MIRIDAE ASSOCIATED WITH PENNSYLVANIA CONIFERS 1. SPECIES ON ARBORVITAE, FALSE CYPRESS, AND JUNIPER

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MIRIDAE ASSOCIATED WITH PENNSYLVANIA CONIFERS 1. SPECIES ON ARBORVITAE, FALSE CYPRESS, AND JUNIPER[1]

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INTRODUCTION

In 1971 a survey of the arthropods associated with ornamental conifers in Pennsylvania was begun. We soon found that the Miridae or plant bugs were among the most abundant and diverse of the arthropod groups collected, and in 1972 we initiated a study of the mirid fauna of Pennsylvania conifers.

Palearctic mirid species associated with conifers are well known. Reuter (1909) gave the host-plant range and seasonal occurrence of 85 species. He discussed the relationship of the mirid fauna to the conifers, i.e., whether the species were mainly phytophagous, predaceous, used the trees only as overwintering sites, or were merely of accidental occurrence. Butler (1923), Kullenberg (1944), and Southwood and Leston (1959) gave detailed biologies of common species. Puchkov (1961) and Strawinski (1964), among others, discussed predaceous habits of certain species.

In contrast, there is no general review of the mirid species occurring on conifers in North America. In his summary of the host plants of North American Miridae, Johnston (1928) stated that entomologists only recently had begun to collect with regard to hosts. P. R. Uhler perhaps was the first to associate North American mirids with conifers when he listed "pines" as hosts in describing several new species (Uhler 1887 a, b). Heidemann (1892) gave notes on seasonal occurrence of seven mirids collected on scrub pine, *Pinus virginiana* Mill., and three species from eastern red cedar, *Juniperus virginiana* L. Knight (1968) found that two conifers, one-leaved pinyon pine, *Pinus cembroides*

[1] This research is part of an overall project, "Pest Management of Arthropods on Conifers," which is financed in part with Pennsylvania Fair Funds, administered by the Pennsylvania Department of Agriculture.

Zucc. var. *monophylla,* and Utah juniper, *J. osteosperma* (Torr.) Little, supported the largest number of mirid species of any plants in the Nevada Test Site.

In North America, life history studies of conifer mirids have not been made. Bradley and Hincks (1968) briefly discussed biology of five *Pilophorus* spp. occurring on jack pine, *P. banksiana* Lamb., and Martin (1966) recorded *Phytocoris eximius* Reuter [2] as an important member of the hemipteran fauna of red pine, *P. resinosa* Ait. Additional biological notes can be found in the faunal works of Knight (1923, 1941, 1968) and Blatchley (1926), and in various species descriptions, mainly by H. H. Knight. Recent taxonomic reviews of the conifer-inhabiting genera *Platylygus* (Kelton and Knight 1970), *Bolteria* (Kelton 1972 a), and *Dichrooscytus* (Kelton 1972b; Kelton and Schaffner 1972), and the predominantly conifer-associated genus *Pilophorus* (Knight 1973) have provided new records of host plants and seasonal occurrence. The scant knowledge of the mirid fauna of North American conifers is further illustrated by the discovery in this survey of two previously undescribed species on pine (Henry 1975) and four Palearctic conifer mirids not known to occur in North America (Wheeler and Henry 1973; Henry and Wheeler 1973, 1974).

This paper, the first in a series on the mirid fauna of Pennsylvania conifers, summarizes our observations on the species associated with arborvitae (*Thuja*), false cypress (*Chamaecyparis*), and juniper (*Juniperus*). These genera, which share a similar mirid fauna, have been placed in the subfamily Cupressineae of the family Pinaceae (Fernald 1950) but now are generally treated as the separate family Cupressaceae (Dallimore and Jackson 1966). Diagnoses of adults and fifth instars of seven species are provided. To further facilitate recognition, figures of the adults and fifth instars are given for those species not previously illustrated. Distribution, seasonal occurrence, host plants, and food habits are summarized for the seven common species. Notes are given for six additional species which occasionally breed on these hosts.

[2] This species frequently has been misidentified, and the record from red pine probably is based on a misidentification.

METHODS

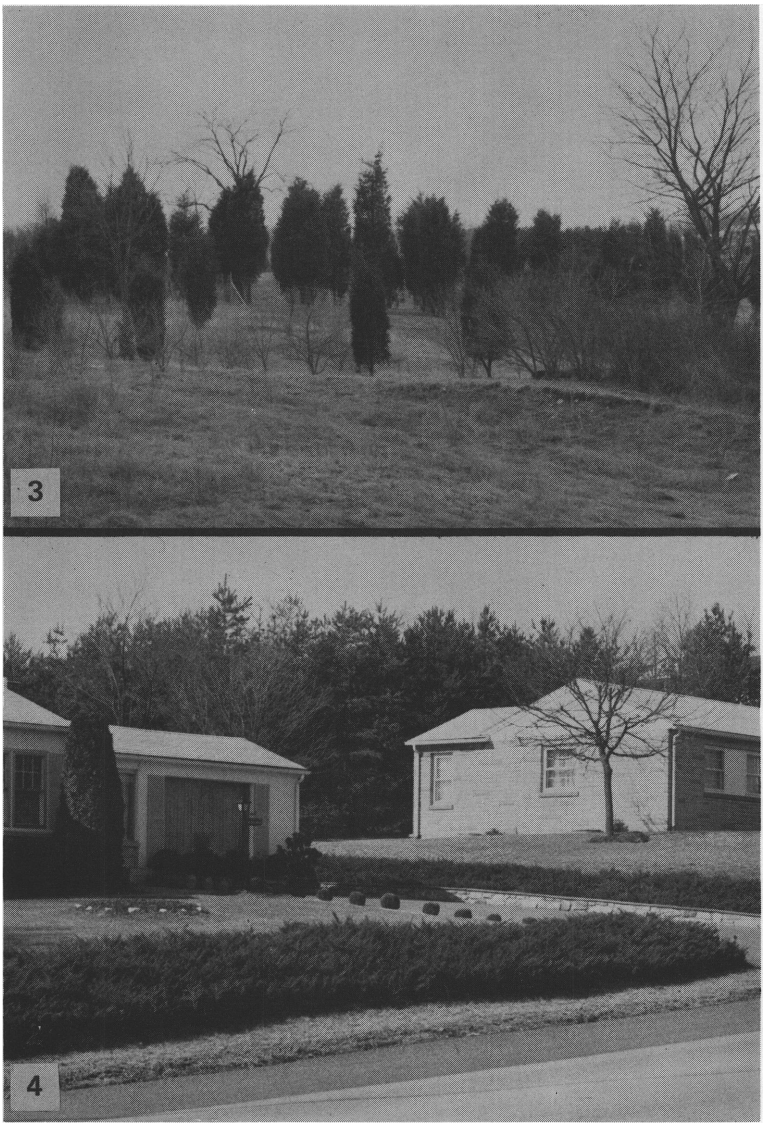
General Collecting and Rearing. — Collections were made nearly statewide during 1972-75, with emphasis placed on plants in nurseries (Fig. 1) and landscape plantings in parks, cemeteries (Fig. 2), and private residences (Fig. 4). Native eastern red cedar trees were also sampled (Fig. 3). When possible, repeat collections were made several times during the season. Mirids were collected by tapping branches of the host over a 10 in. × 12 in. tray and aspirating or hand collecting dislodged specimens. Each collection from a host at one locality was assigned a number, and biological notes for each collection were made. Nymphs were taken to the laboratory and reared to maturity in small plastic cages containing fresh sprigs of the host plant. The host was renewed every 2-3 days. Nymphs of each species, all stages if possible, were preserved in 70% alcohol.

Two plantings at the Pennsylvania Department of Agriculture Building, Harrisburg, Dauphin Co., were used for more regular sampling. A population of *Dichrooscytus elegans* Heidemann was studied during April-August, 1974 by taking weekly collections from a hedge of Andorra juniper (*J. horizontalis* cv. 'Plumosa') and Sargent's juniper (*J. chinensis* var. *sargentii*). Ten sites in the hedge (4 of Andorra and 6 of Sargent's juniper), 15-30 feet apart, were selected for sampling and used throughout the season. A beating tray was placed in the hedge, the overlying branches tapped over the tray (Fig. 5), and all dislodged nymphs and adults counted and released. When adults were present, a glass plate was placed over the tray to prevent them from escaping.

