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Lateral view of head of male *Phytomyza dreisbachi* Steyskal, n. sp. (Diptera: Agromyzidae).

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NEW AND LITTLE-KNOWN AGROMYZIDAE FROM MICHIGAN
(DIPTERA: ACALYPTRATAE)

George C. Steyskal
Systematic Entomology Laboratory, Entomology Research Division
Agr. Res. Serv., USDA

The latest major work on North American Agromyzidae, The Agromyzidae of Canada and Alaska (Spencer, 1969), lists 290 regional species. Of that number, half (147) are new species and 23 are previously described species newly recorded for the continent. It is thus evident that the North American Agromyzid fauna is still poorly known. Among material recently determined for the collection of Michigan State University, East Lansing, were the 5 additional new species herein described. A male allotype for Melanagromyza inornata Spencer (1969), described from the female only, is also described, and more detailed figures of the male postabdomen of Melanagromyza lauta Spencer (1969) are presented. Unfortunately all of the material is from random collecting and no host plants for the species are known. Types are retained in the collections of the United States National Museum of Natural History (USNM) and paratypes are returned to the Michigan State University collections (MSC).

AGROMYZINAE

Agromyza haplacme, n. sp.

Male. Length of wing 2.5 mm.

Head: Front slightly projecting above eye in profile, 1.3 times width of eye; 2 strong, reclinate ors; 3 weak, inclinate ori; orbital setulae strong, reclinate, in single irregular row from level of antenna to upper ors; cheek deeply extended in rear, 1/3 height of eye; 3rd antennal segment circular, finely pubescent; arista swollen in basal 1/7, slender apical part with dense, fine pubescence spreading to width somewhat greater than largest diameter of basal part.

Mesoscutum: 2 strong dc, preceded by 3 much smaller ones; acr setulae rather long, in 6 or 8 irregular rows.

Wing: Costa extending strongly to 3rd vein, weakly to 4th vein; last section of 5th vein 0.63 as long as penultimate; ta at middle of discal cell.

Legs: Middle tibia with 2 short posterior bristles.

Color: Generally black; antenna brown; knees, both ends of tibiae, and all of tarsi yellowish; mesoscutum lightly tomentose; squamae and their fringes whitish; halter white.

Postabdomen: See Fig. 1; distiphallus with simple slender projection 2/3 as long as basiphallus; epandrium with small group of spicules on mesal side of lower margin.

Holotype: male, Bath, Clinton County, Michigan, 22 October 1956 (R. Scheibner), no. 71542 in USNM.

The species runs in Spencer's key (1969) to couplet 15, but differs decidedly in the postabdomen from 2 of the 3 species brought out at that point: A. pseudoreptans Nowakowski and A. ambrosivora Spencer. It is very similar to the 3rd species, A. reptans Fallen, as keyed by Spencer and as described by Nowakowski (1964), by its narrower front, deeper cheek, and several details of the postabdomen, notably the simple apical distiphallus process, which in A. reptans is divided more than halfway to its base.

The species name is a compound noun in apposition, composed of the Greek elements haplo-'simple' + acme 'tip.'

Melanagromyza inornata Spencer (1969:68)

Melanagromyza inornata was described from 2 female specimens taken at Beech Grove, Quebec. Its distinctive characters of large size, broadly projecting orbits with

Agromyza haplacme, n. sp., male postabdomen. a, lateral view, with anterior view of epiphallus and ventral view of aedeagus; b, posterior view of epandrium and cercus in direction of arrow in a; c, hypandrium; d, sperm pump.

Fig. 1. Agromyza haplacme, n. sp., male postabdomen. a, lateral view, with anterior view of epiphallus and ventral view of aedeagus; b, posterior view of epandrium and cercus in direction of arrow in a; c, hypandrium; d, sperm pump.

proclinate setulae, and white squamae are found in a male taken in Clare County, Michigan, 4 May 1950 (R. R. Dreisbach), retained in USNM. The postabdomen of this latter specimen, which has been labeled as allotype, is shown in figure 2. M. inornata was stated by Spencer to be comparable only to M. miranda Spencer. The only part of the postabdomen of M. miranda that was figured is a lateral view of the distiphallus. That part in the allotype of M. inornata is very different. Only eventual securing of males associated with females agreeing in all details with the type of M. inornata will firmly establish the identity of the male of this species. The designation of the present specimen as allotype, a non-codical entity, is purely for convenience.

Melanagromyza lauta Spencer (1969:70)

A male specimen of Melangromyza lauta, described from Simcoe, Ontario, was collected in Cheboygan County, Michigan, 21 June 1948 (Bernard Skud), retained in USNM. I have found that some of the additional postabdominal characters, especially those of the epandrium, shown in figure 3, to be of considerable value in distinguishing species of Melanagromyza.
Fig. 2. *Melanagromyza inornata* Spencer, male postabdomen. a, lateral view, with ventral view of aedeagus; b, posterior view of epandrium and cercus; c, hypandrium; d, sperm pump.

**PHYTOMYZINAE**

*Calycomyza michiganensis*, n. sp.

Male. Length of wing 2mm.

Head: Orbit not projecting above eye, with 2 nearly equal *ors*, 2 weaker *ori*, and a row of setulae, reclinate and strong above, small below, and lowermost few proclinate; 3rd antennal segment as in fig. 4b, round, but flattened at base of arista.

Mesoscutum: 2 strong *dc*, anterior one more than half as long as posterior one; 6 rows of short *acr* setulae.

Wing: as in fig. 4a, last section of 5th vein 2.75 times as long as penultimate.

Legs: Middle tibia with 1 moderately strong posterior bristle.

Color: Upper orbit black from vertex to area between *ors*, becoming narrowly pale tan about *ori*; face piceous above, yellow in lower 2/5; mesoscutum shining black, notopleural area and mesal and posterior sides of humerus yellow; legs black, only fore knees very narrowly reddish yellow; squamae whitish, rim tan, fringe brown.

Postabdomen: As in fig. 4c-e; aedeagus differing only in detail from those of *C. cynoglossi* (Frick) and *C. novascotiensis* Spencer.

Holotype, male, Gull Lake Biological Station, Kalamazoo County, Michigan, 15 August 1964 (Robert W. Matthews), no. 71543 in USNM; paratype male, Ojibway Lake, Isle Royale, Keweenaw County, Michigan, 27 June 1964 (R. B. Willson), in MSU.
Fig. 3. *Melanagromyza lauta* Spencer, male postabdomen. a, lateral view, with ventral views of distiphallus and epiphallus; b, posterior view of epandrium and cercus in direction of arrow in a; c, hypandrium; d, sperm pump.

*C. michiganensis* will run in the key by Spencer (1969:145), if the squamal fringe is considered "at most ochrous brown," to *C. promissa* (Frick) and *C. menthae* Spencer, but if the squamal fringe is considered "dark, brown or black," it will run to *C. menthae* Spencer and *C. althaeae* Spencer at another place in the key. All of these species are differentiated otherwise than in color of the squamal fringe only by aedeagal characters.

*C. michiganensis* and several recently described species will fall into the concept of *C. jucunda* (Wulp) defined by Frick (1956:288), who had a pair of specimens from Dos Palos, Merced County, California, compared with the female type of *Agromyza jucunda* Wulp, from Wisconsin, by Dr. A. Diakonoff. The identity of the Wulp species will remain dubious until more critical examination of the type, including dissection of the post-abdomen, can be made. *C. michiganensis* at least has the mesoscutum quite strongly shining, rather than with the weak shine (met flaauwen glans) cited by Wulp for *A. jucunda*, and it is certainly a different species from the homoeotypes in the Frick collection.

The name *michiganensis* is an adjective referring to the State of Michigan.

Phytomyza *cudu*, n. sp.

Male. Length of wing 2.25 mm; 2nd costal section (fig. 5a), 3 times length of penultimate section; head black; frontal orbit projecting slightly above eye, shining; upper ocelli lacking, 3 incurved ocelli; arista densely short pubescent; thorax black except narrow yellowish dorsal and posterior margins of sternopleuron; mesoscutum lightly gray tomentose; 3+1 strong dc; acr setulae in about 4 irregular rows; squamae, squamal fringe, and halter cream-colored; legs black, narrowly but distinctly yellowish at knees.

Postabdomen as in figure 5; distiphallus with pair of sinuate processes resembling antelope horns.

Holotype, male, Hillsdale County, Michigan, 21 May 1960 (R. and K. Dreisbach), no. 71546 in USNM.
Fig. 4. *Calycomyza michiganensis*, n. sp., details of male. a, wing; b, antenna; c, epandrium and cerci, lateral and posterior views; d, lateral view of aedeagus, with ventral views of gonites and distiphallus; e, sperm pump.

*P. cudu* runs in the key by Spencer to couplet 79, where the length of wing falls between the 2 ranges cited. Among the species brought out in this section of the key (*P. saskatoonensis* Spencer, *P. clematidophoeta* Spencer, *P. loewii* Hendel, *P. aquilegivora* Spencer, and *P. thalictrivora* Spencer), it differs in length of 2nd costal section, pubescence of arista, numbers of *acr* setulae, and especially in conformation of postabdominal parts. In Frick’s key (1959:421), *P. cudu* runs to *P. nigripennis* Fallén, a much larger species. Spencer treated *P. nigripennis* as doubtfully American.

The species name *cudu* is a noun in apposition, in token of the resemblance of the distiphallus in ventral view to the horns of the African antelope known as *kudu*. The genitive of *cudu* would be *cudus*, as in a few Latin nouns ending in -u in the nominative.

