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EFFECTS OF CULTURAL PRACTICES ON THE SPIDER (ARANEAE) FAUNA OF LOWBUSH BLUEBERRY FIELDS IN WASHINGTON COUNTY, MAINE

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ABSTRACT. Spiders of 17 families, 53 genera, and 87 species were captured in pitfall traps (n = 45 traps/year) placed in lowbush blueberry fields in Washington County, Maine, during the summers of 1986 and 1987. Species and numbers of hunting spiders (Lycosidae, Gnaphosidae, Thomisidae) were numerically dominant. Significantly more (ANOVA, *G*-tests) spiders were captured in 1987 than in 1986. Sex ratios were highly biased toward males both years. Species richness, diversity, and evenness of trapped spiders varied among three blueberry cultural treatments (mowing, burning, bearing crop). In 1986, richness and diversity were greatest in crop bearing fields, with spiders more evenly distributed in burned fields. In 1987, species richness, diversity, and evenness were greatest in burned fields. Over all weeks in 1986, there were no significant differences (ANOVA, DMRT) in mean numbers of individuals or species captured among treatments. Significant differences in mean catches among treatments were observed on one of nine sampling dates in 1986. Greater variatiön was seen in 1987 for both individuals and species; significant differences in mean catches among treatments were noted on six of 12 sampling dates. Percentage similarity (*PS*) of species quantities among treatments was > 60; *PS* values were greater in 1986 than in 1987. The blueberry-spider fauna had more species in common (*QS*) with terrestrial habitats than arboreal habitats in Maine.

Lowbush blueberry, *Vaccinium angustifolium* (Ait.), is a perennial shrub native to northeastern North America (Vander Kloet 1978). In Maine, lowbush blueberry is fostered and nurtured for berry production; it comprises a major commercial crop. Numerous cultural practices have been developed and implemented to promote berry production. These practices include: herbicidal control of competing weeds; insecticidal control of pestiferous insects; irrigation of fields during periods of drought; and artificial pruning of older plants by either burning or mowing. Recently, mowing blueberry fields has evolved as an alternative management practice to burning. Since early times, burning blueberry fields was the method used not only to prune blueberry plants, but also to suppress competing vegetation. However, the long-term effects of burning, mowing, or other cultural practices have not been fully evaluated for the blueberry agroecosystem.

In Arkansas, Johnson et al. (1981) and Hopkins & Johnson (1984) reported that spider populations were higher and somewhat more diverse in wild blueberries (*Vaccinium* spp.) than in cultivated, highbush blueberries (*V. corymbosum* L.). However, in Maine the arthropod fauna associated with blueberry plants and with blueberry fields has received scant attention; most studies concern only pest insects (Forsythe & Collins 1986, 1987, 1988). We know of no previous studies concerning the possible effects of either burning or mowing on the araneofauna associated with lowbush blueberry in Maine.

Some information is available about the effects of burning and mowing on spider populations in other ecosystems. Most studies have shown that spider numbers decline following burning (Riechert & Reeder 1972; Nagel 1973; Dunwiddie 1991); however, Aitchison-Benell (1994) found that numbers of bog spiders were high two months after fire and then decreased. Other investigations have shown that spider numbers also decline after mowing (Howell & Pienkowski 1971; Nyffeler & Breene 1990; Dunwiddie 1991).

In this paper, we: 1) describe the araneofauna associated with lowbush blueberry fields in commercial production in Washington County, Maine; 2) compare the density of pitfall-trap catches among three blueberry cultural treatments (pruning by mowing = "mow", pruning by burning = "burn", and bearing crop = "bear"); 3) evaluate the effects of these three cultural treatments on spider species composition and abundance; and 4) compare the terricolous spider fauna of Maine's blueberry fields with that of other habitats.

METHODS

Study sites.—Commercial lowbush blueberry fields that represented three blueberry cultural treatments (mow, burn, bear) were sampled for spiders in Washington County, Maine in 1986 and 1987. Three fields were selected and monitored for each treatment each year.

Treatments.—Burn treatments were applied in November prior to each study year, i.e., 1985 or 1986. Mow treatments were applied in April of each study year, i.e., 1986 or 1987. Mow treatment areas were flail-mowed by the grower using standard commercial flail-mowers. Burn treatment areas were similarly burned with commercial oil burners by the grower. Hexazinone (herbicide) and fertilizer were applied to mow and burn fields by the grower following standard lowbush blueberry management practices (University of Maine Cooperative Extension Service 1986). In 1986, phosmet (insecticide) was applied to one bear field between 4–11 July; in 1987, azinphos-methyl (insecticide) was applied to one bear field between 10–17 July. Both insecticide treatments were standard applications to control blueberry maggot, *Rhagoletis mendax* Curran.

Pitfall traps.—At each study site, we deployed five pitfall traps along line transects; starting points and orientations of transects were chosen at random and were at least 20 m from field edges and roads. Pitfall traps were 0.5 liter plastic drinking cups (height, 13.0 cm; top diameter, 8.6 cm). Each cup was filled to a depth of about 5 cm with ethylene glycol (antifreeze). A rain cover (12.7 × 12.7 cm) constructed of 0.6 cm exterior plywood, and with four 16d nails (length = 8.9 cm) as supports, was placed over each trap and remained in place until the traps were serviced.

In 1986, traps were deployed on 20 June and serviced weekly until 22 August for a total of nine trap weeks. In 1987, traps were deployed on 15 May and serviced weekly until 14 August for a total of 12 trap weeks. At each servicing, traps were removed from the ground and their contents passed through a fine mesh strainer. Captured organisms were placed in small jars with 70% ethanol and transported to the laboratory for sorting and identification of spiders. Potential sample sizes were: n = 45 traps/year; 5 traps/field × 3 cultural treatments × 3 replications/treatment × 9 weeks = 405 in 1986, and × 12 weeks = 540 in 1987.

