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Minute Pirate Bugs (Hemiptera: Anthocoridae)

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Without Abstract

Insects in the family Anthocoridae are referred to as minute pirate bugs or flower bugs. Pirate bugs occur worldwide and occupy a variety of natural and disturbed habitats. All but a few species are predaceous, feeding on small soft-bodied arthropods from a variety of taxonomic groups. Pirate bugs contribute to biological control of pest arthropods in a wide variety of habitats, including orchards, row crops, forests, ornamental plants, greenhouses, and granaries.

Classification and Distribution of the Anthocoridae

The family Anthocoridae includes between 500ï 600 species in 80ï 100 genera worldwide. The systematic position of the Anthocoridae and close relatives remains somewhat unsettled, and there is a distinct need for additional taxonomic and phylogenetic work. Diversity of Anthocoridae tends to be highest in the tropics and the Holarctic Region. Thorough faunistic studies for some geographic regions are lacking, and estimates of diversity will require revision as these studies are done. Checklists for the North American fauna, including information on distribution, are available in publications by Kelton, Henry, and Maw et al. Citations for these works are provided at the end of this chapter. Keys to many North American species are available in Blatchley and Kelton.

The discussion of classification and distribution to be presented here is based on treatments by Cassis and Gross, Schuh and ġtys, Schuh and Slater, Carayon, and Ford (full citations follow at the end of this article). The Anthocoridae are found in the infraorder Cimicomorpha within the suborder Heteroptera (ñtrue bugsò). Classification of the Anthocoridae has seen extensive study and revision since the family was erected in the 1800s, particularly with reference to placement of related families such as the bed bugs (Cimicidae), bat bugs (Polyctenidae), and web lovers (Plokiophilidae), but also with respect to higher level groupings of taxa within the Anthocoridae. Three modern treatments of the pirate bugs allocate genera among seven or eight tribes (Table 9). Carayon, and Cassis and Gross include three subfamilies (Lasiochilinae, Lyctocorinae, Anthocorinae) within the family Anthocoridae. Schuh and Slater elevate the Lasiochilinae and Lyctocorinae to family rank, following the phylogenetic analysis of Schuh and ġtys. Four tribes included within the Lyctocorinae by Carayon (i.e., the Almeidini, Cardiastethini, Scolopini, and Xylocorini) are placed in the Anthocorinae by Cassis and Gross, or in the Anthocoridae by Schuh and Slater. Carayonôs Cardiastethini is considered a junior synonym of Dufouriellini Van Duzee in both the Schuh and Slater treatment and in the Cassis and Gross treatment, following the assessment of ġtys. Péricart used Carayonôs classification in his summary and checklist of the Palaearctic Anthocoridae. I follow the Schuh and Slater scheme throughout this article. Because of the close taxonomic affinity among the Lyctocoridae, Lasiochilidae, and Anthocoridae ï and because taxonomic rank for these groups is still open to discussion ï the present article will not be limited

to the Anthocoridae, but will include as necessary reference also to the Lyctocoridae and Lasiochilidae.

Minute Pirate Bugs (Hemiptera: Anthocoridae), Table 9 Comparison of three classification schemes for the pirate bugs and relatives, including representative genera

