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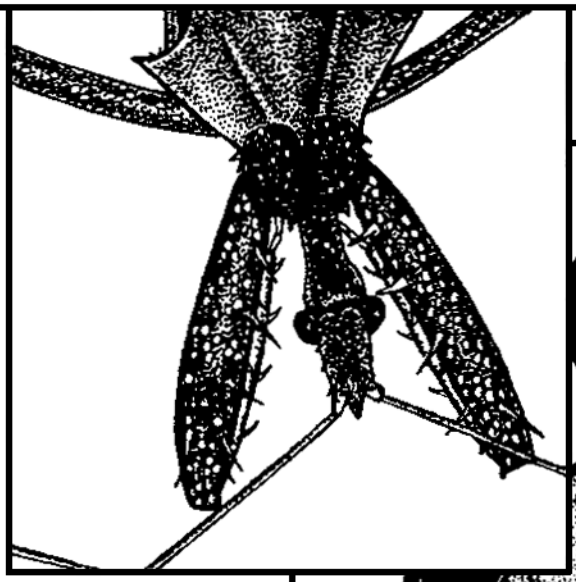
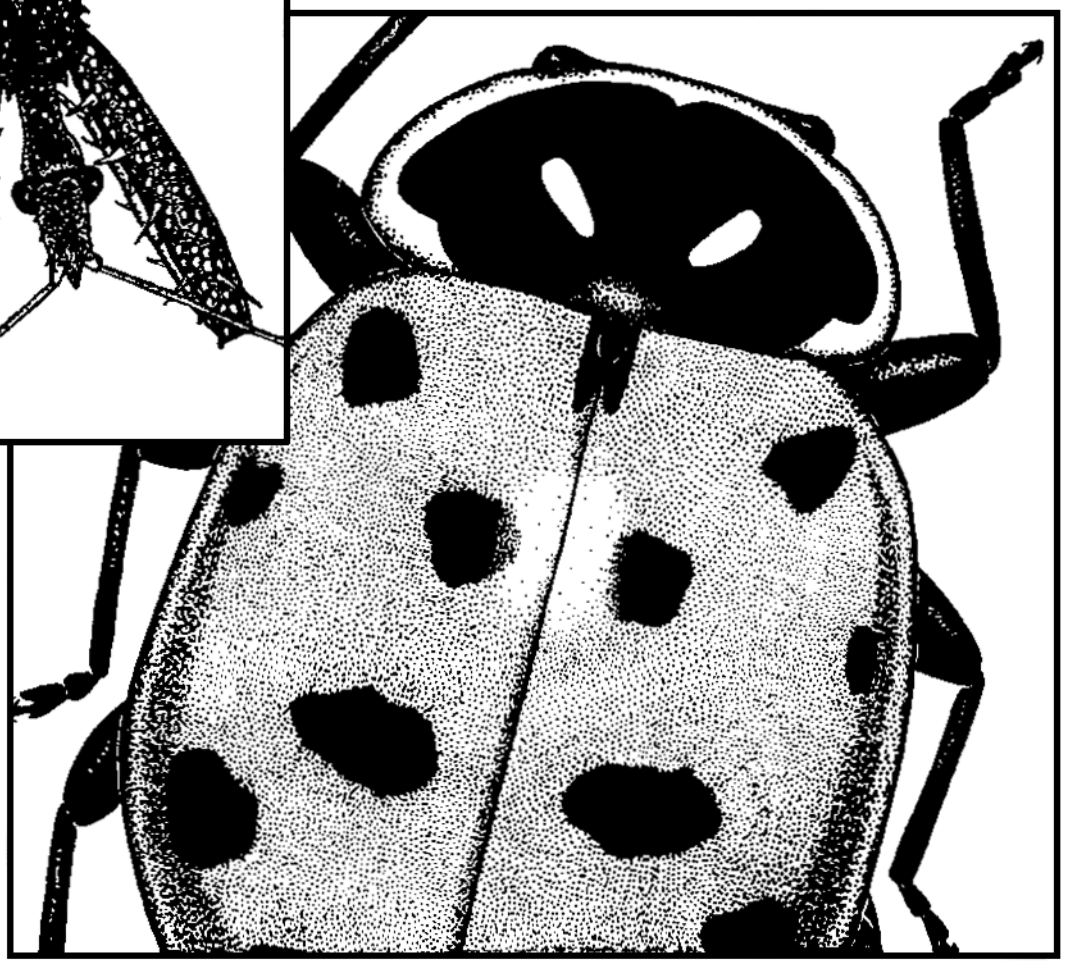
AN ILLUSTRATED GUIDE TO THE **Predaceous Insects of the Northern Texas Rolling Plains**





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An Illustrated Guide to the Predaceous Insects of the Northern Texas Rolling Plains

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INTRODUCTION

The Rolling Plains of Texas is a large region, composed of slightly less than 16 million acres. It is bordered on the west by the Caprock and the High Plains, on the north by the Red River and Oklahoma, on the east by the Cross-Timbers region, and on the south by the Edwards Plateau. The climate is semiarid, mean annual rainfall ranging from 18 to 28 inches. Summers are warm and winters are moderate, with occasional periods of subzero (^{o}F) temperatures. The topography of the region is relatively flat although elevation changes subtly.

Cotton and wheat are the two most important crops in the area, and as much as 1 million acres of each are planted. Alfalfa, onions, sorghum, potatoes, cucurbits, peanuts, mung beans, and guar are grown in smaller acreages. Most of these crops are grown by dryland methods.

In dryland systems, the yield is usually low, so expenses must be held to a minimum. Because of the low yields, whether or not to use a pesticide in a given situation can be a critical decision. Costs of pesticide use are beyond those associated with the pesticide application. Although each application contributes to the overall development of pesticide resistance in insects, of more immediate concern is the destruction of the resident population of beneficial insects. With no predators and parasites to regulate their populations, the pest insect species are left to reproduce at will, leading to further pesticide applications.

This publication can assist growers in recognizing the agriculturally important predators of the region and in understanding where and when these insects may be useful in keeping pest populations below economic threshold levels. By relying on predators to control pest insect populations, economical production can be maintained and problems with pest resurgence and pesticide resistance can be delayed or avoided.

From April 1988 to November 1989, predators on various crops were sampled once per week throughout the growing season. Wheat and cotton were sampled at the Texas Agricultural Experiment Stations at Munday in Knox County and at Chillicothe in Hardeman County. Alfalfa was sampled at Chillicothe. Wheat was sampled at various locations in Wilbarger County and Foard County. Roadside weeds were sampled in each county. Weeds were sampled because they are known to harbor many kinds of predators, which later migrate to crops. Each sample, taken with a standard muslin bag sweep net, consisted of two sets of 25 sweeps across the tops of the plants. The two sets were taken at different sites within each field and combined to give the number of predators per 50 sweeps. From one to three samples were collected in each crop at each location per week.

Although this procedure provided two complete seasons of data from cotton and information from wheat, alfalfa, and weeds, we fully understand its limitations. A multitude of factors such as location, time of day, use of pesticides, prey population, and weather bear greatly upon the presence and detection of predators. Furthermore, although the sweep net is one of the most practical and easily used sampling tools, it is not efficient in collecting all predators. Many more precise sampling techniques have been developed, only to be rejected by growers and scouts as being too cumbersome and time consuming. In short, our survey results cannot be used for such precise goals as comparing population levels among counties or for following the exact development of populations over time, but they can be used to help us determine which species we have and in which crops. Additionally, our technique can be used to suggest when these insects are present and when we might expect their numbers to be greatest.

In this report, each of the important predators is illustrated, briefly described, and accompanied by a list of recorded prey and a discussion of life cycle. Survey results present data about crop preferences, seasonality, and relative abundance of these predaceous insects. The potential of each species for controlling pests is also discussed. The predators have been divided into three groups: the true bugs, the beetles, and other insects. Spiders are not included in this work because technically they are not insects. They, however, are extremely important regulators of pest populations in crops and should not be overlooked. We have attempted to identify, illustrate, and discuss all the more commonly encountered predators. As you use this guide, remember that other predator species may be encountered. All literature in the "References" section was used in assembling the taxonomic and bionomic information contained herein. Particularly important and extensively used references included Gordon (1985) for Coccinellidae, Fall (1912) and Walker (1957) for *Collops*; Slater and Baranowski (1978) and Henry and Froeschner (1988) for Hemiptera in general; Werner and Butler (1958) for Reduviidae and Nabidae; Stoner and Bottger (1965) for *Spanagonicus albofasciatus*; and Lewis (1973) for Thysanoptera. Sterling (1978) provided the basis for inclusion of the red imported fire ant as a predator in cotton. Other information on predators in cotton was gleaned from Bohmfalk et al. (1982), Werner et al. (1979), and Whitcomb and Bell (1964).

Species identifications were confirmed by R. D. Gordon (Coccinellidae) and T. J. Henry (Hemiptera) of the USDA Systematic Entomology Laboratory, Beltsville, MD. Voucher specimens have been deposited in the Texas Agricultural Experiment Station at Vernon insect collection. All illustrations in this text were prepared by the senior author.

This publication, originally published in 1991, was revised in 1996, to expand the sections on syrphids and lacewings. The increased abundance and importance of the cotton aphid in the north Texas Rolling Plains (Slosser et al. 1989, Leser et al. 1992) has resulted in an increased interest in the predators of aphids (Rosenheim et al. 1993).

HEMIPTERA

The order Hemiptera (true bugs) contains eight families in the northern Rolling Plains in which at least some members exhibit predaceous habits. This group includes some of our most important predators. Unlike most lady beetles and lacewings, which feed largely on aphids, many true bugs attack a broad variety of insects. Unfortunately, this host range sometimes includes other predators; however, on the whole, the insects in this group are considered highly beneficial.

The two most outstanding features of the order Hemiptera are the mouthparts and the wings. The mouthparts are modified into a long tube, referred to as a rostrum. When predatory Hemiptera feed, they thrust their stylets into the body of the prey and inject enzymatic fluids, which begin the process of digestion and liquefy the prey's body contents so that the predator can then suck out these fluids.

The other predominant feature of this order is the unique wing structure. On the forewing (the one exposed when the insect is at rest), the front part of the wing is thick and leathery and the posterior region is thin and membranous. No other group of insects has a similar wing structure. The name Hemiptera literally means "half-winged," referring to this peculiar arrangement.

Members of this order undergo incomplete metamorphosis. Rather than progressing through distinct stages, such as caterpillar to pupa to moth, immature true bugs resemble smaller, wingless versions of the adults. These insects are classified to family according to the presence or absence of scent glands and ocelli (simple eyes), the number of segments in the antennae and beak, and the features on the wings. Some familiar pest species in this order include the chinch bug, harlequin bug, bed bugs, lace bugs, lygus bugs, and cotton fleahopper.

Pentatomidae

Known collectively as stink bugs, this family largely consists of plant-feeding species, many of which are serious pests. One subfamily, the Asopinae, consists exclusively of predaceous members although the very young nymphs are plant-juice feeders. Stink bugs may be recognized by their large size, broad shieldlike shape, distinct odor (especially when handled or otherwise threatened), and by five-segmented antennae (the first segment is typically short and somewhat thicker than the rest; Fig. 4). Nearly all stink bugs overwinter as adults. Stink bug eggs are barrel shaped, often banded or brightly colored, and are laid in groups. The nymphs resemble the adults in shape but appear softer bodied and sometimes have color patterns that are lacking in the adults.

Key to Pentatomidae in the Northern Rolling Plains

1. Rostrum not freely articulating, apparently fused to underside of head..... **plant-feeding stink bugs**
1' Rostrum freely articulating throughout its length, somewhat thicker (side view necessary) (predaceous stink bugs) **2**
2. Sides of pronotum reaching a sharp point (Figs. 1 and 2) **3**
2' Sides of pronotum rounded (Figs. 3 and 4) **4**
3. Color uniformly tannish-brown (Fig. 1) ..... ***Podisus maculiventris***
3' Distinctive color pattern, black on green, three white marks at front of scutellum (Fig. 2) .... ***Podisus acutissimus***
4. Color uniformly dark, metallic blue-black (uncommon species) (Fig. 4)..... ***Zicrona caerulea***
4' Distinctive color pattern, orange/red on black (Fig. 3) ..... ***Perillus bioculatus***

Podisus maculiventris (Say) (Fig. 1), known as the spined soldier bug, is probably the most important predaceous stink bug in the United States and is certainly the most common one in the northern Texas Rolling Plains. It is fairly large, 9-14 mm in length.

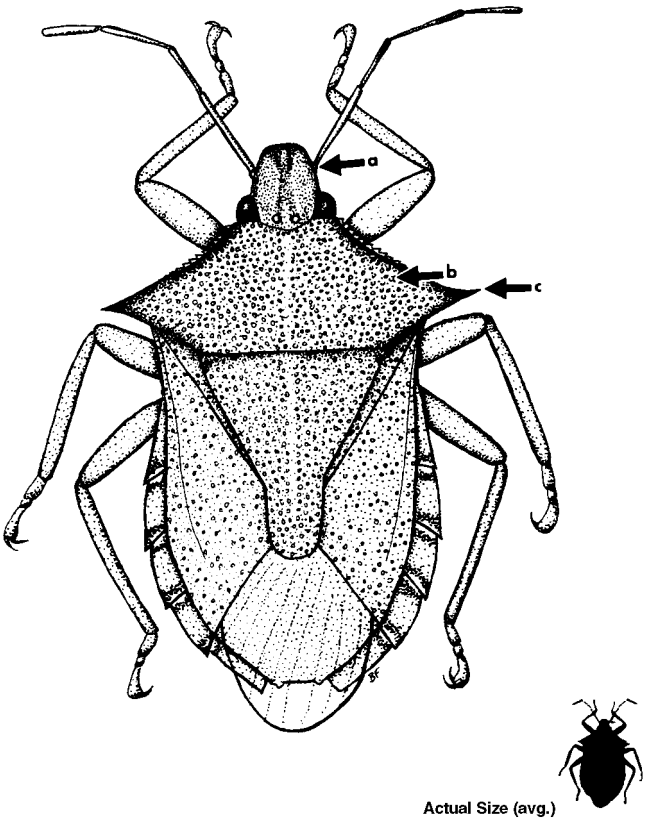

Figure 1. ***Podisus maculiventris*** **(Say), spined soldier bug.**
a. Five-segmented antennae (first segment short).
b. Small pits.
c. Pronotal spine.

Though it is uniformly tannish brown, examination under magnification will reveal a multitude of small pits covering the dorsal surface. This insect can sometimes be confused with the brown stink bugs (*Euschistus* spp.), but the two may be separated by examining the rostrum (couplet 1 in the key).