Seasonal history of *Pilophorus juniperi* Knight and *Phytocoris breviusculus* Reuter was followed by collecting throughout the season on three trees of *J. virginiana* cv. 'Glauca' in a Harrisburg cemetery. Counts were not made, but relative proportions of adults and nymphal stages were recorded.

Food Habits. — To determine the predaceous tendencies of *Parthenicus juniperi* (Heidemann), *Pilophorus juniperi,* and *Phytocoris breviusculus,* housefly eggs and larvae were offered to adult mirids. Preliminary tests were conducted to determine the effect of different diets on adult longevity of *P. juniperi* and *P.*

FIGURES 1-2. — Plantings of arborvitae, false cypress, and juniper; Fig. 1 — Nursery planting of arborvitae and juniper; Fig. 2 — Cemetery planting of false cypress.



FIGURES 3-4. — Fig. 3 — Native eastern red cedar growing in old field; Fig. 4 — Home planting of Andorra juniper.

FIGURE 5. — Beating tray (10 × 12 in.) used to take weekly samples from hedge of Andorra and Sargent's juniper.

breviusculus. A cage consisting of four plastic vials radiating from a central chamber was used (Colburn and Asquith 1970). Moist cotton was placed in the center box and one adult mirid was placed in each of the four vials. Vial 1 had a moist cotton plug; vial 2, mite and scale beatings from the host red cedar trees; vial 3, a fresh sprig of red cedar; and vial 4, a sprig of the host plus mites and scales. Food was renewed every other day.

Bolteria luteifrons Knight

Bolteria luteifrons Knight, 1921, Bull. Brooklyn Ent. Soc. 16:73

B. luteifrons is known from Arkansas, Iowa, Maine, Missouri, North Carolina, New Hampshire, Ontario, Quebec, and South Dakota (Kelton 1972a). We add Colorado (Denver, May 19, 1975, K. Valley, on *J. chinensis* cv. 'Hetzii'); Maryland (College

Park, May 9, 1973, K. Valley, A. G. Wheeler, Jr., on *J. chinensis*); Ohio (Hudson, May 26, 1973, K. Valley, on *J. horizontalis* cv. 'Plumosa'); and Virginia (10 mi. north of Roanoke, April 14, 1974, AGW, on *J. virginiana*). Kelton (1972a) described and figured the adult and male genitalia; Slater (1950) described and figured female genitalia. Knight (1921) noted that since the type-specimen was taken on pine and that the western species of *Bolteria* breed on pine, it was likely that pines would prove to be the host of *luteifrons*. Further collecting, however, has shown that red cedar and cultivated juniper are the hosts (Kelton 1972a). The U.S. National Museum collection has a specimen collected on arborvitae, April 15, 1954, at Clemson, South Carolina. Froeschner (1949) noted that the early-season occurrence of *luteifrons* may account for this species being so poorly known.

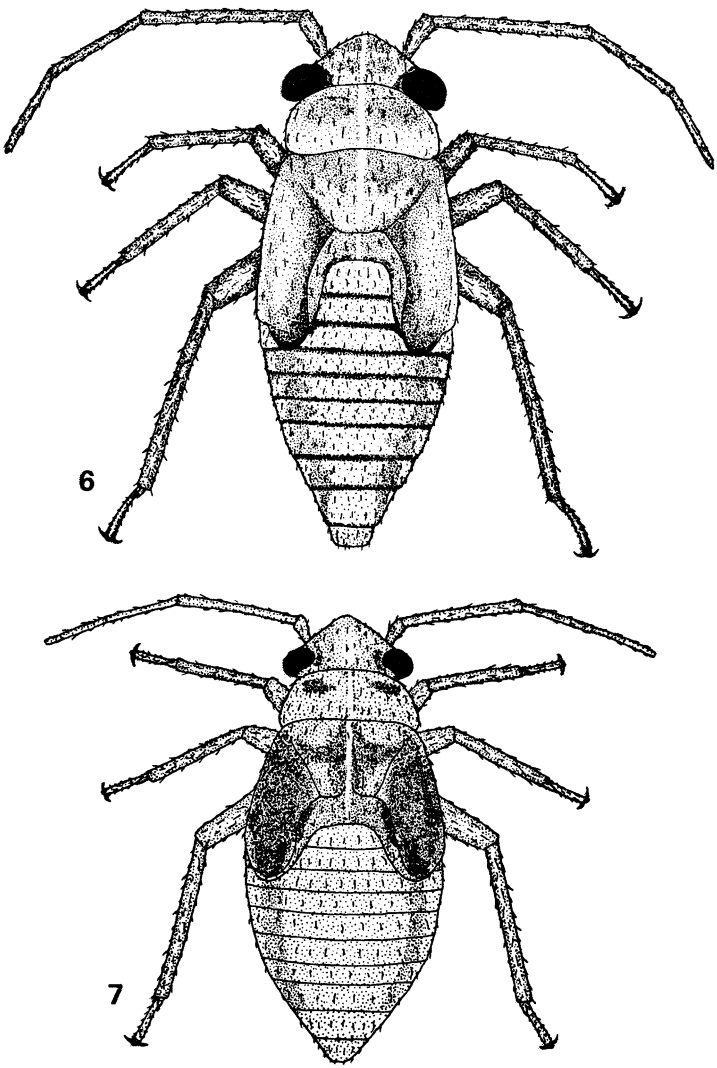
Adult. — Length male 4.00 mm, width 1.56 mm; female 4.40 mm, 1.80 mm. Dorsum brown to fuscous, clothed with very short, recumbent, brown setae. Head shiny, light brown, frons and tylus dark brown, buccula tinged with red. Rostrum brown, fuscous at apex, reaching 5th or 6th abdominal segment in male, genital segment in female. Antennae brownish or testaceous, apex of 3rd and all of 4th segment fuscous. Pronotum shiny brown, calli darker; scutellum pale. Hemelytra brown, darker on clavus and apex of corium and cuneus. Membrane fuscous, veins pale brown. Legs pale brownish; tibiae paler; tarsi fuscous.

Instar V (Fig. 6). — Length 3.40 mm. Dorsum pale brown to testaceous, clothed with short, black, recumbent setae. Head pale brown, eyes red. Rostrum pale, apex black, reaching just beyond hind coxae or to posterior margin of 1st abdominal segment. Antennae uniformly pale brown. Apex of front and exposed area of hind wing pads fumate, fuscous on tips. Abdomen pale testaceous, tinged with red. Legs pale brown, femora brown; apex of last tarsal segment fuscous.

Biology. — This species has the most limited distribution of any of the phytophagous mirids that breed on arborvitae, false cypress, or juniper in Pennsylvania. We collected *luteifrons* only in six western counties (Map 2).

B. luteifrons is an early-season species that breeds on native red cedar and cultivated *J. chinensis, J. communis, J. excelsa, J. horizontalis, J. squamata, Thuja occidentalis* and *T. orientalis*. Adults also were collected on *Chamaecyparis pisifera* (Table 1).

Periodic samples were taken from Greek juniper (*J. excelsa*)



FIGURES 6-7. — Fig. 6 — Fifth instar of *Bolteria luteifrons;* Fig. 7 — Fifth instar of *Dichrooscytus elegans.*

at Hollidaysburg, Blair Co., in 1974. Instar III nymphs were present in the April 30 collection, indicating that eggs hatch about mid-April. Collections on May 15 contained mostly instar V nymphs, although a few fourth instars were present. By May 31 only adults were found; they were last collected on June 22.