Spider identifications.—Only sexually mature spiders were identified to species; species determinations follow the identification keys and descriptions of Kaston (1981). Juveniles, including penultimate stages, were identified to genus. A few specimens (mostly Linyphiidae) were sent to Dr. C. D. Dondale, Ottawa, for species determination or confirmation. Representative specimens of all identified species will be deposited in the arachnid collection, U. S. National Museum of Natural History, Washington, DC.

Data analyses.—*Spider taxa:* We used nonparametric procedures (Sokal & Rohlf 1981) for statistical comparisons at $P = 0.05$. The G-test was used to compare spider abundances between years and by foraging strategy, and to compare sex ratios of trapped males and females. Null hypotheses were: expected abundances equal between years; expected abundances equal between foraging strategies (web spinner, hunter); and expected proportions (0.50: 0.50) of spider sexes.

Data analyses.—*Species richness, diversity, and evenness:* Computations of species richness, diversity, and evenness were made using the program of Ludwig & Reynolds (1988), where: species richness, NO = the number of *all* species in the sample regardless of their abundances (Hill 1973); species diversity, H' = Shannon's index (Shannon & Weaver 1949); and species evenness, $E5$ = a measure of how evenly species are distributed in a sample. For species comparisons, we included only those species represented by adult spiders; hence, our estimates are conservative.

For comparisons of species similarities

among blueberry cultural treatments (*Q*-mode analysis), we used the percent similarity (*PS*) index of Bray & Curtis (1957), which takes into account species quantities in sampling units.

Sørensen's similarity quotient (*QS*), as defined by Price (1975), was used to compare the terricolous spider fauna we found in blueberry fields of Maine with that of other similar and dissimilar habitats in Maine. For these comparisons, we excluded species identified only to genus in the various studies. Hence, our estimates of spider faunal similarities in Maine may be conservative.

Data analyses.—*Treatment effects:* Parametric procedures were used to evaluate treatment effects. Prior to analysis, pitfall-catch data were subjected to Hartley's test for homogeneity of variance (Sokal & Rohlf 1981). Log transformations ($\log_{10}(X + 1)$) were used to stabilize variances. Analysis of variance (ANOVA) ($P = 0.05$) and Duncan's Multiple Range Test (DMRT) ($\alpha = 0.05$) (SAS Institute 1985) were used to evaluate differences in mean catches of individuals and species among treatments by week and over all weeks for each year.

RESULTS

Spider taxa.—Spiders of 17 families, 53 genera, and 87 species were pitfall-trapped in blueberry fields of Washington County, Maine during the summers of 1986 and 1987 (Table 1). Except for number of families, fewer taxa were trapped in 1986 than in 1987: 15 families, 38 genera, 54 species in 1986; 15 families, 44 genera, and 73 species in 1987. Four of the species trapped in 1986 were represented by juveniles only. Species of Araneidae and Anyphaenidae were trapped in 1986 but not in 1987; species of Hahniidae and Tetragnathidae were trapped in 1987 but not in 1986.

For both study years, species composition of spiders differed by foraging strategy; species of hunters were numerically dominant (Fig. 1). In 1986, the hunter guild was comprised mainly of species of Lycosidae (20.4% of all species), Gnaphosidae (14.8%), and Thomisidae (11.1%); collectively, the remaining hunter families comprised 27.8% of the total species ($n = 54$). In 1987, the hunter guild consisted of species of Lycosidae (21.9%), Gnaphosidae (16.4%), and Thomisidae (13.7%); collectively, the remaining hunter families comprised 20.6% of the total species ($n = 73$) trapped that year.

Numbers of individuals also differed by foraging strategy each year; individuals of the hunter guild were by far the most commonly trapped spiders each year and for both years combined (Fig. 2). In 1986, the hunter guild consisted chiefly of individuals of Lycosidae (72.2% of all individuals), Gnaphosidae (6.8%), and Thomisidae (8.8%); collectively, the remaining hunter families comprised 6.7% of the total trapped individuals ($n = 832$). Again, in 1987 the Lycosidae were numerically dominant (77.8% of all trapped individuals), followed by the Gnaphosidae (7.0%) and the Thomisidae (6.5%). Collectively, the remaining hunter families comprised 4.2% of the total trapped individuals ($n = 1,890$).

Spider numbers, life stages, sex ratios.—The pitfall traps yielded a total of 2,722 spiders; 832 (30.6% of all individuals) were trapped in 1986, and 1,890 (69.4% of all individuals) were trapped in 1987 (Table 1). Significantly more spiders were trapped in 1987 than in 1986; likewise, more web spinners and more hunters were trapped in 1987 than in 1986 (Table 1). *G*-tests also indicated that significantly more adult spiders of 13 species and juveniles of two genera (i.e., *Callobius* sp., *Pardosa* spp.) were trapped in 1987 than in 1986. However, adults of only one species (*Pirata minutus* Em.) and juveniles of two genera (*Alopecosa* sp., *Xysticus* sp.) had significantly more spiders trapped in 1986 than in 1987 (Table 1).

For both study years, males were the most prevalent life stage trapped, followed by juveniles and females: 54.6% males, 26.4% juveniles, 19.0% females in 1986; and 62.0% males, 19.3% juveniles, 18.8% females in 1987. Sex ratios of males to females were highly biased toward males both years: ratio 2.9:1, $G = 149.3$, $P < 0.001$ in 1986; and ratio 3.3:1, $G = 460.0$, $P < 0.001$ in 1987.

Species richness, diversity, evenness.—Species richness, diversity, and evenness varied among treatments within years, among treatments between years, and over all treatments between study years (Table 2). In 1986, richness and diversity were greatest in the bear fields; however, spiders were distributed more evenly among species in the burn fields. For the last nine weeks of trapping in 1987, species richness was greatest in the bear

Table 1.—Species and numbers of spiders captured in pitfall traps in blueberry fields of Washington County, Maine, 1986 and 1987 (n = 45 traps/year; 5 traps/field × 3 cultural treatments × 3 replications/treatment). G-test of spider abundance between years; significance levels: * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$. MO = Mow, BU = Burn, BE = Bear.