*Phytomyza dreisbachi*, n. sp.

Male. Length of wing 3.05 mm. Head (fig. 6b) with front broad, projecting well above eye; 2 nearly equal *ors*, 3 or 4 incurved *ori*, long, irregularly disposed orbital setulae; cheek half height of eye; 3rd antennal segment nearly 1/3 longer than deep, bare; broad
Fig. 5. *Phytomyza cudu*, n. sp., details of male, a, wing; b, lateral view, with displaced view (see broken lines) of aedeagus, anterior views of epiphallus and basiphallic projections, and ventral view of distiphallus; c, posterior view of epandrium and cercus; d, sperm pump.

epistoma present; *acr* setulae coarse, in 4 rows posteriorly, 2 rows anteriorly; wing (fig. 6a) with 2nd costal section 2.9 times as long as penultimate section.

Color of frons yellow, narrow orbits, bases of *ors* and *ori*, and ocellar triangle black; antenna black, yellowish only in apical part of dorsal side of 2nd segment; face brown; lower edge of cheek along bases of setae blackish; mesoscutum densely medium gray
Fig. 6. *Phytomyza dreisbachi*, n. sp., details of male. a, wing; b, lateral view of head; c, lateral view of aedeagus and epiphallus, with anterior view of latter and ventral view of distal part of aedeagus; d, hypandrium, ventral view; e, same, lateral view.

tomentose with trace of darker dorsocentral stripes; pleura gray tomentose, upper margin of mesopleuron narrowly yellowish; legs black, apex of fore coxae yellowish, knees rather broadly yellow; wing distinctly brownish, especially anteriorly; squamae cream-colored, fringe yellowish to tan.
Fig. 7. *Phytomyza dreisbachi*, n. sp. a, (male) epandrium, lateral and posterior views; b, (female) ovipositor; c, (female) ventral sperm receptacle; d, (female) egg guide.

Postabdomen as in fig. 6c-e, 7a; aedeagus very similar to that of *P. aquilegiophaga* Spencer (1969:228, fig. 399-400), but differing in proportions and shape of parts.

Female. Similar to male; wing 3.05 - 3.22 mm long; ovipositor sheath 0.63 mm long to extreme base; ovipositor as in fig. 7b; egg guide (fig. 7d) acutely triangular; ventral sperm receptacle as in fig. 7c; spermathecae black, globular, smooth, without basal rim, diameter c 0.22 mm.

Holotype, male, and allotype, Kalkaska County, Michigan, 24 May 1954 (R. R. Dreisbach), no. 71544 in USNM; paratypes, 2 females, Potterville, Eaton County, Michigan, 10 May 1959 (E. A. Scheibner) and Allegan County, 18 May 1959 (R. and K. Dreisbach), in MSU.

*Phytomyza dreisbachi* runs in Spencer's key (1969:219) to couplet 29. Among the species brought out beyond that point, *P. dreisbachi* is most similar to *P. aquilegiophaga* Spencer, especially in conformation of the male postabdomen, but differs therefrom in having the 2nd antennal segment yellowish only dorso-apically, somewhat larger size, longer 2nd costal section of the wing (in *P. aquilegiophaga* 1.75 times as long as penultimate section, or in ratio of 35:20), and details of proportion and shape of parts of the postabdomen. In Frick's key (1959:421), *P. dreisbachi* runs to *P. aquilegiana* Frost, a smaller species with narrower cheeks and one that Spencer has shown to be quite different from species of close relationship to *P. aquilegiophaga*.

The species name *dreisbachi* is a genitive form of the family name of my long-time friend, the late Robert R. Dreisbach, to whom I am proud to dedicate this species which he collected.

*Phytomyza regalensis*, n. sp.

Male. Length of wing 1.85 - 2.1 mm. Orbits with 2 equal *ors*, 1 large and sometimes 1 very small *ori*; cheeks a little more than 1/4 height of eye; 3rd antennal segment small, round, with very short pubescence; arista moderately swollen in basal 1/5; 3+1 strong *dc*;
Fig. 8. *Phytomyza regalensis*, n. sp., male postabdomen. a, lateral view, with ventral views of hypandrium and distal part of aedeagus and anterior view of distiphallic processes; b, anterior view of epiphallus in direction of arrow in a; c, posterior view of epandrium and cercus.

*a* setulae in 4 rows anteriorly, extending backwardly as far as middle poststural *dc*; wing with 2nd costal section 2.5 times as long as 4th section.

Color of frons uniformly dull dark brown to blackish; antenna wholly black, in palest specimen with dorsal side of 2nd segment yellowish; mesoscutum black, with dense bluish-gray tomentum, but in one paratype with humerus (except summit) and notopleural area distinctly yellowish; legs wholly piceous to blackish in holotype, but in paratypes with knees, tibiae, and tarsi brown to yellowish; squamae tawny, fringe brown; halter with cream-colored knob.

Postabdomen as in fig. 8; aedeagus with pair of short distal processes, each bearing on deflected end an elliptical hyaline expansion; epandrium with exceptionally narrow ventral extension.

Holotype, male, Isle Royale, Keweenaw County, Michigan, 19 July 1957 (R. W. Hodges), no. 71545 in USNM; paratypes, 2 males, same data except 9 July 1957, 1 each in USNM and MSU.

*Phytomyza regalensis*, because of its variability in color, will run in the key by Spencer (1969:219) to either couplet 56 (*P. agromyzina* Meigen and *P. notopleuralis* Spencer) or couplet 72 (*P. caprifolii* Spencer and *P. perietymeni* Meijere), from all of
which it differs in little more than postabdominal structures. In Frick's key (1959:421), it will run to *P. periclymeni* Meijere.

The name *regalensis* is an adjective formed from the Latinized name of Isle Royale: *Insula Regalis*.

LITERATURE CITED


SOME STENUS LATR. FROM MICHIGAN (COLEOPTERA: STAPHYLINIDAE) 107th CONTRIBUTION TO THE KNOWLEDGE OF STENINAE

Volker Puthz
Limnologische Fluss-Station des Max-Planck-Instituts für Limnologie, Schlitz/Hessen, Germany

Our knowledge of the nearctic Stenus-fauna is very poor. The main work on the Steninae has been done at the end of the last century by the well known coleopterist Th. L. Casey who is known for his peculiar systematic methods. He published the "Revision of the Stenini of America North of Mexico..." (Philadelphia, 1884), in which he described about 80% of the known species from North America.

Last year I had the opportunity to revise all the types of the Casey Collection in the U.S. National Museum, Washington, D.C. and found numerous synonyms which will be published in other papers.

Recently I received fresh Stenus material from Michigan collected by Father Carlo Brivio, Maryglade College, Memphis, Michigan. These specimens are the subject of this article.

My best thanks are due to Dr. Brivio for the loan of the interesting material and for donating specimens to my collection.

Father Brivio did most of his Michigan collecting at the following localities symbolized as:

A: Maryglade College, about one mile East of Memphis, Macomb County, Michigan. The Belle River runs through the college property, is about 15 meters wide, and, especially during the summer, the water is shallow and slow moving. Much aquatic vegetation, both floating and emergent, develops along the shores and in backwaters. The plant association is formed mainly by Nymphaea, Nuphar, Typha, Scirpus, Phragmites, Sparganium, Sagittaria and different species of sedges. Also there are some temporary marshes. Usually collecting was done along the shores of the river and in the marshes by floating the shores, sweeping the grass with a net, or simply by searching among the debris. The topsoil is mostly sandy.

B: The Edwin S. George Reserve, Livingston County. Locality owned by the University of Michigan. Marshes and swamps.

C: Port Sanilac, Sanilac County. Collecting along the beach of Lake Huron (sand and stones) by sweeping and searching the beach debris.

D: Harbor Beach, Huron County. Localities about as in C.

E: Douglas Lake and the University of Michigan Biological Station, Cheboygan County. The lake is about four to five miles in diameter. Collections were made mainly along the sandy shores (fine sand). Along the lake, in some areas, there are small ponds with the usual aquatic associations of plants.

F: Ann Arbor, Washtenaw County. Here collecting was done mostly along the shores of small ponds (about 25 meters in diameter) and in some marshy areas. Vegetation more or less comparable to that at Maryglade College.

SPECIES LIST

*Stenus* (s.str.) *comma* LeConte. A very widely spread holarctic species of which I do not know any record from Michigan; probably the first state record. A: 4.V.1963, 1 ♂;


*Stenus* (s.str.) *erythropus* Melsheimer. This species is not common in the northern parts of the U.S.A. and is known from Michigan. B: 13.X.1962, 1 ♂.
Stenus (s.str.) neglectus Casey. This species is known from the northwestern states. It is new for Michigan. A: 1.IV.1963, 2 $\varnothing$, 8 $\Theta$; 2.V.1969, 1 $\Theta$. E: 15.VII.1962, 1 $\delta$, 1 $\Psi$.

Stenus (s.str.) vicinus Casey. A species which is widely spread over North America but which is also new for Michigan. A: 1.IV.1963, 1 $\Theta$; 21.V.1966, 1 $\Theta$. 11.X.1968, 1 $\varnothing$.

Stenus (s.str.) femoratus Say. Widely spread over the U.S.A. Known from Michigan. A: 7.IV.1963, 1 $\Theta$; 27.IV.1963, 1 $\Theta$, Lapeer County, 1 mile S Lum, 30.VI.1964, 1 $\delta$, 1 $\varnothing$.

