Relative and Seasonal Abundance of Beneficial Arthropods in Centipedegrass as Influenced by Management Practices

S. KRISTINE BRAMAN AND ANDREW F. PENDLEY

Department of Entomology, University of Georgia, College of Agriculture Experiment Stations, Georgia Station, Griffin, GA 30223

J. Econ. Entomol. 86(2): 494–504 (1993)

ABSTRACT Pitfall traps were used to monitor the seasonal activity of arthropod predators, parasitoids, and decomposers in replicated plots of centipedegrass turf for 3 yr (1989–1991) at two locations. During 1990 and 1991, the influence of single or combined herbicide, insecticide, and fertilizer applications on these beneficials was assessed. In total, 21 species of carabids in 13 genera and 17 species of staphylinids in 14 genera were represented in pitfall-trap collections. Nonsminthurid collembolans, ants, spiders, and parasitic Hymenoptera were adversely affected in the short term by insecticide applications targeting the twolined spittlebug, *Prosapia bicincta* (Say). Other taxa, notably oribatid Acari, increased over time in response to pesticide or fertilizer applications. Although various taxa were reduced by pesticide application during three of four sample intervals, a lack of overall differences in season totals suggests that the disruptive influence of certain chemical management practices may be less severe than expected in the landscape.

KEY WORDS Arthropoda, centipedegrass, nontarget effects

CENTIPEDEGRASS, *Eremochloa ophiuroides* (Munro) Hack, a native of China and Southeast Asia introduced into the United States in 1916, has become widely grown from South Carolina to Florida and westward along the Gulf Coast states to Texas (Duble 1989). It is well adapted to the sandy, acid soils of the southeastern United States, where its popularity as a lawn grass is attributed to low fertility and low maintenance requirements. Although centipedegrass is relatively free of insect and disease problems compared with most warm-season turfgrasses (Beard 1973), certain insects such as ground pearls, *Margarodes* spp. (Homoptera: Margarodidae), and the twolined spittlebug, *Prosapia bicincta* (Say) (Homoptera: Cercopidae), can become persistent, serious pests (Beard 1973, Tashiro 1987). Once primarily a coastal problem, spittlebugs are now a major turf problem in urban areas in the Gulf states and Georgia, particularly during years with heavier than normal spring rainfall (Cobb 1990).

Turfgrasses are inhabited by a diverse fauna of nonpest invertebrates that may help to regulate pest populations (Reinert 1978, Cockfield & Potter 1984a) or improve soil physical properties and aid in nutrient recycling (Potter et al. 1985, 1990a). Beneficial arthropods occurring in turf have been mentioned by several authors (e.g., Bohart 1947, Johnson & Cameron 1969, Mailloux & Streu 1981, Klein 1982, Cockfield & Potter 1984b). Effects of chemical management practices on beneficial invertebrates in cool-season turf have also been assessed (e.g., Cockfield & Potter 1983, Arnold & Potter 1987, Potter et al. 1990b, Vavrek & Niemczyk 1990).

Studies characterizing the beneficial arthropod community and assessing effects of management practices on those invertebrates are especially lacking for warm-season turfgrass species. Research on compatibility of pesticides with the beneficial fauna is essential to the development of ecologically sound integrated pest management programs for turf (Potter & Braman 1991). We report here the seasonal dynamics of predators, parasitoids, and decomposers and their response to chemical inputs in centipedegrass turf.

Materials and Methods

Plots were delineated in established centipedegrass at two University of Georgia research sites in Griffin. Site 1 had received moderate maintenance, including irrigation as necessary to prevent wilt symptoms. Maintenance included fertilizer and herbicide applications as in Georgia turfgrass recommendations (Extension bulletin 978, "Weed control in home lawns," leaflet 313, "Centipede lawns"). Site 2 had been on a very minimal maintenance program with no irrigation applied. Sites were ≈1.6 km apart. Site 1 was surrounded by turf, and site 2 was bordered by woods, pasture, and agricultural crops. The turf was mown weekly to a height of 3.8 cm, and clippings were left on the plots.

Ground-dwelling arthropods were monitored using uncovered pitfall traps containing ethyl-

Table 1. Schedule of fertilizer and pesticide applications to centipedegrass plots during 1990 and 1991

Application date	Treatment[a]	Rate, (kg[AI]/ha)	Target pests
Mid-March	Pendimethalin	2.76	Grass & broadleaf weeds
Mid-April	Nitrogen	40.0	—
Early July	Sethoxydim	0.23	Annual grasses
	Nitrogen	20.0	—
	Chlorpyrifos	0.92	Surface feeding insects
Early September	Nitrogen	20.0	—
	Chlorpyrifos	0.92	Surface feeding insects
Mid-October	Atrazine	1.38	Broadleaf weeds

[a] Pendimethalin and sethoxydim were applied as Lesco Pre-M and Poast, respectively; chlorpyrifos was applied as Dursban 2E.

ene glycol solution (Morrill 1975). Contents of pitfall traps were washed with tap water through a 52-mesh screen and stored in 70% ethyl alcohol. Organisms were counted using a binocular microscope and grouped into major taxa as follows: Araneae, Formicidae, Staphylinidae, Carabidae, parasitic Hymenoptera, oribatid Acari, and Collembola. Staphylinidae and Carabidae were further identified to species; these taxa represent the groups that were consistently observed at both sites.

During 1989, four blocks, each 232.5 m^2, were established at both sites with two traps operated per plot. In total, eight traps per site were emptied weekly from 7 April 1989 through 21 February 1990. During 1990, the experimental sites were subdivided, and treatments were applied according to the schedule listed in Table 1. Plots received one of five treatments: herbicide, insecticide, fertilizer, all three inputs, or no treatment and were arranged in a completely randomized design with three replications (251 m^2; 83.7 m^2 per treatment) per site. Treatments were separated with a 0.9-m untreated border. Insecticide applications were timed to target the twolined spittlebug.

