Spiders in natural pest control: a review

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Spiders in natural pest control: A review[1]

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Abstract

In spite of the large number of studies about the ecology of spiders carried out in the last two decades in different types of ecosystems all over the world, the significance of these animals as natural control agents is still largely unknown. In this paper the literature about that subject is reviewed. Totally 300 scientific papers, published between 1920 and 1984, are cited here.

Several European and American studies have provided evidence, that in undisturbed grassland ecosystems and forest ecosystems spiders can play an important ecological role as predators of insects and other invertebrates. Also in orchards, not treated with pesticides, that are to a certain degree comparable with forest ecosystems, spiders can be abundant predators.

In contrast to that, the opinion about the predatory importance of spiders inhabiting cultivated fields is controversial. The results of some European studies indicate, that the foliage-dwelling spiders of cultivated fields, because of their low population densities, are of minor importance as predators of insects. Other European studies show, that the ground-dwelling spiders of cultivated fields are concerning their abundance a dominant predator group, those significance as control agents still is largely unknown up to the present. In rice fields (swamp ecosystems) in Asia, receiving little or no pesticides, as well as in European and American swamp ecosystems, spiders may be an important predator group.

In houses in South Africa spiders were used successfully as biological control agents against flies.

1 Introduction

Spiders are among the most abundant predators of insects of terrestrial ecosystems (Tischler 1965; van Hook 1971; Moulder and Reichle 1972; Schaefer 1974; Edwards et al. 1976). Under favorable conditions they can reach maximal densities of up to 1000 individuals/m^2 approximately (Pearse 1946; Duffey 1962; Weidemann 1978). It has therefore been supposed for some time that spiders may play an important role as stabilizing agents and/or regulators of insect populations in agroecosystems, forest ecosystems, and other terrestrial ecosystems.

During the last 20 years, numerous studies on the spider faunas in agricultural habitats have been published all over the world. Tables 1–4 give a review classified according to continents and countries: table 1 for Europe (including the U.S.S.R.), table 2 for America, table 3 for Asia, and table 4 for Africa and the Oceanic-Australian region. Also in forest ecosystems many studies on

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Table 1. List of literature on the spider faunas in agroecosystems in Europe, including the U.S.S.R.

Country	Agroecosystem	Authors
Austria	meadows	Luhan (1979)
		Thaler et al. (1977, 1978)
	arable land	Thaler and Steiner (1975)
		Thaler et al. (1977)
	orchards	Pühringer (1982)
Belgium	cereals	De Clercq (1979)
		Cottenie and Clercq (1977)
	diverse crops	Bosmans and Cottenie (1977)
Bulgaria	pasture	Delchev and Kajak (1974)
Czechoslovakia	pasture	Polenec (1968)
	alfalfa	Miller (cit. Luczak, 1979)
	sugar-beet	Miller (1974)
Federal Republic of Germany	meadows	Boness (1953)
		Schaefer and Haas (1979)
	clover	Boness (1958)
	alfalfa	Boness (1958)
	cereals	Basedow (1973)
		Basedow and Mielke (1977)
		Brasse (1975)
	asparagus	Dingler (1935)
	vineyard	Kirn (1978)
	orchards	Kraemer (1961)
		Naton (1976)
	diverse crops	Heydemann (1953)
		Tischler (1958)
Finland	leys	Huhta and Raatikainen (1974)
	cereals	Huhta and Raatikainen (1974)
		Raatikainen and Huhta (1968)
France	alfalfa	Chauvin (1960, 1967)
German Democratic Republic	meadows	Beyer (1981)
		Müller et al. (1978)
	grass-clover mixture	Beyer (1981)
	alfalfa	Geiler (1963)
	cereals	Beyer (1981)
		Dietrich and Götze (1974)
	rape	Beyer (1981)
	sugar-beet	Beyer (1981)
	kohlrabi	Beyer (1981)
	marrow-stem kale	Beyer (1981)
Great Britain	pasture	Cherrett (1964)
		Duffey (1962)
	meadows	Duffey (1974)
	cereals	Fraser (1982)
		Locket (1978)
		Vickerman and Sunderland (1975)
	potato	Dunn (1949)
	sugar-beet	Thornhill (1983)
	orchards	Chant (1956)
Hungary	alfalfa	Balogh and Loksa (1956)
Norway	strawberry	Taksdal (1973)
Poland	pasture	Delchev and Kajak (1974)
	meadows	Breymeyer (1967, 1978)
		Kajak (1960, 1962, 1971, 1978, 1980)
		Kajak and Jakubczyk (1975)
		Kajak et al. (1968, 1971)
	alfalfa	Luczak (1975)
	cereals	Luczak (1974, 1975, 1976, 1979)
	potato	Czajka and Kania (1976)
		Galecka (1966)
		Luczak (1974, 1975, 1976, 1979)
	sugar-beet	Czajka and Goos (1976)
		Goos (1973)
Sweden	strawberry	Almquist (1981)
Switzerland	meadows	Benz & Nyffeler (1980)
		Maurer (1974, 1975)
		Nyffeler and Benz (1979b, 1981b)
	cereals	Nyffeler and Benz (1979a, 1980a)
		Nyffeler and Benz (1981a, 1981b)
		Nyffeler and Benz (1982a, 1982b)
	rape	Nyffeler and Benz (1979a)
U.S.S.R.	meadows	Vilbaste (1965)
	cereals	Ashikbayev (1973)
	potato	Koval (1976)

