DIVERSITY OF THE TRUE BUGS (HEMIPTERA: HETEROPTERA) ON ARNOLD AIR FORCE BASE, TULLAHOMA, TENNESSEE

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ABSTRACT—Species of true bugs were sampled, identified, and evaluated from nine diverse habitats on the 15,816 ha Arnold Air Force Base in Tennessee during a one-year study. Species were sampled using nine collection methods (beat sheet, canopy fogging, direct hand-picking or aerial netting, leaf litter, light trap, Malaise trap, Manitoba trap, pit fall trap, and sweep-net). The 1,360 hemipteran specimens collected represented 97 species in 22 families. Four families (Pentatomidae, Lygaeidae, Reduviidae, and Coreidae) constituted 50% of all species collected, while 75.2% of all specimens were from families Lygaeidae, Miridae, Pentatomidae, and Tingidae. A significant difference in species diversity among habitats was documented. Comparison of Shannon-Wiener diversity indices for species varied from a low of 0.25 in the Maidencane site to a high of 3.11 at a recently burned grassland site, indicating a low to moderate high diversity among sites. Species evenness values ranged from 0.22 at the Maidencane site to 0.96 at the pine site (maximum value = 1). The number of hemipteran species collected per site ranged from three at the Maidencane site to 42 at the recent burned site. More species were collected within the grassland barren (recent burned, 42; burned, 34; non-burned, 29) and Sinking Pond (33) sites than within the forest-dominated (pine, 25; Bradley Creek, 15; and Goose Pond, 11; oak, 9) sites.

The suborder Heteroptera (Order: Hemiptera) comprises a diverse taxa within the 40–45 families recorded from North America (Poole and Gentili, 1997; Schaefer and Panizzi, 2000; Schuh and Slater, 1995). Although several species are widely distributed throughout the United States, most are restricted to specific geographical regions. Hemipterans are recorded from elevations ranging from sea level to above 5,400 m. Several species are economically important, with many of these considered major pests of agricultural and ornamental crops (Schaefer and Panizzi, 2000; Schuh and Slater, 1995). These species may damage plants by feeding on the roots, foliage, flowers, fruit, stems, and trunk. Others are medically important as vectors of pathogens (Reduviidae) (Garcia et al., 2000). In addition, this taxon includes several predaceous species that are highly beneficial against pest species and are useful in regulating pest populations in agricultural crops.

Current information on much of the hemipteran fauna of Tennessee, especially beneficial species, is superficial, scattered, and disorganized. Thus, data are not readily available for decision-making by researchers and administrators on land management or environmental issues. Local records for hemipterans are sparse although true bugs play an important role and comprise an integral component of the various habitats within the state. The objective of this study was to identify hemipteran species associated with various habitats at Arnold Air Force Base (AAFB), Tullahoma, Tennessee.

MATERIALS AND METHODS

Study Sites—The hemipteran fauna was sampled from September 1997 through October 1998 at nine sites in the 15,816 ha AAFB located in Coffee and Franklin Counties, Tennessee, within the Barrens of the Southeastern Highland Rim in Tennessee. The Barrens comprises 1,256 km^2 within the Southeastern Highland Rim physiographic province (Pyne, 2000). Of the nine sites sampled, three were native grassland sites adjacent to an airstrip that contained a: (1) burned grassland site [35°23′29″N, 86°5′18″W] that was burned in spring 1997 as an active management practice for maintenance and restoration of the native plant community; (2) recently burned grassland site [35°23′12″N, 86°5′30″W] that was initially sampled as a non-burned grassland community, but was burned in late fall 1997 for management purposes; and (3) non-burned grassland site [35°23′16″N, 86°5′1″W] that was added in early spring 1998 to compare the insect fauna to that of the burned grassland sites. The remaining six sites included: (4) Goose Pond site [35°23′14″N, 86°1′26″W], a registered National Natural Landmark comprising a 64 ha karst pan mixed hardwood forest wetland area; (5) Maidencane site [35°23′13″N, 86°1′27″W] adjacent to Goose Pond and dominated by a single disjunct coastal grass species (*Panicum hemitomon* Schult); (6) oak site [35°25′1″N, 86°3′8″W] representative of the primary forest component (80% hardwood) found on AAFB and containing the state-designated rare dwarf huckleberry, *Gaylussacia dumosa* (Andr.); (7) Sinking Pond site [35°24′37″N, 86°4′10″W], a compound sink wetland comprising 155 ha with variable fluctuations in water levels that can fill or drain within 24 hours due to underground aquifers, is flooded for about six months each year during the spring and summer, is dry in the fall and winter, and the flora around the pond is dominated by overcup oak (*Quercus lyrata* Walter), river birch (*Betula nigra* L.), and resurrection fern (*Polypodium polypodiodes* L.). This unique habitat is tentatively ranked by the Tennessee Nature Conservancy as G1, meaning critically imperiled globally. Additional sites included: (8) Bradley Creek site [35°20′2″N, 85°59′27″W], a riparian forest composed of a mixed mesophytic hardwood community along the banks of lower Bradley Creek; and (9) pine site [35°21′13″N, 86°8′25″W], a 30-year-old plantation of mature loblolly pine (*Pinus taeda* L.) that is managed by periodically burning the understory to discourage hardwood development. Sites were sampled intensively during September and October 1997 and from March through October 1998, except for Site 3, which was sampled only in 1998.