Stenus (Nestus) tenus Casey. A species widely spread in the northeastern parts of North America. Known from Michigan. A: 1.IV.1963, 3 $\delta$, 3 $\Theta$; 7.V.1963, 1 $\Theta$; 21.V.1963, 1 $\Theta$; 4.V.1964, 1 $\Theta$; V.1965, 1 $\Theta$; 21.V.1966, 1 $\Theta$; 11.IX.1968, 1 $\Theta$; 7.V.1969, 2 $\Theta$; 27.V.1969, 1 $\Theta$.

Stenus (Nestus) angustus Casey. A species widely spread in the northeastern parts of North America. Known from Michigan. A: 4.V.1963, 1 $\Theta$; 31.VI.1963, 1 $\delta$, 1 $\Theta$; 4.IV.1967, 1 $\Theta$; 7.V.1969, 1 $\delta$, 1 $\varnothing$; 14.V.1969, 1 $\Theta$; 15.V.1969, 1 $\Theta$.

Stenus (Nestus) egenus Erichson. A species widely spread over North America and also known from Michigan. A: 31.VII.1963, 1 $\delta$, 1 $\Theta$; 11.VI.1967, 1 $\Theta$. C: 23.VII.1965, 1 $\delta$. E: 23.VI.1962, 3 $\delta$; 9.VII.1962, 1 $\Theta$. F: 1.VI.1962, 1 $\Theta$. Lapeer County, 1 mile S Lum, 30.VI.1964, 1 $\delta$.


Stenus (Nestus) colonus Erichson. A common North American species. A: 1.IV.1963, 1 $\delta$, 1 $\Theta$. 27.IV.1963, 1 $\Theta$; 31.VI.1963, 1 $\Theta$; 4.V.1964, 6 $\delta$, 3 $\Theta$; 7.V.1964, 2 $\Theta$. C: 25.V.1966, 1 $\delta$. Lapeer County, 1 mile S Lum, 30.VI.1964, 1 $\Theta$.

Stenus (Nestus) morio Gravenhorst. A widely spread holarctic species (Puthz, 1967a). A: 1.IV.1963, 2 $\delta$, 6 $\Theta$; 27.IV.1963, 4 $\delta$, 4.V.1963, 7 $\delta$, 13 $\Theta$; 7.V.1963, 3 $\delta$, 5 $\Theta$; 21.V.1963, 2 $\delta$, 3 $\Theta$; 31.VI.1963, 4 $\delta$; 15.VI.1963, 1 $\Theta$; 4.V.1964, 1 $\Theta$; 7.V.1964, 1 $\delta$, 3 $\Theta$; 7.VI.1964, 1 $\delta$, 2 $\Theta$; 21.VI.1965, 1 $\delta$; 21.VI.1966, 3 $\delta$, 3 $\Theta$; 27.VI.1966, 1 $\delta$, 1 $\Theta$; 20.VI.1966, 1 $\delta$; 4.IV.1967, 1 $\delta$; 21.V.1967, 1 $\delta$, 1 $\Theta$; 11.VI.1967, 2 $\delta$; 21.VI.1967, 2 $\delta$, 2 $\Theta$; 27.III.1968, 2 $\delta$, 3 $\Theta$; V.1968, 1 $\Theta$; 7.V.1969, 37 $\delta$, 20 $\Theta$; 15.V.1969, 2 $\delta$, 1 $\Theta$; 16.VI.1969, 1 $\Theta$; 15.V.1970, 1 $\varnothing$. Lapeer County, 1 mile S of Lum, 30.VI.1964, 1 $\Theta$. Macomb County, 1 mile E Romeo, 6.VII.1964, 1 $\delta$, 1 $\Theta$.


*Stenus (Nestus) brivioi* n. sp.

This new species belongs to the *canaliculatus-confusus* group and resembles—regarding the nearctic species—only *S. vinnullus* Cas., *S. caseyi* Puthz, *S. dolosus* Cas., and *S. sectilifer* Cas.

Because of general resemblance to the named species a short description and a detailed comparison is sufficient.

Black, shining, coarsely and densely punctate with a distinct but not long pubescence. Antennae with the first two segments blackish, rest dark brownish, club infuscated. Palpi with the first and the bases of the second and third segments yellowish, the rest infuscated. Legs blackish. Clypeus and labrum moderately densely pubescent.

Length: 3.3-3.8 mm.

Holotype $\delta$ and paratype $\varnothing$: Michigan: Maryglade College, E. of Memphis, Macomb County. (locality A), 11.III.1964 (male) and 4.V.1964 (female), C. Brivio leg.; $\delta$-paratype: Eagle Har., L.Sup., 4.7. (ex coll. Hubbard & Schwarz).

Measurements in microns: width of head: 977; average distance between eyes: 529; width of pronotum: 782; length of pronotum: 882; greatest width of elytra: 1200; greatest length of elytra: 1201; sutural length: 965; posterior tarsi: 165-100-88-82-206.
Male: Legs without spines. 8th sternite with a shallow but distinct, broad emargination in posterior eighteenth. 9th sternite with distinct and long apicolateral teeth which are not curved. 10th tergite broadly rounded. Edeagus (fig.1) with a median lobe completely different in shape from those of the related species.

Female: 8th sternite broadly rounded. Valvifer with a long apicolateral tooth and a smaller one apicomedially. 10th tergite broadly rounded. Spermatheca strongly sclerotized, consisting of a double coiled hose. In *vinnulus* Cas. the spermatheca seems to be smaller and less coiled.

The new species is distinguished from *S. caseyi* Puthz by smooth interstices of the abdominal punctuation (in *caseyi* they are reticulated), from *S. dolosus* Cas and *S. sectilifer* Cas. by very shallow and broad longitudinal furrows of the front (in the compared species the longitudinal furrows are deep and sharp) and the elytra which are less deep impressed. From *S. vinnulus* Cas. the separation is very difficult using only exosceletal characters: in the new species the pronotum is shorter and the punctuation of the fore parts is slightly coarser and denser. From all its relatives the new species is easily distinguished by the edeagus (*vinnulus* Cas.: fig.1, Renkonen 1935; *dolosus* Cas., *sectilifer* Cas. and *caseyi* Puthz: figs 2-4, Puthz 1971).

I dedicate the new species to its collector, the Father Carlo Brivio, with thanks for donating a paratype to my collection.


**Stenus (Tesnus) gratiosus** Casey. A species known from the northeastern parts of the U.S.A. A: 27.IV.1963, 1 ♂.


Stenus (Hypostenus) advena Casey. Distribution: see map in Sanderson, 1957. E: 9.VII.1962, 1 $\varphi$; 15.VII.1962, 1 $\varphi$.

Stenus (Hypostenus) rossi Sanderson. Distribution: see Sanderson, 1957. E: 15.VII.1962, 1 $\varphi$.

Stenus (Hypostenus) callosus Erichson. Widely spread over the eastern states; new for Michigan. B: 6.X.1962, 1 $\varphi$.

Stenus (Hypostenus) punctatus Erichson. One of the most common species in North America. A: 7.V.1962, 1 $\varphi$; 27.VIII.1963, 1 $\varphi$; 21.VIII.1966, 1 $\varphi$; 7.V.1969, 4 $\varphi\delta$; 17.VIII.1970, 1 $\varphi$. F: 5.V.1962, 2 $\delta\varphi$, 1 $\varphi$; 13.V.1962, 1 $\varphi$.

Macomb County, 1 mile E Romeo, 6.VI.1964, 1 $\varphi$.

Stenus (Hypostenus) insperatus n. sp.

This new species belongs to the arculus complex which is characterized by the shape of the 10 tergite. This is pointed into a small fork, about as in furcifer Puthz. (See fig. 129, Puthz 1965). Six species of this complex are known from the nearctic region (S. laetulus Cas., S. perforatus Cas., S. arculus Er., S. lutzi Notm., S. Caenicolus Notm., and S. nitescens Cas.) The seventh species, described below, resembles very closely the last four named species and can only be distinguished—at present!—by its edeagus. The reason for this intricate situation is found in general variability of the four named species.

Shiny, black, coarsely and moderately densely punctate, distinctly pubescent. Antennae reddish yellow, club infuscated. Palpi reddish yellow, third segment slightly infuscated. Legs reddish, apical portion of the femora brownish, basal fourth of tibiae yellowish or at least lighter than the rest of the tibiae. Clypeus and labrum moderately densely pubescent. 10th tergite with a distinct fork at apex.

Length: 2.6-3.2 mm.

Holotype $\delta$ and paratypes (3 $\delta\varphi$, 3 $\varphi\delta$): Michigan: Grand ledge (ex coll. Hubbard & Schwarz); paratypes (1 $\delta$, 2 $\varphi\delta$): Michigan (without further dates) (ex coll. Casey and coll. Hubbard & Schwarz); paratype (1 $\delta$): Iowa City, Iowa, 19.V., Wickham leg.; paratype (1 $\delta$): America borealis (ex coll. Kraatz); paratype (1 $\delta$): no patria but a red round label (ex coll. J. B. Smith). Females which probably belong to the new species but are not designated as paratypes: locality A: 11.III.1964, 2 $\varphi\delta$; 7.VII.1966, 1 $\varphi$, Brivio leg.; Cambridge, Mass., 2 $\varphi\delta$ (ex coll. Hubbard & Schwarz); Can(ada), 1 $\varphi$ (ex coll. Hubbard & Schwarz).

Measurements of the holotype in microns: width of head: 906; average distance between eyes: 482; width of pronotum: 753; length of pronotum: 751; greatest width of elytra: 1152; greatest length of elytra: 1034; sutural length: 823; posterior tarsi: 212-94-82-85-188.

