Seasonal Distribution and Overwintering of *Orius insidiosus* (Say) in Arkansas[1]

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J. Entomol. Sci. 31(1): 76-88 (January 1996)

ABSTRACT The overwintering and seasonal habitats of *Orius insidiosus* (Say), timing of diapause in field populations, and seasonal population dynamics in selected crop and non-crop habitats were evaluated during 1992 and 1993 at two locations, one on southwestern and the other in central Arkansas. Each location consisted of three square miles (≈ 7.77 km^2) of various habitats. Diapause status was determined by dissection. In early spring, females were found primarily on hairy vetch, crimson clover, and hairy buttercup. During that time, these weeds were flowering and were infested with high populations of thrips. During late spring and summer, populations of *O. insidiosus* increased in association with increasing thrips populations and flowering of corn, grain sorghum, cotton, and soybean. In the fall, population densities declined sharply and became widely dispersed. In the winter, females collected from both locations were in reproductive diapause from early November until mid-March. No males were recovered during the winter or early spring. Females in reproductive diapause were found to overwinter in vegetation, primarily grasses including wheat.

KEY WORDS Seasonal distribution, overwintering, *Orius insidiosus*

The insidious flower bug, *Orius insidiosus* (Say), is a polyphagous predator found in a wide variety of field crops, vegetables, shrubs, and wild plants. It feeds on numerous arthropod species and is considered an important predator of corn earworm, *Heliocoverpa zea* (Boddie), in corn (Reid 1991), grain sorghum (Steward et al. 1991), and cotton (Lincoln and Williams 1952). It is considered a very important predator of thrips in soybean (Isenhour and Marston 1981). Several cotton pests including thrips, mites, aphids, *H. zea*, and the tobacco budworm, *Heliothis virescens* (F.), are among the many arthropods upon which *O. insidiosus* feeds (Barber 1936).

The value of *O. insidiosus* as a biological control agent in an integrated control system cannot be defined or predicted without knowing the predator's distribution and abundance and the mechanisms that affect these patterns. *Orius insidiosus* is more abundant in soybean habitats with grasses and mixed weeds than in soybean without weeds (Shelton and Edwards 1983). Furthermore, *O. insidiosus* is most abundant in drill-planted soybean fields

[1] Received 27 February 1995; Accepted for publication 05 October 1995.

(Ferguson et al. 1984). Predators, including *O. insidiosus* are often more abundant in uncultivated areas around the soybean fields than in the soybean fields (Kemp and Barrett 1989). *Orius insidiosus* is most abundant in corn during silking (Dicke and Jarvis 1962, Isenhour and Marston 1981). Corn and alfalfa adjacent to apple orchards serve as a reservoir for *O. insidiosus* throughout the season in Virginia (McCaffrey and Horsburgh 1986).

Overwintering is a critical stage for insects. In many cases high numbers enter the winter, and only a few survive. *Orius insidiosus* is reported to overwinter as adult females (Isaza-Restrepo 1958), or as adults of both sexes (Kingsley and Harrington 1982). Reported overwintering habitats include alfalfa, grasses, leaf litter, and other organic matter (Marshall 1930, Iglinsky and Rainwater 1950, Isaza-Restrepo 1958, Kingsley and Harrington 1982), although well-drained alfalfa fields have been previously described as almost ideal overwintering habitats for *O. insidiosus* adults (Marshall 1930).

Photoperiod and temperature are relevant factors terminating a facultative reproductive diapause in *O. insidiosus* (Kingsley and Harrington 1982). Photoperiod affects diapause induction in *O. insidiosus;* adult females enter reproductive diapause when reared under short periods 10:14 (L:D), with a critical photoperiod between 12:12 and 13:11 (L:D) (Ruberson et al. 1991).

The objectives of this study were to determine overwintering habitats of *O. insidiosus,* to examine the timing of diapause and termination in field populations, and to determine the seasonal distribution and host associations of *O. insidiosus* in Arkansas.