Carayon	Cassis and Gross	Schuh and Slater
Anthocorinae	**Anthocorinae**	**Anthocoridae**
Anthocorini	Almeidini	Almeidini
Acompocoris Reuter	*Almeida*	*Almeida*
Anthocoris Fallén	Anthocorini	Anthocorini
Coccivora McAtee áamp; Malloch	*Acompocoris*	*Acompocoris*
Elatophilus Reuter	*Anthocoris*	*Anthocoris*
Macrotrachelia Reuter	*Coccivora*	*Coccivora*
Temnostethus Fieber	*Elatophilus*	*Elatophilus*
Tetraphleps Fieber	*Macrotrachelia*	*Macrotrachelia*
Blaptostethini	*Temnostethus*	*Temnostethus*
Blaptostethus Fieber	*Tetraphleps*	*Tetraphleps*
Oriini	Blaptostethini	Blaptostethini
Bilia Distant	*Blaptostethus*	*Blaptostethus*
Macrotracheliella Champion	Dufouriellini	Dufouriellini
Montandoniola Poppius	*Amphiareus*	*Amphiareus*
Orius Wolff	*Brachysteles*	*Brachysteles*
Paratriphleps Champion	*Buchananiella*	*Buchananiella*
Wollastoniella Reuter	*Cardiastethus*	*Cardiastethus*
Lasiochilinae	*Dufouriellus*	*Dufouriellus*
Lasiochilus Reuter	Oriini	Oriini
Lyctocorinae	*Bilia*	*Bilia*
Almeidini	*Macrotracheliella*	*Macrotracheliella*
Almeida Distant	*Montandoniola*	*Montandoniola*
Cardiastethini	*Orius*	*Orius*
Amphiareus Distant	*Paratriphleps*	*Paratriphleps*
Brachysteles Mulsant áamp; Rey	*Wollastoniella*	*Wollastoniella*
Buchananiella Reuter	Scolopini	Scolopini
Cardiastethus Fieber	*Calliodis*	*Calliodis*
Dufouriellus Kirkaldy	*Nidicola*	*Nidicola*
Lyctocorini	*Scoloposcelis*	*Scoloposcelis*
Lyctocoris Hahn	Xylocorini	Xylocorini
Scolopini	*Xylocoris*	*Xylocoris*
Calliodis Reuter	**Lasiochilinae**	**Lasiochilidae**
Nidicola Harris áamp; Drake	*Lasiochilus*	*Lasiochilus*
Scoloposcelis Fieber	**Lyctocorinae**	**Lyctocoridae**
Xylocorini	*Lyctocoris*	*Lyctocoris*

Xylocoris Dufour		

Modification of a table in Cassis and Gross

Family Anthocoridae – Tribe Almeidini

This is a poorly known group with few described species, known from the Old World tropics, Japan, Nepal, and Australia.

Anthocorini

The Anthocorini is a highly speciose group found primarily in temperate areas. Members of this group include a number of species important in biological control, particularly in orchards and coniferous forests. The most well known of these insects are in the genus *Anthocoris*, which includes over 50 described species found commonly in temperate regions. Species in the Anthocorini feed on phytophagous arthropods primarily in the canopies of deciduous or coniferous trees, or on the foliage of deciduous shrubs.

Blaptostethini

This is a poorly known group of about seven described species known primarily from the Oriental and Pacific regions.

Dufouriellini

The Dufouriellini is a large group of species whose systematic affinities remain somewhat uncertain. The Dufouriellini are well represented in the Neotropical, Australian, and Palaearctic regions. *Cardiastethus* is the most common genus, comprising about 40 described species having a wide distribution.

Oriini

The Oriini contains the geographically widespread and well-known genus *Orius*, having approximately 70 described species. This group has strong representation in the Oriental, Ethiopian, Palaearctic, and Neotropical regions, but is relatively poorly represented in the Nearctic. The Oriini includes a number of species important in biological control of pests on row crops, in greenhouses, and on ornamental plants.

Scolopini

The Scolopini include at least 13 genera distributed primarily in the Neotropical Region, but with at least some representation in most areas of the world. Species of *Scoloposcelis* are important predators of bark-feeding Coleoptera.

Xylocorini

The Xylocorini occur virtually worldwide, but have heavy representation in the Palaearctic and Nearctic regions. This tribe includes a single genus, *Xylocoris*, having about 40 described species. Species of *Xylocoris* are sources of biological control in stored products, granaries, and beneath the bark of trees. *Xylocoris flavipes* (Reuter) is a geographically widespread species which has been introduced into a number of regions apparently by human commerce.