The only certain distinguishing character which I know at present is the edeagus (fig.3). It is very small and narrow; the median lobe has a lancet-like shape.

The edeagus of arculus Er. (fig.45, Puthz, 1967b) and caeniculus Notm. (Fig.2) are completely different.

Regarding exoskeletal characters Stenus insperatus can be distinguished from S. nitescens Cas. (which was described and is only known from Florida and is probably a synonym of arculus) and arculus Er. by its length (both compared species are 3.3-4.2 mm long), from nitescens furthermore by denser punctation of the pronotum, from arculus by less dense punctation of the fore parts; from caeniculus Notm. only by its shorter body and the edeagus, and from lutzi Notm. (only known by the holotype from Florida)
Fig. 2. *Stenus caenicolus* Notm. (Keene Heights, Essex County, N.Y.): Ventral aspect of edeagus (slightly turned in microscopic slide and slightly simplified). Scale = 0.1 mm.

Fig. 3. *Stenus (Hypostenus) insperatus* n. sp. (paratype): Ventral aspect of edeagus (slightly turned in microscopic slide and slightly simplified). Scale = 0.1 mm.

by its shorter pronotum, coarser punctation of the fore parts and slightly shorter length. Some specimens of the new species have a very shallow groundsculpture on the elytra and the abdomen, but this character seems to be variable in the *arculus* complex s. str..

The holotype has been deposited in the U.S. National Museum, Washington; paratypes in the Deutsches Entomologisches Institut, Eberswalde, and in my collection.

**LITERATURE CITED**


**CHANGE OF NAME FOR THE JOURNAL OF THE MICHIGAN ENTOMOLOGICAL SOCIETY**

The first four volumes of the Journal of the Michigan Entomological Society appeared under the name of *The Michigan Entomologist*. Beginning with Volume 5, Number 1 the Journal will be published as *The Great Lakes Entomologist*. This change of name is intended to reflect better the varied interests of the membership of the Society.
A LIFE HISTORY STUDY OF CAECILIUS AURANTIACUS (HAGEN) (PSOCOPTERA: CAECILIIDAE)

R. Scott Dunham
Department of Biology, Illinois Central College, East Peoria, Illinois 61611

Caecilius aurantiacus is a common, widely distributed psocid in well established forested areas of North America. Published information on this species is fragmentary and limited primarily to taxonomy. This paper is a description of the habits and biology of this small, little known, but common insect. Of the 212 named species in the genus Caecilius (Smithers, 1967), the bionomics of only Caecilius manteri have been published.

METHODS

Most specimens used in this study were collected in the timber west of Funks Grove, McLean County, Illinois. A few were collected at Gull Lake Biological Station of Michigan State University at Hickory Corners, Michigan. Dr. Edward Mockford, of Illinois State University, collected a male and returned it alive to Illinois from a collecting trip to Florida.

Collections were made during the months when the trees were leafed out by beating living branches over an inverted umbrella. The undersides of both green leaves and dried leaves on hanging branches were also individually searched. During the spring and fall months, collecting in leaf litter was accomplished by placing the fallen leaves in a leaf litter sieve and beating it over an open umbrella. Both adults and nymphs were collected from the umbrella with a camel hair brush and placed in vials.

Laboratory cultures were kept in three dram vials (19x65 mm) in which food was placed. Each vial was then plugged with cotton. The food consisted of three parts by volume of dried yeast (Red Star Brand) mixed with one part ground guinea pig chow. Other brands of yeast seem to be unpalatable for cultures soon died out when they were used. This is perhaps due to preservatives which were added to the yeast. This mixture was moistened to a thick watery consistency and spread on small strips of paper (about 10x25 mm). Although other types of paper were sometimes used, 16 or 18 pound weight typing paper was most satisfactory. The strips of paper with the food spread on them were changed about every two days. If longer periods of time were used before replacement, mold would tend to become abundant and the cultures would start to die out. A mold inhibitor, 0.5% propionic acid, was mixed in the food to control this problem but the psocids refused to eat the new mixture. Immediately after hatching, special care was taken to see that the food source was in contact with the side of the vial and near the top of the vial. The young nymphs move to the top of the vial and remain there after hatching. If food is not in the area, they soon starve. Small portions of dried maple or oak leaves (about 15x40 mm) were also placed in the vials as a more natural substrate and food source. The vials were kept in a second closed container in which wet paper toweling was present. This maintained a high relative humidity at all times.

In all cases, except those which are indicated otherwise, cultures were kept at room temperature. For controlled temperature environments, cultures were kept in a small styrofoam cooler. The cooler was equipped with a small appliance light bulb for a source of heat and placed in a refrigerator. A maximum-minimum thermometer was used to keep temperature records.

Observations were made by watching the psocids in the culture vials under a stereoscopic dissecting microscope.

DEVELOPMENT

EGG STAGE.—The eggs are oblong with rounded ends and slightly curved sides. The surface is smooth and shiny. When first laid, the eggs are milk white in color but after 24 to 36 hours the dorsal surface becomes bluish gray. The ventral surface and an irregular U-shaped area at the anterior end remain light gray. Width and length were measured for 50 eggs selected at random (Table 1).
Table 1. Length and greatest width of eggs of *Caecilius aurantiacus*.

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>50</td>
<td>0.29</td>
<td>0.19</td>
<td>0.23</td>
<td>0.024</td>
</tr>
<tr>
<td>Length</td>
<td>50</td>
<td>0.55</td>
<td>0.40</td>
<td>0.48</td>
<td>0.038</td>
</tr>
</tbody>
</table>

Embryonic development was not observed except to note the appearance of the embryo's eyes four to six days after the eggs were laid. The position of the eyes and body position at the time of hatching indicate that the embryo develops on its back. The embryonic exuviae left with the egg after hatching show the presence of an enveloping embryonic membrane. Hatching usually began in seven days when the eggs were kept at 70°F and in about six days at 75°F.

**HATCHING.**—The first observable indication of hatching is a slight lengthening and distortion of the anterior end of the egg. The head of the embryo appears to push its way by internal pressures through the egg. The head is pressed against the chorion and vitelline membrane, stretching the chorion until it gradually gives way to the pressure as the head emerges. The chorion does not appear to be cut by the egg burster or to split along a weakened line or ridge.

![Fig. 1-2. Oviruptor of *Caecilius aurantiacus*. Fig. 1, dorsal view; Fig. 2, lateral view.](image)

The egg burster (Fig. 1,2) is composed of three rib-like thickenings containing rows of small serrate teeth or spines and is situated above the frons, extending from about the eye level to the posterior border of the clypeus. Wachter (1925) and Pearman (1928) described the cutting of the chorion by the pulsating egg burster. Noting that the development of the egg burster was inside the embryonic membrane, Sommerman (1943a, b, c) believed the chorion and vitelline membrane split along a weakened anterior ridge to form a lid-like opening and the egg burster was used to puncture the embryonic membrane.

Wachter (1925) observed a direct relation between the movements of the egg burster and the accumulation of air in the digestive tract and proposed that the egg burster aided in the swallowing of air. The swallowing of air in *C. aurantiacus* appears to be more closely related to the action of a pulsatory area situated immediately behind the middle of the frons. The movement of air into the digestive tract and the movements of the pulsatory area continue after the egg burster is shed. The relationship between the egg burster and the movement of air is more likely due to the role the pulsatory area plays in the operation of the egg burster. The operation of the egg burster by the pulsatory area was described by Pearman (1928).

Internal pressures created by the swallowing of air and possibly muscular action slowly push the embryo into an erect position over the egg. In the erect position, only a small portion of the abdomen is left in the chorion. With the embryo in the erect
position, the embryonic membrane splits and is worked down over the body freeing the antennae and legs. This process is aided by an arching and backward bending of the body. When the last pair of legs is removed, the body is almost horizontal with the venter up. The legs are waved in the air and the body arched upward until the nymph can grasp the egg shell. By this time the legs are dried and hardened. The nymph pulls the remaining portion of the abdomen from the chorion. Fifteen to 20 minutes are generally required to complete hatching. Following the hatching process, the nymph usually remains quiet for a short time while the abdomen contracts to a normal length.

The embryonic membrane and egg burster are left protruding from the chorion.

NYMPHAL STAGES.—The number of nymphal instars was determined by rearing newly hatched nymphs in isolation. The nymphs of many psocids eat their exuviae after molting, but this is not true of *C. aurantiacus*. The presence of exuviae made it very convenient to count the number of nymphal instars and to determine the duration of nymphal instars. The number of nymphal instars is six. The duration of each instar is indicated in Table 2.

Nymphs are pale yellow in color. There is usually a slight darkening of the body color with the aging of the nymphs. The wing pads of the sixth instar nymph darken a few hours before molting the adult stage. The only other coloration found in the nymphal stage is the darkening of the ocellar triangle in the sixth instar. This pigmented area is also found in the adult. Nymphs collected during the first generation in leaf litter and those collected late in the fall, also in leaf litter, are usually darker and more dull yellow than those collected during the summer months. The dull, darker yellow color generally lightens with later instars when nymphs in early instars are taken in the field and reared in the laboratory.

Recognition of various instars can be accomplished by observing antennal segmentation and wing pad development. The antennae of the first instar are relatively much shorter than those of later instars. First-instar nymphs have eight antennal segments; second-instar nymphs have 12, and those of third instar have 12 distinct segments with the first flagellar segment faintly divided. This division becomes complete at the molt to fourth instar, and all subsequent instars have 13 antennal segments. Measurements of the first flagellar segment (Table 3) reflect its division by showing a reduction in its length immediately following the third instar. Sommerman (1943a) found the first flagellar segment faintly divided in the second nymphal instar of *Caecilius manteri*.