Collection Procedures—Because of the diverse feeding habits that include foliage and seed feeders, root feeders, predators, etc. (Schaefer and Panizzi, 2000) and behavior of hemipterans, an array of collecting methods was used. Sampling procedures included: direct sampling of plant vegetation (specimens hand picked or netted for ca. 30 min per site per week); sweep-net sampling (38 cm diam., 82 cm deep and 120 ml volume, 10 samples in 1997 and 5 samples in 1998 were taken weekly per site with each sample consisting of 20 sweeps); beat-sheet sampling (91.4 cm^2, 5–10 samples per site per week); pitfall trapping (60 mm wide, 65 mm deep with 120 ml volume, 5–10 samples per week), light trapping (12-watt, U-shaped blacklight tube with collection unit, with 1 light trap per site sampled overnight every 14–21 days), canopy fogging (Asana XL, 0.66 emulsifiable concentrate applied 8–10 min with a Dyna-Fog Golden Eagle model 2610 fogger, one tree at sites 4, 6–9 (Maidencane and grassland sites excluded) sampled every 4–7 weeks); leaf-litter sampling (sites sampled weekly in 1997 and monthly in 1998, samples placed into Tullgren funnels (125 ml volume) for 48 h); malaise trapping (60 mm wide, 65 mm deep with 120 ml volume collection unit, sites sampled every 1–2 weeks), and Manitoba trapping (2 m^2 black plastic 2 m perpendicular to ground surface, 20 cm diam., 20 cm deep collection unit; sites samples weekly). Each sample was labeled for date, site, and collection method. Samples from all collection sites were taken to the laboratory, where they were processed and identified.

Data Analysis—Specimens were individually pinned or placed on mounted points and identified using standard keys. Species names used were compared with those from listings in texts (Henry and Froeschner, 1988; Poole and Gentili, 1997; McPherson and McPherson, 2001; Schaefer and Panizzi, 2000; Schuh and Slater, 1995; Sweet, 2000; Wheeler, 2001). Family, genus, species, number of specimens collected, number of specimens per site, collection site, collection date, and collection method were entered into Biota® database, and imported into Excel® files for analysis using statistical procedures for analysis of variance (ANOVA) (SAS Institute, 1997). Two different measurements [Berger-Parker and Shannon diversity index (Magurran, 1988; Price and Waldbauer, 1994)] were used to assess species diversity and dominance. A one-way ANOVA was used to compare the diversity indices among sites and collection methods used. Species diversity also was evaluated using Q-dominance to assess the cumulative species abundance and dominance (Kempton and Taylor, 1976). To assess the number of uncommon or rarely encountered species collected, we divided those species represented by a single specimen by the total number of species to obtain a ratio. Voucher specimens of all species are deposited in the University of Tennessee Insect Museum.

RESULTS

From September 1997 through October 1998, 1,360 specimens of true bugs were collected representing 97 species in 22 families from nine sites (Table 1). Species richness (mean = 22 species per site) varied from three species in the Maidencane site to 42 species in the recent burned grassland site (Table 2). Approximately 70% of species collected were present at one or two sites, while only two species, *Lygus lineolaris* (Palisot de Beauvois) and *Euschistus servus* (Say), were considered widespread (present at six or more sites). The three grassland sites represented > 52% of the total species collected at the nine sites. Most species from the recent burned grassland (42), burned grassland (34), and non-burned grassland (29) sites were collected from multiple sites. Within the five forest-dominated sites, species richness ranged from 33 species at Sinking Pond to 9 species at the oak site.