	1986 (9 weeks)			1987 (12 weeks)			
	MO	BU	BE	MO	BU	BE	G
WEB SPINNERS							
Theridiidae							
Achaearanea globosa (Hentz)	1	0	0	0	0	0	
Enoplognatha marmorata (Hentz)	5	4	15	8	14	9	0.89
Enoplognatha sp.	0	0	0	1	1	1	
Euryopis saukea Levi	0	0	1	0	0	0	
Robertus spiniferus (Em.)	1	0	0	0	1	0	
Linyphiidae							
Subfamily Linyphiinae							
Bathyphantes pallidus (Banks)	1	0	1	0	0	7	2.94
Lepthyphantes calcarata (Em.)	0	0	0	0	0	1	
Meioneta fabra (Keys.)	2	0	0	1	1	0	
Meioneta simplex (Em.)	0	0	0	1	0	0	
Microlinyphia mandibulata (Em.)	0	0	0	0	1	1	
Neriene clathrata (Sundv.)	0	0	0	0	0	1	
Oreonetides sp. 1	0	0	0	1	0	0	
Subfamily Erigoninae							
Baryphyma longitarsum (Em.)	0	0	0	1	0	0	
Collinsia plumosus (Em.)	0	0	1	0	0	0	
Grammonota angusta Dondale	0	0	2	1	1	1	0.20
Grammonota capitata Em.	0	0	0	2	0	0	
Pocadicnemis americana Mill.	0	0	0	0	0	2	
Undet. sp.	0	0	0	0	1	1	
Tetragnathidae							
Pachygnatha tristriata C. L. Koch	0	0	0	0	0	1	
Araneidae							
Araneus trifolium (Hentz)	0	1	0	0	0	0	
Neoscona arabesca (Walck.)	1	0	0	0	0	0	
Agelenidae							
Agelenopsis actuosa (Gertsch & Ivie)	1	3	0	0	1	0	1.93
Agelenopsis utahana (Chamb. & Ivie)	0	0	0	1	0	0	
Hahniidae							
Neoantistea agilis (Keys.)	0	0	0	0	1	0	
Dictynidae							
Argenna obesca Em.	1	0	0	0	0	0	
Cicurina pallida Keys.	0	0	0	0	1	0	
Cicurina placida Banks	0	0	0	0	1	1	
Cicurina sp.	1	0	0	0	1	0	
Amaurobiidae							
Callobius bennetti (Blkw.)	0	0	0	5	1	0	
Callobius sp.	0	1	2	8	2	0	3.98*
Webspinner subtotals	14	9	22	30	28	26	11.98***
HUNTERS							
Lycosidae							
Alopecosa aculeata (Clerck)	2	2	3	17	38	20	65.84***

Table 1.—Continued.

	1986 (9 weeks)			1987 (12 weeks)			
	MO	BU	BE	MO	BU	BE	*G*
Alopecosa kochi (Keys.)	0	0	0	4	4	2	
Alopecosa sp.	4	6	6	1	2	0	9.77**
Hogna frondicola (Em.)	0	0	3	4	5	6	8.73**
Hogna sp.	10	9	7	12	23	2	1.93
Pardosa distincta (Blkw.)	68	53	57	98	22	96	3.67
Pardosa fuscula (Thor.)	0	0	0	0	1	0	
Pardosa hyperborea (Thor.)	0	1	0	0	3	1	1.93
Pardosa milvina (Hentz)	0	0	0	1	2	0	
Pardosa moesta Banks	29	22	10	50	81	238	244.95***
Pardosa saxatilis (Hentz)	7	5	4	7	34	53	61.25***
Pardosa xerampelina (Keys.)	0	2	1	6	65	37	126.30***
Pardosa spp.	7	5	6	37	39	40	80.03***
Pirata insularis Em.	0	0	0	1	0	0	
Pirata minutus Em.	7	17	12	3	4	10	6.96**
Pirata sp.	0	1	1	1	1	1	0.20
Schizocosa communis (Em.)	46	41	34	73	92	79	42.27***
Schizocosa crassipalpata Roewer	0	0	1	0	1	2	1.05
Schizocosa saltatrix (Hentz)	0	0	0	0	0	1	
Schizocosa sp.	0	0	0	3	10	3	
Trochosa terricola Thor.	0	0	1	1	1	4	3.96*
Trochosa sp.	0	0	2	3	2	0	1.33
Undet. sp.	59	0	50	4	7	113	0.97
Anyphaenidae							
Wulfila saltabundus (Hentz)	0	0	1	0	0	0	
Liocranidae							
Agroeca ornata Banks	0	0	0	1	0	0	
Agroeca sp.	0	0	1	0	0	0	
Phrurotimpus alarius (Hentz)	1	0	0	0	0	0	
Phrurotimpus borealis (Em.)	1	1	0	1	0	0	0.34
Scotinella divesta (Gertsch)	0	0	0	0	0	1	
Clubionidae							
Clubiona bishopi Edwards	1	0	0	0	0	0	
Clubiona johnsoni Gertsch	1	2	1	6	4	5	6.78**
Clubiona kastoni Gertsch	0	1	0	0	0	0	
Clubiona sp.	1	0	0	1	2	1	1.93
Corinnidae							
Castianeira cingulata (C. L. Koch)	0	4	0	0	0	0	
Castianeira descripta (Hentz)	4	6	8	1	6	6	0.81
Castianeira sp.	2	1	4	0	2	0	2.94
Gnaphosidae							
Drassodes neglectus (Keys.)	0	0	0	2	1	1	
Drassyllus depressus (Em.)	1	0	0	0	1	0	
Drassyllus socius Chamb.	0	0	0	0	2	0	
Gnaphosa muscorum (L. Koch)	5	1	5	0	6	0	1.49
Gnaphosa parvula Banks	2	1	2	5	5	6	6.06*
Gnaphosa sp.	1	2	2	1	5	4	1.70
Haplodrassus bicornis (Em.)	0	0	0	5	4	7	
Haplodrassus hiemalis (Em.)	0	0	0	0	1	1	
Haplodrassus signifer (C. L. Koch)	0	3	5	18	12	10	23.29***
Haplodrassus sp.	0	1	1	2	1	2	1.33

Table 1.—Continued.

