

**HARMOSTES FRATERCULUS (HEMIPTERA: RHOPALIDAE):
FIELD HISTORY, LABORATORY REARING, AND
DESCRIPTIONS OF IMMATURE STAGES**

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Abstract.—Seasonal history of the rhopalid *Harmostes fraterculus* (Say) was followed in south central Pennsylvania during 1978–81. Adults of this more southern, apparently migrant species appeared in late July to early August. A first Pennsylvania generation developed in flower heads of the composite *Eupatorium fistulosum* Barratt in August and early September; a second generation was produced on this host and on *E. perfoliatum* L. during mid-September and October. A hypothesis is proposed to explain its migratory flight. Notes on oviposition and mating behavior are given, duration of the egg and nymphal stages is recorded, and all immature stages are described and illustrated.

Harmostes fraterculus, described from Indiana and Georgia in the genus *Syr-mastes* (Say, 1831), was placed in the largely Neotropical genus *Harmostes* Burmeister by Stål (1870). One of the few widely distributed species of the genus in North America, this rhopalid is uncommon in most collections and apparently is less frequently collected than the wide-ranging *H. reflexulus* (Say). Torre-Bueno (1941) defined the range of *H. fraterculus* as New Jersey south to Florida, west to California and Arizona, and through Mexico into Central America. In a generic revision, Göllner-Scheiding (1978) noted that in the eastern United States she had seen specimens from as far north as Pennsylvania. *Harmostes fraterculus* is known to occur as far south as Guatemala and in South America is replaced by the closely related *H. parafraterculus*, described by Göllner-Scheiding (1978).

With the exception of Yonke and Walker's (1970a, b) study of *H. reflexulus*, the field biology and immature stages of *Harmostes* species are poorly known. Information on *H. fraterculus* is limited to notes on habits and host associations. Rosenfeld (1911) observed adults overwintering in Spanish moss in Louisiana. Blatchley (1926), Froeschner (1942), and Hoffman (1975) reported collections from "boneset" and "Joe Pye weed," plants of the composite genus *Eupatorium*. Nymphs have been found on various ragweed species in southern California: *Ambrosia acanthicarpa* Hooker (Goeden and Ricker, 1974), *A. dumosa* (Gray) Payne (Goeden and Ricker, 1976a), and *A. chenopodiifolia* (Benth.) Payne (Goeden and Ricker, 1976b). In Mexico, Brailovsky and Soria (1981) collected *fraterculus* on composites of the genera *Eupatorium*, *Haplopappus*, and *Verbesina*.

In September 1978 we found large populations of *H. fraterculus* on *Eupatorium fistulosum* Barratt at two sites near Harrisburg, Pennsylvania. We had not collected this rhopalid previously in the state, and the few Pennsylvania specimens we located in various insect collections had been taken in late summer or early fall. Coupled with its absence from nearby colonies of the same host, we suspected *H. fraterculus* was a migrant in Pennsylvania, populations occurring north of the permanent range only in certain years, as is known for heteropterans like the harlequin bug, *Murgantia histrionica* (Hahn). We began studies in 1979 to elucidate the seasonal history of Pennsylvania populations and to determine whether this rhopalid overwinters in the state. In this paper we present a generalized seasonal history for *H. fraterculus* in Pennsylvania, report on certain aspects of its habits in the laboratory, and describe and illustrate the immature stages.

STUDY AREAS AND METHODS

Field studies.—Seasonal history was observed periodically at two sites near Harrisburg (Dauphin Co.), Pennsylvania, from late September to early November 1978 and at regular intervals at these and additional areas during 1979–81. The main sites for field work, about 10 km apart, were low-lying areas along streams that were dominated by colonies of Joe-Pye weed, *Eupatorium fistulosum*, a perennial herb of moist habitats which, like most members of the genus, has corymbose, discoid heads. Boneset, *E. perfoliatum* L., was common at one of the sites.