Diversity indices indicate differences among the nine sites (Table 2). The Berger-Parker index projects the highest species diversity within the pine site (12.25), while the Shannon index projects the highest species diversity in the recent burned grassland site (3.11), although the pine site was second in species diversity (3.04). Diversity, as calculated by the Shannon index, ranged from 0.25 in the Maidencane site to 3.11 at the recent burned grassland site, indicating a low to moderately high diversity among sites (Table 2). Species diversity was significantly lower in the Maidencane site compared to the other eight sites in the Berger-Parker index (*d.f.* = 48, $F = 2.83$, $P < 0.05$), and compared to the burned grassland, Bradley Creek, Goose Pond, oak, and Sinking Pond sites in the Shannon index (*d.f.* = 48, $F = 2.80$, $P < 0.01$). Moderate diversity levels were calculated for the remaining sites by both indices. Species diversity as determined by Q-statistic infers that 17 species represented over 75% of the specimens collected. This inference was determined by comparing the cumulative number of species collected against the number of individual specimens obtained for each species.

Species evenness values ranged from 0.22 at the Maidencane site to 0.96 at the pine site (maximum value = 1) (Table 2). Except for the non-burned site (0.73), evenness values were considered to be high at the remaining sites. Statistical comparison of the cumulative values for species richness reveals a significant difference in hemipteran density. The Goose Pond, Maidencane, and oak sites were significantly lower (*d.f.* = 48, $F = 1.58$, $P < 0.05$) than the burned, recent burned, non-burned, and Sinking Pond sites. No significant differences were noted among the remaining sites.

The efficacy of a collection method in sampling the fauna is often the result of a combination of factors including species mobility, relative abundance, sampling time, and affinity to that specific method. As such, those methods (Manitoba traps) directed at specific groups resulted in fewer species collected than with more general methods (sweep netting, beat sheeting, etc.), but demonstrated a higher species evenness due to only one species collected (Table 3). The number of species collected was significantly higher (*t*-test, *d.f.* = 36, $F = 12.93$, $P < 0.01$) only for the sweep-net samples compared to the other eight methods. The highest numbers of species were obtained using sweep nets (60), direct sampling (33), beat sheets (31), fogging (19), and pitfall traps (17); all involved sampling at or near ground level (Table 3). The leaf litter and Manitoba traps consistently had lower diversity values in both the Berger-Parker and Shannon indices. Only one species, *Arilus cristatus* (L.), was collected using a Manitoba trap. Two lygaeids, *Drymus crassus* Van Duzee and *Sphragisticus* sp., were obtained from leaf litter. Because most hemipterans that are found on grasses and shrubs feed on foliage, seeds, or flowers rather than other plant parts, or are

TABLE 1. Species of Hemiptera (n = 97) collected at nine sampling sites on Arnold Air Force Base, Tullahoma, Tennessee, 1997–1998.

Family	Genus	Species	Site[a]	Sampling method[b]	Spec.[c]	Associations[d]	Distribution[e]
Alydidae	*Alydus*	*eurinus* (say)	1, 2, 3, 9	BT, DI, FG, ML, PF, SW	50	vegetation, grains	E,[e] MW, SW
Alydidae	*Alydus*	*pilosulus* (Herrich-Schäeffer)	1, 2, 3	BT, ML, PF, SW	21	vegetation, Leguminosae	widespread
Aradidae	*Mezira*	*granulata* (Say)	7	DI	1	fungus, pines, red oak	E, MW
Belostomatidae	*Lethocerus*	*griseus* (Say)	4, 7	LT	2	predator, aquatic	widespread
Berytidae	*Jalysus*	*wickhami* Van Duzee	6, 7	BT, SW	6	grasses	E
Coreidae	*Acanthocephala*	*femorata* (F.)	8	PF	1	yellow thistle, shrubs, trees	SE, SW
Coreidae	*Acanthocephala*	*terminalis* (Dalls)	7, 8	SW, FG	2	grasses, flowers, shrubs, trees	E, SW
Coreidae	*Euthochtha*	*galeator* (F.)	1, 2, 3, 4	DI, FG, PF, SW	9	shrubs, weeds nr. water	S
Coreidae	*Merocoris*	*typhaeus* (F.)	1, 2, 3	BT, FG, SW	18	flowers, plants nr. water	E, MW
Coreidae	*Leptoglossus*	*corculus* (Say)	9	SW	1	shrubs, grasses	E
Coreidae	*Leptoglossus*	*oppositus* (Say)	7	DI	1	low shrubs, curcubids, cowpea, peach	E, MW
Coreidae	*Leptoglossus*	*phyllopus* (L.)	2	SW	2	fruit, vegetables, cotton, sorghum, thistle	E, SW
Coreidae	*Piezogaster*	*calcarator* (F.)	3	BT	1	low shrubs	—
Corixidae	*Trichocorixa*	*calva* (Say)	7	LT	1	predator, aquatic	widespread
Corixidae	*Hesperocorixa*	*nitida* (Fieber)	7	DI	1	small streams	widespread
Corixidae	*Hespercorixa*	*vulgaris* (Hungerford)	7	DI	1	small streams	widespread
Corixidae	*Sigara*	*signata* (Fieber)	7	LT	1	herbivore, nr. streams, lotic areas	widespread
Cydnidae	*Amnestus*	*pusillus* Uhler	9	LT	2	root-feeder, shrubs, debris	E, MW, SW
Cydnidae	*Microporus*	*obliquus* Uhler	2	SW	1	foliage, cantaloupe, mesquite	SE, W
Cydnidae	*Pangaeus*	*bilineatus* (Say)	1, 2, 8	BT, FG, PF	21	foliage of trees, vegetables, cotton	widespread
Cydnidae	*Sehirus*	*cinctus* (Palisot)	1, 2	BT, SW	3	flowers, foliage (Labiate)	E, MW
Gelastocoridae	*Gelastocorus*	*oculatus* (F.)	8	DI	2	predator, aquatic	widespread
Gerridae	*Gerris*	*argenticollis* Parshley	7	DI	4	predator	E
Hydrometridae	*Hydrometra*	sp.	7	DI	1	nr. streams, on vegetation	—
Lygaeidae	*Drymus*	*crassus* Van Duzee	8	LL	2	shrubs	E
Lygaeidae	*Ischnodemus*	sp.	1, 2, 5	BT, PF, SW	118	—	—
Lygaeidae	*Kleidocerys*	*resedae* (Panzer)	2, 6	FG, SW	11	flowers, grasses in moist soil	widespread
Lygaeidae	*Ligyrocoris*	*diffusus* (Uhler)	1, 2, 3	BT, ML, PF, SW	38	tall grasses in meadows	E, W
Lygaeidae	*Myodocha*	*serripes* Olivier	1, 2, 3, 9	LT, ML, PF	19	grasses (oats), strawberries, seeds	E, MW