	1986 (9 weeks)			1987 (12 weeks)			
	MO	BU	BE	MO	BU	BE	*G*
Herpyllus ecclesiasticus Hentz	0	0	0	1	0	0	
Micaria riggsi Gertsch	0	0	2	1	4	1	2.09
Sergiolus decoratus Kaston	1	0	0	0	0	0	
Zelotes fratris Chamb.	0	2	0	2	0	1	0.20
Zelotes hentzi Barrows	3	1	11	6	2	6	0.03
Zelotes sp.	2	1	2	2	1	4	0.33
Philodromidae							
Ebo iviei Sauer & Platnick	0	0	0	1	0	0	
Philodromus placidus Banks	0	0	0	0	1	0	
Philodromus sp.	0	0	0	0	1	0	
Thanatus formicinus (Clerck)	0	0	0	1	1	0	
Thanatus striatus C. L. Koch	0	0	0	0	1	0	
Thanatus sp.	2	0	0	1	2	0	0.20
Thomisidae							
Coriarachne utahensis (Gertsch)	0	0	0	3	0	0	
Ozyptila distans Dondale & Redner	0	0	1	0	0	1	
Ozyptila sp.	0	0	0	1	0	0	
Xysticus alboniger Turnbull, Dondale & Redner	2	0	1	0	1	3	0.14
Xysticus ampullatus Turnbull, Dondale & Redner	2	3	3	8	2	25	18.29***
Xysticus discursans Keys.	0	0	1	3	3	7	12.20***
Xysticus emertoni Keys.	0	0	0	1	2	4	
Xysticus ferox (Hentz)	0	0	0	2	0	7	
Xysticus fervidus Gertsch	0	0	0	0	1	0	
Xysticus pellax O. P.-Camb.	0	0	1	0	0	0	
Xysticus triguttatus Keys.	7	12	22	9	20	13	0.01
Xysticus winnipegensis Turnbull, Dondale & Redner	0	0	0	0	0	1	
Xysticus spp.	6	6	6	1	1	4	6.28*
Salticidae							
Euophrys monadnock Em.	0	0	2	1	1	0	
Evarcha hoyi (Peckham & Peckham)	1	0	0	0	0	0	
Habronattus decorus (Blkw.)	0	1	0	0	1	0	
Habronattus viridipes (Hentz)	3	2	0	9	8	4	10.59**
Habronattus sp.	1	0	0	1	1	0	0.34
Phidippus purpuratus Keys.	0	0	2	0	2	0	
Phidippus whitmani Peckham & Peckham	0	0	0	0	0	1	
Phidippus sp.	1	0	0	1	0	2	1.05
Talavera minuta (Em.)	0	0	0	0	0	1	
Hunter subtotals	290	215	282	424	545	837	411.45***
Spider Totals	304	224	304	454	573	863	422.26***

fields; however, diversity and evenness were greatest in burn fields (Table 2). Over 12 weeks in 1987, species richness, diversity, and evenness were greatest in the burn fields, followed by bear fields for richness, and mow fields for diversity and evenness. And, over all treatments, species richness, diversity, and evenness generally were greater in 1987 than

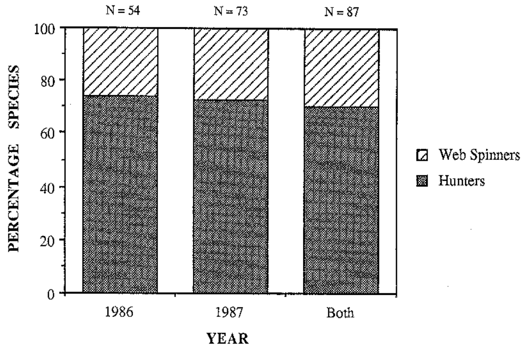

Figure 1.—Percentages of spider species, by foraging strategy (web-spinner, hunter), captured in pitfall traps, blueberry fields, Washington County, Maine; 9 weeks, 1986; 12 weeks, 1987; and both years combined.

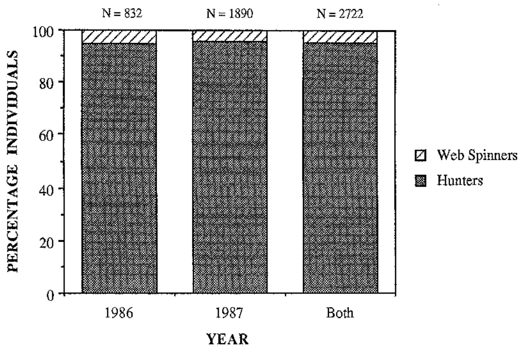

Figure 2.—Percentages of spider individuals, by foraging strategy (web-spinner, hunter), captured in pitfall traps, blueberry fields, Washington County, Maine; 9 weeks, 1986; 12 weeks, 1987; and both years combined.

in 1986 (Table 2). For both study years combined and over all treatments, the computed values were: $NO = 87$, $H' = 2.77$, $E5 = 0.52$.

The ranking order of species abundance for the 10 most commonly trapped species also differed between study years (Table 3). Because of their common occurrence in trap catches, *Pardosa distincta, P. moesta*, and *Schizocosa communis* were among the three top-ranked species each study year and for both years combined. The dominance of the hunter guild was very evident in the rank order of species abundance; for each year and both years combined, fully 90% were hunters with only one web-spinner species, *Enoplognatha marmorata* (Hentz), included among the rankings.