During spring and early summer 1979–82 we collected extensively near the study areas to try to find overwintering individuals of *H. fraterculus*; once flower buds of *E. fistulosum* were well developed (late June to early July), we concentrated on sampling the host plants rather than on general collecting. When adult rhopalids appeared on the hosts (late July to early August), we sampled the plants weekly or biweekly through September in 1979 and until mid-October in 1980; periodic observations were continued until November. Samples were taken by tapping flower heads of the host over a small tray, collecting 10 to 20 nymphs (except when first instars were scarce in early samples), and sorting them to stage in the laboratory. The relative proportion of adults to nymphs was estimated in the field at each sample date.

Laboratory studies.—Field-collected adults were placed in small, plastic petri dishes containing florets of *E. fistulosum* and a source of moisture, and were held at 20–22°C under an approximate 12-h photoperiod. We made notes on mating and oviposition behavior and removed eggs to individual dishes to determine incubation times and duration of nymphal stages. We tried to rear *H. fraterculus* on sunflower seeds soaked in water and cracked in half, the technique used by Yonke and Walker (1970a) to rear *H. reflexulus*. The mortality, however, was so great, particularly with early-stage nymphs, that we had to substitute excised disc flowers of Joe-Pye weed. A small portion of the cyme, consisting of 6–8 capitula, was cut from a flower head and the stalk inserted through Parafilm® stretched over the opening of a glass genitalia vial filled with water. Even then, a high mortality prevented us from rearing any individual from egg to adult. Therefore, the developmental times obtained are based partially on determination of instars for field-collected nymphs of various stages.

DESCRIPTIONS

Fifth instar (in alcohol, $n = 5$) (Fig. 1).—Elongate-pyriform, somewhat dorsoventrally flattened, testaceous, mottled or reticulate with brown or reddish brown, often forming small to large testaceous spots, a pale stripe along meson from anterior margin of pronotum onto scutellum. Antenna cylindrical, segment I shorter, broader, II and III distinctly flattened, IV fusiform. Dorsum covered with numerous fine setae, most arising from tubercles or white papillae. Wing pads reaching 3rd or 4th abdominal segment, their apices sometimes dark brown; dorsal abdominal scent glands opening between tergites IV–V and V–VI, surrounded by dark rims; trichobothrial pattern as in Fig. 2. Legs dark brown, femora with small testaceous spots; metafemora with 2 stout spines on ventral aspect near apex.

Length 4.58–6.17 mm, $\bar{x} = 5.55$. Head, length 1.04–1.20 mm, $\bar{x} = 1.16$; width 0.90–1.00 mm, $\bar{x} = 0.95$; interocular space 0.64–0.70 mm, $\bar{x} = 0.66$. Protergal length 0.60–0.64 mm, $\bar{x} = 0.62$; humeral width 1.54–1.64 mm, $\bar{x} = 1.60$. Antennal lengths I, 0.36–0.40 mm; II, 0.66–0.70; III, 0.68–0.74; IV, 0.60–0.64. Labial lengths I, 0.80–0.86 mm; II, 0.70–0.74; III, 0.66–0.78; IV, 0.62–0.70, reaching beyond metacoxae to 2nd abdominal segment.

Fourth instar (in alcohol, $n = 3$) (Fig. 3).—Form and color similar to 5th instar, the white papillae on dorsal surface of abdomen and spines on metafemora less distinct. Wing pads reaching 2nd abdominal segment.

Length 3.84–4.40 mm, $\bar{x} = 4.16$. Head, length 0.94–1.10 mm, $\bar{x} = 1.04$; width 0.76–0.80, $\bar{x} = 0.78$; interocular space 0.52–0.54 mm, $\bar{x} = 0.53$. Protergal length 0.42–0.46 mm, $\bar{x} = 0.44$; humeral width 1.12–1.16 mm, $\bar{x} = 1.13$. Antennal lengths I, 0.30–0.34 mm; II, 0.52; III, 0.54–0.56; IV, 0.50–0.52. Labial lengths I, 0.66–0.70 mm; II, 0.60; III, 0.52–0.60; IV, 0.60–0.64.

Third instar (in alcohol, $n = 4$) (Fig. 4).—Similar to preceding instar, but more elongate, the reddish markings less intense, the tubercles and white papillae less distinct. Mesothoracic wing pads covering metathoracic pads, which extend to 1st abdominal segment. Labium reaching 3rd abdominal segment.