Dichrooscytus elegans Heidemann

Dichroscytus [sic] *elegans* Heidemann, 1892, Proc. Ent. Soc. Wash. 2:225

D. elegans, previously referred to as *D. tinctipennis* Knight or *D. elegans* Uher (see Wheeler and Henry (1975) for a clarification of the nomenclature), has a wide distribution in eastern North America (Carvalho 1959; Kelton 1972b). A new state record is Nebraska (Nemaha Co., 3.5 mi. S. of Brock, August 22, 1975, AGW, on *J. virginiana*). Kelton (1972b) illustrated male genitalia. Heidemann (1892) noted that *elegans* occurred on red cedar during June and July in the Washington, D.C. area. Knight (1927b) recorded it from eastern arborvitae, and Kelton (1972b) added common juniper, *J. communis,* to the list of hosts.

Adult. — Length male 3.80 mm, width 1.56 mm; female 3.60 mm, 1.60 mm. Dorsum green and reddish, clothed with recumbent brownish setae. Rostrum reaching middle of hind coxae. Antennae green, 3rd and 4th segments becoming fuscous. Head greenish-yellow. Pronotum and scutellum green and finely rugose. Hemelytra reddish, central area of clavus and apex of corium dark brown in some specimens; embolium, base and lateral margin of cuneus yellowish-green. Membrane fuscous, veins reddish. Venter and legs green; claws fuscous.

Instar V (Fig. 7).— Length 2.76 mm. Dorsum green, tinged with red, especially along abdominal margins; marked with fuscous, brown on pronotum and wing pads; clothed with short, black, recumbent setae. Dorsal abdominal scent gland opening apparently absent.

Biology. — *D. elegans* was collected nearly statewide, and with *D. repletus,* was the most abundant mirid breeding on arborvitae and juniper. We collected *elegans* from many junipers and arborvitae in nurseries and landscape plantings: *Juniperus chinensis, J. communis, J. excelsa, J. horizontalis, J. sabina, J. scopulorum, J. virginiana, Thuja occidentalis, T. orientalis,* and *Chamaecyparis* sp. (See Table 1 for a list of juniper varieties and cultivars). Large populations developed on *Juniperus* and *Thuja* but not on *Chamaecyparis.*

FIGURE 8. — Egg of *Dichrooscytus elegans* inserted in scale-like foliage of *Juniperus chinensis.*

Eggs are deposited loosely within the scale-like foliage, and unhatched eggs were often dislodged when taking beating samples. Leaves near oviposition sites sometimes die (Fig. 8).

Seasonal history was elucidated through weekly sampling of a

hedge of Andorra and Sargent's juniper at Harrisburg during April-August, 1974. A few eggs had hatched on April 12, and by the 16th, first-instar nymphs were becoming numerous, although unhatched eggs and a few second instars also were beaten from the plants. Weekly sampling was begun on April 17. The April 24 sample consisted mainly of second instars; the May 1 sample, mainly of fourth instars. Fifth instars were present by May 8, but fourth instars still predominated. Nymphs averaged nearly 30/beating tray in this sample (Fig. 9).

The first adults were seen on May 15 (in 1973 they were observed on May 13). They became more numerous than late instars on May 22 and began to decline in numbers by late May. (Heidemann's (1892) observation that *D. elegans* was less common than *D. repletus* on the same trees probably was a result of his collecting in June and July when populations of *elegans* were declining.) The population used for weekly sampling was nearly a week ahead of nearby populations, possibly because the building offered protection. Populations in Washington Co. and the northern counties lagged behind by as much as two weeks in 1973. A sample taken at Cresson, Cambria Co. (elev. 2400 ft.), illustrated the effect of higher altitudes on development. On May 14, 1975, first and second instars were found when fourth and fifth instars were present at Harrisburg (elev. 365 ft.).

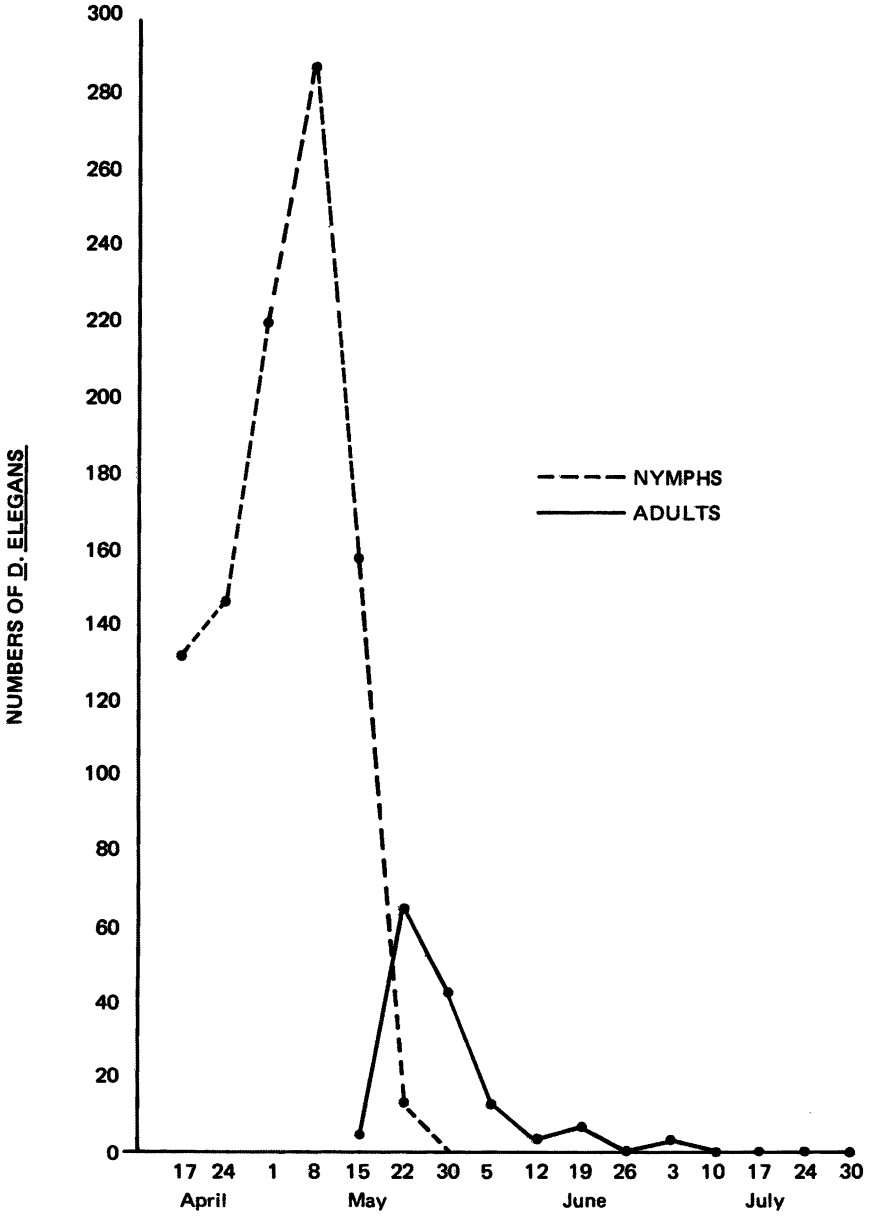
On two occasions we found nymphs of a second generation. Instars III-IV were taken on Pfitzer juniper on August 23, 1973, in Warren Co. and instars IV-V on *J. chinensis* cv. 'Blaauw' on September 5, 1974, in Lycoming Co.

Collections from the Andorra-Sargents juniper hedge during 1973 indicated that small numbers were associated with Andorra juniper. In the 1974 weekly samples, numbers from Andorra were always less than 10% of the total even though 40% of the plants (4 of 10 sample sites) were Andorra juniper.

Dichrooscytus repletus (Heidemann)

Lygus repletus Heidemann, 1892, Proc. Ent. Soc. Wash. 2:225

This species has been known as *D. viridicans* Knight, but we have shown that Heidemann's (1892) description was sufficient to recognize the species and to validate Uhler's manuscript name


NUMBERS OF D. ELEGANS
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
NYMPHS
ADULTS
17 24 1 8 15 22 30 5 12 19 26 3 10 17 24 30
April
May
June
July

(Wheeler and Henry 1975). *D. repletus* occurs commonly in eastern North America and has been recorded from eleven states, the District of Columbia, and four Canadian provinces (Kelton 1972b). We add Nebraska (Nemaha Co., 3.5 mi. S. of Brock, August 22, 1975, AGW, on *J. virginiana*). Akingbohungbe et al. (1973) described the fifth-instar nymph, and Kelton (1972b) figured male genitalia. Heidemann (1892) described *repletus* from red cedar, and Kelton (1972b) added eastern arborvitae and common juniper to its known hosts.