Our survey detected only small numbers of spined soldier bugs. This may be due to poor recovery by sweeping and, in large part, to their probable nocturnal habits. Although only two were collected by sweeping cotton (one in mid-July, the other in late November) and one from weeds (late July), many dozens were found throughout the summer and early fall in the ultraviolet-light trap at the Vernon Station, where they were seen feeding on large numbers of bollworm moths, which had also been caught by the trap. Observations of our sweep samples indicate that this species appears to be of almost nonexistent significance in controlling pests in the Rolling Plains, but it may in fact have a greater importance than our survey effort indicates.

Although *P. maculiventris* is a generalist, feeding on a wide variety of prey, it does seem to prefer prey in immature stages. It has been recorded as an effective predator of the larvae of Colorado potato beetle and Mexican bean beetle, lygus bug nymphs, and larger bollworms. It is cannibalistic. Spined soldier bugs are known from all areas of the United States, but are common only east of the Rockies.

Podisus acutissimus (Say) (Fig. 2) is an attractive species. Living specimens are a bright, almost iridescent shade of light green and have a specific pattern of black-and-white markings. It is generally smaller (8-10 mm) than *P. maculiventris.* Although no *P. acutissimus* were collected in our surveys, we have occasionally found them in cotton fields. Little specific information is available about their predatory habits. Because of its scarcity in our area, it probably does little to regulate pest populations.

Perillus bioculatus (F.) (Fig. 3) is a rather large (8.5-12 mm) and colorful species, having a distinctive black-and-reddish color pattern, although the red portions may be faded to orange, pink, yellow, or even white. It is seldom found in cotton or wheat because of its prey preferences. Our survey failed to detect any *P. bioculatus* although individuals are seen fairly frequently in our area. The adults are often encountered in the fall as they enter houses and other structures, to seek overwintering sites.

Some studies have suggested that this species apparently prefers eating the larvae of Colorado potato beetles although smaller nymphs have been seen feeding on Colorado potato beetle eggs. *P. bioculatus* is such an effective predator of this pest that it has been introduced into Europe for control of Colorado potato beetle there. Although not having an impact on cotton or wheat pests, this predator may provide some benefit to our vegetable growers. It ranges throughout the United States.

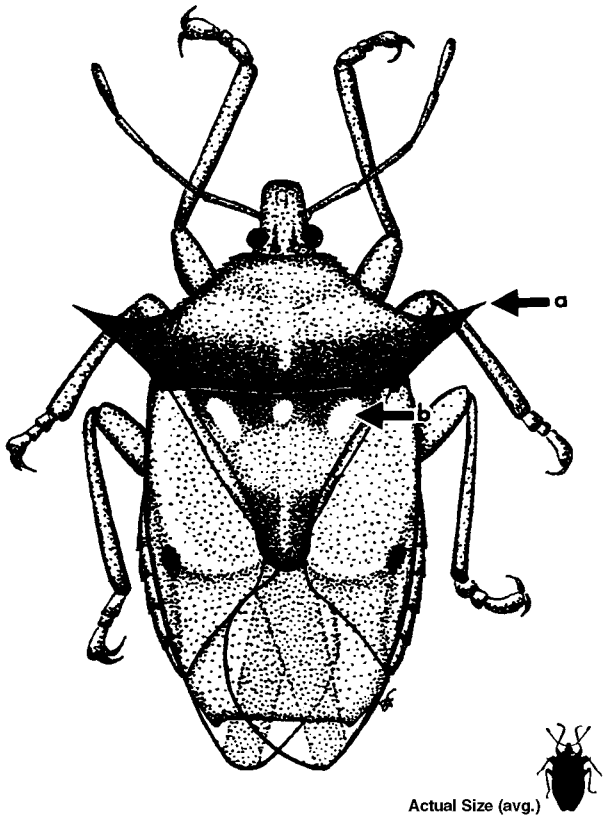

Figure 2. ***Podisus acutissimus*** **(Say), a stink bug.**
a. Pronotal spine.
b. White spots on scutellum.

Zicrona caerulea (L.) (Fig. 4) is a small (approximately 6 mm), beautiful bug, having a deep blue-black or purple-black metallic coloration. Being uncommon, it was not detected in the survey, and the only specimens encountered in our area are two individuals collected from evening primrose (*Oenothera* sp.), May 23, 1978, in Foard County. Its prey preferences are unknown.

Lygaeidae

Lygaeidae is a large family exhibiting diverse habits. Most of its members, however, are plant feeders. Although they can vary greatly in size and shape, all lygaeids have four-segmented antennae and beaks, ocelli, and few (four or five) veins on the membranous part of the wings. One group, subfamily Geocorinae, has developed predaceous habits.

Geocoris spp. are common predators, and members in the genus *Geocoris* are known as big-eyed bugs. They are small (2-4 mm) and dully colored gray or tan to nearly black. Their most outstanding characteristic is

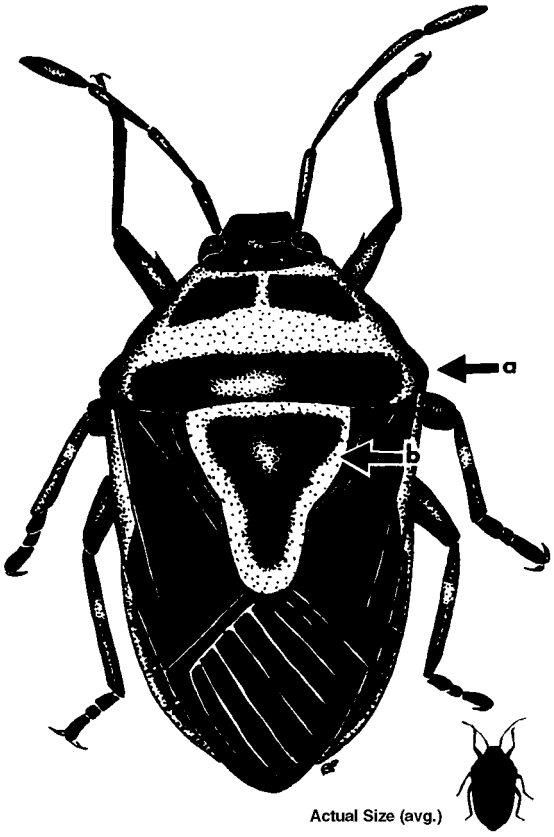

Figure 3. ***Perillus bioculatus*** **(F.), a stink bug.**
a. Smooth pronotal angle.
b. Color pattern on scutellum.

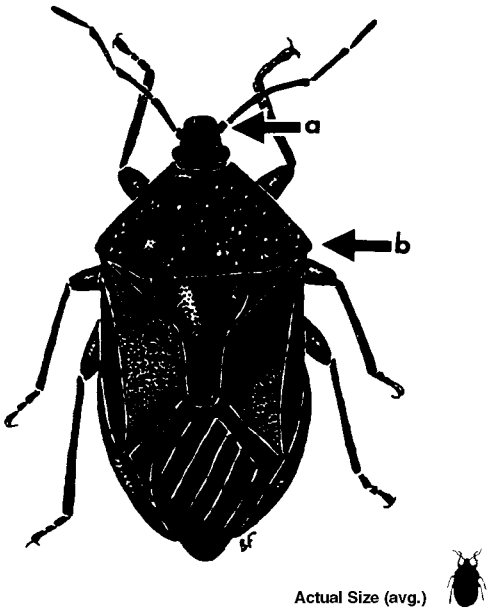

Figure 4. ***Zicrona caerulea*** **(L.), a stink bug.**
a. Five-segmented antennae.
b. Smooth pronotal angles.

their large, kidney-shaped eyes, which make the head appear broader than the pronotum (Figs. 5 and 6).

Although *Geocoris* spp. are known to supplement their diets with plant material, they do not damage plants and are considered highly beneficial. Big-eyed bugs appear to favor warm weather. Our survey consistently detected modest numbers (1-2 per 50 sweeps) in cotton and weeds from late April through September and only intermittently detected them in alfalfa during this period. They were found in wheat only during May, possibly too late to affect yield by decreasing the numbers of pests. Large numbers of *Geocoris* spp. have been known to occur in cotton fields.

Big-eyed bugs lay their oval, gray-white eggs singly on plant tissue. Nymphs are much like adults, only smaller and wingless. Very young nymphs are primarily egg-feeders, whereas older nymphs and adults feed

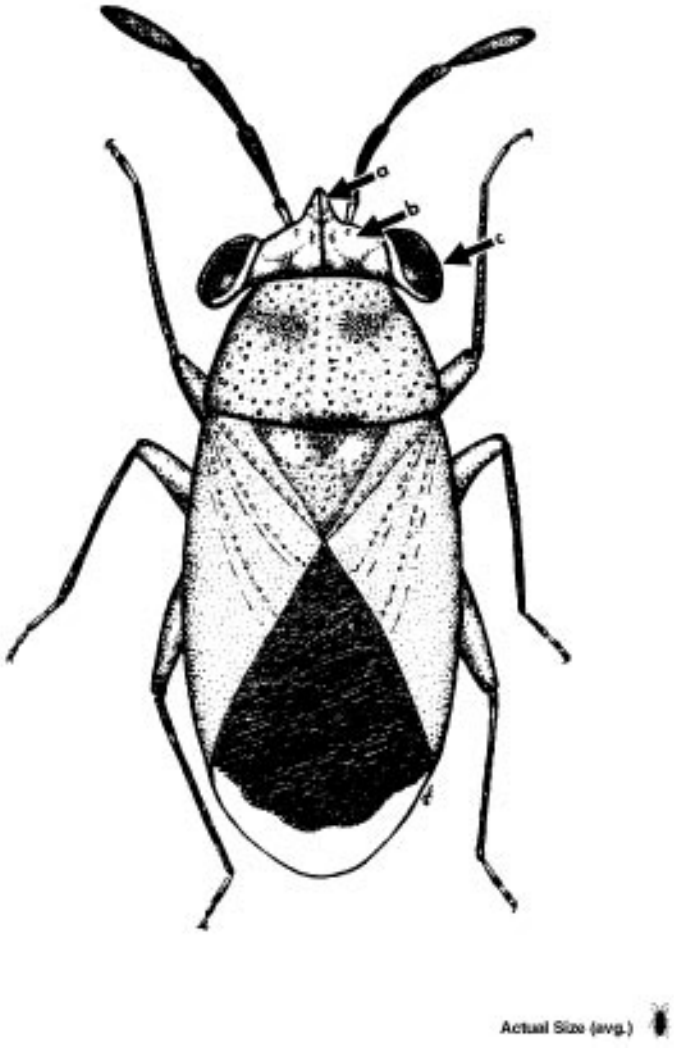

Figure 5. ***Geocoris punctipes*** **(Say), a big-eyed bug.**
a. Longitudinal groove.
b. Head smooth and shiny.
c. Large eyes.

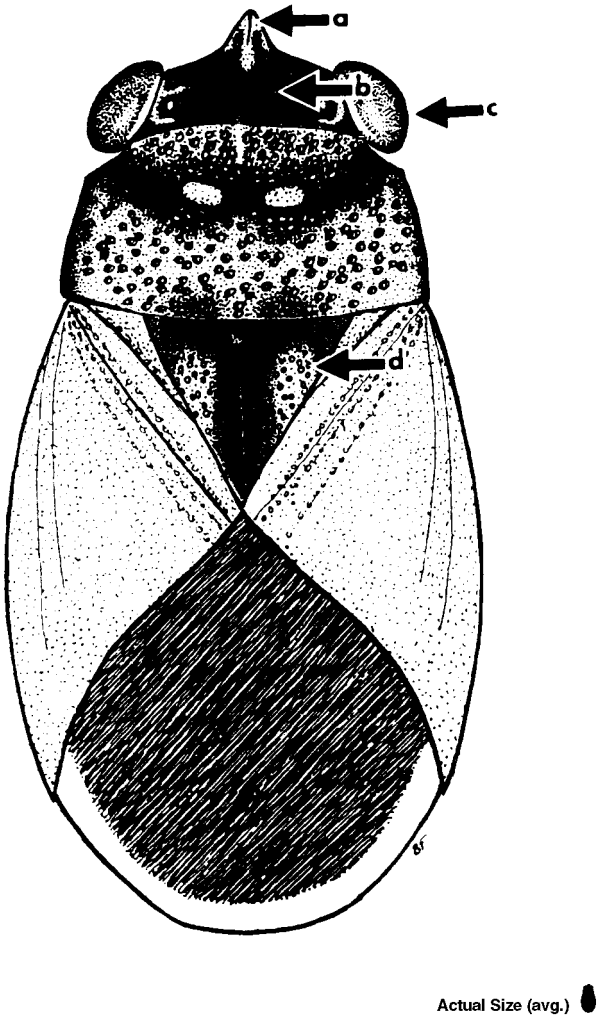

Figure 6. ***Geocoris pallens*** **Stal, a big-eyed bug.**
a. Longitudinal groove short or absent.
b. Head rough, not shining.
c. Large eyes.
d. Scutellum solid black or bicolored.

on all life stages of their prey. They have been recorded overwintering as adults on winter grains, weeds, and alfalfa, although our surveys failed to detect them in these situations.

Because of their small size and lack of grasping legs, big-eyed bugs limit themselves to small, rather defenseless prey, for which they lie in wait and ambush. Given these constraints, their impressively broad prey list includes bollworm-tobacco budworm eggs and small larvae, cotton fleahoppers, lygus bug nymphs, various aphids, young pink bollworms, spider mites, leafhoppers, mealybugs, whiteflies, thrips, treehoppers, ants, and other predators such as *Orius* and *Nabis.*

Two species of *Geocoris* have been identified in our area. Here, *G. punctipes*, which is the slightly larger species, is probably the more common species of *Geocoris*. Field separation of these species can be difficult. We made no attempt to distinguish among them in our survey, as they all seem to share similar habits. A key to the species follows.

Key to *Geocoris* in the Northern Rolling Plains

1. Head area between eyes smooth and shiny; longitudinal groove on head (Fig. 5).....***Geocoris punctipes*** **(Say)**
1' Head area between eyes rough, not shining; longitudinal groove very short or lacking (Fig. 6).....***Geocoris pallens*** **Stal**

Berytidae

Members of the small family Berytidae are known as stilt bugs because of their long, thin appendages. They are easily recognized for this reason and because of their antennae, which have four segments — the first being extremely long and the fourth being short and thickened (Fig. 7). Some assassin bugs have long legs and a thin body and may be mistaken for stilt bugs but, unlike stilt bugs, have modified front legs for grasping. All stilt bugs are plant feeders but may supplement their diet with insect eggs and soft-bodied insects.

Jalysus spp. (Fig. 7) have been shown to feed on various insect eggs. The most common species in our area is *J. wickhami* V. D. Stilt bugs are thin, 6-8 mm long, and straw colored. The prothorax is covered with small pits. One peculiar feature is the area of thorax around the scent gland opening that forms a spine which projects outward from the body.

Findings of *Jalysus* in our surveys were rare; one was taken on cotton in early July and one from wheat in early April. They apparently are uncommon in our area.