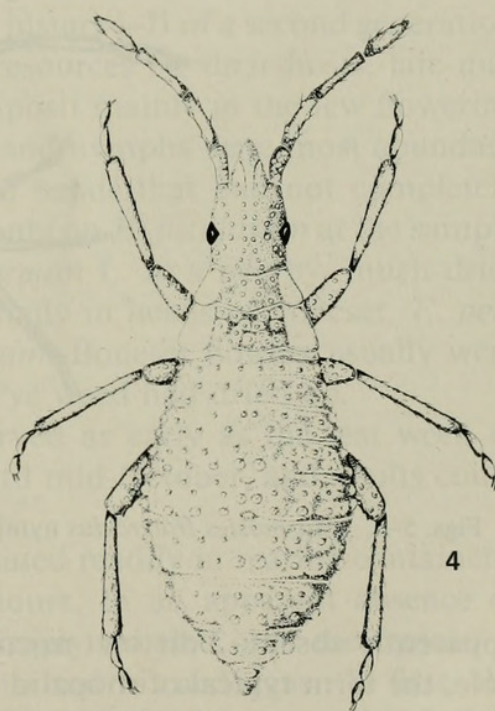
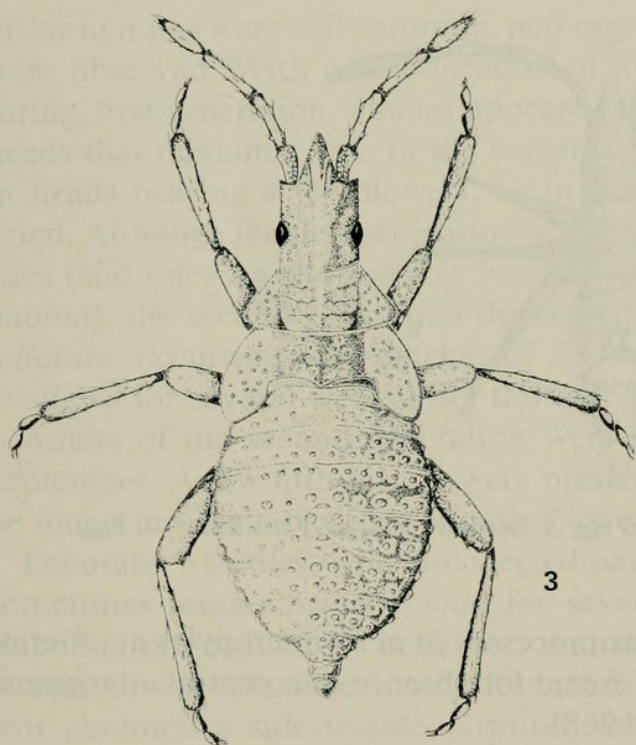
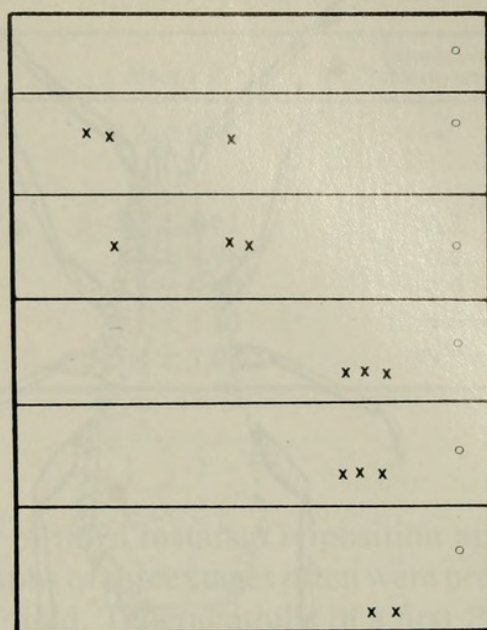
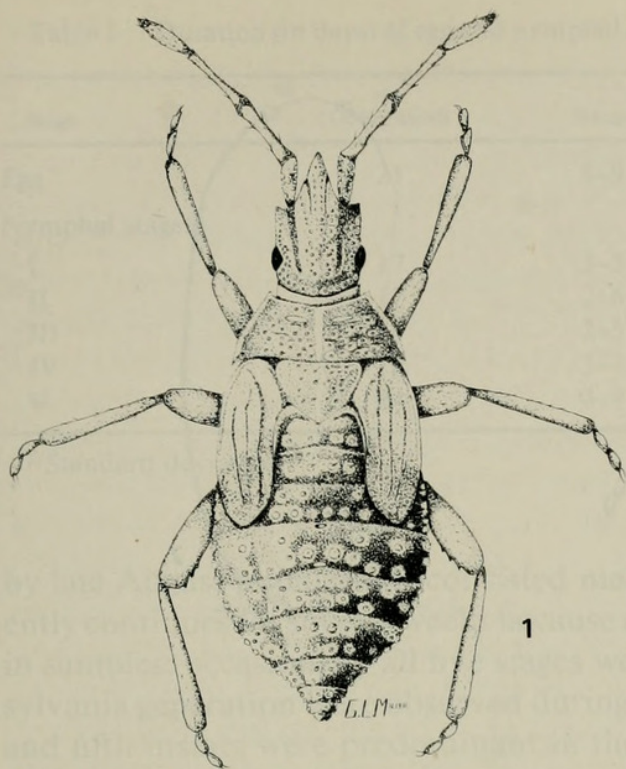
Length 2.60–3.20 mm, $\bar{x} = 2.96$. Head, length 0.74–0.80 mm, $\bar{x} = 0.78$; width 0.60–0.62 mm, $\bar{x} = 0.61$; interocular space 0.42–0.44 mm, $\bar{x} = 0.43$. Protergal length 0.26–0.28 mm, $\bar{x} = 0.27$; humeral width 0.76–1.04 mm, $\bar{x} = 0.85$. Antennal lengths I, 0.20–0.28 mm, II, 0.36–0.40; III, 0.40–0.42; IV, 0.40–0.44. Labial lengths I, 0.50–0.52 mm; II, 0.44–0.46; III, 0.40–0.46; IV, 0.50–0.54.

