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THE FOOD PLANTS OF SOME "PRIMITIVE" PENTATOMOIDEA (HEMIPTERA: HETEROPTERA)

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ABSTRACT

The food plants of the Cydnidae (Cydninae, Sehirinae, Scaptocorinae, Amnestinae, Garsauriinae, Thaumastellinae, Parastrachiinae, Corimelaeninae), Plataspidae, Megarididae, Cyrtocoridae, and Lestoniidae, compiled from the literature, are discussed. So too are the habitats of these insects, most of which live on or are associated with the ground. This association supports an earlier assertion that life on the ground was the way of life of the early hemipterans.

Most of these groups are polyphagous. However, the Plataspidae feed largely upon legumes, the Scaptocorinae upon the roots of Gramineae, some Cydninae also upon legumes, and many Sehirinae upon members of the advanced dicot subclass Asteridae. Fallen seeds and roots are the preferred plant parts.

A group of mostly small drab shieldbugs appears to be primitive in the Pentatomoi-
dea: "primitive" in the sense of possessing several plesiomorphic features, and "a
group" because they also share some apomorphies; neither the autoplesiomorphies
nor the autapomorphies are shared with other pentatomoids (Schaefer, in prep.). I
have also suggested (1981) that the early heteropterans lived on the ground, not up on
plants (see also Schaefer, in press). Accordingly, some knowledge of these pentato-
moids' biology may be useful in working out their phylogenetic relationships, and
interesting of course in its own right.

These families are the Cydnidae (*sensu lato*: see below), Plataspidae, Lestoniidae,
Cyrtocoridae, Megarididae, and Canopidae. Their food plants and habitats are listed
and briefly discussed here. Almost all records are from the literature, and I have been
careful to eschew "sitting on" or probing records; I have always preferred records of
nymphs' feeding. Therefore I hope any errors are ones of omission, not commission.

RESULTS

Cydnidae

I follow here the classification of this family of Dolling (1981), who included the

subfamilies Cydninae, Sehirinae, Amnestinae, Garsauriinae, and Scaptocorinae (groups usually included) as well as the Corimelaeninae and Thaumastellinae (groups previously treated as separate families). There is some evidence the Corimelaeninae should be raised to family level, with two subfamilies; my results here argue neither for nor against such a view, and I follow Dolling's placement. The Parastrachiinae, a subfamily recently erected and placed in the Cydnidae (Schaefer et al., in press) may also some day require family rank.

Cydninae.— Members of this subfamily feed very widely indeed (Table 1). The food plant families represent sixteen dicot and two monocot orders and all dicot subclasses except one (classification of Cronquist, 1968). Only two species feed on members of the Magnoliidae (on Papaveraceae), the most primitive of the dicot subclasses (Cronquist, 1968), and none on another primitive subclass, Hamamelidae. Six species in six genera feed on members of the most advanced subclass, Asteridae. This is a low number, compared to the number of species in this subclass; and only three species (and three genera) feed on composites, an asterid family that is one of the largest plant families.

By far the most cydnines feed on Rosidae, members of seven orders being fed upon. The most popular family is Leguminosae (Rosales), particularly among members of the genus *Geotomus*, where Cruciferae and Gramineae are also used. Grasses are also commonly fed upon by other cydnines, particularly by species of *Aethus*. Grasses and legumes occur most frequently in Table 1, but in no consistent way: they often occur as but part of a more generalized diet.

No clear pattern emerges from these data. Cydnines feed very widely, and legumes, crucifers, and grasses are perhaps favored. No real specificity is evident, at the subfamily level or at the generic (except perhaps *Aethus* on grasses). To some extent, the variety of plants in Table 1 reflects the difficulty of knowing if the bugs actually feed on the roots where they are found.

It may be significant that these bugs, probably primitive within the Pentatomoi-dea, do not feed on the most primitive subclasses; nor do they feed to any great extent on the most advanced subclass, the Asteridae.

According to most authors, they feed on the roots of plants. But Stoner (1920) several times found *Cydnus obliquus* carrying a small seed with the middle legs. "When the insect was freed from the sand and allowed to walk freely" (p. 340), it retained the seed and walked with the other legs.

Other cydnines are also known to feed on seeds. Concerning *Adrisa*, Van den Berg (1980, p. 225) writes, "The *Adrisa* spp. live in the debris underneath wattle trees. They feed on the seeds of both *A[cacia] cyclops* and *A. saligna* as well as many other wattle species. All the seeds of *A. saligna* collected about 2 months after seed fall showed the characteristic feeding tubes of seed feeding Hemiptera and were non viable [*sic*]. As *Adrisa* spp. are the most dominant feeders underneath the trees, most of the inviability can be attributed to them".

Many cydnines live in dry areas and several are actually in sand. This is often aeolian sand (e.g., several species of *Aethus* [Stehlik, 1983]), but *Geotomus punctulatus* and *Aethus pilosulus* live in shore dunes. A great majority of cydnines feeds on roots in the sand or sandy soil, but Stehlik (1983) reports of one, *Cydnus aterrimus*, that the first instars feed on *Euphorbia* roots but that "older nymphs and adults creep

Table 1. Food plants and habitats of the Cydnidae: Cydninae

Insect species	Plant genus	Plant family	Remarks	Reference
<i>Cydnus aterrimus</i> (Forster)	<i>Solanum</i>	Solanaceae	underground parts	Ehanno 1961,
	<i>Sedum</i>	Crassulaceae		de la Fuente 1972
	<i>Geranium</i>	Geraniaceae	"auf einer Sanddüne"	
	<i>Mentha</i>	Labiatae	(Lindberg, 1932)	
	<i>Euphorbia</i> <i>Potentilla</i>	Euphorbiaceae Rosaceae	"auf und im sand"	Günther, et al. 1982
<i>C. sp.</i>	<i>Elymus</i>	Gramineae (monocot)	around roots	Stoner 1920
<i>Pangaesus bilineatus</i> (Say)	<i>Fragaria</i>	Rosaceae	roots	Sailer 1954
	<i>Spinacia</i>	Chenopodiaceae		McPherson & Mohlenbrock 1976
	<i>Arachis</i>	Leguminosae	major pest	Highland & Lummis 1986 Smith & Pitts 1974
<i>Geocnethus piriithous</i> Linnavuori			"on grasses under coffee trees"	Linnavuori 1973
<i>G. eavicollis</i> (Blatchley)			"buried a short dis- tance in sand, thinly covered with debris..."	Hussey 1925
<i>Melanaethus pennsylvanicus</i> (Signoret)			under litter in peach orchard	McPherson & Mohlenbrock 1976
<i>Macroscytus brunneus</i> (F.)	<i>Glaucium</i>	Papaveraceae	"in sand, among roots, ... underneath stones ... on ground"	de la Fuente 1972 Ribes 1984

<i>M. japonensis</i>	<i>Fatsia</i> <i>Cinnamomum</i> <i>Ilex</i> <i>Hibiscus</i> <i>Chironomus</i>	Araliaceae Lauraceae Aquifoliaceae Malvaceae (Insecta)	fruits, in laboratory on ground, under leaves on or in soil roots predacious and cannibal- istic when starved	Miyamoto 1955 Miyamoto 1965 Kobayashi 1953, 1954a, b <i>ditto</i> Miyamoto 1965
<i>Psammozetes ater</i> (Distant)			sand around roots of littoral plants	Miyamoto 1965
<i>Chilocoris confusus</i> (Horvath)			in soil around roots of grass	Miyamoto 1965
<i>Adrisa magna</i> (Uhler)			in or on groundcover of evergreen forest	Tomokuni (pers. comm.)
<i>Adrisa</i> spp.	<i>Acacia</i>	Leguminosae	on seeds under trees	Van den Berg 1980, 1982
<i>Geotomus elongatus</i> (Herrich-Schaeffer)	<i>Onobrychis</i> <i>Sinapis</i>	Leguminosae Cruciferae	"auf lockerem Boden, unter Pflanzen" (Wagner 1966)	de la Fuente 1972
<i>G. punctulatus</i> (Costa)	<i>Cakile</i> <i>Glaucium</i> <i>Euphorbia</i>	Cruciferae Papaveraceae Euphorbiaceae		de la Fuente 1972
<i>G. pygmaeus</i> (Dallas)	<i>Glycine</i> , <i>Trifolium</i> Gramineae spp.	Leguminosae Gramineae	"in Bunengebieten," in dunes, among roots	Wagner 1966 Ribes 1984
<i>G. sp.</i>	<i>Acacia</i> <i>Glycine</i>	Leguminosae Leguminosae	roots roots and fallen seeds on seeds under trees	Kobayashi 1964, 1981 Kobayashi 1974 Van den Berg 1982
<i>Microporus nigrinus</i> (F.)			roots under plants, in sandy areas	Kobayashi 1981 Singer 1952