Wing pads do not appear until the third instar. Wing pad size, shape, and position makes each instar readily recognizable. Drawings of each instar of *C. manteri* have been published by Sommerman (1943a). These drawings show close similarity to comparable stages of *C. aurantiacus*.

Table 2. Duration in days of stages in the life cycle of *Caecilius aurantiacus* at 72°F, relative humidity near saturation, and fresh food provided every 48 hours.

<table>
<thead>
<tr>
<th>Instar number</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of psocids to reach instar</td>
<td>30</td>
<td>27</td>
<td>27</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>Minimum days to reach instar</td>
<td></td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Maximum days to reach instar</td>
<td></td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Mean No. of days to reach instar</td>
<td></td>
<td>2.7</td>
<td>5.2</td>
<td>7.7</td>
<td>10.2</td>
<td>13.0</td>
<td>15.6</td>
</tr>
<tr>
<td>Mean stadal length</td>
<td>2.7</td>
<td>2.5</td>
<td>2.5</td>
<td>2.4</td>
<td>2.8</td>
<td>2.6</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 3. Measurements (mm) of indicated structures of laboratory-reared individuals of *Caecilius aurantiacus*. N = 10 in each case.

<table>
<thead>
<tr>
<th>Instar Number</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length of 3rd segment of antenna</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Minimum</td>
<td>.06</td>
<td>.09</td>
<td>.13</td>
<td>.09</td>
<td>.15</td>
<td>.23</td>
<td>.38</td>
</tr>
<tr>
<td>Maximum</td>
<td>.08</td>
<td>.10</td>
<td>.17</td>
<td>.12</td>
<td>.19</td>
<td>.29</td>
<td>.47</td>
</tr>
<tr>
<td>Mean</td>
<td>.07</td>
<td>.10</td>
<td>.14</td>
<td>.11</td>
<td>.17</td>
<td>.26</td>
<td>.42</td>
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<tr>
<td>S.D.</td>
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<td>.004</td>
<td>.013</td>
<td>.009</td>
<td>.012</td>
<td>.018</td>
<td>.025</td>
</tr>
<tr>
<td><strong>Length of posterior tibia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>.14</td>
<td>.20</td>
<td>.26</td>
<td>.34</td>
<td>.41</td>
<td>.61</td>
<td>.77</td>
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<tr>
<td>Maximum</td>
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<td>.32</td>
<td>.29</td>
<td>.57</td>
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<td>.29</td>
<td>.36</td>
<td>.48</td>
<td>.65</td>
<td>.84</td>
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<tr>
<td>S.D.</td>
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<td>.009</td>
<td>.018</td>
<td>.016</td>
<td>.046</td>
<td>.025</td>
<td>.039</td>
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<tr>
<td><strong>Minimal distance between eyes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
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<td>.24</td>
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<td>.15</td>
<td>.20</td>
<td>.26</td>
<td>.26</td>
<td>.32</td>
<td>.35</td>
<td>.41</td>
</tr>
<tr>
<td>Mean</td>
<td>.14</td>
<td>.19</td>
<td>.23</td>
<td>.25</td>
<td>.28</td>
<td>.32</td>
<td>.37</td>
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<tr>
<td>S.D.</td>
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<td>.008</td>
<td>.016</td>
<td>.009</td>
<td>.020</td>
<td>.021</td>
<td>.017</td>
</tr>
<tr>
<td><strong>Length of forewing or forewing-pad</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>–</td>
<td>–</td>
<td>.08</td>
<td>.19</td>
<td>.36</td>
<td>.70</td>
<td>2.30</td>
</tr>
<tr>
<td>Maximum</td>
<td>–</td>
<td>–</td>
<td>.12</td>
<td>.26</td>
<td>.43</td>
<td>.84</td>
<td>2.53</td>
</tr>
<tr>
<td>Mean</td>
<td>–</td>
<td>–</td>
<td>.10</td>
<td>.21</td>
<td>.38</td>
<td>.78</td>
<td>2.45</td>
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<tr>
<td>S.D.</td>
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<td>–</td>
<td>.010</td>
<td>.017</td>
<td>.023</td>
<td>.038</td>
<td>.073</td>
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<tr>
<td><strong>Total body length</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>.66</td>
<td>.93</td>
<td>1.04</td>
<td>1.32</td>
<td>1.55</td>
<td>1.88</td>
<td>2.07</td>
</tr>
<tr>
<td>Maximum</td>
<td>.79</td>
<td>.98</td>
<td>1.32</td>
<td>1.47</td>
<td>1.78</td>
<td>2.24</td>
<td>2.42</td>
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<tr>
<td>Mean</td>
<td>.73</td>
<td>.95</td>
<td>1.15</td>
<td>1.40</td>
<td>1.66</td>
<td>2.10</td>
<td>2.22</td>
</tr>
<tr>
<td>S.D.</td>
<td>.040</td>
<td>.018</td>
<td>.057</td>
<td>.046</td>
<td>.072</td>
<td>.115</td>
<td>.108</td>
</tr>
<tr>
<td><strong>Number of segments in antenna</strong></td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 3 contains measurements taken from live nymphs and adults to indicate growth rate and various morphological changes from instar to instar. The size ratio for minimal distance between eyes for adjacent instars varies 1.37 (between first and second) to 1.09 (between third and fourth), thus departing rather markedly from Dyar's rule.

**ECDYYSIS.**—The process of ecdysis was observed in the third, fifth, and sixth instars. Most of the observations closely paralleled those of Pearman (1928).

In her studies of *Caecilius manteri*, Sommerman (1943a) noted that nymphs seem to return to the same general area to molt. Nymphs of *Caecilius aurantiacus* appear to return to about the same location as for previous molts before becoming inactive in preparation for the next molt. This preference of molting sites is probably due only to the availability of suitable sites in the small culture chambers. The period of inactivity before molting varies in duration from only a few minutes to, and one case, over one hour.
The first visible signs of molting are the contractions of the abdomen and the lowering of the head. The contractions occur at the rate of 10 to 20 per minute. The only other observable movement is a periodic movement of the mouth parts. Air bubbles can be seen moving in the abdomen. As molting begins, the abdomen extends, the thorax begins to raise, and the head position lowers. The old cuticle splits along the top of the head and thorax as the thorax is arched upward. The old cuticle is then worked over the head, over the sides of the thorax and down the abdomen. As the head is freed, it is straightened, freeing the antennae and the first two pairs of legs. The hind legs are the last to be freed and appear to be the most difficult to remove. If they are not freed within a short time, they dry in the old cuticle. Nymphs have been seen dragging their exuviae, attached by the hind leg, after ecdysis was completed. This problem is probably more acute in the laboratory where the atmosphere is drier than in nature.

After all the legs and the antennae are freed, the psocid remains suspended by the tip of its abdomen keeping the legs extended. The legs, while suspended, are waved and from time to time seem to vibrate as they are exercised and strengthened. While the legs are drying, the wing pads expand to the length typical of the new instar. Within two or three minutes the insect starts testing the new legs by gradually touching the tarsi to the substrate and lifting them. When the legs are completely dry, all legs are placed on the substrate and the nymph walks out of the remaining exuviae. During all this time air bubbles can be seen moving in the abdomen. About ten minutes are required to complete the entire molting process. The newly molted nymph generally remains rather inactive for several minutes before continuing normal activities.

ADULT STAGE.—The final molt is very much like the five previous molts. Four to five hours before the sixth instar molts the wing pads darken to a yellowish brown. Unlike the expansion of wing pads in earlier molts, the wings are expanded after the adult has completely freed itself from the exuviae. Ten to 15 minutes are needed to expand and straighten the wing pads to their normal adult length. A newly emerged adult is pale yellow and requires from 24 to 48 hours to acquire full adult coloration. During this time there is a continual darkening of the pale yellow body color until it has reached a bright yellow or in some cases more of a brownish yellow. The adult also acquires several distinct dark brown markings on the head, antennae, thorax, and wing veins during the first 24 hours after ecdysis. These markings have been described by Mockford (1965). The occurrence of the markings follows a definite sequence:

1) The posterior ends of veins R_2+3, R_4+5, M_1, M_2, M_3+4, and Cu_{13} darken. The darkening of these veins occurs in about three hours.
2) In about five hours, the markings on the dorsal surface of the thorax start to appear. These markings continue to darken for about 48 hours.
3) The anterior margin of the anal region begins to darken in about 12 hours.
4) Head markings start to appear and the antennae start to darken in about 15 hours.

EFFECT OF TEMPERATURE ON COLORATION.—The above sequence is based on observations following the final molt of the psocid kept at a temperature of 70°F. Although timed observations were not made at other temperatures, the darkening appears to be more rapid and intense when the psocid is reared in a cooler environment. When temperatures averaged above 72°F, the body remained much lighter and the only markings to occur were those on the outer margin of the wing. Adults reared in the laboratory at approximately 75°F lack much of the dark coloration characteristic of field-collected specimens and those reared at approximately 70°F. These observations suggest that temperature plays an important role in the production of the body pigments.

The dark markings on the head, thorax and wings are much more prominent in adults collected in the field in early spring and late fall than in summer-collected adults. Similar observations were made on the nymphal states. It was also noted that specimens from Alaska and other northern areas were more darkly pigmented than those from more southern areas.

