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A Faunal Study of the Mecoptera (Insecta) of Rocky Branch Nature Preserve, Clark County, Illinois

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A FAUNAL STUDY OF THE MECOPTERA (INSECTA) OF ROCKY BRANCH NATURE PRESERVE, CLARK COUNTY, ILLINOIS

by

Jimmie W. Griffiths

Thesis

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ABSTRACT

The Mecoptera (Insecta) of the Rocky Branch Nature Preserve located near Clarksville, Clark County, Illinois are described. Specimens were collected by diurnal netting, Malaise traps, pitfall traps, and flight traps. Specimens from Rocky Branch in the collections of Eastern Illinois University, the Illinois Natural History Survey at Champaign-Urbana, and Hastings College, Nebraska, were also examined.

A total of 805 specimens from Rocky Branch were collected and/or examined. Nine species representing three families were identified: three Panorpidae (*Panorpa speciosa*, *P. helena* and *P. banksi*); five Bittacidae (*Hylobittacus apicalis*, *Bittacus strigosus*, *B. stigmaterus*, *B. pilicornis* and *B. punctiger*); and one Meropeidae (*Merope tuber*).

Sex ratios of some species in collections showed significantly more females, possibly due to behavioral difference between sexes and/or higher male mortality. A wide variation in patterns of wing maculations within *P. helena* and *P. speciosa* was also observed.

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Introduction

The order Mecoptera is a relatively primitive order of holometabolous insects, consisting of 500 extant species divided into 32 genera and nine families. Fossil evidence has revealed 348 species of Permian, Mesozoic, and Tertiary Mecoptera. These have been separated into 87 genera and 34 families (Byers and Thornhill 1983). Five extant families are known for North America, four of which occur in Illinois (Webb, et al 1975).

The family Panorpidae is characterized by the upturned male genitalia that resemble a scorpion stinger, hence the common name "scorpionflies." One genus and nine species are known to occur in Illinois. The Bittacidae, or "hangingflies," can be recognized by raptorial hind tarsi and the way they hang from vegetation by their prothoracic legs. Two genera and six species are known to occur in Illinois. The Meropeidae, or "earwigflies," get their common name from the large forceps-like male terminalia. One species occurs in North America; there are few published records of its occurrence in Illinois. The Boreidae occur in the winter months of October through April and are characterized by rudimentary wings. "Snow scorpionflies" are commonly associated with moss and their dark bodies are easily seen on snow. One species occurs in Illinois; it is restricted to the southwestern

tip of the state. (Webb, et al 1975).

The objectives of this study are to list the species of Mecoptera occurring in the Rocky Branch Nature Preserve near Clarksville, Illinois, a unique natural area in east-central Illinois, and to describe their seasonal occurrence and habits. It is hoped that this work will add to our understanding of the distribution and biology of this order in Illinois.

METHODS AND MATERIALS

Study Area

The Rocky Branch Nature Preserve is located in Sections 29 and 30, T12N, R12W in Clark County, Illinois (Fig. 1). It consists of a 52.6 hectare woodlot that was purchased by the Illinois Nature Conservancy and put under the jurisdiction of Eastern Illinois University (Ebinger & Parker 1969). The nature preserve is situated on Illinoian glacial till and includes a deep valley with sandstone outcroppings. An oak-hickory climax community occupies the drier high ground, while the moist stream bed consists primarily of a Beech-Maple community (Decker 1971; Ebinger 1988; Ebinger and Parker 1969; Ebinger and Hellinga 1970; Ebinger and Clapp 1988; Ebinger and Aikman 1991). Rocky Branch Creek bisects the nature preserve.

Methods of Investigation

One-hundred and seventy eight specimens collected prior to 1992 at Rocky Branch were examined and identified. These specimens are housed in the collections of Eastern Illinois University, the Illinois Natural History Survey at Champaign, and Hastings College, Nebraska.

Six-hundred and twenty seven specimens were collected during 1992 and 1993 by a variety of methods. Malaise traps were set in areas of differing

vegetational composition. Pitfall traps were set in numerous locations using a variety of baits including canned fruit, human dung, minnows, and battery powered lights. UV light traps and flight intercept traps were also used. Trips were made to the nature preserve at least once per week for trap maintenance and diurnal netting. The collection of Mecoptera at the Illinois Natural History Survey in Champaign, which includes specimens identified by Webb and Penny, was examined to aid in the identification of the Rocky Branch specimens. Examples of each species identified were examined by Dr. George Byers of the University of Kansas to confirm identifications.

For the study of genitalia, the dissecting techniques of Webb, et al (1975) were followed. Terminal segments of female Panorpa spp. were removed and left overnight in 10% KOH solution. Once cleared, the subgenital plate was removed with forceps and a dissecting needle used to expose the genital plate. This structure is of taxonomic importance and can be viewed with a dissecting microscope. Male genitalia were cleared in a similar manner.

Definitions of Terms

The terminology used is that of Torre-Bueno (1962). Specific terminology applicable to Mecoptera includes the following:

Anal Horn - a protrusion in the form of a horn or spike located on the dorsal side of seventh abdominal segment of some male Panorpidae (Fig. 2).

Apical Band - pigmented area on the apical end of the wings of Panorpidae; may be broken or contain "holes" or spots lacking pigmentation (Fig. 9, AB).

Apical Cross Vein - in Bittacidae, a cross vein connecting veins 1A and Cu_2 near where 1A meets the posterior margin of the wing (Fig. 22, AC).

Basal Band - a usually well defined spot located centrally at the basal end of the forewing of Panorpidae; located on and below radius. A second spot may be located near posterior margin directly below the first basal spot (Fig. 9, BB).

Basistyles - basal portion of male terminalia surrounding the aedeagus (Fig. 4, BS).

Dististyles - a small, pointed, nonarticulated process in males, moveably attached to basistyles. Used to grasp female during copulation (Fig. 4, DS).

Genital Plate - a platelike sternite that underlies the genitalia in females and is covered by the subgenital plate (Fig. 14-17).

Humeral Spots - small spot(s) between costa and subcosta in the humeral part of the forewing of Panorpidae (Fig. 9, HS).

Pterostigmal Band - pigmented band located proximad of the apical band, extending from the anterior to

posterior margins of the forewings of Panorpidae; may be broken or forked posteriorly (Fig. 9, PB).

Marginal spot - a spot located between the pterostigmal and basal bands on the anterior margin of the forewings of Panorpidae (Fig. 9, MS).

Spermathecal Apodeme - in female Panorpidae, median portion of the genital plate, consisting of apodemes alongside spermathecal duct (Fig. 15).

Subcostal Crossvein - in Bittacidae; crossvein connecting Sc_1 and $Sc_2 + R_1$ on the anterior portion of the wings (Fig. 23, ScC).

Subgenital Plate - located ventrally on the ninth abdominal segment of female Panorpidae; covers the genital plate (Fig. 5).

Ventral Parameres - paired ventral processes from base of the aedeagus in males (Fig. 4, VP).

Results

A total of 805 specimens from Rocky Branch were examined and identified. They included three families, four genera, and nine species. Malaise traps were responsible for collecting 315 specimens, 67 specimens were taken in pitfall traps, 11 in flight traps, and 412 were collected by diurnal netting. Ultraviolet light traps were ineffective in collecting Mecoptera. For a complete breakdown of trapping method and sex for each species, see Table 1.

KEY TO THE MECOPTERA OF ROCKY BRANCH, ILLINOIS

1. Tarsi with a single, large apical claw that reflexes back against the fourth tarsal segment .....Bittacidae.. 2

   Tarsi with two small apical claws (Fig. 3)..... 7

2. Apices of wings dark brown (Fig. 20); forewings held out to side at rest, hind wings held out to sides but inclined ventrally..... ..... Hylobittacus apicalis

   Apices of wings not dark brown (Fig. 21-25); both pairs of wings folded over back.... Bittacus.. 3

3. Apical crossveins present (Fig. 21-22)..... 4

   Apical crossveins absent (Fig. 23-25)..... 5

4. Hind femora with brown spots surrounding base of setae; wings mottled with small, light brown

spots (Fig. 21)..... B. punctiger

Hind femora without brown spots surrounding setae; wings lacking small brown spots (Fig. 22)..... ..... B. pilicornis

5. Subcostal crossvein distal to first fork of radial sector (Fig. 23)..... B. occidentis*

Subcostal crossvein basal to first fork of radial sector (Fig. 24-25)..... 6

6. Wing membranes colorless; crossveins margined (Fig. 24)..... B. strigosus

Wing membranes yellow to amber; crossveins not margined (Fig. 25)..... B. stigmaterus

7. Wings broad, rounded apically, with numerous costal crossveins; body slightly depressed; head strongly opisthognathous. Meropeidae (Fig. 26). ..... Merope tuber

Wings narrow, elongate, with few costal crossveins; body not depressed; head hypognathous with a well developed rostrum (Fig. 2). Panorpidae.... ..... Panorpa.. 8

8. Pterostigmal band of wings not continuous from anterior to posterior margin (Fig. 6-7); males lack an anal horn on the 6th abdominal tergum... 9

Pterostigmal band continuous from anterior to posterior margin (Fig. 8-9); anal horn present on 6th abdominal tergum of male (Fig. 2)..... 10

9. First basal spot of wings relatively large, humeral spot small but present (Fig. 6). Genital plate of female narrow, basal plate elongate, over 1.5 mm in length (Fig. 14). Ventral parameres of male straight, slender (Fig. 10)..... ..... P. banksi

   First basal spot relatively small, humeral spots absent (Fig. 7). Female genital plate elongate, basal plate oval, approximately 1.4 mm in length (Fig. 15). In males, ventral parameres thick, sigmoidally curved with barbs covering apices (Fig. 11)..... P. sigmoides*

10. Humeral spots of wings absent, basal band broken or complete (Fig. 8). In females, distal plate tapered basally; basal plate absent (Fig. 16). In males, ventral parameres unbranched; basistyles with 1-3 dark setae near base of dististyles (Fig. 12)..... P. helena

    Humeral spots present, basal band broken (Fig. 9). In females, distal plate broad basally, deeply emarginate apically; basal plate absent (Fig. 17). In males, ventral parameres are branched; basistyles lack dark setae (Fig. 13)..... ..... P. speciosa

* denotes species not collected in Rocky Branch Nature Preserve but found in neighboring counties.

SPECIES ACCOUNTS

Family Panorpidae (Panorpa spp.)

Members of this group are characterized by a yellow-amber body, clear to amber wings with brown to black wing maculations, two small tarsal claws and narrow wings with few costal crossveins. They are 15 to 20 mm in length and males possess genitalic structures that are held above the body resembling a scorpion stinger.

Panorpids are often observed perched on the leaves of low lying herbaceous vegetation in shaded to semi-shaded woodland areas. When disturbed, panorpids either fly a few meters to safety, or drop to the ground and hide in leaf litter. Most species prefer humid areas associated with lower elevations, although some species in the P. lugubris group prefer more open areas (Webb, et al 1975). Early reports portrayed panorpids as predaceous, but more recent studies suggest that dead or dying arthropods are their major food source (Webb, et al 1975). I have observed adults in nature feeding on decaying nuts, fruit, bird droppings, and other dead panorpids. In the laboratory, they fed on canned fruit,

hamburger, cat food, meat loaf and corned beef.

The sexual behavior of the genus Panorpa has been studied in great detail by many authors, including Byers (1958, 1962a, 1962b, 1963, 1965, 1967, 1969, 1973a, 1974, 1988, 1989a, 1989b, 1990), Byers and Covell (1981), Byers and Thornhill (1983), Grell (1938), Kaltenbach (1978), Micholeit (1971), Potter (1938), Rupprecht (1974), Thornhill (1973, 1974, 1978b, 1979a, 1979c, 1980a, 1980b, 1981, 1987, 1992), Thornhill and Johnson (1974), and Thornhill and Sauer (1991, 1992). Larval development and life histories have been studied by Byers (1963), Miyake (1912), Rottmar (1966), Shiperovitsch (1925), Steiner (1930), and Yie (1951).

At the Rocky Branch Nature Preserve, adult specimens of Panorpa were collected by a variety of methods including Malaise traps, flight traps, pitfall traps baited with human dung and fruit, and diurnal netting. Larvae of Panorpa spp. were collected in pitfall traps baited with canned fruit. One specimen was found in a fungus, 10 cm into the stipe, at the base of the pileus.

Panorpa speciosa Carpenter

Diagnostic Description. Wings clear to amber with faintly margined crossveins; apical and pterostigmal bands complete, but basal band broken (Fig. 9). Humeral spots vary from 1-4; wing maculations varied (see Fig. 42). Legs and abdomen pale to dark yellowish brown. In

males: the ninth tergum is elongate, broad basally and apically emarginate; ventral parameres are branched; each dististyle has a dark patch of setae near the base (Fig. 13). In females: genital plate short and oval; distal plate broad apically and deeply emarginate; basal plate absent (Fig. 17).

Range. Occurs in the north from Indiana west to Iowa and Minnesota; in the south from Tennessee to Arkansas. This species is common and widespread throughout Illinois (Fig. 30).

Specimens Examined. Three hundred and ninety-seven specimens from Rocky Branch were identified (159 males, 234 females, and four specimens of unknown sex).

Remarks. Malaise traps collected 206 specimens, pitfall traps collected 59 specimens, flight traps collected five specimens, and diurnal netting collected 127 specimens. Specimens were taken from early May through the middle of October with the majority of specimens taken in August and September (Fig. 28).

