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The Mecoptera of Michigan

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THE MECOPTERA OF MICHIGAN[1]

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INTRODUCTION

To date, no one has published on the Mecoptera of Michigan. A comprehensive taxonomic paper on the Mecoptera of Illinois, by Donald W. Webb, Illinois Natural History Survey, and Norman D. Penny, University of Kansas, is in preparation and will include keys to and descriptions of the midwestern species of Mecoptera. It is hoped that the present paper will supplement the publication by Webb and Penny and enable interested persons in Michigan to easily identify adult Mecoptera.

The most recent revision of the North American Mecoptera was by F. M. Carpenter (1931). Carpenter published additional papers in 1932, 1935, 1936, 1939, and 1953, in which he described new species and expanded species distributions. More recently, G. W. Byers and his students have done a great deal to further our knowledge of not only the North American Mecoptera but also the mecopteran faunas of other regions. Byers (1958, 1962a, 1973) has described several new nearctic species and is planning a taxonomic revision of the North American Mecoptera.

In North America, the Mecoptera, commonly called scorpionflies or snoutflies, have been almost neglected in the past by all but taxonomists and morphologists, and few biological or ecological studies have been conducted on the group. Two years ago one of us (Thornhill) initiated a study of the comparative ecology and comparative behavior of the eastern Mecoptera, and in connection with these investigations has done extensive collecting in Michigan.

In this paper we provide keys and brief seasonal, distributional and habitat information for all the species of Mecoptera known from Michigan. The seasonal occurrences and county records for the species are based on specimens in the University of Michigan Museum of Zoology (UMMZ), Ann Arbor; Entomological Museum of Michigan State University (MSU), East Lansing; literature records; and specimens collected by the authors. The counties of Michigan are shown in Figure 37. The black dots on the maps in Figures 38 through 57 are based on specimens actually seen by the authors and open circles indicate localities based on literature records only. It should be mentioned that many of the specimens in the two museums mentioned above had been previously identified by G. W. Byers, University of Kansas, or F. M. Carpenter, Museum of Comparative Zoology, Harvard University.

The extant Mecoptera is a small group containing only a few hundred described species, with about 75 species described from North America. Michigan has 20 known species representing four of the five families in North America: Bittacidae, four species; Boreidae, one species; Meropeidae, one species; Panorpidae, 14 species. Mecoptera are found throughout Michigan and typically are inhabitants of cool, mesic forests with a dense undergrowth of herbs and shrubs. In such habitats, they are often the most abundant large insects and may reach very high population numbers.

The feeding habits of adult Mecoptera are diverse. The Panorpidae are scavengers eating primarily dead or moribund arthropods, but occasionally feeding on living slugs, vertebrate carrion or pollen. The Bittacidae are predaceous on various arthropods; the Boreidae apparently eat only mosses of various species. The food habits of the Meropeidae are unknown; however, Hepburn (1969) suggested that, based on the morphology of the alimentary canal, *Merope tuber* is probably phytophagous. One female of this relatively rare species was collected alive in a Malaise trap during the present investigation and observed in captivity for a week. The specimen was supplied with various species of

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plants from the collection site and dead insects but was never observed feeding, and apparently died of starvation as all the fat reserves had been utilized as shown by dissection shortly after death.

The immature stages of most species of Mecoptera are unknown. To date, the immatures of only 13 North American species of *Panorpa* have been described (Felt, 1896; Byers, 1963; Gassner, 1963; Mampe and Neunzig, 1965; Boese, 1973). Boese, using chaetotaxy, developed a key to the known larvae of *Panorpa*. Setty (1939, 1940, 1941) described the immature stages of several species of North American bittacids and those of *Boreus* were described by Brauer (1863), Williams (1916) and Withycombe (1922, 1926). The immature stages of the Meropeidae are unknown.

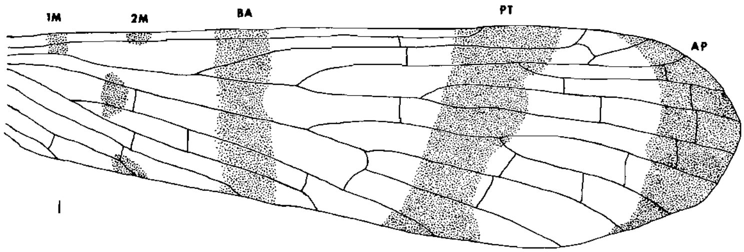
All the Michigan Panorpidae and Bittacidae are probably univoltine. However, the species in Northern Michigan may require more than one year for development. The voltinism of the Boreidae and Meropeidae is unknown. Adult populations of *Panorpa* and *Bittacus* often increase to peak densities in less than a week or ten days after the first adults appear. In the population dynamics of the Mecoptera, as in most insect populations that have been studied, the males begin to emerge and eventually reach their population peak before the females. The adaptive significance of this emergence strategy by the males probably involves the advantage a male gains from being in a state of sexual readiness when the greatest number of sexually receptive females are available.

Entomologists often cite the seasonal distributions of insects, as we have done in this paper, but no one understands the adaptive significance of seasonal appearance and longevity in any species. Complete or partial seasonal isolation occurs frequently in insects as well as in other invertebrates (Emerson, 1949). The importance of seasonal isolation in the prevention or reduction of gene flow between species is largely unknown although often assumed. S. G. Smith (1953, 1954) found that no natural hybridization occurred when unseasonably high temperatures resulted in simultaneous hatching of the spruce bud worm (*Choristoneura fumiferana*) and the pine bud worm (*C. pinus*).

A quantitative ecological study by one of the authors (Thornhill), which will be reported in a subsequent paper, revealed that many eastern North American species of *Panorpa* have very similar ecological requirements. As many as eight species may co-occur in a particular woods. However, the peak densities of the species within a woods are separated seasonally and in some cases the species are separated spatially. This study indicates that the seasonal appearances of the adults of many species of *Panorpa* are due to selective pressures of interspecific competition for food, and that a seasonal succession in the emergence times of the species reduces competition. Current ecological theory and techniques have been applied very little to the study of insect populations in nature, and perhaps the adult emergence strategies of many other insect species have evolved in the context of interspecific ecological competition.

METHODS AND MATERIALS

The chief method of collecting adult Mecoptera is to flush them from the vegetation and net them when they come to rest. Adult panorpids can also be collected on traps baited with raw meat and designed as follows. Two pieces of plyboard (1 ft X 1 ft) bolted together about two inches apart, form the top and bottom of the trap. A small cylinder of screen wire, surrounded by a larger mesh and heavier screen, is used to contain the meat bait. The larger mesh wire around the outside of the smaller mesh wire is necessary to prevent birds and small mammals from removing the bait. The plyboard parts of the trap are covered with a synthetic resin such as Tanglefoot® or Stickem Special® (Michel and Pelton Co., Emeryville, California) to entangle attracted panorpas. Stickem Special® is the most desirable resin because it is more easily removed than Tanglefoot® from both the insect specimens and the investigator. Specimens can be pulled off the trap, placed in gasoline for a few hours and then put into ethyl acetate overnight to remove the resin. This results in almost perfect specimens. The use of traps is often desirable because they can be placed in a habitat and examined later. In addition, on numerous occasions traps have been helpful in obtaining specimens from sites where no panorpas were observed prior to trapping.