spiders have been carried out (review in Vité 1953; Kirchner 1964; Moulder and Reichle 1972; Nyffeler 1982a). Furthermore, spiders have been studied in garden ecosystems (e.g. Nyffeler 1983).

In spite of the large number of existing studies, the significance of the spiders as natural control agents in agroecosystems, forest ecosystems, and

Table 2. List of literature on the spider faunas in agroecosytems in America

Country	Agroeco-system	Authors
Brazil	sugarcane	Barbosa et al. (1979)
Canada	over-grazed pasture	Turnbull (1966)
	meadows	Dondale (1971, 1977); Dondale and Binns 1977; Dondale et al. (1970, 1972); Fox and Dondale (1972)
	wheat	Doane and Dondale (1979)
	orchards	Dondale (1956, 1958); Dondale et al. (1979); Putman (1967); Putman and Herne (1966)
Panama	seed reser-vation	Breymeyer (1978)
	pasture	Breymeyer (1978)
	banana plants	Harrison (1968)
Peru	cultivated fields	Aguilar (1965)
	cotton	Aguilar (1974)
U.S.A.	pasture	Howard and Oliver (1978); Peck and Whitcomb (1978); Whitcomb et al. (1963a); Wolcott (1937)
	meadows	Wolcott (1937)
	alfalfa	Howell and Pienkowski (1971); Muniappan and Chada (1970b); Schlinger and Dietrick (1960); Wheeler (1973); Yeargan (1975a, b); Yeargan and Cothran (1974); Yeargan and Dondale (1974)
	cereals	Horner (1972); Muniappan and Chada (1970a)
	grain sorghum	Bailey and Chada (1968)
U.S.A.	sweet corn	Everly (1938)
	rice	Woods and Harrel (1976)
	soybeans	Blickenstaff and Huggans (1962); Culin and Rust (1980); Deitz et al. (1976); Lesar and Unzicker (1978a, b); Turnipseed (1975); Whitcomb (1980)
	cole	Pimentel (1961)
	guar	Rogers and Horner (1977)
	sugarcane	Hensley et al. (1961); Negm and Hensley (1969)
	cotton	Burleigh et al. (1973); Clark and Glick (1961); Dean et al. (1982); Dorris (1970); Johnson et al. (1976); Kagan (1943); Leigh and Hunter (1969); Lockley et al. (1979); McDaniel and Sterling (1979); Pfrimmer (1964); Pieters and Sterling (1974); Shepard and Sterling (1972); Stam et al. (1978); Whitcomb and Bell (1964); Whitcomb and Tadic (1963); Whitcomb et al. 1963a, b)
	citrus	Carroll (1980); Muma (1973, 1975)
	orchards	Legner and Oatman (1964); McCaffrey and Horsburgh (1978, 1980); Specht and Dondale (1960)
	diverse crops	Bilsing (1920); Whitcomb (1974, 1975)