PARTHENOGENESIS.—The distribution of bisexual and male-less populations of this species was discussed by Mockford (1971). Males occur primarily in the geographically peripheral populations. In Illinois only three males have been found. During five years of
collecting this species at Funks Grove, Illinois, I have never collected a male. A laboratory strain from Funks Grove has been maintained for 17 generations without the appearance of a male.
On one occasion, a male was collected in Florida by Dr. Edward Mockford and returned to Illinois. When this male was introduced to females in the laboratory culture, the females exhibited a completely negative response to the presence of the male. Females of various ages were placed with the male but always with the same result.

OVIPosition.—Egg laying generally begins two to three days after the adult stage is reached. Once a female starts egg laying, one cluster per day is usually laid until her death. During this time 100 or more eggs are usually laid (Table 4). Eggs are laid in clusters with numbers ranging from 2 to 23 per cluster. Although the mean number of eggs per cluster is much higher, eight is the most common number (Fig. 3). The number of ovarioles present in different members of the family Caeciliidae is six, eight, or ten (Wong and Thornton, 1968). My observations of the internal morphology of *C. aurantiacus* showed the ovariole number of this species to be eight. Therefore, more than one mature egg per ovariole must be present at the time of oviposition.

Table 4. Summary of data on duration of adult life, pre-oviposition period, and oviposition for females of *Caecilius aurantiacus* collected in the stages indicated from Funks Grove, Illinois.

<table>
<thead>
<tr>
<th></th>
<th>Days lived as adult</th>
<th>No. Days to lay 1st eggs</th>
<th>No. egg clusters</th>
<th>Total No. eggs laid</th>
<th>Av. No. eggs per cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collected as an adult (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>22</td>
<td>–</td>
<td>17</td>
<td>216</td>
<td>12.8</td>
</tr>
<tr>
<td>Low</td>
<td>7</td>
<td>–</td>
<td>5</td>
<td>34</td>
<td>6.5</td>
</tr>
<tr>
<td>Mean</td>
<td>16</td>
<td>–</td>
<td>12</td>
<td>119</td>
<td>9.9</td>
</tr>
<tr>
<td>S.D.</td>
<td>4.4</td>
<td>–</td>
<td>3.5</td>
<td>59.5</td>
<td>2.48</td>
</tr>
<tr>
<td>Collected in the 6th instar (20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>21</td>
<td>5</td>
<td>14</td>
<td>229</td>
<td>17.2</td>
</tr>
<tr>
<td>Low</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>33</td>
<td>6.2</td>
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<tr>
<td>Mean</td>
<td>16</td>
<td>3</td>
<td>11</td>
<td>115</td>
<td>10.5</td>
</tr>
<tr>
<td>S.D.</td>
<td>3.5</td>
<td>–</td>
<td>2.8</td>
<td>38.8</td>
<td>3.55</td>
</tr>
<tr>
<td>Collected in the 4th and 5th instar (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>19</td>
<td>3</td>
<td>17</td>
<td>212</td>
<td>16.6</td>
</tr>
<tr>
<td>Low</td>
<td>11</td>
<td>1</td>
<td>7</td>
<td>69</td>
<td>8.6</td>
</tr>
<tr>
<td>Mean</td>
<td>15</td>
<td>2</td>
<td>11</td>
<td>138</td>
<td>12.5</td>
</tr>
<tr>
<td>S.D.</td>
<td>2.9</td>
<td>–</td>
<td>4.4</td>
<td>51.6</td>
<td>2.29</td>
</tr>
</tbody>
</table>

The number of eggs laid and the average number of eggs per cluster seemed to vary with the stage in the life cycle in which the psocid was collected (Table 4). Females collected as adults, during the sixth instar and during the fourth and fifth instars, when brought into the laboratory, averaged 9.9 (adults), 10.5 (sixth instar), and 12.5 (fourth and fifth instars) eggs per cluster. The means obtained from those collected as adults and those collected in the fourth and fifth instars lumped together were compared, using the "t" test. A "t" value of 2.3 (17 d.f.) was obtained, which is significant at the 5% level. The length of time required for these psocids to become adapted to the laboratory environment or the presence of larger quantities of food during development in cultures than in the natural environment could account for these differences.

The eggs are laid in crevices or along the veins on the undersides of leaves. If the leaves are dried and curled, eggs are laid mostly on the inner surfaces. In laboratory cultures, most eggs are laid on dried leaves rather than the paper on which food is placed. On occasion, eggs are laid on the glass surface of the culture vials.
A female about to oviposit walks nervously over a small area on which the eggs will be laid. During this time the abdomen is being contracted and extended in a pumping action probably orienting the eggs into laying position. As the egg starts to emerge, the tip of the abdomen is pressed down, the egg deposited, and then the abdomen raised. Fifteen to 20 minutes are generally required to lay a cluster of eggs. Immediately after the last egg is laid, the process of covering the eggs with webbing begins. The female rapidly moves her head back and forth over the eggs touching the labium to the leaf until the cluster is covered with a dense layer of webbing. The precise origin of the webbing was not observed. Ten to 15 minutes are generally required to cover a cluster. There are seldom more than two or three pauses for rest during the process.

The webs seem to help hold the eggs in place. The webs are firmly attached to the leaf surface, and also adhere to the eggs. With care, a web can be removed intact with eggs stuck to it. The webbing appears to offer little protection from predators. Mites were observed under the webbing and on occasions traces of egg masses were found where predators had stripped away the webbing. Parasitic mymarid wasps were also observed moving through the dense webbing, presumably to oviposit in the psocid eggs.

Laboratory specimens fed primarily yeast many times lack the ability to web eggs. On one occasion, after laying her last egg, a female went through the motions of webbing her eggs for ten minutes without leaving a single strand of silk.

DIAPAUSING EGGS.—Eggs collected in the field in late September and October frequently would not hatch when placed under normal laboratory conditions. These eggs appear to be in winter diapause and will be referred to as diapausing eggs in the following discussion.

On October 12, 1968, a large number of egg clusters were brought into the laboratory. Of these, all eggs hatched in eight clusters including 78 eggs; one egg hatched in each of three clusters including 33 eggs; no eggs hatched in 11 clusters including 106 eggs. The eggs which did not hatch remained normal in appearance.

The production of diapausing eggs by females collected in late September and October varied with the state of development of the female at the time of its capture. Some females captured as adults laid diapausing eggs for the remainder of their lives, while in others only the first cluster or two laid in the laboratory diapaused. Some females reared from nymphs collected in the sixth instar laid diapausing eggs in their first cluster after becoming adult, while their subsequent egg clusters hatched normally. Others laid all normal eggs from the beginning. Females reared from nymphs collected in lower instars never laid diapausing eggs.

Attempts to break this presumed diapause by using various cold temperatures over different time periods were largely unsuccessful. Only a few treated eggs showed sporadic hatching. Experiments designed to produce adults which would lay diapausing eggs, by altering temperatures during rearing to adult stage were also unsuccessful. Attempts to control the photoperiod to which eggs were subjected were not undertaken but the importance of light in the breaking of diapause in eggs seems unlikely since the eggs are normally found overwintering buried in the leaf litter.

BEHAVIOR

WEBBING.—Both nymphs and adults spin very fine strands of webbing which are sparsely spread above the feeding surface. Nymphs in the second instar and possibly the first instar have the ability to spin webs.

Webbing was never observed in the natural environment but was common in laboratory-reared specimens. The large grazing area and low population concentration may account for the lack of visible webbing in the natural environment.

The loose webs appear to serve the purpose of helping to keep the feeding surface clean. Fecal material and dead specimens were common in the webbing. Dead specimens were always young nymphs and probably the result of the individual becoming caught in the webbing and not being able to escape. The webbing is so sparsely spread that it is improbable that it could offer any protection. C. aurantiacus appears to lack the ability
to detect vibrations in the web as was observed in *Archipsocus floridanus* by Mockford (1957). All attempts to stimulate a reaction in nymphs by disturbing the web failed.

**FLIGHT**.—On several occasions in the laboratory and in the field, an adult would try to escape by flying. Although the wings of *C. aurantiacus* are well developed, its flight is rather weak. Very seldom would the psocid fly more than one or two feet before landing.

On no occasion did any individuals appear to be attracted to the lights in the room, although records of psocids being attracted to night lights are common in the literature (Mockford, personal communication). Mockford (1962) observed *Archipsocus frater* flying rapidly around the light of a desk lamp. *C. aurantiacus* males have been collected at night lights in Georgia.

**USE OF “ABDOMINAL BLISTERS”**.—Located on the ventral surface of the abdomen are two expandable swellings, the “abdominal blisters”, one between the fifth and sixth and other between the sixth and seventh segments. These structures secrete a moist, probably sticky, substance and can be protruded to come into contact with the substrate. The blisters aid the psocid in holding its position on a leaf when the leaf is moving. The use of these blisters was observed by tapping the side of a culture vial when the psocid was walking upside down on the glass. Each time the vial was tapped, the psocid dipped its abdomen so that it touched the surface. Contact of the blisters on the glass was noted by the moisture on the glass. The presence of the abdominal blisters is common among those psocids whose habitat is green leaves (Mockford, personal communication).

**ECOLOGICAL OBSERVATIONS**

**GENERAL RANGE AND HABITAT**.—*Caecilius aurantiacus* is found throughout the eastern half of the United States, across Canada to the Pacific Coast, along the coast from Oregon to southern Alaska, in eastern Mexico and the highlands of southern Mexico (Mockford, 1965).