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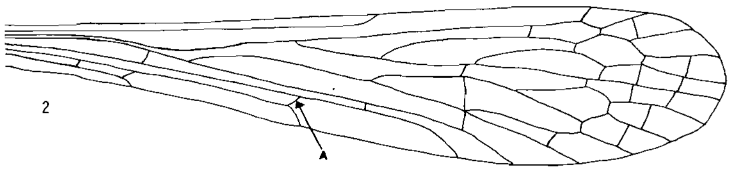

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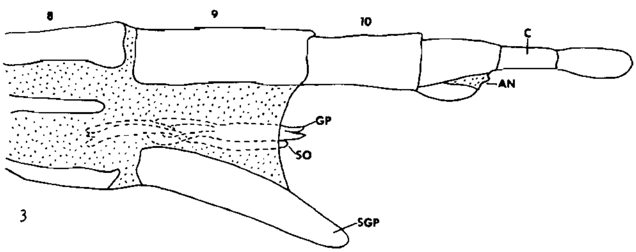

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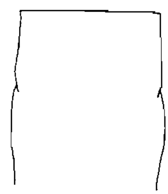

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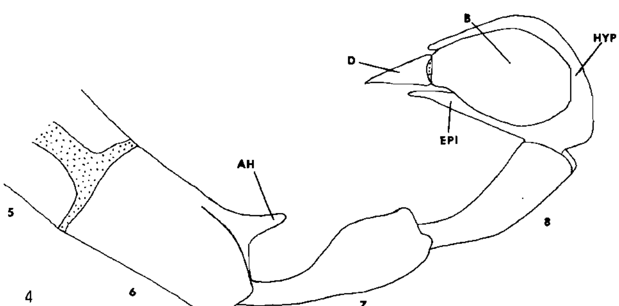

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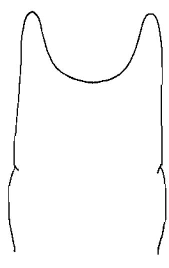

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Fig. 1. Hypothetical forewing of *Panorpa*. 1M-first marginal spot; 2M-second marginal spot; AP-apical wing band; BA-basal wing band; PT-pterostigmal wing band. Fig. 2. Hypothetical forewing of *Bittacus*. A-anal crossvein. Fig. 3. Terminal abdominal segments of a female *Panorpa*, left lateral view. AN-anus; C-cercus; GP-genital plate; SGP-subgenital plate; SO-spermathecal opening. Fig. 4. Terminal abdominal segments of a male *Panorpa*, left lateral view. AH-anal horn; B-basistyle; D-dististyle; EPI-preëpiproct; HYP-hypovalve (ninth sternum). Fig. 5. Truncate preëpiproct (ninth abdominal tergum), dorsal aspect. Fig. 6. Preëpiproct with lateral lobes, dorsal aspect.

Malaise traps designed after Townes (1972) have been used with limited success to collect Mecoptera, especially the rare nocturnal species *Merope tuber*. *Panorpa* species and some *Bittacus* species can be collected at light traps, but this method usually yields relatively few specimens.

The adults of the flightless genus *Boreus* are present during the winter months and may be collected as they walk or hop on the snow and among moss plants on days when the temperature is above or not far below freezing.

A NOTE ON NOMENCLATURAL CHANGES IN THE MICHIGAN MECOPTERA

There have been several name changes in the Panorpidae since the publication of Carpenter's (1931) revision. George W. Byers (1962b), after examination of type specimens in European museums, made the following nomenclatural changes:

Panorpa debilis Westwood 1846 (=*P. canadensis* Banks 1895).

Panorpa subfurcata Westwood 1846 (=*P. signifer* Banks 1900).

Panorpa modesta Carpenter is also a synonym of *P. subfurcata* (Byers, personal communication).

Panorpa helena Byers 1962 (=*P. venosa* Westwood 1846 of American authors: Hine, 1901; Esben-Peterson, 1921; Carpenter, 1931).

In addition, Byers (personal communication) has determined that *Panorpa chelata* Carpenter 1931 is a junior synonym of *P. banksi* Hine 1901.

TAXONOMIC CHARACTERS USED IN IDENTIFYING MECOPTERA

In identifying *Panorpa* males, the most important taxonomic characters are structures of the genital bulb (Figs. 4, 7). The genital bulb consists primarily of a highly modified ninth abdominal segment. The sternum of this segment is bifurcate for most of its length and is referred to as the hypovalves (Figs. 4 HYP, 7 HYP). The tergum, called the pre-epiproct (Figs. 4 EPI, 5, 6), forms the dorsum of the bulb and its shape is of taxonomic importance. The dististyles (Figs. 4 D, 7 D) or genital forceps, which articulate with the basistyles (Figs. 4 B, 7 B) or gonocoxites, grasp the female during copulation and are also important in the male's aggressive behavior. Accessory lobe-like structures (Fig. 8 AL) are present on the dististyles of some species. The penis and two pairs of parameres- the ventral parameres (Fig. 7 VP) and the dorsal parameres (Fig. 7 DP)- are located between the basistyles. In addition to the structures of the genital bulb, the presence or absence of an anal horn (Fig. 4 AH) on the sixth abdominal segment is also of taxonomic importance.

The genital bulbs of all known Michigan species of *Panorpa* have been drawn to scale, and in each drawing the left hypovalve has been partially removed to expose the inner structures.

The most important single structure in determining *Panorpa* females is the internal genital plate (Figs. 3 GP, 21). It usually consists of a distal plate (Fig. 21 DIP) that is furcate distally and a basal plate (BP). An accessory plate (Fig. 22 AC) may be present and in some cases partially ensheaths a part of the genital plate. The spermathecal duct (Fig. 21 SD) is heavily sclerotized and produces two spermathecal apodemes (SA) that extend into the eighth segment. The shape of the subgenital plate (Fig. 3 SGP) is also used in differentiating certain species.

In dried specimens the tip of the adbomen can be immersed in boiling water for several minutes which allows easy displacement or removal of the subgenital plate, thus exposing the genital plate. The genital plate can be dissected from the abdomen of the female for examination and placed in mounting medium on a paper point. The point can then be placed on the same pin with the rest of the specimen and this allows for easy subsequent examination of the plate.

Although in most species of *Panorpa* the wing markings are not consistent, they can be used along with other structures in the identification of females. Figure 1 contains a diagram of a hypothetical panorpid forewing to illustrate the position of the wing bands employed in the key. Three continuous bands of infuscation (apical band, AP: pterostigmal band, PT; basal band, BA), which are fairly consistent in location, are recognizable in some species. In other species the bands may be broken or reduced to a series of spots. In addition, small spots (1M, 2M) on the anterior margin at the base of the wing (marginal spots in the terminology of Carpenter, 1931) are useful taxonomic characters.

The species of *Bittacus* in Michigan can be identified without reference to the male or female genitalia. Figure 2 shows a bittacid forewing with the taxonomic character labelled that is utilized in the key.

KEY TO THE FAMILIES OF MICHIGAN MECOPTERA

1. Flightless species, wings without veins and reduced to thick projections (male) or to small oval pads (female); female with ovipositor; shiny black insects, 2 to 4 mm in length . . . .(*Boreus brumalis* Fitch) . . . Boreidae (p. 44)
1'. Flying insects, wings and venation normal; 8 mm or more in length 2
2(1'). Tarsi raptorial, with a single claw . . . . (*Bittacus*) . . . Bittacidae (p. 43)
2'. Tarsi not raptorial, with two claws 3
3(2'). Ocelli absent; wings oval, venation dense, with numerous crossveins . . . .(*Merope tuber* Newman) . . . Meropeidae (p. 45)
3'. Ocelli present; wings relatively long and narrow, venation reduced, with few crossveins . . . .(*Panorpa*) . . . Panorpidae (p. 46)