Materials and Methods

Sampling locations. Two study locations were chosen in two different areas of the state. A 3-m^2 ($\approx$ 7.7 km^2) location in central Arkansas was selected in an area of traditional cotton production which typically experiences multiple applications of insecticides throughout the midsummer months (Lonoke Co.). A second location of similar size and geography was selected in a southwest Arkansas area which has had little cotton production in the last 15 years and experiences traditionally low insecticide use (Little River Co.). Both locations were sampled during 1992 and 1993. The sampling locations were similar in the amount of fallow or roadside weedy habitats, presence of standing water throughout the summer (bayou), and similar agricultural production practices other than cotton (soybean, wheat, grain sorghum and rice). The location in Little River Co. had significant acreage of corn in the area (200 ha), although little was within the confines of the study site ($\approx$ 10 ha). More than half of the central location had cotton grown commercially, whereas in the southwest, only approximately 2 ha of cotton were planted for experimental purposes. At the southwest Arkansas location, the crops sampled were corn, soybean, grain sorghum (1992 only), and cotton. Only cotton and soybean were available for sampling in central Arkansas. Non-crop areas included fallow, non planted areas, and field borders in both locations.

Seasonal sampling methods. Crop and non-crop areas in each location were sampled during 1992 beginning on 27 April in the southwest location and on 2 May in the central location. Samples were taken weekly during late spring, summer, and early fall in both locations. In non-crop areas, 50 sweep net (38-cm in diam) samples were taken on each sampling date when appropriate for a given habitat (each sample was 40 sweeps). Various sampling methods were used according to the crop and the time of the season. In corn, 50 randomly-selected whole-plant visual samples were taken on each sampling date. In early season cotton and soybean, a dislodgment technique was used. The sampling apparatus for this technique consisted of a metal loaf pan (24 × 14 × 9 cm) covered with a removable wire screen mesh which allowed insects through. The insects were dislodged into the pan by striking the plants against the screen. The cover was removed and *O. insidiosus* inside the pan were counted. After 3 to 4 wks a larger pan (34 × 29 × 13 cm) was used to accommodate the larger plants. Later in the season, beat sheet samples (Boyer and Dumas 1969) were taken. On each sampling date, 50 randomly selected samples were taken from both cotton and soybean. Each sample consisted of a one meter row. In grain sorghum, we took 50 random samples weekly using the "beat-bucket" technique (Hall et al. 1983).

The same procedures were repeated during 1993, with sampling beginning on 7 May and 5 May in southwest and central Arkansas, respectively. Additionally, leaf area measurements were taken throughout the season for cotton, corn, and soybean in both locations. Ten plants were randomly chosen from each field on every sampling date. Plants were transported to the laboratory, dissected, and measured individually using a leaf-area meter (Li-Cor model 3100). The leaf area per plant was estimated as the average of 10 plants. The leaf areas were measured to compare population trends to the number/cm^2 among the crop types.

Overwintering. Attempts were made to identify sites within each sampling location of the latest and largest *O. insidiosus* populations in hopes of increasing the probability of locating overwintering habitats. Two hundred random sweep net samples were taken at every sampling date during the fall when appropriate for a given habitat (each sample was 40 sweeps). Samples were taken biweekly from old field borders and in non-field areas from late September 93 through April 1994.

Sampling continued throughout the winter months in old field borders, in nearby weedy areas, and in wheat fields. Sampling early or late in the day was avoided. In addition to the sweep net samples, leaf litter and samples of other dead or dying plant material were taken from each location. We planned to take 16 litter samples, on each sampling date, using Berlese funnels to extract insects from the samples. During the spring months, samples were taken biweekly in wheat fields, alfalfa fields, grasses, and spring weeds. Collected *O. insidious* were transported to the laboratory, and females were dissected to determine diapause status. Females with no obvious oocytes in the ovaries and well-developed fat bodies were considered to be in reproductive diapause (Fig. 1).