Phymatidae

Known as ambush bugs, Phymatidae is a small family entirely composed of predators. They are easily recognized by their distinctive shape — squat and spiny — and an abdomen that is wide and flat across the middle. Of further importance in recognition are the greatly enlarged front legs, modified for grasping prey. Most specimens are 8-10 mm long.

Although having a voracious appetite, these insects are of little importance in agriculture because they prefer resting on flowers of weeds and roadside plants, where they feed upon nectar and pollen-feeding insects, usually bees. They are rarely found in cotton and almost never in wheat. Our survey failed to detect any ambush bugs. All specimens in our collection originating from the Rolling Plains belong to the genus *Phymata* (Fig. 8).

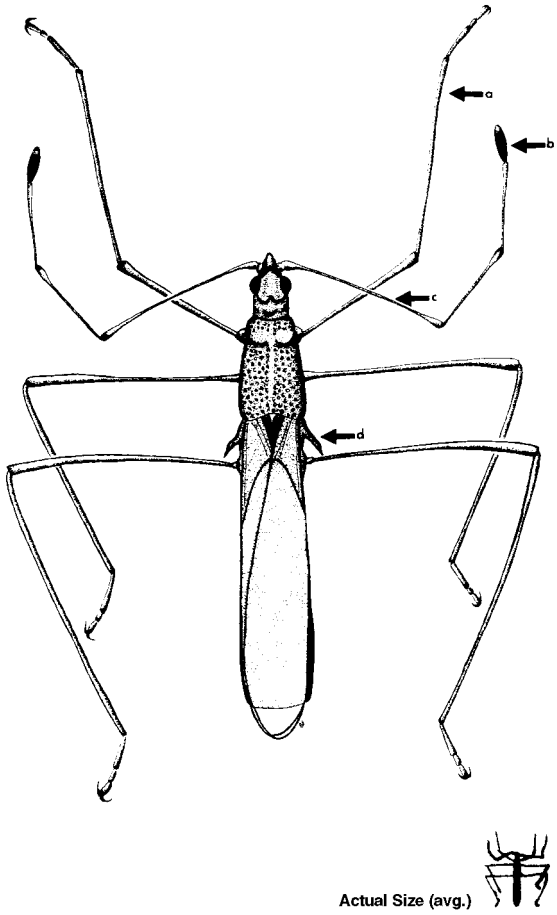

Figure 7. ***Jalysus wickhami*** **Van Duzee, a stilt bug.**
- **a. Long legs.**
- **b. Fourth antennal segment short and swollen.**
- **c. First antennal segment very long.**
- **d. Area around scent gland drawn out into spine.**

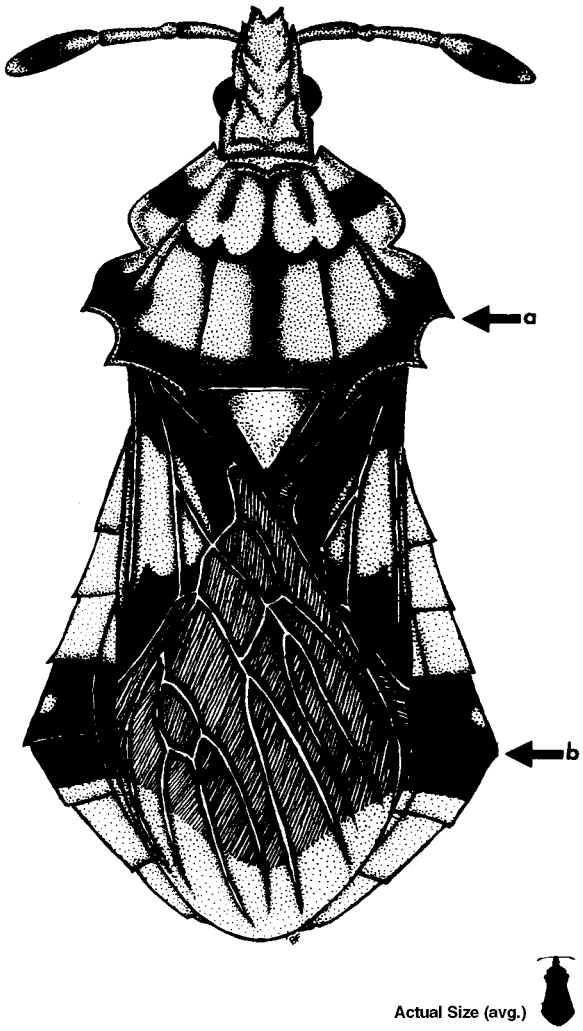

Figure 8. ***Phymata*** **sp., an ambush bug.**
- **a. Spiny thorax.**
- **b. Wide, flat abdomen.**

Reduviidae

Insects in the family Reduviidae are widely known as assassin bugs. Virtually all members of this large family feed on some form of animal matter. Although some have become specialized, feeding on human and animal blood (kissing bugs), most are predaceous on other insects. Their large size and aggressive nature enable them to eat many insects, such as mature bollworms, that are seldom fed upon by other predators.

This family is characterized by the short, sharply curved beak (Fig. 9), which fits into a groove between the front legs. Many assassin bugs can inflict a painful bite, and it is a good policy to avoid handling them. In our area, the three groups commonly found in agricultural situations probably have some impact upon pest populations.

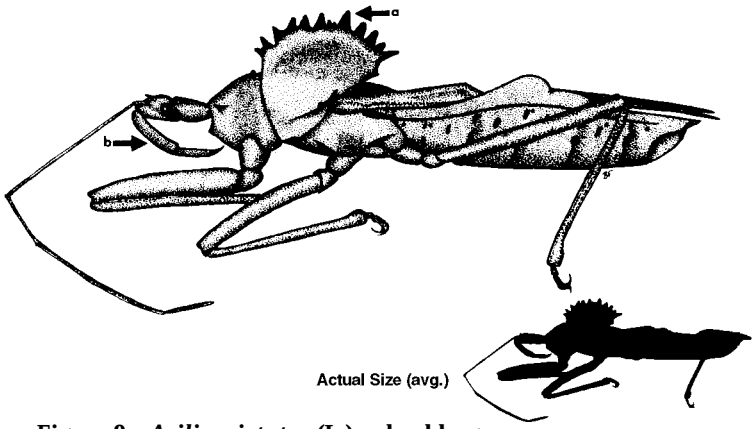

Figure 9. ***Arilis cristatus*** **(L.), wheel bug.**
- **a. Spiny ridge on thorax.**
- **b. Short, curved stylet.**

Key to Agriculturally Important Reduviidae of the Northern Rolling Plains

1. Size very large (28-36 mm); thorax has prominent spiny ridge running down its middle (Fig. 9) ..... ***Arilus cristatus*** **(L.)**
1' Smaller (<20 mm); thorax may bear spines but never on a ridge down the middle (Figs. 10 and 11) **2**
2. Front tibiae with spines on inner surface (Fig. 10) ..... ***Sinea*** **spp.**
2' Inner surface of front tibiae bare and smooth, often with a sticky substance or dense hair; body form typically narrower (Fig. 11) ..... ***Zelus*** **spp.**

Arilus cristatus (L.) (Fig. 9), called the wheel bug, is known for its excruciatingly painful bite. Wheel bugs are large (28-33 mm), dark brown, and are most notable for the large, spiny ridge on the thorax, which has been compared to a cog, hence the name "wheel bug." The bottle-shaped eggs are laid in the fall on twigs or other firm surfaces, where they overwinter. Nymphs hatch in the spring. Younger nymphs display red and black patterns. The older nymphs resemble the adults in coloration.

A. cristatus are regularly found in cotton fields throughout the eastern United States, where they are reported to be excellent predators of mature bollworm larvae. However, they are seldom common and are not thought to be of much benefit in controlling pest populations. Our surveys produced no wheel bugs although we encountered them fairly frequently in cotton while conducting other projects.

Sinea spp. (Fig. 10) are medium-large (12-15 mm) assassin bugs and are uniformly brown. The best identifying feature is the front legs, which are slightly swollen and covered with spines. The eggs, laid in clusters, are oval and brownish and have a lighter colored cap. Nymphs are similar to adults but are markedly swaybacked. Specimens from our survey have all been identified as *S. diadema* (F.).

When their numbers are sufficiently large, *Sinea* are regarded as important predators. They have a broad range of known prey, including cotton fleahoppers, lygus bugs, aphids, pink bollworm larvae, bollworm and tobacco budworm larvae of all sizes, spotted cucumber beetles, cabbage loopers, and older cotton-leaf perforator larvae. Because of their opportunistic nature, they eat other predators, including convergent lady beetles, spotted lady beetles, and big-eyed bugs. *Sinea* are one of the few predators known to eat boll weevils.

Unfortunately, we have not found these insects in numbers large enough to suggest that they have much impact on pest populations in the northern Rolling Plains. In our survey, *Sinea* were found on weeds from May to October and from September to October in cotton. None were collected in wheat or alfalfa. When they were present, numbers were low: a maximum of 1 found per 50 sweeps.

Zelus (Fig. 11) is another assassin bug genus. *Zelus* are sometimes confused with *Sinea*, but *Zelus* spp. are frequently bicolored, often red and green, whereas *Sinea* spp. are solid brown. Closer examination will reveal that *Zelus* spp. lack spines on their slender front legs. Instead, these legs are covered with a sticky substance to aid in catching and retaining prey. Specimens often have particles of sand or other debris stuck to their legs. The nymphs resemble the adults and are not nearly as swaybacked as *Sinea.* The eggs are brown cylinders with a white collarlike cap and are laid in groups.

Two species have been encountered in our area. *Z. tetracanthus* Stal (formerly known as *Z. socius*) is the larger of the two (13-16 mm) and has four small spines on the pronotum. *Z. renardii* Kolenati (Fig. 11) is smaller (10-13 mm) and lacks distinct spines on the pronotum. The smaller species is more brightly colored. Living specimens are bright green with red wings. Dried specimens fade greatly. These two species were not differentiated in our survey.

Zelus spp. appear to favor late summer and autumn. We consistently found them from mid-July to November in cotton and weeds but only in October in

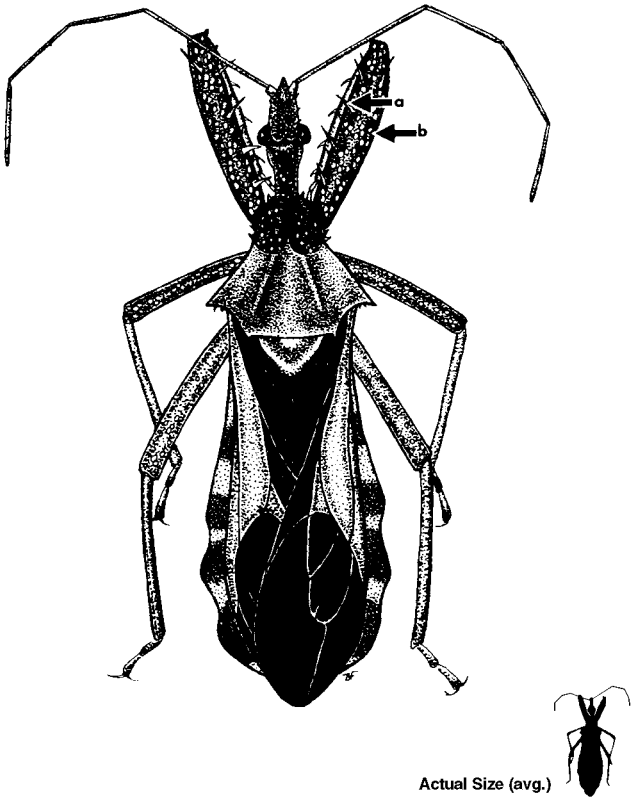

Figure 10. ***Sinea diadema*** **(F.), an assassin bug.**
a. Spines on front tibiae.
b. Front femora slightly swollen.

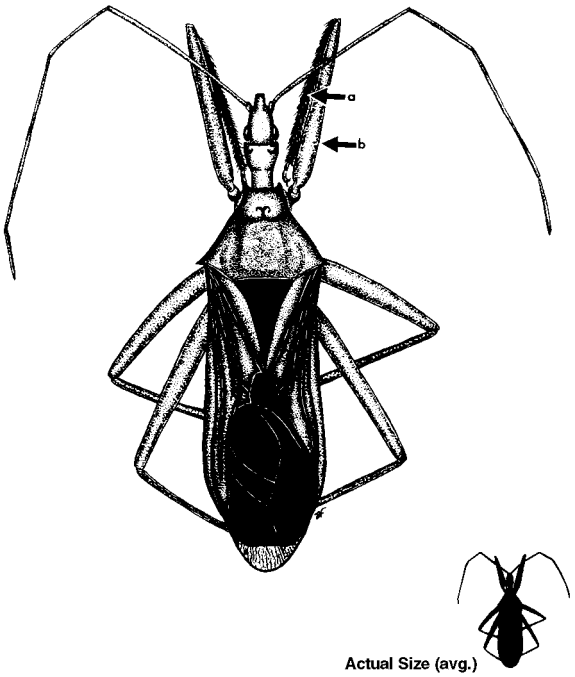

Figure 11. ***Zelus renardii*** **Kolenati, an assassin bug.**
- **a. Front tibiae lacking spines although commonly hairy.**
- **b. Front femora not especially swollen.**

alfalfa. Numbers encountered July through September in cotton were low (approximately 1 per 50 sweeps), but the population seemed to increase thereafter until frost (mid-November). Nearly 5 *Zelus* spp. per 50 sweeps were found in cotton in early November, and 7 per 50 sweeps were found in alfalfa in early October. Numbers in weeds were consistently low; no more than 1 was collected from 50 sweeps at any time throughout the summer and fall.

The prey range for *Zelus* is similar to that of *Sinea*. *Zelus* and *Sinea* constitute one of the few predator groups that take boll weevil adults and mature bollworm larvae. This, coupled with their ability to develop at least moderate numbers in the late summer and fall, enhances their potential to be of significant impact in controlling cotton pests in the northern Rolling Plains.

Nabidae

Nabidae is another family with exclusively predaceous habits. Within this family, only members of the genus *Nabis* are common in agricultural settings.

Nabis spp. (Fig. 12), known as damsel bugs, are slender, dull tan-grey, 6-9 mm in length, and have very slender antennae. The most distinctive feature of the entire family is the pronotum, which is apparently divided into two sections. Another important feature is the presence of many small cells at the tip of the wing. Damsel bugs can be confused with small assassin bugs, but damsel bugs never have spines or sticky material on the front legs.

Two species, *N. alternatus* Parshley and *N. roseipennis* Reuter, have been identified from our area. They have similar habits. The eggs are inserted into plant tissue, and the nymphs greatly resemble smaller, softer-bodied versions of the adults. As adults, they overwinter in leaf litter and comparable protected areas or on winter crops.