Fifteen traps per site were operated from 1 March 1990 through 29 October 1990 and from 9 January 1991 through 28 October 1991. Traps were placed in the center of each plot, one per plot. Pitfall samples were divided into four sample periods per year based on timing of treatment applications. Sample periods during 1990 were: I, 3 April–27 June; II, 5 July–26 July; III, 2 August–23 August; and IV, 4 September–29 October. During 1991, sample periods were: I, 2 April–8 July; II, 15 July–29 July; III, 5 August–29 August; and IV, 5 September–28 October. Weekly counts were pooled within each sample period, and the abundance of various arthropod groups compared between treatments and the control using an orthogonal contrasts test (Sokal & Rohlf 1981) following a significant analysis of variance (ANOVA) for each site. The fauna collected at each site was generally unique to the site, although some species occurred in both locations. The effect of site was considered in the ANOVA models and was highly significant for all taxa except spiders during 1991, with similarly significant treatment × site interactions. For these reasons, sites were considered separately during analysis. Significance at $\alpha = 0.1$ was interpreted as indicative of meaningful trends because of the considerable variability found in pitfall trap data.

Results

Seasonal Occurrence and Abundance. Relative abundance of the >203,000 predators, parasitoids, and decomposers collected varied with site (Table 2). Carabidae and Formicidae were significantly ($P < 0.001$) more abundant at site 2. Certain species, however, such as *Agonum punctiforme* Say, were more prevalent at site 1. Other major taxonomic groups were proportionally similar at both sites. Cicindellids, anthocorids, nabids, dermapterans, and assorted Chilopoda were captured in numbers too small to permit an assessment of their seasonal dynamics.

Spiders were well represented throughout the year (Fig. 1). Immature spiders were especially abundant during late June, early July, and again in September. Families of spiders trapped included Erigonidae, Thomisidae, Haniidae, Lycosidae, Gnaphosidae, Salticidae, Tetragnathidae, Agelinidae, Clubionidae, Ctenizidae, and Linyphiidae.

Ants were the most abundant predators captured (Table 2). Ants were most active during the summer months but were captured year round (Fig. 1). Species identified included *Solenopsis invicta* (Buren), *Prenolepis imparis* (Say), *Iridomyrmex humilis* (Mayr), *Formica schaufussi* Mayr, and *Ponera pennsylvanica* Buckley (Hymenoptera: Formicidae).

Twenty-one species of carabids and 16 staphylinid species were identified from pitfall-trap collections (Table 2). Only the collection of adults is reported here. Relative abundance of these species varied with site (Table 2) and among years. *Agonum punctiforme* Say (Coleoptera: Carabidae), for example, was the most abundant carabid at site 1, but *Harpalus* sp. (probably *pennsylvanicus* DeGeer (Coleoptera: Carabidae)) was more abundant at site 2. *Scarites subterraneus* F. (Coleoptera: Carabidae) also was common at both sites each year. Carabids

Table 2. Relative abundance of arthropods collected from pitfall traps in centipedegrass, Griffin, GA, 1989–1991

Taxa	Mean no. collected (% of total) [% of family total] Site 1	Site 2
Carabidae	**219.3 (0.5)**	**497.6 (2.2)**
Agonum punctiforme Say	[61.0]	[16.9]
Harpalus sp. prob. *pennsylvanicus* DeGeer	[5.8]	[40.4]
Scarites subterraneus F.	[13.3]	[10.4]
Notiophilus novemstriatus LeConte	[2.4]	[7.2]
Anisodactylus furvus LeConte	[3.1]	[7.1]
Amara aenea DeGeer	[6.8]	[0.7]
Abadicus permundus Say	[0.6]	[4.9]
Amara sp.	[0.6]	[2.4]
Calosoma sayi Dejean	[2.2]	[0.3]
Notiophilus semistriatus Say	[0.1]	[1.4]
Cratacanthus dubuis Beauv.	[1.4]	[1.5]
Calathus opaculus LeConte	[0.1]	[1.5]
Selenophorus pedicularis Dejean	[1.2]	[0.7]
Cyclotrachelus brevoorti LeConte	[0.1]	[1.3]
Anisodactylus rusticus (Say)	[0.9]	[0.7]
Harpalus gravis LeConte	[0.1]	[0.6]
Amara obesa Say	[0.0]	[0.3]
Anisodactylus dulcicollis (LaFerte)	[0.0]	[0.1]
Chlaenius impactifrons Say	[0.0]	[0.3]
Selenophorus palliatus F.	[0.1]	[0.1]
Selenophorus fatuus LeConte	[0.1]	[0.1]
Unidentified phena	[0.1]	[0.8]
Staphylinidae	**666.3 (1.3)**	**513.0 (2.3)**
Apocellus sphaericollis (Say)	[65.3]	[52.2]
Atheta macrops Notman	[5.5]	[12.6]
Coproporus laevis LeConte	[8.5]	[7.7]
Bryoporus rufescens (LeConte)	[7.8]	[6.9]
Echiaster brevicornis (Casey)	[1.8]	[5.4]
Meronera venustula (Erichson)	[3.0]	[4.2]
Quedius neomolochinus Korge	[0.4]	[3.6]
Astenus fusciceps (Casey)	[3.1]	[1.3]
Philonthus nr. *fimetarius* (Garv.)	[1.0]	[1.7]
Stenus sectilifer Casey	[1.0]	[0.1]
Astenus prolixus (Erichson)	[0.6]	[1.2]
Philonthus hepaticus Erichson	[0.6]	[1.0]
Acrotona hebeticornis Notman	[0.3]	[0.6]
Sepedophilus sp.	[0.3]	[0.0]
Aleocharinae, assorted sp.	[0.5]	[0.4]
Aleochara verna Say	[0.1]	[0.3]
Belonuchus rufipennis (F.)	[0.0]	[0.1]
Unidentified phena	[0.2]	[0.7]
Formicidae	**1,127.3 (3.4)**	**3,349.3 (15.1)**
Spiders	**1,920.3 (3.8)**	**1,559.0 (7.0)**
Parasitic Hymenoptera	**1,711.0 (3.4)**	**593.6 (2.7)**
Oribatid Acari	**10,763.3 (21.6)**	**4,120.0 (18.5)**
Sminthurid Collembola	**8,553.0 (17.2)**	**2,443.3 (10.9)**
Nonsminthurid Collembola	**24,841.3 (49.9)**	**9,180.3 (41.3)**