Mean numbers of individuals and species.—Over all weeks in 1986, there was no significant difference in mean numbers of individuals (ANOVA, $F = 0.78$, $df = 42$) trapped (Table 4). In 1987, significantly more individuals were captured in the bear fields than in either the mow or burn fields (ANOVA, $F = 8.00$, $df = 42$). Although mean numbers of species trapped in 1986 did not differ significantly (ANOVA, $F = 0.85$, $df = 42$), both bear and burn fields had significantly more species than mow fields (ANOVA, $F = 9.02$, $df = 42$) in 1987. To minimize temporal variation and equalize sample sizes, we excluded the first three weeks of trapping in 1987 and reanalyzed the data. As expected, mean catches of individuals and species were slightly lower for nine weeks of trapping in 1987. However, all test comparisons remained the same, except mean catches of species in burn fields did not differ significantly from

Table 2.—A comparison of spider species richness, diversity, and evenness among three blueberry cultural treatments, Washington County, Maine, 1986, 1987 (*NO* = number of all species; *H'* = Shannon diversity index; *E5* = evenness index; all from BASIC program SPDIVERS.BAS (Ludwig & Reynolds 1988)).

	1986 (9 weeks)				1987 (9 weeks)				1987 (12 weeks)			
	Mow	Burn	Bear	All	Mow	Burn	Bear	All	Mow	Burn	Bear	All
Richness												
NO	29	25	31	50	33	35	38	59	43	49	44	73
Diversity												
H'	2.26	2.34	2.59	2.54	2.22	2.51	2.32	2.51	2.63	2.74	2.44	2.73
Evenness												
E5	0.54	0.61	0.59	0.51	0.51	0.56	0.50	0.53	0.51	0.59	0.48	0.52

Table 3.—Ranking order of abundance for the 10 most commonly trapped terricolous spiders in blueberry fields of Washington County, Maine, 1986 and 1987, and both years combined.

1986 (9 weeks)	1987 (9 weeks)	1987 (12 weeks)	Both years
1. *Pardosa distincta*	*Pardosa moesta*	*Pardosa moesta*	*Pardosa moesta*
2. *Schizocosa communis*	*Schizocosa communis*	*Schizocosa communis*	*Pardosa distincta*
3. *Pardosa moesta*	*Pardosa distincta*	*Pardosa distincta*	*Schizocosa communis*
4. *Xysticus triguttatus*	*Pardosa saxatilis*	*Pardosa xerampelina*	*Pardosa xerampelina*
5. *Pirata minutus*	*Pardosa xerampelina*	*Pardosa saxatilis*	*Pardosa saxatilis*
6. *Enoplognatha marmorata*	*Enoplognatha marmorata*	*Alopecosa aculeata*	*Xysticus triguttatus*
7. *Castianeira descripta*	*Xysticus triguttatus*	*Xysticus triguttatus*	*Alopecosa aculeata*
8. *Pardosa saxatilis*	*Alopecosa aculeata*	*Haplodrassus signifer*	*Enoplognatha marmorata*
9. *Zelotes hentzi*	*Pirata minutus*	*Xysticus ampullatus*	*Pirata minutus*
10. *Gnaphosa muscorum*	*Gnaphosa parvula* *Habronattus viridipes*	*Enoplognatha marmorata*	*Haplodrassus signifer*

mean catches in either mow or bear fields (Table 4).

Summaries of mean numbers of individuals and species of spiders captured in pitfall traps by sampling week are shown in Figs. 3 and 4, respectively. In 1986, the only significant difference in mean number of individuals occurred on 18 July (ANOVA, $F = 4.01$, $df = 42$) (mow > bear). Peaks in mean number of individuals on 25 July (bear) and 8 August (mow) were due to large numbers of spiderlings captured in one trap on each date ($n = 50$ and 57, respectively). Much greater variation between and among cultural treatments was observed in 1987. Bear fields had significantly more individuals than mow fields on 22 May and 7 August (ANOVA, $F = 4.11$ and 5.04, respectively, $df = 42$) and significantly more individuals than either burn or mow fields on 5, 12, and 19 June (ANOVA, $F = 6.42$, 5.63, and 9.34, respectively, $df = 42$) (Fig. 3). Significantly more individuals were captured in burn fields than mow fields on 29 May (ANOVA, $F = 3.94$, $df = 42$). The large peak in mean numbers of individuals captured in bear fields on 7 August was due to large numbers of spiderlings ($n = 44$ and 66) in two traps.

In 1986, significantly more species were found in mow fields compared to bear fields on 18 July (ANOVA, $F = 2.82$, $df = 42$). Similar variations were observed in mean numbers of species trapped in 1987 (Fig. 4). Significantly more species were trapped in bear than in mow fields on 22 May, 5 June, 19 June, and 7 August (ANOVA, $F = 4.51$, 3.25, 5.14, and 5.11, respectively, $df = 42$). Bear fields had significantly more species than either mow or burn on 12 June (ANOVA, $F = 5.26$, $df = 42$); burn fields had significantly more species than mow on 29 May (ANOVA, $F = 3.60$, $df = 42$).

In 1986, mean numbers of individuals and species generally declined in all fields after 4

Table 4.—Comparison of mean individuals and species of spiders associated with three blueberry cultural treatments. Column means followed by the same letter are not significantly different ($P = 0.05$); ANOVA and DMRT. Log transformations, $\log_{10}(X + 1)$, were used to stabilize variances. Sample sizes were: 15 traps/treatment × 9 weeks = 135, 1986 and 1987; 15 traps/treatment × 12 weeks = 180, 1987.