Our survey efforts detected *Nabis* spp. in all crops and at all times of the year. The numbers in cotton tended to be low; the high, nearly 1 per 50 sweeps, was

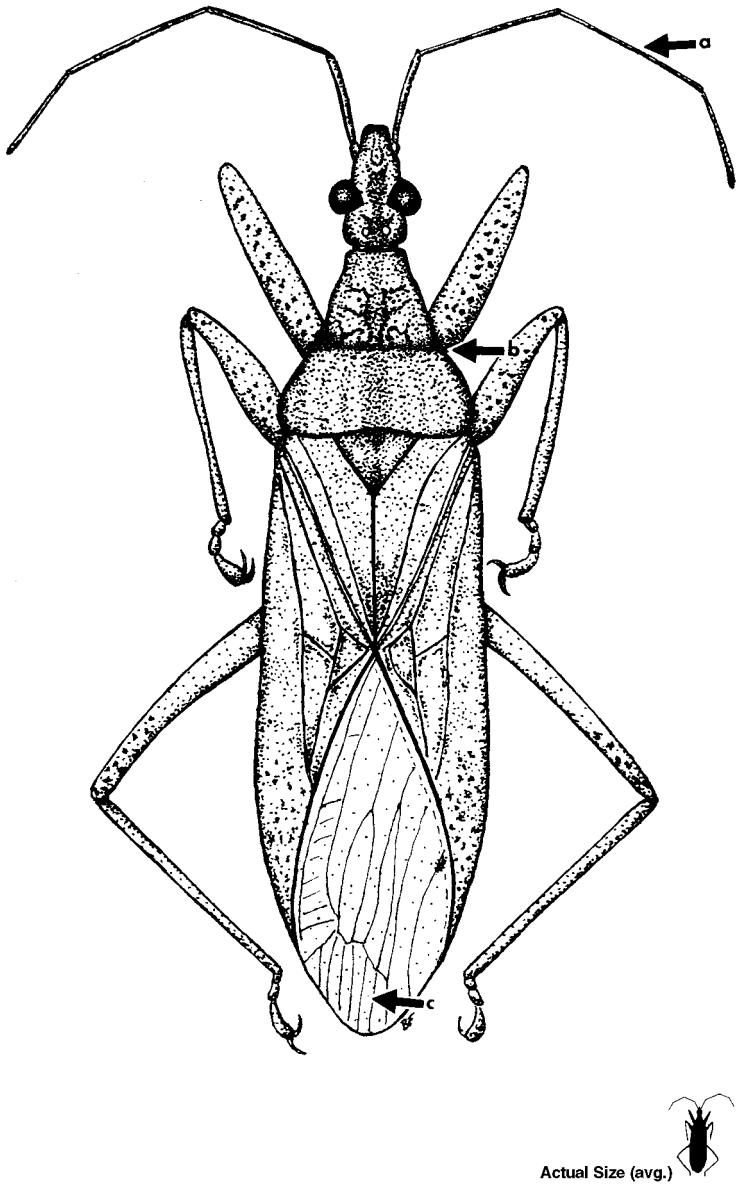

Figure 12. ***Nabis alternatus*** **Parshley, a damsel bug.**
- **a. Thin antennae.**
- **b. Prothorax two-lobed.**
- **c. Many cells at margin of wing.**

in early August. A high of 9 per 50 sweeps was detected in alfalfa in mid-May; numbers decline to around 1 per 50 sweeps from late June to December. In wheat, the mean was 5 per 50 sweeps in late November, declining to 1 or fewer per 50 sweeps in December. The population began to increase in April, and large numbers (as many as 18.5 per 50 sweeps) appeared throughout May. Numbers on weeds remained low but steady through the cooler months, and no detections occurred from mid-July to September.

Damsel bugs feed on a wide variety of prey, accepting nearly any insect within a certain size range. Cotton fleahopper, lygus bugs, aphids, eggs and small larvae of pink bollworm and various other lepidopterous pests, leafhoppers, and spider mites have been recorded as prey. They are known as particularly effective predators of bollworm and tobacco budworm eggs and small larvae. They also consume other predators, especially *Orius* and *Geocoris*. This is one of our most important and abundant predators.

Anthocoridae

The members of the family Anthocoridae, known as minute pirate bugs or flower bugs, are all small, the largest being only about 5 mm long. They have a specialized section of the wing known as a cuneus, which makes the wing appear to bend down about three-quarters of the way toward its posterior (this is sometimes hard to see with the naked eye because of their small size). Most are predaceous. The most important minute pirate bugs from the standpoint of natural control belong to the genus *Orius*. Two species are common in the U.S., one eastern and one western. Because of our central location, we are fortunate to have both.

Key to Common *Orius* Species in the Northern Rolling Plains

1. Predominantly black, clavus black (Fig. 13) ..... ***Orius tristicolor*** **(White)**
1' Large area of dorsal surface, including clavus, white (Fig. 14) ..... ***Orius insidiosus*** **(Say)**

Orius tristicolor (White) (Fig. 13) is primarily a western species. It is a tiny (approximately 2 mm) but handsome black-and-white bug. The eggs are inserted into plant tissue so that only the cap protrudes. The nymphs are amber and slightly convex, bearing little resemblance to the adults. They overwinter as adults on winter crops.

Our survey detected *O. tristicolor* throughout most of the year in all crops although none were found during the coldest months (December - March). They were almost always present in weeds from May to October, and the greatest abundance (2-4 per 50 sweeps) seem to occur in May and June. In wheat, small numbers were detected in late November; then none were detected until April and May, when as many as 15.5 per 50 sweeps were found. Numbers in cotton were low (1-2 per 50 sweeps), but they were consistently present from June to November. In alfalfa, we detected phenomenal numbers, peaking in June (27 per 50 sweeps), followed by a decline and a second peak in September (47 per 50 sweeps).

Although *O. tristicolor* is most often associated with thrips and mites, it is also known to consume bollworm eggs and small larvae, stink bug eggs, lygus nymphs, aphids, whiteflies, leafhoppers, and the crawlers of scale insects.

Orius insidiosus (Say) (Fig. 14) is comparable to *O. tristicolor* in size and shape but can be easily discerned by the greater proportion of white on its surface. It is sometimes known as the insidious plant bug. The nymphal description and life cycle are similar to *O. tristicolor*. This species is distributed throughout the eastern United States and has been found in Colorado and the Pacific coast.

O. insidiosus apparently does not favor summers in the northern Rolling Plains. Although a few individuals were collected in wheat in April and May, none were taken in any crop from late May to mid-October until a few were found in alfalfa and cotton in October and November. Findings of this species were intermittent, and when collections were taken, numbers were low in cotton and wheat. In alfalfa, 2-4 per 50 sweeps were detected from mid-November to mid-December. None were found on weeds.

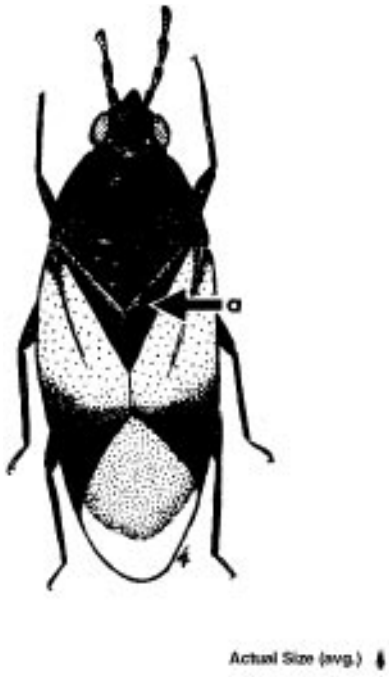

Figure 13. ***Orius tristicolor*** **(White), a minute pirate bug.**
a. Clavus black.

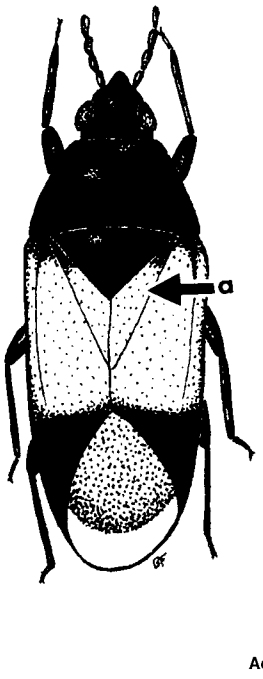

Figure 14. ***Orius insidiosus*** **(Say), the insiduous plant bug.**
a. Clavus white.

As with *O. tristicolor*, *O. insidiosus* is associated with thrips but also consumes mites, cotton fleahopper nymphs, aphids, young lygus nymphs, whiteflies, and small larvae of various lepidopterous pests including pink bollworm and bollworm.

Both species of *Orius* are among the most abundant and voracious of predators; their importance far exceeds their small size. They can expand their numbers rapidly in response to outbreaks of favored prey, such as thrips. *Orius* spp. prefer plant terminals and flowers (where large numbers of thrips are likely to be present). One situation in which *Orius* spp. can be of significant benefit is in seedling cotton, where thrips can cause severe damage. These predators may be present in large numbers on the undersides of leaves when mites are present.

Another characteristic contributing to the significance of *Orius* spp. is their ability to survive insecticide treatments better than most other predators. This may be due to their small size and preference for hiding in closed spaces, thus avoiding contact with sprays.

Miridae

Miridae is the largest family of Hemiptera, and its members are known as plant bugs. Their most distinguishing feature is the cuneus (Fig. 15), an adaptation of the wing that appears as a break in the leathery part so that the remaining portion of the wing angles downward. They are typically small, sometimes brightly colored, and always lacking ocelli. In many species, the first two antennal segments are fairly stout, whereas the last two segments are slender. Most of these bugs are plant feeders.

This family includes two important pests of cotton: lygus bugs, *Lygus* spp., and cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter). Both of these are known to feed on eggs of bollworms and tobacco budworms and therefore may have at least some beneficial impact. However, because of their highly destructive plant-feeding habits, they are considered pests and will not be included further in this guide. Another species, *Spanagonicus albofasciatus* (Reuter), known as the black-and-white fleahopper, may be considered beneficial because of its predatory nature.

Spanagonicus albofasciatus (Reuter) (Fig. 15) feeds primarily on plants but has a strong tendency to supple-

Figure 15. ***Spanagonicus albofasciatus*** **Reuter, black-and-white fleahopper.**
a. All antennal segments black.
b. White pattern in middle.
c. Cuneus.

ment its diet with animal material. Individuals seem to develop faster and have greater survival in the presence of suitable prey. *S. albofasciatus* is sometimes classified as a pest, but cotton plants tolerate its presence. The worst-case scenario suggests that this species could damage cotton only in the seedling stage. Cotton is not thought to be a preferred host.

S. albofasciatus is small, 2-2.5 mm in length. It is black with white markings, the white areas typically form a band across the middle of the back. All segments of the antennae are black. In males, the second antennal segment has a highly swollen appearance. The fine hairs on its dorsum are transparent or silver. Known prey include aphids, lygus bug eggs, banded-winged whitefly, spider mites, and the eggs and young larvae of *Heliothis* spp.

In our survey, low numbers were found consistently in cotton and occasionally in weeds. None were found in alfalfa or wheat. *S. albofasciatus* is known to develop on weeds, but our survey failed to generate any supporting evidence for this. The low numbers collected suggest that this species is of little significance in regulating pest populations in the Rolling Plains. Black-and-white fleahoppers, however, may have some impact when taken in combination with the entire predator complex.

COLEOPTERA

Coleoptera, commonly known as beetles, is the largest order in terms of the number of species, not only among insects, but of all living things. Some 30,000 species occur in America north of Mexico. They vary greatly in size, shape, color, and habits. Considering their numbers and diversity, it is not surprising that many are predaceous.

The most distinctive feature of beetles is the wing structure. The front pair of wings is hard or leathery and covers the back when at rest. These hardened wings are known as elytra, and they cover the membranous hind wings, which are used for flight. All beetles have chewing mouthparts and undergo complete metamorphosis. The larvae of beetles are sometimes referred to as grubs.

In addition to the predaceous species, this order contains some of our best known and most destructive pests including boll weevil and spotted cucumber beetle. Although predaceous beetles are numerous, only three groups are important enough and common enough in the northern Rolling Plains to be discussed here.

Carabidae

Known as ground beetles, Carabidae is a large and common family. Although all ground beetles are predaceous, some feed on seeds and other plant material. They are highly variable in size, color, and habit. Many species are black and shiny. Most are encountered scurrying about on the ground. They are seldom seen flying. As predators, they are typically generalists, feeding on a wide assortment of insects as prey.

The primary feature distinguishing the carabids from other beetles is the arrangement of the hind legs in relation to the abdomen (Fig. 16). The hind coxae (the first leg segment) are large and extend across the first two abdominal segments. The trochanters (second leg segment) are often conspicuously lobed. In most other beetles, the hind coxae do not reach the second abdominal segment, and the hind trochanters are never noticeably lobed. Certain other groups of beetles share this characteristic with the carabids, but they are all either aquatic or rare, so it is unlikely that they would be encountered in agricultural settings in our area.

Ground beetles were not collected in our survey because of their scarcity on plants and their nocturnal habits. They typically remain on the soil surface, where they prey upon insects that fall off plants. Larvae are predaceous and live under soil or in debris. They overwinter as adults or larvae in the soil.

Carabids, because of their great abundance in our area and voracious appetites, undoubtedly affect pest populations. Members of the genus *Lebia* have been known to eat as many as 10 *Helicoverpa zea* eggs per day.

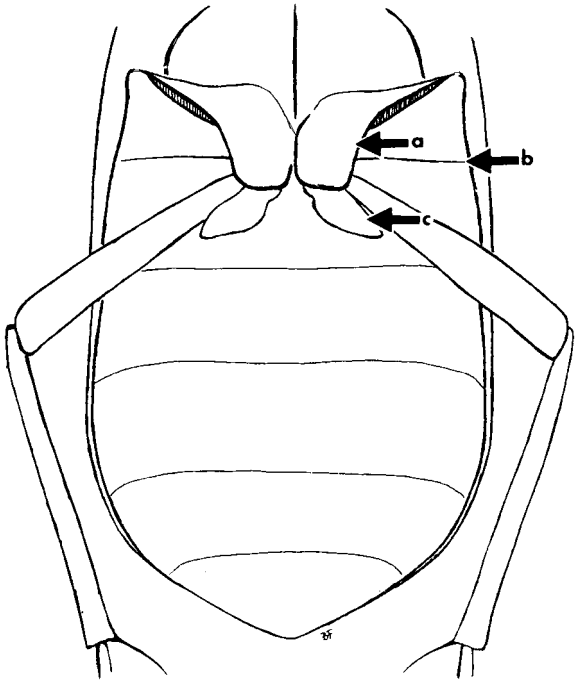

Figure 16. Ventral abdomen of Carabidae.
a. Coxa large, crossing suture between segments 1 and 2 (b).
c. Trochanter lobelike.