Adult. — Length male 3.20 mm, width 1.24 mm; female 3.60 mm, 1.48 mm. Dorsum uniformly green, pubescence short, recumbent and brown to black. Cuneus yellowish, often with inner margin reddish. Similar to *elegans* but slightly smaller and without reddish markings on hemelytra.

Instar V. — Length 2.78 mm. Uniformly green, clothed with short, black, recumbent setae. Dorsal abdominal scent gland opening apparently absent. May be separated from *elegans* by the uniform green color.

Biology. — We collected *D. repletus* throughout Pennsylvania on most of the same hosts used by *D. elegans* (Table 1).

Eggs of *repletus* were inserted into first-year galls produced by a cedar gall rust (*Gymnosporangium* sp.) on Pfitzer juniper (Fig. 10). Several galls harbored 4-5 eggs. Undoubtedly, *D. repletus* also utilizes other sites on the plant for oviposition. Eggs hatch about 3-4 weeks after those of *elegans*. Hatching dates varied considerably among populations occurring in the same area. Instars I-II were found near Harrisburg as early as May 8 in 1974, and May 19 in 1973; however, in both years early instars were not observed until the last week of May at the cemetery in Harrisburg. Collections from the Philadelphia area on May 17, 1973, consisted mainly of second instars, with a few first and third instars present. In northern counties, early instars were collected during early June.

At the cemetery site, instars I-II predominated in the June 4 collection; instars III-IV, on June 11; and instar V, on June 19 when the first adults appeared in both 1973 and 1974. Our

FIGURE 9. — Population trends of *Dichrooscytus elegans* on Andorra-Sargent's juniper hedge at Harrisburg, Pennsylvania, April-July 1974.

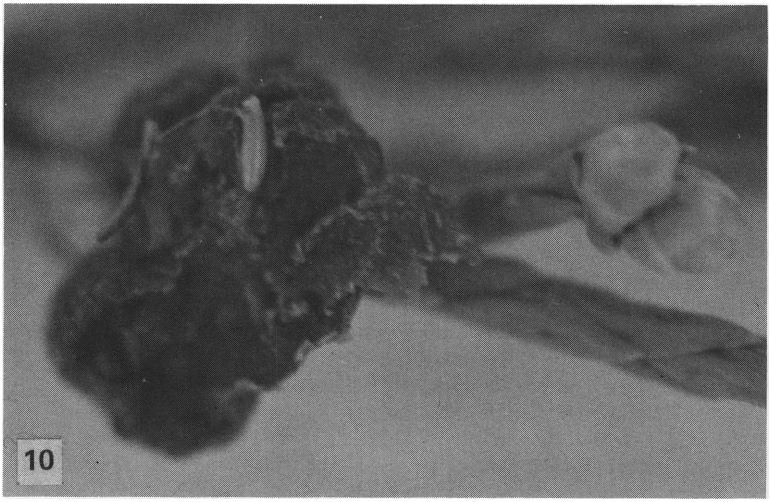


FIGURE 10. — Egg of *Dichrooscytus repletus* inserted into cedar rust gall on *Juniperus chinensis.*

earliest record of adults was June 11 at Philadelphia. Adults are most abundant during late June to mid-July.

Like most phytophagous mirids occurring on woody plants, *repletus* has been considered to be a univoltine species. In 1973-75, however, there was a small second generation. Apparently the majority of the eggs laid during mid-summer enter diapause and hatch the following May, but a few hatch the same season. Beginning in late July to early August, eggs hatched at many of the localities where collections had been made in May and June and continued to hatch sporadically until October. Populations were less well synchronized than in the first generation. Early instars could be found on a plant next to one with late instars; and nearby plants sometimes did not have a second generation of *repletus*. Nymphs generally were present until mid-September, but one third instar was collected on October 31; the last adult was taken at Harrisburg on October 14.

In some areas we found large populations of both *D. elegans* and *D. repletus* on the same hosts, the population peaks occurring about a month apart. On the Andorra-Sargent's juniper hedge

at Harrisburg that harbored large numbers of *elegans,* fewer than 10 specimens of *repletus* were collected during weekly sampling.

Parthenicus juniperi (Heidemann)

Psallus juniperi Heidemann, 1892, Proc. Ent. Soc. Wash. 2:225

Knight (1941) noted that *P. juniperi* was common east of the 100th meridian, or nearly everywhere red cedar occurred in natural stands. This mirid has been recorded from the District of Columbia, Florida, Indiana, Massachusetts, Missouri, New York, and West Virginia (Carvalho 1958), Ohio (Watson 1928), North Carolina (Brimley 1938), and Wisconsin (Akingbohungbe et al. 1972). We add Georgia (Clark Co., Stonehenge, July 8-14, 1967, C. L. Smith, at light) and Nebraska (Nemaha Co., 3.5 mi. S. of Brock, August 22, 1975, AGW, on *J. virginiana*). Knight (1941) illustrated the adult; Akingbohungbe et al. (1973) described the fifth-instar nymph. This species was described from red cedar (Heidemann 1892) and apparently has been reported only from that plant. Heidemann (1905) thought that there were two generations each season and that adults overwintered.

Adult. — Length male 2.90 mm, width 1.12 mm; female 2.80 mm, 1.08 mm. Generally pale brown to testaceous, often tinged with salmon; clothed with both simple and scale-like pubescence. Head testaceous, clothed with long, simple, brown setae; eyes large in male, sparsely set with micro-setae. Antennae brownish, 3rd and 4th segments becoming fuscous. Pronotum brownish, clothed with golden and brown simple setae, intermixed with silvery sericeous pubescence; scutellum tinged with fuscous. Hemelytra testaceous or brownish, with a patch of black scale-like setae at apex of corium; cuneus tinged with pale red; membrane fumate. Venter brownish; propleura and sternum tinged with salmon or brownish orange. Legs brownish; hind femora speckled with red.

Instar V (Fig. 11). — Length 2.00 mm. Dorsum generally pale yellow, tinged with orange or pink, shiny, clothed with long, erect, brownish to black setae. Head and antennae pale. Wing pads pale, sometimes becoming infuscated at apices. Abdominal scent gland opening distinctly orangish. Legs pale, apex of last tarsal segment and claws black; hind femora saltatorial.

Biology. — *P. juniperi* was common throughout Pennsylvania (Map 1) but was never as abundant as *Dichrooscytus elegans* or *D. repletus.* In addition to native and cultivated red cedar, we

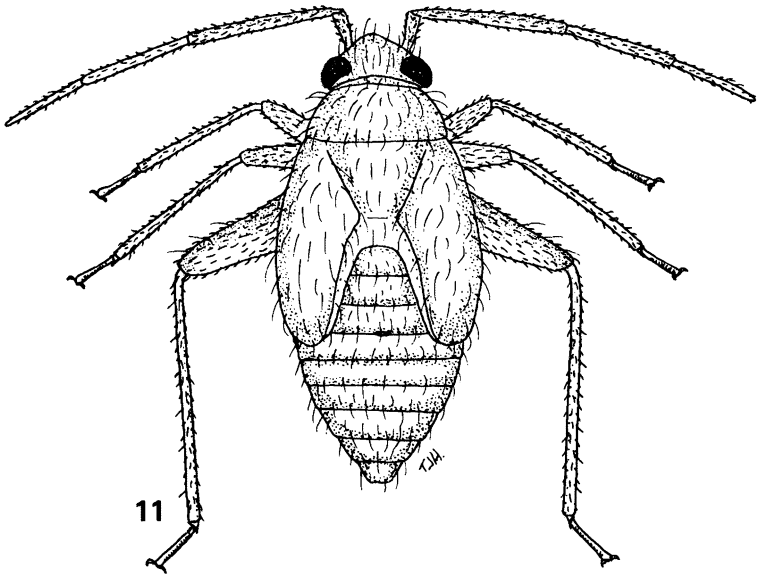


FIGURE 11. — Fifth instar of *Parthenicus juniperi.*

found this species breeding on cultivated *Juniperus chinensis, Thuja occidentalis, T. orientalis, Chamaecyparis lawsoniana, C. obtusa,* and *C. pisifera* (Table 1).