Panorpa helena Byers

Diagnostic Description. Wings clear to amber; crossveins not margined; apical and pterostigmal bands complete. Webb, et al (1975) describe this species as having a broad and complete basal band; this band was conspicuously broken in the majority of specimens examined from Rocky Branch. The observed variation in wing maculations is shown in Fig. 41. First basal spot

present, but humeral spots absent (Fig. 8). Legs pale yellow, with the 4th and 5th tarsal segments dark brown to black. In males, ninth tergum broad basally and apically emarginate; ventral parameres unbranched; basistyles with 1 to 3 pairs of dark setae near base of dististyles (Fig. 12). In females, genital plate oval; distal plate oval, tapered basally and emarginate apically; basal plate absent (Fig. 16).

Range. Occurs in the north from Massachusetts east to North Dakota; in the south from Georgia to Kansas. This species is common throughout Illinois (Fig. 31).

Specimens Examined. One hundred and three specimens from Rocky Branch were identified (48 males and 55 females).

Remarks. Malaise traps collected 36 specimens, three were collected in pitfall traps, and 64 were collected by diurnal netting. Specimens were collected from early May through early October with the majority during May and June (Fig. 28).

Panorpa banksi Hine

Diagnostic Description. Wing membranes faintly yellow with several margined crossveins; apical band narrow and reduced with several brown subapical spots; pterostigmal band broken posteriorly into several dark brown spots; basal band broken; first humeral spot present but faint; first basal spot well developed (Fig.

6). In males, ninth tergum apically emarginate and elongate, ventral parameres unbranched, barbed, extending beyond the base of dististyles (Fig. 10). In females, genital plate elongate, with a short, apically emarginate distal plate; basal plate elongate and oval (Fig. 14).

Range. Occurs in the north from Maine to Wisconsin and Iowa; in the south from South Carolina and Georgia to Tennessee. This species was previously unreported from Rocky Branch and surrounding counties (Fig. 32).

Specimens Examined. Thirty-two specimens from Rocky Branch were identified (18 males, 13 females, and one damaged specimen).

Remarks. Twenty-six specimens were manually collected, two males were collected in pitfall traps, and malaise traps collected four specimens. Specimens were collected from early June through early July (Fig. 28). Webb reports this species scattered throughout Illinois. Two specimens in the Eastern Illinois University collection were misidentified by Penny (see Webb, et al 1975) as P. sigmoides.

Panorpa sigmoides Carpenter

Diagnostic Description. Wing membranes clear to pale yellow with margined crossveins; apical band broken into two thin bands; pterostigmal band broken and forked; basal band broken forming two distinct spots; humeral spots absent; first basal spot small but

distinct (Fig. 7). In males, ninth tergum apically emarginate, broad basally; ventral parameres thick, barbed, and sigmoidally curved, extending beyond base of dististyles, ending in a point (Fig. 11). In females, genital plate elongate and oval; distal plate broad and apically emarginate, basal plate broad and oval (Fig. 15).

Range. Occurs in the north from Ohio to Wisconsin and Minnesota; in the south from Tennessee to Missouri. This species is reported throughout Illinois (Fig. 33).

Specimens Examined. No specimens were collected at Rocky Branch, but many specimens have been collected 25 miles to the west at Fox Ridge State Park in Coles County.

Remarks. Two specimens from Rocky Branch in the E.I.U. collection identified as P. sigmoides by N. D. Penny (Webb, et al 1975) are determined to be P. banksi.

Family Bittacidae

This family includes three North American genera: Bittacus, Hylobittacus, and Apterobittacus (a wingless form found in California). The slender wings and legs of the winged genera somewhat resemble tipulid flies. Members of this family prefer moist, shaded areas, although some species range into drier habitats. Bittacids are predaceous, hanging from low lying

vegetation by their front tarsi, waiting to capture prey with their raptorial hind tarsi (Fig. 18, 19). They appear to have a preference for small soft-bodied Diptera and Homoptera (Webb, et al 1975). Mating behaviors have been studied by Bornemissza (1964, 1966), Brownson (1964), Byers and Thornhill (1983), Mickoleit and Mickoleit (1978), Newkirk (1957), Setty (1931, 1939, 1940, 1941), and Thornhill (1976, 1977, 1978a, 1979a, 1979b, 1980c, 1980d, 1983, 1984). Biology of these species has been described by Byers (1954, 1958, 1962a, 1962b, 1965, 1969, 1973a, 1977, 1987, 1988, 1989a, 1989b, 1990), Byers and Covell (1981), Byers and Thornhill (1983), Thornhill (1974, 1975), and Thornhill and Johnson (1974).

In this study, specimens were collected by Malaise traps and diurnal collecting. Pitfall traps were ineffective in collecting Bittacidae.

Genus Hylobittacus

This genus includes one species, Hylobittacus apicalis. Hylobittacus was included in Bittacus until Byers (1979) separated it based on several characteristics including: resting posture, wing venation and pigmentation, egg shape, time of activity, and structure of the proctiger in the male.

Hylobittacus apicalis

Diagnostic Description. Body pale yellow to brown; wings pale. Pterostigmal spot and apices of wings dark brown to black; apical crossvein absent; subcostal crossvein basal to fork of radial sector (Fig. 20). At rest, fore-wings held out to the sides while the hind-wings are inclined ventrally to the sides (Byers 1979).

Range. Occurs in the north from New York to Missouri; in the south from the Carolinas to Oklahoma. Collected throughout Illinois except in the northern counties (Fig. 34).

Specimens Examined. Eighty-four specimens from Rocky Branch were examined (35 males and 46 females).

Remarks. Seventeen specimens were collected by Malaise traps and diurnal netting resulted in 64 specimens. Specimens were collected from early June through early August with the majority in June and July (Fig. 29).

On July 6, 1993, I witnessed a specimen of H. apicalis carrying a Panorpa banksi female wrapped in spider web, suggesting kleptoparasitism.

Genus Bittacus

Of the six midwestern species representing this genus, four have been recorded from Rocky Branch.

Bittacus pilicornis Westwood

Diagnostic Description. Body dark yellow to brown.

Wings amber with margined crossveins; apical crossvein present and subcostal crossvein basal to first fork of radial sector (Fig. 22).

Range. Occurs in the north from Maine to Minnesota; in the south from Florida to Arkansas. This species is common throughout Illinois (Fig. 35).

Specimens Examined. Sixty one specimens from Rocky Branch were examined (29 males and 32 females).

Remarks. Specimens were collected by diurnal netting with the exception of one female collected in a Malaise trap. Specimens were collected from late May through late July, with 74% of the collections occurring in June (Fig. 29).

Bittacus stigmaterus Say

Diagnostic Description. Body yellow to brown. Wings amber, uniform in color with slightly darker pterostigma, crossveins not margined; apical crossvein absent and subcostal crossvein basal to the first fork of radial sector (Fig. 25). I have observed this species flying low to the ground in very dense vegetation making its detection very difficult.

Range. Occurs in the north from New York to Minnesota and Nebraska; in the south from South Carolina to Texas. Records of this species are scattered throughout Illinois (Fig. 36).

Specimens Examined. Fourteen specimens from Rocky Branch were examined (six males and eight females).

Remarks. Malaise traps and diurnal netting each resulted in seven specimens. Specimens were collected from late July through early September (Fig. 29).

Bittacus strigosus Hagen

Diagnostic Description. Body yellow to brown with pale yellow legs. Wings clear with heavily margined crossveins; apical crossvein absent, subcostal crossvein basal to first fork of radial sector (Fig. 24).

Range. Occurs in the north from New York to Montana; in the south from South Carolina to Louisiana. B. strigosus is widespread throughout Illinois (Fig. 37).

Specimens Examined. Eighty-one specimens were collected at Rocky Branch (32 males and 48 females; one specimen was damaged and could not be sexed).

Remarks. Malaise traps collected 17 specimens and diurnal netting 64 specimens. Specimens were collected from mid June through August (Fig. 29).

Bittacus punctiger Westwood

Diagnostic Description. Body pale yellow to brown with a dark brown abdomen. Brown spots are located at the base of each femoral seta. Wings yellow with conspicuous brown maculations; apical crossvein present, subcostal crossvein basal to the first fork of radial sector (Fig. 21).

Range. Occurs in the north from Pennsylvania to

Illinois; in the south from Florida to Texas. Webb, et al (1975) reported this species in small numbers from Alexander, Franklin, and Union Counties (Fig. 38).

Specimens Examined. Two specimens, both females, were collected at Rocky Branch.

Remarks. One specimen was collected in 1991 and one in 1992, both in the third week of June (Fig. 29) by Malaise trap.

Bittacus occidentis Walker

Diagnostic Description. Body dark yellow to brown; legs brown with hind femora swollen. Wings yellow; apical cross-vein absent, subcostal crossvein distal to the first fork of radial sector (Fig. 23).

Range. Occurs in the north from New York to Nebraska; in the south from Georgia to Arizona. In Illinois, specimens have been recorded from Adams, Champaign, Coles, Cook, McDonough, and Sangamon Counties (Fig. 39).

Specimens examined. No specimens were collected at Rocky Branch, but numerous specimens from Coles County, Illinois have been collected in the past few years.

Remarks. Webb, et al (1975) reported that all specimens were collected at lights or by light traps. Byers (1993) also reported collecting B. occidentis abundantly at lights at the University of Kansas and notes "outbreaks" occurring at seven year intervals. U-

V light traps were repeatedly set at Rocky Branch during this survey and in previous years, but no specimens of B. occidentis have been collected.

Family Meropeidae

This family includes one species in the genus Merope in North America (Merope tuber) and one species in Austromerope in Australia. Meropeids have broadly rounded, densely veined wings. Differences in wing venation, and the lack of ocelli and notal organ separate the Meropeidae from the South American family Notiothaumidae, which is similar in appearance.

Merope tuber Newman

Diagnostic Description. Body and wings pale yellow to brown; wings broad and rounded at apex with numerous crossveins. Body flattened dorsoventrally; head strongly opisthognathous. Male terminalia elongate, forceps like, approximately 1/3 length of body. (Fig. 26).

Range. Occurs in the north from Maine to Minnesota; in the south from Georgia to Kansas. Webb, et al (1975) recorded only seven specimens of Merope tuber from Illinois, collected in Champaign and Union Counties. I now have records from ten additional locations in Illinois (Fig. 40).

Specimens Examined. Thirty-four specimens were

collected at Rocky Branch (12 males and 22 females).

Remarks. Malaise traps accounted for 25 specimens, six were collected in flight traps, and three were collected in pitfall traps baited with carrion or deer dung. Specimens were collected from late June through late October with most occurring in August.

The enlarged eye facets suggest that Merope tuber is nocturnal. The biology and habits of this species are very poorly known and it has only recently been collected with any frequency. This may be due to the increasing use of Malaise traps by entomologists, as discussed by Byers (1973a). Although M. tuber has been collected at Rocky Branch by Malaise traps, flight traps and pitfall traps, assiduous efforts to collect adults during day and night have been unsuccessful. This species may be a scavenger since it is collected by procedures that are successful in collecting Panorpa spp.

Discussion

A wide variation in wing maculations was noted in two Rocky Branch Panorpa species. Webb et al (1975) described P. helena as having an entire basal band, but 89% of the specimens I examined possessed a broken basal band. Figure 41 illustrates the variation in wing maculation in P. helena at Rocky Branch. Webb et al (1975) also reported P. speciosa as having a broken basal band, although approximately 10% of the specimens I examined had a complete basal band. Humeral spots varied from two to four, and a wide variation in wing color and crossvein margining was found (Fig. 42). Wings of specimens with a complete basal band were generally darker, with heavier margining of the crossveins.

A variety of collecting strategies were utilized during this study. Traps were set in areas considered favorable for collecting Mecoptera. Malaise traps were effective in collecting many Mecoptera. Seventy-four percent of Merope tuber were collected in this manner. Malaise trapping success was varied in collecting Panorpidae, ranging from 52% of P. speciosa collected, to 12.5% of P. banksi. Bittacidae were less frequently collected by this trap. Excluding B. pilicornis, with only one Malaise trapped specimen of a total of 61 collected by all means, 24% of other species of bittacids were collected by this method (Table 1).

Malaise trapping was important in collecting some rare species like Bittacus punctiger and Merope tuber. Unlike diurnal netting, this trap collects continuously over a 24 hour period. The success of Malaise traps depends upon trap placement. In this study, traps were placed in "flyways" in sheltered wooded habitats where the contours of the terrain would cause flying insects to pass through the area. Traps were also placed in areas with visibly high populations of Mecoptera.

Diurnal netting was also effective in collecting Mecoptera, although nocturnal and secretive species could be missed. In the case of B. pilicornis, specimens were most often collected by diurnal netting, with 60 collected, compared to only one by Malaise trap. It should be noted that Malaise traps were placed in areas that were some distance from the locations where B. pilicornis was most frequently collected by diurnal netting.

Pitfall traps were successful in collecting Panorpidae, including good numbers of P. speciosa (n=59) but very few P. helena and P. banksi. No Bittacidae were collected by pitfall traps, perhaps due to their predatory habits, in contrast to the scavenging behavior of adult Panorpidae. Pitfall traps were baited with a variety of materials. Mixed fruits were the most successful baits, collecting more specimens than other baits, particularly Panorpa speciosa females, with 42

specimens compared to 15 males. Pitfall traps baited with deer dung and carrion were effective in collecting Merope tuber.

Flight traps collected a few Merope tuber and a few Panorpa speciosa. Traps were set in insect "flyways," but were much less effective than Malaise traps. Flight traps are effective in collecting insects that fall down when meeting an obstruction in flight. Most Mecoptera fly upwards when meeting an obstruction thus avoiding capture by flight traps.