<i>M. flavicornis</i> (F.)			under plants, in sandy areas	Singer 1952
<i>Cephalocteus scarabaeoides</i> (F.)	<i>Centaurea</i>	Compositae	"zwischen den Wurzeln," sap on roots	Lindberg 1932 de la Fuente 1972
<i>Ambyothus diffourii</i> Amyot et Serville	<i>Centaurea</i> , <i>Artemisia</i>	Compositae	sap on roots	de la Fuente 1972
<i>Aethus flavicornis</i> (F.)	<i>Polygonum Koeleri</i> , <i>Weingaertneria Erianthus</i> , <i>Calamagrostis</i>	Polygonaceae Gramineae (monocot)		de la Fuente 1972
	<i>Centaurea Carex</i>	Compositae Cyperaceae	"schwimmt" in sand"	Burghardt & Rieger 1978
<i>A. hispidulus</i> (Klug) <i>Aethus</i> spp.	<i>Thymus Ononis</i>	Labiatae Leguminosae		Southwood & Leston 1959 Southwood & Leston 1959
<i>A. nigratus</i> (F.)	<i>Nerium</i>	Apocyanaceae		Lodos & Önder 1980
			sandy places	Linnavuori 1977
	<i>Achillea</i> , <i>Artemisia Weingaertneria</i> other grasses	Compositae Gramineae (monocot) Gramineae (monocot)		Lodos & Önder 1980 de la Fuente 1972 Hoebeke & Wheeler 1984
	<i>Glycine</i> , <i>Trifolium</i>	Leguminosae	roots grass-covered soil "saugt an unterirdischen Pflanzenteilen" in sand	Kobayashi 1954b Miyamoto 1965 Hertzel 1983 Stehlik 1983

<i>A. flavicollis</i> (F.)	<i>Corynephorus</i> <i>Artemisia</i> <i>Oenothera</i>	Gramineae (monocot) Compositae Onagraceae	"saugt an Wurzeln" "Verpaarung im Sand" xerothermic localities, in sand	Hertzel 1983 Stehlik 1983
<i>A. hispidulus</i> (Klug)			"among roots and fallen leaves"	Linnavuori 1960
<i>A. syriacus</i> (Horvath)			"among roots and fallen leaves in dunes and gardens"	Linnavuori 1960
<i>A. pilosulus</i> (Klug)	<i>Panicum</i> <i>Zygophyllum</i> <i>Halozyton</i>	Gramineae (monocot) Zygophyllaceae Chenopodiaceae		Lotos & Önder 1980
			"colonizes haline biotypes: in sand"	Ribes 1984
<i>A. indicus</i> (Westwood)	<i>Setaria</i> , <i>Digitaria</i>	Gramineae (monocot)	seeds, on ground	Kobayashi 1974
<i>A. laiticollis</i> (Wagner)	<i>Triticum</i> , <i>Pennisetum</i>	Gramineae (monocot)	"underground on meso- cotyl of young seedlings"	Sandhu & Deol 1977, Ghauri 1975
<i>Blaena setosa</i> Walker	<i>Acacia</i>	Leguminosae	"on seeds under trees in soil"	Van den Berg 1980
			"under dead logs"	Froeschner 1960
<i>Dallastellus leurus</i> (Froeschner)			"associated with ant nests"	Froeschner 1975
<i>D. murinus</i> (Van Duzee)			"in humus of a humid forest"	Froeschner 1980

up to the upper parts of plants and feed prevailing on the contents of seeds" (p. 157), a habit somewhat similar to the sehirine *Tritomegas sexmaculatus* (see below).

Sehirinae.— This subfamily is more closely associated with the advanced dicot subclass Asteridae than any other of the trichophoran groups whose foodplant preferences I have examined so far. Of the eight sehirine genera (28 species) in Table 2, members of five (12 species) feed on asterids; seven families of asterids in five orders are represented. The Asteridae is the most recently evolved dicot subclass (Cronquist, 1968). If a group shows a preference for feeding on a recently arisen source of food, the possibility exists the group too has recently arisen. One may reasonably suggest, then, that the *Sehirinae* is a more recent subfamily than the *Cydninae*, which prefers members of the older dicot subclass, Rosidae.

Sehirus seems the sehirine genus most closely tied to asterids, six of the eight species for which data are available feeding on some asterid plant. Most species are polyphagous, but the high incidence of asterids in the bugs' wide diet seems significant. Also significant is the frequent occurrence of two families (Labiatae, Boraginaceae) of the Lamiales, an asterid order fed upon by a number of *Sehirus* species.

Except for one record on Ranunculaceae and one on Fagaceae, sehirines do not appear to feed on the two most primitive of the dicot subclasses, Magnoliidae and Hamamelidae; and fewer sehirines than cydnines feed on Gramineae, a monocot family particularly associated with the Scaptocorinae (see below).

Aside from these vague patterns, the *Sehirinae* are not tied—as subfamily or as individual genera—to any particular group of plants, and many of the widespread sehirines are quite polyphagous.

The *Sehirinae* are found more often up on plants than the *Cydninae*, although from the literature it is clear they too frequent the ground (Table 2). Indeed, Schmitz (1976) writes that only *Sehirus* of the *Cydnidae* lives up on plants. Nevertheless, such accounts as Stehlik's (1983) suggest these bugs leave the plants for the ground to hibernate; but most of the records in Table 2 are not of hibernating bugs. Of *Tritomegas sexmaculatus*, Stehlik (1983) writes, "It lives . . . on the bottom parts of the host plants and in the mating period . . . creeps to their upper parts" (p. 169). *Sehirus luctuosus* also mates "on the upper parts of plants" (p. 170), but nymphs and pre-mating adults live on the ground as well as up on the host plant (Stehlik, 1983). At least one sehirine, *Ochetostethus opacus*, lives in aeolian sands, like some cydnines (Stehlik, 1983).

That *Sehirus* lives up on plants, perhaps alone among cydnids, and feeds upon the advanced subclass Asteridae, suggests *Sehirus* is one of the more recently evolved genera in the family.

Scaptocorinae, *Amnestinae*, *Garsauriinae*, *Thaumastellinae*, *Parastrachiinae*.— Members of the Scaptocorinae are associated with Gramineae, and may be pests on the roots of bananas (*Scaptocoris divergens*) and sugarcane (several species in several parts of the world) (Table 3). This association is so tight, the record on *Solanum* should be verified.

The four remaining subfamilies are small. Two species of *Amnestus*, the only genus in the Amnestinae, are associated with ant nests, and all are on the ground (Table 3). Of the two species of *Parastrachia*, the sole genus in Parastrachiinae (Schaefer et al., in press), nothing is known of the biology of *P. nagaensis* Distant. *P.*

Table 2. Food plants and habitats of Cydnidae: *Sehirinae*

Insect species	Plant genus	Plant family	Remarks	Reference
<i>Sehirus fuscipennis</i> Horvath	<i>Centranthus</i>	Valerianaceae		Horvath 1899
<i>S. c. cinctus</i> (de Beauvoir)	<i>Stachys Monarda</i> <i>Lamium, Solidago,</i> <i>Helianthus</i>	Labiatae Compositae	seeds fallen seeds	McDonald 1968, McPherson & Mohlenbrock 1976, Horvath 1899, Sites & McPherson 1982
<i>S. c. albonotatus</i> Dallas	<i>Stachys</i>	Labiatae		McDonald 1968
<i>S. maculipes</i> Mulsant	<i>Centranthus</i>	Valerianaceae		Lodos & Önder 1980
<i>S. luctuosus</i> Mulsant & Rey	<i>Echium</i> <i>Cerastium</i> <i>Salvia</i> <i>Verbascum</i> <i>Artemisia</i>	Boraginaceae Caryophyllaceae Labiatae Scrophulariaceae Compositae	"Wurzelhals" (Voigt 1978) roots or nutkins of <i>Cerastium</i> and <i>Echium</i> (Groves 1961)	Voigt 1978, Thomas 1954, de la Fuente 1972,
<i>S. dubius</i> (Scopoli)	<i>Thesium</i> <i>Linum</i> <i>Echium</i> <i>Salvia, Thymus</i> <i>Artemisia</i> <i>Astragalus</i> <i>Pinus, Juniperus</i>	Santalaceae Linaceae Boraginaceae Labiatae Compositae Leguminosae (Gymnospermae)	"sandy soil"	Bakony & Vasarhelyi 1981 Lodos & Önder 1980, de la Fuente 1972, Heiss 1977, Dethier 1980