Family Lasiochilidae

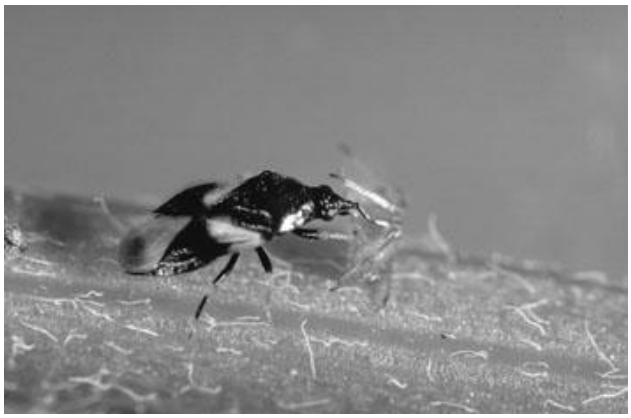
The Lasiochilidae are a poorly studied group with species occurring in most geographic regions, but having the strongest representation in the Neotropical Region and on Pacific islands; the family is virtually absent from the Palaearctic. *Lasiochilus* is composed of approximately 50 described species having a relatively wide distribution. Members of this family are small (3ï 4 mm), and occur on the ground in litter, under the bark of trees, or on plant surfaces.

Family Lyctocoridae

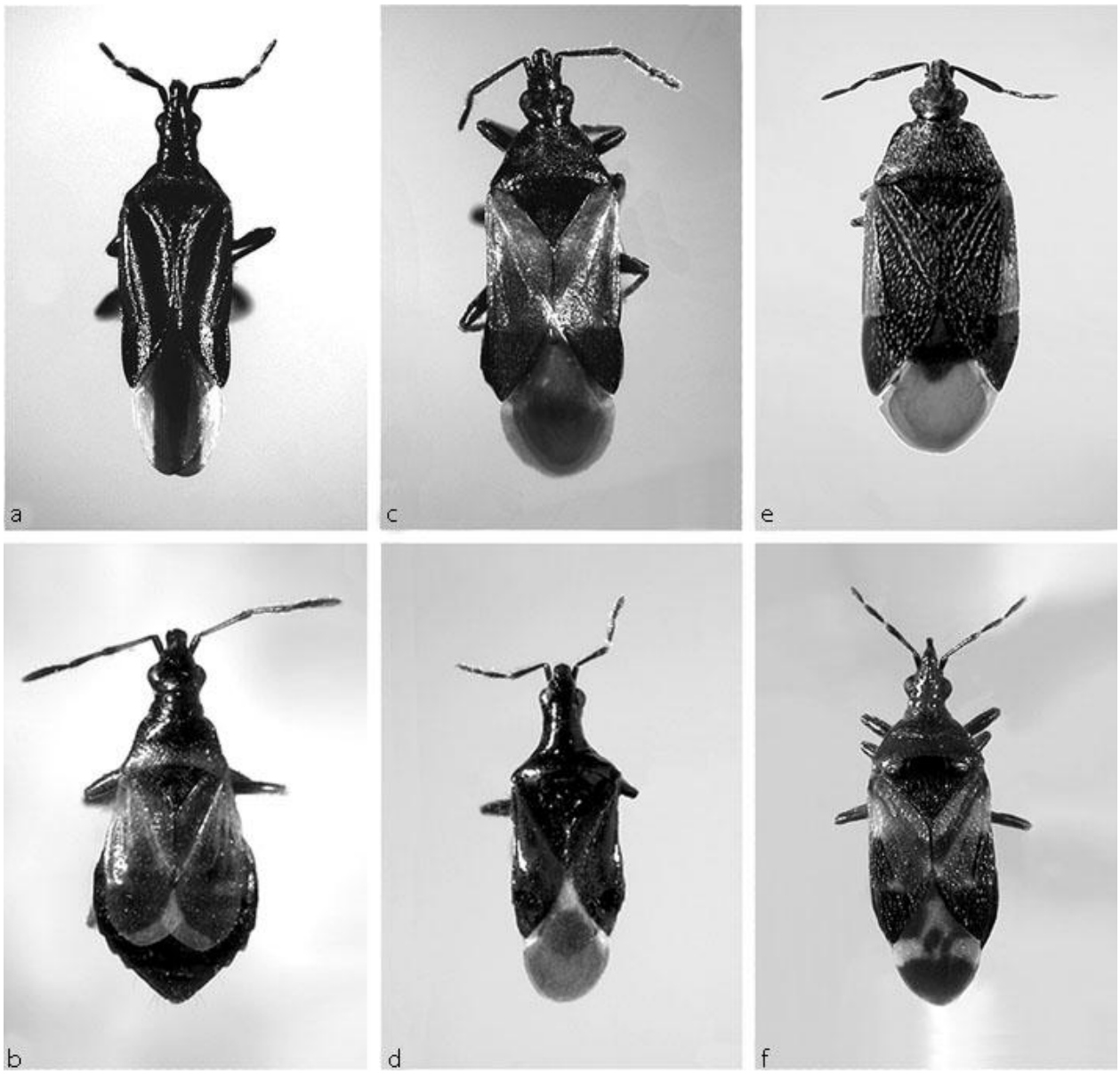
The Lyctocoridae are widely distributed, but with a strong presence in temperate regions. One species, *Lyctocoris campestris* (Fabricius), is essentially cosmopolitan, likely because of unintentional introductions outside of its native range. Members of this family can be found in a number of habitats, including in stored products, in decaying vegetation, beneath bark, and in the nests of birds or mammals.