Our early-season records of *juniperi* are incomplete. Collections of instars III-IV on June 11, 1973, and instars IV-V on June 8, 1974, at Harrisburg indicate that eggs hatch about mid-May in central Pennsylvania. The first adults were taken on June 21 in the southeast, June 25 in the southwest, and June 26 at Harrisburg. Eggs of the second generation hatched in mid- to late July, and adults matured during August. Collection of one adult and late instars on August 1 in a York Co. nursery, and then many adults and early instars on the same trees on August 16, suggests that there is a third generation. Nymphs were present until the end of August and adults until early October. Although Heidemann (1905) suggested that adults overwinter, and Blatchley (1926) found an adult in February under a log at Dunedin, Florida, our records do not indicate that adults

of *juniperi* overwinter in Pennsylvania. They were never taken in early spring before nymphs appeared as happens with species that overwinter as adults.

In the laboratory adults fed readily on housefly eggs and early-stage larvae. They avoided older housefly larvae but fed on freshly killed larvae.

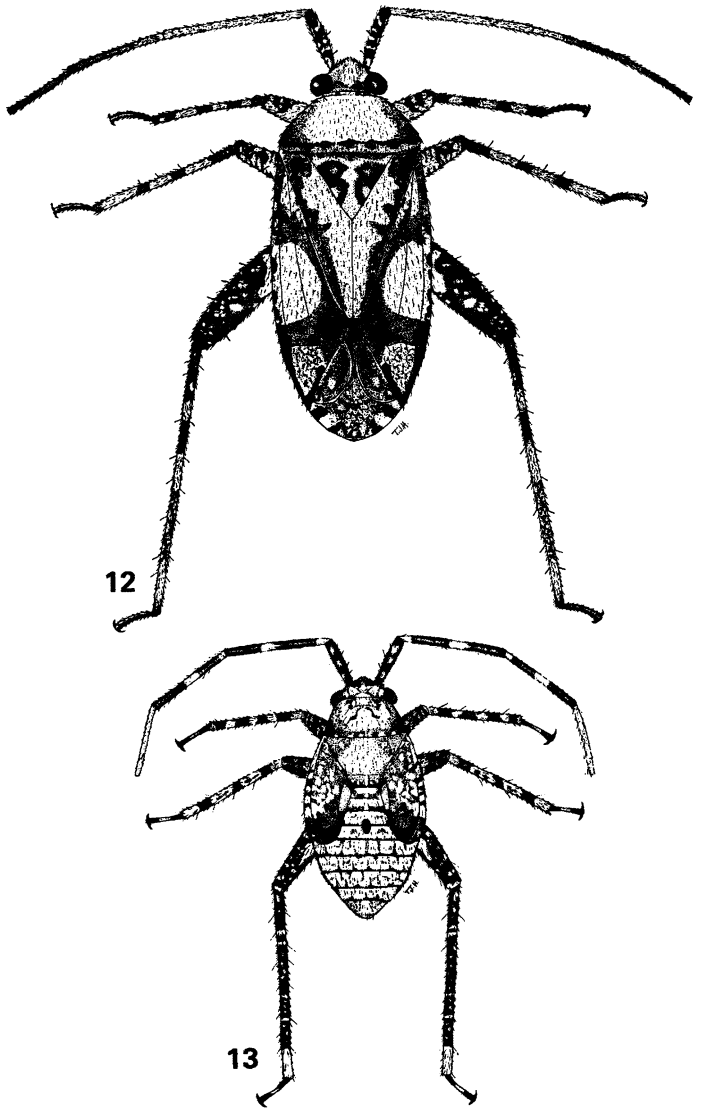
Phytocoris breviusculus Reuter

Phytocoris breviusculus Reuter, 1876, Ofv. K. Vet. Ak. Förh. 32:68

This mirid is widely distributed in the United States, although Knight (1927a, 1941) considered it rare in the eastern states. Carvalho (1959) recorded *breviusculus* from Alabama, Colorado, District of Columbia, Illinois, Indiana, Kansas, Mississippi, Missouri, Ohio, and Texas. We add North Carolina (Mecklenburg Co., 10 mi. S. of Charlotte, June 30, 1973, AGW, instar III on *J. virginiana*). Knight (1927a) noted that *breviusculus* was attracted to light and that two specimens were beaten from mesquite. Later, Knight (1968) reported "mesquite" as the host plant. This species also has been reared from apple branches infested with San Jose scale, *Quadraspidiotus perniciosus* (Comstock) (Knight 1941).

Adult (Fig. 12). — Length male 3.9 mm, width 1.60 mm; female 4.12 mm, 1.72 mm. Dorsum brown to dark brown, clothed with recumbent, brown to fuscous simple pubescence, intermixed with white sericeous setae. Rostrum reaching just past posterior margin of hind coxae. Antennae I, reddish brown, marked with several large white spots; II, testaceous, pale at base, slightly darker at apex; III and IV testaceous to brown. Pronotum brown, paler on calli and disk; posterior margin with 4 small flattened protuberances. Hemelytra brown, more testaceous on clavus, and large round area on middle of corium; cuneus reddish. Membrane marbled with fuscous, a large clear spot near apex of cuneus. Legs testaceous; hind femora largely brown with many small white spots; front and middle tibiae with 3 dark annuli, hind tibiae brownish with scattered white markings; tarsi and claws brown to fuscous.

Instar V (Fig. 13). — Length 2.8 mm. Dorsum brown with many pale irrorations; clothed with long, erect, brown pubescence, intermixed with shorter more recumbent setae. Head mostly pale with reddish lines on frons and vertex. Antennae I, brown with several pale spots; II, brown with a pale annulus at base and near middle; III, brown, with pale annulus at base and middle; IV, brown to testaceous. Wing pads brownish, darker



FIGURES 12-13. — *Phytocoris breviusculus*. Fig. 12 — adult; Fig. 13 — fifth instar.

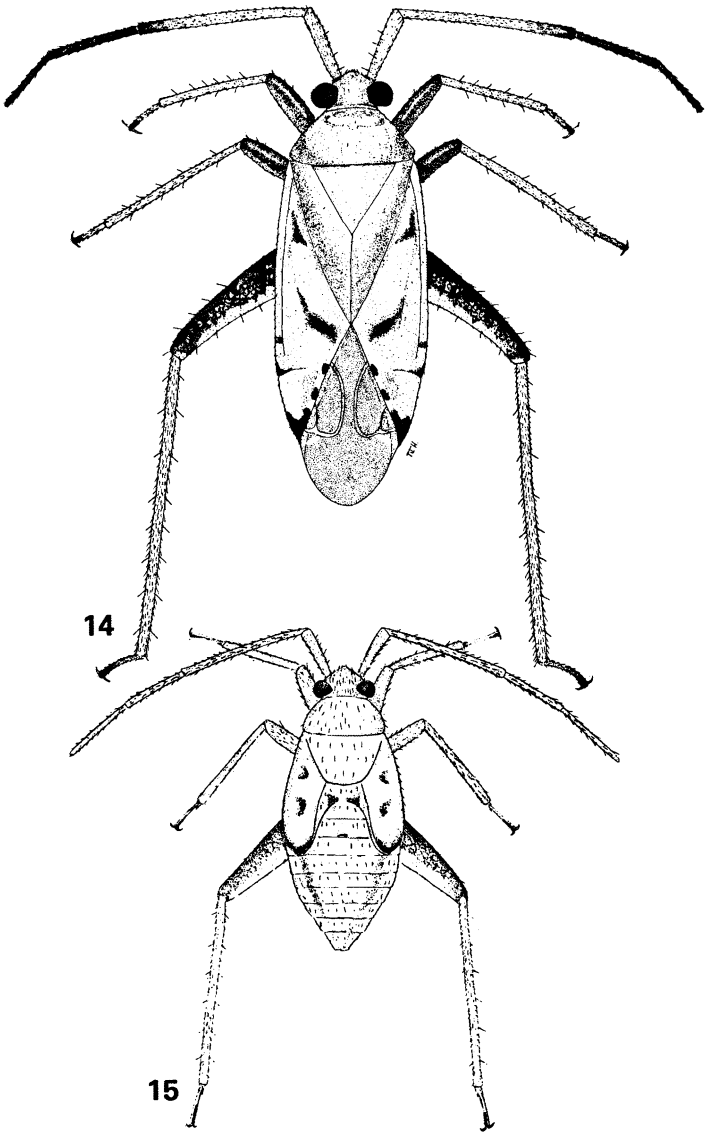
at apex. Abdominal segments bordered by fine reddish-brown lines. Legs brown; femora blotched with small white spots; front and middle tibiae brown with 4 white annuli, hind tibiae with scattered white spots, apex pale; tarsi pale at middle.