One of our most efficient predators, *Calosoma scrutator* (F.), (Fig. 17) is one of the few ground beetles known to regularly climb plants to take prey. It is a brilliant metallic green with multicolored highlights. Members of this genus are often called caterpillar hunters because of their habit of eating many moth larvae. They also eat adult insects, including bollworm moths. *Calosoma* spp. are highly attracted to light and give off a foul odor when handled. They are large, reaching sizes longer than 25 mm.

Two other species common to our area are also illustrated. *Colliuris pennsylvanicus* (L.) (Fig. 18) is a small (5-8 mm), delicate, rather strange-looking beetle. It is black and orange-red. The thorax and head are highly elongated. These insects can be found at light sources or in leaf litter or other debris. *Harpalus* sp. (Fig. 19) is rather large (18-25 mm), shiny, and black.

Calosoma, *Colliuris*, and *Harpalus* are not necessarily the most common ground beetles in the northern Rolling Plains, but we show them to illustrate the variety of forms within this family.

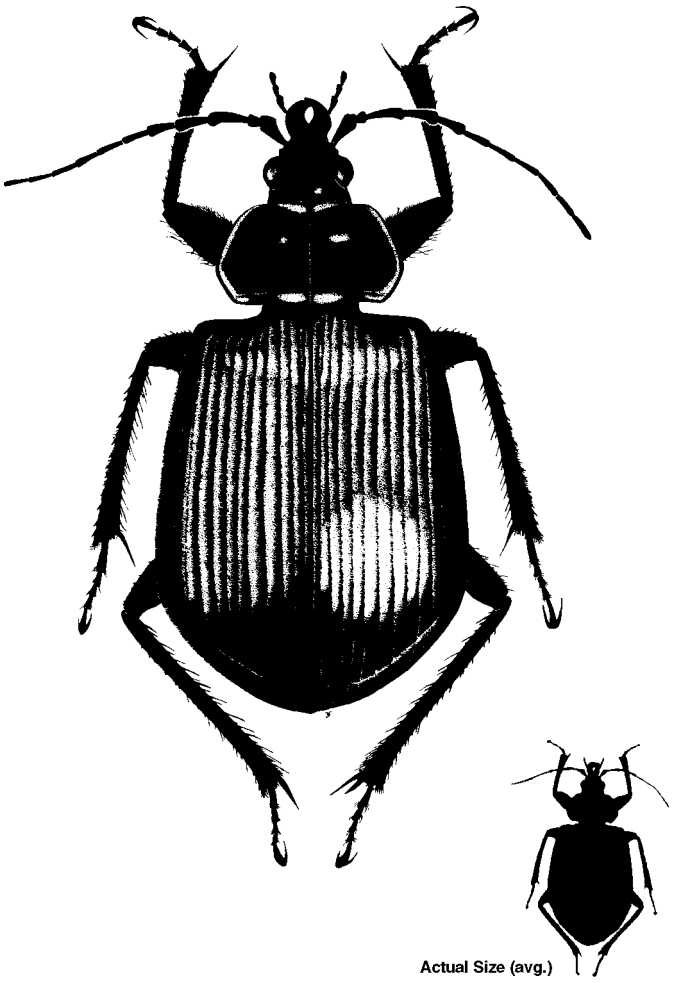

Figure 17. *Calosoma scrutator* (F.), a caterpillar hunter ground beetle.

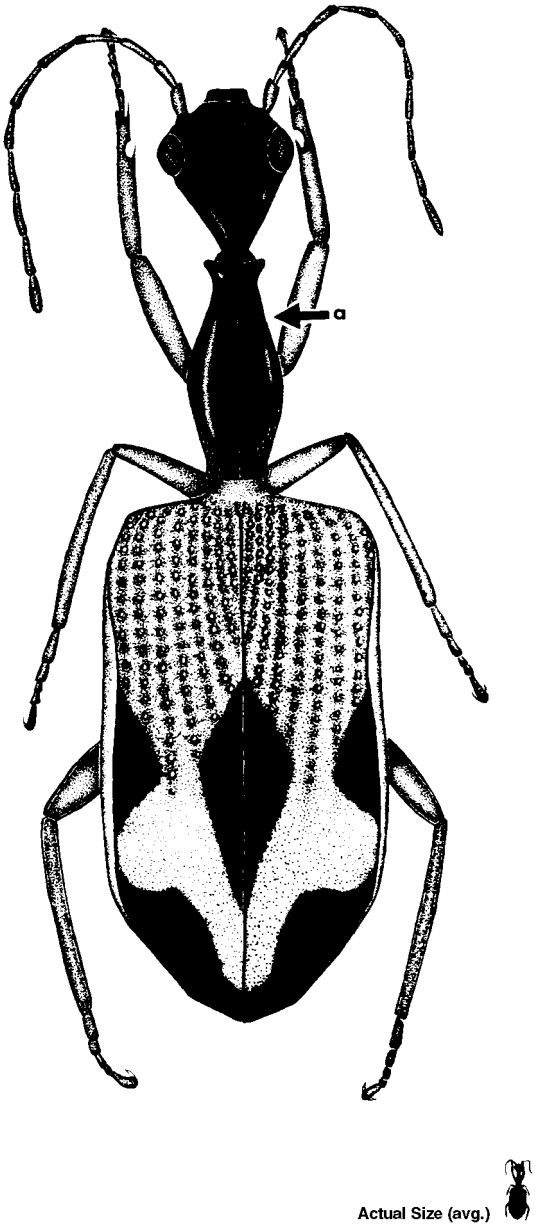

Figure 18. *Colliuris pennsylvanicus* (L.), a ground beetle. a. Elongate thorax.

Cicindela rectilatera Chaud. (Fig. 20) represents a specialized group, which is often given its own family (Cicindelidae — the tiger beetles). Unlike other ground beetles, many cicindelids are active during the day. They differ from carabids primarily in their shape, the head being as wide as or wider than the thorax. Most range from 10 to 15 mm in length. Typically brightly colored, they are frequently seen in sandy areas, where they are quite active. Their larvae live in burrows in the sand, where they trap and consume prey. The adults are predaceous on a wide variety of insects. This group is also common in our area.

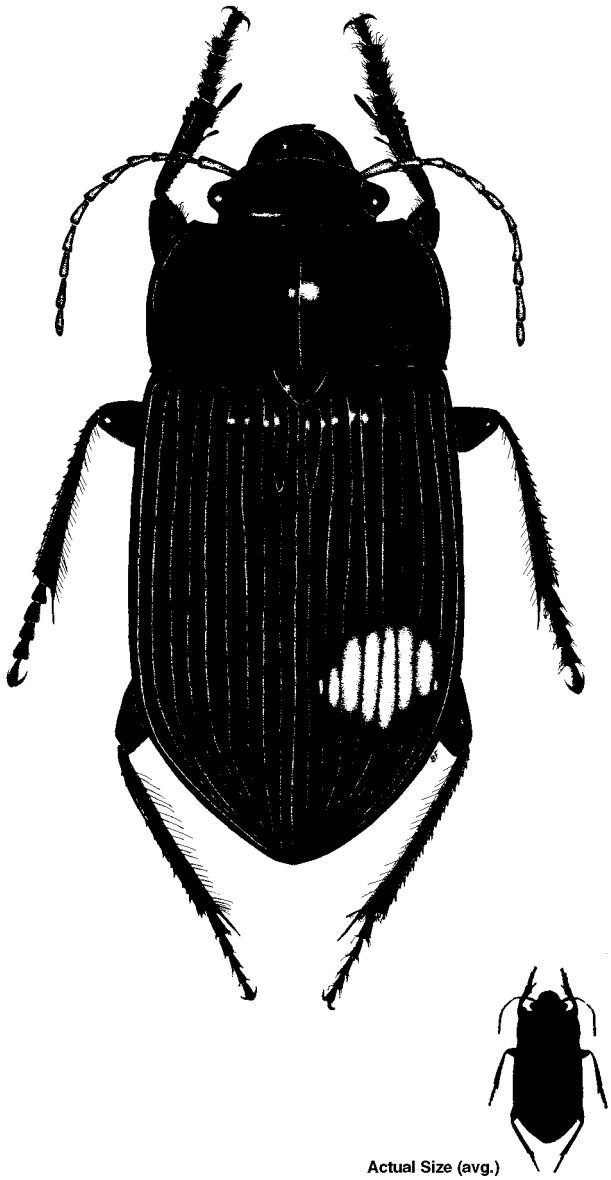

Figure 19. ***Harpalus*** **sp., a ground beetle.**

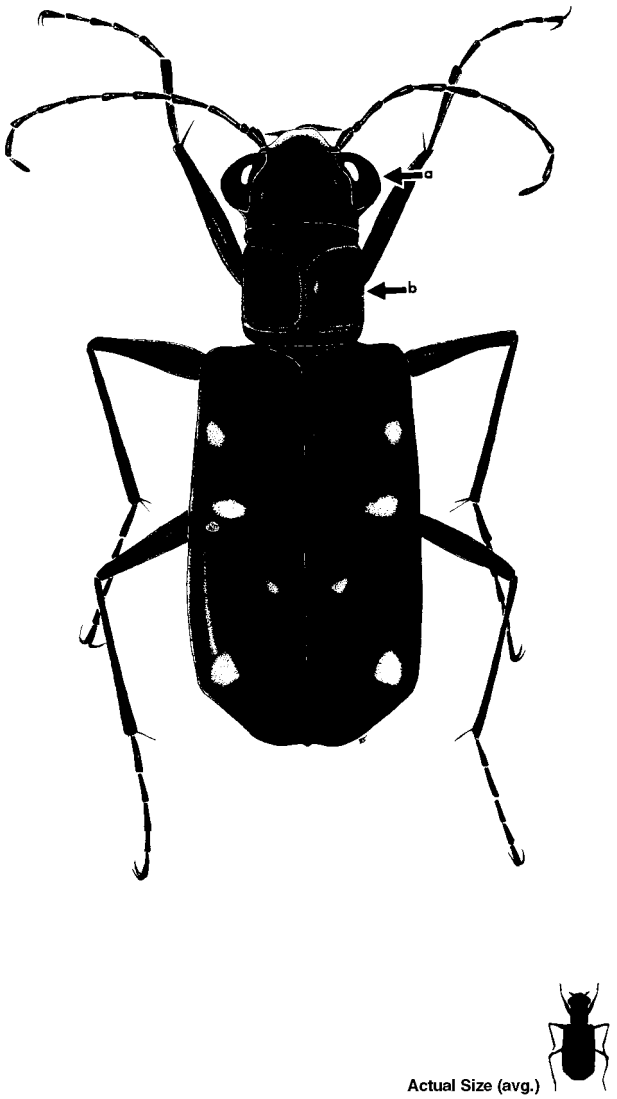

Figure 20. ***Cicindela*** **sp., a tiger beetle.**
a. Head (including eyes) wider than pronotum (b).

Melyridae

Known as soft-winged flower beetles, Melyridae is a relatively modest family of small beetles. They are soft-bodied, and the wing covers are more pliable than those of most beetles.

The subfamily Malachiinae, which includes the important predators of the genus *Collops*, has orange, inflatable balloonlike structures at the sides of the abdomen. In males, the third antennal segment is highly enlarged. Most collops beetles are blue with orange markings.

Collops eggs are laid in clusters in soil debris. They are yellow or orange, fading to white just before hatching. The pinkish-red larvae live in the soil, where they feed on small insects. They are seldom seen. Overwintering takes place in the adult stage. In addition to being predators, both larvae and adults are known to scavenge dead insects. The prey of collops beetles includes just about anything small and fairly unaggressive including stink bug eggs, aphids of many types, and eggs and larvae of various caterpillars. Three species are commonly encountered in our area.

Key to *Collops* of the Northern Rolling Plains

1. Elytra with longitudinal stripe at side (Fig. 21) ... ***Collops vittatus* (Say)**
1' Elytra with lateral stripe across middle (Fig. 22) **2**
2. Prothorax solid orange, lacking spot ..... ***Collops quadrimaculatus* (F.)**
2' Prothorax with 1 or 2 dark spots in middle ..... ***Collops balteatus* LeC.**

Collops vittatus (Say) (Fig. 21) is small, 5-7 mm in length. It is primarily dark blue, with an orange stripe at each side. The prothorax is orange and may or may not have a central dark spot. None were found in the survey, but we have occasionally seen specimens in cotton and wheat fields.

Collops quadrimaculatus (F.) (Fig. 22) is the most common of the three species in our area. It is the smallest, 4-6 mm long. Individuals are dark blue with orange areas forming a crosslike pattern on their backs. The prothorax is solid orange, never spotted. They are apparently most common during the warm months. We found them from May to October in weeds and alfalfa and from July to September in cotton. They were found throughout May in wheat. At their most common, numbers approached 4.0 per 50 sweeps in May on wheat and in August on weeds. In cotton, numbers peaked to 2.5 per 50 sweeps in August.

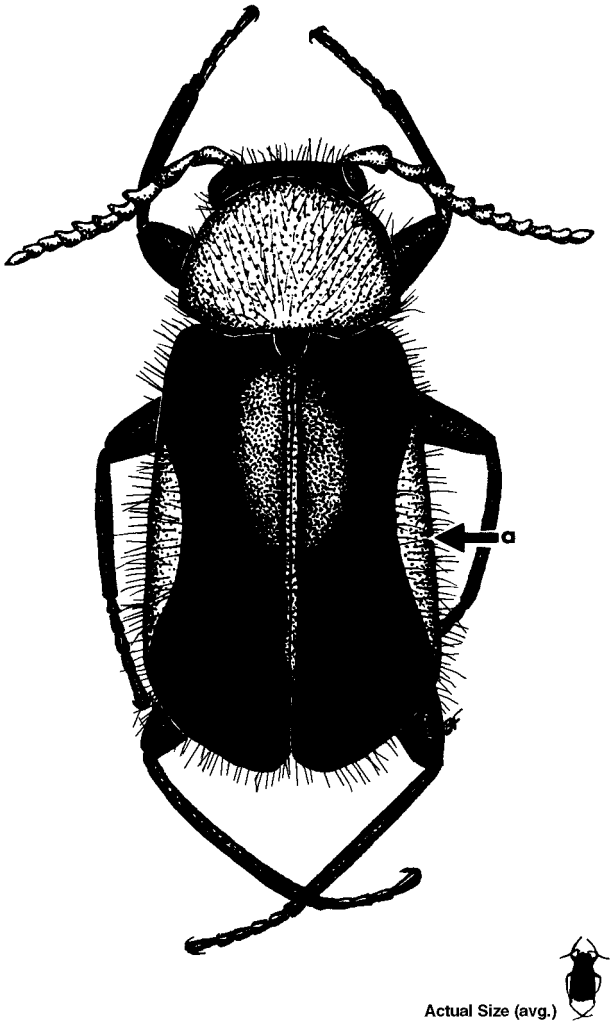

Figure 21. *Collops vittatus* (Say), a collops beetle. a. Orange lateral stripe.