were most abundant in autumn (Fig. 1). Adult *A. punctiforme* were abundant from October to February. *Harpalus* sp. adults were collected most often in September and October. *S. subterraneus* adults were most abundant from May to July.

Apocellus sphaericollis (Say) (Coleoptera: Staphylinidae) was the most abundant staphylinid collected, constituting over half of the individual specimens collected at both sites. Activity of adults was greatest from June to August during 1989 and 1991, with continued activity through September during 1990 (Fig. 1).

Parasitic Hymenoptera were captured in large numbers in pitfall traps each year (Fig. 2; Table 2). Although species belonging to the superfamilies Ichneumonoidea and Chalcidoidea were often captured, those found in greatest abundance were proctotrupoids. Peaks in adult abundance were apparent in May and September each year, with additional periods of increased activity in January of 1990 at both locations.

Oribatid mites (Fig. 2) increased each year at both sites. Greatest activity occurred from June to August in 1989 and 1990; during 1991, peak abundance occurred during April–June. Collembola collected in large numbers in pitfall traps (Table 2; Fig. 2) were primarily Sminthuridae, Entomobryidae, and Isotomidae. Sminthurids were most abundant in winter and spring samples. July–September collections were generally composed of nonsminthurid collembolans.

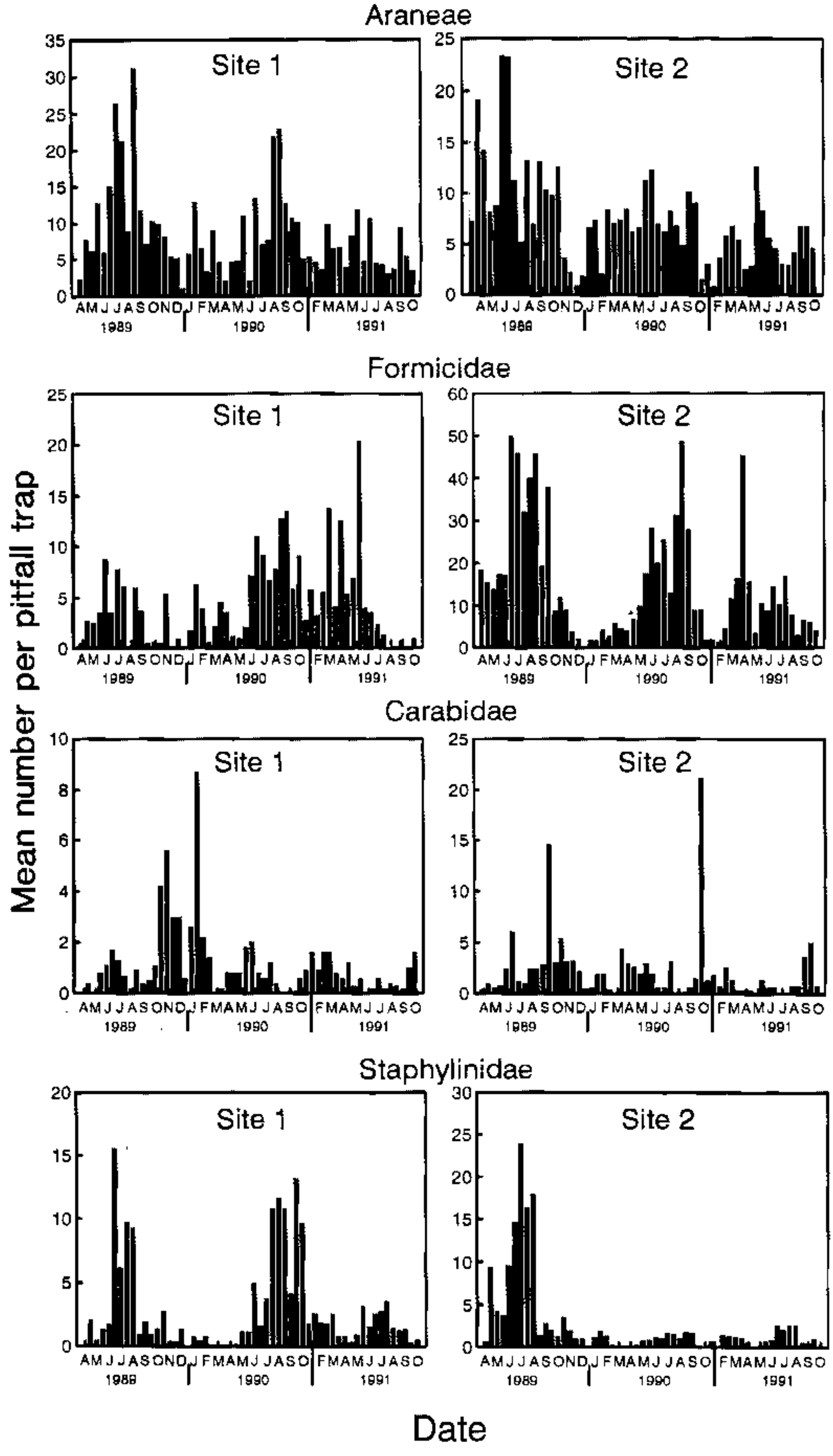

Fig. 1. Seasonal abundance of predaceous arthropods in centipedegrass as measured by pitfall traps.