Field condition	X (±SE) individuals 1986 (9 weeks)	1987 (9 weeks)	1987 (12 weeks)	X (±SE) species 1986 (9 weeks)	1987 (9 weeks)	1987 (12 weeks)
MOW	2.25a (0.43)	2.45b (0.40)	2.52b (0.36)	0.99a (0.10)	1.41b (0.20)	1.47b (0.18)
BURN	1.66a (0.23)	2.62b (0.28)	3.18b (0.26)	1.04a (0.12)	1.64ab (0.15)	1.89a (0.11)
BEAR	2.25a (0.51)	4.26a (0.71)	4.79a (0.61)	1.23a (0.15)	2.01a (0.12)	2.32a (0.13)

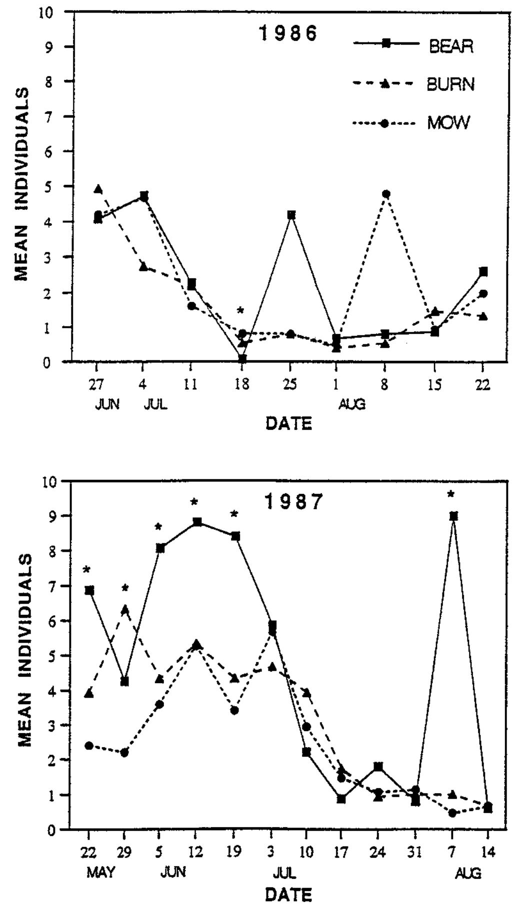

Figure 3.—Mean number of spider individuals, by treatment (mow, burn, bear), captured in pitfall traps, blueberry fields, Washington County, Maine; 1986, 1987, for each trapping date (n = 15 traps/treatment). ANOVA and DMRT; significance level: ★ = $P < 0.05$.

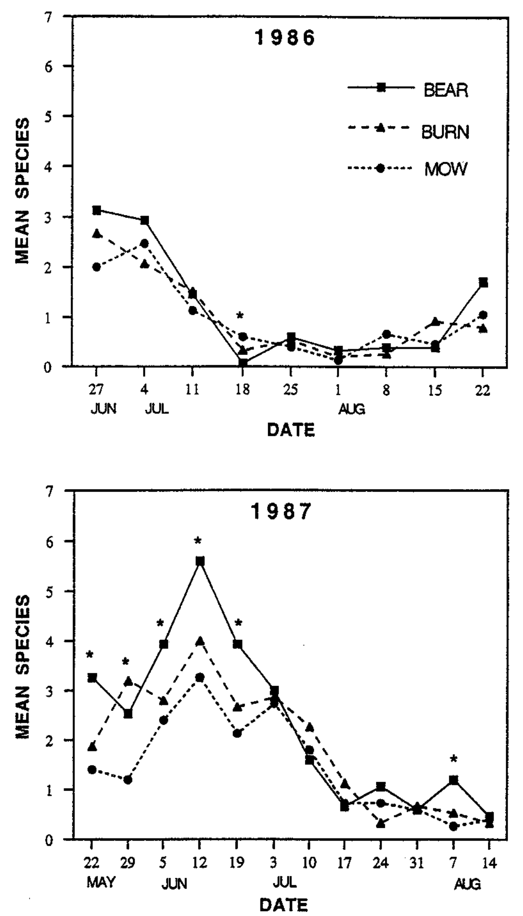

Figure 4.—Mean number of species, by treatment (mow, burn, bear), captured in pitfall traps, blueberry fields, Washington County, Maine; 1986, 1987, for each trapping date (n = 15 traps/treatment). ANOVA and DMRT; significance level: ★ = $P < 0.05$.

July; however, slight increases were noted in late August. Mean numbers of individuals and species generally declined in all fields after 3 July in 1987.

To assess the potential impact of insecticide applications on mean catches of spiders, we examined the variability in catches of both individuals and species before and after such applications in 1986 and 1987. For bear fields in 1986, there were no significant reductions in mean catches of either individuals (ANOVA, $F = 0.60$, $df = 12$) or species (ANOVA, $F = 0.51$, $df = 12$) of spiders immediately following application of phosmet to one bear field in early July. However, we detected some variability among replications for both mean catches of individuals (ANOVA, $F = 8.23$, $df = 12$) and species (ANOVA, $F = 8.30$, $df = 12$) following application of azinphos-methyl to one bear field in 1987. Nonetheless, this variability could not be attributed solely to application of the insecticide because differences occurred in both treated and untreated fields.

Faunal similarities.—Percentage similarity (*PS*) of species quantities among treatments was generally > 60%, but variable (Table 5). These similarity coefficients were greater in 1986 than in 1987. Comparisons that included the burn treatment had slightly greater *PS* values in 1986; however, this pattern was not evident in 1987 (Table 5).

Table 5.—A comparison of percentage similarity coefficients for spiders associated with three blueberry cultural treatments (Mow, Burn, Bear), Washington County, Maine, 1986, 1987. (*PS* = Bray-Curtis similarity index; BASIC program SUDIST.BAS (Ludwig & Reynolds 1988)).

	Treatment comparison		
Study year	Mow-Burn	Mow-Bear	Burn-Bear
1986 (9 weeks)	77.9	68.9	73.1
1987 (9 weeks)	62.8	64.8	56.8
1987 (12 weeks)	60.4	62.4	62.1

Community comparisons.—As expected, the terricolous spider fauna associated with blueberry fields we sampled in Maine had more species in common (i.e., higher *QS* values) with terrestrial habitats than with arboreal habitats (Table 6). For terrestrial habitats, many species of Lycosidae were shared in common between blueberry fields and spruce-fir forests of Maine (Jennings et al. 1988; Hilburn & Jennings 1988). These included species of *Pardosa*, such as *P. hyperborea* (Thorell), *P. moesta* Banks, and *P. xerampelina* (Keyserling), and species of *Pirata*, such as *P. insularis* Emerton and *P. minutus* Emerton. Arboreal-terrestrial species in common included *Grammonota angusta* Dondale, *Neoscona arabesca* (Walckenaer), *Philodromus placidus* Banks, and *Xysticus discursans* Keyserling.