<i>S. morio</i> (L.)	<i>Anchusa</i> , <i>Borago</i> , <i>Cynoglossum</i> , <i>Echium</i> <i>Verbascum</i> <i>Thesium</i>	Boraginaceae	sandy soil	Lodos & Önder 1980
<i>S. niveimarginatus</i> (Scott)		Scrophulariaceae Santalaceae	roots, stalks, leaves, seeds	Thomas 1954, Kobayashi 1964, Hiura et al. 1959, Kobayashi 1954b, Hasegawa 1966, Tachikawa 1974
<i>S. variegatus</i> (Signoret)			in or on soil	Hasegawa 1960
<i>S. biguttatus</i> (L.)	<i>Melampyrum</i>	Scrophulariaceae		Hertz 1983
<i>S. melanopterus</i> (Herrich-Schaeffer)			"common on bushes and trees"	Linnavuori 1960
<i>Canthophorus melanopterus</i> (Herrich-Schaeffer)	<i>Thesium</i>	Santalaceae		de la Fuente 1972
<i>C. impressus</i> (Horvath)	<i>Thesium</i>	Santalaceae	higher altitudes	Voigt 1980
<i>C. dubius</i> Scopolii	<i>Thesium</i>	Santalaceae		Voigt 1980, Hertz 1983
<i>Ochetostethus nanus</i> (Herrich-Schaeffer)	<i>Koeleria</i> , <i>Weinmannia</i> <i>Pinus</i> <i>Quercus</i>	Gramineae (monocot) (Gymnospermae) Fagaceae	"auf trockenen Wiese" in mountains	Lindberg 1932 de la Fuente 1972
<i>O. sahlbergi</i> Wagner			"among roots and fallen leaves in sandy places"	Linnavuori 1960
<i>O. opacus</i> (Herrich-Schaeffer)			"polyphagous"; on sand	Stehlik 1983

<i>Amaurocoris curtus</i> Stål				in sand	Linnavuori 1977, Hertzel 1983
<i>Legnotus fumigatus</i> (Costa)					Josifov 1970
<i>L. limbosus</i> (Geoffroy)					Josifov 1970, de la Fuente 1972, Thomas 1954, Southwood & Hine 1950
	<i>Galium</i>	Rubiaceae			
	<i>Galium</i> <i>Sinapis</i> <i>Stachys</i> , <i>Lamium</i> <i>Teucrium</i> , <i>Thymus</i> <i>Clematis</i> <i>Artemisia</i>	Rubiaceae Cruciferae Labiatae Ranunculaceae Compositae		prefers <i>Galium</i> (de la Fuente 1972, Stehlik 1983) sandy banks (Groves 1964) "enge tropische Bindung <i>Galium</i> (Hertzel 1983)	
<i>L. picipes</i> (Fallén)	<i>Galium</i> <i>Artemisia</i>	Rubiaceae Compositae		"Wurzelhals" roots of <i>Galium</i> sunny, dry places under <i>Galium</i>	Voigt 1978, de la Fuente 1972, Thomas 1964, Singer 1952
<i>L. triguttulus</i> (Motschulsky)	<i>Lamium</i>	Labiatae			Hiura 1958, Hiura et al. 1959, Hasegawa 1960, 1966 Miyamoto 1965 Miyamoto 1965, Hasegawa 1966, Tachikawa 1974
<i>Crocistethus</i> <i>wallianus</i> (Fieber)	<i>Rumex</i> <i>Paronychia</i> <i>Glaucium</i> <i>Euphorbia</i>	Polygonaceae Caryophyllaceae Papaveraceae Euphorbiaceae		adults on <i>Lamium</i> , nymphs in soil female cares for eggs in soil on sand hills among roots	de la Fuente 1972, Lindberg 1932
<i>C. basalis</i> Fieber <i>C. aeneus</i> Brullé				on sand on sand	Lindberg 1932 Lindberg 1932

<i>C. impressus</i> Horvath	<i>Thesium</i>	Santalaceae		Heiss 1977
<i>C. maculipes</i> (Mulsant & Rey)	<i>Centranthus</i>	Valerianaceae		de la Fuente 1972
<i>Adomerus biguttatus</i> (L.)	<i>Melampyrum</i>	Scrophulariaceae	on plants and among dry leaves	de la Fuente 1972, Stelhik 1983
<i>Tritomegas</i> <i>sexamaculatus</i> (Rambur)	<i>Ballota</i> <i>Daucus</i>	Labiatae Umbelliferae		Boselli 1932, Heiss 1977, de la Fuente 1972
			"prefers humid conditions"	Bakuni & Vasarhelyi 1981
<i>T. bicolor</i> (L.)	<i>Lamium, Stachys</i>	Labiatae	immatures on Labiatae	de la Fuente 1972
	<i>Crataegus</i>	Rosaceae	adults on inflorescences of these plants	de la Fuente 1972
	<i>Prunus, Rubus</i>			
	<i>Clematis</i>	Ranunculaceae	as above	
	<i>Lamium</i>	Labiatae	40 [stage?] found at roots [hibernating?] in April; adults feed on stems	Southwood & Hine 1950
	<i>Cydonia</i>	Rosaceae		Lodos & Önder 1980
	<i>Ligustrum</i>	Oleaceae		Lodos & Önder 1980
			early instars in calyx of <i>Lamium</i>	Paul 1953
	<i>Ballota</i>	Labiatae	nymphs & adults on young seedheads	Woodward 1949

japonensis adults live up in low trees but do not feed; the nymphs feed on the ground, on the ripe seeds of *Schoepfia jasminodora* (Table 3; Tachikawa and Schaefer, 1985).

The Garsauriinae too contains only one genus. One species (Table 3) has been found under bark (a groundlike habitat) in Africa. And five specimens of *G. aradoides* were collected in Japan below the loose bark of a large fallen tree; the tree was moist but not rotted (M. Sakai in M. Tomokuni, letter Jan. 26, 1983). The flattened shape of garsauriines suggests under bark is their usual home; one wonders if they are mycetophagous.

Nothing is known of the food plants of Thaumastellinae, but the insects occur on the ground, where they may feed upon seeds (M.H. Sweet, in Schaefer and Wilcox, 1971).

Corimelaeninae.— This subfamily, like the other cydnid subfamilies, shows no particular food plant preferences at the subfamilial or generic level (Table 4). McPherson and his colleagues have found several species of Nearctic *Corimelaena* feeding on umbellifers, but several of these species feed also on other and unrelated plants. Wheeler (1981, p. 634) writes, "It seems likely that... *Galgupha* spp. consistently are associated with reproductive structures of prostrate spurge" (*Euphorbia* spp.); this may be true in general, but *Galgupha* species feed on other plants as well (Table 4).

Many of these bugs feed on a variety of plants, and populations of one widely polyphagous corimelaenine, *Thyreocoris pulicarius*, may build up to annoying numbers, becoming "destructive to plants and often troublesome on raspberries on account of its offensive odor" (quoted in Stoner [1920], p. 29). Stoner writes also that the numbers of the bug sometimes build up on potato plants to the point of causing wilting of the leaves, although the bugs prefer the tender stems. At other times the insects have been local and minor pests on various grass and flower crops (Stoner 1920).

Most corimelaenines feed up on the nitrogen-rich reproductive parts of plants; a few occur on the ground (Table 4), and these are not quiescent stages. Adults of *Galgupha aterrima* and *G. atra* feed on the ground, presumably upon ripe seeds, and their nymphs feed up on the developing seeds. This pattern may be more widespread and explain why some records (nymphs?) are up on plants and others (adults?) are on the ground. There may also be differences among genera: *Corimelaena* seems generally to occur up on plants, whereas *Cydnoides* (and *Thyreocoris*?) may be found more often on the ground.