Ultra-violet light traps were ineffective in collecting Mecoptera at Rocky Branch. Bittacus occidentis has been collected with U-V traps 40 km west of Rocky Branch in Coles County (Webb, et al 1975) and has been collected in smaller numbers throughout the state at light. Webb et al (1975) state that all Illinois specimens were collected using light traps or at lights. Byers (1954, 1993) and Setty (1940) also report observations of B. occidentis at lights. Light traps have been placed at Rocky Branch on numerous occasions in the past eight years, but no specimens of Bittacus occidentis have been collected. Therefore, I conclude that B. occidentis is unlikely to occur at Rocky Branch.

Sex ratios for specimens collected were tested for significance using a Chi-square test for equal expected frequencies (Table 1). Byers and Thornhill (1983)

report a sex ratio of 1:1 should be expected, but male mortality may be higher. Flight trap data were pooled with Malaise trap data.

Sex ratios were significantly biased towards females for Malaise trapped M. tuber (X^2=3.90), P. speciosa (X^2=6.88) and H. apicalis (X^2=4.76). Sex ratios for collected specimens were not significantly different for the remaining species. Collection bias in sex ratio may be a result of differences in activity between sexes, rather than actual adult sex ratio. Females may be more active, searching for mates or oviposition sites and therefore collected more frequently than males.

Baited pitfall traps collected significantly more females than males of P. speciosa (X^2=12.79). Ratios were not significantly different for the remaining species. This bias could be a result of females utilizing an available food source to gain resources for egg production or a result of an actual difference in operational sex ratio.

Diurnal netting produced no significant differences in sex ratios for all species collected by this method. This method of collecting may result in data representing the true adult sex ratio. Alternatively, males may be more actively searching for food to use as nuptial gifts, thus becoming more susceptible to diurnal netting. Male panorpids may be more visible by perching

in exposed areas to attract females and therefore be more likely to be collected by diurnal netting.

In conclusion, much work remains to be done on the biology and life histories of many species of Mecoptera. The biology of Merope tuber remains largely unknown. Many larval panorpids need describing as well as larval foraging habits. At Rocky Branch, more studies are needed to understand resource partitioning and abundance of Mecoptera species throughout their season of occurrence. Certain species of Bittacidae occupy specific areas of the nature preserve. What are the reasons for these apparent site preferences? Lastly, more collecting of less common species needs to be done to gain more information about sex ratios in the nature preserve.

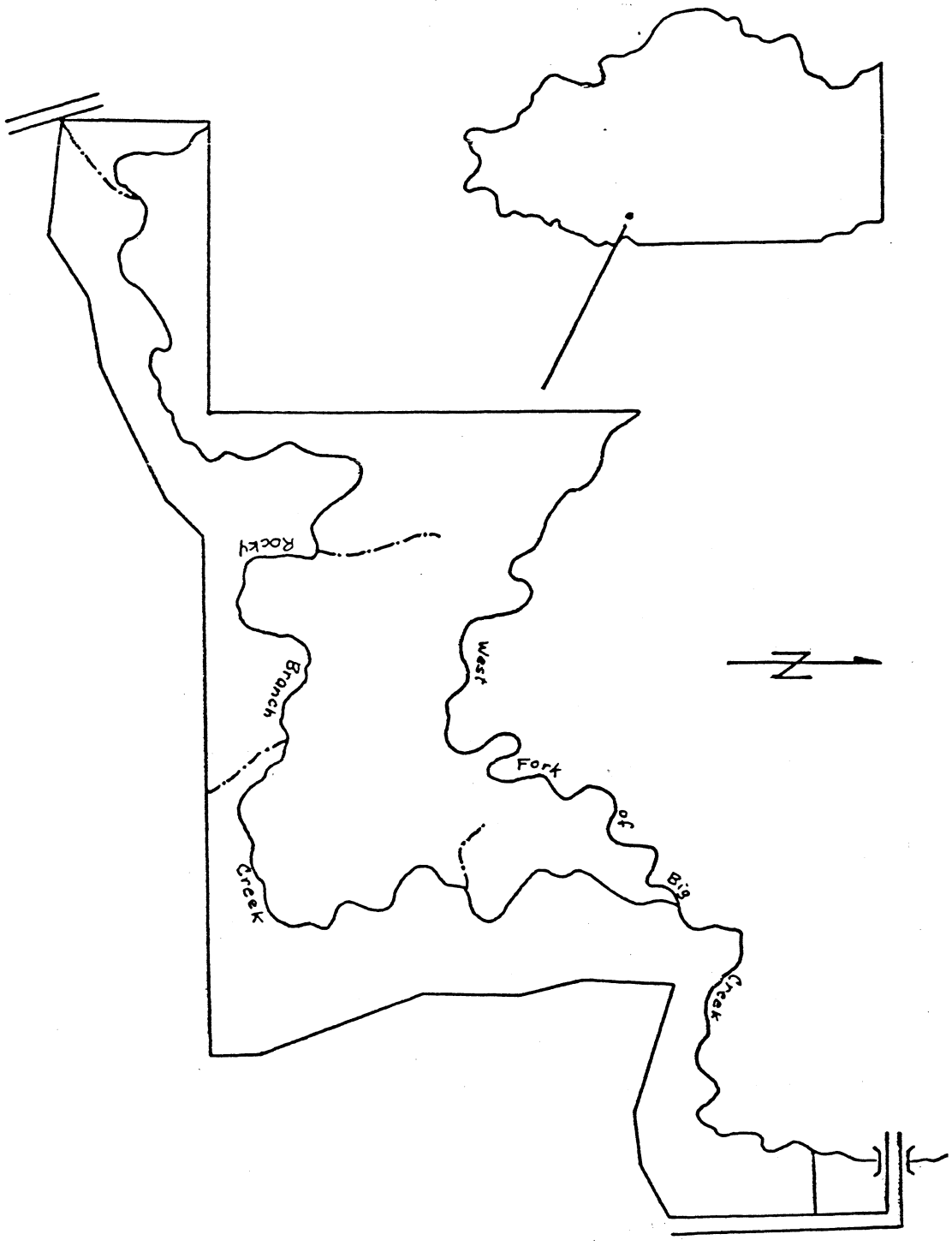


Figure 1. Map of the Rocky Branch Nature Preserves.

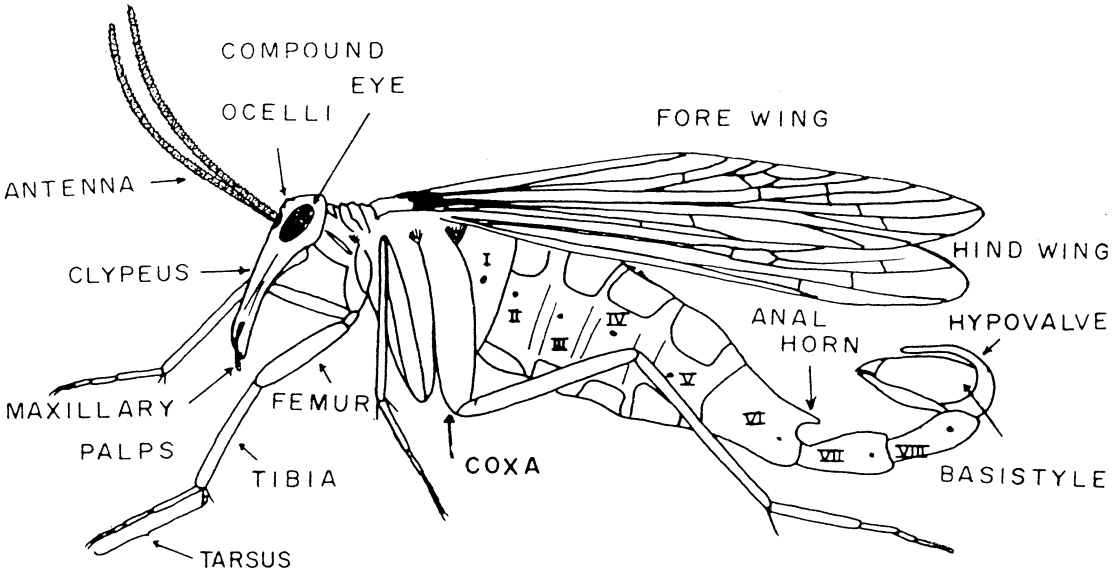


Figure 2. Panorpa sp. adult male (redrawn from Webb, et al 1975).

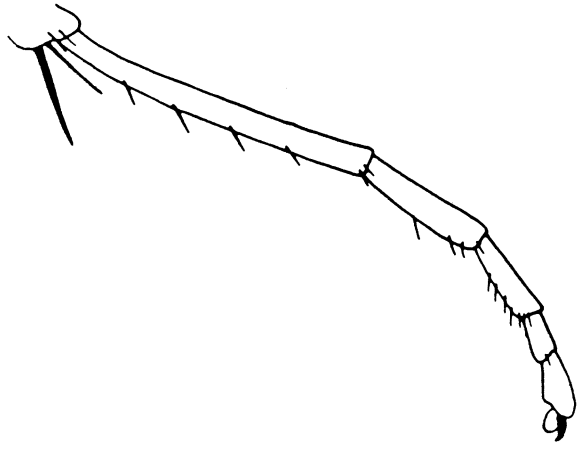
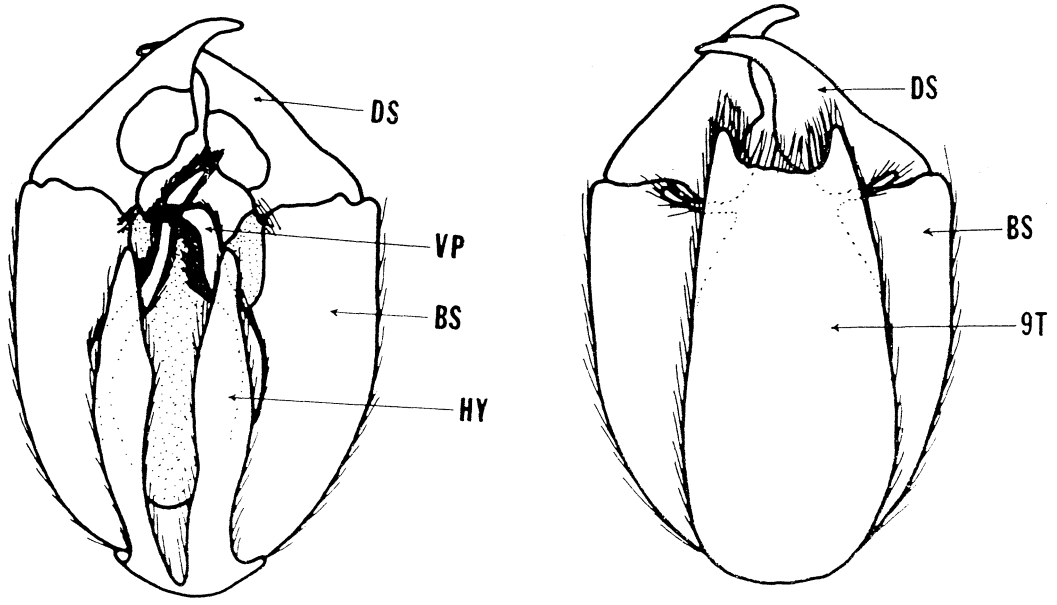
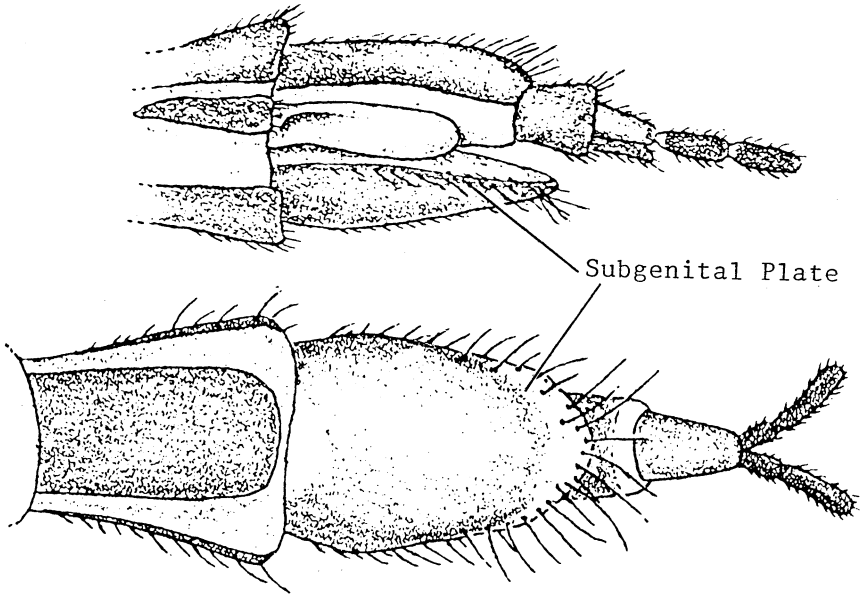