This psocid can be collected on the foliage of broad-leaved trees and shrubs in well established wooded areas. It is most common on green leaves of Sugar Maple (*Acer saccharum* Marsh), Pawpaw (*Asimina triloba* Dunal), and Oak (*Querus* spp.). It can also be found on dried leaves. The first generation lives in the ground leaf litter.

**ECOLOGICAL RELATIONSHIP TO OTHER PSOCIDS**.—Two other species of psocid, *Caecilius sommermanae* Mockford, and *Polypsocus corruptus* (Hagen), have been collected feeding on the same leaves as *C. aurantiacus*. The life cycles of these three species seem to parallel each other and they appear to feed on the same material. Although a detailed study of the ecological relationships of these species is not available at this time, they appear to occupy the same ecological niche. Observations contrary to this idea have been made but whether these species avoid inter-specific competition is questionable. *C. aurantiacus* and *P. corruptus* lay eggs in clusters with webbing over the eggs, *C. sommermanae* lays eggs singly and with no webbing. The webbing covering the eggs of *C. aurantiacus* completely covers the eggs while the eggs of *P. corruptus* are only loosely covered by webbing. *C. sommermanae* is much more active than the other two species. *P. corruptus* is generally more gregarious than the others. *C. aurantiacus* is parthenogenic, while males are present in both *P. corruptus* and *C. sommermanae*.

**LIFE CYCLE**.—*Caecilius aurantiacus* can be collected in adult or nymphal stages in central Illinois between May 1 and November 1. The first generation hatches and matures in the ground leaf litter. When the adult stage of the first generation is reached in mid-to late May, the trees are fully leafed and the adults migrate from the ground leaf litter to the green leaves in the trees or to dried leaves on broken, hanging branches. All summer and early autumn generations are on the foliage. The insects fall to the ground with the leaves in late autumn. The latest date that these psocids can be collected is determined by the first hard freeze or snow fall. The latest collection dates at Funks Grove, Illinois, were November 10, 1964 (fourth and fifth-instar nymphs and adults) and November 8, 1965 (adults—none found on November 14). On November 21, 1966, numerous frozen adults in good state of preservation were found following a snow fall the night before.
Table 5. Two years' collecting data for *Caecilius aurantiacus* at Funks Grove, Illinois, indicating probable generations.

<table>
<thead>
<tr>
<th>Date</th>
<th>Stages</th>
<th>Generation No.</th>
<th>Date</th>
<th>Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td></td>
<td></td>
<td>1965</td>
<td></td>
</tr>
<tr>
<td>1 May</td>
<td>2nd &amp; 3rd instars</td>
<td>1</td>
<td>May 8</td>
<td>2nd &amp; 3rd instars</td>
</tr>
<tr>
<td>16 May</td>
<td>5th &amp; 6th instars</td>
<td></td>
<td>May 16</td>
<td>5th &amp; 6th instars</td>
</tr>
<tr>
<td>22 May</td>
<td>Adults</td>
<td></td>
<td>May 22</td>
<td>Adults</td>
</tr>
<tr>
<td>1 June</td>
<td>Eggs</td>
<td>2</td>
<td>June 5</td>
<td>Eggs</td>
</tr>
<tr>
<td>10 June</td>
<td>2nd instars</td>
<td></td>
<td>June 10</td>
<td>2nd instars</td>
</tr>
<tr>
<td>16 June</td>
<td>3rd, 4th, &amp; 5th instars</td>
<td></td>
<td>June 16</td>
<td>3rd, 4th, &amp; 5th instars</td>
</tr>
<tr>
<td>24 June</td>
<td>6th instars</td>
<td></td>
<td>June 24</td>
<td>6th instars</td>
</tr>
<tr>
<td>5 July</td>
<td>Adults, eggs</td>
<td></td>
<td>July 5</td>
<td>Adults</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Aug</td>
<td>5th &amp; 6th instars</td>
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<td>17 Aug</td>
<td>4th, 5th, &amp; 6th instars</td>
<td>4</td>
<td>Oct. 2</td>
<td>All stages</td>
</tr>
<tr>
<td>19 Aug</td>
<td>5th &amp; 6th instars and adults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 Aug</td>
<td>Same</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Sept</td>
<td>6th instar &amp; adults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Oct</td>
<td>Adults</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Nov</td>
<td>Adults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Nov</td>
<td>Adults</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Collecting data (Table 5) indicate four distinct generations and a probable fifth during one season in central Illinois. The length of a generation in nature is apparently greater than for specimens reared in the laboratory. The second generation at Funks Grove, Illinois, in 1965 required between 37 and 41 days, while an average laboratory generation at 72°F requires 25 days. Seven generations can be reared in the laboratory during the growing season for this species in central Illinois.

FOOD.—The digestive tracts of several adults were removed and squashed between a microscope slide and cover slip for microscopic observation of materials eaten. The gut samples consisted primarily of fungal hyphae, fungal spores, and particles believed to be fragments of leaf epidermal cells.

PARASITES AND PREDATORS.—Two types of parasites infect psocids. The first of these is represented by several species of tiny mymarid wasps of the genus *Alaptus* which parasitize the eggs. *Alaptus caecili* Girault, has been observed emerging from the eggs of *Caecilius aurantiacus* on numerous occasions (Sommerman, 1943a, b). On several occasions *C. aurantiacus* eggs collected at Funks Grove, Illinois and Gull Lake, Michigan hatched as *A. caecili* instead of the expected psocid. On one occasion, newly emerged wasps were observed ovipositing in *C. aurantiacus* eggs laid in the laboratory. Broadhead and Wapshere (1966) have made a comprehensive study of psocid populations and the effects of mymarid wasps.

The second type of parasite is a hymenopterous larva which feeds on psocid nymphs and adults. The larva lives in the abdomen of the psocid. It emerges from the abdomen to spin its cocoon and the psocid dies. Although this parasite is not known in *C. aurantiacus*, Sommerman (1956) observed the larvae in nymphs of *C. sommermanae* Mockford. These larvae were believed to be braconid wasps.
Literature on the arthropod predators of psocids was reviewed by Broadhead (1958). Betts (1955) observed predation on psocids by titmice. The only predator which I have seen in the field feeding on C. aurantiacus was a crab spider (Thomisidae). Mites are very common on the leaves with the psocid. Many times the mites would become so abundant in the laboratory cultures that the psocid population would die out. These mites probably affected the psocid population more as competitors than as predators although mites and mite eggs were observed under the webbing of the psocid egg clusters.

ACKNOWLEDGMENTS

I wish to express my thanks to Dr. Edward L. Mockford of Illinois State University for his help in the identification of psocid species, the use of his psocid collection, and his helpful advice throughout this study including critical reading of the manuscript. I would also like to thank Dr. Roland L. Fischer of Michigan State University for his helpful criticism and advice in preparing the report on which this paper was based.

LITERATURE CITED

THE DISTRIBUTION OF SAPERDA INORNATA AND OBEREA SCHAUMII (COLEOPTERA: CERAMBYCIDAE) WITHIN THE CROWNS OF LARGE TREMBLING ASPEN, POPULUS TREMULOIDES

John C. Nord and Fred B. Knight

The larvae of Saperda inornata Say and Oberea schaumii LeConte inhabit the stems of trembling aspen (Populus tremuloides Michaux) root suckers and the twigs of larger trees. Nord et al. (1972a, 1972b) reported the biologies of these species in Upper Michigan and northern Wisconsin. S. inornata has a one or two year life cycle, probably depending on how early the egg is laid. Most (77.5%) O. schaumii develop in three years while 5.0% require only two years and 17.5% require four years to develop.

Knight (1963) described the distribution of galleries made by S. inornata and O. schaumii in the crowns of large trembling aspen, P. tremuloides, in Upper Michigan. Similar distribution data were gathered from 180 large trembling aspen felled in a survey designed to determine the relative abundance of S. inornata and O. schaumii in stands of different site quality (Nord and Knight 1972b). The analysis of that distribution data and comparisons with that of Knight (1963) are presented here. Inter- and intra-specific competition in light of the results and other behavioral information are discussed.

METHODS

The location of the study areas and the sampling procedure used were given by Nord and Knight (1972b). Galleries of S. inornata and O. schaumii were recorded by aspect, i.e. northeast, southeast, southwest, or northwest quadrant. All galleries except those found in the top branches, where aspect could not be designated, were included in the analysis of aspect. An analysis of variance was made to test for significant differences in numbers of galleries between aspects.

The galleries were recorded by their position in the crown, i.e. upper half or lower half of the living crown. Only currently active galleries or inactive galleries with egg niches that looked as though they had been made within the past two years for S. inornata and three years for O. schaumii were considered in the analysis of crown level. Old galleries were not considered because many of them located in the lower crown at the time of sampling, were in the upper half of the crown when the eggs were laid and, therefore, the position in the crowns at the time of oviposition could not be accurately ascertained for all. The differences in the number of galleries found in each crown level were analyzed with a t-test.

RESULTS AND DISCUSSION

DISTRIBUTION OF S. INORNATA GALLS WITHIN THE CROWNS

ASPECT.—Table 1 shows the number of S. inornata galls by aspect within the crowns of large trembling aspen. An analysis of the variance showed that there were no significant differences between the number of galls found in each of the four quadrants. Knight (1963) also found no significant differences between aspects.

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1Research partially supported by the North Central Forest Experiment Station, U.S. Forest Service, USDA. The field work was done on the Ottawa National Forest.
2USDA, Forest Service, Forest Sciences Laboratory, Carlton Street, Athens, Georgia 30601.
3School of Forest Resources, Nutting Hall, University of Maine, Orono, Maine 04473.
4Knight (1963) reported the species he studied as S. moesta LeConte. It was later considered to be S. inornata when it became apparent that the separation of S. moesta and S. concolor (=S. inornata) using the shape of the egg niche was untenable (Nord and Knight, 1972a) and reared specimens from P. tremuloides in the same study areas proved to be S. inornata.
Table 1. Total* number of *S. inornata* galls by aspect in the crowns of 180 large trembling aspen.