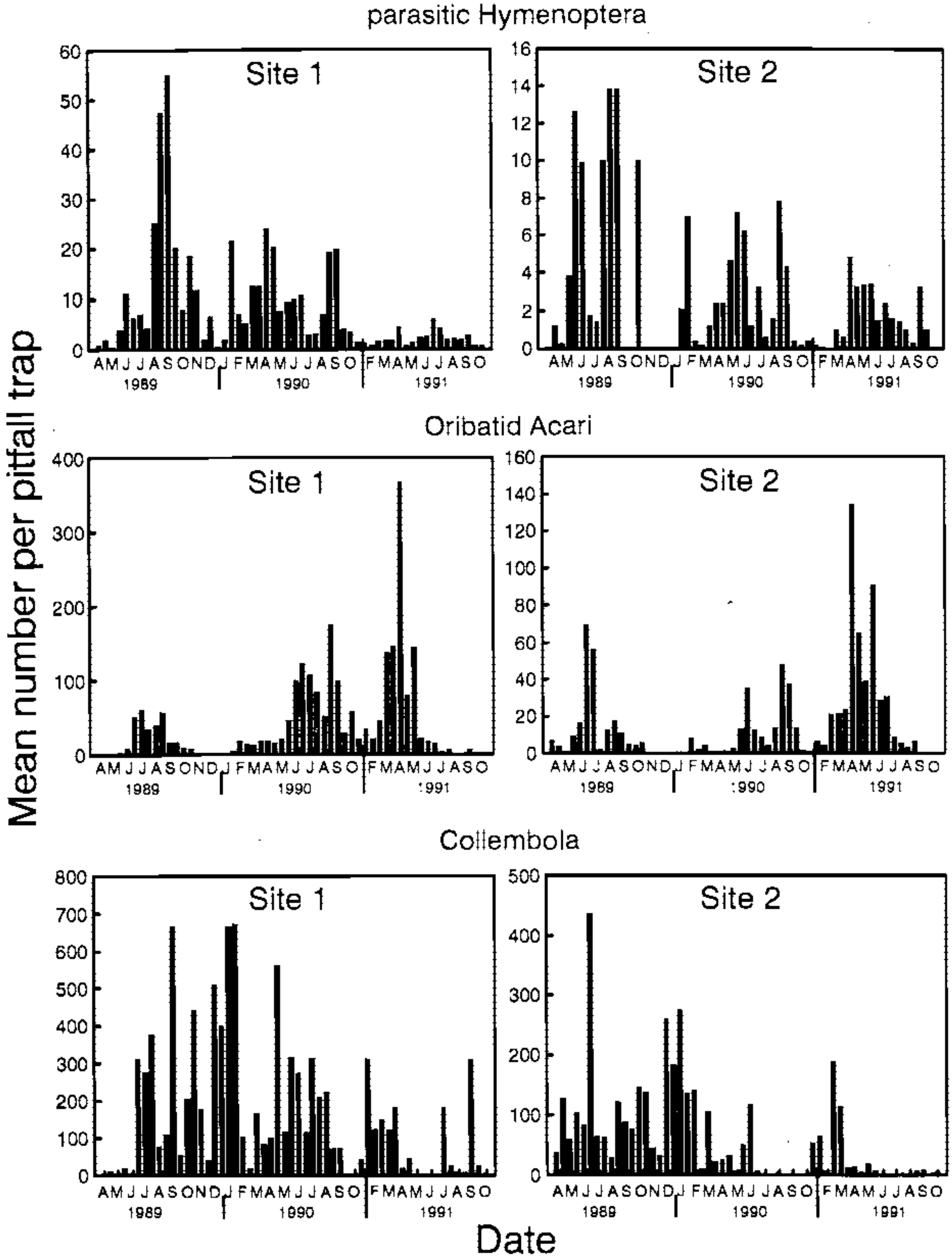

Fig. 2. Seasonal abundance of arthropods in centipedegrass as measured by pitfall traps.

Influence of Chemical Management Practices. The influence of chemical management practices on the previously mentioned arthropod groups was variable depending upon year, location, and sample interval (Figs. 3–6). Small plots in our test are typical of the patchy environment associated with diverse landscape plantings and were readily reinvaded by arthropods following chemical disruption. The numbers of spiders, ants, parasitic Hymenoptera, and nonsminthurid