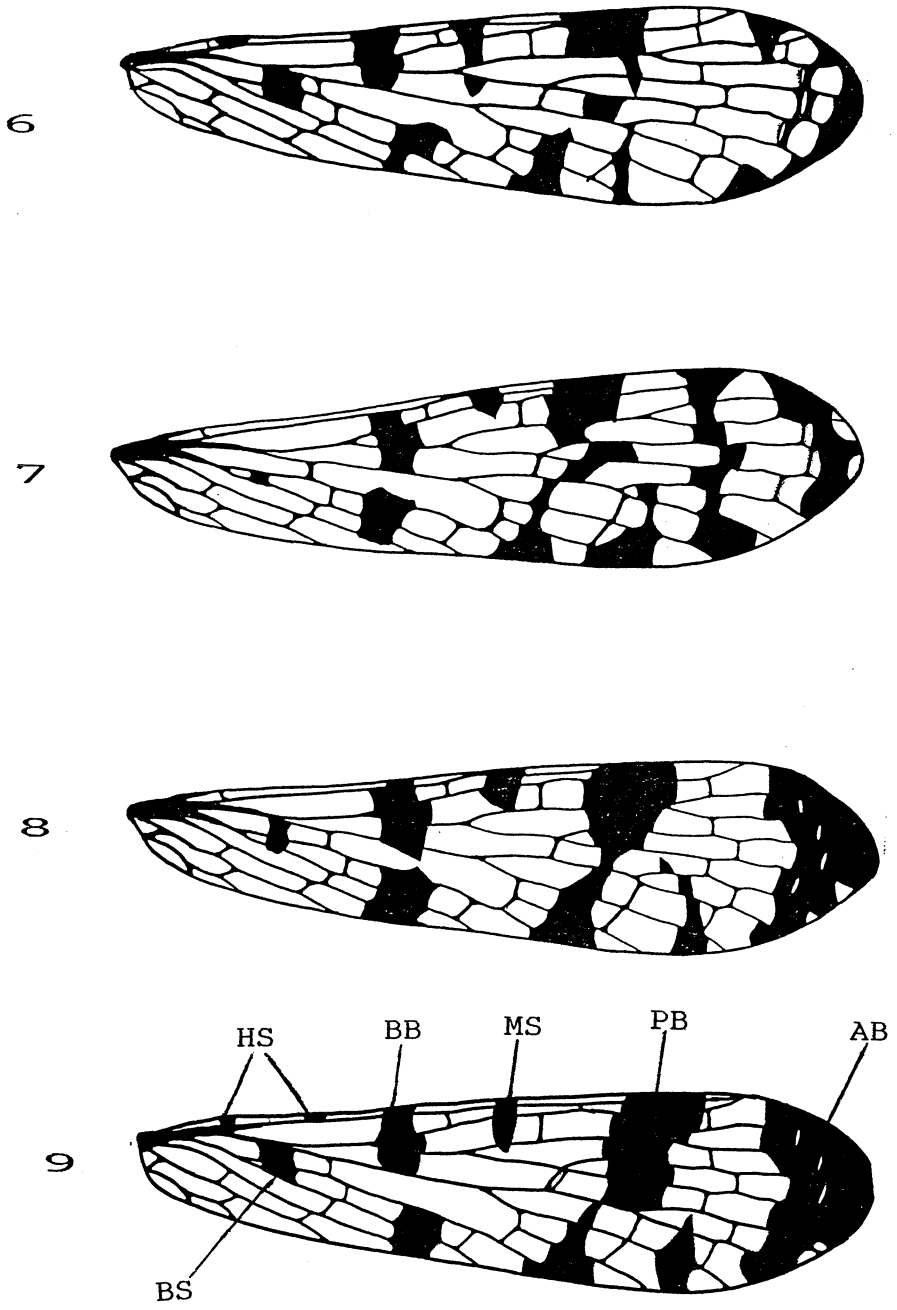
Figure 3. Hind tarsus of Panorpa sp. (redrawn from Borror, et al 1989).



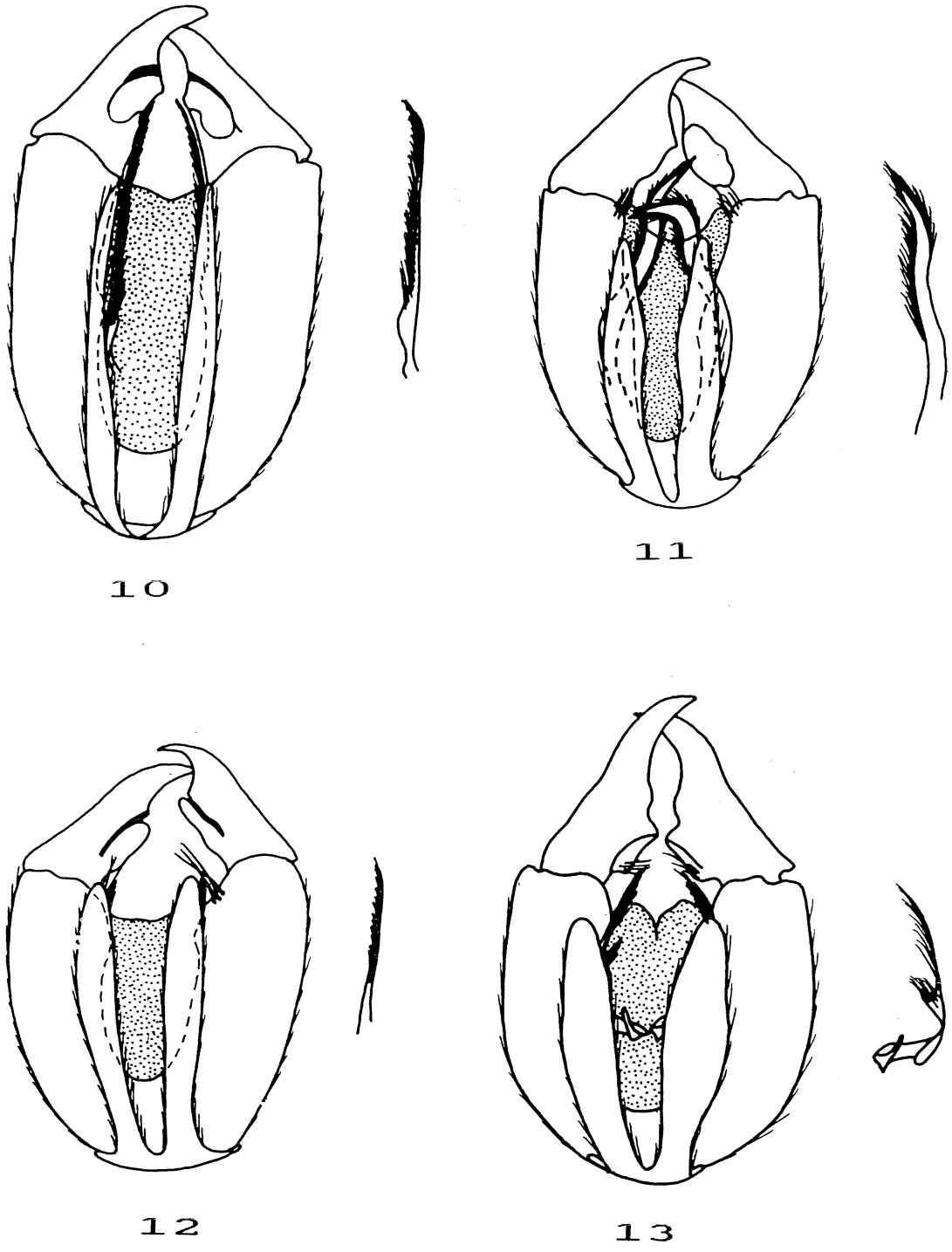
Figures 4A-B. Ventral and dorsal view of Panorpa sigmoides male terminalia. DS dististyles; VP-ventral parameres; BS-basistyles; HY-hypovalve; 9T-ninth tergum. (redrawn from Webb, et al 1975).



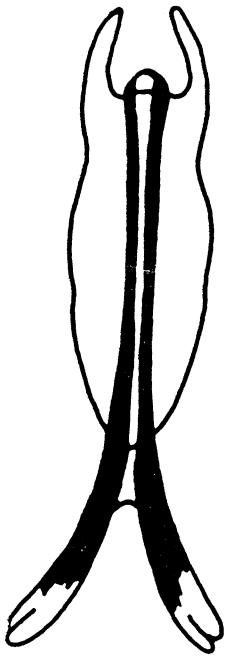
Figures 5A-B. Lateral and ventral view of female Panorpa sp. terminalia. (redrawn from Byers, 1993).



Figures 6-9. Panorpa spp. forewings. 6. P. banksi; 7. P. sigmoides; 8. P. helena; 9. P. speciosa. AB-apical band; BB-basal band; PB-pterostigmal band; HS-humeral spots; BS- basal spots; MS-marginal spot.



Figures 10-13. Male terminalia and ventral parameres of Panorpa. 10. P. banksi; 11. P. sigmoides; 12. P. helena; 13. P. speciosa. (redrawn from Webb, et al 1975).



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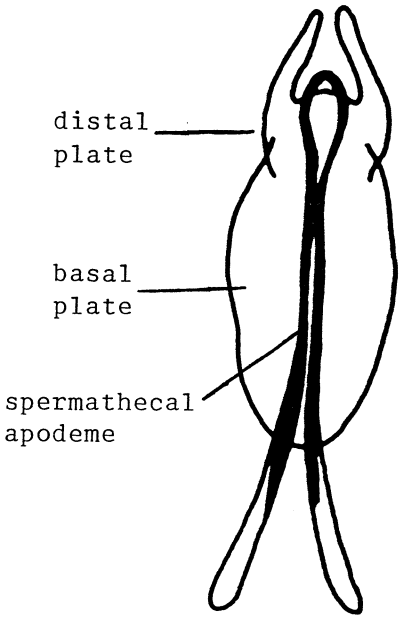

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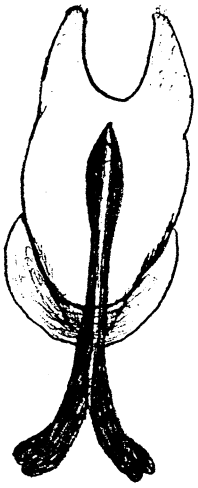

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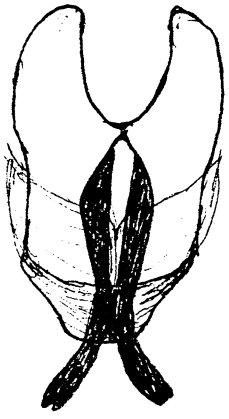

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Figures 14-17. Genital plates of female Panorpa.
14. P. banksi; 15. P. sigmoides;
16. P. helena; 17. P. speciosa.

Figure 18. Hylobittacus apicalis (Family Bittacidae

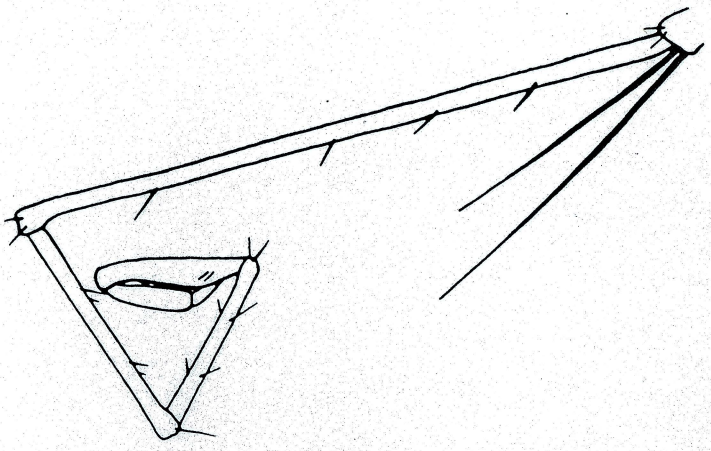
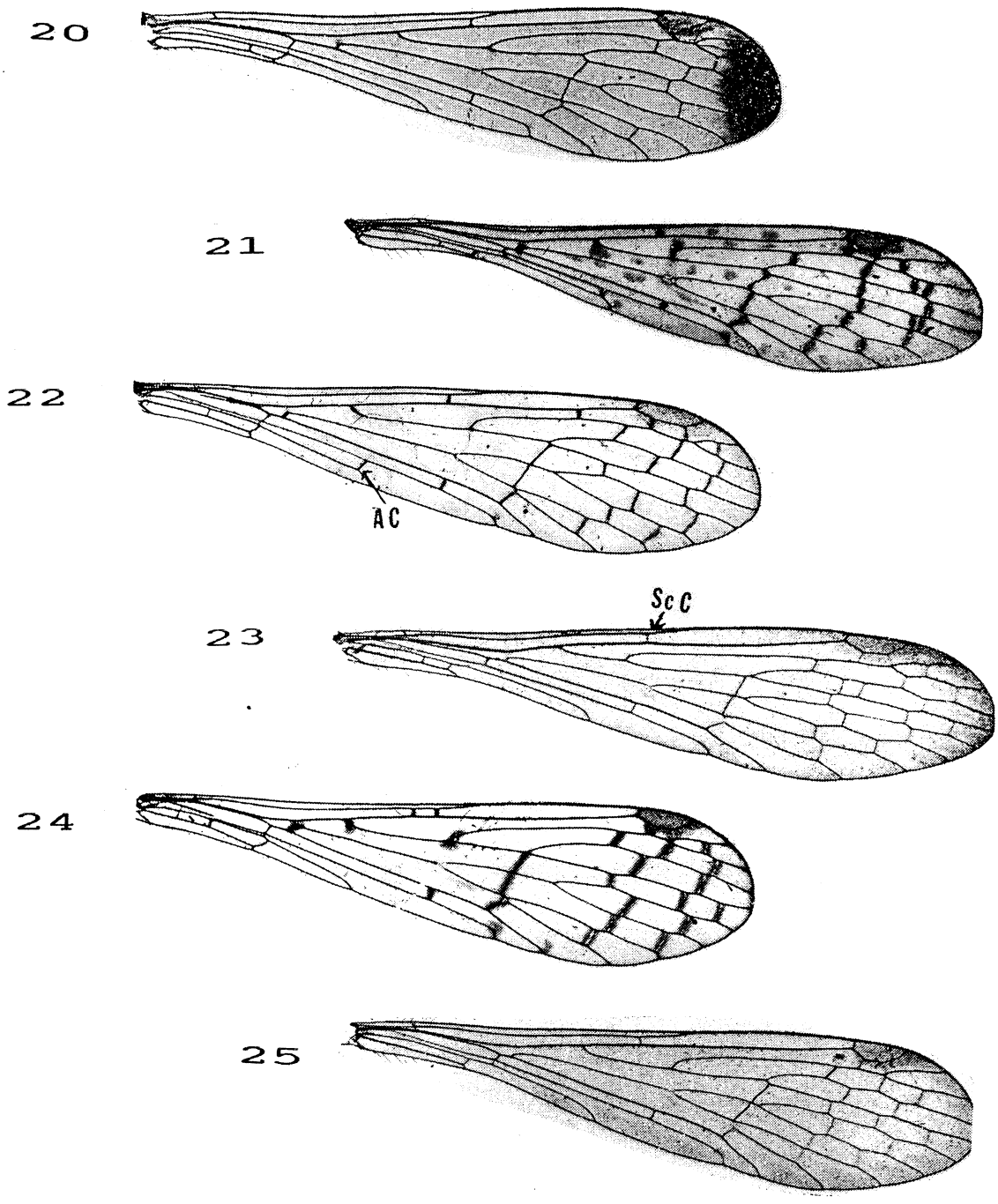


Figure 19. Hind tarsus of Bittacidae (redrawn from Borror, et al 1989).