Biology. — *P. breviusculus* was collected from six counties in eastern Pennsylvania (Map 2). It was found most commonly on red cedar and Chinese juniper (Table 1). On red cedar at the Harrisburg cemetery, instars I-II were found on May 20. Instars II-III were predominant on May 30; IV-V, on June 10. By June 19 adults and instar V nymphs were common. On the hedge of Andorra and Sargent's juniper used for weekly sampling, instars I-II were collected on May 15. The four nymphs taken on May 30 and three on June 5 were the largest numbers taken during weekly sampling.

Samples from red cedar and Sargent's juniper indicated that *breviusculus* is bivoltine. On July 9 only one adult was collected on red cedar, but instars II-III of a second generation were abundant; on July 31 instars III-IV were common. On Sargent's juniper instars II-IV were collected on June 26, and on July 21 instar IV nymphs were predominant. Adults again were common on August 6. Additional evidence for a second generation was obtained during August from collections on red cedar in a York Co. nursery. On August 1 instars III-IV and adults were numerous; and on August 16 instars IV-V and adults were collected. Collections of adults during May-June and again in August-September by Froeschner (1949) indicate that *breviusculus* may have two generations in Missouri.

On red cedar, *P. breviusculus* is associated with parts of the plant that are heavily infested with scale, both juniper scale, *Carulaspis juniperi* (Bouché), and *C. minima* (Targ.-Tozz.). On Sargent's juniper, nymphs were most abundant when spruce mite, *Oligonychus ununguis* Jacobi, populations were high. We collected adults on branches of common hemlock, *Tsuga canadensis* (L.) Carr., infested with the scale *Fiorinia externa* Ferris and have reared it from balsam fir infested with the scale *Aspidiotus cryptomeriae* (Kuwana). We also have found *breviusculus* breeding on apple, crabapple, and honeylocust.

In the laboratory adults fed readily on house fly eggs and early-



FIGURES 14-15. — *Phytocoris junipericola.* Fig. 14 — adult; Fig. 15 — fifth instar.

stage larvae. Adults completely deflated the eggs before moving to others. This behavior was in contrast to that of *Pilophorus juniperi* which only partially deflated the eggs. Adults avoided older house fly larvae but fed on freshly killed ones. Longevity when given four different food sources also pointed to predaceous tendencies in this species. In four replications using the special test cages, longevity averaged 8.0 days with water only, 8.7 days with mite and scale beatings, 6.3 days with red cedar, and 15.3 days with red cedar plus mites and scales. Searching behavior also suggested that *breviusculus* is at least a facultative predator. This mirid continually searched over the plant, often probing the proboscis in and around the juniper needles.

Our observations, as well as data on specimens in the U.S. National Museum collection, show that *Juniperus* spp. are not the only hosts of *breviusculus* and that this mirid may feed on scales attacking various plants, including orchard crops. The USNM collection has a specimen collected on a "twig heavily infested with San Jose scale" at Bridgeville, Delaware; a specimen that "emerged from a box containing twigs infested with San Jose scale" at Plainsville, Ohio (probably the record given by Knight (1941)); and specimens taken on peach or in peach orchards in Hamilton Co., Tennessee, and Brown and Kerr Co., Texas.

Phytocoris junipericola Knight

Phytocoris junipericola Knight, 1927b, Proc. Biol. Soc. Wash. 40:16

Carvalho (1959) recorded *junipericola* from the District of Columbia, Indiana, and Maryland. We add North Carolina (Stokesdale, July 4, 1973, AGW, on *J. virginiana*) and West Virginia (nr Falling Waters, July 4, 1973, AGW, instars IV-V on *J. virginiana*). This species is known to breed on red cedar (Knight 1927b, 1941).

Adult (Fig. 14). — Length male 4.51 mm, width 1.60 mm; female 4.34 mm, 1.63 mm. Dorsum testaceous, clothed with simple golden pubescence. Rostrum reaching 5th or 6th abdominal segment. Antennae I, testaceous; II, testaceous, fuscous to black at apex; III and IV fuscous. Head and pronotum testaceous. Hemelytra with transverse fuscous marks just past base and before cuneus, area posterior to each mark pale and translucent;

cuneus tinged with red, apex fuscous; a fuscous dot present at apex of corium and at middle of inner margin of cuneus. Membrane smoky. Venter brown to dark brown. Legs testaceous, femora brownish, hind femora tinged with red.

Instar V (Fig. 15). — Length 2.60 mm. Dorsum testaceous, thinly clothed with simple brown pubescence. Eyes red; rostrum reaching 5th abdominal segment; antennae pale to testaceous. Pronotum tinged with light brown; wing pads testaceous, black at basal angles and apex. Abdomen tinged with reddish. Legs testaceous, hind femora marked with reddish brown on dorsal half, dark area broken by smaller pale spots.

Biology. — We collected *junipericola* from eight counties in eastern Pennsylvania (Map 2), most often on native red cedar growing in old fields and along roadsides. Occasionally we found it breeding in smaller numbers on red cedar, Pfitzer juniper, and Sawara false cypress in nurseries and landscape plantings. Adults also were taken on eastern arborvitae (Table 1).

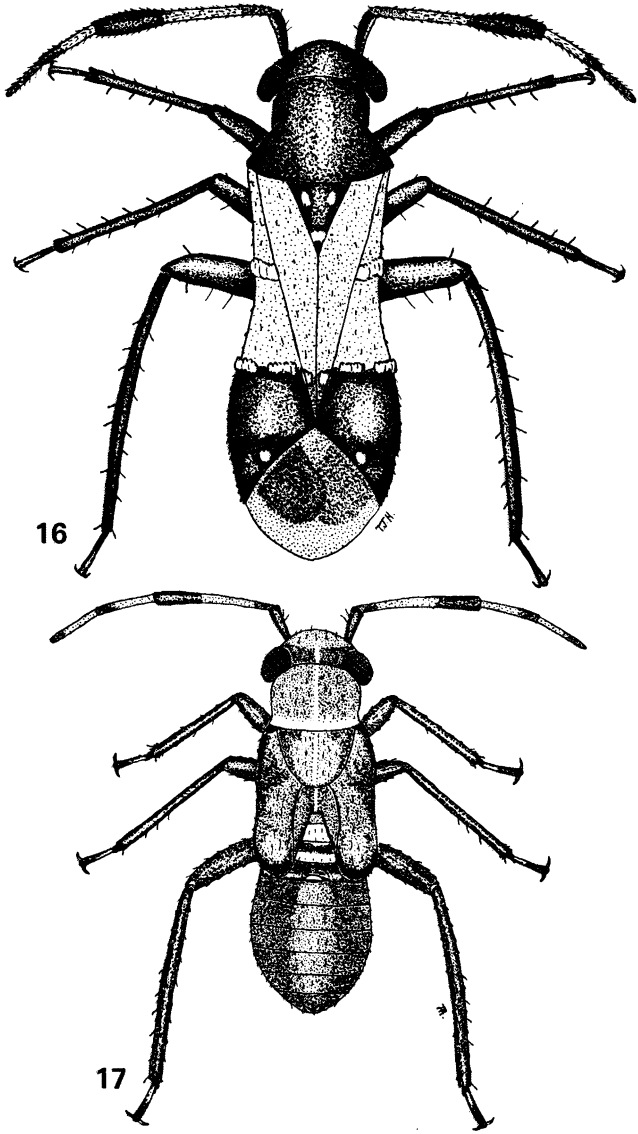
We did not sample one population throughout the season; thus our records of seasonal history are based on collections from several areas. Instars I-II were taken in northeastern counties in mid- to late June. In the southeast eggs probably hatch in early June. Instars III-V were present in the southeast on July 12, and adults were first observed on July 12 in York Co. A fifth instar nymph was taken there as late as August 16, but our records give no evidence for a second generation. Our latest record for adults is September 13.