Results and Discussion

In non-crop areas, adult *O. insidiosus* were collected in spring weeds such as hairy vetch, *Vicia villosa* Roth, crimson clover, *Trifolium incarnatum* (L.), hairy buttercup, *Ranunculus sardous* Crantz, and grasses including dallis grass,

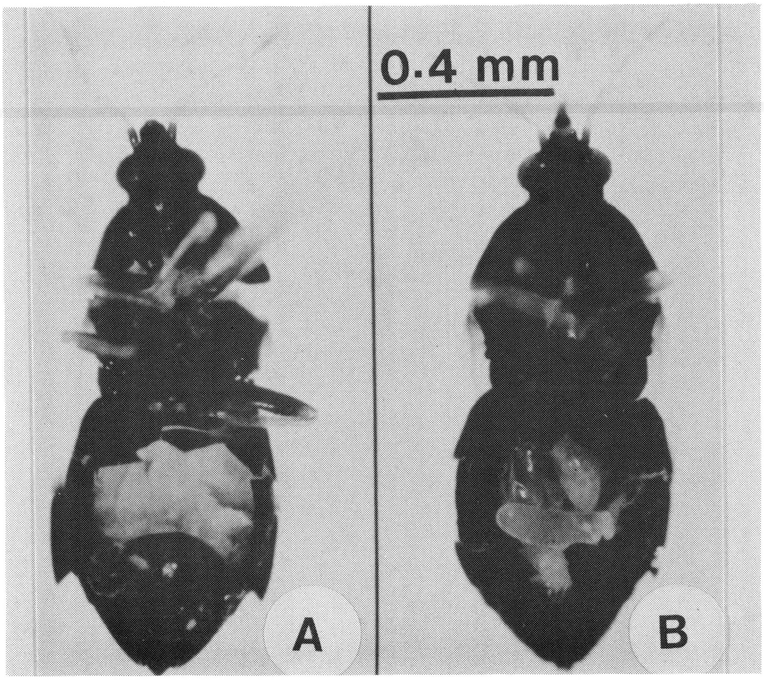

Fig. 1. Dissected female *O. insidiosus* showing the (A) well-developed fat body in diapausing female, and (B) presence of mature ova in a non-diapausing female.

Paspalum dilatatum Poir, barnyard grass, *Echinochloa crus-galli* L., and Johnsongrass, *Sorghum halepense* (L.). During that time, the weeds were flowering and sustained high thrips densities (i.e., 20 to 30 thrips/sample). A high proportion of nymphs in the samples (i.e., 50% in late May and early June) indicated the importance of these habitats for population development. A sampling bias against nymphs was expected due to their small size and coloration (orange), which blended with the many flower parts and pollen and were difficult to distinguish from the numerous immature thrips. Populations tended to decline in early June (Fig. 2) as more habitats including soybean, grain sorghum, corn, and cotton became available. Therefore, it is likely that these population declines were not reductions in density (i.e., number per ha) but were declines in intensity in a given habitat (Southwood 1978). Similar population trends of *O. insidiosus* during 1992 and 1993 were found in the non-crop habitats (Fig. 2). However, in the central Arkansas location, fewer numbers of adults and nymphs were recovered in the samples. This may be due to the cumulative effect of numerous insecticide applications in the nearby cotton fields.