Figures 20-25. Forewings of Bittacidae. 20. Hylobittacus apicalis; 21. Bittacus punctiger; 22. B. pilicornis; 23. B. occidentis; 24. B. strigosus; 25. B. stigmateris. AC-apical crossvein; ScC-subcostal crossvein. (redrawn from Webb, et al 1975).

Figure 26. Female and male Merope tuber.

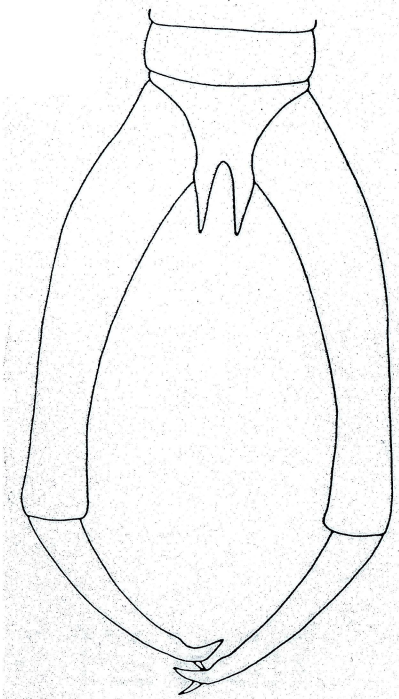


Figure 27. Terminalia of male Merope tuber (redrawn from Borror, et al 1989).

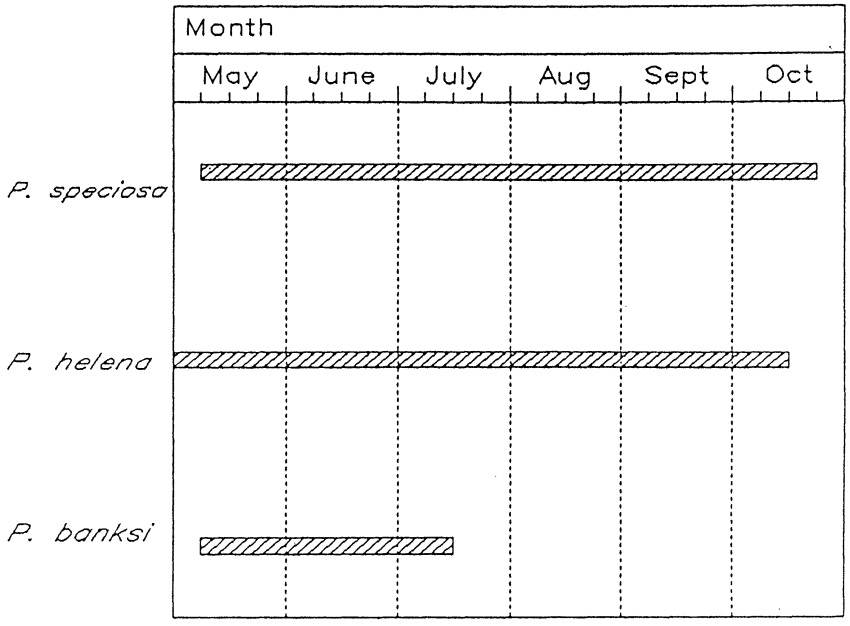


Figure 28. Dates of adult occurrence of Panorpidae at Rocky Branch, Illinois.

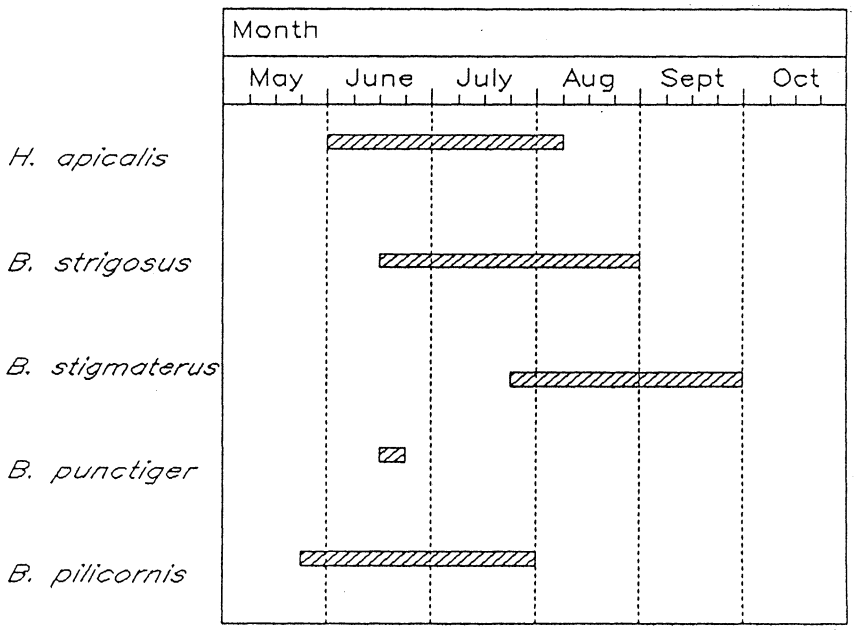


Figure 29. Dates of adult occurrence of Bittacidae at Rocky Branch, Illinois.

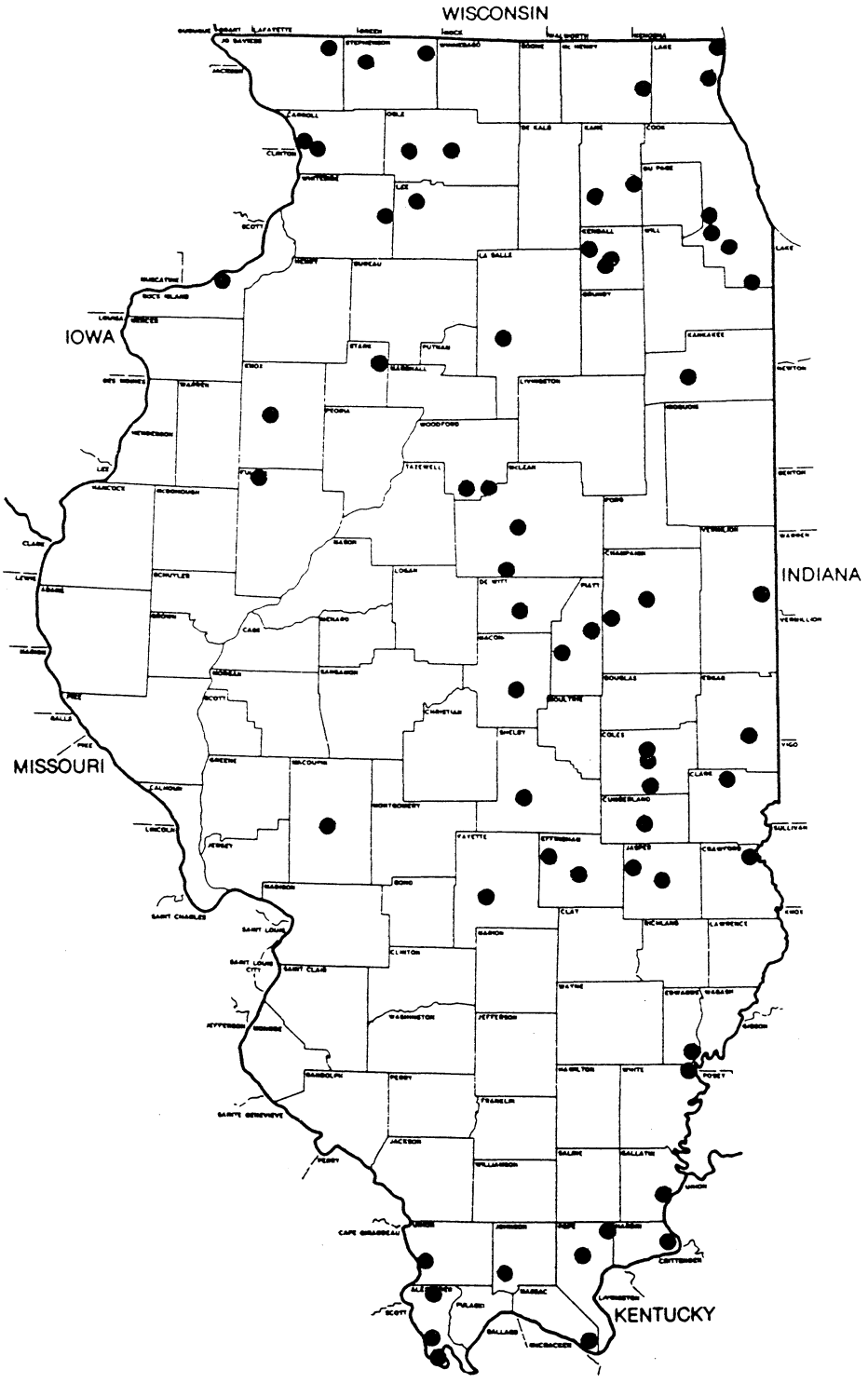


Figure 30. Distribution of Panorpa speciosa in Illinois.

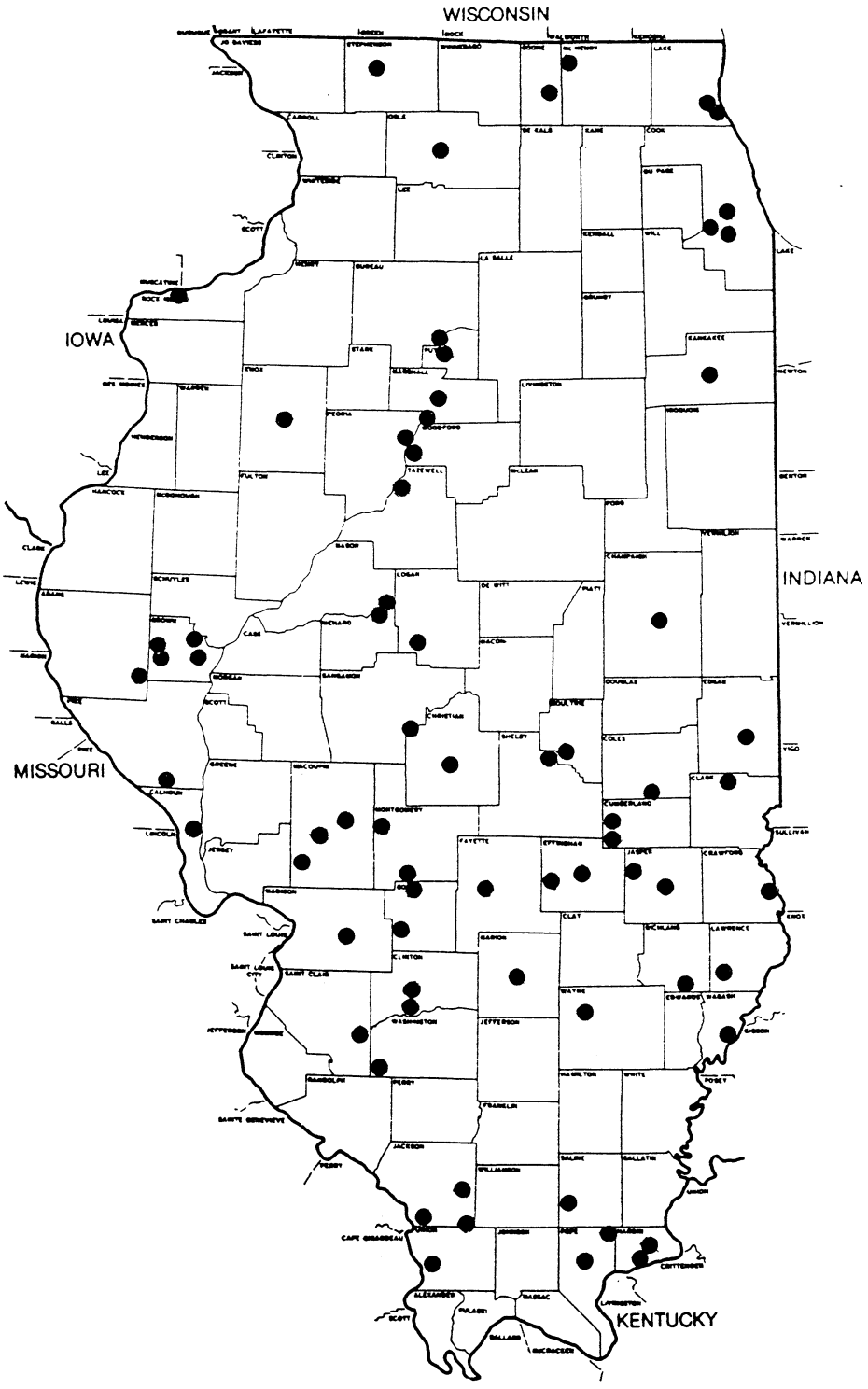


Figure 31. Distribution of Panorpa helena in Illinois.