Morphology

Members of the Anthocoridae are relatively small (1.5ï 5 mm), having an oval or elongate-oval shape (Figs. 55 and 56). Most are brownish in general coloration. Wing markings or shadings give some species a checkered appearance. The body is generally somewhat flattened, and may be either glabrous or pubescent. The head extends horizontally, with large compound eyes on each side. Paired ocelli are present near the eyes in the adult (ocelli are not present in nymphs). Antennae are four-segmented and inserted anterior of the eyes. Mouthparts are of the piercing-sucking type, in the form of a slender beak or labium. The labium has three visible segments, and may be short or quite long (in some species extending to the end of the abdomen). The labium serves to house the four piercing stylets (paired mandibles and paired maxillae), which collectively form the two channels through which digestive enzymes and the ingested food products are moved. The pronotum is trapezoidal, bearing paired callosities that are prominent in some species and inconspicuous in other species. Anthocorids have two pairs of wings: the membranous hind wings, and the thickened forewings (hemelytra) that are characteristic for the true bugs. Most members of the family have fully sized wings, although there are species in some genera (e.g., *Xylocoris*, *Temnostethus*, *Anthocoris*, and *Elatophilus*) that exhibit brachyptery. The forewing has a triangular cuneus, unlike what is found in many other Heteroptera. Genitalia in the male are asymmetrical (discussed below). The ovipositor is well-developed in most species, but is greatly reduced in some taxa (e.g., *Cardiastethus*).



Minute Pirate Bugs (Hemiptera: Anthocoridae), Figure 55 A common North American pirate bug, *Orius tristicolor* (White) (Oriini) (photograph by Jack Kelly Clark, courtesy of University of California Statewide IPM Program).



Minute Pirate Bugs (Hemiptera: Anthocoridae), Figure 56 Some Anthocorini and Oriini. (**a**) *Macrotrachelia* sp. (possibly *M. nigronitens* (Stål)) (Anthocorini), length approximately 3.3 mm excluding antennae; (**b**) brachypterous *Anthocoris dimorphicus* Anderson & Kelton (Anthocorini), 2.9 mm; (**c**) *Elatophilus* sp. (Anthocorini), 3.1 mm; (**d**) *Macrotracheliella nigra* Parshley (Oriini), 2.4 mm; (**e**) *Melanocoris nigricornis* Van Duzee (Anthocorini), 3.1 mm; (F) *Anthocoris nemoralis* (Fabricius) (Anthocorini), 3.5 mm.

Specimens of Anthocoridae may resemble insects from other families of Heteroptera, including especially members of the Miridae. Morphological characteristics in the Anthocoridae that can be used to separate them from other Heteroptera include: two ocelli; labium with three visible segments; generally an absence of pronounced veins in the hemelytral membrane; presence of a cuneus; and presence of asymmetrical genitalia in males. Insects within the Lasiochilidae, Lyctocoridae, and Anthocoridae may often be very similar in appearance. Placement of specimens in the correct family may require access to faunistic treatments that include keys for identifying genera and species, from which family affiliation can then be derived. Examination of genitalia may be necessary in some cases to confirm or to ascertain family affiliation.