Knight (1927b) suggested that *junipericola* is phytophagous because he found it on terminal twigs of red cedar and because its hypodermal pigments were the same as those of the plant-feeding *Parthenicus juniperi*. We did not make observations on its feeding habits but also believe this species is phytophagous.

Pilophorus juniperi Knight

Pilophorus juniperi Knight, 1923, Conn. Nat. Hist. Surv. Bull. 34:543

Carvalho (1958) recorded *juniperi* from the District of Columbia, Illinois, Maryland, Massachusetts, Minnesota, New Jersey, New York, and South Dakota. Knight (1973) added Iowa, and Akingbohungbe et al. (1972) added Wisconsin. We add North Carolina (Mecklenburg Co., 10 mi. S. of Charlotte, June 30, 1973, AGW, on *J. virginiana*). Knight (1973) figured the adult,



FIGURES 16-17. — *Pilophorus juniperi.* Fig. 16 — adult; Fig. 17 — fifth instar.

and Akingbohungbe et al. (1973) described the last instar. *P. juniperi* is known to breed on red cedar and may be partially predaceous (Knight 1941).

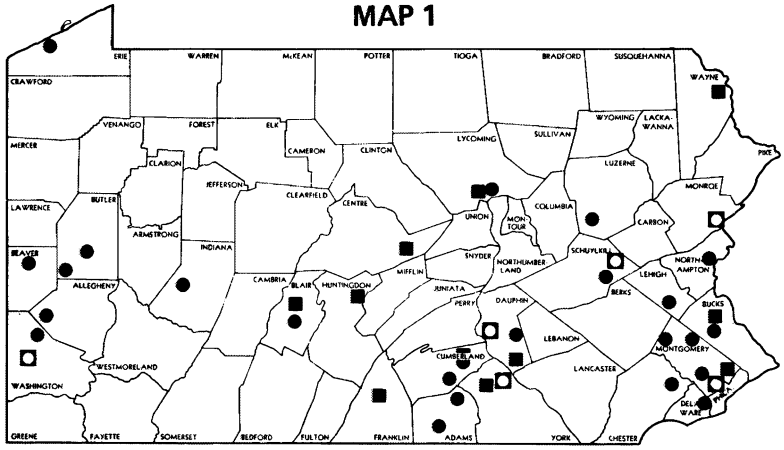
Adult (Fig. 16). — Length male 3.33 mm, width across posterior silvery line 1.22 mm; female 3.35 mm, 1.20 mm. Dorsum generally shiny black, clothed with recumbent, brown to black setae. Rostrum reaching base or middle of mesocoxae. Antennae I, brownish; II, brownish, with apical half black and thickened; III, white, apex brown; IV, brown. Scutellum shiny black with a silvery patch of setae at basal angles and apex. Hemelytra brownish orange with a transverse silvery patch set mid-way on embolium and corium, shiny black behind posterior silvery line. Membrane fumate to fuscous with a darker cloud formed in the middle. Legs and venter fuscous.

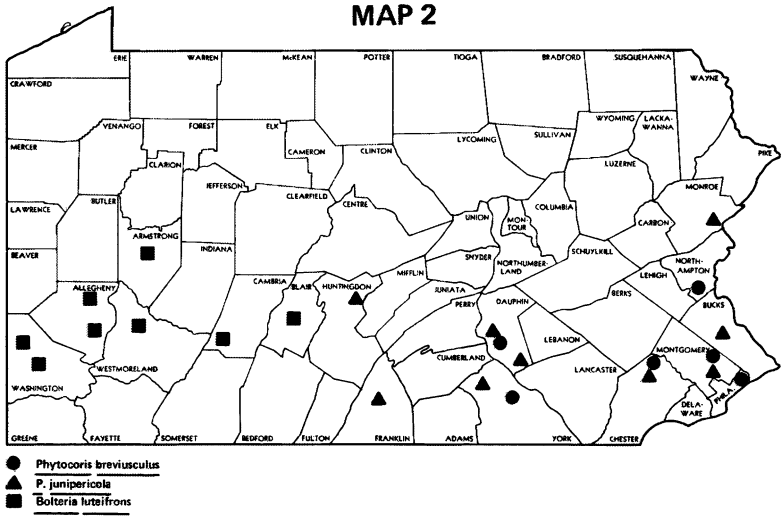
Instar V (Fig. 17). — Length 2.90 mm. Dorsum red to brown, clothed with very short, recumbent, black or brown setae. Head brown, vertex more reddish. Rostrum brown, black at apex; reaching anterior margin of middle coxae. Antennae I, brownish-red; II, testaceous, reddish-brown on apical third, gradually swollen from middle to apex; III, white, fumate on apical half; IV, fumate. Pronotum brown, pale along basal margin and median line, wing pads brown, darker at apex and along margins. Abdomen red; 1st, apical half of 2nd, and part of 3rd segment white, last segment fuscous. Legs testaceous; coxae white, red apically; hind legs more reddish brown.

Biology. — This species was collected in 12 counties (Map 1), mainly on native and cultivated red cedar. Occasionally we found it breeding on varieties and cultivars of Chinese juniper. Adults have been collected on Sawara and Lawson false cypress and Oriental arborvitae (Table 1).

In the large population on three *J. virginiana* cv. 'Glauca' trees at the cemetery in Harrisburg, eggs hatched in early to mid-June, and by July 9 in both 1973 and 1974, instars IV and V were abundant, and a few adults were present. More than 200 *juniperi* were beaten from the trees on July 15 with late-instar nymphs still more abundant than adults. By July 30, only adults were found. Our latest record is August 29.

We found *juniperi* most commonly on red cedar heavily infested with juniper scale and the related scale *C. minima*. In the laboratory, nymphs fed on scales by inserting the proboscis into the scale dorsally or at its base. Adults fed on eggs and





MAPS 1-2. — Map 1 — Distribution of *Parthenicus juniperi* and *Pilophorus juniperi* in Pennsylvania; Map 2 — *Bolteria luteifrons, Phytocoris breviusculus,* and *P. junipericola.*

early-stage larvae of the housefly. In contrast to *P. breviusculus,* adults did not completely consume contents of the eggs. The experiment using the four-chambered cage was run only once but also suggested that *juniperi* is partially predaceous. Longevity was three days with water only, with mites and scales, and with red cedar, but it was ten days with red cedar plus mites and scales.

Other Species

Nymphs of six additional mirid species were collected occasionally on arborvitae, false cypress, and juniper. Most of these species are predators that are associated with other coniferous or deciduous hosts.

Atractotomus magnicornis (Fallén). — Knight (1923) first reported this Palearctic species from North America. We often found large populations of this predator on spruce but have made three collections of adults and nymphs on Irish juniper in Washington Co. and one collection of adults and nymphs on the same host in Indiana Co. All collections were made during June.

Deraeocoris nubilis Knight. — This predaceous species usually occurs on pines. During June-August, we collected a few adults and nymphs on Sargent's and Hetz juniper at Harrisburg. Nymphs also were taken on *J. chinensis* in Butler, Chester, and Wayne counties.

Phytocoris conspurcatus Knight. — We collected this species on various deciduous trees but more often on hemlock. On August 1, late instars were found on red cedar in a York Co. nursery. The mirids may have been feeding on the large population of juniper scale on the trees. One adult was taken when the same trees were sampled on August 16. An adult was taken on *Thuja* sp. in Chester Co. and in Clinton Co. Knight (1941) noted that *conspurcatus* is a predaceous, bark-inhabiting species.