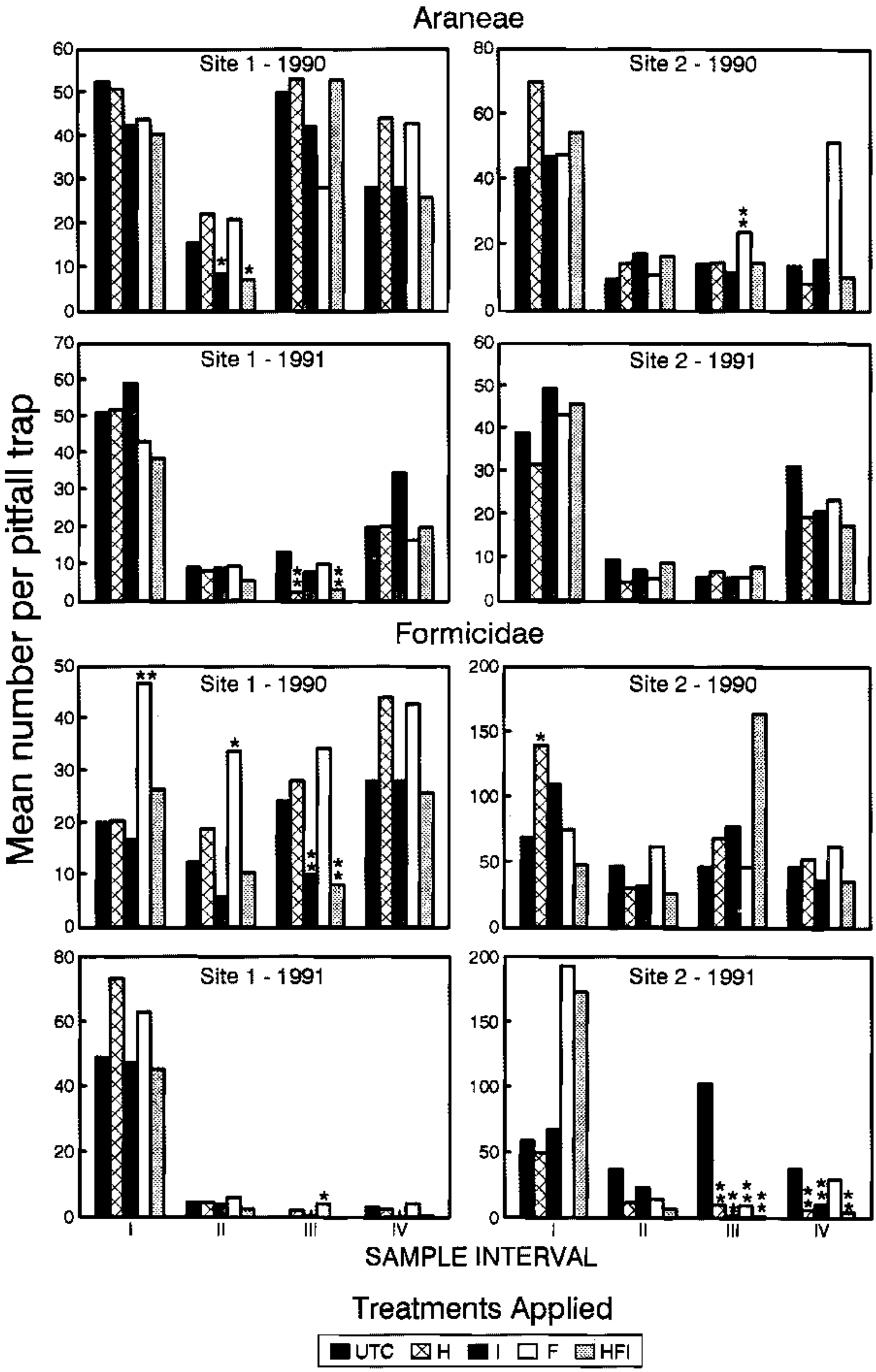

Fig. 3. Influence of chemicals on arthropods in centipedegrass. H, herbicide; I, insecticide; F, fertilizer; HFI, combined inputs; UTC, untreated control.