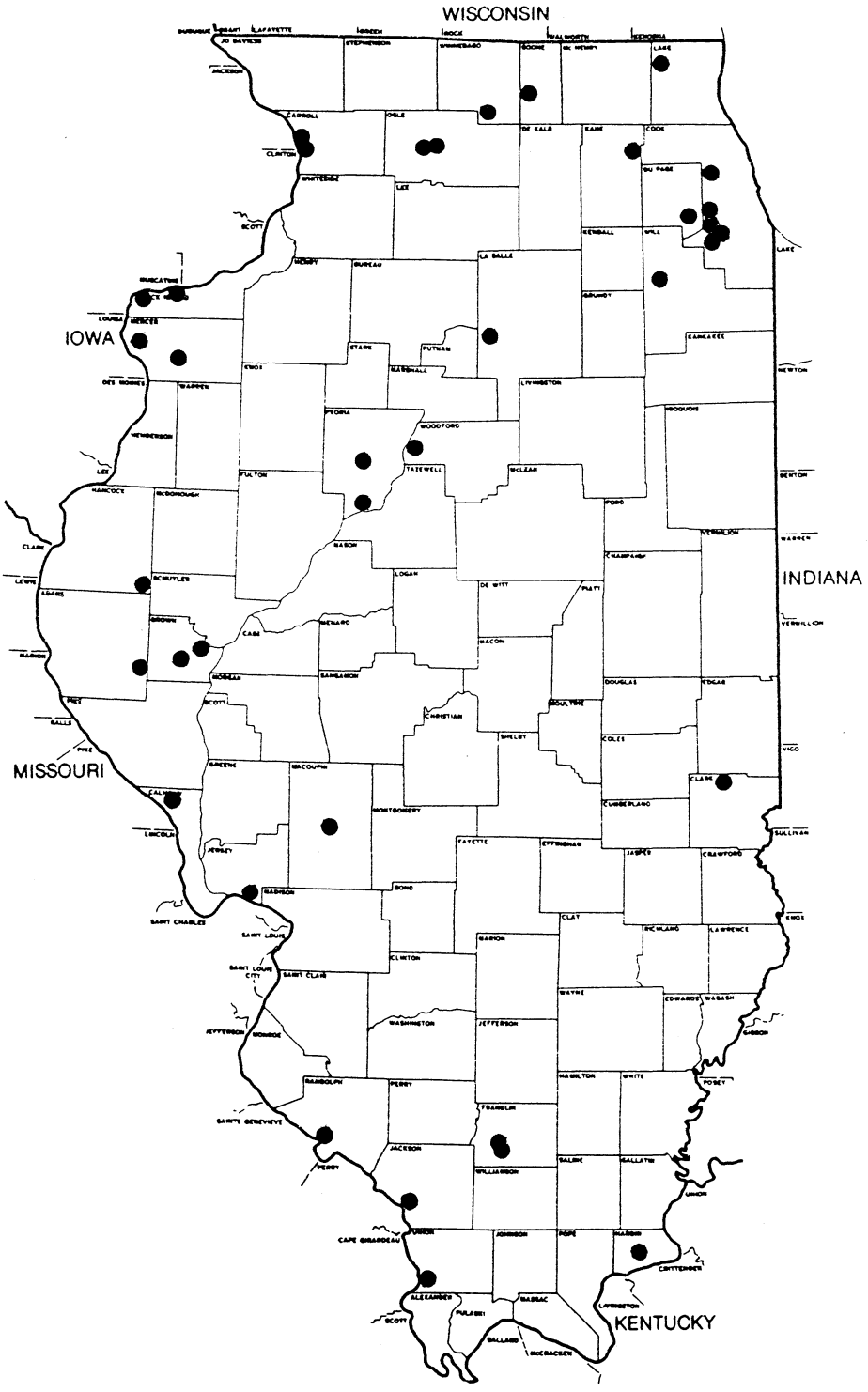


Figure 32. Distribution of Panorpa banksi in Illinois.

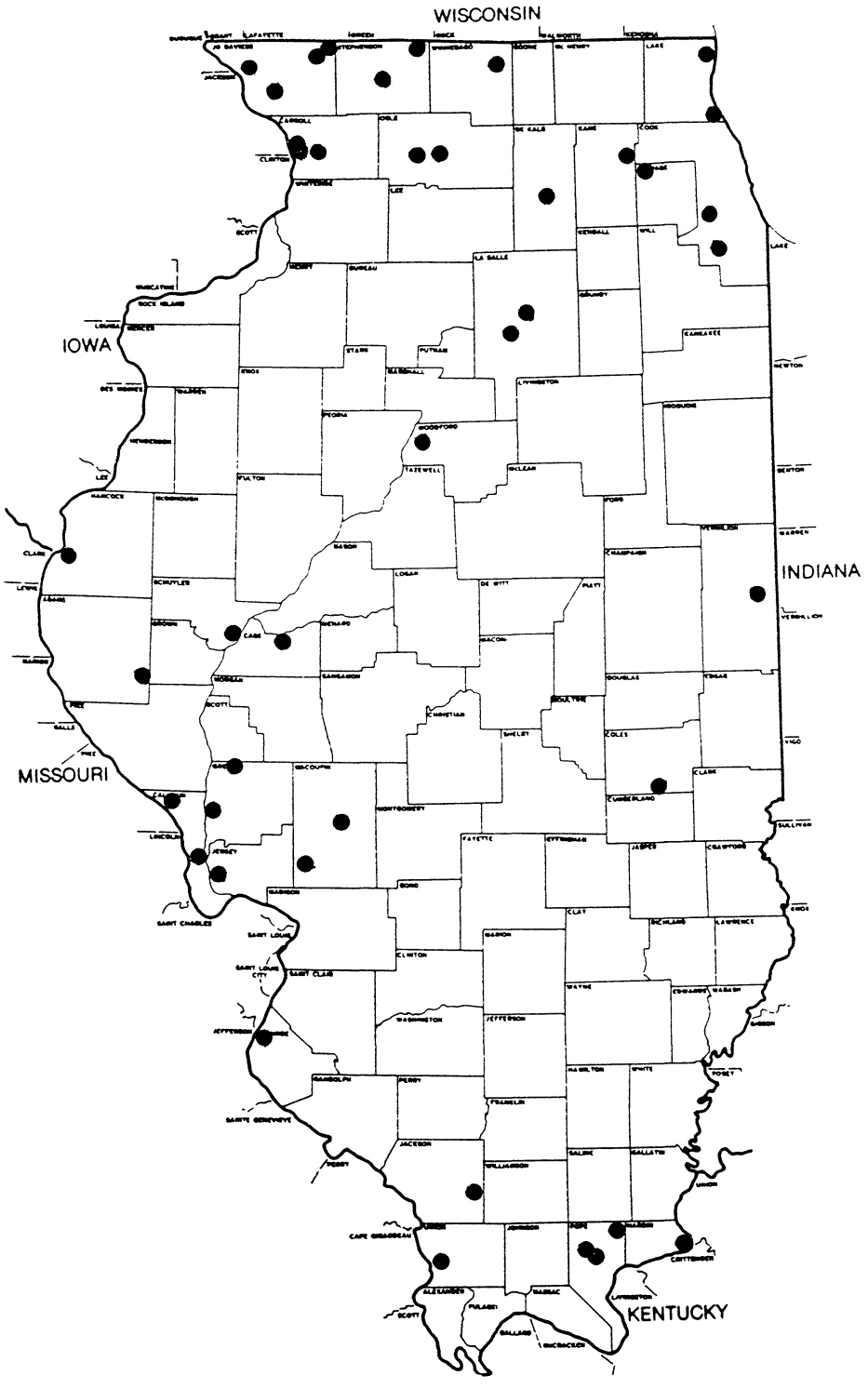


Figure 33. Distribution of Panorpa sigmoides in Illinois.

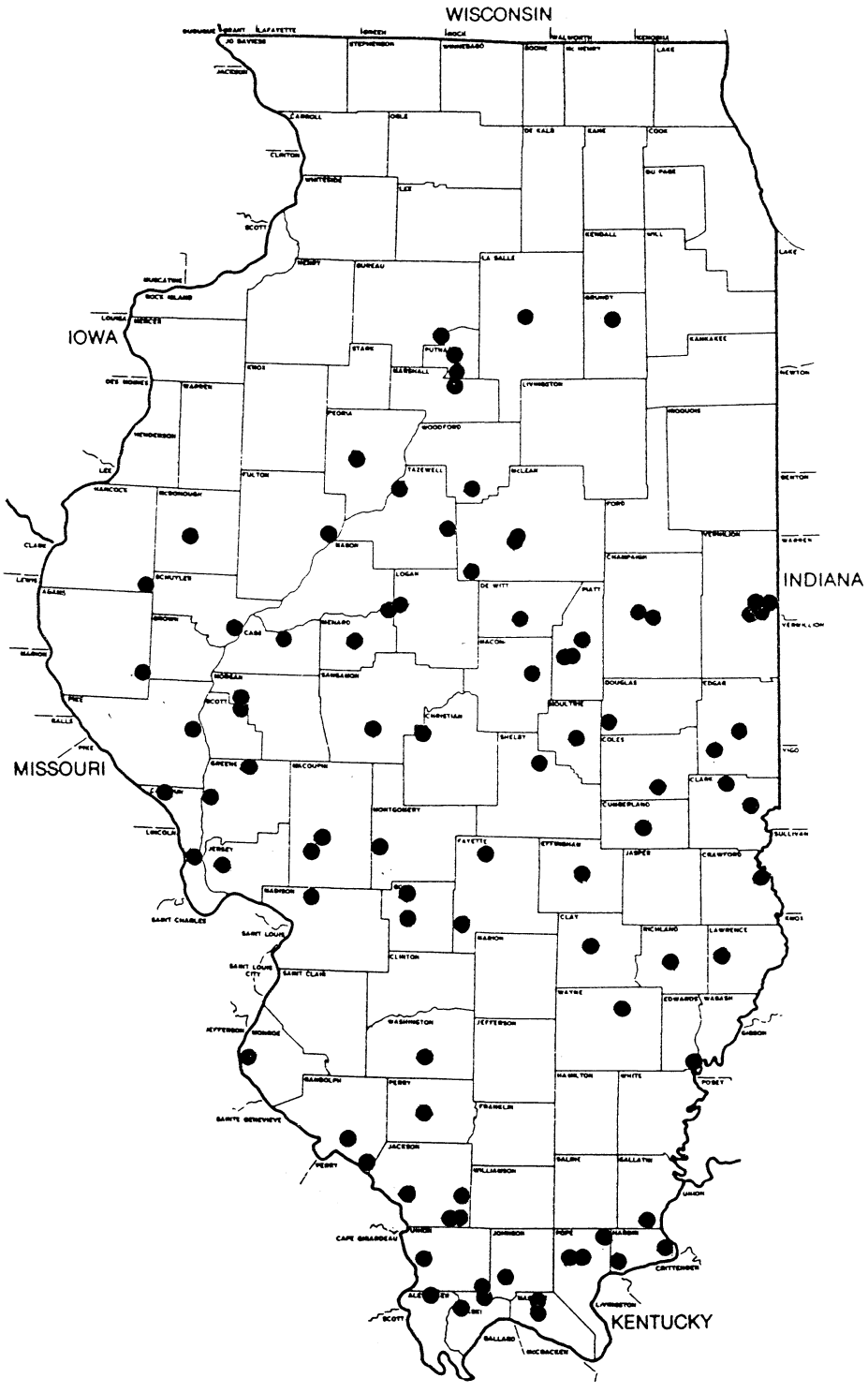


Figure 34. Distribution of Hylobittacus apicalis in Illinois.