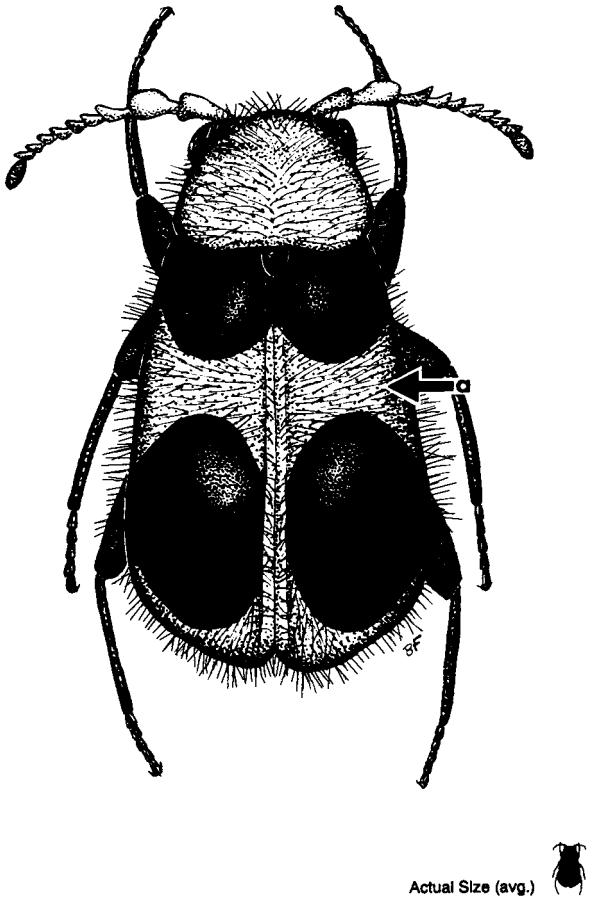

Figure 22. *Collops quadrimaculatus* (F.), a collops beetle. a. Orange horizontal stripe in middle.

Collops balteatus LeC. is a common species in Texas to our south and east, but it is apparently rare in the northern Rolling Plains. None were collected in our surveys, and only one specimen from Wilbarger County, collected on August 10, is present in our collection. It greatly resembles *C. quadrimaculatus* in color and pattern but is larger (6-7 mm) and has 1 or 2 dark spots in the center of the pronotum.

Coccinellidae

The family Coccinellidae, lady beetles, is a familiar group to almost everyone. They are small- to medium-sized, convex beetles, which are typically brightly colored, often with a pattern of spots. Although coccinellids can sometimes be confused with leaf beetles (Chrysomelidae), they can be recognized by the number of tarsal segments (the tarsi are the last set of leg segments). Lady beetles have four tarsal segments ap-

pearing as three; leaf beetles have five tarsal segments appearing as four.

Lady beetle eggs are brightly colored, typically yellow-orange, and laid in groups on plant tissue. The larvae are long and moderately flattened (Fig. 23). They are predaceous and highly mobile. The pupae (Fig. 24) are typically attached to plant tissue. They overwinter as adults.

This is one of the most important groups of predators, its members becoming very common, especially when aphids are present. Though other small prey are taken, aphids seem to be the preferred prey of most lady beetles. Nearly all lady beetles are predaceous. The only important plant-feeding pests in this group are the Mexican bean beetle and the squash beetle.

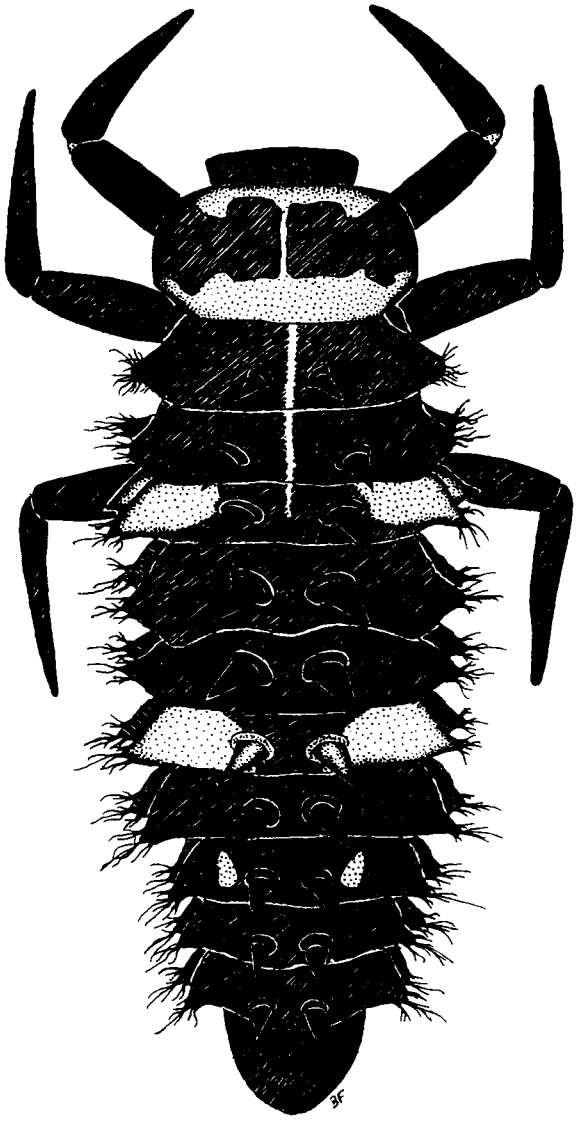

Figure 23. ***Hippodamia convergens*** **Guerin-Meneville, convergent lady beetle, larva.**

The following key is meant only to aid in the identification of our most common coccinellid species. Persons having specimens that do not pass readily through this key may wish to consult R. Gordon's *The Coccinellidae (Coleoptera) of America North of Mexico* (1985).

Key to Coccinellidae of the Northern Rolling Plains

1. Small, <3 mm; dark-colored, with dull orange at sides (Fig. 25) ..... ***Scymnus loewii*** **Mulsant**
1' Larger, >3 mm; color pattern not as above **2**
2. Black, with red spot on each elytron **3**
2' Red-orange, pinkish-orange, or tan; spots, if present, dark **4**
3. Prothorax solid black (Fig. 27) ..... ***Chilocorus cacti*** **(L.)**
3' Prothorax with white markings at sides (Fig. 28) ..... ***Olla v-nigrum*** **(Mulsant) (plagiata form)**
4. Elytra completely void of dark markings (Fig. 30) ..... ***Cycloneda munda*** **(Say)**
4' Elytra with pattern of black spots **5**
5. Color tan ..... ***Olla v-nigrum*** **(Mulsant) (abdominalis form)**
5' Color orange-red or pink **6**
6. Shape highly convex; seven spots on elytra (Fig. 31) ..... ***Coccinella septempunctata*** **(L.)**
6' Shape less convex, somewhat flattened; more than seven spots on elytra **7**
7. Color pinkish; spots large; no white spots on pronotum (Fig. 32) ..... ***Coleomegilla maculata*** **(DeGeer)**
7' Color red-orange; spots small; two white spots on pronotum (Fig. 33) ..... ***Hippodamia convergens*** **Guerin-Meneville**

Scymnus loewii Mulsant (Fig. 25) is a small (approximately 2-mm-long) lady beetle with dull-orange sides and a black center forming a "V" on the abdomen. Although this pattern is known to vary, all the specimens collected in our area conform to this description. The larvae of the lady beetle and its relatives (Fig. 26) have wax-producing glands and are covered with white, waxy filaments. As such, they are sometimes confused with mealybugs. As with most lady beetles, this species consumes aphids and probably mites as well.

Other related species (tribe Scymnini) occur in our area and share with *S. loewii* the small size, larval characteristics, and prey preferences. These related species are relatively uncommon.

Low to moderate numbers of *Scymnus* were collected in cotton from June to September, in weeds from April to September, and in wheat during April and May. Finds in alfalfa were intermittent. The population in cotton could sometimes be significant; numbers up to 7 per 50 sweeps were encountered in June and July. Numbers in wheat were consistently low, seldom exceeding one individual per 50 sweeps although nearly 4 per 50 sweeps were found in Knox County in mid-May.

Chilocorus cacti (L.) (Fig. 27) is known as the twice-stabbed lady beetle because of its two red spots. The rest of the dorsal surface is shiny black. It is highly convex and generally runs about 5 mm in length. None were collected in our surveys, but several specimens from the area are present in our collection. The primary prey is scale insects; aphids are taken but not preferred.

Olla v-nigrum (Mulsant) has two distinct forms. The *plagiata* form (Fig. 28) is black with two red spots and greatly resembles *C. cacti*. It is also called the twice-

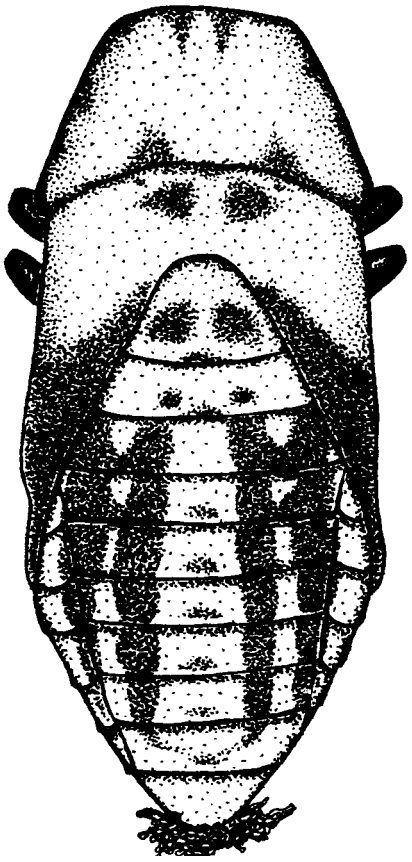

Figure 24. ***Hippodamia convergens*** **Guerin-Meneville, convergent lady beetle, pupa.**

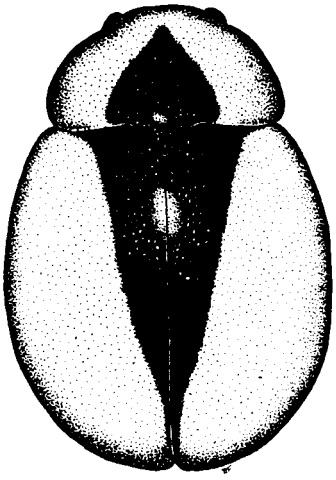

Figure 25. ***Scymnus loewii*** **Mulsant, a lady beetle.**

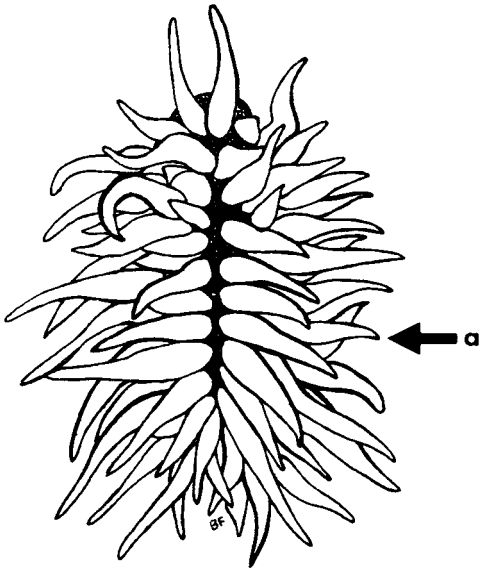

Figure 26. ***Scymnus*** **sp., a lady beetle, larva.**
a. Wax filament.

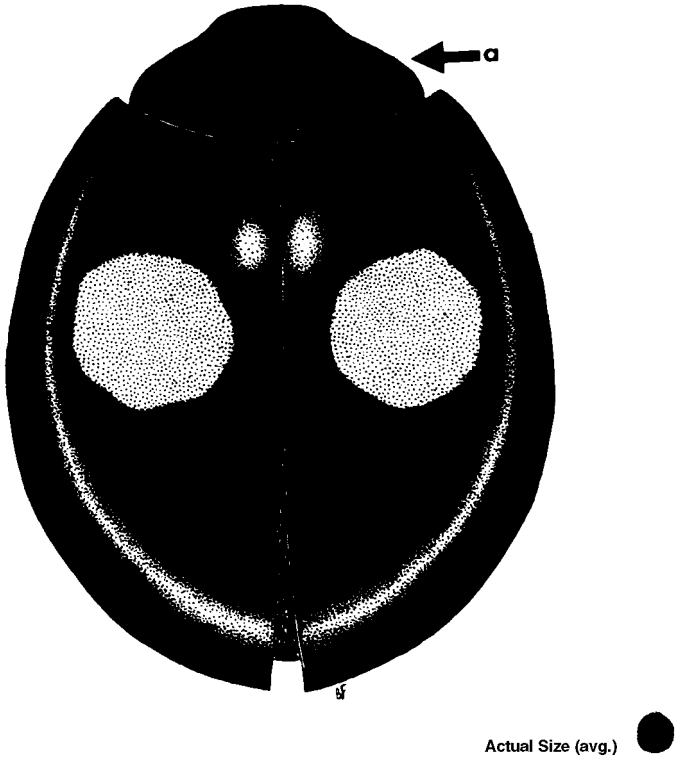

Figure 27. ***Chilocorus cacti*** **(L.), twice-stabbed lady beetle.**
a. No white markings on pronotum.

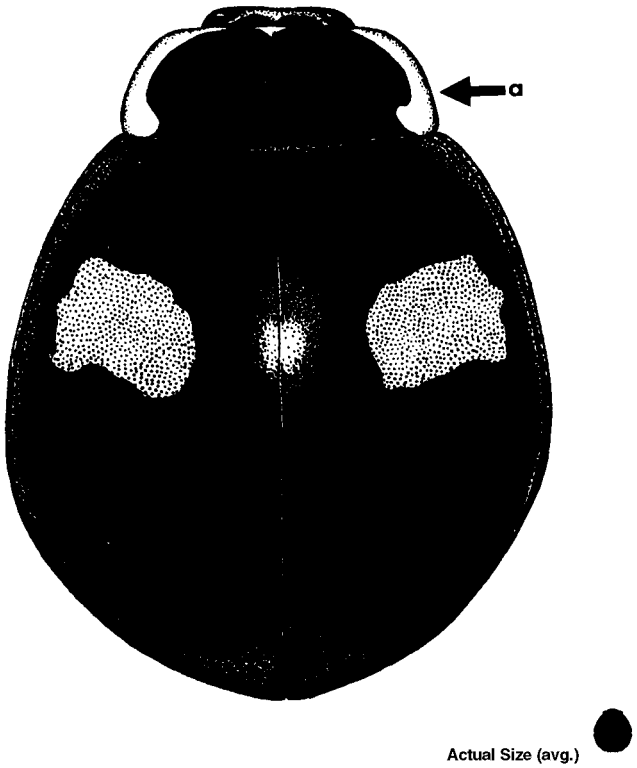

Figure 28. ***Olla v-nigrum*** **(Mulsant), twice-stabbed lady beetle.**
a. White markings on pronotum.