Plataspidae

Carayon (1949) writes of several *Plataspis* species, "infeodes aux Leguminosae, comme la majorité des Plataspidae"; those he studied laid their eggs (in oöthecae) on the bark of their arboreal hosts. Table 5 attests to the accuracy of the quoted statement. Other plant families fed upon are the Rhamnaceae, Santalaceae, and Sapindaceae, all of the subclass Rosidae. Linnavuori (1977) gives a number of *Acalypha* records for African plataspids (Table 5), but I am not certain that these represent true feeding records and that the plataspids do indeed prefer this euphorb to legumes.

Table 3. Food plants and habitats of the Cydnidae: Scaptocorinae, Garsauriinae, Amnestinae, and Parastrachiinae

Insect species	Plant genus	Plant family	Remarks	Reference
Scaptocorinae				
<i>Scaptocoris divergens</i> Froeschner	<i>Musa</i>	Musaceae (monocot)	feeds on roots	Timonin 1961 Ruth 1961, Willis & Roth 1962
<i>Scaptocoris</i> sp.	<i>Solanum</i>	Solanaceae		Basso, et al. 1974
<i>S. castanea</i> Perty	<i>Saccharum</i> <i>Amophila</i> , <i>Uniola</i>	Gramineae (monocot) Gramineae (monocot)	in soil among roots (from ballast?)	Roth 1981 Froeschner & Steiner 1983
<i>S. talpa</i> Champion	<i>Saccharum</i>	Gramineae (monocot)	among roots	Champion 1900
<i>Stibaropus</i> <i>molginus</i> (Schiödt)	<i>Saccharum</i>	Gramineae (monocot)	on roots	Wilbrink 1912
<i>S. formosanus</i> (Takano & Yanagihara)	<i>Oryza</i> , <i>Eleusine</i> , <i>Digitaria</i> , <i>Saccharum</i>	Gramineae (monocot)	in soil and around roots	Hasegawa 1960, Miyamoto 1965
	<i>Saccharum</i>	Gramineae (monocot)	a pest in Taiwan	Esaki & Ishihara 1951
Garsauriinae				
<i>Garsauria haglund</i> Bergroth			"under bark of huge fallen tree"	Linnavuori 1977
Amnestinae				
<i>Amnestus lenkoi</i> Froeschner			"associated with ant nests"	Froeschner 1975

<i>A. pequinus</i> Froeschner			"associated with ant nests"	Froeschner 1975
<i>A. pallidus</i> Zimmer	<i>Antennaria</i>	Compositae	occasionally under stones (Parshley 1923)	Blatchley 1926
<i>A. spinifrons</i> (Say)			ground, moist situations	Froeschner 1960 (summary of literature)
Parastrachiinae				
<i>Parastrachia japonensis</i> (Scott)	<i>Schoepfia</i>	Olacaceae	ripe seeds; eggs, nymphs on ground	Tachikawa & Schaefer 1985

Table 4. Food plants and habitats of the Cydnidae: Corimelaeninae.

Insect species	Plant genus	Plant family	Remarks	Reference
<i>Corimelaena obscura</i> McPherson & Sailer	<i>Sanicula</i>	Umbelliferae		McPherson & Sailer 1978
<i>C. pulicaria</i> (Germar)	<i>Daucus</i> , <i>Chaerophyllum</i>	Umbelliferae		McPherson & Mohlenbrock 1976
	<i>Apocynum</i>	Apocynaceae		
	<i>Rhus</i>	Anacardiaceae		
	<i>Asclepias</i>	Asclepiadaceae		
	<i>Verbascum</i>	Scrophulariaceae		
	<i>Erigeron</i> , <i>Antennaria</i>	Compositae		
<i>C. agrella</i> McAtee	<i>Phlox</i> <i>Chaerophyllum</i>	Polemoniaceae Umbelliferae	leaves	McPherson 1974, McPherson & Mohlenbrock 1976
<i>C. extensa</i> Uhler	<i>Nicotiana</i>	Solanaceae	"the only member of its family which lives upon tobacco"	Howard 1900
	<i>Nicotiana</i>	Solanaceae	ripening fruit	Lung & Goeden 1982
<i>C. cognata</i> Van Duzee	<i>Eucnide</i>	Loasaceae		Van Duzee 1923
<i>C. l. lateralis</i> (F.)	<i>Daucus</i>	Umbelliferae	nymphs: umbel adults: cup	McPherson 1972
	<i>Chaerophyllum</i>	Umbelliferae		McPherson & Mohlenbrock 1976, Van Duzee 1923
	<i>Elymus</i>	Gramineae (monocot)		
	<i>Erigeron</i>	Compositae		
	<i>Geranium</i>	Geraniaceae		

<i>C. nitiduloides</i> (Say)	<i>Plantago</i>	Plantaginaceae	flower spikes	Van Duzee 1904
<i>C. nigra</i> Dallas	<i>Ranunculus</i>	Ranunculaceae	seeds	McPherson 1979
<i>Thyreocoris ater</i> (Amyot & Serville)	<i>Agrotis</i>	Gramineae (monocot)		Stoner 1922
	<i>Plantago</i>	Plantaginaceae		Stoner 1922
	"blue grass"	Gramineae (monocot)		Stoner 1922
	<i>Castilleja</i>	Scrophulariaceae	seeds of <i>Castilleja</i>	Stoner 1922
<i>T. scarabaeoides</i> (L.)	<i>Ranunculus</i>	Ranunculaceae		de la Fuente 1972, Lodos & Önder 1980
	<i>Sambucus</i>	Caprifoliaceae	in plant litter	Singer 1952
			on dry ground	Wagner 1966
<i>Galgupha aterrima</i> McAtee & Malloch	<i>Veronica</i>	Scrophulariaceae	adults under mats of	McPherson &
	<i>Carex</i>	Cyperaceae (monocot)	<i>Euphorbia maculata</i> ;	Mohlenbrock 1976,
	<i>Euphorbia</i>	Euphorbiaceae	nymphs on inflorescences and developing capsules (Wheeler 1981)	Wheeler 1981
<i>G. atra</i> Amyot & Serville	<i>Plantago</i>	Plantaginaceae	see <i>G. aterrima</i>	McPherson &
	<i>Rubus</i>	Rosaceae		Mohlenbrock 1976,
	<i>Helianthus</i>	Compositae		Wheeler 1981
	<i>Euphorbia</i>	Euphorbiaceae		
<i>G. loboprostethia</i> Sailer	<i>Medicago</i>	Leguminosae		Sailer 1941
<i>G. carinata</i> McAtee & Malloch	<i>Oxalis</i>	Oxalidaceae	on capsules	McPherson & Mohlenbrock 1976
<i>G. schulzii</i> (F.)	<i>Boerreria</i>	Rubiaceae	on flowers	Callan 1948

<i>G. vinculata</i> Germar	<i>Boerreria</i>	Rubiaceae	on flowers	Callan 1948
<i>G. ovalis</i> Hussey	<i>Plantago</i>	Plantaginaceae	on flowers	Biehler & McPherson 1982
<i>Allocoris gillettei</i> Van Duzee	<i>Galium</i>	Rubiaceae	damages fruits	Batra 1984
<i>Cydnoides ciliatus</i> <i>orientis</i> McAtee & Malloch			in loose sand around grass roots	Hart 1919

The family may be characterized as specializing on legumes, sharing this distinction with several coreoid groups (Schaefer, 1980; Schaefer and O'Shea, 1979; Schaefer and Mitchell, 1983), the Malcidae: Chauliopininae (Sweet and Schaefer, 1985) and perhaps a few—but certainly not many—other heteropterian groups. The few statements available indicate plataspids feed less on reproductive part of the plants, than on vegetative parts (Table 5).

These insects feed up on plants. But plataspids too are associated with the ground. The nymphs of European *Coptosoma* spp. "live on and below host plants in large aggregations" (Davidová-Vilimová and Stys, 1982: p. 144). Maxwell-Lefroy and Howlett (1909) confirms this observation, for Indian species: "... it is probable that nymphs of this group live wholly in concealment at the surface of the soil and at the roots of plants" (p. 672). Finally, Green (1900) reports a *Coptosoma* sp., "a colony of which was being attended by a species of *Crematogaster*" (p. 185).