<table>
<thead>
<tr>
<th>Replication</th>
<th>(Site)</th>
<th>NE</th>
<th>SE</th>
<th>SW</th>
<th>NW</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>57</td>
<td>51</td>
<td>51</td>
<td>54</td>
<td>213</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>39</td>
<td>35</td>
<td>38</td>
<td>29</td>
<td>141</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>42</td>
<td>44</td>
<td>35</td>
<td>22</td>
<td>143</td>
</tr>
<tr>
<td>Total</td>
<td>–</td>
<td>138</td>
<td>130</td>
<td>124</td>
<td>105</td>
<td>497</td>
</tr>
</tbody>
</table>

*All galleries (old and current) except those in the top branch where aspect was not designated.

Table 2. Current *S. inornata* galls by crown level in 180 large trembling aspen.

<table>
<thead>
<tr>
<th>Area</th>
<th>Site</th>
<th>Lower Half</th>
<th>Upper Half</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>40</td>
<td>16</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>8</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>II</td>
<td>40</td>
<td>6</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>2</td>
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<td>4</td>
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<tr>
<td>III</td>
<td>40</td>
<td>8</td>
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<td>19</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>2</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>IV</td>
<td>40</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>11</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>–</td>
<td>65</td>
<td>84</td>
<td>149</td>
</tr>
</tbody>
</table>

CROWN LEVEL.—A t-test showed that there was no significant difference between the number of *S. inornata* galls found in the lower and upper half of the crown (Table 2). Knight (1963) found no significant differences between crown levels either. Considering these results and that new egg niches were found only in twigs ranging from 5-15 mm in diameter, it is concluded that *S. inornata* females oviposit in the periphery of the living crown without "preference" to crown level or aspect.

**DISTRIBUTION OF O. SCHAUMII GALLERIES WITHIN THE CROWNS**

ASPECT.—Table 3 shows the number of *O. schaumii* galleries by aspect within the crowns of large trembling aspen. An analysis of variance showed that there were no significant differences between the number of galleries found in each of the four quadrants. Unlike the results of Knight (1963) there was not a significant higher number of galleries in the south half of the crown.

CROWN LEVEL.—There were over five times as many *O. schaumii* ovipositions in the upper half of the crown as in the lower half (Table 4). A t-test showed the differences
Table 3. Total* number of *O. schaumii* galleries by aspect in the crowns of 180 large trembling aspen.

<table>
<thead>
<tr>
<th>Replication</th>
<th>(Site)</th>
<th>NE</th>
<th>SE</th>
<th>SW</th>
<th>NW</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>21</td>
<td>78</td>
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<tr>
<td>2</td>
<td>50</td>
<td>10</td>
<td>14</td>
<td>14</td>
<td>15</td>
<td>53</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>13</td>
<td>13</td>
<td>15</td>
<td>17</td>
<td>58</td>
</tr>
<tr>
<td>Total</td>
<td>–</td>
<td>42</td>
<td>46</td>
<td>48</td>
<td>53</td>
<td>189</td>
</tr>
</tbody>
</table>

*All galleries (old and current) except those in the top branch where aspect was not designated.

Table 4. Current *O. schaumii* galleries by crown level in 180 large trembling aspen

<table>
<thead>
<tr>
<th>Area</th>
<th>Site</th>
<th>Lower Half</th>
<th>Upper Half</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>40</td>
<td>4</td>
<td>24</td>
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<td>Total</td>
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<td>23</td>
<td>123</td>
<td>146</td>
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between the mean number of galleries in each crown level to be highly significant. Knight (1963) found no significant differences between crown levels for total counts of *O. schaumii*. The inclusion of old galleries may have been the reason for this finding for reasons stated above. The number of currently active galleries found by Knight (1963) was low, but most of them were found in the upper crown.

Considering the results of this analysis and that new egg niches were found only in twigs ranging from 5-13 mm in diameter, it is concluded that *O. schaumii* females tend to oviposit most often in the periphery of the upper crowns of large trembling aspen.

**INTER- AND INTRA-SPECIFIC COMPETITION.**—At first it appeared as if *S. inornata* and *O. schaumii* occupied very similar ecological niches, i.e. they both lived in the small stems of aspen suckers and in the twigs of larger trees. There was no evidence that one species oviposited more frequently on trees in a physiological state different from those that the other species “selected.” In fact they were often found in the same areas and on the same individuals. Therefore, it appeared as though there might be competition for space between the two species, and it could be an important factor in
the population dynamics of the insects. Intra-specific competition was also a possibility. A comparison of life cycles, behavior, distribution of the larvae within the host and other field observations indicated that, although there may be some overlapping of their ecological niches, competition was not important.

Most of the overlap in the ecological niches of *S. inornata* and *O. schaumii* seemed to occur during the first year of life for both species, and particularly among larvae living in the sucker stands. In sucker stands, the average age and diameter of oviposition sites was about the same for both species (Table 5). In large trees, although the average age of *O. schaumii* oviposition sites was about two years younger than that of *S. inornata*, the average diameter of oviposition sites was about the same for both species. However, *O. schaumii* oviposited more frequently (84%) in the upper half of the crown than *S. inornata* (56%). Therefore the overlap of their ecological niches was apparently not as complete in larger trees as it was in sucker stands. *O. schaumii* may have adapted to upper crown twigs because they grow more rapidly than those in the lower crown, and thus are more apt to be large enough to accommodate the large galleries of the late instars (Nord et al. 1972a).

Table 5. Comparison of the age and diameter of trembling aspen root sucker and tree twig internodes at the time of oviposition by *S. inornata* and *O. schaumii*.

<table>
<thead>
<tr>
<th>Species</th>
<th>Root Suckers</th>
<th>Tree Twigs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age (yrs.)</td>
<td>Diameter (mm.)</td>
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<tr>
<td><em>S. inornata</em></td>
<td>3.0</td>
<td>1-5</td>
</tr>
<tr>
<td><em>O. schaumii</em></td>
<td>3.0</td>
<td>1-6</td>
</tr>
</tbody>
</table>

In natural infestations, even in the highly infested patches of aspen and plantings of aspen hybrids, no egg niche (or multiple oviposition, in the case of *S. inornata*) was found close enough (11-18 cm) to that of the other species to create a competitive situation. Of course the low population levels of both species in relation to the great amount of space available reduced the chance that such competition would occur (Nord and Knight, 1972b). However, the fact that oviposition sites of the two species were never found in close proximity supports the hypothesis that something other than chance was operative in preventing the females from oviposition near each other. Inter-specific competition between first-year larvae may be prevented by a behavioral characteristic of the females when “selecting” an oviposition site.

It was evident that second year larvae of *S. inornata* and *O. schaumii* did not have to compete with newly hatched larvae of the same species or of the other species. New egg niche sites of both species tended to be farther out on the twig or stem than year-old egg niche sites probably because the latter had grown too large in diameter for oviposition during the intervening year. Twigs and stems containing third-year larvae of *O. schaumii* were even larger and thus farther removed from new egg niche sites. Furthermore, *O. schaumii* always extended its gallery downward into a section of larger diameter, thus the likelihood was small that a female of either species would oviposit during the succeeding year over a vulnerable portion of the *O. schaumii* gallery. It could be stated in another way: eggs of either species were not likely to be laid in a place where the newly-hatching larvae would have to compete with a mid- to late instar *O. schaumii* larva. Not infrequently an *O. schaumii* egg niche was made on the upper surface of a side twig within about five cm of the sucker stem. In that case the larva bored down the twig and into the stem which was usually much too large for new ovipositions.

Competition between offspring of the same female was prevented by the tendency of females to move to another sucker or branch after oviposition (Nord, et al. 1972a, 1972b). The low populations of both species, which were apparent during this study, and
the seemingly random movement of females throughout a stand reduced the chance of competition between offspring of different females of the same species. Competition between S. inornata larvae in a multiple oviposition is possible and some evidence of that was reported by Grimble and Knight (1970). The peripheral gallery of one larva often passed under the adjoining egg niches; but whether or not there was a live individual or gallery there before that happened could not be determined because the evidence was obliterated by the invading larva.

LITERATURE CITED


BOOK REVIEW


Seeing the appearance of this desirable reprint of “Noctuidae of North America” by Augustus R. Grote is like finding a long-lost friend on a country collecting trip. It is full of valuable lore relating to the pursuit and description of many new noctuid species of yesteryear. The four coloured plates depicting 45 species are reproduced with remarkable fidelity when compared with the originals. The pages of descriptive notes dealing with the Walker types of North American Noctuidae contained in the British Museum readily portray the keen competition coupled with criticism that was rampant with professional entomologists of that era. The feature entitled “A Colony of Butterflies,” to the memory of Thomas Say, points up the authors deep concern for the preservation of certain scarce species at that early date. A foreword was added to this reprinted edition. It is an excellent and most thorough biography of Grote by Ronald S. Wilkinson. Perhaps its greatest asset is that Dr. Wilkinson cites the reference used in compiling the biography, a practice which others should emulate. This reprint will serve as a treasured historic documentation to all students of lepidoptera, besides being a valuable addition to all entomological libraries.

John H. Newman
Department of Entomology
Michigan State University
East Lansing, Michigan 48823
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