Biology and Life History

Members of the Anthocoridae, Lasiochilidae, and Lyctocoridae are predaceous on small soft-bodied arthropods in a variety of natural or managed habitats. Many species prey upon herbivorous arthropods that attack forbs, shrubs, or trees. Important prey taxa include aphids, psyllids, mites, thrips, scale insects, psocids, and eggs or small larvae of Lepidoptera, Coleoptera, and Diptera. Species of *Orius* are commonly associated with flowers of herbaceous plants, where they feed extensively on thrips and other small arthropods. A number of genera in the Anthocorini (*Melanocoris* Champion, *Tetraphleps*, *Elatophilus*) occur exclusively on coniferous trees, where they feed on aphids and scale insects. Species of *Anthocoris* are common on deciduous trees and shrubs, and prey extensively on psyllids, aphids, and other soft-bodied arthropods. *Scoloposcelis*, *Xylocoris*, and *Lyctocoris* are often found beneath the bark of trees feeding on eggs and larvae of bark beetles. *Xylocoris* and *Lyctocoris* also occur in stored products and granaries, in nests of birds or mammals, in poultry houses, in decaying plant litter, in manure piles, under tree bark, or in ant nests. *Lyctocoris campestris* may occasionally feed on the blood of mammals, including on humans. *Nidicola marginatus* Harris & Drake has been collected from guano beneath roosting bats.

Anthocoridae may often supplement their diets with pollen or plant juices. Species of *Orius* occur commonly in the flowers of herbaceous vegetation, and are known to supplement their diets with pollen. *Orius pallidicornis* (Reuter) appears to have an exclusively plant diet, feeding on pollen from a limited number of species. *Paratriphleps laeviuscula* Champion is a Central and South American species now known to occur in Florida, where it inhabits the flowers of sapodilla (*Manilkara zapota*) and feeds on pollen. Species of *Anthocoris* and *Orius* are known to accumulate systemic insecticides from root-treated plants, due to their habit of ingesting plant juices.

Diet breadth in the Anthocoridae shows a range from highly generalized species to highly specialized species. The generalist species *Anthocoris nemoralis* (Fabricius) has been recorded from over 20 plant genera in Europe and from 13 plant genera in North America, with the latter records occurring only since 1958 following the accidental and intentional introductions of this predator into the Nearctic. *Anthocoris antevolens* White, a widespread North American species, has been recorded from well over 20 plant genera. Species such as *Orius tristicolor* (White) and *Orius insidiosus* (Say) occur on the flowers of a diverse number of plant species, apparently because a primary prey species, the western flower thrips (*Frankliniella occidentalis* (Pergande)), is itself highly generalized. *Lyctocoris campestris* occurs in a variety of habitats, including compost piles, moldy grain, beneath leaf or straw litter, birds nests, mammal burrows, or beneath the bark of trees.

In contrast, many other Anthocoridae show highly restricted diets. Several species of *Anthocoris* reproduce largely or entirely on a few plant species (e.g., *A. gallarumulmi* (De Geer) on elm [*Ulmus*], *A. bakeri* Poppius on manzanita [*Arctostaphylos*], *A. sarothamni* Douglas & Scott on broom [*Cytisus*], *A. dimorphicus* Anderson & Kelton on willow [*Salix*], and *A. visci* Douglas on mistletoe [*Viscum*]). Presumably, the limited host plant range reflects some type of diet specialization (*A. bakeri*, for example, appears to prey extensively on aphids that gall *Arctostaphylos*). Other Anthocoridae are restricted to a few related plant species, and include species of *Melanocoris* (restricted to *Pinus* and *Picea*), *Elatophilus* (restricted to *Pinus*), and *Acompocoris* (*Pinus* and *Picea*). Species of *Elatophilus* often appear to occur in association with scale insects (*Matsucoccus* Cockerell) occurring on *Pinus*; some *Elatophilus* species are attracted to the sex pheromones of *Matsucoccus* scale insects. *Brachysteles parvicornis* (Costa) may feed largely on mites within the Oribatida. Diet breadth in some species may change seasonally. For instance, females of some *Anthocoris* species accumulate on willows (*Salix*) in early spring as the bugs emerge from overwintering sites, and may complete a generation on those hosts before the summer hosts (which can include a number of different plant taxa) are later colonized.