TABLE 1. Continued.

Family	Genus	Species	Site[a]	Sampling method[b]	Spec.[c]	Associations[d]	Distribution[e]
Lygaeidae	*Neacoryphus*	*bicrucis* (Say)	1, 2, 3, 9	BT, FG, LT, SW	12	flowers, shrubs in moist soils	E, MW
Lygaeidae	*Neortholomus*	*scolopax* (Say)	1, 2, 3	BT, ML, SW	27	flowers, weeds, goldenrod	E, SW
Lygaeidae	*Oedancala*	*dorsalis* (Say)	1, 2, 3	BT, SW	16	grasses nr. fields	E, SW
Lygaeidae	*Paromius*	*longulus* (Dallas)	2, 3, 9	BT, PF, SW	36	grasses	E
Lygaeidae	*Perigenes*	*constrictus* (Say)	1	PF	2	grasses nr. streams	E, MW, W
Lygaeidae	*Phlegyas*	*abbreviatus* (Uhler)	1, 3, 4	DI, SW	18	grasses in meadows	E, MW
Lygaeidae	*Pseudopachybrachius*	*basalis* (Dallas)	1, 2, 4, 9	PF, SW	59	grasses	E, SW
Lygaeidae	*Sphragisticus*	sp.	1, 2	LL, PF	2	—	E
Lygaeidae	*Zeridoneus*	*costalis* (Van Duzee)	1	PF	2	weeds nr. streams	E
Miridae	*Fulvius*	*brunneus* (Provancher)	7	PF	12	fields, meadows	widespread
Miridae	*Hyaliodes*	*vitripennis* (Say)	4, 6	FG	5	plants, *Vitis* sp., predator of aphids	E, S
Miridae	*Lygus*	*lineolaris* (Palisot de Beauvois)	1, 2, 3, 4, 6, 8, 9	BT, DI, LT, SW	218	Compositae, Umbelliferae	widespread
Miridae	*Phytocoris*	*depictus* Knight	7	FG	6	oaks	NE, MW
Miridae	*Stenodema*	*trispinosa* (Reuter)	2, 9	LT	3	grasses in moist meadows	widespread
Miridae	*Stenotus*	*binotatus* (F.)	2, 3	SW	10	orchardgrass, grasses in meadows	exotic, widespread
Nabidae	*Carthasis*	*decoratus* (Uhler)	6	FG	2	predator, shrubs	E
Nabidae	*Lasiomerus*	*annulatus* (Reuter)	8	SW	1	predator, foliage, low shrubs nr. water	E
Nabidae	*Nabis*	*roseipennis* Reuter	8, 9	DI, SW	3	predator, on tall grasses nr. water	E, SW
Nabidae	*Hoplistoscelis*	*sordidus* (Reuter)	7, 8	BT, DI, SW	15	predator, foliage weeds nr. woods, ragweed	E, SW
Nabidae	*Nabicula*	*subcoleoptrata* Kirby	2, 3	PF	2	predator, low foliage (wetlands)	E, MW
Nepidae	*Ranatra*	*nigra* Herrich-Schäeffer	7	DI	3	predator, on aquatic plants	E, S
Notonectidae	*Notonecta*	*irrorata* Uhler	7	DI	3	predator, assoc. with aquatic weeds	E, MW, SW
Pentatomidae	*Acrosternum*	*hilare* (Say)	1, 8, 9	BT, DI, FG, LT, SW	7	fruits, vegetables, cotton, soybeans, oak	widespread
Pentatomidae	*Banasa*	*dimidiata* (Say)	4, 7	LT, SW	2	grasses, *Vaccinium,* fruit trees, berries	widespread
Pentatomidae	*Brochymena*	*cariosa* Stål	7	DI	1	elm, oak, pine, willow	E, MW
Pentatomidae	*Coenus*	*delius* (Say)	1, 3	BT, SW	4	grasses, soybean, raspberry	E, MW
Pentatomidae	*Euschistus*	*ictericus* (L.)	5	DI, SW	6	tall grasses, iris, thistle, soybeans	E, MW