Studies that employed the same sampling methodology as used in Maine's blueberry fields (i.e., pitfall traps) had higher *QS* values than those that employed radically different methods (e.g., pruned branches) (Table 6).

DISCUSSION

Spider taxa.—Our pitfall-trap catches indicate that the terricolous spider fauna associated with blueberry fields in Washington County, Maine is comprised chiefly of hunting spiders. Few species and few individuals of web-spinning spiders are captured in pitfall traps placed in these habitats. These results are consistent with similar pitfall-trap studies (Uetz 1975; Hilburn & Jennings 1988; Jennings et al. 1988) where the hunter guild is dominant among trap catches. No doubt other sampling methods (e.g., quadrat, D-vac, sweep net) would yield additional species and individuals of both web-spinner and hunter foraging guilds. Because most web-spinners are relatively sedentary compared to the more active, cursorial hunters (Gertsch 1979), pitfall traps capture few web-spinning species of spiders (Uetz 1975). Nevertheless, there are exceptions where species of web-spinning spiders (e.g., wandering species of Agelenidae, Hahniidae, and Linyphiidae) frequently occur in pitfall-trap catches (Jennings et al. 1988; Hilburn & Jennings 1988).

Because so few of Maine's diverse habitats have been investigated extensively for spiders, our collections from blueberry fields of Washington County provide new habitat association data and range extensions for many of the species. Of particular interest are collections of *Oreonetides* sp. 1, *Alopecosa kochi* (Keyserling), *Ebo iviei* Sauer & Platnick, and *Xysticus winnipegensis* Turnbull, Dondale & Redner. The linyphiid, *Oreonetides* sp. 1, apparently is undescribed and has been taken from dense, spruce-fir forests of Piscataquis County, Maine (Jennings et al. 1988). Our collections of *Alopecosa kochi*, *Ebo iviei*, and *Xysticus*

Table 6.—Comparison of spider faunas in different communities and habitats of Maine (*QS* = Sørensen's Similarity Quotient). Species identified only to generic level were excluded.

Community	Habitat	Sampling method	*QS*	Source
Spruce-fir	Ground	Pitfall traps	28.8	Hilburn & Jennings (1988)
Spruce-fir	Ground	Pitfall traps	28.4	Jennings et al. (1988)
Spruce-fir	Tree	Pruned branches	7.8	Jennings & Collins (1987)
Spruce-fir	Herb-shrub	Malaise traps	7.3	Jennings & Hilburn (1988)
Spruce-fir-mixed hardwoods	Ground	Litter expellant	7.2	Jennings et al. (1990)
Spruce-fir	Tree	Pruned branches	6.8	Jennings & Dimond (1988)
Spruce-fir	Tree	Pruned branches	3.8	Jennings et al. (1990)

winnipegensis extend the known ranges for these species in the United States. The lycosid, *A. kochi*, occurs principally in the western United States; however, it has been taken as far north as southern Ontario and Massachussets (Dondale & Redner 1979). The philodromid, *E. iviei*, is known from the western United States and western provinces of Canada, and prior to this study, as far east as Massachussets (Sauer & Platnick 1972; Dondale & Redner 1978). Before our study, the thomisid, *X. winnipegensis,* was known from very limited habitats and localities of Manitoba and New Brunswick, Canada (Dondale & Redner 1978).

Spider numbers, life stages, sex ratios.— We are unable to fully explain the apparent disparity in trap catches of spiders between study years. Why were there more spiders and more species of spiders captured in 1987 than in 1986? Possible causative factors include: differences in microhabitats studied each year and between years; temporal differences in sampling periods between years, and possible differences in potential-prey abundances between years.

Numerous features of the habitat can influence spider abundance (for a review, see Riechert & Gillespie 1986). However, other than the three blueberry cultural treatments (mow, burn, bear), we did not measure habitat parameters such as plant cover, litter depth, or moisture gradient. Because of scheduled treatments by blueberry growers, our study design required selection of new sites in 1987. Hence, sampling sites differed between years. The blueberry fields of Washington County, Maine represent a mosaic of diverse microhabitats, with varying soils, litter, and plant structure. Possibly some of the sites selected in 1987 were more favorable and, consequently, supported greater populations of spiders than sites selected and studied in 1986.

Although the same number of traps was used both study years (5 traps/field $\times$ 3 fields/ treatment $\times$ 3 treatments = 45 traps/year), sampling duration varied between years (9 trap weeks, 1986; 12 trap weeks, 1987). Hence, the longer sampling period in 1987 may account for some of the observed differences in spider abundance between study years. When the first three weeks of trapping in 1987 were excluded, spider abundance remained greater in 1987 (Σ = 1260) than in 1986 (Σ = 832). Likewise, spider species composition remained greater in 1987 (Σ = 59) than in 1986 (Σ = 50). We suspect that factors other than sampling duration were responsible for between-year disparities of some individual species, e.g., *Pardosa xerampelina* (Keyserling) (Table 1).

Many spider families have stenochronous species that reproduce in spring and summer (Schaefer 1987); hence, we expected juveniles to be abundant among trap catches. However, juveniles comprised < 30% of total trap captures in the blueberry fields each year. Apparently our trapping periods (20 June–22 August 1986; 15 May–14 August 1987) spanned the time when many spider species reached sexual maturity, but before offspring were produced. Offspring (young spiderlings) were evident in some of our trap catches, especially in late July and early August 1986, and again in early August 1987. Some traps yielded 44–66 young lycosid spiderlings (probably *Schizocosa communis*) of similar size, shape, and coloration, which possibly indicates that these spiderlings came from the same clutch.

The preponderance of male spiders in our trap catches is not unusual because pitfall traps are selectively biased toward capture of wandering cursorial spiders (Uetz & Unzicker 1976). Male spiders generally are more mobile and may move considerable distances in search of mates; hence, the sexes are seldom equally represented in pitfall-trap catches (Hallander 1967; Muma 1975; Jennings et al. 1988; Hilburn & Jennings 1988).