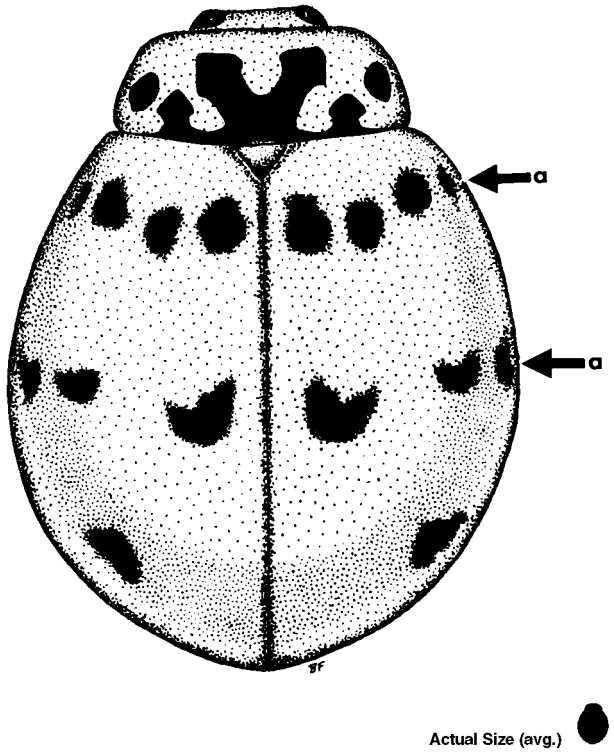

Figure 29. ***Olla v-nigrum*** **(Mulsant), ash-grey lady beetle.**
a. Two rows of dark spots.

stabbed lady beetle. However, the twice-stabbed form of *Olla* has white markings along the side of the pronotum, whereas the pronotum of *C. cacti* is completely black. *Olla* is approximately the same size as *C. cacti* but with a greater range of variation; it is not unusual to see individuals that are significantly larger or smaller than 5 mm.

The *abdominalis* form of *Olla* (Fig. 29) is known as the ash-gray lady beetle. It is comparable in size and shape to the twice-stabbed form but is tan-gray with two rows of black spots across the abdomen. Sometimes these markings become fused into one or a few large spots. Both forms feed on a variety of aphids. Low numbers of both forms were found in all crops from May to October.

Cycloneda munda (Say) (Fig. 30) is a highly convex lady beetle in which the orange-red elytra lack any sort of dark markings. The prothorax has white markings along its sides and front. It ranges in size from 4 to 6 mm. Its primary prey are aphids although it has been known to consume the eggs of various lepidopterous pests including those of cabbage looper, bollworms, tobacco budworms, and armyworms. No specimens of *C. munda* were discovered in our surveys although several specimens are present in our collection, including some taken from cotton.

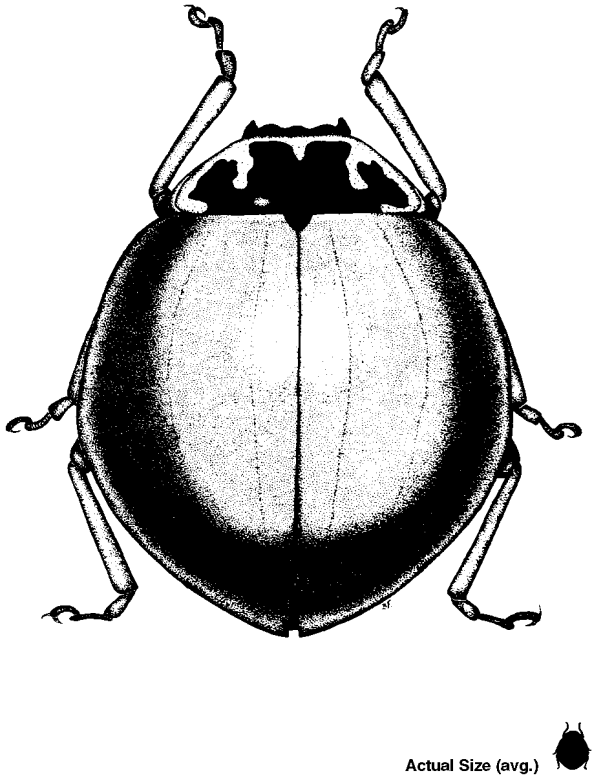

Figure 30. ***Cycloneda munda*** **(Say), a lady beetle.**

Coccinella septempunctata (L.) (Fig. 31) is known as the seven-spotted lady beetle but is often simply referred to as "C7." It was introduced from Europe repeatedly and has become established in our area. It is fairly robust, 6-8 mm long, and highly convex in shape. In addition to the seven dark spots on the orange-red elytra, there are pale areas on either side of the elytral suture where it joins the pronotum. The pronotum is black with white markings anteriorly. This species is primarily a predator of aphids. We found them only in cotton from July to September, suggesting a preference for warmer conditions. While only one was found in 1988, considerably more were encountered in 1989. They may still be in the process of colonizing our region.

Coleomegilla maculata (DeGeer) (Fig. 32) is called the spotted lady beetle. It is different from most other lady beetles in its being pinkish, rather than reddish-orange. The spots are large and sometimes join, creating a diversity of patterns. Individuals range in size from 4 to 8 mm long and are somewhat flattened. They primarily feed upon aphids although they may

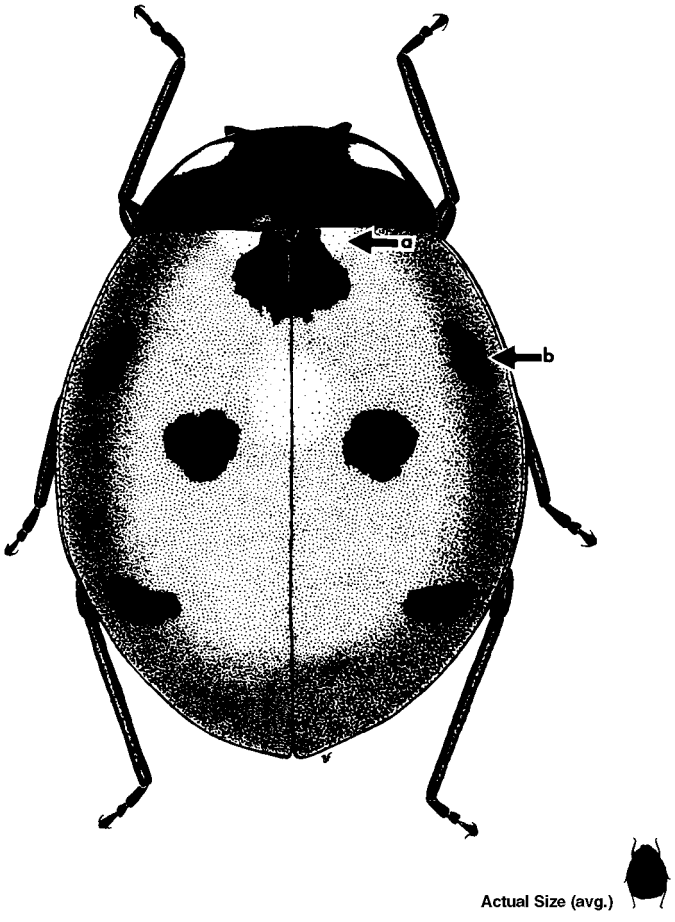

Figure 31. ***Coccinella septempunctata*** **(L.), seven-spotted lady beetle.**
- **a. Light region to side of elytral suture at pronotum.**
- **b. Seven spots.**

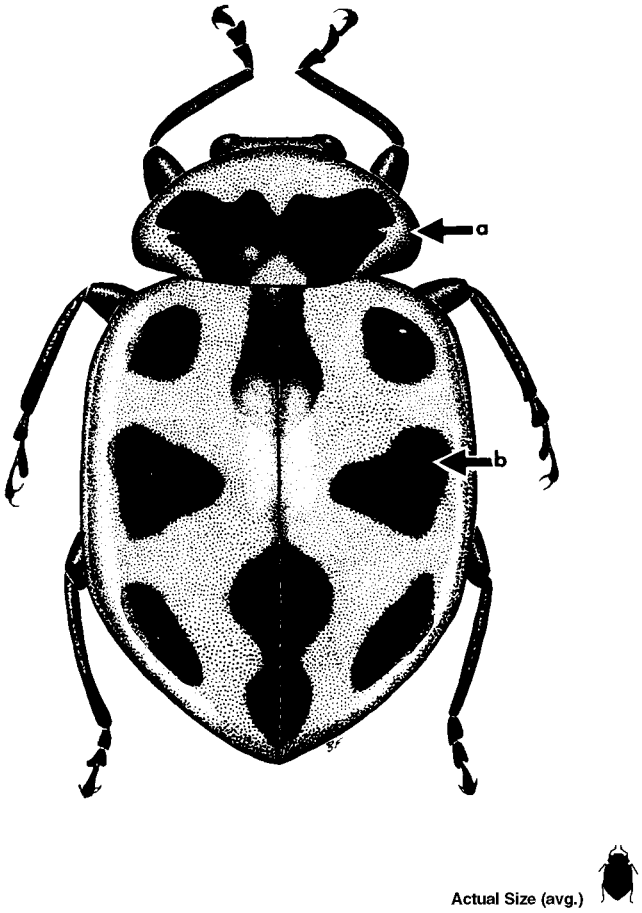

Figure 32. ***Coleomegilla maculata*** **(DeGeer), spotted lady beetle.**
- **a. No white markings on pronotum.**
- **b. Large spots.**

supplement their diets with pollen. They are also known to eat the eggs of lepidopterous pests including bollworm, cabbage looper, cotton leafworm, and various armyworms. None were collected in our survey although many are in our collection; we have encountered them in cotton.

Hippodamia convergens Guerin-Meneville, (Fig. 33) is known as the convergent lady beetle because the two white spots on the pronotum are not parallel. It is without doubt the most important and common lady beetle in the northern Rolling Plains. They range from 4 to 7 mm in length and have small black spots on the elytra. In some individuals, the spots are reduced or absent, but the pronotal pattern remains constant.

H. convergens seems to prefer aphids but is also noted for being an efficient predator of moth eggs, notably bollworm and tobacco budworm. Each individual is able to consume as many as 12 eggs per day; young caterpillars are also eaten.

Numbers of *H. convergens* seem closely tied to aphid populations. When aphid numbers are high, numbers of convergent lady beetles tend to be large, so it seems

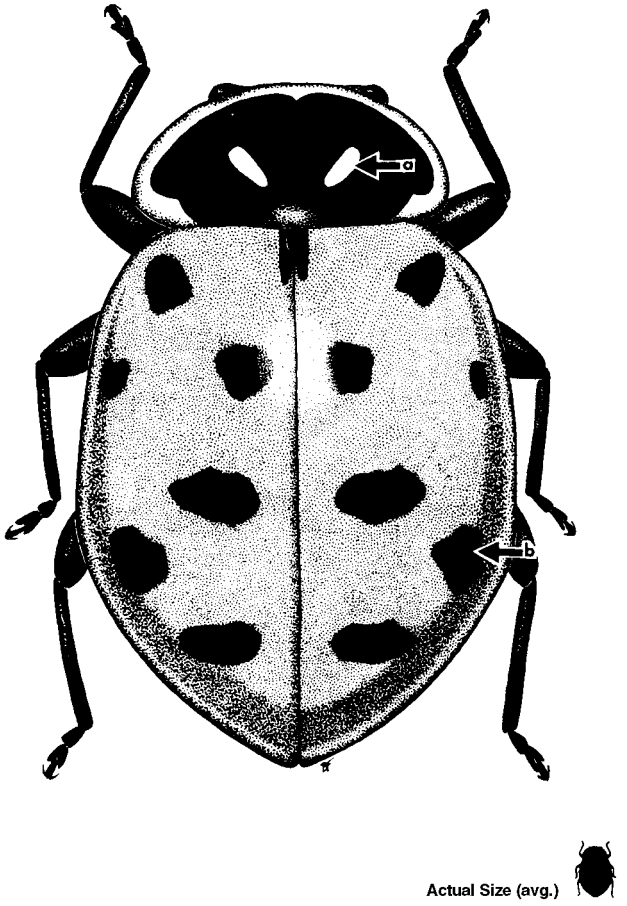

Figure 33. ***Hippodamia convergens*** **Guerin-Meneville, convergent lady beetle.**
a. Convergent white spots on pronotum.
b. Small spots.

that *H. convergens* can respond quickly and efficiently to aphid outbreaks. When aphid numbers are low, convergent lady beetles supplement their diets with pollen and nectar.

Present and active year-round, *H. convergens* is one of the few truly abundant predators in the northern Rolling Plains. We detected them from April to November in weeds, from April to December in alfalfa, from July to November in cotton, and from December to May in wheat. Weeds seem to be a good shelter for this species. Numbers as high as 9 per 50 sweeps were detected in May and June; numbers then dropped as the weather became warmer and rose again in September. In wheat, they were most common in May, where populations as high as 27 per 50 sweeps were recorded. They were present in cotton throughout the growing season; numbers ranged from less than 1 to 8 per 50 sweeps although a count of 27 per 50 sweeps was noted in late June.

Other species of *Hippodamia* occur in our area but are considerably less common. *H. glacialis* (F.) is similar to *H. convergens* in size and appearance but lacks dark markings on the anterior half of the elytra and has larger dark markings on the posterior half. *H. parenthesis* (Say) is also similar, but it lacks the pair of white spots on the pronotum and has larger markings on the elytra. The posterior spots form a pattern resembling a pair of parentheses.

Anthicidae

Members of the genus *Notoxus*, family Anthicidae (Fig. 34), often called hooded beetles, can be common in cotton fields. They are small (approximately 3 mm in length) tan beetles with black patches on the elytra. Their most outstanding feature is the pronotum, which projects forward over the head. As common as they are, little is known about their biology. They are thought to be at least partly predaceous, consuming bollworm eggs and other insect material in addition to the secretions from nectar glands of cotton. This group was not included in our survey.