Second instar (in alcohol, $n = 4$) (Fig. 5).—More pyriform and paler than preceding instar; integument appearing more smooth.

Length 2.04–2.20 mm, $\bar{x} = 2.09$. Head, length 0.58–0.64 mm, $\bar{x} = 0.61$; width 0.40–0.46 mm, $\bar{x} = 0.45$; interocular space 0.28–0.34 mm, $\bar{x} = 0.33$. Protergal length 0.16–0.18 mm, $\bar{x} = 0.17$; humeral width 0.48–0.68 mm, $\bar{x} = 0.61$. Antennal lengths I, 0.14–0.18 mm; II, 0.24–0.28; III, 0.28–0.30; IV, 0.32–0.34. Labial lengths I, 0.36–0.40 mm; II, 0.34–0.40; III, 0.30–0.32; IV, 0.42–0.44.

First instar (in alcohol, $n = 2$) (Fig. 6).—More elongate, less dorsoventrally flattened than preceding instars; dorsal abdominal scent gland openings indistinct; labium sometimes extending beyond abdomen.

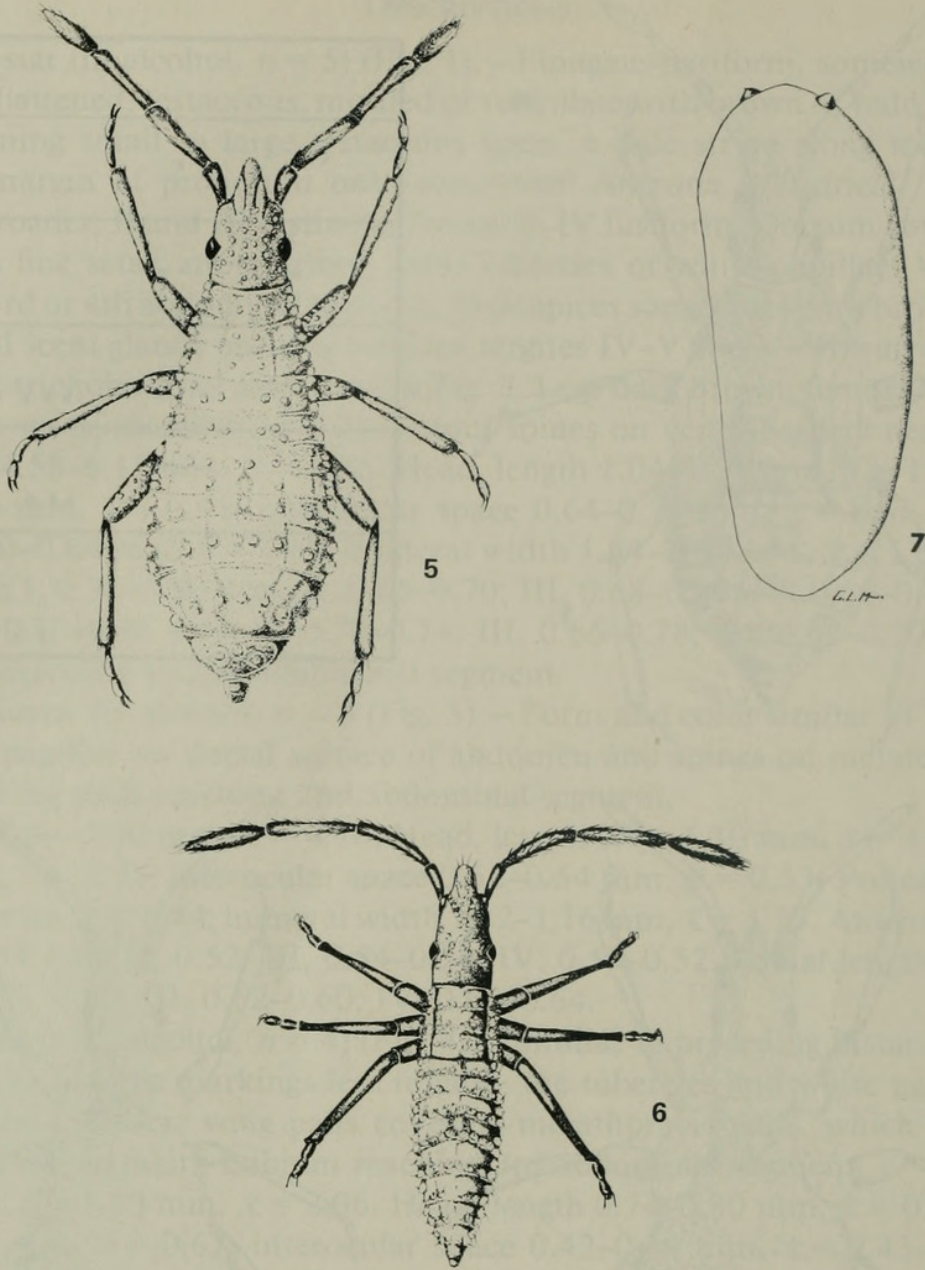
Length 1.40–1.42 mm, $\bar{x} = 1.41$. Head, length 0.42–0.44 mm, $\bar{x} = 0.43$; width 0.34; interocular space 0.24–0.26, $\bar{x} = 0.25$. Protergal length 0.28–0.30 mm, $\bar{x} = 0.29$; humeral width 0.36–0.40 mm, $\bar{x} = 0.38$. Antennal lengths I, 0.14 mm; II,



Figs. 1-4. *Harmostes fraterculus* nymph. 1, Fifth instar. 2, Trichobothrial pattern of fifth instar; diagram represents left side of abdominal sterna II-VII and shows trichobothria (X) and spiracles (O). 3, Fourth instar. 4, Third instar.

0.20–0.22; III, 0.24–0.26; IV, 0.30–0.34. Labial lengths I, 0.34–0.38 mm; II, 0.32; III, 0.30–0.32; IV, 0.40.

Egg ($n = 5$) (Fig. 7).—Length 1.00–1.06 mm, $\bar{x} = 1.03$. Elongate oval, white when deposited, turning orange to dark brown before hatching, distinct sculpturing



Figs. 5-7. *Harmostes fraterculus* nymph and egg. 5, Second instar. 6, First instar. 7, Egg.

apparently absent; 2 distinct micropylar processes or aero-micropyles at anterior pole, the form typical of rhopalid eggs except for absence of a ventral attachment stalk (see Southwood, 1956; Cobben, 1968).