Anthocoridae that occur on plants insert their eggs into plant tissues. Species that attack aphids or scale insects on coniferous trees insert their eggs into the needles, whereas those species that inhabit the foliage of deciduous plants often insert the eggs into leaf tissues. Anthocoridae that occur under bark insert their eggs into the inner surface of the bark, into rotting wood, or into cracks in the bark. Species of *Xylocoris* that inhabit manure piles

insert their eggs into cracks in the manure, whereas those species that inhabit straw piles insert their eggs into the decaying straw. In species having a reduced or vestigial ovipositor (e.g., *Cardiastethus*), eggs are deposited on the substrate near prey. Lifetime egg production per female is highly variable even within species, and is probably affected extensively by diet quality. Lifetime estimates of fecundity obtained from laboratory trials are available for *Anthocoris* (70ï 220 eggs), *Cardiastethus* (35ï 45 eggs), *Lyctocoris* (95 eggs), *Montandoniola* (50ï 150 eggs), *Orius* (90ï 130 eggs), and *Xylocoris* (20ï 80 eggs).

The pirate bugs have hemimetabolous development, in which the immatures (nymphs) undergo incomplete metamorphosis, and resemble the adults morphologically except in lacking wings, ocelli, and reproductive structures. Nymphs have five instars. Development rates of eggs and nymphs increase with increasing temperature. Anthocoridae in temperate regions overwinter as adults in reproductive diapause. For those species which have been examined, diapause is controlled by photoperiod, with long days prompting reproduction and short days leading to diapause. The critical photoperiod that prompts diapause for a given species may often depend upon latitude. Sex ratios for overwintering adults are often female-biased, and in some Anthocoridae the males appear not to overwinter. Most species of Anthocoridae have two or more generations per year depending upon latitude and elevation. Some species (e.g., *Anthocoris gallarumulmi*) appear to be univoltine throughout their respective geographic ranges.

Reproduction, Mating, and the Paragenital System

The pirate bugs have several reproductive traits and associated structures that differ from most other Heteroptera. Unlike most Heteroptera, the Anthocoridae, Lyctocoridae, and Lasiochilidae (plus some related taxa such as the Cimicidae) have fertilization of the eggs occurring within the vitellarium of the ovaries, rather than in the genital ducts. The anthocorid egg lacks micropyles, and fertilization takes place before the chorion is deposited. Oocyte maturation is inhibited in unmated females. Unfertilized eggs generally degenerate and are resorbed before they reach maturation, and unmated females deposit few or no eggs.

The Anthocoridae and related taxa have evolved a number of unique reproductive structures that are used extensively by taxonomists in developing classification schemes and in defining phylogenetic affinities among higher level taxa (Table 10). In the Anthocoridae and Lyctocoridae, insemination of the female by the male is not done via the usual route through the female genitalia. Rather, insemination occurs outside of the reproductive tract, within the abdominal cavity, and is thus referred to as extragenital insemination. The sperm migrate through the haemocoel or through specialized structures in the female (see below) to the ovaries, and fertilize the developing egg within the vitellarium before deposition of the chorion. It is not clear what evolutionary pressures have led to extragenital insemination in the Anthocoridae or other taxa showing this trait, but it has been suggested that it is a means by which the male circumvents female resistance or bypasses female control of sperm allocation and egg fertilization.

Minute Pirate Bugs (Hemiptera: Anthocoridae), Table 10 Comparison of reproductive traits and structures (including the female paragenital system) among Lasiochilidae, Lyctocoridae, and Anthocoridae

	Lasiochilidae	Lyctocoridae	Anthocoridae
1. Insemination	1. intragenital	1. extragenital	1. extragenital
2. Intromittent organ	2. phallus	2. phallus with acus	2. paramere and/or phallus
3. Paragenital system	3. none	3. spermalege	3. spermalege, often in form of copulatory tube(s)
4. Site of copulation	4. female's genital opening (intragenitalic)	4. between segments VII-VIII to right of genital opening	4. variable
5. Sperm	5. bursa copulatrix	5. seminal conceptacles	5. seminal conceptacles or