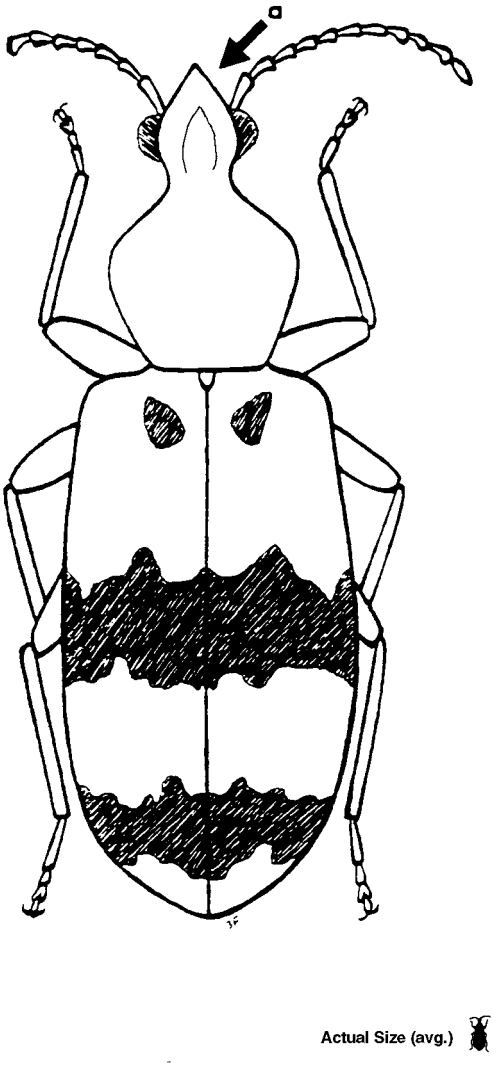

Figure 34. ***Notoxus*** **sp., a hooded beetle.**
a. Pronotum pointed anteriorly, extends above head.

OTHER PREDATORS

Many types of predaceous insects exist that are not associated with agricultural situations. Although they are sometimes encountered in such areas, they seldom, if ever, have an impact upon pest populations. Examples of this group include dragonflies, various wasps, and preying mantids. None of these insects were encountered in our surveys.

Another group, which at least merits mention, includes normally plant-feeding species that sometimes eat the eggs of other insects, notably those of tobacco budworm and bollworm. This group includes various crickets and grasshoppers, as well as several species of true bugs discussed in the section on Hemiptera.

Thysanoptera

Thrips, of the order Thysanoptera, are extremely small (less than 2 mm), delicate insects. They have highly modified mouthparts, described as "piercing-rasping," which are designed to break the surface of cells and suck out their contents. Although most thrips are plant feeders, many are predaceous.

Large numbers of thrips can develop where the food supply is good, typically in flowers where pollen is plentiful. Thrips can also be abundant in other situations, such as in seedling cotton. Where large numbers of plant-feeding thrips are present, there tends to be a corresponding population of predatory thrips.

Two species of predatory thrips may occur in our area: the banded-winged thrips, *Aeolothrips fasciatus* (L.) (family Aeolothripidae), and the six-spotted thrips, *Scolothrips sexmaculatus* (Pergande) (family Thripidae). Both species are minute, slender, and dark with light spots on the wings. They are difficult to tell apart in the field but can be easily separated from the lighter colored plant-feeding species.

We encountered few predaceous thrips in our surveys, suggesting either that our survey was inadequate in detecting them or that they are simply rare here. We suspect that they are rare here because close examination of hundreds of seedling cotton plants at peak thrips densities revealed no predatory thrips. According to our findings, predaceous thrips probably have no beneficial impact on agriculture in the northern Rolling Plains.

Formicidae

Some ants (family Formicidae, order Hymenoptera) are regarded as pests because they defend from predators such honeydew-producing pests as scale insects and aphids. Other ants, notably those in the genus *Solenopsis* (the fire ants) have been proven to be highly effective predators in cotton fields, where they reduce the numbers of boll weevil larvae and callow adults in open bolls. Few other predators are effective in reducing populations of boll weevils. In southern and eastern Texas, the principal species is *S. invicta* Buren, the red imported fire ant (Fig. 35). This ant is considered a pest because of its noxious habits. The red imported fire ant is known only from a few isolated populations in the Rolling Plains. It is replaced in our area by the native species *S. xyloni* McCook, the southern fire ant, which is small (typically 2-3 mm), varying in color from golden to red to almost black. Southern fire ants form open, flat mounds having many entrances. Although they do sting, the southern fire ant does so less aggressively than the red imported fire ant.

Fire ants are easily separated from other ants by their antennal configuration: 10-segmented antennae, the last 2 segments being swollen and forming a club. It is difficult to tell species of fire ants apart. Ants were not included in our survey, because of their ground-dwelling habits and the difficulty in performing field identifications.

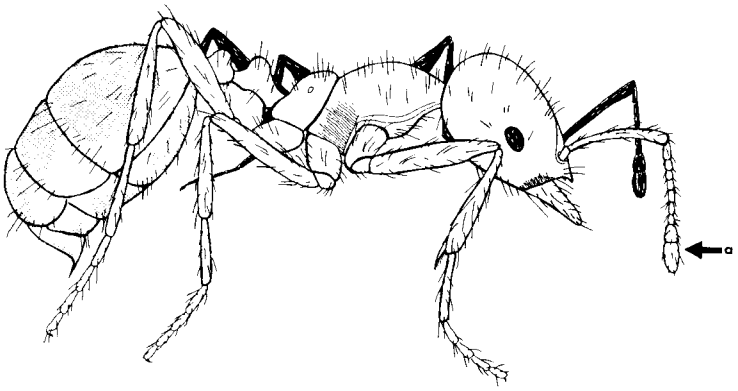

Figure 35. *Solenopsis invicta* Buren, red imported fire ant. a. Ten-segmented antennae (two-segmented club).

Neuroptera

Of all the predators discussed in this "miscellaneous" section, lacewings (order Neuroptera) are by far the most important in our area. Two main types exist here.

Brown lacewings (family Hemerobiidae) (Fig. 36) are the smaller and rarer of the two. The adults have brownish, semitransparent wings and beaded antennae. Both adults and larvae are predaceous. The eggs are laid directly on plant material. Larvae are not commonly seen. They tend to hide from view and to place debris on their backs in an effort to camouflage themselves. Few brown lacewings were found in our surveys. A high of nearly 3 per 50 sweeps was recorded in wheat in early May. Low numbers were intermittently found in cotton from July to November.

Green lacewings (family Chrysopidae) (Fig. 37) are larger (1-2 cm) and much more common, especially in agricultural areas. They have clear wings, and the body color is typically a bright green. The adults have thread-

like antennae. Eggs are laid atop stalks, singly or in groups, depending upon the species (Fig. 38). Larvae (Fig. 39) are flat, long, and grayish. They are highly mobile and actively hunt prey. The prey are caught and subdued with the large, sickle-shaped mandibles. Each mandible has a hole in the tip, through which the prey's body fluids are sucked. The mature larva spins a round silken cocoon (Fig. 40), which is fastened to the plant. A few adult green lacewings are predaceous, but most feed only upon honeydew, nectar, and pollen. The adults are typically nocturnal. The casual observer often finds them at lights, where they are commonly attracted. This habit, along with the foul-smelling liquid emitted by many species when handled, makes this group familiar to most people. Green lacewings overwinter in the adult stage.

The principal prey of green lacewings is aphids, but mites, whiteflies, and small caterpillars are eaten also. Green lacewings are known to be effective predators of bollworm and tobacco budworm eggs and to reduce their populations greatly.

In our survey, low numbers of green lacewings were consistently detected in all crops throughout the year. The numbers collected varied greatly from date to date. The population in wheat peaked in April and May; a maximum of 4 per 50 sweeps was found. The population in cotton was stable throughout the summer and fall; numbers ranged from 1 to 10 per 50 sweeps. Encounters with green lacewings in weeds and alfalfa were less frequent, although many (4-9 per 50 sweeps) occurred in alfalfa through late August and September.

A survey of the members of the order Neuroptera present in north-central Texas was conducted by Vogtsberger (1990) in 1988 and 1989. The area he defined as "north-central Texas" includes the northern Rolling Plains area covered in our work. In contrast to the methods used in our survey, he relied upon light trapping as his primary means of gathering specimens. He found specimens of brown lacewings and green lacewings throughout the year with peak populations detected in August and September. While there only seemed to be the one late summer peak with the brown lacewings, he found an additional population peak among some species of green lacewings in March and April.

Vogtsberger found 10 species of brown lacewings in 3 genera. Of these, he defined *Micromus subanticus* (Walker) as the most abundant species in the area with *Sympherobius amiculus* (Fitch) second. He identified 13 species of green lacewings in 7 genera. Of these, *Chrysoperla carnea* (Stephens) was by far the species most commonly encountered. *Chrysoperla rufilabris* (Burmeister), *Chrysopa quadripunctata* Burmeister, *Chrysopa oculata* Say, *Chrysopa nigricornis* Burmeister

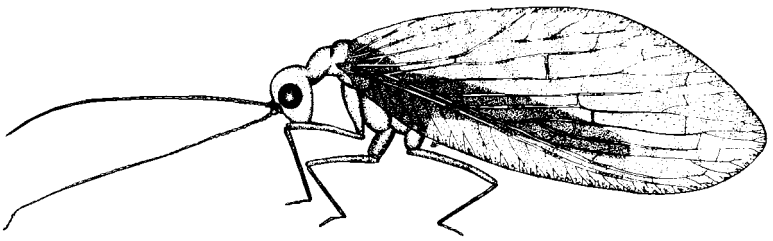

Figure 36. Hemerobiidae, a brown lacewing.

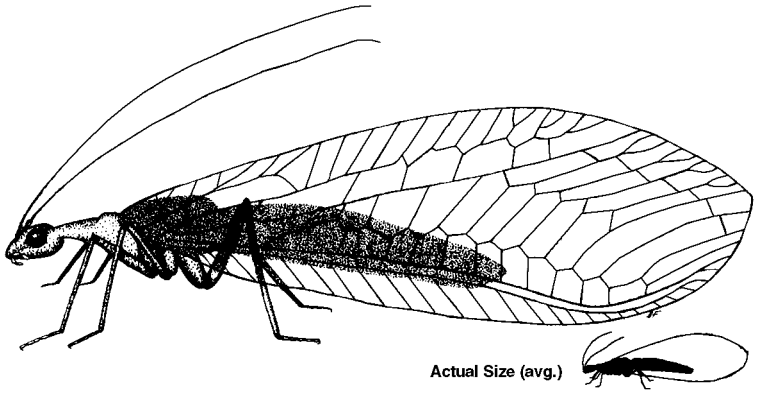

Figure 37. Chrysopidae, a green lacewing.

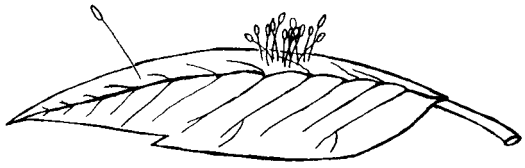

Figure 38. Chrysopidae, a green lacewing, eggs on leaf.

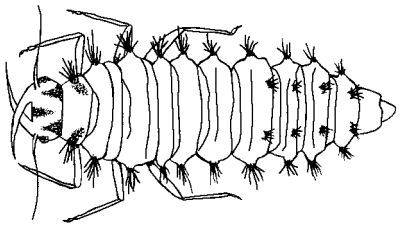

Figure 39. Chrysopidae, a green lacewing, larva.

Figure 40. Chrysopidae, a green lacewing, pupa.

and *Eremochrysa punctinervis* (McLachlan) were also encountered with comparative regularity.

Identification of lacewings to the level of species and even genus is quite difficult because much of the taxonomy is based upon differences in wing venation and male genitalia. With brown lacewings, few field characters exist to separate species. Among the green lacewings in our area, some color differences occur. For example, *Eremochrysa punctinervis* (McLachlan) has an overall brownish color which is in contrast with the greenish tint of our other species. This insect is also noted for its spotted wing venation. *Chrysopa quadripunctata* Burmeister has orange spotting, to varying degrees, on its dorsal surfaces. *Chrysopa nigricornis* Burmeister is often distinguished by its large size and by its antennae, the basal one-quarter of which are darkly colored. *Chrysopa oculata* Say is often known as the "golden-eyed lacewing" for the obvious reason. It also stands out from other lacewings because of the elaborate but variable pattern of black markings on its face. *Chrysoperla carnea* (Stephens) is often known as the "common green lacewing". It usually has a pale line running along its upper surface. Members of this species frequently turn brownish during overwintering. *Chrysoperla rufilabris* (Burmeister) resembles *C. carnea* in having a light dorsal stripe, but is distinguished from that species by having some degree of reddish marking on its face. It may lighten during the winter but does not turn overtly brownish. These field characters may be used only very broadly as there is great variability among the features mentioned. Fortunately, precise identification of members of this group is not generally required in the field because all of our species function similarly as beneficial predators.

Syrphidae

Syrphids are flies (order Diptera). In the species of agricultural interest, the eggs are laid on leaves near aphids. The larvae, a type of maggot (Fig. 41), live on plant leaves, where they feed on aphids. They may be recognized by their often large size (about 1 cm), their light greenish to mottled brown coloration, and by the fact that they have no head or legs. In the usual overwintering stage, the hardened puparium (Fig. 42) is fastened to the plant. Fig. 43 shows a typical adult syrphid. It should be noted that there is a great deal of diversity within this family with respect to color, size and shape. In most species found in fields in the Rolling Plains, the adults are housefly-sized, shiny black-and-yellow flies, which are frequently seen hovering around plants. This behavior has given rise to a frequently applied name, "hover flies." Many, because of their coloration and behavior, are considered mimics of bees and wasps. They are nectar feeders.

Syrphid maggots can sometimes be common in agricultural areas, especially when large numbers of aphids are present, although we found few in our 1988-89 surveys. This may be as much due to sampling error as to their relative scarcity in our area. Although not quantified, our informal surveys in 1993 seemed to produce more syrphids, both adults and larvae. This may be due to the fact that cotton aphids have been considerably more abundant in the last several years.

This is a large group and identification of genera and species is difficult. Virtually all syrphid flies fitting the description and habits outlined above which are found in agricultural settings in the Rolling Plains may be assumed to be aphid predators and, therefore, beneficial.

Figure 41. Syrphidae, a syrphid fly, larva.

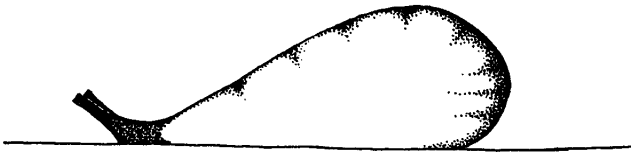

Figure 42. Syrphidae, a syrphid fly, pupa on leaf surface.

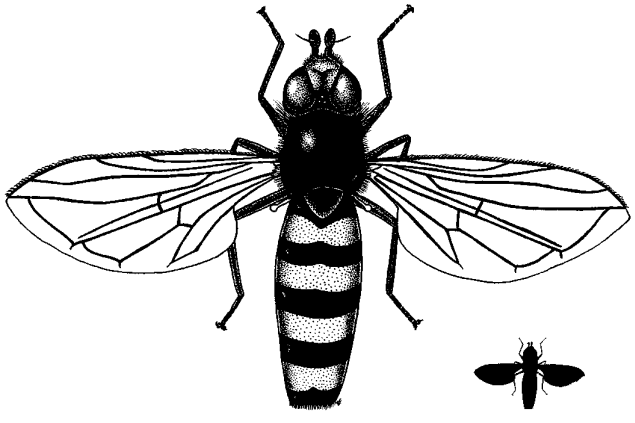

Figure 43. Syrphidae, a syrphid fly.

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