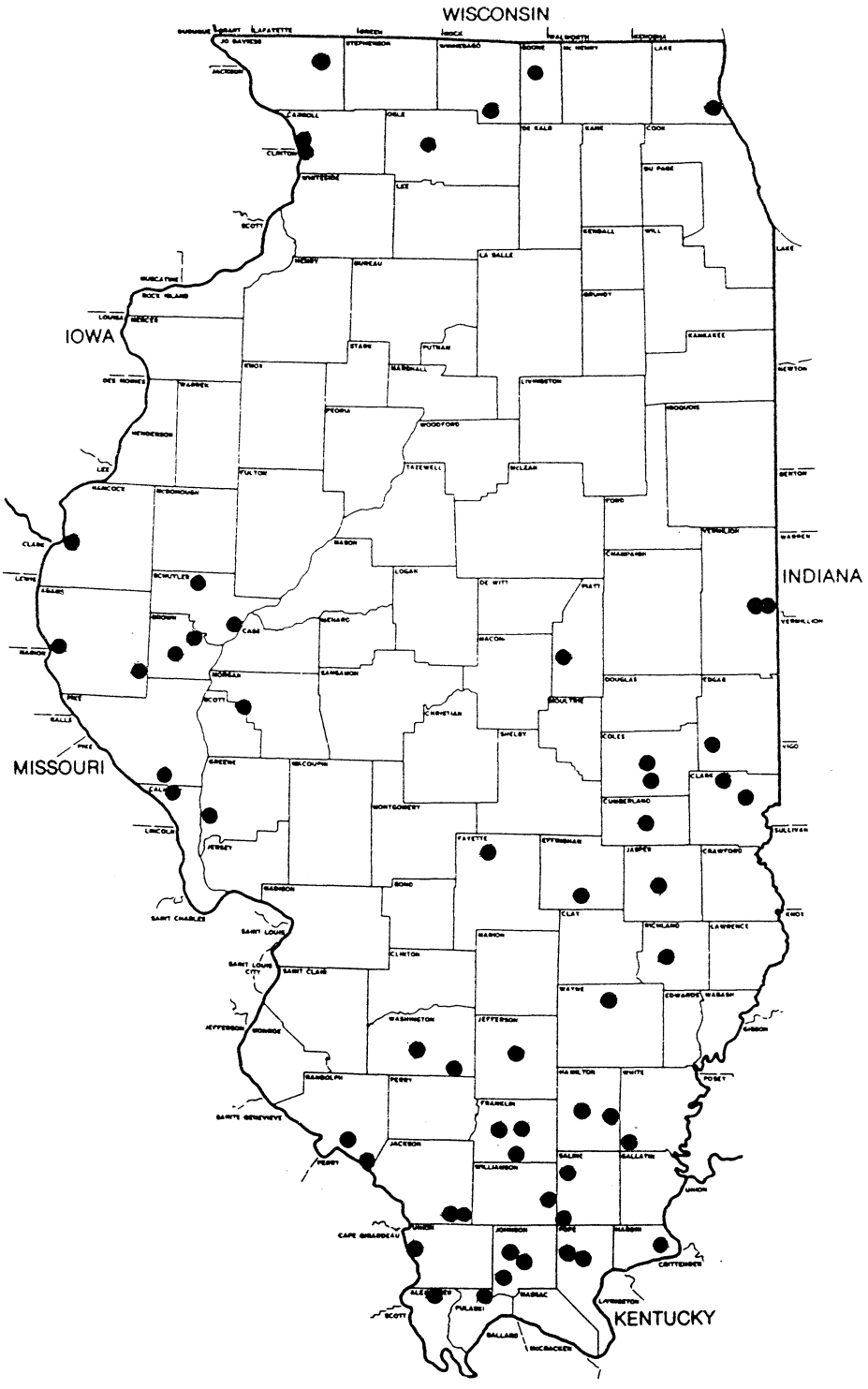


Figure 35. Distribution of Bittacus pilicornis in Illinois.

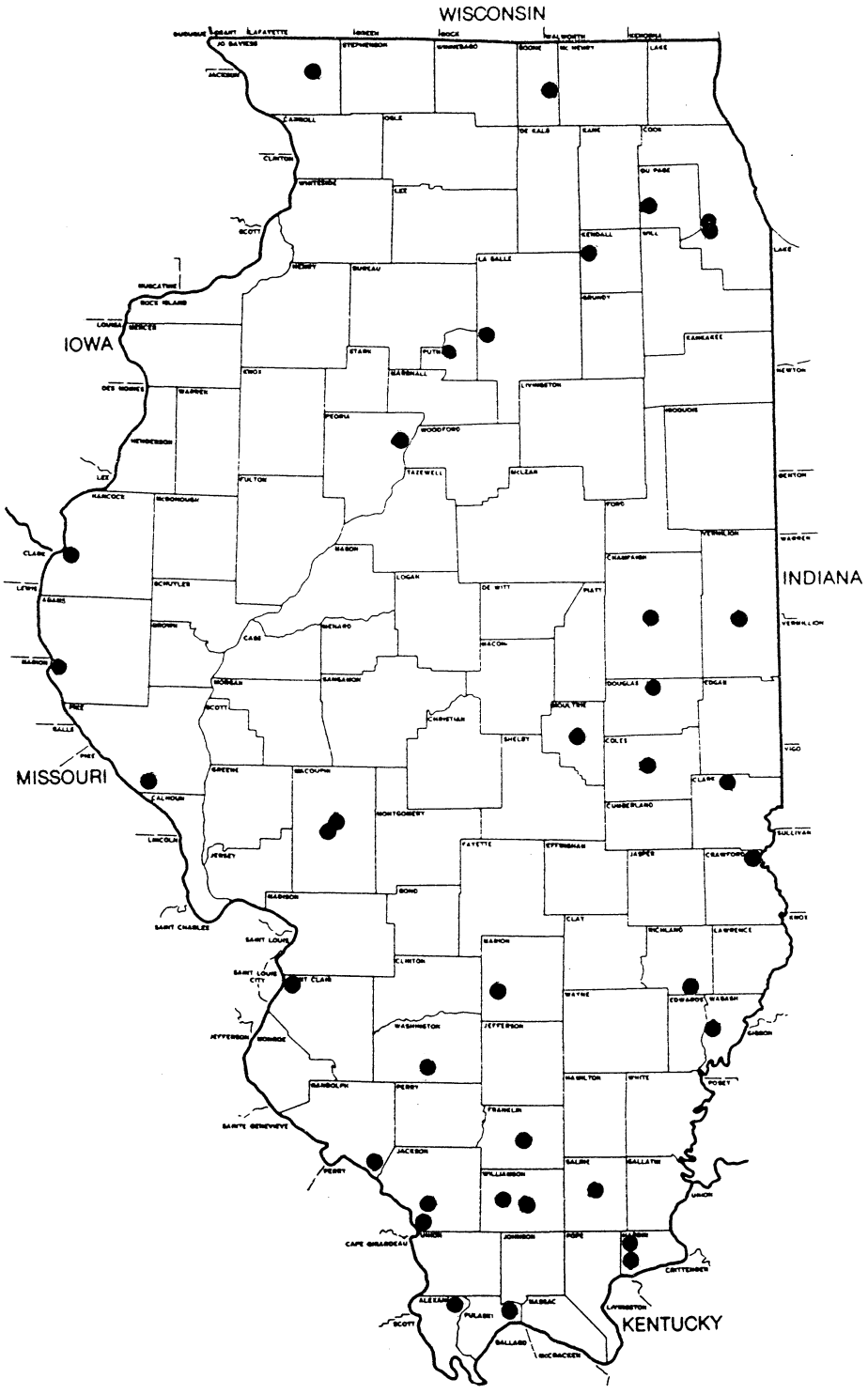


Figure 36. Distribution of Bittacus stigmaterus in Illinois.

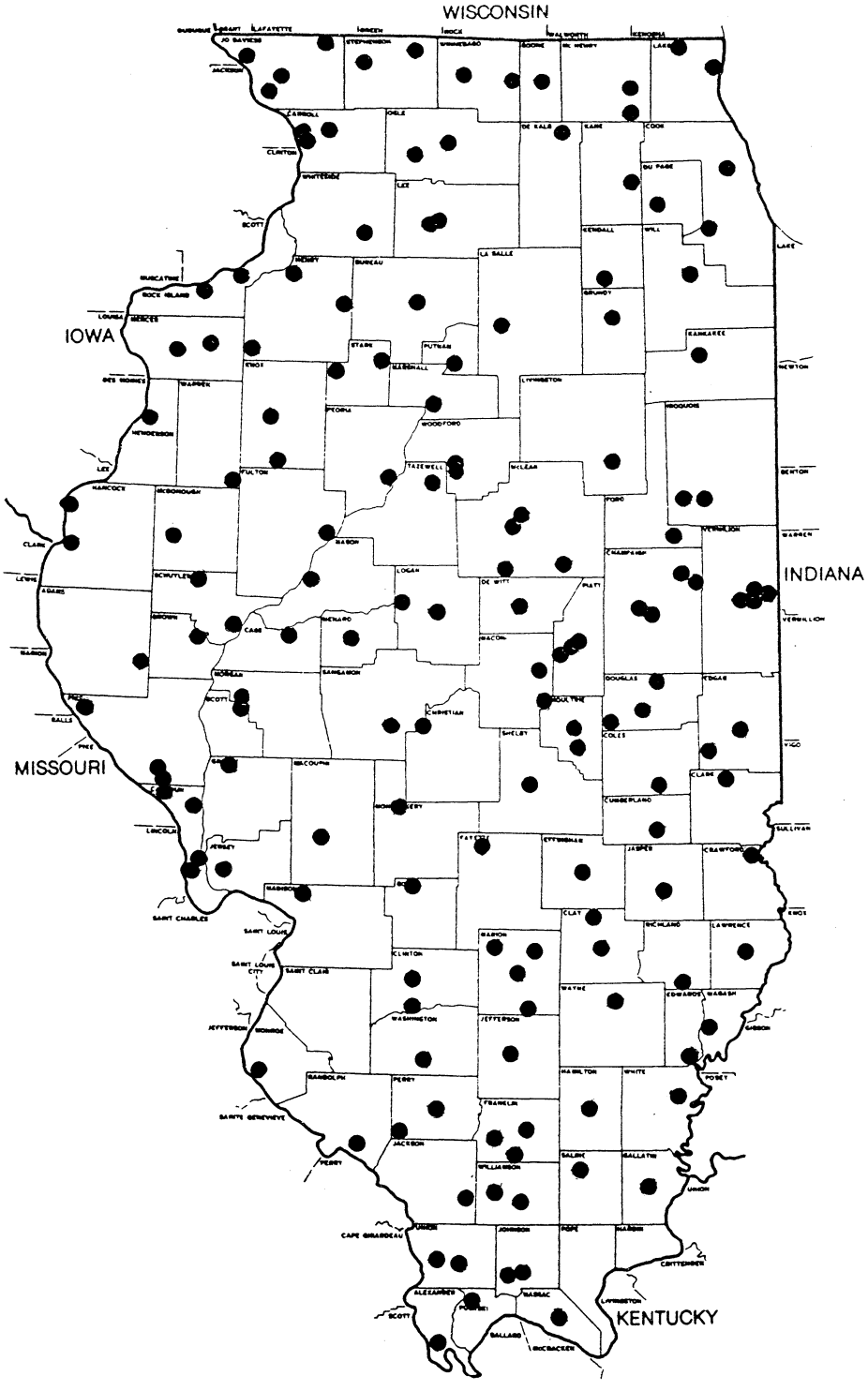


Figure 37. Distribution of Bittacus strigosus in Illinois.

Figure 38. Distribution of Bittacus punctiger in Illinois.

Figure 39. Distribution of Bittacus occidentis in Illinois.

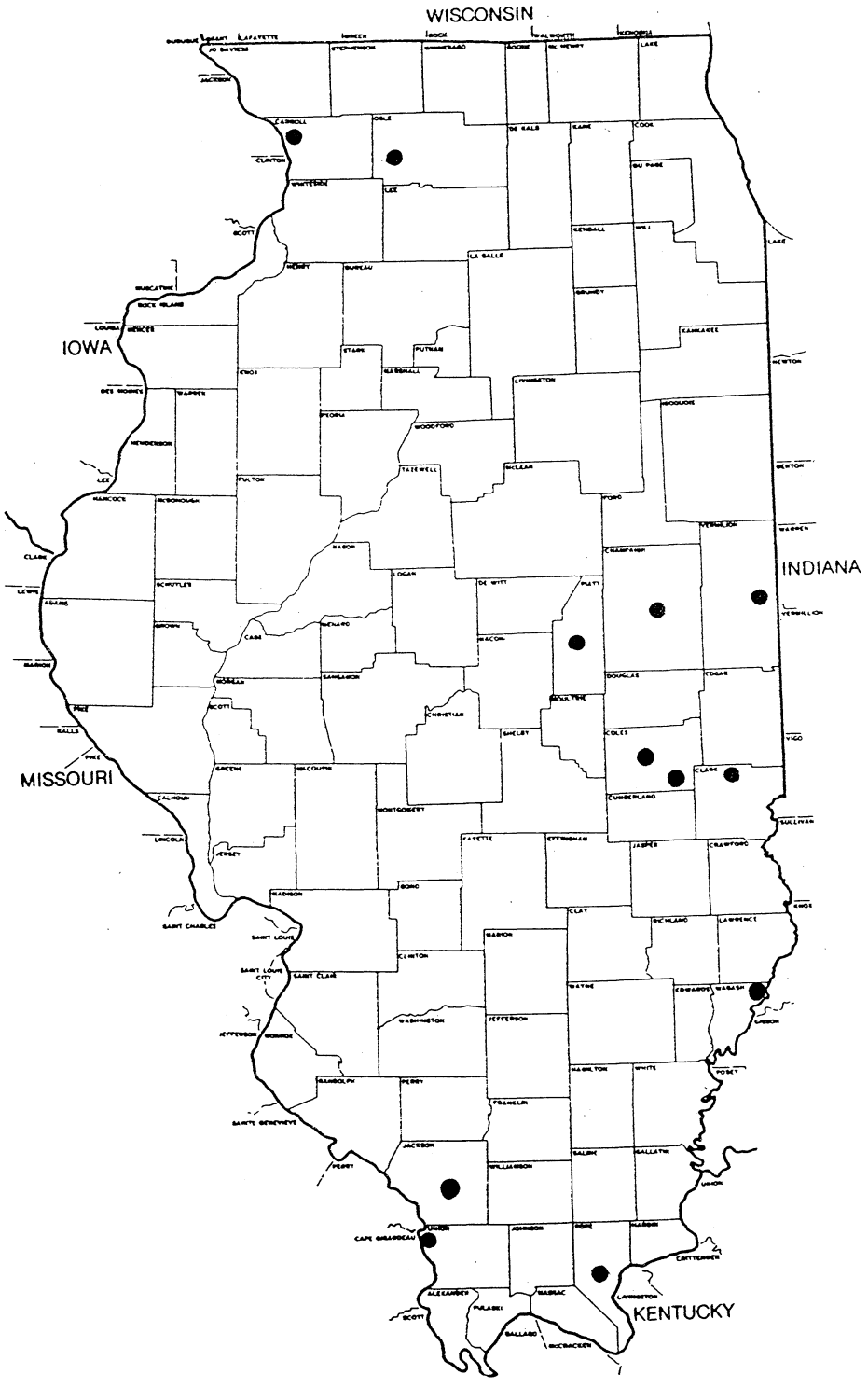


Figure 40. Distribution of Merope tuber in Illinois.