Phytocoris erectus Van Duzee. — Like *P. conspurcatus, P. erectus* is found on a variety of deciduous trees. We also have taken it frequently on firs, *Abies* spp., and during July-August, we found a small population breeding on Hetz juniper at Harrisburg. Knight (1941) considered *erectus* to be predaceous.

Phytocoris neglectus Knight. — This species also has been taken on deciduous hosts, particularly apple, *Malus pumila* Mill. One

instar II nymph was collected April 30, on *Chamaecyparis obtusa* at Harrisburg. It was reared on spruce mites on sprigs of its host and matured on May 20. An instar IV nymph was collected on Irish juniper infested with aphids, *Cinara* sp., in a Butler Co. nursery on August 14, and a fifth instar was found on Hetz juniper infested with juniper scale in an Allegheny Co. nursery on May 26. Two adults were taken on eastern arborvitae in a Snyder Co. nursery on June 18. *P. neglectus* is known to be predaceous (Knight 1941).

Psallus piceicola Knight. — The usual host is spruce, but this mirid also breeds on Irish juniper. We found a large population on this host in an Indiana Co. cemetery during June 1973 and August 1974. *P. piceicola* was also taken on Irish juniper in nurseries in Butler, Erie, Northumberland, Tioga, and Washington counties. A fifth instar was collected in June on eastern arborvitae in Delaware Co. Brown and Clark (1956) suggested that *piceicola* has predaceous tendencies, but their specimens from larch may actually have been *Plagiognathus laricicola* Knight, a species similar to *piceicola*.

Discussion

Except for *Phytocoris breviusculus,* the mirids found breeding commonly on arborvitae, false cypress, and juniper in Pennsylvania have previously been recorded from cupressaceous plants. Native red cedar has most often been reported as a host; mirids have not been collected extensively on ornamental arborvitae and juniper, and in fact, definite associations with ornamental species and cultivars have never been established. We have found that most of the species and cultivars of juniper and the two species of arborvitae used commonly in ornamental plantings serve as hosts of mirids. We record *Chamaecyparis* as a new host plant for the Miridae and juniper as the first coniferous host of *Phytocoris breviusculus.*

Dichrooscytus elegans, D. repletus, and *Parthenicus juniperi* were abundant on native red cedar and on ornamental arborvitae and juniper. These mirids were associated with nearly all the common juniper cultivars and varieties with the notable exception of Irish juniper. This cultivar, however, supported the only pop-

TABLE 1. — Host plants of the 7 common mirid species occurring on arborvitae (*Thuja*), false cypress (*Chamaecyparis*), and juniper (*Juniperus*) in Pennsylvania. Naming of cultivars and varieties follows that of den Ouden and Boom (1965).

	Bolteria luteifrons	*Dichrooscytus elegans*	*D. repletus*	*Parthenicus juniperi*	*Phytocoris breviusculus*	*P. junipericola*	*Pilophorus juniperi*
Chamaecyparis lawsoniana			X	X			X
C. obtusa			X	X			
C. pisifera		X	X	X		X	X
cv. 'Aurea'			X				
cv. 'Squarrosa'		X		X			X
C. thyoides			X				
C. sp.	X	X	X				
Juniperus chinensis		X	X	X			
cv. 'Armstrongii'		X	X				
cv. 'Blaauw'		X					
cv. 'Hetzii'	X	X	X	X	X	X	X
cv. 'Kaizuka'		X					
cv. 'Keteleeri'		X					
cv. 'Pfitzeriana'	X	X	X	X		X	X
cv. 'Stricta'	X	X	X				
var. *sargentii*		X	X		X		X
J. communis	X						
cv. 'Hibernica'		X	X	X			

TABLE 1. — *Continued*

	Bolteria luteifrons	*Dichrooscytus elegans*	*Parthenicus* *D. repletus*	*Parthenicus* *juniperi*	*Phytocoris breviusculus*	*P. junipericola*	*Pilophorus juniperi*
J. excelsa	X	X					
J. horizontalis							
cv. 'Bar Harbor'		X					
cv. 'Plumosa'	X	X	X		X		
J. sabina		X					
J. scopulorum							
cv. 'Blue Heaven'		X					
J. squamata							
cv. 'Meyeri'	X	X	X	X			
J. virginiana (native)		X	X	X	X	X	X
J. virginiana (cult.)	X	X	X	X	X	X	X
cv. 'Burkii'		X	X	X			X
cv. 'Canaertii'							X
cv. 'Glauca'		X	X	X	X		X
cv. 'Hillspire'		X					
cv. 'Skyrocket'		X	X	X			
Thuja occidentalis	X	X	X	X		X	
T. orientalis	X	X	X	X			X
T. standishii			X				

ulations on cupressaceous plants of the normally spruce-inhabiting *Atractotomus magnicornis* and *Psallus piceicola*. Mirids were always rare on Greek and Meyer's juniper, cultivars with spiny foliage. *Bolteria luteifrons* was collected only on ornamental arborvitae and junipers but undoubtedly occurs on native red cedar in Pennsylvania. *P. breviusculus* was collected only on ornamental junipers, and *Pilophorus juniperi* and *Phytocoris junipericola* were taken more frequently on native red cedar.

Mirids associated with the three host genera are largely phytophagous. *B. luteifrons, D. elegans, D. repletus, Parthenicus juniperi,* and *Phytocoris junipericola* are plant feeders, although in the laboratory *P. juniperi* exhibited predaceous tendencies. *Pilophorus juniperi* and *Phytocoris breviusculus* are mainly predaceous. The six species breeding occasionally on arborvitae and juniper are predators (with the possible exception of *Psallus piceicola*) that normally occur on other conifers or on deciduous trees.

Parthenicus juniperi is the only species previously shown to be multivoltine. We found that this species produces three generations and *P. breviusculus* two generations in Pennsylvania. In certain populations *D. elegans* and *D. repletus* were bivoltine. A small second generation of *repletus* was found at many sample sites; in contrast, a second generation of *elegans* was found at only two locations. Second generation eggs of *repletus* appeared to hatch sporadically over a period of several weeks. Nymphs usually were present on only a few plants in an ornamental planting. Apparently almost all the eggs laid during summer overwinter and only a small percentage hatch later the same season.

The hatching of a fraction of the overwintering eggs has not been reported for the Miridae. Populations of other insects exhibit genetic heterogeneity in their diapause development, but the selective forces which cause varying patterns of voltinism are not clearly understood. Perhaps different patterns enable a species to exploit marginally favorable periods while maintaining reserve populations or allow a species to avoid predation or parasitism by temporally restricted species (Slansky 1974).

Intensive studies of the mirid fauna of other plants, e.g., scotch

broom (Waloff and Southwood 1960) and honeylocust (Wheeler and Henry 1976), have revealed specific differences in oviposition sites, food habits, and seasonal histories. *Dichrooscytus elegans* and *D. repletus,* the most abundant mirids on cupressaceous hosts, showed dissimilarities in their life histories. Based on only a few observations, eggs of *elegans* were placed within the scale-like juniper foliage, while eggs of *repletus* were laid in cedar rust galls. The times of appearance of the species are also distinct. Eggs of *elegans* hatch in late April in central Pennsylvania, and adults appear in mid-May. Eggs of *repletus* hatch about four weeks later when nymphs of *elegans* are disappearing; adults mature in mid- to late June as those of *elegans* are becoming scarce.

The host plants of *elegans* and *repletus* were similar: most of the common cultivars and varieties of *Juniperus chinensis, J. communis, J. horizontalis,* and *J. virginiana.* Andorra, Hetz, Pfitzer, and Sargent's juniper usually supported large numbers of these mirids. *D. elegans* developed large populations on the Andorra-Sargent's juniper hedge used for weekly sampling but only an occasional *D. repletus* was collected. On many arborvitae and juniper plants large numbers of both species are present, the population peaks occurring about a month apart. The most significant difference in host-plant range is seen in the utilization of *Chamaecyparis. D. repletus* often was as numerous on false cypress as on arborvitae and juniper, but only a few specimens of *elegans* were taken on *Chamaecyparis,* even when these plants were growing near arborvitae and juniper harboring large numbers of *elegans.*

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