Megarididae, Canopidae, Cyrtocoridae, Lestoniidae

Almost nothing is known about the biology of these families. *Lestonia haustorifera* China occurs on the gymnosperm *Callitris preissi* (Cupressaceae), but not on a related species (McDonald, 1970).

The other three families are Neotropical. *Cyrtocoris gibbus* (F.) has been recorded from the legume *Mimosa* (Costa Lima, 1940), and a species of *Cyrtocoris* near *trigonus* (Germar) has been collected in large numbers (together with third-fifth instars) on the ground below some unidentified low dried plants (J. Eger, personal communication). Two species of Megarididae, *Megarid puertoricensis* Barber and *M. semiamicta* McAtee & Malloch, feed on *Eugenia* (Myrtaceae) (Barber, 1939; Wolcott, 1936, respectively), the latter on the plant's flowers (Wolcott, 1936). I have not found any mention of the biology of the Canopidae.

GENERAL

Of some interest are the plant groups that these bugs do *not* feed upon. Few feed on monocots, gymnosperms, or (except for the Plataspidae and some Cydninae) on the largest of the dicot families, Leguminosae; and few feed upon the most primitive of the dicot subclasses, Magnoliidae and Hamamelidae. Almost all other members of the Pentatomoidea, as well as of the related superfamilies Lygaeoidea, Coreoidea, and Pyrrhocoroidea, also shun these plants (Schaefer, various papers, and unpublished), although there are exceptions. Plants of the most advanced dicot subclass, Asteridae, are also little used, although the Sehirinae feed on rather more of them than do members of the other heteropterian groups listed.

Legumes are perhaps protected from these bugs by chemical defenses (Janzen, 1969). The lack of feeding on the others, however—all relatively primitive plants,—suggests the major groups of these bugs arose coeval with the plants they feed upon. Had they arisen early and been feeding on early flowering plants, it is unlikely they had switched to the later plants when these became available (if the early ones

produced adequate seed). For these bugs are—as family-groups—quite polyphagous, no one group being tied to a particular group of plants (always excepting the *Plataspidae*). Being general feeders, it is unlikely these bugs would have forsworne the early flowering plants; rather, they would have continued to feed on them as well as on the later plants. That this has not occurred, that the earlier plants are almost studiously ignored, suggests the bugs arose later than these early plants.

On the other hand, it may be that the early flowering plants (principally gymnosperms, magnoliids, hamamelids) produced seeds not suited to the early seed-feeding pentatomoids. The early bugs may have been few, and their radiation may have awaited the arising of the large angiosperm subclasses, especially the *Rosidae*. This would place somewhat more recently the radiation of these bugs, and place further into the past their origin.

Certainly these bugs are old: they with their several autoplesiomorphies I believe older than many other pentatomoids; and they are also old enough that considerable host-switching has occurred: this at least partly explains the variety of hosts within family-groups and even within genera. But it is not at all certain that host-switching has occurred in a large way by the ancestral bugs from early flowering plants to more recent ones. For now the question remains open. Answers may be suggested by fossil evidence (of the bugs) and study of the early flowering plants' seeds' suitability.

The *Plataspidae* specialize on legumes, as do several other land heteropteran groups (see above). It is likely that these groups' ancestors broached the legumes' deterrent defenses and the groups radiated on this abundant and nitrogen-rich food.

Although root-feeding is often assumed, particularly in the *Cydnidae*, many of these insects feed upon seeds (see above, under *Cydninae*). Only the *Scaptocorinae* feed exclusively on roots. The others probably feed on what is available. It is likely that seed feeding is primitive: seed feeding is widespread in the relatives of these groups (Schaefer, various publications); and seed feeding occurs so frequently in the literature on cydnids and their relatives (see Tables) that it is quite possibly the way of feeding of these bugs' ancestors. It is less clear that members of the other pentatomoid families feed on seeds.

Living on the ground too is widespread, correlated of course with feeding on fallen seeds and on roots (although I maintain the on-ground habit came before the seed- and root-feeding habit [Schaefer, 1981]). Even the *Plataspidae*, which appear to feed on above-ground vegetative parts (Table 5), have some associations with the ground. Such associations occur frequently throughout the major groups (Schaefer, 1981); they are frequent too in the *Homoptera* (Schaefer, in press, in prep.).

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Table 5. Food plants and habitats of the Plataspidae

Insect species	Plant genus	Plant family	Remarks	Reference
<i>Coptosoma variegatum</i> Montandon	<i>Desmodium</i>	Leguminosae		Yang 1934
	<i>Dodonaea</i>	Sapindaceae		Yang 1934
	<i>Santalum</i>	Santalaceae		Chatterjee 1934
	<i>Zizyphus</i>	Rhamnaceae		Chatterjee 1934
<i>C. siamicum</i> Walker	<i>Santalum</i>	Santalaceae		Chatterjee 1934
	<i>Dodonaea</i>	Sapindaceae		Chatterjee 1934
	<i>Zizyphus</i>	Rhamnaceae		Chatterjee 1934
	<i>Canthium</i>	Rubiaceae		Chatterjee 1934
	<i>Pterolobium</i> , grain legumes	Leguminosae		Chatterjee 1934, Singh et al. 1978
	<i>Butea</i>	Leguminosae		Chatterjee 1934
<i>C. ostensum</i> Distant	<i>Santalum</i>	Santalaceae		Chatterjee 1934
<i>C. fuscomaculatum</i> Distant	<i>Zizyphus</i>	Rhamnaceae		Chatterjee 1934
	<i>Astragalus</i> , <i>Coronilla</i> , <i>Onobrychis</i>	Leguminosae		Heiss 1977, Voigt 1978, Dobsik 1974
<i>C. mucronatum</i> Seidenstücker	<i>Onionis</i> , <i>Medicago</i>	Leguminosae		Davidová-Vilimová & Stys 1982
<i>C. angularis</i> (Stål)	grain legumes	Leguminosae		Singh et al. 1978
<i>C. atomaria</i> (Stål)	grain legumes	Leguminosae		Singh et al. 1978
<i>C. cincta</i> (Kirkaldy)	grain legumes	Leguminosae		Singh et al. 1978

<i>C. noualhieri</i> Montandon	<i>Xanthium</i>	Compositae		Moizuddin & Ahmad 1975
<i>C. xanthogramma</i> (White)	<i>Canavalia</i> , <i>Strongylodon</i>	Leguminosae		Beardsley & Fluker 1967
<i>C. nubilum</i> (Germar)	grain legumes <i>Acalypha</i>	Leguminosae Euphorbiaceae		Singh et al. 1978, Linnavuori 1977
<i>C. marginella</i> Dallas	grain legumes, <i>Desmodium</i> , <i>Cajanus</i> , <i>Dolichos</i> , <i>Gliricidia</i> , <i>Crotalaria</i>	Leguminosae	stem & fruit stem stem stem stem	Golding 1927
<i>C. punctissimum</i> Montandon	<i>Glycine</i>	Leguminosae	stem, petiole, leaf, pod	Kobayashi 1981
<i>C. biguttula</i> Motschulsky	<i>Glycine</i>	Leguminosae	stem, petiole, leaf, pod	Kobayashi 1981
<i>C. japonicum</i> Matsumura	<i>Glycine</i>	Leguminosae	stem, petiole, leaf, pod	Kobayashi 1981
<i>C. hirsutum</i> Montandon	<i>Chaetacme</i>	Leguminosae		Linnavuori 1977
<i>C. nigropunctatum</i> Stål	<i>Acalypha</i>	Euphorbiaceae		Linnavuori 1977
<i>C. pygmaeum</i> Jensen-Haarup	unidentified	Leguminosae		Linnavuori 1977
<i>C. stali</i> (Montandon)	grain legumes	Leguminosae		Singh et al. 1978
<i>C. costale</i> Stål	<i>Psoralea</i>	Leguminosae		Seidenstücker 1963, Lodos & Önder 1978