other terrestrial ecosystems is still largely unknown. This could be attributed to the fact that up to the present most studies were limited either to the investigation of the species composition and the seasonal occurrence of spiders in the field (sweep net and pitfall trap collections) or to measurements of respiration, food consumption tests, and prey preference trials in the laboratory. However, the results of investigations on the nutrition of spiders in the laboratory cannot readily be extrapolated to field conditions, because spiders may behave differently in the laboratory than in the field. In the laboratory, certain hunting spiders consume considerably more prey than would be

Table 3. List of literature on the spider faunas in agroecosytems in Asia

Country	Agroeco-system	Authors
India	maize	Sharma and Sarup (1979)
		Singh and Sandhu (1976)
	rice	Kalode (1976)
		Samal and Misra (1975)
	cotton	Battu and Singh (1975)
	citrus	Sadana and Kaur (1974)
	grapevines	Sadana and Sandhu (1977)
Israel	citrus	Shulov (1938)
	apple orchards	Mansour et al. (1980a, b, c)
		Mansour et al. (1981)
Japan	rice	Hamamura (1969, 1971)
		Hashimoto (1974)
		Hirano and Kiritani (1976)
		Itô et al. (1962)
		Kakiya and Kiritani (1976)
		Kang and Kiritani (1978)
		Kawahara (1975)
		Kawahara and Kiritani (1975)
		Kawahara et al. (1969, 1971)
		Kiritani (1977, 1979)
		Kiritani and Kakiya (1975)
		Kiritani and Kawahara (1973)
		Kiritani et al. (1972)
		Kobayashi (1975, 1977)
		Kobayashi and Shibata (1973)
		Koyama (1972, 1975, 1976)
		Miyai et al. (1978)
		Okuma (1974, 1977)
		Sasaba and Kiritani (1974)
		Sasaba et al. (1970)
		Sasaba et al. (1973a, b)
		Suzuki and Kiritani (1974)
		Tanaka (1973, 1975)
		Tanaka and Hamamura (1968)
Japan	rice	Toyoda and Yoshimura (1966)
		Yaginuma (1965)
		Yamano (1977)
	cabbage	Kayashima (1960)
		Suzuki and Okuma (1975)
	taro	Nakasuji (1976)
	tea	Kaihotsu (1979)
		Terada (1977)
		Terada et al. (1978)
	mulberry	Kayashima (1967, 1972)
	citrus	Kaihotsu (1979)
		Nohara and Yasumatsu (1965)
	orchards	Hukusima (1961)
		Hukusima and Kondo (1962)
		Okuma (1973)
Korea	rice	Choi et al. (1978)
		Hokyo et al. (1976)
		Okuma et al. (1978)
		Paik and Kim (1973)
		Paik et al. (1974)
	mulberry	Paik et al. (1973)
People's Republic of China	rice	Anonymous (1979)
Philippines	rice	Gavarra and Raros (1975)
		Irri Ann. Report (1973, 1974)
		Irri Ann. Report (1976, 1977)
		Irri Ann. Report (1978)
		Lucero and Raros (1975)
		Salinas and Raros (1975)
Taiwan	rice	Chiu et al. (1974)
		Chu and Okuma (1970)
		Chu and Wang (1972, 1973)
		Chu et al. (1975, 1976a, b, c)
		Chu et al. (1977)
Thailand	rice	Okuma (1968)
		Okuma and Wongsiri (1973)

available under natural conditions (Miyashita 1968a, b; Hagstrum 1970; Kessler 1973; Breymeyer and Jóźwik 1975). Moreover, the prey composition established by means of prey preference tests often does not correspond to the prey composition realized in the field. Pest insects which are regularly preyed on by a spider species in the laboratory may be entirely missing in the prey composition of the field (temporal and/or spatial isolation of predator and prey). Thus, the results of faunistic field studies and of nutritional analyses in the laboratory cannot be combined to a genuine whole. There is a great