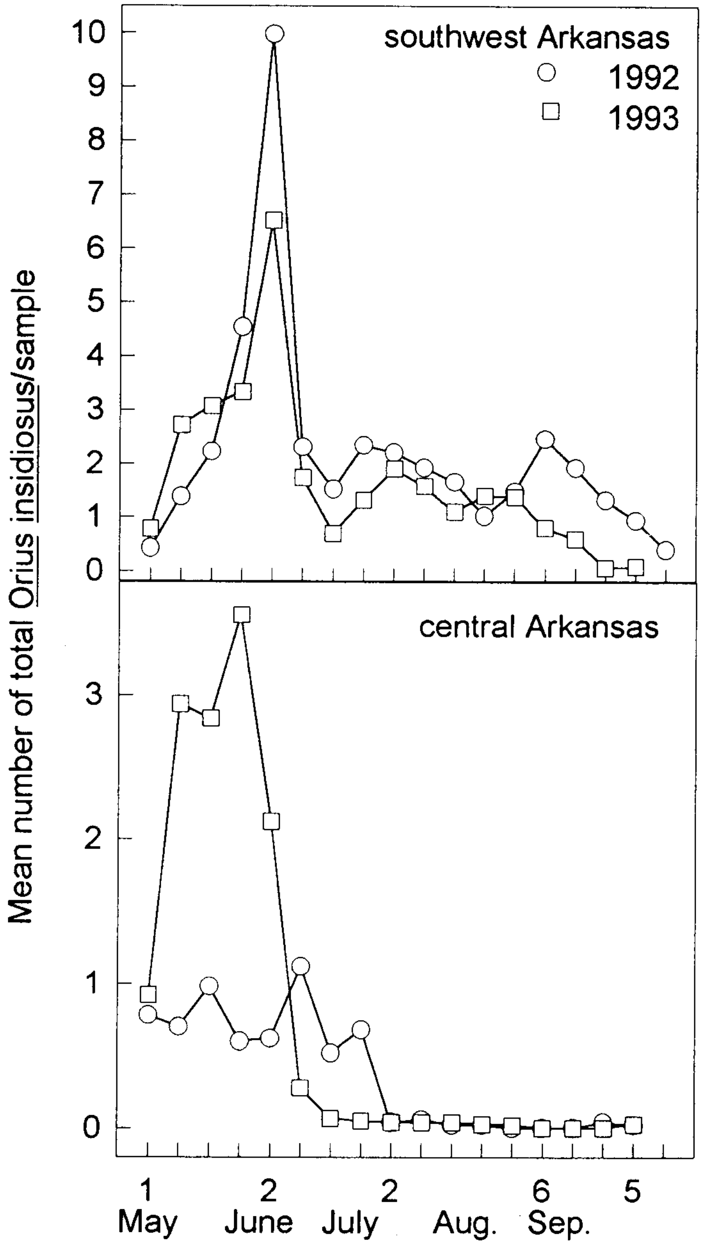

Fig. 2. Population trends for the insidious flower bug, *O. insidiosus,* in non-crop areas during 1992 and 1993 in central and southwest Arkansas (sample = 40 sweeps).

In corn, *O. insidiosus* populations were low early in the season, then peaked during silking and pollen shedding in mid-June. As the season progressed and corn reached maturity, populations rapidly declined (Fig. 3). Population trends were similar during 1992 and 1993. Seasonal peaks of *O. insidiosus* population during silking and pollen shedding were previously reported from Ohio (Dicke and Jarvis 1962), Missouri (Isenhour and Marston 1981), and Kentucky (Isenhour and Yeargan 1981). However, Pickett and Gilstrap (1986) reported an increase in *O. insidiosus* populations late in the season after silk and pollen were no longer available. They suggested this increase was due to an *O. insidiosus* numerical response to high densities of spider mite prey commonly associated with corn grown in arid regions such as the Texas High Plains.

In sorghum, *O. insidiosus* populations peaked once (Fig. 3) during flowering, concurrent with high thrips populations. Steward et al. (1991) reported that *O. insidiosus* is the most abundant predator in grain sorghum and reported similar density fluctuations. Furthermore, Jacobson and Kring (1994) reported that adults were effective predators of eggs and young larvae of corn earworm in grain sorghum panicles.