<i>C. putoni</i> Montandon	<i>Hedysarum</i>	Leguminosae	Seidenstücker 1963
<i>C. maurum</i> Vidal	<i>Astragalus</i>	Leguminosae	Seidenstücker 1963, Lodos & Önder 1978
<i>C. sandahli</i> Reuter	<i>Rhynchosia</i>	Leguminosae	Sys & Davidová-Vilimová 1979
<i>Brachyplatys subaeneus</i> (Westwood)	<i>Pueraria</i> , grain legumes, <i>Acacia</i> , <i>Dolichos</i>	Leguminosae	Kershaw 1910, Singh et al. 1978, Banerjee 1958, Maxwell-Lefroy & Howlett 1909
<i>B. testudinigra</i> (DeGeer)	<i>Acalypha</i>	Euphorbiaceae	Linnavuori 1977
<i>B. truncaticeps</i> Montandon	<i>Acalypha</i>	Euphorbiaceae	Linnavuori 1977
<i>B. advenus</i> Linnavuori	<i>Acalypha</i>	Euphorbiaceae	Linnavuori 1977
<i>B. ethiops</i> Dallas	<i>Acalypha</i>	Euphorbiaceae	Linnavuori 1977
<i>B. silphoides</i> (F.)	<i>Oryza</i>	Gramineae	Yang 1934
<i>B. deplanatus radians</i> (Vollenhoven)	grain legumes	Leguminosae	Singh et al. 1978
<i>B. pallipes</i> (F.)	grain legumes	Leguminosae	Singh et al. 1978
<i>B. vahlii</i> (F.)	grain legumes	Leguminosae	Singh et al. 1978
<i>Plataspis variegata</i> Guérin	<i>Albizzia</i> , <i>Mimosa</i> , <i>Melia</i>	Leguminosae Meliaceae	Carayon 1949
	<i>Grevillea</i>	Proteaceae	

<i>P. coccinelloides</i> (Laporte)	as above			Carayon 1949
<i>P. flavosparsa</i> Montandon	<i>Albizia</i>	Leguminosae		Carayon 1949
<i>Megacopta lobata</i> (Walker)	<i>Glochidion</i>	Euphorbiaceae	Young buds and leaves	Ren 1984
<i>M. horvathi</i> (Montandon)	<i>Vigna</i> , <i>Pueraria</i> , other legumes	Leguminosae	pest on tender shoots	Ren 1984
<i>M. cribraria</i> (F.)	<i>Acacia</i> , <i>Pueraria</i> , <i>Sesbania</i> , <i>Cajanus</i> , <i>Dolichos</i>	Leguminosae	shoots	Banerjee 1958, Singh 1978, Kershaw 1910, Yang 1934, Chatterjee 1934, Ahmad & Moizuddin 1976
			"important pest of legumes in China"	Ren 1984

REFERENCES

- Ahmad, I. and M. Moizuddin (1976) Biological control measures of bean plataspid (Heteroptera: Pentatomoidea) in Pakistan. *Proc. Entomol. Soc. Karachi* **6**: 85-86.
- Bakonyi, G. and T. Vasarhelyi (1981) Contribution to the Heteropteran fauna of the Hortobágy National Park, I. *The Fauna of the Hortobágy National Park*, **1981**: 55-63.
- Banerjee, M.R. (1958) A study of the chromosomes during meiosis in twenty-eight species of Hemiptera (Heteroptera, Homoptera). *Proc. Zool. Soc. Calcutta* **11**: 9-37.
- Barber, H.G. (1939) Insects of Puerto Rico and the Virgin Islands—Hemiptera-Heteroptera (excepting the Miridae and Corixidae). *Scientific Survey of Puerto Rico and the Virgin Islands* **14(3)**: 263-441.
- Basso, L.V., D. Link, and O.J. Lopes (1974) Entomofauna de algunas solanaceas em Santa Maria, RS. *Rev. Centro Cienc. Rur* **4**: 263-270.
- Batra, S.W.T. (1984) Phytophages and pollinators of *Galium* (Rubiaceae) in Eurasia and North America. *Environ. Entomol.* **13**: 1113-1124.
- Beardsley, J.W., Jr., and S. Fluker (1967) *Coptosoma xanthogramma* (White), (Hemiptera: Plataspidae) a new pest of legumes in Hawaii. *Proc. Haw. Entomol. Soc.* **19**: 367-372.
- Biehler, J.A. and J.E. McPherson (1982) Life history and laboratory rearing of *Galgupha ovalis* (Hemiptera: Corimlaenidae), with descriptions of immature stages. *Ann. Entomol. Soc. Amer.* **75**: 465-470.
- Blatchley, W.S. (1926) Heteroptera or True Bugs of Eastern North America. Indianapolis. Nature Publ. Co. 1116 pp.
- Boselli, F.B. (1932) Instinti materni del *Sehirus sexmaculatus* Rhr. (Heteroptera: Cydnidae). *Bol. Lab. Zool. Portici* **26**: 2-7.
- Burghardt, G. and C. Rieger (1978) Die Wanzenfauna der sandhausener Flugsanddünen. *Veröff. Naturschutz. Landschaftspflege Bad.-Württ.* **47/48**: 393-413.
- Callan, E.M. (1948) The Pentatomidae, Cydnidae and Scutelleridae of Trinidad, B.W.I. *Proc. Royal Entomol. Soc. London* **17**: 115-124.
- Carayon, J. (1949) L'oothèque d'Hémiptères Plataspidés de l'Afrique tropicale. *Bull. Soc. Entomol. France* **54**: 66-69.
- Champion, G.C. (1900) A species of *Scaptocoris*, Perty, found at the roots of sugar-cane. *Entomol. Mon. Mag.* **36**: 235-237.
- Chatterjee, N.C. (1934) Entomological investigations on the spike disease of sandal (24). Pentatomidae (Hemipt.). *Indian Forest Rec.* **20**: 1-31.
- China, W.E. (1931) Morphological parallelism in the structure of the labium in the hemipterous genera *Coptosomoides*, gen. nov., and *Bozius*, Dist. *Ann. Mag. Nat. Hist.* **7(10)**: 281-286.
- da Costa Lima, A. (1940) In setos do Brasil. 2º Tomo, Capítulo XXII. Hemípteros. Rio de Janeiro. Escola Nacional de Agronomia. 351 pp.
- Cronquist, A. (1968) The Evolution and Classification of Flowering Plants. Boston, Houghton-Mifflin. 396 pp.
- Davidová-Vilimová, J. and P. Stys (1982) Bionomics of European *Coptosoma* species (Heteroptera, Plataspidae). *Acta Univ. Carolin., Biol.* **1980**: 463-484.
- Dethier, M. (1980) Hémiptères des pelouses alpines au Parc National Suisse. *Rev. Suisse Zool.* **87**: 975-990.
- Dolling, W.R. (1981) A rationalized classification of the burrower bugs (Cydnidae). *Syst. Entomol.* **6**: 413-431.
- Ehanno, B. (1961) Contribution à la connaissance des Hémiptères Pentatomides armoricaines. *Bull. Soc. Sci. Bretagne* **36**: 47-58.
- Esaki, T. and T. Ishihara (1951) Hemiptera of Shansi, North China. II. Pentatomoidea. *Mushi* **22**: 29-44.
- Froeschner, R.C. (1960) Cydnidae of the Western Hemisphere. *Proc. U.S. Natl. Mus.* **111**: 337-680.
- Froeschner, R.C. (1975) Three new species of burrowing bugs found in association with ants in Brazil (Hemiptera: Cydnidae). *J. Kans. Entomol. Soc.* **48**: 105-110.
- Froeschner, R.C. (1980) Notes on a collection of Cydnidae (Hemiptera) from Ecuador and the Galápagos Islands made in 1964-1965 by the Expedition N. et J. Leleup. *Bull. Inst. Roy. Sci. Nat. Belg. (Entomol.)* **52**: 1-4.
- Froeschner, R.C. and W.E. Steiner, Jr. (1983) Second record of South American burrowing bug, *Scaptocoris castaneus* Perty (Hemiptera: Cydnidae), in the United States. *Entomol. News.* **94**: 176.