Table 4. List of literature on the spider faunas in agroecosystems in Africa and in the Oceanic-Australian region

Country	Agroecosystem	Authors
Australia	cotton	BISHOP (1979, 1980, 1981)
		BISHOP and BLOOD (1980)
		ROOM (1979)
	orchards	DONDALE (1966)
		MACLELLAN (1973)
Egypt	clover	NEGM et al. (1975)
	cotton	WIESMANN (1955)
	granati trees	TEMERAK (1981)
Fiji Islands	coconut	TOTHILL et al. (1930)
New Guinea	coffee	ROBINSON and ROBINSON (1974)
South Africa	strawberry	DIPPENAAR-SCHOEMAN (1976, 1979a, b)

danger that speculations disregarding this ambiguity lead to wrong results. Correspondingly, the opinions on the ecological relevance of spiders differ widely. BRISTOWE (1958) for instance estimates for Great Britain: "Even if we were so cautious as to attribute a hundred victims in the year to each spider, I calculate with a very conservative estimate of the spider population for the country as a whole that the weight of insects consumed annually in Britain exceeds that of the human inhabitants." The Canadian ecologist TURNBULL (1973) gives an even higher estimate: "I have calculated from 37 published censuses of spider populations that the mean density of spiders in a large variety of environments was 130.8 spiders/square meter, or 1 308 000/hectare. If the food consumption of *Argiope argentata* were representative of that of all spiders (which it is not), the average total weight of food consumed per year by spiders would be . . . 42 490 kg/hectare." Referring to these computations FOELIX (1982) wrote: "Even if such claims were realistic, it would be wrong to assume that spiders play a major role in the control of insect pests."

In the following a survey is given about what is currently known on the ecological role of the spiders as predators of insects in undisturbed grassland ecosystems, agroecosystems, and forest ecosystems (comp. also VITÉ 1953; KIRCHNER 1964, 1967; LUCZAK 1979; NYFFELER and BENZ 1981a, 1982a; NYFFELER 1982a, 1982b; RIECHERT 1984).

2 Ecological importance of the spiders in grassland and cereal ecosystems

Spiders can be of ecological importance in diverse respects. For example, they can be food for other predators (WHITCOMB 1974). Or the dead insects stored in spider webs can be food sources for kleptoparasites such as scorpionflies (THORNHILL 1975; NYFFELER and BENZ 1980b). In this paper, only the role of spiders as predators will be discussed.

An ecological importance of spiders as natural control agents is to be expected in abandoned grasslands foremost, where they can feed and reproduce in the vegetation without human interference. Large funnel web spiders and orb-weaving spiders often live in high population densities in such habitats. With their strong webs they capture large numbers of voluminous insects. The orb-weaver *Argiope bruennichi,* e.g. may capture up to 7 grasshoppers/web/day (NYFFELER and BENZ 1981b). LOHMEYER and PRETSCHER (1979) found on the average 6 webs of *A. bruennichi* per m^2 in an abandoned grassland near Bonn (Federal Republic of Germany). This corresponds to a web area of 3000 m^2/ha ground area (NYFFELER 1982b). It is evident that such a gigantic web area exerts an enormous predatory pressure on insect populations. If we consider that every spider captures about 10 insects/web/day (NYFFELER 1982b), these orb-weavers would destroy 3×10^7 insects/ha in 50 days. Polish studies have also shown that the orb-weaving spiders can exert a strong predatory pressure on the insect populations in the vegetation zone of abandoned grasslands (KAJAK et al. 1968; KAJAK and OLECHOWICZ 1970; KAJAK 1971). Thus, web-building spiders eliminated 25–40 % of the adult Diptera in undisturbed grasslands (KAJAK and OLECHOWICZ 1970).