Figure 41. Variation in wing maculations of Panorpa helena.

Figure 42. Variation in wing maculations of Panorpa speciosa.

Table 1. COLLECTING RESULTS FOR MECOPTERA SPECIES TAKEN FROM ROCKY BRANCH NATURE PRESERVE, CLARK COUNTY, ILLINOIS.

Species	Diurnal Netting M	F	X^{2*}	Malaise Traps ** M	F	X^2	Pitfall Traps M	F	X^2	Total M	F	X^2
Merope tuber	0	0	-	10	21	3.90	2	1	-	12	22	2.94
Panorpa speciosa	58	68	0.79	86	124	6.88	15	42	12.79	159	234	14.31
Panorpa helena	32	32	0	15	21	1.00	1	2	-	48	55	0.48
Panorpa banksi	15	10	1.00	1	3	-	2	0	-	18	13	0.81
Hylobittacus apicalis	31	33	0.06	4	13	4.76	0	0	-	35	46	1.49
Bittacus strigosus	26	37	1.92	6	11	1.47	0	0	-	32	48	3.20
Bittacus pilicornis	29	32	0.15	0	1	-	0	0	-	29	33	0.26
Bittacus punctiger	0	0	-	0	2	-	0	0	-	0	2	-
Bittacus stigmaterus	3	4	0.14	3	4	0.14	0	0	-	6	8	0.28

* $\alpha = 0.05$, df = 1.

** Totals include flight trapped specimens.

Literature Cited

Bornemissza, G. E. 1964. Sex attractant of male scorpionflies. Nature 203:786-787.

Bornemissza, G. E. 1966. Observations on the hunting and mating behavior of two species of scorpionflies (Bittacidae: Mecoptera). Aust. J. Zool. 14:371-382.

Borror, D. J., Triplehorn, C. A., and N. F. Johnson. 1989. An Introduction to the Study of Insects, 6th ed. Philadelphia, PA: Saunders College Publishing, 875 pp.

Brownson, W. M. 1964. The feeding and mating behavior of the hangingfly, Bittacus strigosus Hagen. Unpublished M.A. Thesis. Kent State Univ., Kent, Ohio. 42 pp.

Byers, G. W. 1954. Notes on North American Mecoptera. Ann. Entomol. Soc. Am. 47:484-510.

Byers, G. W. 1958. Descriptions and distributional records of American Mecoptera. J. Kans. Entomol. Soc. 31:213-222.

Byers, G. W. 1962a. Descriptions and distributional records of American Mecoptera. II. J. Kans. Entomol. Soc. 35:299-307.

Byers, G. W. 1962b. Type specimens of Nearctic Mecoptera in European museums, including descriptions of new species. Ann. Entomol. Soc. Am. 55:466-476.

Byers, G. W. 1963. The life history of Panorpa nuptialis (Mecoptera: Panorpidae). Ann. Entomol. Soc. Am. 56:142-149.

Byers, G. W. 1965. Families and genera of Mecoptera. Twelfth Int. Con. of Entomol. Proc.:123.

Byers, G. W. 1967. Synonymy in the Panorpidae (Mecoptera). J. Kans. Entomol. Soc. 40:571-576.

Byers, G. W. 1969. Ecological and geological relationships of southern Appalacian Mecoptera (Insecta). pp. 265-276 In Perry C. Holt (ed.), The distributional history of the biota of the southern Appalacians. Part I: Invertbrates. Virginia Polytechnic Institute, Research Division Monograph 1.

Byers, G. W. 1973a. Descriptions and distributional records of American Mecoptera. III. J. Kans. Entomol. Soc. 46:362-375.

Byers, G. W. 1973b. Zoogeography of the Meropeidae (Mecoptera). J. Kans. Entomol. Soc. 46:511-516.

Byers, G. W. 1974. Synonymy in North American Panorpidae. J. Kans. Entomol. Soc. 47:22-25.

Byers, G. W. 1977. Revision of the genus Pazius (Mecoptera:Bittacidae). Revta. Biol. Trop. 25:109-121.

Byers, G. W. 1979. Hylobittacus, a new genus of North American Bittacidae (Mecoptera). J. Kans. Entomol. Soc. 52:402-404.

Byers, G. W. 1987. Order Mecoptera, pp. 246-252 In: F.W. Stehr (ed.), Immature Insects. Dubuque, Iowa: Kendall/Hunt, 754pp.; illus.

Byers, G. W. 1988. Geographic affinities of the North American Mecoptera. Mem. Entomol. Soc. Can. No. 144:25-30.

Byers, G. W. 1989a. Homologies in wing venation of primitive Diptera and Mecoptera. Proc. Entomol. Soc. Wash. 91:497-501.

Byers, G. W. 1989b. Order Mecoptera: Scorpionflies and Hangingflies, pp. 482-488 In: Borror, D. J., Triplehorn, C. A., and Johnson, N. F. An Introduction to the Study of Insects. Saunders College Publishing, Philadelphia.

Byers, G. W. 1990. Order Mecoptera, pp.177-178. In: M. Kosztarab and C. W. Schaefer (ed.), Systematics of the North American Insects and Arachnids: Status and Needs. Blacksburg: Virginia Polytechnic Institute and State University.

Byers, G. W. 1993. Autumnal Mecoptera of southeastern United States. Kans. Univ. Sci. Bull. 55:57-96.

Byers, G. W. and C. V. Covell, Jr. 1981. An annotated checklist of the scorpionflies (Mecoptera) of Kentucky. Entomol. News 92:196-198.

Byers, G. W. and R. Thornhill. 1983. Biology of the Mecoptera. Ann. Rev. Entomol. 28:203-228.

Decker, L. J. 1971. A survey of the water quality and

fishes of Rocky Branch Nature Preserve, Clark County, Illinois. Unpublished M.S. Thesis, Eastern Illinois University, Charleston, Ilinois. 68 pp.

Ebinger, J. E. and H. M. Parker. 1969. Vegetation survey of an oak-hickory maple forest in Clark County, Illinois. Trans. Ill. St. Acad. Sci. 62:379-387.

Ebinger, J. E. and G. A. Hellinga. 1970. Additions to the flora of Clark County, Illinois, from the Rocky Branch Nature Preserve. Trans. Ill. St. Acad. Sci. 63:392-396.

Ebinger, J. E. 1988. Woody understory after the spring burn at the Rocky Branch Nature preserve, Clark County, Illinois. Trans. Ill. St. Acad. Sci. 81:23-25.

Ebinger, J. E. and L. A. Clapp. 1988. Vegetation survey of Rocky Branch Nature Preserve, Clark County, Illinois. Trans. Ill. Acad. Sci. 81:19-24.

Ebinger, J. E. and K. E. Aikman. 1991. Understory survey at the Rocky Branch Nature Preserve, Clark County, Illinois. Trans. Ill. St. Acad. Sci. 84:12-19.

Grell, K. G. 1938. Der Darmtraktus von Panorpa communis L. und seine Anhänge bei Larvae und Imago. Zool. Jb. (Anat. Ontog. Tiere) 64:1-86.

Kaltenbach, A. 1978. Mecoptera (Schnabelhafte, Schnabelfliegen). Handb. Zool. 4:1-111. Berlin:

de Gruyter.

Mickoleit, G. 1971. Zur phylogenetischen und funktionellen Bedeutung der sogenannten notalorgane der Mecoptera (Insecta, Mecoptera). Z. Morph. Ökol. Tiere. 69:1-8.

Mickoleit, G. and E. Mickoleit. 1978. Zum Kopulationsverhalten des Mückenhaftes Bittacus italicus (Mecoptera:Bittacidae). Entomol. Gen. 5:1-15.

Miyake, T. 1912. The life history of Panorpa klugi MacLachlan. J. Coll. Agric. Imp. Univ. Tokyo 4:117-139.

Newkirk, M. 1957. On the black-tipped hangingfly (Mecoptera:Bittacidae). Ann. Entomol. Soc. Am. 50:302-306.

Potter, E. 1938. The internal anatomy of larvae of Panorpa and Boreus (Mecoptera). Proc. R. Entomol. Soc. Lond. Series A 13:117-130.

Rottmar, B. 1966. Über Zuchtung, Diapause und postembryonale Entwicklung von Panorpa communis L. Zool. Jb. (Anat. Ontog. Tiere) 83:497-570.

Rupprecht, R. 1974. Vibrationssignale bei der Paarung von Panorpa (Mecoptera, Insecta). Experientia 30:340-341.

Setty, L. R. 1931. The Biology of Bittacus stigmaterus Say (Mecoptera, Bittacusidae). Ann. Entomol. Soc. Am. 24:467-484.

Setty, L. R. 1939. The life history of Bittacus

strigosus with a description of the larvae. J. Kans. Entomol. Soc. 12:126-128.

Setty, L. R. 1940. Biology and morphology of some North American Bittacidae (order Mecoptera). Am. Midl. Nat. 23:257-353.

Setty, L. R. 1941. Decriptions of the larvae of Bittacus apicalis and a key to bittacid larvae (Mecoptera). J. Kans. Entomol. Soc. 14:64-65.

Shiperovitsch, V. J. 1925. Biology and life cycle of Panorpa communis L. Rev. Russe Ent. 19:27-40.

Steiner, P. 1930. Studien an Panorpa communis L. Z. Morphol. Ökol. Tiere 17:1-67.

Thornhill, R. 1973. The morphology and histology of new sex phermone glands in male scorpionflies, Panorpa and Brachypanorpa (Mecoptera: Panorpidae and Panorpodidae). Great Lakes Ent. 6:47-55.

Thornhill, R. 1974. Evolutionary ecology of Mecoptera. Unpublished Ph.D. Dissertation. Univ. of Michigan, Ann Arbor.

Thornhill, R. 1975. Scorpionflies as kleptoparasites of web-building spiders. Nature 258:709-711.

Thornhill, R. 1976. Sexual selection and nuptial feeding behavior in Bittacus apicalis (Insecta: Mecoptera). Am. Nat. 110:529-548.

Thornhill, R. 1977. The comparative predatory and sexual behavior of hangingflies (Mecoptera: Bittacidae). Occas. Pap. Mus. Zool. Univ. Mich.

677:1-43.

Thornhill, R. 1978a. Sexually selected predatory and mating behavior of the hangingfly Bittacus stigmaterus (Mecoptera: Bittacidae). Ann. Entomol. Soc. Am. 71:597-601.

Thornhill, R. 1978b. Some arthropod predators and parasites of adult scorpionflies (Mecoptera). Environ. Entomol. 7:714-716.

Thornhill, R. 1979a. Male and female sexual selection and the evolution of mating strategies in insects, pp 81-121. In: M. S. Blum and N. A. Blum (ed.), Sexual Selection and Reproductive Competition in Insects. New York: Academic. 463 pp.

Thornhill, R. 1979b. Adaptive female-mimicking behavior in a scorpionfly. Science 205:412-414.

Thornhill, R. 1979c. Male pair-formation pheromones in Panorpa scorpionflies (Mecoptera: Panorpidae). Environ. Entomol. 8:886-888.

Thornhill, R. 1980a. Competition and coexistence among Panorpa scorpionflies (Mecoptera: Panorpidae). Ecol. Monogr. 50:179-197.

Thornhill, R. 1980b. Rape in Panorpa scorpionflies and a general rape hypothesis. Anim. Behav. 28:52-59.

Thornhill, R. 1980c. Mate choice in Hylobittacus apicalis (Insecta: Mecoptera) and its relation to some models of female choice. Evolution 34:519-538.

Thornhill, R. 1980d. Sexual selection in the black-tipped hangingfly. Sci. Am. 242:162-172.

Thornhill, R. 1981. Panorpa (Mecoptera: Panorpidae) scorpionflies: systems for understanding resource-defence polygyny and alternative male reproductive efforts. Ann. Rev. Ecol. Syst. 12:355-386.

Thornhill, R. 1983. Cryptic female choice and its implications in the scorpionfly Harpobittacus nigriceps. Am. Nat. 122:765-788.

Thornhill, R. 1984. Alternative female choice tactics in the scorpionfly Hylobittacus apicalis (Mecoptera) and its implications. Am. Zool. 24:367-383.

Thornhill, R. 1987. The relative importance of intra- and interspecific competition in scorpionfly mating systems. Am. Nat. 130:711-729.

Thornhill, R. 1992. Female preference of the pheromone of males with low fluctuating asymmetry in the Japanese scorpionfly (Panorpa japonica: Mecoptera). Behav. Ecol. 3:277-283.

Thornhill, R. and J. B. Johnson. 1974. The Mecoptera of Michigan. Great Lakes Entomol. 7:33-53.

Thornhill, R. and P. Sauer. 1991. The notal organ of the scorpionfly Panorpa vulgaris: an adaptation to coerce mating duration. Behav. Ecol. 2:156-164.

Thornhill, R. and P. Sauer. 1992. Genetic sire effects on the flying ability of sons and daughters and

mating success of sons in a scorpionfly. Anim. Behav. 43:255-264.

Torre-Bueno, J. R. 1962. A glossary of entomology. Brooklyn Entomological Society, New York. 336 pp.

Webb, D. W., Penny, N. D., and J. C. Marlin. 1975. The Mecoptera, or scorpionflies, of Illinois. Ill. St. Nat. Hist. Surv. Bull. 31(7):252-316.

Yie, S. T. 1951. The biology of the Formosan Panorpidae and morphology of eleven species of their immature stages. Mem. Coll. Ag., National Taiwan Univ. 2:1-111.