- de la Fuente, J.A. (1972) Revision de los Pentatómidos ibéricos. Familia Cydnidae Billberg, 1820. *Bol. R. Soc. Españ. Hist. Nat. (Biol.)* **70**: 33-78.
- Ghauri, M.S.K. (1975) On a new subspecies of *Aethus laticollis* Wagner (Hemiptera: Heteroptera: Cydnidae) as a serious pest of *Pennisetum typhoides* (Burm.) in India. *J. Bombay Nat. Hist. Soc.* **72**: 226-229.
- Golding, F.D. (1927) Notes on the food-plants and habits of some southern Nigerian insects. *Bull. Entomol. Res.* **18**: 95-99.
- Green, E.E. (1900) Note on the attractive properties of certain larval Hemiptera. *Entomol. Mon. Mag.* **36**: 185.
- Günther, H., C. Rieger, and G. Burghardt (1982) Die Wanzenfauna des Naturschutzgebietes "Mainzer Sand" und benachbarter Sandgebiete (Insecta: Heteroptera). *Mainzer Naturw. Arch.* **20**: 1-36.
- Hart, C.A. (1919) The Pentatomoidea of Illinois with keys to the nearctic genera. *Bull. Illinois Natur. Hist. Surv.* **13**: 157-223.
- Hasegawa, H. (1960) Heteroptera of Niigata Prefecture, Japan. *Bull. Nagaoka Municipal Sci. Mus.* **(1)**: 19-65. (in Japanese)
- Hasegawa, H. (1966) Hemiptera. in Y. Kurosawa and T. Hidaka ed., *Iconographia insectorum*, Shôgakukan, Tokyo, 476 pp. (in Japanese)
- Heiss, E. (1977) Zur Heteropterenfauna Nordtirols (Insecta: Heteroptera). VI: Pentatomoidea *Veröff. Mus. Ferdinandeum (Innsbruck)* **57**: 53-77.
- Hertzel, G. (1983) Beiträge zur Insektenfauna der DDR: Heteroptera—Plataspidae und Cydnidae. *Faunis. Abh. Staatl. Mus. Tierk. Dresden* **10**: 111-124.
- Highland, H.B. and P.F. Lummis (1986) Use of light traps to monitor flight activity of the burrowing bug, *Pangaeus bilineatus* (Hemiptera: Cydnidae), and associated field infestations in peanuts. *J. Econ. Entomol.* **79**: 523-526.
- Hiura, I. (1958) The topics of bugs. *Nature Study* **4**: 100-102. (in Japanese)
- Hiura, I. et al. (1959) Pentatomid bugs in Tokushima Prefecture. *Shikoku (Hemiptera, Pentatomoidea). Konchû-Kagaku*, **(9)** 9-46. (in Japanese)
- Hoebeker, E.R. and A.G. Wheeler, Jr. (1984) *Aethus nigratus* (F.), a Palearctic burrower bug established in eastern North America (Hemiptera-Heteroptera: Cydnidae). *Proc. Entomol. Soc. Wash.* **86**: 738-744.
- Horvath, G. (1899) Note sur le *Schirus maculipes* et especes affines. *Rev. Entomol.* **18**: 82-84.
- Howard, L.C. (1900) The principal insects affecting the tobacco plant. *U.S. Dept. Agric. Farmers Bull.* **120**: 1-32.
- Hussey, R.F. (1925) Some new or little-known Hemiptera from Florida and Georgia. *J. N.Y. Entomol. Soc.* **33**: 61-67.
- Ishihara, T. (1947) An introduction to Pentatomidae from Japan. *Mushi-shizen* **17**: 55-69. (in Japanese)
- Janzen, D.H. (1969) Seed-eaters versus seed size, number, toxicity and dispersal. *Evolution* **23**: 1-27.
- Josifov, M. (1970) Ergebnisse der Albanien-Expedition 1961 des Deutschen Entomologischen Instituts. **82**. Beitrag. Heteroptera. *Beitr. Entomol.* **20**: 825-956.
- Kershaw, J.C.W. (1910) On the metamorphoses of two coptosomine Hemiptera from Macao. *Ann. Soc. Entomol. Belg.* **54**: 69-73.
- Kobayashi, T. (1953) The developmental stages of six species of the Japanese Pentatomoidea (Hemiptera). *Sci. Rep. Matsuyama Agric. Coll.* **(11)**: 73-89.
- Kobayashi, T. (1954a) The biology of some pentatomoids (2). *Shin Konchû* **7(10)**: 22-24. (in Japanese)
- Kobayashi, T. (1954b) The rearing method of the pentatomoids. *Shin Konchû* **7(11)**: 11-14. (in Japanese)
- Kobayashi, T. (1964) Developmental stages of *Geotomus pygmaeus* (Dallas and *Sehirus niveimarginatus* (Scott) (Cydnidae). *Kontyû* **32**: 21-27.
- Kobayashi, T. (1974) A note on *Aethus indicus* (Westwood) and *Geotomus pygmaeus* (Dallas) in Ishigaki Island. *Rostria* **23**: 123. (in Japanese)
- Kobayashi, T. (1981) Insect pests of soybeans in Japan. *Misc. Publ. Tohoku Natl. Agric. Exp. Sta.* **2**: 1-39.
- Lindberg, H. (1932) Inventa entomologica itineraria Hispanici et Maroccani quod ab 1926 fecerunt Harald et Hakan Lindberg. XIII. Hemiptera Heteroptera (excl. Capsidae et Hydrobiotica). *Comment. Biol.* **3**: 1-55.
- Linnavuori, R. (1960) Hemiptera of Israel. I. *Ann. Zool. Soc. Zool. Bot. Fenn. "Vanamo"* **22**: 1-71.
- Linnavuori, R. (1973) Studies on African Heteroptera. *Arq. Mus. Bocage (Ser. 2)* **4**: 26-69.
- Linnavuori, R. (1977) Hemiptera of the Sudan, with remarks on some species of the adjacent countries. **5**.

- Tingidae, Piesmididae, Cydnidae, Thaumastellidae and Plataspididae. *Acta Zool. Fenn.* **147**: 1-81.
- Lodos, N. and F. Önder (1980) Türkiye Pentatomoidea (Heteroptera) üst familyası üzerinde araştırmalar.
- III. Familya Cydnidae Billberg. *Ege Üniv. Ziraat Fakült. Yayın.* **381**: 81 pp.
- Lung, K.Y. and R.D. Goeden (1982) Biology of *Corimelaena extensa* on tree tobacco, *Nicotiana glauca*. *Ann. Entomol. Soc. Amer.* **75**: 177-180.
- Maxwell-Lefroy, H. and F.M. Howlett (1909) Indian Insect Life. London. Thacker, Spink & Co. 786 pp.
- McDonald, F.J.D. (1968) Some observations on *Sehirus cinctus* (Palisot de Beauvois) (Heteroptera: Cydnidae). *Can. J. Zool.* **46**: 855-858.
- McDonald, F.G.D. (1970) The morphology of *Lestonia haustorifera* China (Heteroptera: Lestoniidae). *J. Nat. Hist.* **4**: 413-417.
- McPherson, J.E. (1972) Life history of *Corimelaena lateralis lateralis* (Hemiptera: Corimelaenidae) with descriptions of immature stages and list of other species or Scutelleroidea found with it on wild carrot. *Ann. Entomol. Soc. Amer.* **65**: 906-911.
- McPherson, J.E. (1974) Three negro bug state records for Illinois (Hemiptera: Corimelaenidae). *Trans. Ill. State Acad. Sci.* **67**: 361-363.
- McPherson, J.E. (1979) Additions and corrections to the list of Michigan Pentatomoidea (Hemiptera). *Great Lakes Entomol.* **12**: 27-30.
- McPherson, J.E. and R.H. Mohlenbrock (1976) A list of the Scutelleroidea of the La Rue-Pine Hills Ecological Area with notes on biology. *Great Lakes Entomol.* **9**: 125-169.
- McPherson, J.E. and R.I. Sailer (1978) A new species of *Corimelaena* (Hemiptera: Thyreocoridae) from American north of Mexico. *J. Kans. Entomol. Soc.* **51**: 516-520.
- Miyamoto, S. (1955) Food habits of *Macroscytus japonensis*. *Pulex* (6): 23-24. (in Japanese)
- Miyamoto, S. (1965) Hemiptera-Heteroptera. in Asahina, S. et al. (ed.), *Iconographia Insectorum Japonicorum Colore naturali edita Volumen III*, Hokuryukan, Tokyo., 358 pp. (in Japanese)
- Moizuddin, M. and I. Ahmad (1975) Some aspects of internal anatomy of *Coptoma noualhieri* Mont. (Pentatomoidea: Plataspidae) with reference to phylogeny. *Rec. Zool. Surv. Pakistan* **7**: 101-110.
- Paul, A.R. (1953) Life history of the pied shield bug, *Sehirus bicolor* L. (Hem., Cydnidae). *Entomol. Mon. Mag.* **88**: 210-211.
- Ren, S. (1984) Studies of the fine structure of egg-shells and the biology of *Megacopta* Hsiao et Jen from China (Hemiptera: Plataspidae). *Entomotaxonomia* **6**: 327-332.
- Ribes, J. (1984) Heteroptera of Eivissa and Formentera. Pp. 365-376 in *Biogeography and Ecology of the Pityusic Islands*. H. Kuhbier et al., ed. The Hague, W. Junk.
- Roth, L.M. (1961) A study of the odoriferous glands of *Scaptocoris divergens* (Hemiptera: Cydnidae). *Ann. Entomol. Soc. Amer.* **54**: 900-911.
- Sailer, R.I. (1941) Additional notes on *Galgupha loboprostethis* Sailer (Thyreocorinae). *J. Kans. Entomol. Soc.* **14**: 19.
- Sailer, R.I. (1954) Concerning *Pangaues billineatus* (Say) (Hemiptera: Pentatomidae, subfamily Cydninae). *J. Kans. Entomol. Soc.* **27**: 41-44.
- Sandhu, G.S. and G.S. Geol. (1977) New records of pest on wheat. *Indian J. Entomol.* **37**: 85-86.
- Schaefer, C.W. (1980) The host plants of the Alydinae, with a note on heterotypic feeding aggregations (Hemiptera: Coreoidea: Alydidae). *J. Kans. Entomol. Soc.* **53**: 115-122.
- Schaefer, C.W. (1981) The land bugs (Hemiptera: Heteroptera) and their adaptive zones. *Rostrum* **33** Suppl.: 67-83.
- Schaefer, C.W. (in press) The early habitat of the Auchenorrhyncha. *Proc. Sixth Auchenorrhynch Symp.* (Turin).
- Schaefer, C.W., W.R. Dolling, and S. Tachikawa (in press) The shieldbug genus *Parastrachia* and its position in the Pentatomoidea (Hemiptera). *Zool. J. Linn. Soc.*
- Schaefer, C.W. and D. Wilcox (1971) A new species of Thaumastellidae (Hemiptera: Pentatomoidea) from southern Africa. *J. Entomol. Soc. So. Africa* **34**: 207-214.
- Schaefer, C.W. and R. O'Shea (1979) Host plant of three coreine tribes (Hemiptera: Heteroptera: Coreidae). *Ann. Entomol. Soc. Amer.* **76**: 519-523.
- Schaefer, C.W. and P.L. Mitchell (1983) Food plants of the Coreoidea (Hemiptera: Heteroptera). *Ann. Entomol. Soc. Amer.* **76**: 591-6.5.
- Schmitz, G. (1976) Fam. Cydnidae. Pp. 353-67 in *La Faune Terrestre de l'Île de Sainte-Helene: Heteropteres, Troisieme Parties. Ann. Mus. Roy. Afr. Centr. (Ser. 8, Sci. Zool.)* No. 215. (Tervuren).