Species richness, diversity, evenness.— Our results for these parameters are somewhat conflicting and inconsistent between study years. Intuitively, we predicted that the bear treatment would have the greatest and most diverse assemblage of spiders. The bear treatment was the least disturbed of the three treatments studied. However, our results indicate that species richness and diversity of spiders vary unpredictably and inconsistently among the three blueberry cultural treatments (Table 2). The only consistent trend observed was that spiders were more evenly distributed among species in the burn treatment, both study years. We suspect that factors other than cultural treatment *per se* were responsible for the observed variability in richness, diversity, and evenness of spiders. Uetz (1975) found that species diversity of spiders in an oak-tuliptree-maple forest of Delaware was significantly correlated with prey abundance; he also found that litter depth and habitat space were important determinants of within-habitat species diversity. Because predators often hide in dense litter, the effects of mowing and burning on litter structure and depth in Maine's blueberry fields warrant future investigation.

Treatment effects.—The pitfall-trap methods used during this study yielded inconsistent results regarding possible treatment effects on mean numbers of individuals and species of spiders trapped in blueberry fields. In general, more individuals and more species of spiders were trapped in the least disturbed habitat (i.e., bear fields); however, these were not consistent between study years (Table 4). Because of habitat perturbations and resultant changes in litter-plant structure, we had expected that fewer individuals and species of spiders would be caught in the burn and mow treatments. However, our pitfall-trap results yielded few significant differences among all treatments (Table 4). We suspect that timing of burn and mow treatments, depth or intensity of fire burn and the elapsed time between these perturbations and our study period may all have been significant factors influencing mean catches of spiders.

The burn treatments were accomplished in November (about seven months prior to commencement of pitfall trapping) each study year. Burning generally acts as a sanitation procedure by removal or reduction of plant structure and litter (Ismail & Yarborough 1981). Blueberry fields burned in the fall have several months to recover before the next growing season. This prolonged time period also may allow recolonization by spiders since aerial dispersal and colonization of neighboring habitats are common phenomena among spiders (Bishop 1990; Bishop & Riechert 1990; Greenstone 1982, 1990). The following spring after fall burning, the blueberry plants put on new growth. Such growth provides habitat space and attracts potential prey for spiders.

Conversely, spring burning may have detrimental effects on spider populations immediately after burning and during the growing season. Several investigators have reported declines in spider numbers following spring burning of grasslands and prairies (Rice 1932; Riechert & Reeder 1972; Nagel 1973; Dunwiddie 1991). The effects of spring burning on arthropod populations in blueberry fields are unknown.

The mow treatments for this study were accomplished in April, about 1–2 months prior to pitfall trapping. Although these treatments were less drastic perturbations (i.e., creation of litter and debris) than burning, far less time elapsed between mowing and pitfall trapping than between burning and trapping. In general, fewer spiders and fewer species of spiders were trapped in the mow treatment compared to the burn treatment; however, only one such comparison was statistically significant (i.e., species trapped, 12 weeks, 1987 (Table 4)). Because of the short time interval between mowing and trapping, spiders had less time to recover and colonize the mow fields. For European hay meadows, Nyffeler & Breene (1990) found that 40% fewer spiders were captured in pitfall traps after mowing. They also concluded that mowing frequency decreased spider populations sampled by sweep net. In Maine, flail mowing may result in increases in pest populations in lowbush blueberry fields (Forsythe & Collins 1988; DeGomez et al. 1990). Such pest populations are potential prey for spiders; however, there may be a lag time between predator-prey population buildup.

We suspect that some of the yearly differences in mean trap catches of spiders (Table 4) may be due to temporal changes in prey density and diversity. Warren et al. (1987) and others have suggested that changes in spider populations may reflect changes in prey density and prey diversity. Pest insect populations in Washington County, Maine in 1986 were generally low, and with few outbreaks reported (Forsythe & Collins 1986). However, in 1987 a variety of pest insects infested blueberry fields throughout Washington County (Forsythe & Collins 1987). Blueberry spanworm larvae, *Itame argillacearia* (Packard), were present in many fields and larval feeding damage was observed from early May through late June. High larval populations of blueberry flea beetle, *Altica sylvia* Malloch, also were noted in 1987. Blueberry sawfly, probably *Neopareophora litura* (Klug), began appearing in high numbers in June 1987 (Forsythe & Collins 1987). Because spiders respond to increases in prey density (Riechert & Gillespie 1986) and abundance of prey influences habitat (e.g., herbivory), differences in pest insect population levels may explain some of the observed differences in spider abundance between study years.

Faunal similarities.—The relatively high (> 60) percentage similarities of spider species quantities observed between treatment comparisons (mow–burn, mow–bear, burn–bear) are not unexpected because the treatment habitats were similar in plant-species composition and plant structure. Habitat structure and diversity are variables that affect spider species composition and abundance (Greenquist & Rovner 1976; Riechert & Gillespie 1986). Because the comparisons that included the burn treatment had slightly higher similarity coefficients, we conclude that the burn treatment had minimal effects on spider-species composition. This conclusion is supported by the generally greater species diversity indices (Table 2) observed for the burn treatment in 1987. Similar indices in 1986 indicated that the burn treatment ranked third in species richness, and second for species diversity (H').

Community comparisons.—Our results are consistent with earlier findings, i.e., the araneofauna associated with similar terrestrial habitats have species of spiders shared in common (Jennings & Hilburn 1988). Dissimilar habitats, in this case terrestrial *vs.* arboreal, have few species in common. We also conclude that Maine communities with similarly dominant spider families (e.g., abundant Lycosidae) are apt to share species in common. Geographical location and spider species distributions also are factors that may influence such community comparisons (Jennings & Collins 1987). Evidently, sampling methodology should not be ignored, because both habitat and sampling method may influence the determination of which species are shared in common.

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