TABLE 1. Continued.

Family	Genus	Species	Site[a]	Sampling method[b]	Spec.[c]	Associations[d]	Distribution[e]
Pentatomidae	*Euschistus*	*servus* (Say)	1, 2, 3, 5, 6, 7, 9	BT, DI, FG, ML, SW	46	flowers of plants, sorghum, variety of crops	E, W
Pentatomidae	*Euschistus*	*tristigmus* (Say)	8, 9	BT, DI, SW	11	flowers of plants, cotton, soybeans	E, MW
Pentatomidae	*Mormidea*	*lugens* (F.)	1, 2, 3, 9	PF, FG, SW	17	foliage of bushes	E, W
Pentatomidae	*Nezara*	*viridula* (L.)	1, 2	SW	2	soybeans, sorghum, vegetables, pecan	widespread
Pentatomidae	*Oebalus*	*pugnax* (F.)	1, 2, 3	BT, DI, FG, SW	39	rice, grains, general plant foliage	E, MW
Pentatomidae	*Parabrochymena*	*arborea* (Say)	4, 7	DI, SW	3	tree foliage (elm, oak, pine, beech, willow)	E, MW
Pentatomidae	*Podisus*	*maculiventris* (Say)	7, 8, 9	DI, SW	6	predator	widespread
Pentatomidae	*Stiretrus*	*anchorago* (F.)	2	DI	1	predator; on flowers, thistle	E, MW
Pentatomidae	*Thyanta*	*custator accerra* McAtee	1, 2, 9	LT, SW	7	low shrubs, pine, bean, sorghum, grains	E, W
Pentatomidae	*Thyanta*	*calceata* (Say)	1, 2, 3, 9	BT, SW	18	trees, shrubs in wet areas	SE, MW
Pentatomidae	*Trichopepla*	*semivittata* (Say)	2, 3	BT, SW	8	Umbelliferae	E, MW
Phymatidae	*Macrocephalus*	*cimicoides* Swederus	1, 2	DI, SW	4	predator	S, W
Phymatidae	*Lephoscutus*	*prehensilis* (F.)	3	SW	1	predator, foliage low vegetation	SE, SW
Phymatidae	*Phymata*	*fasciata* (Gray)	1, 2, 3, 7, 9	BT, DI, SW	7	predator, on flowers—Compositae	S, SW
Phymatidae	*Phymata*	*vicina* Handlirsch	9	SW	1	predator	—
Reduviidae	*Apiomerus*	*crassipes* (F.)	6	DI	1	predator; foliage shrub, buildings	E, SW
Reduviidae	*Arilus*	*cristatus* (L.)	7	MN	2	predator; on low shrub, grasses	E, SW
Reduviidae	*Barce*	*fraterna* (Say)	7	DI	1	grasses, semi-aquatic	E, SW
Reduviidae	*Empicoris*	*errabundus* (Say)	6, 7, 9	FG	8	hickory	E, MW
Reduviidae	*Melanolestes*	*picipes* (Herrich-Schäeffer)	7	DI	1	predator; under stones, debris	E, SE
Reduviidae	*Sinea*	*diadema* (F.)	1, 2	SW	3	predator; on grasses, flowers, trees	widespread
Reduviidae	*Sinea*	*spinipes* (Herrich-Schäeffer)	3, 4, 8, 9	BT, SW	6	predator; on flowers—Compositae	E, MW
Reduviidae	*Sirthenea*	*carinata* (F.)	4	LT	1	predator; flowers, weeds, wetland	E, SW
Reduviidae	*Triatoma*	*sanguisuga* (Leconte)	4	LT	1	predator; on flowers, pine, oak	E, SW

TABLE 1. Continued.