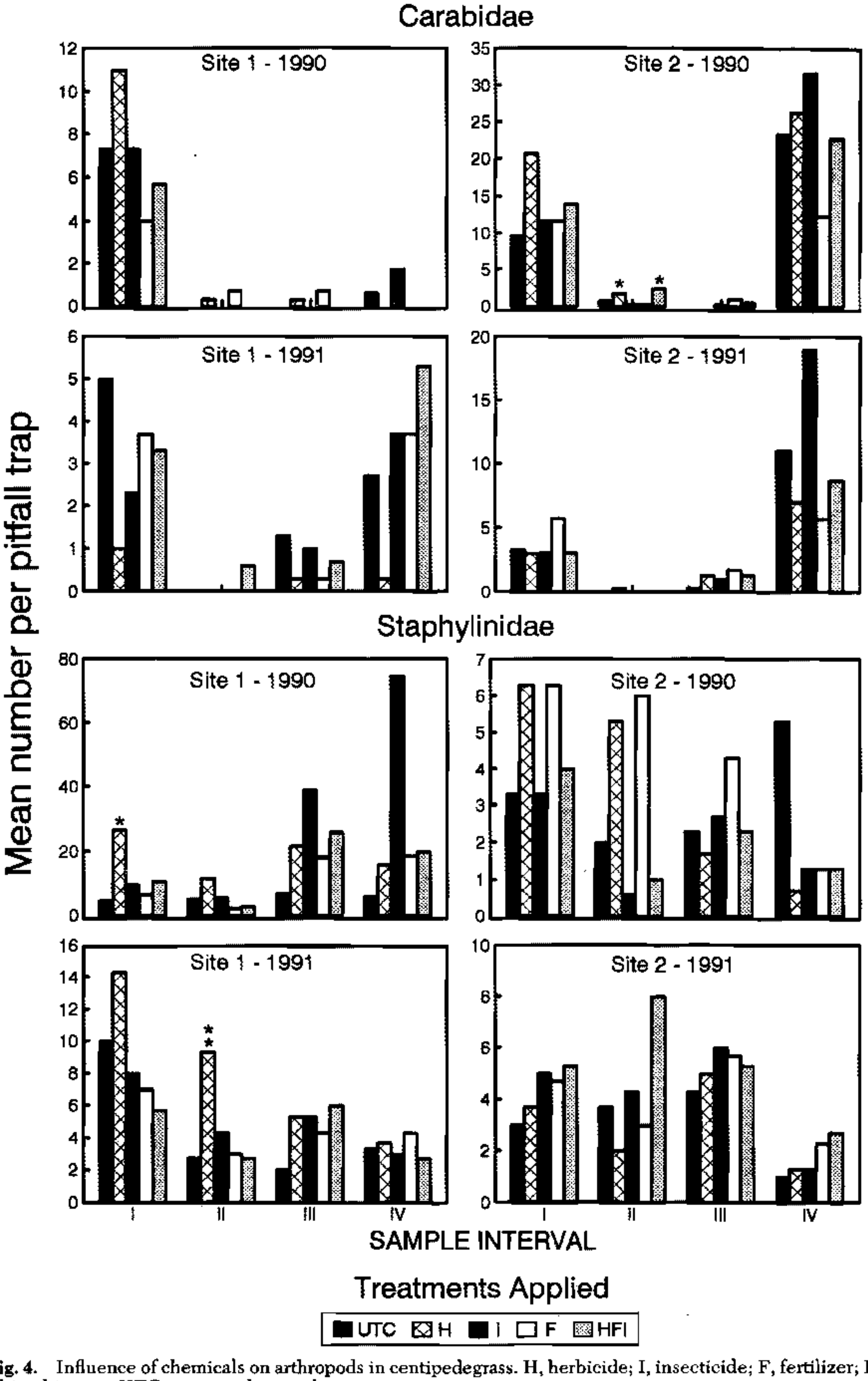

Fig. 4. Influence of chemicals on arthropods in centipedegrass. H, herbicide; I, insecticide; F, fertilizer; HFI, combined inputs; UTC, untreated control.

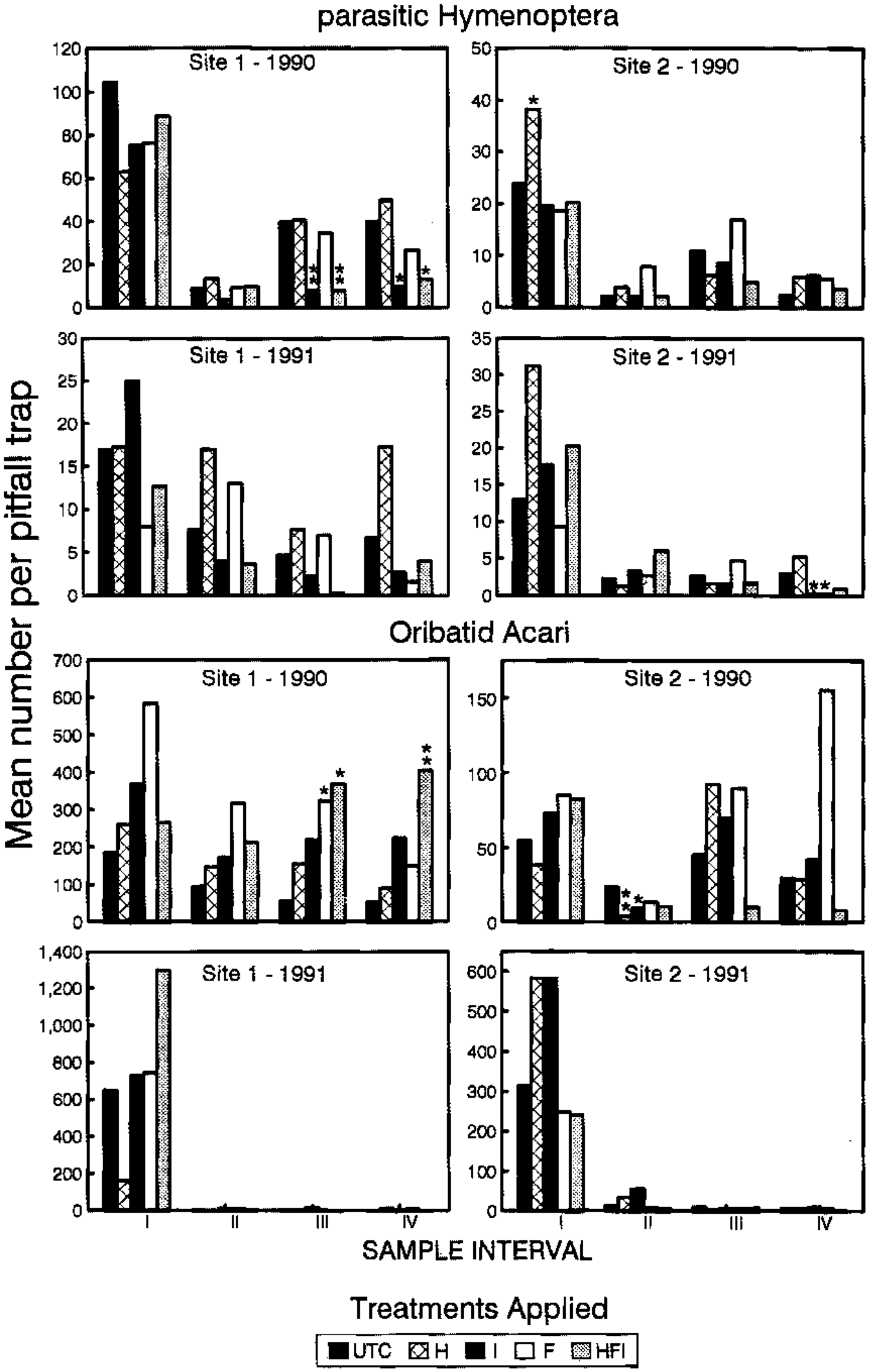

Fig. 5. Influence of chemicals on arthropods in centipedegrass. H, herbicide; I, insecticide; F, fertilizer; HFI, combined inputs; UTC, untreated control.