BIOLOGY

Seasonal history.—Adults first appeared on flower heads of their host plants during the last week of July in 1979 and the first week of August in 1980, just as a few flowers of Joe-Pye weed were beginning to open. In both years the seasonality of populations was similar, and the phenological pattern here presented is based on a composite of 1979-80 samples supplemented by observations made in 1978 and 1981.

During the week following their first collection, adults increased noticeably in numbers, and mating pairs were observed on flower heads of *E. fistulosum*. First-instar nymphs were found two to three weeks after the appearance of adults, and

Table 1. Duration (in days) of egg and nymphal stages of *Harmostes fraterculus* reared at 20–22°C.

Stage	No. Observations	Range	Mean ± s ¹	Cumulative Mean Age
Egg	21	8–9	8.2 ± 0.40	—
Nymphal stages				
I	17	3–5	3.3 ± 0.61	3.3
II	12	2–6	3.3 ± 0.98	6.6
III	11	2–5	3.3 ± 0.90	9.9
IV	18	3–7	4.1 ± 1.13	14.0
V	24	4–8	5.4 ± 1.02	19.4

¹ Standard deviation.

by late August populations consisted mainly of third instars. Oviposition apparently continues for several weeks because nymphs of three stages often were present in samples; occasionally all five stages were found. Teneral adults of a first Pennsylvania generation were observed during the first week of September when fourth and fifth instars were predominant in the population.

During mid-September, the number of first-generation adults increased, late-instar nymphs were still common, and eggs and instars I–II of a second generation were observed. With a deterioration of food resources on their hosts, late-maturing, first generation females appeared to oviposit mainly in the few flowering heads that remained; late in the season adults and nymphs were most abundant in heads bearing a few flowers, or in withered heads that had not completely dried. Although the first generation was found only on *E. fistulosum* at the sample sites (and once on the Joe-Pye weed *E. purpureum* L. in a nearby, much drier habitat), the second generation developed partially in heads of boneset, *E. perfoliatum*, occurring near patches of *E. fistulosum*. Boneset flowers usually were available for several weeks after those of Joe-Pye weed had dried up.

Adults of the second generation were observed as early as the last week of September. A few fifth instars were present until mid-October, and adults could be found until late October or early November.

Laboratory studies.—Field-collected pairs mated readily in rearing containers, sometimes remaining *in copula* for several hours. In an apparent absence of elaborate pre-copulatory behavior, the male simply crawled over the female; if receptive, she remained motionless, and he inserted his aedeagus. At first, the pair assumed a side-to-side position, then often oriented tail-to-tail. Mutiple matings were observed for several pairs.

The single female observed in oviposition crawled over and probed the excised florets, and thrust her ovipositor into the disc flowers. Oviposition times ranged from 35 s to 1 min 5 s ($\bar{x}$ = 53 s, n = 5). Eggs usually were deposited singly into disc flowers and placed on the inner edge of involucral bracts, on ovaries, or on the pappus; a few were laid in clusters of two or three.

The average incubation time was 8.2 days (Table 1). Instars I–III each averaged 3.3 days; the duration of the fourth stage was slightly longer, and the fifth stage was the longest. We were unable to rear *H. fraterculus* from egg to adult, and the average of 19.4 days required for nymphal development is based partly on times determined for field-collected nymphs. Even though our data cannot be compared

directly to those of Yonke and Walker (1970a), who reared 67 nymphs of *H. reflexulus* from egg to adult, our 19.4 days is close to the 21.7 days required for the development of *reflexulus* nymphs.

DISCUSSION

Our field studies, although contributing to the biological knowledge of a poorly known species, raise several questions. Is *Harmostes fraterculus* capable of overwintering in south central Pennsylvania? Based on the data now available, we believe this rhopalid migrates into the area during late summer of most years and is near the northern limits of its range. The only evidence tending to negate a migratory theory is the appearance of populations at the sample sites for three consecutive seasons; one might not expect a "fall out" to occur each season in the same colonies of *Eupatorium*. Still, the large size of the colonies under observation and the patchiness of rhopalid populations in nearby areas, coupled with the additional information to be presented, reinforce our original assumption regarding the status of *H. fraterculus* in Pennsylvania.