Family	Genus	Species	Site[a]	Sampling method[b]	Spec.[c]	Associations[d]	Distribution[e]
Reduviidae	*Zelus*	*cervicalis* Stål	1, 2, 3	BT, SW	6	predator; grasses, trees, shrubs nr. ponds	S, SW
Rhopalidae	*Arhyssus*	*nigristernum* (Sign.)	9	SW	4	weeds	E
Rhopalidae	*Harmostes*	*fraterculus* (Say)	2, 9	BT, DI, SW	3	flowers—Compositae	E, W
Rhopalidae	*Harmostes*	*refluxulus* (Say)	1, 2, 3, 9	BT, PF, SW	41	flowers, meadows, nr. streams	widespread
Rhopalidae	*Liorhyssus*	*hyalinus* (F.)	1, 2	SW	2	grasses, sorghum	widespread
Rhopalidae	*Arhyssus*	*nigristernum* (Sign.)	9	SW	4	weeds	E
Rhopalidae	*Stictopleurus*	*punctiventris* (Dallas)	6, 7	FG, SW	2	foliage, shrubs, meadows, grasses, grains	NE, MW, W
Scutelleridae	*Homeamus*	*parvulus* (Germar)	2	SW	3	foliage, trees, low grasses, timothy	E, MW
Thyreocoridae	*Corimelana*	*lateralis* (F.)	1, 2, 3, 8, 9	BT, DI, FG, SW	25	weeds, grass, soybean, potato, carrot	E, W
Thyreocoridae	*Corimelana*	*marginella* Dallas	2	BT, SW	3	flowers, foliage nr. streams	E, MW
Thyreocoridae	*Corimelana*	*obscura* McPher. & Sail.	7	DI	1	clover, snake-root	E, MW
Thyreocoridae	*Corimelana*	*pulicaria* (Germar)	1, 2, 3, 7	BT, DI, SW	22	general plant feeder, grains (rice)	E, W
Thyreocoridae	*Galgupha*	*aterrima* Malloch	7	SW	1	herbivore on grasses in fields	E, S
Tingidae	*Atheas*	*austroriparius* Heidemann	2, 3	BT, SW	2	brier	S
Tingidae	*Corythucha*	*aesculi* Osborn & Drake	7, 8	FG, SW	6	—	E
Tingidae	*Corythucha*	*cydoniae* (Fitch)	7	FG, LI, ML, SW	221	oak, maple, apple, rose	widespread
Tingidae	*Leptopharsa*	*oblonga* (Say)	7	SW	1	foliage of Leguminosae	E, MW
TOTAL		97			1360		

[a] Site: 1 = burned grassland; 2 = recent burned grassland; 3 = non-burned grassland; 4 = Goose Pond Woodland; 5 = Maidencane in Goose Pond; 6 = oak; 7 = Sinking Pond; 8 = Bradley Creek; 9 = pine.

[b] Sampling method codes: BT = Beat sheet; DI = Direct collect; FG = Fog; LL = Leaf litter; LT = Light trap; ML = Malaise; MN = Manitoba; PF = Pitfall trap; and SW = Sweep net.

[c] Total number of specimens collected at all sites.

[d] Host and distribution records from: Arnett, 1993; Blatchley, 1926; McPherson, 1982; Schaefer and Panizzi, 2000; Schuh and Slater, 1995.

[e] Abbreviations: E = eastern; S = southern; SE = southeastern; NE = northeastern; W = western; MW = midwestern; SW = southwestern; and widespread = throughout the United States

TABLE 2. Diversity measures for the true bugs sampled at nine sites at Arnold Air Force Base, Tullahoma, Tennessee, 1997–1998.