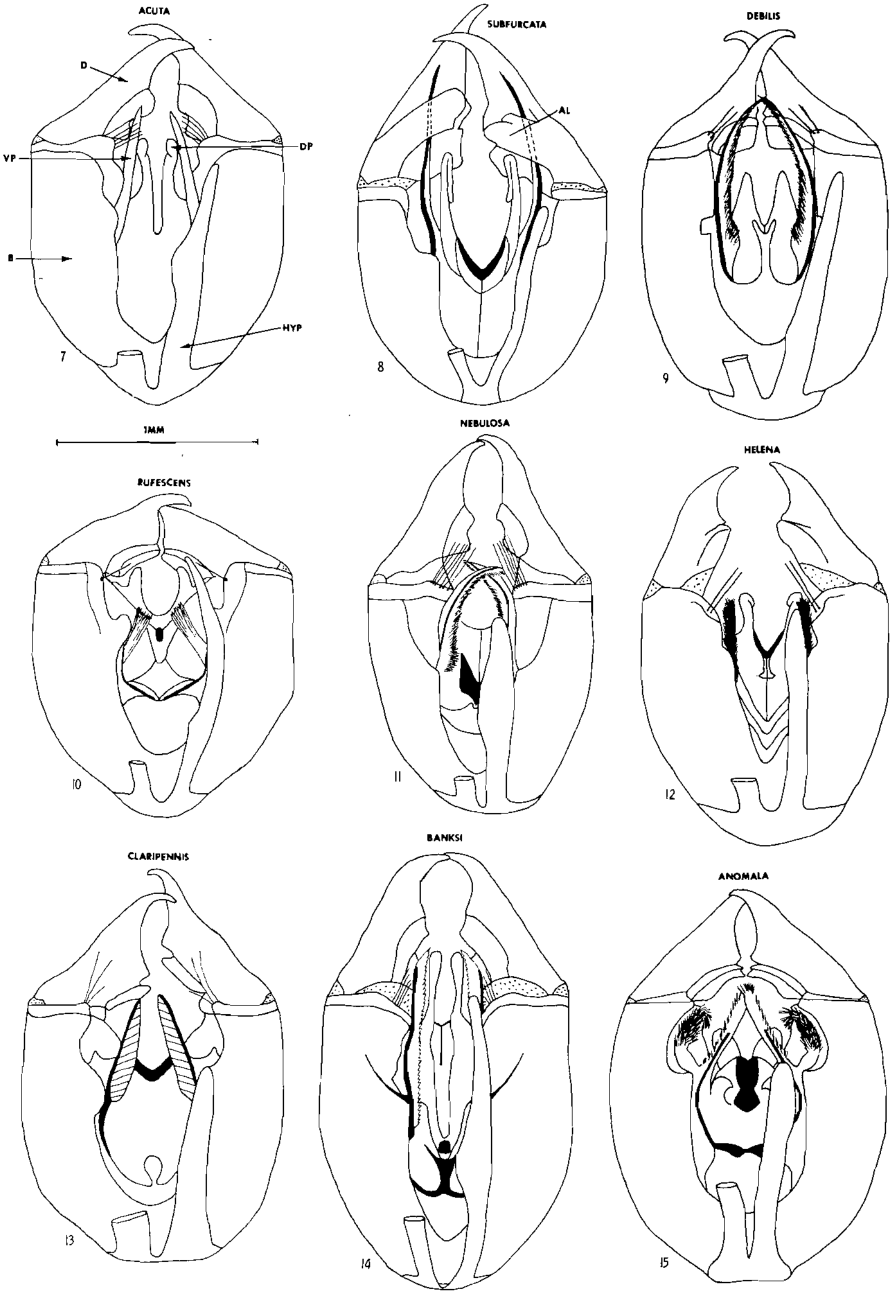
KEY TO THE SPECIES OF *BITTACUS* IN MICHIGAN

1. Apices of wings darkly colored . . . . *apicalis*
1'. Wings uniform in color, aspices not pigmented 2
2(1'). Anal crossvein (Fig. 2 A) present; antennae with long setae . . . . *pilicornis*
2'. Anal crossvein absent; antennae with short setae 3
3(2'). Wing membrane yellow; crossveins not margined with pigment . . . . *stigmaterus*
3'. Wing membrane colorless; crossveins margined with pigment . . . . . . *strigosus*

KEY TO THE MALES OF THE *PANORPA* SPECIES IN MICHIGAN

1. Anal horn (Fig. 4 AH) present 2
1'. Anal horn absent 9
2(1). Dististyles with enlarged, medially projecting accessory lobes 3
2'. Dististyles without accessory lobes 5
3(2). Dististyles very large, much longer than the basistyles; accessory lobes large, extending from the base to almost the apices of the dististyles (Fig. 16) . . . . *mirabilis*
3'. Dististyles shorter than the rest of the genital bulb; accessory lobes much smaller, restricted to the basal half of the dististyles 4
4(3'). Background of wing colorless (Fig. 8) . . . . *subfurcata*
4'. Background of wing distinctly yellow (Fig. 18) . . . .*hungerfordi*
5(2'). Ventral parameres furcate, each consisting of two branches (Fig. 15) . .*anomala*
5'. Ventral parameres simple, not furcate 6
6(5'). Ventral parameres short, mostly concealed within the interior of the genital bulb and not reaching the base of the dististyles (Fig. 10). . . . . *rufescens*
6'. Ventral parameres longer, extending beyond the base of the dististyles 7
7(6'). Small papillae, surmounted by setae, on inner distal margins of basistyles; ventral parameres curved inward, with their apices usually touching or crossing (Fig. 9) . . . .*debilis*
7'. No papillae distally on basistyles; ventral parameres straight or nearly so . . . 8
8(7'). Two long and thick setae on each of the inner distal margins of basistyles; crossveins not margined with pigment (Fig. 12) . . . .*helena*
8'. Two to four thin setae on each of the inner distal margins of basistyles; crossveins narrowly margined with pigment (Fig. 13). . . . . *claripennis*
9(1'). Interior of genital bulb exposed and extending between dististyles 10
9'. Interior of genital bulb concealed 11
10(9). Dististyles broad, abruptly curved apically (Fig. 19) . . . . *submaculosa*

The Great Lakes Entomologist, Vol. 7, No. 2 [1974], Art. 1



Figs. 7-15. Genital bulbs of male panorpas, ventral view. All same scale. Fig. 7. B-basistyle; D-dististyle; DP-dorsal paramere; HYP-hypovalve (ninth sternum); VP-ventral paramere. Fig. 8. AL-accessory lobe.

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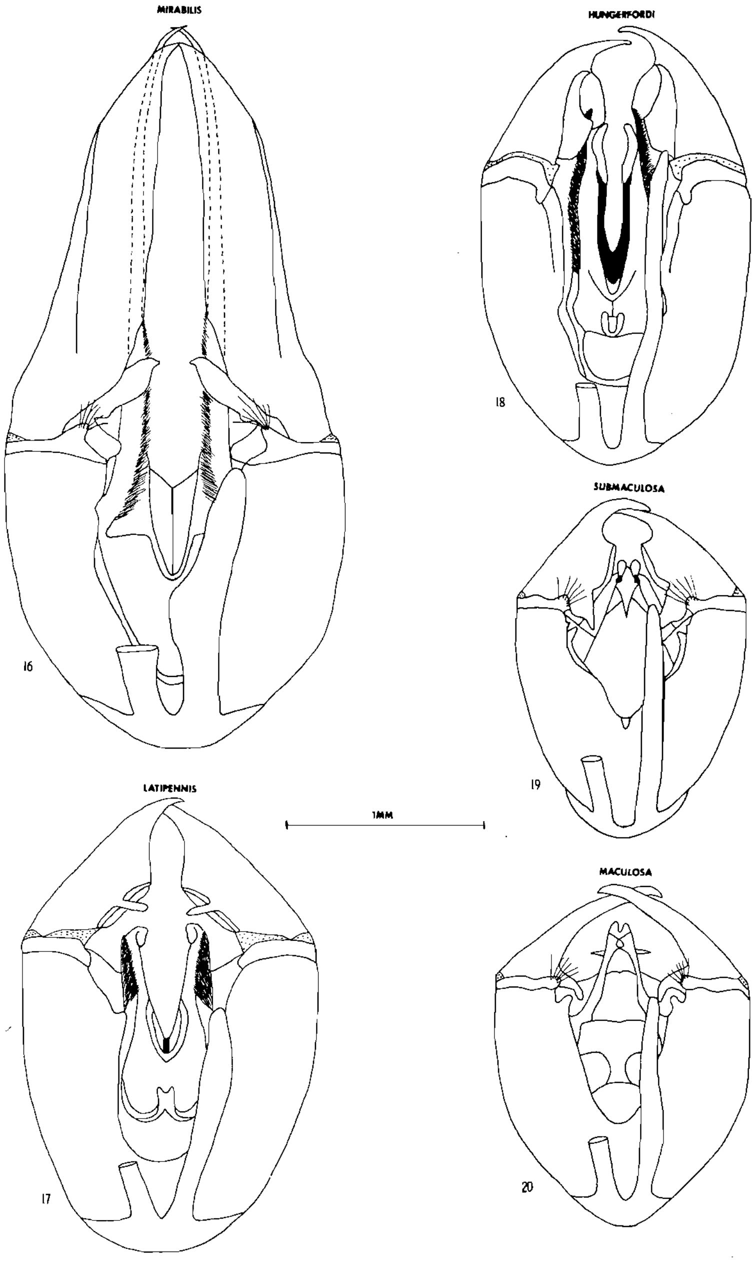
10′. Diststyles slender, smoothly curved (Fig. 20) . . . . *maculosa*
11(9′). Ventral parameres sharply curved and usually crossing distally (Fig. 11). . . . . *nebulosa*
11′. Ventral parameres straight or nearly so 12
12(11′). Diststyles with a small, medially projecting lobe near the basal inner margins; hypovalves short and wide (Fig. 17). . . . . *latipennis*
12′. Diststyles without lobe on inner margins; hypovalves longer and more narrow . 13
13(12′). Preëpiproct truncate distally (Fig. 5) or with two very small lateral lobes; genital bulb rounded (Fig. 7) . . . . *acuta*
13′. Preëpiproct with two well developed distal lobes (Fig. 6); ventral parameres narrow and extending to base of diststyles; genital bulb elongate (Fig. 14) . . . . *banksi*