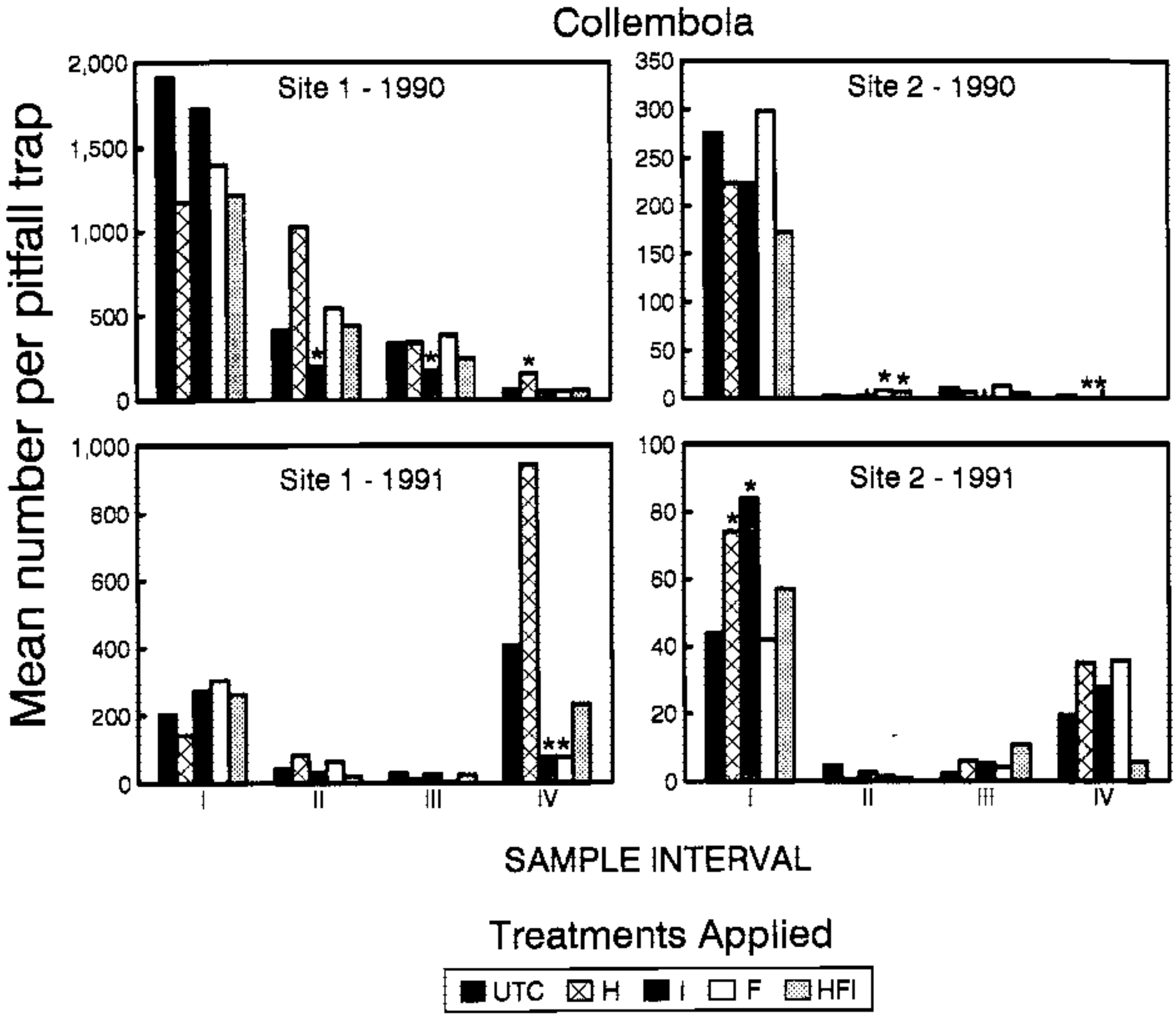

Fig. 6. Influence of chemicals on arthropods in centipedegrass. H, herbicide; I, insecticide; F, fertilizer; HFI, combined inputs; UTC, untreated control.

Collembola were significantly reduced by insecticide applications during 1990 at site 1 but were generally not statistically separable at site 2. Plots treated with herbicide at site 1 had higher numbers of nonsminthurid Collembola in the fourth sampling interval during 1990–1991. Oribatids increased in fertilizer and insecticide-treated plots during 1990 at site 1 during the third and fourth sample intervals, but were reduced at site 2 during the second sample interval.

During 1991, the abundance of ants, parasitic Hymenoptera, and nonsminthurid Collembola were again reduced in insecticide-treated plots but generally repopulated rapidly. Carabids and sminthurid Collembola were unaffected each year in these small-plot studies. Staphylinids became more abundant in herbicide and insecticide-treated plots (site 1, 1990 and 1991) (Fig. 4). The predominant staphylinid, *A. sphaericollis*, is a scavenger, feeding on humus and decaying vegetation and is a pest of greenhouse-grown violets (Chittenden 1915). This may explain the increased abundance of this species in particular in treated plots. Only *Coproporus laevis* LeConte was reduced by the insecticide treatments at site 1 and only during 1990.

Discussion

A variety of arthropods, including predatory, parasitic, and decomposer groups, was found to occur in centipedegrass turf as indexed by pitfall traps. Many of the genera we collected have been reported from turfgrass in other states. Cockfield & Potter (1984b) collected staphylinids in the genera *Meronera*, *Bryoporus*, *Apocellus*, *Philonthus*, *Quedius*, and *Coproporus* in Kentucky bluegrass and tall fescue. Carabids in their samples were represented by 30 species or phena including those in the genera *Amara*, *Agonum*, *Scarites*, *Calathus*, *Chlaenius*, *Anisodac-*

tylus, and *Harpalus*. Mailloux & Streu (1981) described the population fluctuations of staphylinids in the genera *Meronera*, *Philonthus*, *Atheta*, and *Tachyporus* in New Jersey turfgrass and reported that an *Amara* sp. was the most common adult carabid in the habitat.