storage			spermatic pocket

Characteristics of the reproductive system show some similarities and some differences among the Lasiochilidae, Lyctocoridae, and Anthocoridae, and these traits have been used extensively in assessing phylogenetic affinities among these groups. The Lasiochilidae differ from the Anthocoridae and Lyctocoridae in that insemination is of the more typical insect type, occurring within the femaleôs reproductive system (i.e., intragenital insemination), as opposed to the extragenital insemination characteristic of the Anthocoridae and Lyctocoridae. In all three families, the male genitalia are asymmetric. The right paramere is highly reduced or is absent. The intromittent organ in the Lasiochilidae and Lyctocoridae is the phallus. In the Lyctocoridae, the apex of the phallus is sclerotized and in the form of an acus (needle), used to penetrate the abdominal wall of the female for insemination (ñtraumatic inseminationò). For the Anthocoridae, the left paramere or the phallus acts as the intromittent organ. In the Oriini, for example, a portion of the left paramere (the flagellum) is inserted within a specialized female organ (the copulatory tube, as discussed below), and the short membranous phallus slides along the paramere to deposit sperm. The paramere itself may be of quite complex shape in the Oriini, and in fact is used extensively in differentiating species of *Orius* within some difficult species complexes. The Anthocorini exhibit a different strategy. In these species, the paramere is reduced to a relatively simple, sickle-like organ, which is inserted only partially within the copulation site of the female. The male then inflates his long, membranous phallus through the femaleôs copulatory tube to deposit sperm. In the Xylocorini, the left paramere is sharply pointed, and is used to pierce the abdominal wall of the female at the copulation site. Copulation may actually lead to scars that are visible on the surface of the female.

Extragenital insemination in the Anthocoridae and related taxa has led to the evolution in females of structures collectively referred to as the paragenital system (spermalege). These organs are thought to have evolved as a means for the female to reduce costs associated with traumatic insemination, caused by wounding of the cuticle at the copulation site or by the introduction of infections and infectious agents within the haemocoel of the female as the male inseminates her. The spermalege consists of simple to complex structures that act to guide the maleôs intromittent organ to a specific insemination site (the ectospermalege), and to receive the sperm (the mesospermalege). In some taxa (e.g., the Anthocorini and Oriini), the ectospermalege consists of a specialized copulatory tube, produced as an invagination of the epidermis that opens between sternites VII-VIII on the ventral surface of the female, just lateral of the femaleôs genital opening. The copulatory tube receives the paramere and phallus (as in the Oriini) or phallus (as in the Anthocorini). The distal end of the copulatory tube enters a pouch (spermatic pocket or sperm pouch), which acts to temporarily store the sperm. In the Lyctocoridae, newly deposited sperm collect first in the mesospermalege (a collection of specialized cells at the copulation site), and then migrate through the haemocoel to the sperm storage structures at the base of the ovaries. In the Xylocorini, the mesospermalege may be partially open or completely enclosed. If the mesospermalege is partially open, sperm move from the mesospermalege into the haemocoel, and migrate through the haemocoel to the sperm storage sites at the base of the ovaries. If the mesospermalege is completely enclosed, the structure extends to and connects with the sperm storage structures.

The actual site of copulation in the Anthocoridae and related taxa is highly variable. In the Lasiochilidae, which lacks a paragenital system, insemination takes place within the femaleôs genital tract. In the Lyctocoridae, the male pierces the female on her ventral side between segments VII and VIII, to the right of the femaleôs genitalic opening. Within the Anthocoridae, site of copulation varies among tribes. In the Oriini and Anthocorini, the copulatory tube opens between abdominal segments VII and VIII on the femaleôs ventral side, usually to the left of her genital opening. Female Blaptostethini actually have paired copulatory tubes, located on her ventral side between abdominal segments VII and VIII. In the Xylocorini, the site of copulation in some species is on the dorsal side of the female, towards the anterior end of the abdomen, while in other species copulation takes place on the lateral (right) side of the abdomen.