KEY TO THE FEMALES OF THE *PANORPA* SPECIES IN MICHIGAN

1. First and/or second marginal spots present in forewing (Fig. 1, 1M, 2M) . . . 2
1′. No marginal spot present in forewing 7
2(1). Crossveins with pigmented margins 3
2′. Crossveins not margined 5
3(2). Genital plate elongate and slender; apical projections of distal plate slender and acute (Fig. 32) . . . . *banksi*
3′. Genital plate not elongate and slender; projections of distal plate with somewhat rounded apices 4
4(3′). Accessory plate well developed (Fig. 22 AC) ensheathing basal portion of genital plate ventrally (Fig. 22) . . . . *anomala*
4′. Accessory plate less developed, not extending to ventral side of genital plate (Fig. 36) . . . . *rufescens*
5(2′). Background of wing colorless (Fig. 31) . . . . *subfurcata*
5′. Background of wing yellow 6
6(5′). Genital plate small; spermathecal apodemes divergent distally; background of wing usually pale yellow (Fig. 34). . . . . *helena*
6′. Genital plate elongate; spermathecal apodemes only slightly divergent distally; background of wing deep yellow (Fig. 30) . . . . *hungerfordi*
7(1′). Crossveins without pigmented margins 8
7′. Crossveins margined 11
8(7). Accessory plate present (Fig. 22 AC) 9
8′. Accessory plate absent 10
9(8). Genital plate small; spermathecal apodemes divergent distally; background of wing pale yellow (Fig. 34) . . . . *helena*
9′. Genital plate elongate; spermathecal apodemes only slightly divergent distally; background of wing deep yellow (Fig. 30) . . . . *hungerfordi*
10(8′). Distal portion of spermathecal apodemes divided into fingerlike parts; background of wing colorless or yellow (Fig. 23) . . . . *mirabilis*
10′. Distal portion of spermathecal apodemes undivided; background of wing colorless (Fig. 31) . . . . *subfurcata*
11(7′). At least one continuous band present in forewing (Fig. 1) 12
11′. All bands in forewing broken or reduced to a series of spots 16
12(11). Genital plate slender and elongate, projections of distal plate acute (Fig. 32). . . . . *banksi*
12′. Genital plate not slender and elongate, projections of distal plate more rounded 13
13(12′). Genital plate large; posterior margin with deep incision; small, slightly sclerotized accessory plate present at base (Fig. 24) . . . . *latipennis*
13′. Genital plate small; posterior margin much less incised; accessory plate large or absent 14
14(13′). Posterior margin of genital plate with a narrow incision; genital plate ovate; accessory plate absent (Fig. 35) . . . . *claripennis*
14′. Posterior margin of genital plate with a wide incision; accessory plate present. . 15

The Great Lakes Entomologist, Vol. 7, No. 2 [1974], Art. 1



Figs. 16-20. Genital bulbs of male panorpas, ventral view. All are the same scale as in Figs. 7-15.

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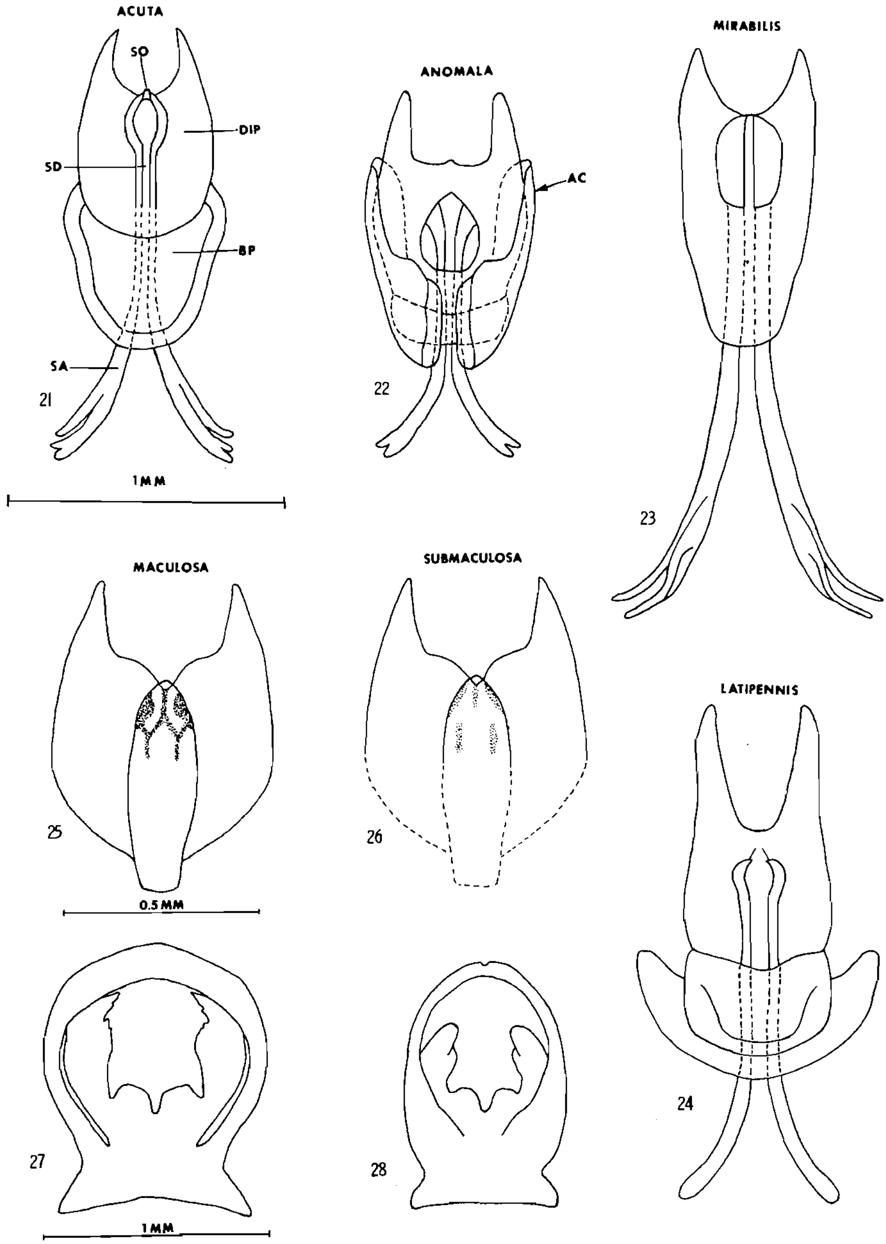
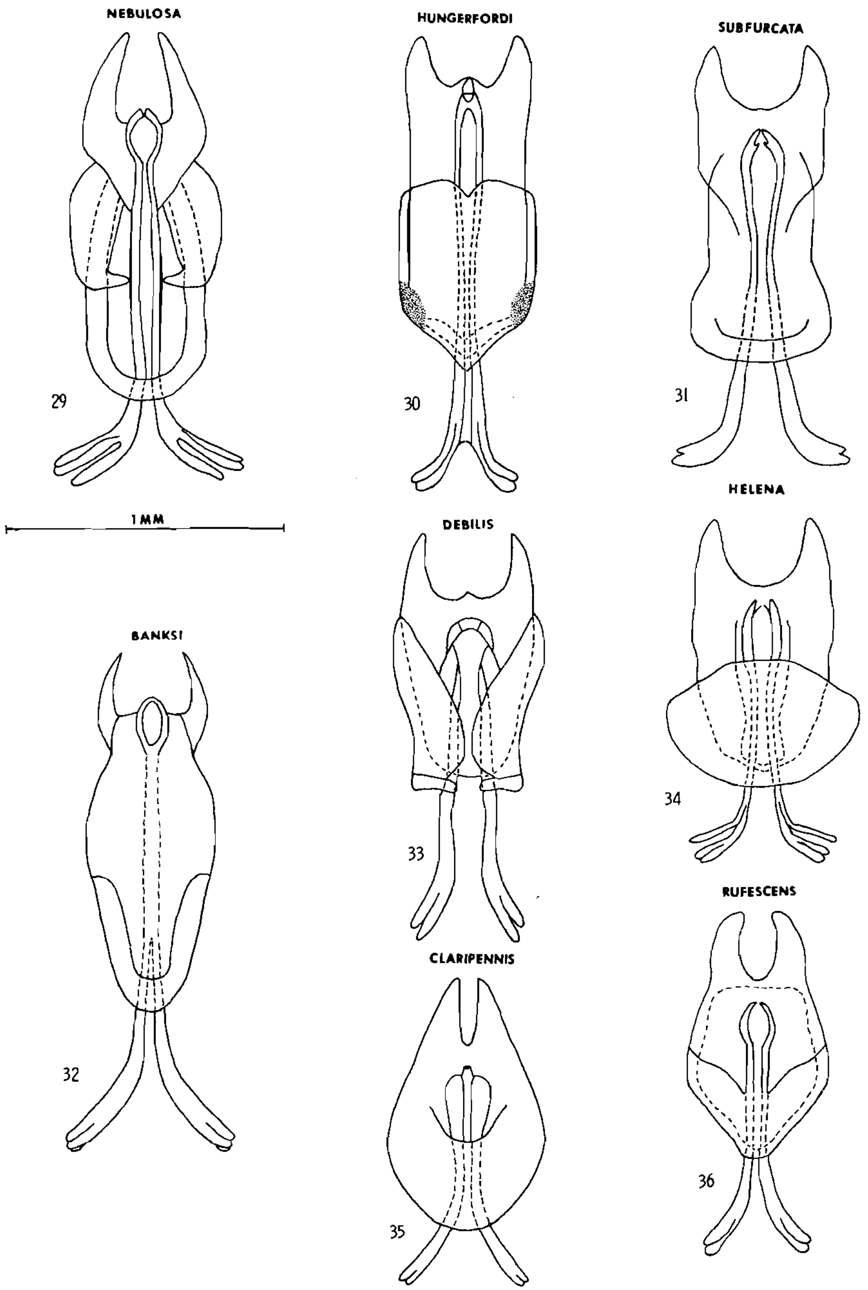