Funnel web spiders (Genus *Agelena*) can also occur in high population densities in undisturbed grasslands. Near Zurich (Switzerland), more than 3 funnel web spiders/m^2 on the average were counted in some abandoned grassland habitats. At certain points of aggregation within such a habitat, up to 12 funnel web spiders/m^2 were found. The food of such funnel web spiders was composed of up to 23 % of bees (NYFFELER and BENZ 1978). In other countries, too, it has been observed that funnel web spiders can be predators of bees. OLBERG (1960) wrote on this subject: "Sometimes, 20 to 30 captured honey-bees on the average can be found in each web; thus, with a spider that frequent, a considerable damage can result. This is why flocks of sheep are driven through the dangered areas. The fleecy animals destroy the webs, which cannot be replaced immediately, as is the case in orb weaving-spiders." This example demonstrates that spiders can have a noticeable effect on insect populations.

Not only web-building spiders, but also hunting spiders (these are spiders which capture their prey without a web, e.g. wolf spiders) can be important natural control agents of invertebrates in undisturbed grasslands as the work of VAN HOOK (1971) and SCHAEFER (1974) indicates.

In contrast to undisturbed habitats, cultivated meadows and annual crops are in Central Europe unsuitable for the colonization by and survival of foliage-dwelling spiders. In such agroecosystems the periodical harvest of the vegetation is an extreme stress for the foliage-dwelling spiders (destruction of the microhabitats and egg-sacs of numerous spiders); a periodical recolonization of the fields from surrounding undisturbed habitats is necessary (see also TISCHLER 1958; GEILER 1963; LUCZAK 1979). Population densities and biomasses of spiders in the vegetation zone of cultivated meadows and cereal fields are low. As a consequence of the low spider densities, the numbers of prey killed by the foliage-dwelling spider communities of these cultivated habitats are low, compared to the values estimated for undisturbed grasslands; it was estimated that $\leq$ 2 kg insects (fresh weight)/ha/year are killed by spiders in the vegetation of such cultivated meadows and annual crops (see KAJAK 1971; NYFFELER and BENZ 1979a).

The agroecosystems in parts of Southern Europe are to some extent cultivated in a considerably more extensive way than in Central Europe. It is therefore conceivable that the spiders still have a greater predatory importance in some cultivated fields of Southern Europe than in those of Central Europe. Thus, near Florence (Italy), rather high spider numbers were found in the vegetation zone of a weedy cereal field (STREULI, pers. comm.).

In contrast to the vegetation zone, the spiders living on the ground surface of cultivated meadows and cereal fields in Central Europe show relatively high population densities (r-strategists, e.g. *Erigone atra*). Together with the carnivorous beetles (Carabidae and Staphylinidae), they belong to the most abundant ground-dwelling predators of insects in cereal fields near Zurich (Switzerland). German studies had also established that spiders form an important component within the ground-dwelling predator-complex (TISCHLER 1958, 1965; GEILER 1963; BASEDOW 1973; BRASSE 1975; BASEDOW and MIELKE 1977). In the German Democratic Republic, one has even recorded that spiders and harvestmen can form up to one third of all invertebrates captured in pitfall traps (GEILER 1963). The diets of the ground-dwelling spiders overlap to some extent with those of the predatory Carabidae and Staphylinidae, which also feed on Collembola, aphids, and Diptera. Further investigations will be necessary to establish whether this ground-dwelling predator-complex has a significant influence on pest insects (e.g. aphids). First studies already indicate that the ground-dwelling predator potential actually exerts a strong predatory pressure on insect populations (BASEDOW 1973; KAJAK and JAKUBCZIK 1975; DE CLERCQ 1979). In any event, this ground-dwelling predator-complex probably has a stabilizing effect on insect populations, as assumed by the American ecologist RIECHERT (1974) for spiders in general.

Studies from Japan, India, China, Taiwan, Korea, Thailand, and the Philippines provide evidence that such ground-dwelling spiders, because of their high population densities in rice fields (which receive little or no pesticides), have a damping influence on the populations of pest insects, mainly harmful cicadas (ITÔ et al. 1962; OKUMA 1968; IRRI Annual Report 1973; CHIU et al. 1974; GAVARRA and RAROS 1975; KIRITANI and KAKIYA 1975; SAMAL and MISRA 1975; HOKYO et al. 1976; NAKASUJI 1976; KANG and KIRITANI 1978; KIRITANI 1979). Rice fields are swamp ecosystems. In European swamp ecosystems, spiders may also be an important group of predators (MILLER and OBRTEL 1975). The same is assumed concerning the ecological role of spiders as predators in American swamp ecosystems (GARCIA and SCHLINGER 1972).