	Berger-Parker		Shannon				
Sites	Index	Means[1]	H′	Max	Means	Evenness	Richness
Burned grassland	5.89	1.85bcd	2.95	3.58	0.84bc	0.82a	34a
Recent burned grassland	4.98	2.82bcd	3.11	3.78	1.73ab	0.82a	42a
Non-burned grassland	2.67	3.52b	2.48	3.40	1.78ab	0.73a	29ab
Goose Pond	3.60	1.58cd	2.08	2.30	0.76bc	0.90a	11c
Maidencane	1.06	5.57a	0.25	1.10	2.34a	0.22a	3c
Oak	3.50	1.08d	2.20	2.40	0.17c	0.92a	9c
Sinking Pond	4.15	2.28bcd	2.83	3.22	1.04bc	0.88a	33a
Bradley Creek	4.33	2.25bcd	2.40	2.71	1.04bc	0.89a	15abc
Pine	12.25	3.02bc	3.04	3.04	1.43ab	0.96a	26abc

[1] Means followed by the same letter do not differ significantly within same column (t-test for: Berger-Parker, $d.f. = 48$, $F = 2.83$, $P < 0.05$; Shannon: $d.f. = 48$, $F = 2.80$, $P < 0.01$; Evenness; $d.f. = 48$, $F = 1.58$, not significant; and Richness: $d.f. = 48$, $F = 1.58$, $P < 0.05$).

predators of plant-inhabiting insects, sampling methods directed to these plant parts were most efficient in obtaining the highest number of species. Species diversity was significantly higher for collections by sweep nets compared to other methods used except for direct, light traps, and pitfall traps in the Berger-Parker index ($d.f. = 36$, $F = 2.28$, $P < 0.05$) and the direct and pitfall traps in the Shannon index ($d.f. = 36$, $F = 5.40$, $P < 0.05$). Seventy-three species were collected with one or two collecting methods, 23 species with three to five collection methods, and only one species using six or more methods.

Because an assessment of the number of rarely collected species within a habitat depends on the sample size, sampling time, and species behavior, comparing the results from the nine sampling methods may not accurately reflect the number of species present within a specific habitat. For example, only six species of the possible dozens of mirid species potentially present in these habitats were collected as a result of the limited collection time focused on a specific taxa. Ten specimens of the exotic species *Stenotus binotatus* (F.) were collected from the burned and non-burned grassland sites. Thus, when the cumulative data for specimens from all sites were pooled, the infrequently collected species (single specimen of each species) represented 25% of the total number of species collected. The proportion of those species collected in low or single numbers during this study was highly correlated with the collection method used. Of the 24 species represented by one specimen, the lowest proportion (8.3%) was obtained from beat sheets and pitfall traps, while the highest proportion (45.8%) was obtained from direct collection samples. Single specimens were obtained from beat sheet, direct, light traps, pit-fall traps, and sweep-net samples.

A low family constancy in both species and specimen numbers is indicated by the data. Fourteen of the 22 families (63.6%) were represented by fewer than five species. The highest numbers of families were recorded from Sinking Pond (17), recent burned

TABLE 3. Diversity measures for the true bugs sampled using nine collection methods at Arnold Air Force Base, Tullahoma, Tennessee, 1997–1998.

	Berger-Parker		Shannon				
Methods	Index	Means[1]	H′	Max	Means	Evenness	Richness
Beat	2.44	2.09b	2.43	3.43	1.22b	0.84abc	31b
Direct	7.80	3.13ab	3.21	3.50	1.41ab	0.95abc	33b
Fog	4.00	1.67bc	2.08	2.30	0.62bc	0.95abc	19b
Leaf litter	1.50	1.50bc	0.64	0.69	0.64bc	0.92abc	2b
Light	8.00	2.30abc	2.38	2.48	1.10b	0.96ab	14b
Malaise	3.50	1.50bc	1.75	1.79	0.44bc	0.99a	7b
Manitoba	1.00	1.00c	0.00	0.00	0.00c	1.00a	1b
Pitfall	4.38	2.19abc	2.24	2.89	1.36ab	0.78c	17b
Sweep	4.35	3.75a	3.07	4.09	2.28a	0.78c	60a

[1] Means followed by the same letter do not differ significantly within same column (t-test for: Berger-Parker: $d.f. = 36$, $F = 2.28$, $P < 0.05$; Shannon: $d.f. = 36$, $F = 5.40$, $P < 0.05$; Evenness: $d.f. = 36$, $F = 3.58$, $P < 0.05$; and Richness; $d.f. = 36$, $F = 12.93$, $P < 0.01$).

grassland (13), non-burned grassland (11), pine (11), burned grassland (10), and Bradley Creek (10) sites. The lowest numbers of families (2) and species (3) were collected in the Maidencane site dominated by a single grass species. Fifty percent of all species collected were from four families: Pentatomidae (16 species), Lygaeidae (14 species), Reduviidae (10 species), and Coreidae (8 species). Of all specimens collected, 75.2% were in the four families Lygaeidae (362), Miridae (254), Pentatomidae (178), and Tingidae (230).