Figs. 21-26. Genital plates of female panorpas. Ventral view. Figs. 21-24, all same scale as in Fig. 21. Fig. 21. BP-basal plate; DIP-distal plate; SA-spermathecal apodemes; SD-spermathecal duct; SO-spermathecal opening. Fig. 22. AC-accessory plate. Figs. 25 and 26, both same scale. Figs 27 and 28, subgenital plates of female panorpas, dorsal aspect; both same scale. Figs. 25 and 27, *P. maculosa.* Figs. 26 and 28, *P. submaculosa.*



Figs. 29-36. Genital plates of female panorpas, ventral view. All same scale as Figs. 21-24.

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15(14′). Spermathecal apodemes slightly sinuous, divergent only at their apices; forewing length 10-11 mm, width 3mm (Fig. 33) . . . . *debilis*
15′. Spermathecal apodemes not sinuous, divergent their entire length beyond genital plate; forewing length 11-11.5 mm, width 4 mm (Fig. 22) . .*anomala*
16(11′). Genital plate incompletely developed, basal plate and spermathecal apodemes absent 17
16′. Genital plate completely developed, all structures present 18
17(16). Subgenital plate rounded (Fig. 27), dorsal depression of subgenital plate with pair of lamellae which extend to the posterior margin of depression; axial and basal portions of genital plate usually discernible (Fig. 25). . . *maculosa*
17′. Subgenital plate not rounded (Fig. 28), inner lamellae not extending to posterior margin of depression; axial and basal portions of genital plate not completely developed or discernible (Fig. 26) . . . . *submaculosa*
18(16′). Spermathecal apodemes not widely divergent distally 18
18′. Spermathecal apodemes widely divergent distally 19
19(18). Spermathecal apodemes extending only slightly anterior to genital plate (Fig. 29) . . . . *nebulosa*
19′. Spermathecal apodemes extending beyond plate at least one-half the length of the plate (Fig. 33) . . . . *debilis*
20(18′). Accessory plate present, partially surrounding genital plate (Fig. 22) . .*anomala*
20′. Accessory plate absent 21
21(20′). Genital plate slender and elongate; wing markings dark brown or black (Fig. 32) . . . . *banksi*
21′. Genital plate shorter and wider; wing markings brown (Fig. 21) . . . . . . *acuta*

Family BITTACIDAE
THE HANGINGFLIES
Genus **BITTACUS** Latreille

apicalis Hagen 1861. (Black-tipped Hangingfly). (Fig. 38). June 20 to August 30. This hangingfly is apparently only common in the southeastern portion of Michigan and may not occur outside this area in the state. In many moist deciduous woods in Washtenaw, Livingston and Wayne counties, this species reaches population numbers in the thousands and several specimens may be collected with one sweep of an insect net. In fact, during July it is difficult to locate a moist shaded woods in southeastern Michigan where this species does not occur. The typical woodland habitat of this species has a dense herb stratum comprised of jewelweed (*Impatiens* spp.) and nettle (*Laportea canadensis*). In such habitats in southeastern Michigan, *B. apicalis* often occurs with large populations of two other bittacids: *B. pilicornis* and *B. strigosus.*

pilicornis Westwood 1846. (Hairy-horned Hangingfly). (Fig. 39). June 11 to August 23. Like *B. apicalis, B. pilicornis* is known only from the southern portion of Michigan. This is the earliest bittacid to emerge in southern Michigan in the spring. *B. pilicornis* is more localized in its distribution and occurs in smaller numbers than *B. apicalis,* even though the typical habitat is similar to that described for *B. apicalis.*

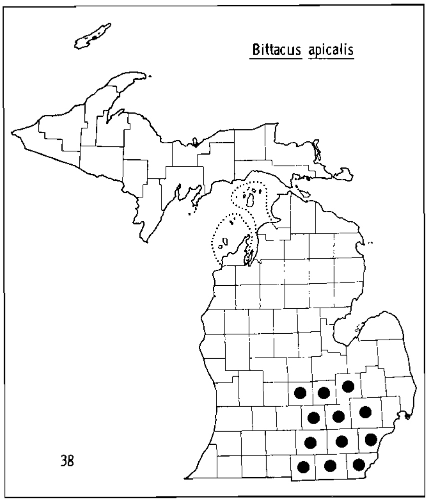
stigmaterus Say 1823 (Fig. 40). July 23 to August 9. This hangingfly has been recorded farther north than any other Michigan bittacid but is apparently relatively uncommon. We found this species in small numbers in Washtenaw Co. during late August in a section of a mesic deciduous forest with an understory of lobelia (*Lobelia* sp.), sunflower (*Helianthus* sp.), bramble (*Rubus* sp.), and horse-balm (*Collinsonia canadensis*). In addition, two males of this species were collected in Washtenaw Co. at night in Malaise traps placed in a weedy field about 30 yards from a swamp.

strigosus Hagen 1861. (Striated Hangingfly). (Fig. 41). July 1 to September 23. *B. strigosus* is widely distributed in southern and central Michigan. The peak population of adults of this species come just after that of *B. apicalis,* seasonally. *B. strigosus* often occurs in very large numbers. The largest populations are found in mesic deciduous forests with lush herbaceous undergrowth, while smaller populations are often found in fairly dry oak-hickory forests.

Fig. 37. The counties of the State of Michigan.