3 Ecological importance of spiders in forest ecosystems and orchards

As a comparison to the studied Gramineae habitats, some tree ecosystems will be briefly discussed. With regard to forest ecosystems, WEIDEMANN (1978) attributes an important role to the ground-dwelling spiders as predators of insects, in combination with the other litter-dwelling predators. American scientists, too, concluded that the ground-dwelling spiders can be of great importance as predators of insects in forests (CLARKE and GRANT 1967; MOULDER and REICHLE 1972; MANLEY et al. 1976). In contrast to this, the predatory importance of the foliage-dwelling spiders of forest ecosystems is still controversial (VITÉ 1953; KIRCHNER 1964; NYFFELER 1982a). Some field studies had shown that certain spider species in the vegetation were little effective in reducing populations of lepidopteran pests (POINTING 1966; KIRCHNER 1967; FURUTA 1977). According to data by the last mentioned authors, some spider species could reduce moth populations by 5 % at the most. A slightly higher mortality was recorded by ENGEL (1942), who estimated that during a pine moth calamity, 12–23 % of the moth population was destroyed by spiders; but at the same time he also observed that significantly fewer moths were killed by spiders than by bugs. The ineffectiveness of certain spider species as predators of moths might be connected with the moths' ability to escape from these spiders' webs (KIRCHNER 1967; NYFFELER and BENZ 1981c). However, this negative effect may not be very important, since other insects seem not to be killed at a higher rate by forest spiders. Thus, for a comparison, the mortality of chestnut gall wasp populations as a result of predation by spiders was of the same magnitude in normal years (7–20 %) as that recorded by ENGEL for the pine moth (NAKAMURA and NAKAMURA 1977). Contrary to what has been said so far, some other authors have assumed that foliage-dwelling spiders may be important predators of Lepidoptera, aphids, and mosquitos in forest ecosystems (SUBKLEW 1939; JUILLET 1961; DABROWSKA-PROT et al. 1968a, b; LUCZAK 1968; FOX and GRIFFITH 1976).

Like the forests, orchards are also tree ecosystems. Field studies have shown that spiders form an abundant predator group in pesticide-free orchards (HARRISON 1968; MACLELLAN 1973; CARROL 1980). Several authors have therefore supposed that spiders play an important role as natural control agents in pesticide-free orchards (CHANT 1956; KAYASHIMA 1972; MACLELLAN 1973; MANSOUR et al. 1980a), though precise results do not exist. However, it has been demonstrated that the treatment of orchards with pesticides leads to a significant reduction of the numbers of spiders (CHANT 1956; SPECHT and DONDALE 1960; DONDALE et al. 1979; MANSOUR et al. 1980b; MCCAFFREY and HORSBURGH 1980). This indicates that pesticide treatments reduce the spiders' predatory importance in orchards.

4 Using spiders in biological pest control

Ground-dwelling spiders, together with the ground-dwelling raptorial Carabidae and Staphylinidae, form an important predator potential in cereal fields. This predator potential can be utilized within "programs for integrated pest control" (BASEDOW and MIELKE 1977; KIRITANI 1979). Thus, attempts have been made in Japan to raise the spider density in rice fields artificially by releasing *Drosophila* flies. This additional food then caused an increased fertility in the spiders (KOBAYASHI 1975). According to a report of the Chinese News Agency Xinhua of August 15, 1979, in the Peoples Republic of China several species of spiders are introduced into rice fields as biological control agents of rice pests.

As most spiders are cannibals, it would probably be difficult to breed large numbers of spiders in the laboratory. RUPPERTSHOFEN (1976) and KAYASHIMA (1967) have looked for an alternative. They have proposed that egg sacs of spiders could be gathered somewhere and placed in forests or mulberry plantations respectively to raise the population density of spiders.