- Seidenstücker, G. (1963) Anatoliens Coptosoma-Arten (Heteroptera, Plataspididae). *Reichenbachia* **20**: 155-160.
- Singer, K. (1952) Die Wanzen (Hemiptera-Heteroptera) des unteren Maingebietes von Hanau bis Würzburg mit Einschluss des Spessarts. *Mitt. Naturwissensch. Mus. Stadt Aschaffenburg* (n.F.) **5**: 1-128.
- Singh, S.R., H.F. van Emden, and T.A. Taylor (1978) Check list of insect and mite pests of grain legumes. Pp. 399-417 in *Pests of Grain Legumes: Ecology and Control*. London. Academic Press.
- Sites, R.W. and J.E. McPherson (1982) Life history and laboratory rearing of *Sehirus cinctus cinctus* (Hemiptera: Cydnidae), with descriptions of immature stages. *Ann. Entomol. Soc. Amer.* **75**: 210-215.
- Smith, J.W. and J.T. Pitts (1974) Pest status of *Pangaeus bilineatus* attacking peanuts in Texas. *J. Econ. Entomol.* **67**: 111-113.
- Southwood, T.R.E. and D.J. Hine (1950) Further notes on the biology of *Sehirus bicolor* (L.) (Hem., Cydnidae). *Entomol. Mon. Mag.* **86**: 299-301.
- Southwood, T.R.E. and D. Leston (1959) *Land and Water Bugs of the British Isles*. London. F. Warne & Co., Ltd. 436 pp.
- Stehlik, J.L. (1983) Results of the investigations on Hemiptera in Moravia made by the Moravian Museum (Pentatomoidea II). *Acta Mus. Moraviae* **68**: 153-172.
- Stoner, D. (1920) The Scutelleroidea of Iowa. *Univ. Iowa Stud. Nat. Hist.* **8**: 1-140.
- Stys, P. and J. Davidova-Vilimova (1979) *Coptosoma sandahli*—a third European species of Plataspidae (Heteroptera). *Acta Entom. Bohemosl.* **76**: 140-142.
- Sweet, M.H. and C.W. Schaefer (1985) Systematic status and biology of *Chauliops fallax* Scott, with a discussion of the phylogenetic relationships of the Chauliopinae (Hemiptera: Lygaeidae). *Ann. Entomol. Soc. Amer.* **78**: 526-536.
- Tachikawa, S. (1974) On parental care in Heteroptera. *Insectarium* **11(10)**: 220-223.
- Tachikawa, S. and C.W. Schaefer (1985) Biology of *Parastrachia japonensis* (Hemiptera: Pentatomoidea: ?-idae). *Ann. Entomol. Soc. Amer.* **78**: 387-397.
- Thomas, D.C. (1954) Notes on the biology of some Hemiptera Heteroptera I.—Introduction and shieldbugs (Pentatomoidea). *Entomologist* **87**: 25-30.
- Timonin, M.I. (1961) The interaction of plant, pathogen, and *Scaptocoris talpa* Champ. *Can. J. Bot.* **39**: 695-703.
- Van den Berg (1980) Natural enemies of *Acacia cyclops* A. Cunn. ex G. Don and *Acacia saligna* (Labill.) Wendl. in western Australia. III. Hemiptera. *Phytophylactica* **12**: 223-226.
- Van den Berg, M.A. (1982) Hemiptera attacking *Acacia dealbata* Link., *Acacia decurrens* Willd., *Acacia longifolia* (Andr.) Willd., *Acacia mearnsii* De Wold. and *Acacia melanoxylon* R. Br. in Australia. *Phytophylactica* **14**: 47-50.
- van Duzee, E.P. (1904) Annotated list of the Pentatomidae recorded from America north of Mexico, with descriptions of some new species. *Trans. Amer. Entomol. Soc.* **30**: 1-80.
- van Duzee, E.P. (1923) Expedition of the California Academy of Sciences to the Gulf of California in 1921. *Proc. Calif. Acad. Sci.* (4) **12**: 123-200.
- Voigt, K. (1978) Die Wanzen der Russheimer Altreheingebiets. *Natur. u. Landschaftsschutz-gebiete Bad-Württ.* **10**: 407-444.
- Voigt, W. (1980) Ein unerwartetes Vorkommen von *Canthophorus impressus* (Horv.) (Heteroptera, Cydnidae) im Böhmischem Mittelgebirge (Ceské Stredohorí). *Acta Faun. Entomol. Mus. Nat. Pragae* **16**: 129-130.
- Wagner, E. (1966) *Die Tierwelt Deutschlands*. 54. Teil. Wanzen oder Heteropteren I. Pentatomorpha [sic]. Jena, G. Fischer Verlag. 235 pp.
- Wheeler, A.G., Jr. (1981) Insect associates of spurge, mainly *Euphorbia Maculata* L., in eastern United States. *Proc. Entomol. Soc. Wash.* **83**: 631-641.
- Wilbrink, G. (1912) De kedirische wortelwants. *Meded. Proefstation Java-Suikerindustrie*. **22**: 1111-1123.
- Willis, E.R. and L.M. Roth (1962) Soil and moisture relations of *Scaptocoris divergens* Froeschner (Hemiptera: Cydnidae). *Ann. Entomol. Soc. Amer.* **55**: 21-33.
- Woodward, T.E. (1949) Notes on the biology of some Hemiptera-Heteroptera. *Entomol. Mon. Mag.* **85**: 193-206.
- Yang, W. (1934) Revision of Chinese Plataspidae. *Bull. Fan. Mem. Inst. Biol. (Peiping)* **5**: 137-235.