In cotton, populations of *O. insidiosus* generally peaked twice during the growing season. A first peak was observed early in the season when thrips populations were high. The second peak occurred much later, when bolls were fully developed but the cotton was still flowering (Figs. 4, 5). The susceptibility of *O. insidiosus* to organic insecticides in cotton has been well documented (Kinzer et al. 1977, Campbell and Hutchins 1952, Burke 1959, Newsome and Smith 1949, Gaines 1954). It is probable that applications of various insecticides (e.g., control lepidopteran and boll weevils) disrupted *O. insidiosus* populations.

In soybean, *O. insidiosus* populations were greater than in cotton but considerably more variable (Figs. 4, 5). Populations peaked early in the season particularly in 1992, when thrips populations were high and again during flowering. These findings support Isenhour and Marston's (1981) study which reported that *O. insidiosus* exhibited a preference for flowering soybeans. Their study also demonstrated that predation by *O. insidiosus* is a major regulating mechanism of thrips populations in soybean.

The leaf area measurement data are not shown because the population trends of *O. insidiosus* in corn, cotton, and soybean on the basis of density per unit of leaf area (i.e., no./cm^2) were virtually identical to those described on a per plant or per row-meter basis.

Overwintering study. A total of 100 and 102 *O. insidiosus* adults were collected in central and southwestern Arkansas, respectively, during the sampling periods (Table 1). Low densities such as these were expected based on previous observations for heteropteran species which tend to overwinter as widely-dispersed individuals (Isaza-Restrepo 1958, Wheeler and Stimmel 1988). Both sexes of *O. insidiosus* were found in the fall in field borders, primarily in foxtail, *Setaria glauca* L., which was the dominant grass. Other grasses, such as quackgrass, *Agropyron repens* (L.), and barnyard grass, *E. crus-galli* L., were present in sampling locations. The number of *O. insidiosus* found decreased as the winter progressed. The females found in mid-November in grasses and later in the winter in wheat, *Triticum aestivum* L., were all in reproductive diapause.