Collembolans, ants, spiders, and parasitic Hymenoptera were adversely affected in the short term by insecticide applications targeting the twolined spittlebug. The staphylinid *A. sphaericollis*, oribatid Acari, and nonsminthurid Collembola increased over time in response to insecticide, herbicide, or fertilizer applications, partly in response to increased decaying organic matter or a decrease in predators, or both (Wegorek & Trojanowski 1986, Arnold & Potter 1987, Turner et al. 1987, Vavrek & Niemczyk 1990). Our data suggest that turf areas in a patchy landscape environment should be readily recolonized by beneficial arthropods following judiciously timed application of pesticides. Effects of the moderate turf maintenance program examined here were variable but were generally less severe and of shorter duration than might be expected. However, when additional insecticide applications are required (e.g., for white grub or billbug control), negative effects on nontarget groups would likely be more severe than is reported here (Arnold & Potter 1987, Vavrek & Niemczyk 1990). Rushton et al. (1989) found the frequency of use of chlorpyrifos to be an important factor influencing the composition of ground beetle and spider communities in grasslands where a few highly invasive and colonizing species tended to dominate. Knowledge of the effects on nontarget arthropods of treatments applied to large turf areas over longer periods remains as a critical need for assessment of the effects of management practices on the turfgrass ecosystem.

Acknowledgments

We are grateful for helpful discussion with B. J. Johnson and R. N. Carrow (Department of Agronomy, University of Georgia) in developing this project. We are appreciative of the capable technical assistance provided by Sue Smith. G. D. Buntin (Department of Entomology) and R. N. Carrow (Department of Agronomy, University of Georgia) improved the manuscript with their comments on an earlier draft. J. Howard Frank (University of Florida), Paul Lago and Edward Zuccaro (University of Mississippi), and Cecil Smith (University of Georgia) kindly provided identifications of Staphylinidae, Carabidae, and Formicidae, respectively.

References Cited

Arnold, T. B. & D. A. Potter. 1987. Impact of a high-maintenance lawn-care program on non-target invertebrates in Kentucky bluegrass turf. Environ. Entomol. 16: 100–105.

Beard, J. B. 1973. Turfgrass: science and culture. Prentice-Hall, Englewood Cliffs, NJ.

Bohart, R. M. 1947. Sod webworms and other lawn pests in California. Hilgardia 17: 267–307.

Chittenden, F. H. 1915. The violet rove beetle. USDA Bull. 264.

Cobb, P. O. 1990. Warm season insect control. Landscape Management. 29: 36–44.

Cockfield, S. D. & D. A. Potter. 1983. Short term effects of insecticidal applications on predaceous arthropods and oribatid mites in Kentucky bluegrass turf. Environ. Entomol. 12: 1260–1264.

1984a. Predation on sod webworm (Lepidoptera: Pyralidae) eggs as affected by chlorpyrifos application to Kentucky bluegrass turf. J. Econ. Entomol. 77: 1542–1544.

1984b. Predatory insects and spiders from suburban lawns in Lexington, KY. Great Lakes Entomol. 17: 179–184.

Duble, R. L. 1989. Southern turfgrasses: their management and use. TexScape, College Station, TX.

Johnson, M. E. & R. S. Cameron. 1969. Phytophagous ground beetles. Ann. Entomol. Soc. Am. 62: 909–914.

Klein, M. G. 1982. Biological suppression of turf insects, pp. 91–97. *In* H. D. Niemczyk & B. G. Joyner [eds.], Advances in turfgrass entomology. Chemlawn, Columbus, OH.

Mailloux, G. & H. T. Streu. 1981. Population biology of the hairy chinchbug (*Blissus leucopterus hirtus* Montandon: Hemiptera: Lygaeidae). Ann. Soc. Entomol. Que. 25: 51–90.

Morrill, W. L. 1975. Plastic pitfall trap. Environ. Entomol. 4: 596.

Potter, D. A. & S. K. Braman. 1991. Ecology and management of turfgrass insects. Annu. Rev. Entomol. 36: 383–406.

Potter, D. A., B. L. Bridges & F. C. Gordon. 1985. Effect of N fertilization on earthworm and microarthropod populations in Kentucky bluegrass turf. Agron. J. 77: 367–372.

Potter, D. A., A. J. Powell & M. S. Smith. 1990a. Degradation of turfgrass thatch by earthworms (Oligochaeta: Lumbricidae) and other soil invertebrates. J. Econ. Entomol. 83: 205–211.

Potter, D. A., M. C. Buxton, C. T. Redmond, C. G. Patterson & A. J. Powell. 1990b. Toxicity of pesticides to earthworms (Oligochaeta: Lumbricidae) and effect on thatch degradation in Kentucky bluegrass turf. J. Econ. Entomol. 83: 2362–2369.

Reinert, J. A. 1978. Natural enemy complex of the southern chinchbug in Florida. Ann. Entomol. Soc. Am. 71: 728–731.

Rushton, S. P., M. L. Luff & M. D. Eyre. 1989. Effects of pasture improvement and management on the ground beetle and spider communities of upland grasslands. J. Appl. Ecol. 26: 489–503.

Sokal, R. R. & F. J. Rohlf. 1981. Biometry, 2nd ed. Freeman, San Francisco.

Tashiro, H. 1987. Turfgrass insects of the United States and Canada. Cornell University Press, Ithaca, NY.

Turner, A. S., J. S. Bale & R. O. Clements. 1987. The effect of a range of pesticides on non-target organisms in the grassland environment, pp. 290–295. *In* Proceedings, Crop Protection in Northern

Britain, 1987. Dundee University, Association for Crop Protection in Northern Britain.
Vavrek, R. C. & H. D. Niemczyk. 1990. Effect of isofenphos on nontarget invertebrates in turfgrass. Environ. Entomol. 19: 1572–1577.
Wegorek, W. & H. Trojanowski. 1986. Influence of intensive pesticide application in field cultures on some components of biocoenosis. Colloques de l'INRA 36: 27–37.

Received for publication 8 April 1992; accepted 14 September 1992.