The superfamily Pentatomoidea (Cydnidae, Pentatomidae, Scutelleridae, and Thyreocoridae) includes an estimated 222 species in North America (Froeschner, 1960; Henry and Froeschner, 1988; McPherson, 1982), many of which are economically important (DeClercq, 2000; Panizzi et al., 2000). Several specimens (39) of *Oebalus pugnax* (F.), one of four species of this Neotropical genus in North America, were collected. Other Neotropical genera collected included *Mormidea* and *Stiretrus*. However, some stink bugs that occur within this region, e.g., *Murgantia histrionica* (Hahn) and *Perillus bioculatus* (F.), were not collected during our study. Some rather uncommon species, e.g., *Coenus delius* (Say), were collected from the burned and non-burned grassland sites with both beat sheets and sweep nets. Thyreocoridae (Corimelaenidae), although not often encountered due to their small size and behavior of feeding on the foliage of a variety of trees and shrubs in areas near water (Blatchley, 1926), was represented by four species. Only one scutellerid species, *Homaemus parvulus* (Germar), was collected during this study from sweep-net sampling of grasses at the recent burned grassland site. *Homaemus parvulus* is one of four species in this genus known to occur east of the Mississippi River (Blatchley, 1926; Lattin, 1964; Hoffman, 1971; Henry and Froeschner, 1988). Hoffman (1971) recorded 79 species of Pentatomoidea from the bordering states of Virginia and North Carolina; 16 species were collected and identified during this one-year study.

The lygaeids are primarily seed feeders with the number of species estimated at 295 to 322 in the United States (Arnett, 1993; Ashlock and Slater, 1988). We identified 14 species from eight of the nine collection methods. These species were collected primarily in the grassland sites. However, four species were collected at the pine site, two species at the Goose Pond site, and one species at the Bradley Creek, Maidencane, and oak sites.

The superfamily Coreoidea, represented by the families Alydidae, Coreidae, and Rhopalidae, is considered to be primarily tropical with species numbers higher in the southern than in the northern United States (Hoffman, 1975). Although most are foliage feeders, some species injure seeds and fruits of their host plants (Mitchell, 2000). Of the 87 coreid species of this superfamily recorded from the United States (Henry and Froeschner, 1988), 27 species were recorded in Virginia (Hoffman, 1975) compared to 15 identified in this study.

Although we did not conduct aquatic sampling, seven aquatic and semi-aquatic families (Belostomatidae, Corixidae, Gelastocoridae, Gerridae, Hydrometridae, Nepidae, and Notonectidae) were represented. Except for the belostomatid and two corixids collected in a light trap, all of the aquatic and semi-aquatic families were visually observed and collected. Other families (Anthocoridae and Piesmatidae) not collected during this study are known to be present in the state.

Discussion

Although the high percentage of species recorded from the grassland barren sites may reflect sample size, it also may reflect the importance of habitat type. The higher number and composition of plant species within the three grassland barren sites due to the recent disturbance by fire may provide more suitable hosts for hemipterans resulting in the collection of greater numbers within these sites. The low species numbers recorded in the wetland sites (Maidencane and Goose Pond) with fewer host plants support this concept. Some of the smaller aquatic and semi-aquatic families were represented by a single species. The mirids were represented by only six species in this study as a result of the limited time directed at any specific taxa. Also, the Tingidae with 154 North American recorded species were represented by only four species. Additional long-term studies are needed to comprehensively document the species present within the various habitats.

The differences in values exhibited by the Berger-Parker and Shannon indices may be a result of the latter being more heavily weighted to the most abundant species and less weighted to species richness. Species diversity by the Shannon index is heavily weighted for the number of samples. When the ratio of specimens collected to the species recorded within each of the nine sites are compared, the Berger-Parker measurements appear to be influenced more by the number of specimens. The evenness of species indicated by the Shannon index assumes all species in the habitats were accounted for in the samples, which might partly explain the value differences exhibited by the two indices.

Data obtained on these 97 species provide the basis for development of a database of the Hemiptera within Tennessee and contribute to our understanding of the hemipteran diversity within the region. Development of such a database will provide vitally important information in support of programs such as biodiversity initiatives, environmental impact studies, and implementation of pest management strategies. From a management perspective, these results indicate that the unique habitats sampled differ in their species composition, and a closer focus should be made of potential indicator species. The collection of 70% of the species by one or two collection methods suggest that these data might be used to develop a more targeted approach for monitoring a specific taxon. These data also may be useful in developing effective strategies to protect and manage native vegetation communities or individual plant species and the associated native insect species should they become threatened by habitat destruction, overexploitation, invasion by exotic species, spread of diseases, or pollution.

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