Family BOREIDAE
THE SNOW SCORPIONFLIES
Genus **BOREUS** Latreille

brumalis Fitch 1847. (Snow Scorpionfly). (Fig. 42). February 17 to March 12. Dr. J. W. Leonard, University of Michigan, has collected this species in late February and early March in *Sphagnum* mosses along Hunt Creek, Montmorency County. There are four specimens of this species in MSU, which were apparently collected on that campus



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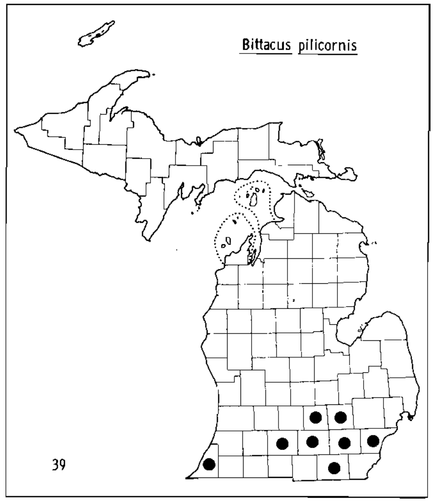

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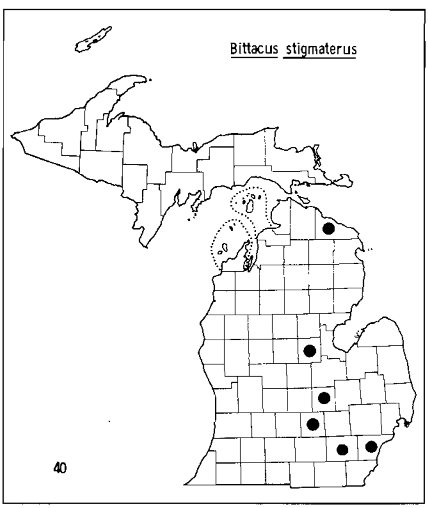
(Ingham Co.) on February 17. Carpenter (1931) lists this species from Detroit (Wayne Co.), but no date was given. We were unable to find this species in Michigan despite considerable time spent searching along Hunt Creek and at various sites in southern Michigan. Apparently this insect occurs in very low numbers or its distribution is very localized in the state. Outside the state, adults have been most commonly collected on the snow or among various species of mosses when the temperature is near freezing.

Family MEROPEIDAE
Genus **MEROPE** Newman

tuber Newman 1838. (Earwig Scorpionfly). (Fig. 43). May 14 to September 25. A single species of *Merope* occurs in North America, where it is widely distributed but infrequently collected. It has been recorded from most of the eastern states and is



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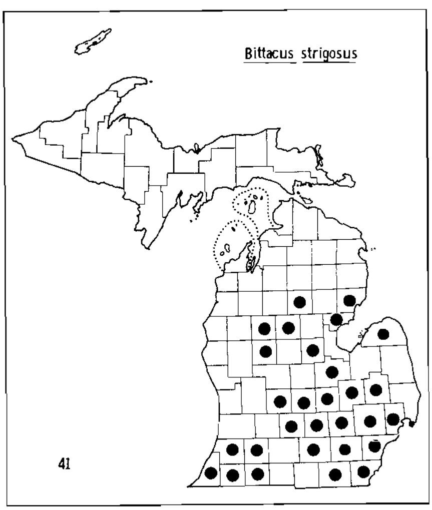

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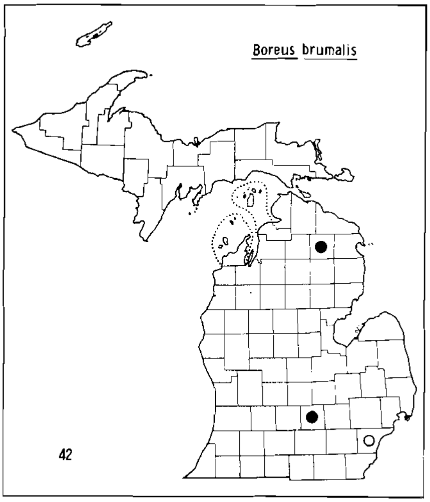
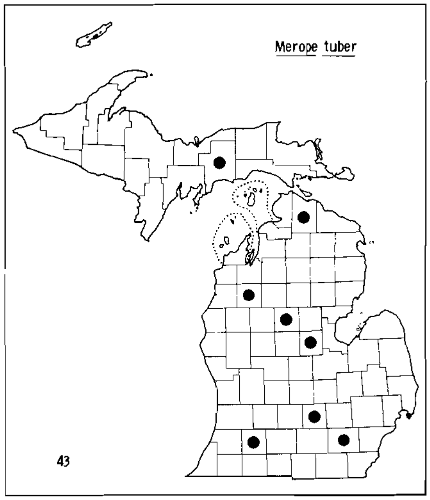


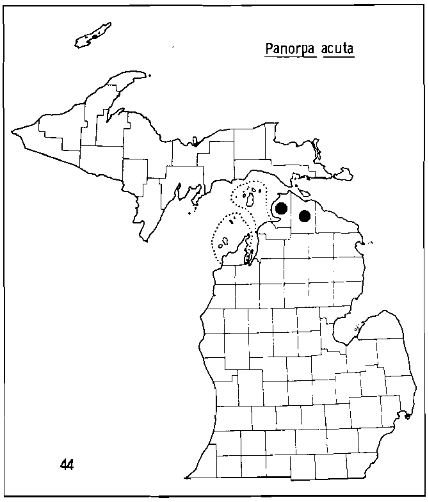


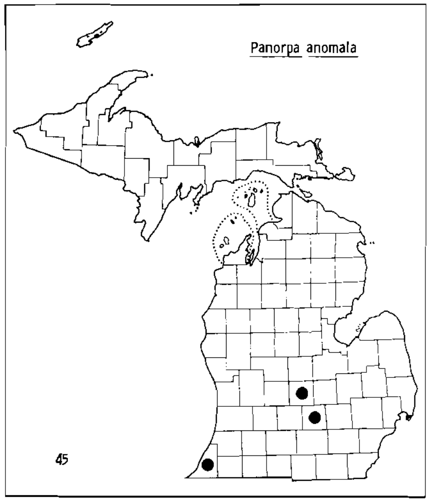
reported in this paper from eight counties in Michigan (Fig. 43). It is apparently nocturnal, as many specimens have been collected at lights. About 50 were collected in Malaise traps near Ann Arbor, Michigan, by Robert Carlson, National Museum of Natural History, during 1967. This is one of the largest series of this species collected to date. Dr. Carlsŏn (personal correspondence) stated that most of the specimens were collected between late August and early September, and catches of more than one specimen per day occurred during hot humid nights. In an attempt to live trap this species for behavioral studies, we placed Malaise traps at this same collection site during June, July and August of 1971, 1972 and 1973; but only one specimen (a female) was trapped, and that in 1972.

Since a known habitat of this species has not been described, a brief description of the site near Ann Arbor where this species was at least once fairly abundant follows. The most prominent feature at the site is a narrow strip of mesic woods adjacent to a cattail and sedge marsh. A few specimens of *Merope* were collected by Carlson in traps set up in the marsh, but most were trapped around a spring seepage area in the woods next to the marsh. The dominant trees are catalpa (*Catalpa bignonioides*), slippery elm (*Ulmus rubra*), hawthorn (*Crataegus* spp.) and boxelder (*Acer negundo*). Most of the trees are less than 25 feet tall and for the most part form a partially closed canopy. The shrub stratum consists of young dominants, especially hawthorn (*Crataegus* sp.), and an occasional elderberry (*Sambucus* sp.). The *Crataegus* shrubs in some areas form an almost impenetrable barrier. The herb stratum is comprised of jewelweed (*Impatiens* sp.), aster (*Aster* sp.), cone flower (*Rudbeckia laciniata*) and burdock (*Arctium* sp.).

Family PANORPIDAE
THE SCORPIONFLIES
Genus PANORPA Linne

acuta Carpenter 1931. (Figs. 7, 21, 44). July 28 to August 8. This species is apparently limited to the northernmost part of the Lower Peninsula. G. W. Byers (1954) collected a single male; August 8, "The Gorge", University of Michigan Biological Station, Douglas Lake, Cheyboygan Co.; from the low vegetation of a spring seepage in a cool ravine shaded by maple and hemlock. Byers (1954) felt that the male was probably *P. acuta*, but the preëpiproct had very small lateral lobes, unlike typical Appalachian *P. acuta*. After examination of the type of *P. acuta* Byers (1962a) con-