The spermatheca is reduced to a small vermiform gland having no sperm storage function (Lasiochilidae), or is absent altogether (Lyctocoridae and Anthocoridae). In the Lyctocoridae, sperm travel from the spermalege at the site of insemination through the haemocoel into sperm storage organs (seminal conceptacles) located at the base of the ovaries. In the Anthocoridae, sperm are stored either in the sperm pocket (species having copulatory tubes: Oriini, Anthocorini, Scolopini, Blaptostethini) or in seminal conceptacles (Xylocorini). The seminal

conceptacles in the Xylocorini and Lyctocoridae are not homologous, as they derive from different tissues in the two taxa. From the sperm storage organs (sperm pocket or seminal conceptacles), the sperm move to the ovaries through specialized conducting tissues, and fertilize the eggs within the vitellarium.

Economic Importance

The pirate bugs are sources of biological control in annual and perennial crops, in forests, in greenhouse crops, on ornamental plants, and in stored products. Several species of *Anthocoris* are known important sources of biological control in temperate fruit orchards, where they feed extensively on pest psyllids and aphids. Species of *Orius* occur in greenhouses and in a variety of row crops, where they feed on thrips, mites, aphids, and eggs of pest Lepidoptera. These predators may be particularly important natural enemies of flower thrips. *Xylocoris* and *Lyctocoris* attack beetle and moth pests in stored products and granaries. Aphid and scale pests that inhabit the canopies of coniferous trees are attacked by *Elatophilus*, *Tetraphleps*, *Melanocoris*, and *Acompocoris*, whereas bark beetle pests are fed upon beneath bark by species of *Xylocoris*, *Scoloposcelis*, and *Lyctocoris*. Other species are important natural enemies of pests on ornamental plants, including *Montandoniola*, *Macrotrachelia*, and *Macrotracheliella* on ornamental fig (*Ficus*), where they feed on the Cuban laurel thrips (*Gynaikothrips ficorum* (Marchal)). Species reared in insectaries for shipment and release include *Orius insidiosus*, *Orius laevigatus* (Fieber), *Orius majusculus* (Reuter), and *Anthocoris nemoralis*.

The Anthocoridae have been used in a number of classical biological control efforts. Classical biological control is the importation and release of exotic natural enemies for controlling non-indigenous pests. *Anthocoris nemoralis*, a species native to Europe, was released into western North America in the early 1960s to control an introduced psyllid pest of pears (*Cacopsylla pyricola* (Förster)). The predator is now established in British Columbia, Washington, Oregon, and California. Its effectiveness in controlling the psyllid pest of pears, however, is unclear. The North American *Orius insidiosus* has been introduced into Europe and Hawaii for controlling Thysanoptera and Lepido-ptera, and is established in Hawaii. *Montandoniola moraguesi* (Puton) is native to southeast Asia, but has been released in southern California, Texas, Bermuda, and Hawaii to control Cuban laurel thrips. The predator has become established in Bermuda and Hawaii, apparently as a consequence of these introductions. Two species of *Tetraphleps* were introduced into North America from India and Pakistan for control of the balsam woolly aphid (*Adelges piceae* (Ratzeburg)), a non-indigenous pest of various coniferous trees. Apparently neither species became established.

A number of species have become established outside of their native ranges because of accidental introductions or dispersal. Effects of these introductions upon native predators (via competition) and native prey (via predation) are unknown, but are potentially important. There has been speculation, for example, that *Anthocoris nemoralis*, which was introduced intentionally into North America from Europe but which has moved into habitats other than the target pear orchard, may compete with native *Anthocoris* species. Species that associate with stored food products (*Lyctocoris*, *Xylocoris*) have spread dramatically outside of their native ranges, apparently because of human commerce. These and other species of Anthocoridae are regularly intercepted at ports-of-entry on transported flowers, fruits and vegetables, or on other plant materials. As of 1999, it was thought that more than 50% of the anthocorid fauna in Hawaii was non-indigenous, with many of the exotic species arriving because of accidental introductions. *Montandoniola moraguesi*, which has been used extensively in classical biological control efforts against thrips on *Ficus*, is now established in the southeastern United States, apparently because of accidental introduction or natural dispersal. In North America, non-indigenous species that have become established because of apparent accidental introductions or natural dispersal can be found in the genera *Anthocoris*, *Brachysteles*, *Buchananiella*, *Dufouriellus*, *Lyctocoris* (Lyctocoridae), *Montandoniola*, *Orius*, *Temnostethus*, and *Xylocoris*. Effects of these exotic species on North American ecosystems are unknown.

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