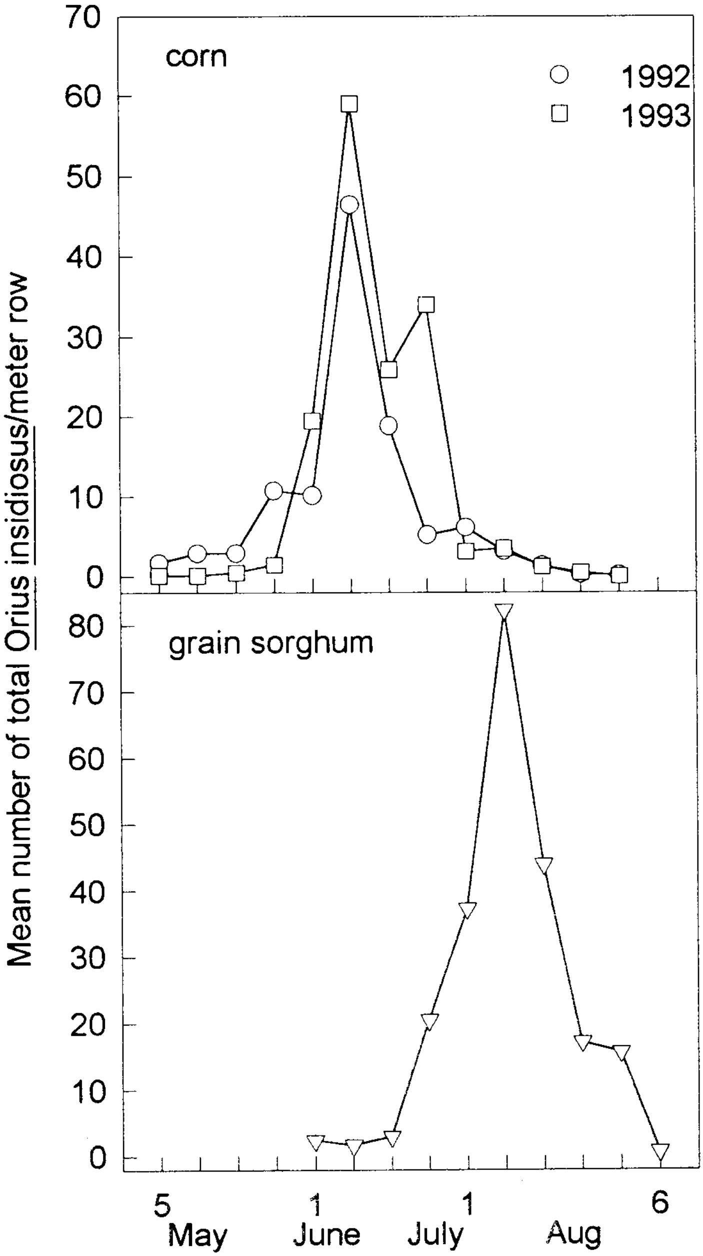

Fig. 3. Population trends for the insidiosus flower bug, *O. insidiosus*, in corn during 1992 and 1993, and in grain sorghum during 1992, in southwest Arkansas.

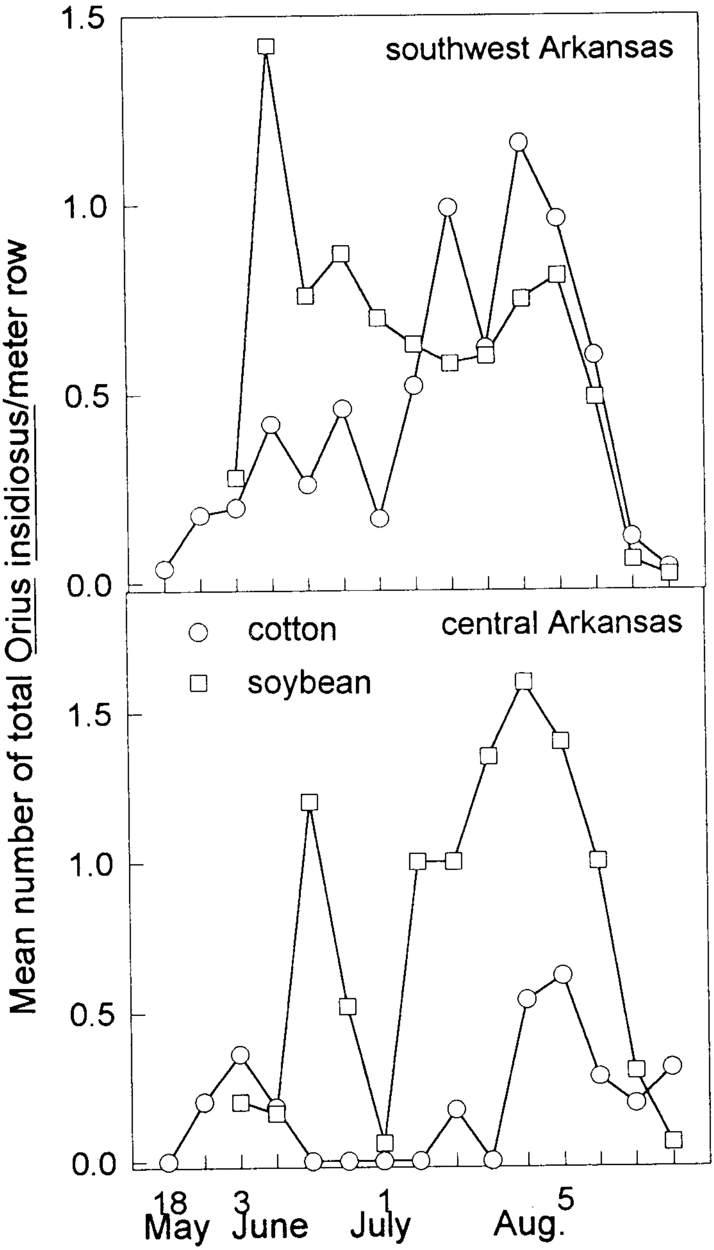

Fig. 4. Population trends for the insidious flower bug, *O. insidiosus,* in cotton and soybeans during 1992 in southwest and central Arkansas.