Another example on the use of spiders for biological pest control is reported from South Africa. There, spiders were settled in houses. STEYN (1959) recorded a reduction of the fly populations by 99 % within 2½ months and, at the same time, a pronounced decrease of gastrointestinal infections of men in that region, because the vectors of disease were destroyed.

There are several reports in literature about house-dwelling spiders as predators of pest insects (comp. LORANDO 1929; MATHIS and BERLAND 1933; HASE 1934; SAUTET 1936; KULLMANN 1970/

71; EDWARDS 1979); in stables in Canada it could be observed that the prey of the comb-footed spider *Steatoda bipunctata* consisted mainly of harmful insects such as house flies, *Tenebrio* beetles, etc. (NYFFELER unpubl.).

What about the possibility of utilizing spiders for biological pest control in Central Europe? Here, spiders could only become of greater importance, if it were possible to increase the numbers of spiders in cultivated fields. This would be possible if the area of the "ecological cells" (abandoned grasslands, hedges, wet areas, etc.; definition of "ecological cell" see KLOFT 1978) which serve as predator-reservoirs for agroecosystems, could be enlarged. However, uncultivated lands of that kind may serve as reservoirs for predators and pest organisms as well. The expansion of the area of the "ecological cells" could therefore also bring about an increase of pest incidence. With present day knowledge it is difficult to estimate, whether the useful effect (reservoirs of predators) or the detrimental effect (reservoirs of pests) would ultimately prevail. Intensive research on the complex functions of such "ecological cells" in the agricultural landscape would be necessary, before the expansion of their area with the intentions of increasing the predators' densities in the cultivated areas could be recommended.

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Zusammenfassung

Spinnen in der natürlichen und biologischen Schädlingsbekämpfung: Ein Literaturüberblick

Weltweit wurden in den letzten 20 Jahren in verschiedenen Ökosystem-Typen zahlreiche Studien über die ökologische Bedeutung der Spinnen als Prädatoren durchgeführt. Trotz der großen Zahl durchgeführter spinnenökologischer Studien ist die Funktion der Spinnen als Prädatoren von Insekten und anderen Invertebraten heute noch weitgehend ungeklärt. In vorliegender Arbeit wird die Literatur über dieses Thema (insgesamt sind 300 wissenschaftliche Arbeiten, die zwischen 1920 und 1984 über dieses Thema publiziert wurden, aufgeführt) analysiert.

Mehrere europäische und amerikanische Studien haben gezeigt, daß Spinnen in unbewirtschafteten Grasland-Ökosystemen und Forst-Ökosystemen eine große ökologische Bedeutung als Prädatoren von Insekten haben können. Auch in ungespritzten Obstanlagen, die man bis zu einem gewissen Grad mit Forst-Ökosystemen vergleichen kann, stellen Spinnen manchmal eine häufige Prädatorengruppe dar. Im Gegensatz dazu ist die ökologische Bedeutung der in Kulturfeldern lebenden Spinnen als Insektenvertilger noch weitgehend umstritten. Einige europäische Studien deuten darauf hin, daß den in der Vegetationsschicht von Kulturfeldern lebenden Spinnen ihrer niedrigen Populationsdichten wegen wahrscheinlich keine große Bedeutung als Prädatoren von Insekten zukommt. Aus anderen europäischen Studien geht hervor, daß die epigäischen Spinnen der Kulturfelder bezüglich ihrer Abundanz eine dominante Prädatorengruppe darstellen, deren Funktion als Kleinräuber allerdings noch weitgehend unbekannt ist. In asiatischen Reisfeldern, die nicht oder wenig mit Pestiziden behandelt wurden, können Spinnen eine wichtige Bedeutung als Prädatoren von Schädlingen haben. Reisfelder sind Sumpfökosysteme; auch in europäischen und amerikanischen Sumpfökosystemen können Spinnen eine abundante Prädatorengruppe darstellen.

In Südafrika wurden Spinnen erfolgreich bei der biologischen Bekämpfung von Fliegen in Häusern eingesetzt.

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