches of crop fields – was likewise observed to frequently capture and eat apterous ants (NYFFELER et al. 1988) and Coleoptera (WHITCOMB et al.

Table 4. Prey overlap of the spider *Achaearanea riparia* with other spiders inhabiting winter wheat fields near Zurich

Percentages (by numbers) based on total of identifiable prey items

Prey taxa	Theridiidae <i>Achaearanea riparia</i> %	Theridiidae <i>Theridion impressum</i> ^a %	Araneidae <i>Nuctenea cornuta</i> ^a %	Micryphantidae <i>Erigone</i> spp. and <i>Oedothorax</i> spp. ^b %	Lycosidae <i>Pardosa</i> spp ^c %
Apterous ants	24.0				
Other Hymenoptera	18.3	0.5		1.0	3.4
Carabidae	10.3				3.4
Staphylinidae	7.6				1.7
Other Coleoptera	4.6	3.5	0.3		
Aphidina	15.6	46.6	15.2	41.3	27.1
Cicadina	0.8				
Heteroptera	1.1	0.9			
Thysanoptera		9.8	9.6	1.9	
Diptera	7.6	30.4	74.6	14.4	27.1
Collembola				40.4	25.4
Ephemeroptera		8.3	0.3		
Lepidoptera					1.7
Dermaptera	0.8				
Orthoptera	0.4				
Acari	4.9			1.0	3.4
Araneae	2.3				6.8
Prey overlap (α) of	$\alpha = 0.45$				
<i>A. riparia</i> with other	$\alpha = 0.15$				
spiders	$\alpha = 0.34$				
($\bar{\alpha} \alpha = 0.34$)	$\alpha = 0.43$				

^a From NYFFELER and BENZ (1979). – ^b From NYFFELER and BENZ (1988a). – ^c From NYFFELER and BENZ (1988b).

1963; NYFFELER et al. 1988). Analogous to *A. riparia*, black widow spiders often entrap even the largest beetles with their tangled webs (WHITCOMB 1974). The capacity for killing oversized prey organisms (which may be several times larger and heavier than the predator) is characteristic of various theridiid spiders (GERTSCH 1979; NYFFELER and BENZ 1982) and may be explained by the family-specific attack behaviours.

The feeding habits of *A. riparia* were compared with those of other spider species occurring in the same habitat (table 4). Prey overlap (coefficient α) of *A. riparia* with a compared spider species was calculated using the method proposed by PIANKA (1974):

$$\alpha_{jk} = \frac{\sum_{i=1}^n p_{ij} p_{ik}}{\sqrt{\sum_{i=1}^n p_{ij}^2 \sum_{i=1}^n p_{ik}^2}},$$

where p_{ij} and p_{ik} represent the proportions of the i^{th} food component used by the j^{th} species (*A. riparia*) and k^{th} species (compared spider species). Values ranged between 0 (no overlap) and +1 (complete overlap). Though all spiders of table 4 evidently are generalist predators each utilizing a variety of prey types, calculated values of prey overlap of *A. riparia* with the other spiders are rather low ($\alpha < 0.46$; average prey overlap $\bar{\alpha} = 0.34$). Our calculated overlap values may even be overestimated when compared with calculation at species level of the prey organisms (in this study prey items were not identified at species level). The low prey overlap values indicate that the "feeding niche" of *A. riparia* differs significantly from other spiders' of the same habitat, which may be explained by *A. riparia*'s specific foraging technique (see above) enabling it to utilize as prey insect groups (such as Formicidae and Carabidae) that are not or rarely captured by the other spider species (see NYFFELER and BENZ 1979, 1988a, b). Thus, *A. riparia* plays a unique role as a forager within the spider community of the winter wheat ecosystem.

Acknowledgements

We thank Professor Dr. H. U. THIELE, Dept. of Zoology, University of Cologne, FRG, for the identification of Carabidae, and Dr. F. WEILENMANN for the permission to carry out this study in winter wheat fields of the Swiss Agricultural Experiment Station Zurich-Reckenholz.

Zusammenfassung

Beute-Analyse bei der Spinne Achaeearanea riparia (Blackw.), einem polyphagen Prädator in Winterweizenfeldern

In Winterweizenfeldern in der Ostschweiz wurde die Erbeutung von Getreidearthropoden durch die Kugelspinne *Achaeearanea riparia* (Blackw.) studiert. Diese Spinnenart, die im Winterweizenökosystem in Populationsdichten von schätzungsweise 0,6 Ind./m² auftrat, ist gemäß dieser Studie ein unspezifischer Prädator von kleinen bis mittelgroßen, weichhäutigen und gepanzerten Arthropoden. Mit ihren irregulären Netzen (sogenannte „Fußangelnetze“), die in der bodennahen Zone der Vegetationsschicht gebaut waren, erbeutete *A. riparia* in Winterweizenfeldern verschiedenartige Arthropoden, v. a. Hymenoptera (zahlenmäßig 36 %), Coleoptera (19 %), Homoptera (14 %), Diptera (6 %) und Arachnida (6 %).

Ein Vergleich der Resultate dieser Studie mit Beutedaten aus der Literatur zeigt, daß *A. riparia* in früheren Studien (in nichtlandwirtschaftlichen Habitaten) als „spezialisierte Ameisenfresser“ (Trend zu Monophagie) aufgefaßt wurde; diese Ansicht wird durch die vorliegende, in Winterweizenfeldern durchgeführte Studie relativiert. In Wirklichkeit ist *A. riparia* ein polyphager Prädator (Nahrungsgeneralist), dessen „Nahrungsnischenbreite“ eine Funktion der habitatspezifischen Zusammensetzung der potentiellen Beute ist.