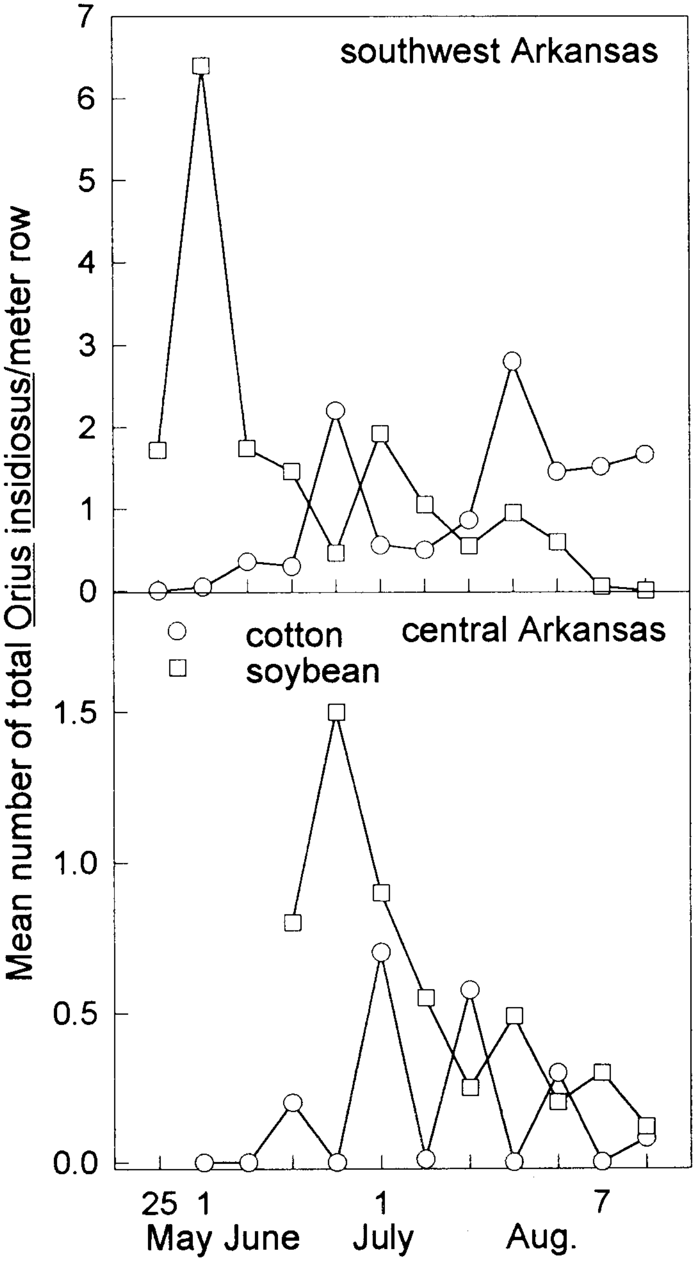

Fig. 5. Population trends for insidious flower bug, *O. insidiosus*, in cotton and soybeans during 1993 in southwest and central Arkansas.

Table 1. Total numbers and diapausing females of *Orius insidiosus* adults found in central Arkansas (Lonoke Co.) and southwestern Arkansas (Little River Co.) during fall (1992), winter (1992-93), and spring (1993).