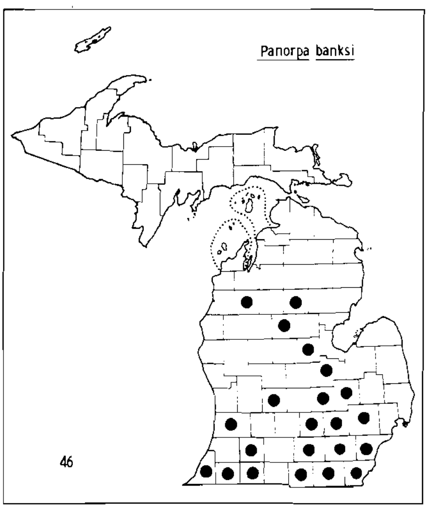


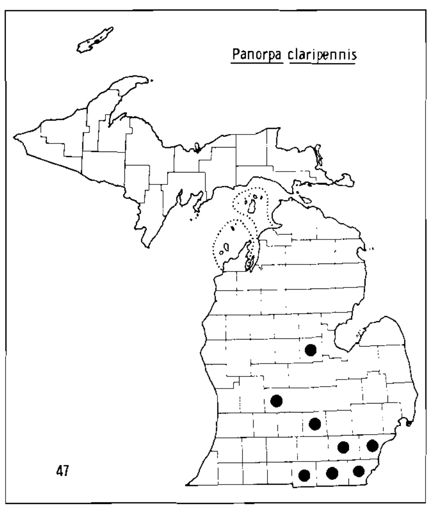


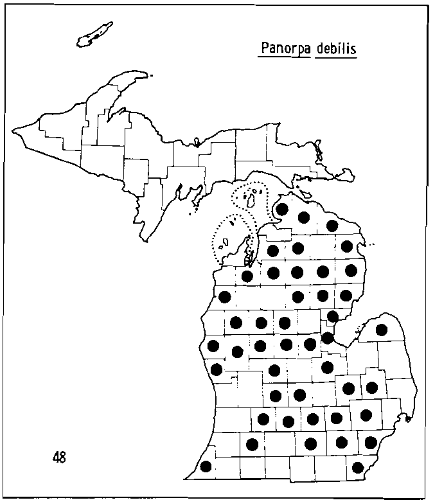
firmed the specimen as belonging to this species. The authors collected a single female of *P. acuta* in Emmet Co. about 11 miles west of Byers' collection locality on July 28, 1973, in a primarily beech-maple forest.

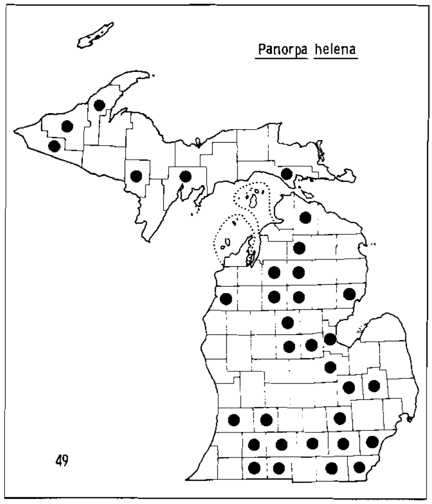
As we were unable to locate additional male specimens from Michigan, it was stated in the key to the male panorpas (couplet 13) that the male of *P. acuta* has small lateral lobes on the preëpiproct or a truncate preëpiproct without lobes. A male of *P. acuta* with either condition is separable from males of other Michigan panorpas because other species have well developed lateral lobes on the distal margin of the preëpiproct.

P. acuta has not been collected in the region between the northern Lower Peninsula of Michigan and the Appalachian Mountains. Perhaps the population in northern Michigan is a geological relict formed in a manner similar to that hypothesized by Cantrall (1970) to explain the disjunct populations of certain Michigan









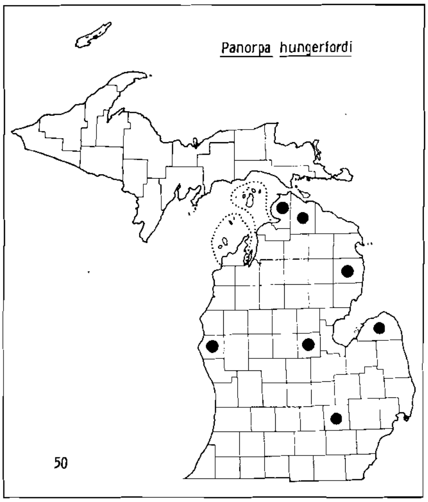
Orthoptera and P. W. Smith (1957) to account for changes in the ranges of certain vertebrate populations. Thus it may be reasonable to suspect that during the cool and humid Climatic Optimum Period following the recession of the Wisconsin Glaciation, *P. acuta* extended its range north and westward from the southern Appalachian Mountains simultaneously with the northward extension of the Appalachian forest. With the onset of the Xerothermic Period, characterized by hot and dry conditions, populations that may have occured in Ohio, Indiana and southernmost Michigan were extirpated, leaving the northern Lower Peninsula relict population that exists today.

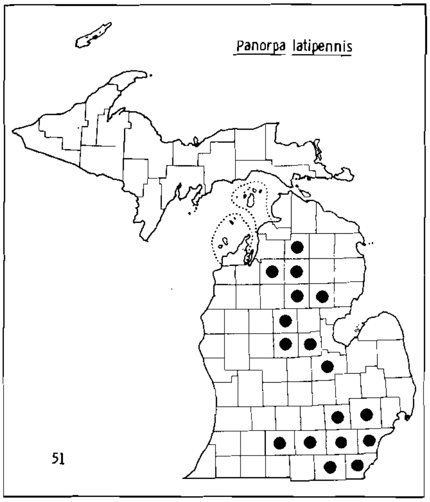
anomala Carpenter 1931. (Figs. 15, 22, 45). June 18 to July 19. Byers (1973) first reported this species from Michigan. The authors collected this species in small numbers at two localities: July 3, 1973, Clinton Co., about four miles west of Lansing, floodplain forest along the Grand River (20 specimens); July 4, 1973, Berrien Co., Warren Woods State Park, floodplain forest along the Galien River (25 specimens). Both sites were characterized as follows: partially closed overstory of boxelder *(Acer negundo)*, elm *(Ulmus rubra)*, red maple *(Acer rubra)*, silver maple *(Acer saccharinum)*, and black maple *(Acer nigrum)*; shrub stratum of elderberry *(Sambucus canadensis)* and young dominants; dense herb stratum of jewelweed *(Impatiens* spp.), nettle *(Laportea canadensis)*, goldenrod (*Solidago* spp.), poison ivy *(Toxicodendron radicans)* and coneflower *(Rudbeckia laciniata)*. This species is probably more widespread in the southern part of the state than is indicated by the distribution map.

banksi Hine 1901. (Figs. 14, 32, 46). May 25 to August 21. This is one of several species of *Panorpa* in our fauna that has a wide tolerance of ecological conditions. Although the largest populations of this species occur in moist deciduous woods, it can also be found in smaller numbers in upland habitats such as oak-hickory forests with little low vegetation. In favorable habitats this species is often very abundant.

claripennis Hine 1901. (Figs. 13, 35, 47). May 17 to August 2. We have only found *P. claripennis* in floodplain and swamp forests and never in beech-maple or oak-hickory forests. In southeastern Michigan, this species is often very abundant in floodplain forests along water courses and is one of the first panorpas to emerge in the spring.

debilis Westwood 1846. (Figs. 9, 33, 48). June 10 to September 14. Like *P. banksi*, this species occurs in a variety of moist habitats in Michigan, as well as in more upland habitats. It is the last species of *Panorpa* to emerge in southeastern Michigan and often occurs in very large numbers. *P. debilis* has not yet been recorded from the Upper Peninsula of Michigan but probably occurs there.

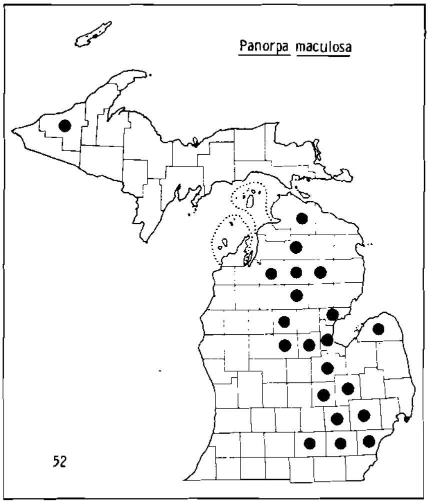


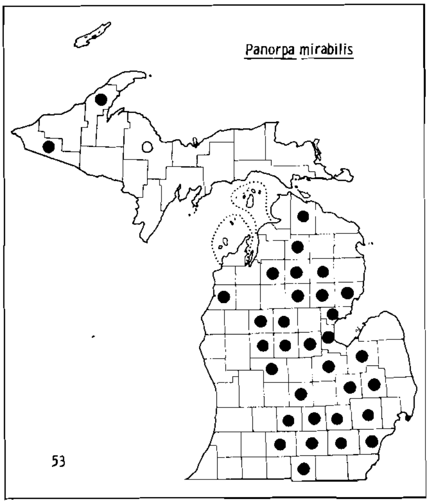


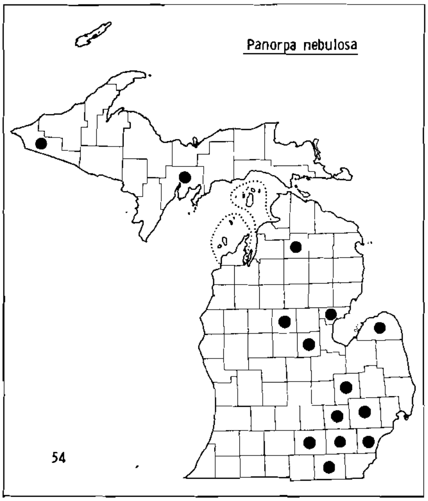
helena Byers 1962. (Figs. 12, 34, 49). May 20 to September 3. This is another species with apparently wide ecological tolerances being found both in lowland forests and in upland forests. The largest populations of this species in southern Michigan are found in floodplain forests where it co-occurs with large number of *P. claripennis*. *P. helena* is only occassionally found in oak-hickory or beech-maple forests in our area.