References

- BASEDOW, T., 1973: Der Einfluß epigäischer Raubarthropoden auf die Abundanz phytophager Insekten in der Agrarlandschaft. *Pedobiologia*, Jena, **13**, 410–422.
- BENZ, G., 1969: Beitrag zur Spinnenfauna der Ostschweiz. *Mitt. Schweiz. Entomol. Ges.* **42**, 22–33.
- BRASSE, D., 1975: Die Arthropodenfauna von Getreidefeldern auf verschiedenen Böden im Braunschweiger Raum. *Pedobiologia*, Jena, **15**, 405–414.
- BRISTOWE, W. S., 1941: *The Comity of Spiders*. London: Ray Society.
- DE CLERCQ, R.; PIETRASZKO, R., 1983: Epigeal arthropods in relation to predation of cereal aphids. In: *Aphid Antagonists*. Ed. by R. CAVALLORO. Proc. Meeting of the EC Experts' Group, Portici/Italy, 23–24 Nov. 1982. Rotterdam: A. A. Balkema. pp. 88–92.
- GERTSCH, W. J., 1979: *American Spiders*. 2nd ed. New York: Van Nostrand.
- HURTUBIA, J., 1973: Trophic diversity measurement in sympatric predatory species. *Ecology* **54**, 885–890.
- KREBS, C. J., 1985: *Ecology: the Experimental Analysis of Distribution and Abundance*. 3rd ed. New York: Harper & Row.
- LOCKET, G. H.; MILLIDGE, A. F., 1951/53: *British Spiders*, Vol. I/II. London: Ray Society.
- LUCZAK, J., 1975: Spider communities of the crop-fields. *Pol. Ecol. Stud.* **1**, 93–110.
- NØRGAARD, E., 1956: Environment and behaviour of *Theridion saxatile*. *Oikos* **7**, 159–192.
- NYFFELER, M., 1982: Field studies on the ecological role of the spiders as predators of insects in agroecosystems. Ph. D. thesis, Swiss Fed. Inst. Technology, Zurich, Switzerland.
- NYFFELER, M.; BENZ, G., 1979: Zur ökologischen Bedeutung der Spinnen der Vegetationsschicht von Getreide- und Rapsfeldern bei Zürich (Schweiz). *Z. ang. Ent.* **87**, 348–376.
- 1982: Freilanduntersuchungen zur Nahrungsökologie der Spinnen: Beobachtungen aus der Region Zürich. *Anz. Schädlingsskde., Pflanzenschutz, Umweltschutz* **54**, 33–39.
- 1987: Spiders in natural pest control: A review. *J. Appl. Ent.* **103**, 321–339.
- 1988a: Prey and predatory importance of micryphantid spiders in winter wheat fields and hay meadows. *J. Appl. Ent.* **105**, 190–197.
- 1988b: Feeding ecology and predatory importance of wolf spiders (*Pardosa* spp.) (Araneae: Lycosidae) in winter wheat fields. *J. Appl. Ent.* **106**, 123–134.
- NYFFELER, M.; DONDALE, C. D.; REDNER, J. H., 1986: Evidence for displacement of a North American spider, *Steatoda borealis* (Hentz), by the European species *S. bipunctata* (Linnaeus) (Araneae: Theridiidae). *Can. J. Zool.* **64**, 867–874.
- NYFFELER, M.; DEAN, D. A.; STERLING, W. L., 1988: The southern black widow spider, *Latrodectus mactans* (Araneae: Theridiidae), as a predator of the red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae), in Texas cotton fields. *J. Appl. Ent.* **106**, 52–57.
- PIANKA, E. R., 1974: Niche overlap and diffuse competition. *Proc. U.S. Nat. Acad. Sci.* **71**, 2141–2145.
- POOLE, R. W., 1974: *An Introduction to Quantitative Ecology*. New York: McGraw-Hill.
- RAATIKAINEN, M.; HUHTA, V., 1968: On the spider fauna of Finnish oat fields. *Ann. Zool. Fenn.* **5**, 254–261.
- SUNDERLAND, K. D.; FRASER, A. M.; DIXON, A. F. G., 1986a: Distribution of linyphiid spiders in relation to capture of prey in cereal fields. *Pedobiologia*, Jena, **29**, 367–375.
- — — 1986b: Field and laboratory studies on money spiders (Linyphiidae) as predators of cereal aphids. *J. Appl. Ecol.* **23**, 433–447.
- THIELE, H. U., 1977: *Carabid Beetles in their Environments. A Study on Habitat Selection by Adaptations in Physiology and Behaviour*. Zoophysiology and Ecology 10. Berlin-Heidelberg-New York: Springer.
- WIEHLE, H., 1937: Theridiidae oder Haubennetzspinnen (Kugelspinnen). *Tierwelt Deutschlands* **33**, 119–222. Jena: G. Fischer.
- WHITCOMB, W. H., 1974: Natural populations of entomophagous arthropods and their effect of the agroecosystem. In: MAXWELL, F. G. and HARRIS, F. A. (Eds.). *Proc. Summer Inst. Biol. Control Plant Insects and Diseases*. Jackson: Univ. Press of Mississippi. pp. 150–169.
- WHITCOMB, W. H.; EXLINE, H.; HUNTER, R. C., 1963: Spiders of the Arkansas cotton field. *Ann. Entomol. Soc. Am.* **56**, 653–660.

Authors' address: Dr. sc. nat. MARTIN NYFFELER and Prof. Dr. phil. GEORG BENZ, Department of Entomology, Swiss Federal Institute of Technology, ETH-Zentrum, CH-8092 Zurich, Switzerland