Pennsylvania specimens of this rhopalid are scarce in the insect collections we examined (American Museum of Natural History—AMNH; Cornell University—CU; New York State Museum—NYSM; and National Museum of Natural History—USNM), and none was taken before August. Göllner-Scheiding's (1978) record is the only published one from the state. In tracking Joe-Pye weed north from the Harrisburg area, we found populations in Columbia and Northumberland counties, but we did not collect specimens in the extreme northern counties or in southern New York. There are no New York specimens in the collections of AMNH, CU, NYSM, or USNM. The Canadian record Göllner-Scheiding (1978) had in mind undoubtedly is that of Provancher (1886), which was based on a misidentification of the lygaeid *Ortholomus scolopax* (Say) (see Van Duzee, 1912: 319; Slater, 1964: 341).

At the two main sample sites and additional areas near Harrisburg we have never encountered adults of *H. fraterculus* before late July, even though extensive surveys have been conducted for this study and as part of projects involving other insects. We have, however, made early-season collections of adults of *H. reflexulus* and have found nymphs developing on yarrow, *Achillea millefolium* L., during June.

It appears that *H. fraterculus* overwinters within 100 miles of Harrisburg. We have seen specimens collected from early April and May in the northern Virginia and Washington, D.C., area (CU, USNM) and one taken "under sign board on tree" at Cape May Courthouse, N.J., on March 29 (AMNH).

Like *H. reflexulus*, *H. fraterculus* apparently overwinters in the adult stage in its permanent range, at least as far north as the Washington area and southern New Jersey. This rhopalid is closely associated with Joe-Pye weed, not only in Pennsylvania but farther south; we have collected nymphs from *E. fistulosum* (and *Conyza canadensis* (L.) Cronq.) in North Carolina. *Eupatorium* spp. and *C. canadensis* do not bloom until mid- to late summer. What happens to populations of the rhopalid earlier in the season? Have early-season generations been overlooked on a composite of the same tribe or some other composite? Does the bug use a succession of hosts like *H. reflexulus* (Yonke and Walker, 1970a) and the lygaeids *Lygaeus equestris* L. (Solbreck and Kugelberg, 1972) and *L. kalmii* L.

(Hunt, 1979)? Or, in the northern fringes of its range, is *fraterculus* "getting by" on plants of unrelated families before *Eupatorium* comes into bloom? Is it possible that this rhopalid, essentially a southern species that ranges into Central America, does not breed until late summer under more northern photoperiods? The pentatomid *Proxys punctulata* (Palisot de Beauvois) has a similar range, and breeding populations are known from as far north as southern Illinois where adults do not emerge from overwintering sites and begin to reproduce until mid- to late June (Vangeison and McPherson, 1975).

Although further study is needed to clarify some of these points, we believe the following summary provides the most logical explanation of seasonality for *H. fraterculus* in Pennsylvania. Our hypothesis also may be relevant to populations of other rhopalids and to certain species in other families of Hemiptera-Heteroptera.

As a specialist herbivore on flower heads of composites growing in somewhat temporary habitats, *H. fraterculus* engages in migratory or nontrivial flights. Rhopalid adults have been collected by day at heights of 200–5000 ft. (61–1523 m) and at night at 500–5000 ft. (152–1253 m) (Glick, 1939). Southwood and Leston (1959) regard the rhopalid *Liorhyssus hyalinus* (F.) as a migrant insect in England. For *H. fraterculus*, migratory movements, perhaps combining active flight with passive dispersal on convective air currents, could be nonspecific in direction but still adaptive because food resources presumably would be available in all directions and at all distances. As Dingle (1972) and others have noted, most small migrant insects undergo unspectacular movements that make migratory flights difficult to detect. Outbursts or irruptions of *H. fraterculus* in all directions from a "core" population most likely would be detected only in areas north of the permanent range, e.g., Pennsylvania. In most cases of successful colonization of *Eupatorium*, the rhopalid would be able to overwinter. In Pennsylvania there also is the possibility of a late-fall, return flight. In northern areas of its range, the large milkweed bug, *Oncopeltis fasciatus* (Dallas), is thought to migrate south with northerly winds as day length decreases in autumn (Dingle, 1972).

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