		Diapausing Females		Non-Diapausing Females		Males		Total	
Month	Week	C*	SW**	C	SW	C	SW	C	SW
Sept.	3	–	0	–	6	–	2	–	8
Oct.	1	0	0	16	7	10	2	26	9
	3	0	0	6	12	1	5	7	17
Nov.	1	0	7	5	0	3	2	8	9
	3	4	6	0	0	1	1	5	7
Dec.	1	6	–	0	–	0	–	6	–
	2	–	5	–	0	–	0	–	5
	3	5	3	0	0	1	2	6	5
	4	4	–	0	–	0	–	4	–
Jan.	2	4	4	0	0	0	0	4	4
	4	5	5	0	0	0	0	5	5
Feb	2	1	4	0	0	0	0	1	4
	4	1	4	0	0	0	0	1	4
Mar.	2	2	3	0	0	0	0	2	3
	4	0	0	4	4	0	0	4	4
Apr.	2	0	0	7	2	0	0	7	2
	4	0	0	14	16	0	0	14	16

* central location. ** southwest location.

The day lengths in mid-November (≅11.5 hrs) are sufficient to induce diapause in the majority of the population (Ruberson et al. 1991).

No overwintering males were collected after late December, although males were collected prior to this (Table 1). These data conflict with previous studies in Wisconsin (Kingsley and Harrington 1982) that suggested that both males and females overwinter. Females collected in reproductive diapause and kept under a long photoperiod regimen 14:10 (L:D) laid fertile eggs. This observation supports Kingsley and Harrington's (1982) suggestion that *O. insidiosus* females mate before overwintering.

No *O. insidiosus* were recovered from samples of leaf litter or from dead or dying plant materials, although numerous species of Coleoptera and Lepidoptera unrelated to this study were recovered. Similarly, Wheeler and Stimmel (1988) did not find overwintering *O. insidiosus* in magnolia leaf litter samples, and other overwintering heteropterans in leaf litter samples were low in numbers. Although our sampling of all dominant habitats was intensive, the total numbers of *O. insidiosus* recovered in late fall and during the winter were very low (Table 1). These data provide a good indication that *O. insidiosus* overwinter as scattered individuals. High winter mortality that many Heteroptera experience may be due to cold temperatures (Wheeler and Stimmel 1988) and/or predators that are active at cool temperatures (e.g., spiders) (Dowdy 1955) may contribute to low survival in overwintering *O. insidiosus* populations. All females found after late March had mature ova indicating that diapause had terminated previously (Table 1). The day length in late March (≅ 12.5 hrs) is apparently long enough to terminate the reproductive diapause. These data support previous evaluation of *O. insidiosus* diapause in the laboratory (Ruberson et al. 1991). In late March, reproductive females were found in spring weeds such as hairy vetch, crimson clover, and hairy buttercup. The majority of females found in central Arkansas were in hairy buttercup habitats, whereas in southwestern Arkansas, they were found in hairy vetch habitats. Hairy buttercup and hairy vetch were more available at central and southwest location, respectively. During this time, these weeds were flowering and were infested with high populations of thrips.

Overall, seasonal sampling indicated that the populations in the spring were concentrated in spring weeds. The number of individuals increased in the spring habitats and declined as other habitats became available. During the summer season, *O. insidiosus* populations increased when the prey number increased (e.g. thrips) and also during flowering (cotton, corn, soybean, sorghum) or silking (corn).

In conclusion, *O. insidiosus* was found to overwinter as adult females in reproductive diapause in winter vegetation. In the spring, *O. insidiosus* was found in spring weeds at relatively high densities where the populations continued to increase until other habitats became available. During late spring and early summer, *O. insidiosus* moved into the numerous available agriculture habitats. Our study showed that the seasonal distribution of *O. insidiosus* was affected by plant phenology (flowering) and prey availability (especially thrips). Better understanding of seasonal distribution and overwintering biology of this predator may lead to practices that increase or allow prediction of its abundance and efficacy as a biological control agent. The timing of the predator's movement into and out of overwintering habitats is critical in evaluating the processes involved in early season population development.

Acknowledgment

We thank Gordon and Worth Matteson, T. Jordan, and J. Nipps for the use of their fields. This article is published with the approval of the Director of the Arkansas Agricultural Experiment Station. This research was supported in part by a USDA special grant (USDA/CSRS/92-34195-7162) and represents a portion of the senior author's dissertation.

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