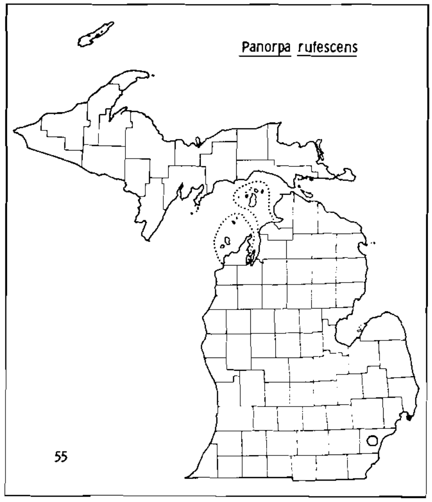
hungerfordi Byers 1973. (Figs. 18, 30, 50). July 19 to September 18. This recently described species is very similar to *P. virginica*, an Appalachian species. Although we have not yet collected *P. hungerfordi* in the state, we have visited two sites where it was collected previously: Edwin S. George Reserve in Livingston Co., an oak-hickory forest adjacent to a large swamp and with an understory of gooseberries (*Ribes* spp.), horse-balm *(Collinsonia canadensis)* and bracken fern *(Pteridium aquilinum)*; and a beech-maple-aspen forest, 4.5 miles west of Pellston, Emmet Co.

latipennis Hine 1901. (Figs. 17, 24, 51). May 16 to July 20. This species and *P. mirabilis*, are the earliest species of *Panorpa* to emerge each spring in moist deciduous forests in









southeastern Michigan. *P. latipennis* is the only species of *Panorpa* studied by the authors that inhabits forested situations somewhat less mesic than the other species. This species occurs in the largest numbers in moist deciduous forests, as do all other Michigan panorpas, but the other species are most abundant in the most mesic portions of the woods. *P. latipennis*, however, is most abundant on slightly higher and drier ground. In a typical beech-maple–oak-hickory forest in southeastern Michigan in June, *P. mirabilis* is often the most abundant species in the mesic areas of the woods; i.e., around temporary ponds and along streams. At this same time, *P. latipennis* is most abundant in the ecotonal habitats surrounding these mesic areas. The two habitats have conspicuously different vegetational types, particularly the understory vegetation: the mesic areas have an understory of nettle *(Laportea)*, elderberry *(Sambucus)* and jewelweed *(Impatiens)*; whereas, the ecotonal areas around these sites have an understory of Solomon's Seal *(Polygonatum pubescens)*, horse-balm *(Collinsonia canadensis)*, May-apple *(Podophyllum peltatum)* and geranium *(Geranium maculatum)*. The authors have rarely collected *P. latipennis* in floodplain forests along creeks or rivers, but it commonly occurs on wooded slopes above floodplains.

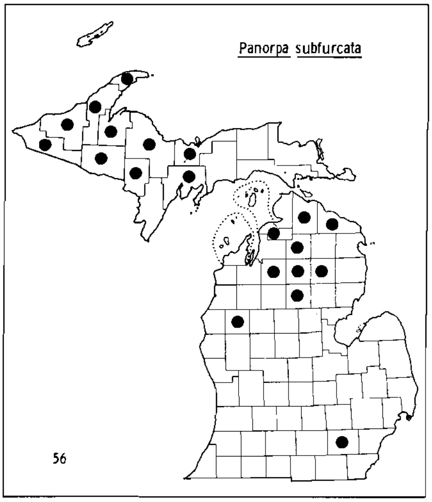
maculosa Hagen 1861. (Figs. 20, 25, 27, 52). June 10 to August 25. This species occurs both in low mesic woods and in drier habitats such as oak-hickory woods with little understory. In most wooded areas in southeastern Michigan it is the least abundant of the *Panorpa* species.

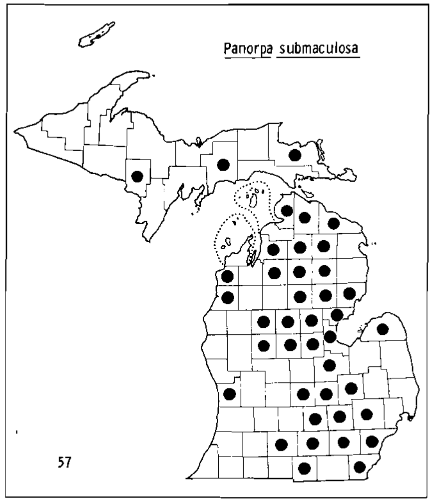
mirabilis Carpenter 1931. (Figs. 16, 23, 53). May 17 to July 25. This is a very common species throughout the state. The habitat of this species in southeastern Michigan was described earlier in this paper under *P. latipennis.* In the central and northern Lower Peninsula of Michigan this species occurs in almost any moist wooded area.

nebulosa Westwood 1846. (Figs. 11, 29, 54). May 25 to August 25. *P. nebulosa* is apparently widely distributed in Michigan, occurring in both the Upper and Lower Peninsulas of the state. It is a common species in June and July in most deciduous forests in southern Michigan. The largest population of this species encountered in the state occurs in a virgin beech-maple forest in western Washtenaw County.

rufescens Rambur 1842. (Figs. 10, 36, 55). This is primarily a coastal species occurring along the eastern coast and as far west as Mississippi. Carpenter (1931) listed, possibly in error, this insect from Detroit (no date) at the edge of Lake Erie; however, we have been unable to locate a population of this species in Michigan.

subfurcata Westwood 1846. (Figs. 8, 31, 56). May 29 to September 1. This species is widely distributed in the Upper Peninsula and in northern and central Michigan, where





it reaches fairly large population numbers in floodplain forests along water courses. It is also less abundant in the wooded edges of marshes and swamps in these parts of the state. There is one specimen in the UMMZ from the southern part of the Lower Peninsula of Michigan (Washtenaw Co.); however, we have been unable to locate this species in this area.

submaculosa Carpenter 1931. (Figs. 19, 26, 28, 57). May 20 to September 3. This is a species of wide distribution and probably occurs in every county in the state. It may occasionally be collected in dry upland forests but reaches great numbers only in mesic deciduous forests. Any partially shaded moist habitat in southeastern Michigan contains at least a few individuals of this species.

ADDITIONAL SPECIES

Published distributional records (Carpenter, 1931; Byers, 1954, 1958, 1962a, 1973) suggest that four additional species may be collected in Michigan in the future. *Bittacus occidentis* Walker is a widespread species in eastern North America and has been collected in Indiana, Ohio and Illinois. This species is phototropic and may be collected at lights (Setty, 1940; Caron, 1966).

Panorpa dubitans Carpenter is known only from northwestern Indiana and northern Illinois. One of the collection sites is Laporte Co., Indiana (Byers, 1962), which is adjacent to Berrier Co., Michigan. We attempted without success to locate this species in southwestern Michigan.

P. galerita Byers is recorded from eastern Wisconsin and northeastern Ohio. It may occur in Michigan.

P. sigmoides Carpenter is known from west central Indiana, northern Ohio and northern Illinois. This species may occur in the southern part of Michigan.

ACKNOWLEDGMENT

We are grateful to George W. Byers, University of Kansas, for critically reading the manuscript and for pointing out consistent taxonomic characters useful in distinguishing the females of *Panorpa submaculosa* and *P. maculosa*.

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