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Eucnemid larvae of the Nearctic region. Part V: Fifth instar larval descriptions for eight species of *Microrhagus* Dejean, 1833 (Coleoptera: Eucnemidae: Melasinae: Dirhagini), with descriptions of four new species and notes on their biology

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Eucnemid larvae of the Nearctic region. Part V: Fifth instar larval descriptions for eight species of *Microrhagus* Dejean, 1833 (Coleoptera: Eucnemidae: Melasinae: Dirhagini), with descriptions of four new species and notes on their biology

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**Abstract.** Fifth instars for eight of the nine species of *Microrhagus* Dejean (Coleoptera: Eucnemidae: Melasinae: Dirhagini), all endemic in the Nearctic region, are described and illustrated. Biological information is provided, along with a brief discussion of the larval morphology among the eight Nearctic species of *Microrhagus*. Adult descriptions are provided for four new species. These new species include *Microrhagus breviangularis* **new species**, *Microrhagus carinicollis* **new species**, *Microrhagus lecontei* **new species** and *Microrhagus opacus* **new species**. A checklist and identification keys for both adults and most known larvae are provided.

**Key Words.** Dirhagini, *Microrhagus*, descriptions, new species, larval morphology, adult morphology, Nearctic region, Wisconsin.

## Introduction

This research, as part of an on-going series, was a culmination of eight years of field and lab work to identify larval types of *Microrhagus* Dejean 1833 through association with reared adults and to document their biology. Observations of subtle, yet compelling differences among the larvae examined—particularly shape, size and placement of areoles on the segments, as well as characteristics of prothoracic scleromes and microtrichial patches—resulted in closer examination of external morphology of reared adults within the group.

Those observations led to discovery of three undescribed *Microrhagus* species reared from larvae collected in northeastern and southern Wisconsin. Discovery of a fourth species resulted from comparison of holotype images of *Microrhagus audax* Horn provided by Robert Davidson of the Carnegie Museum with specimens in collections and on the Internet. Differences in pronotal exoskeleton, anterior lateral pronotal ridge, scutellum, and lateral shape at the apices of the hind angles revealed a undescribed species often misidentified as *M. audax*.

*Microrhagus* is a cosmopolitan and speciose group consisting of 121 extant species distributed largely in the subtropical and tropical regions of the world. Thirty-seven species are distributed from Mexico through South America (Blackwelder 1944; Cobos 1957, 1964). Seven other species are found along the eastern coast of the Australian continent (Calder 1998). Forty-four species occur in Southeast Asia, including a number of new species. Nine species are distributed across the African continent, including Madagascar and Mauritius (Cobos 1959; Fleutiaux 1945; Vinson 1958). Fifteen species are found in the Palearctic region from Great Britain to Japan (Kovalev 2013; Muona 2007). The remaining nine species are from North America, north of Mexico. *Microrhagus audax* Horn is an uncommon, widespread species frequently collected in the southern areas of the region. *Microrhagus brunneus* Otto was recently described from seven states. *Microrhagus pectinatus* LeConte is widespread across much of eastern United States and Canada, extending its range to the Pacific Northwest region. Both *Microrhagus subsinuatus* LeConte and *Microrhagus triangularis* (Say) are widespread across eastern United States and Canada. Four new species, *M. breviangularis*, *M. carinicollis*, *M. lecontei* and *M. opacus* are described from eastern United States. Muona (1993a) have recorded five undescribed, extinct species of *Microrhagus* from Eocene Baltic amber.

Much of the known biology was based on field observations or adults collected through various means. Larval information and biology were unknown until recently when I randomly selected rotten logs in search of larval Eucnemidae for future investigations.

The following account for eight *Microrhagus* species is the fifth paper in a long term series of papers (Otto 2012a, 2012b, 2013b, and 2014) covering descriptions of larval Eucnemidae in the Nearctic region, with notes on their biology.

## Materials and Methods

Rotten logs and limbs were randomly searched for presence of eucnemid larvae. When larvae were discovered, a small section of wood was removed to isolate the desired larval type from larvae of other eucnemid species found in different areas of the same log or limb. Representative larvae were collected from the wood and stored in empty plastic vials for preservation at a later time. Pieces of wood containing other larvae were placed in 3.8 L plastic Ziploc® bags with collection data written on the front side (Fig. 1). Some bags were placed outside in a large plastic bin for the winter season and moved indoors during the mid-winter thaw to break diapause. Bags were set aside and checked for emergence of associated adult beetles. Bags were left open for several days to dry out wood pieces to ensure undesirable mold did not appear on the surfaces, then bags were resealed after surfaces dried. When associated adults were discovered in the bag, pieces of wood were carefully examined for presence of other reared adults on surfaces and within the rotten sapwood (Fig. 2). Associated adults were stored in a plastic vial during examination of all wood pieces. All carefully examined pieces of wood were returned to the bag and monitored for additional adult specimens for the next two days. Wood was discarded after all adults were collected. Reared, associated adults were stored frozen in plastic vials until examination and curation.

Larvae were preserved by initial immersion in a hot water bath for 15–20 minutes. Dimensions of length and width were measured using a ruler. Length was measured from the mandibles to the apex of the ninth abdominal segment. Width was measured across the prothoracic region. All specimens were subsequently placed in labeled 1 dram vials filled with 70% ethanol for permanent storage.

Adult measurements were taken using a ruler. Length was measured from the apex of the head to the apex of the elytra. Width was measured across the humeri. Aedeagi were dissected following immersion of sectioned abdomen in KOH for three hours at a concentration of one tablet in 40 ml of water. Aedeagi were suspended in Germ-X® hand-sanitizer for imaging. The abdomen was secured on cardstock and pinned beneath the corresponding specimen. The dissected aedeagus was stored in a microvial filled with glycerin and pinned beneath the abdomen and corresponding specimen.

Larvae were suspended in Germ-X® hand-sanitizer during the imaging process. Adult, larval, and aedeagi images were taken with a JVC KY-F75U digital camera attached to a Leica® Z16 APO dissecting microscope with apochromatic zoom objective and motor focus drive, using a Synchroscope Auto-Montage® System and software. Imaged larval specimens were triple-rinsed with distilled water to remove any gel before being replaced in the vial.

Terminology of Muona & Teräväinen (2008) was used in descriptions of these larvae. An additional term, circumanal asperities, will be used to describe the shape of the outer line around the top of the anus. Numbering of lateral projections starts near the base of the head and concludes just before the mandibles. Mandibles are not included as lateral projections in the descriptions. Mandibular descriptions are provided separately. Adult descriptions follow the same format of Otto (2013a). Kovalev (2013) replaced the term clypeus with “epistomal part of epicranium”. Eucnemidae lack an epistomal sulcus, which would separate the clypeus from the frons below antennal insertions on the front, lower side of the head. Therefore, the term “frontolclypeal region” will be used instead of “clypeus” or “epistomal part of epicranium” in these descriptions.

Label data for holotypes and allotypes are reported verbatim; data are condensed for paratypes. Codens for collections in which types and larval specimens are deposited include:

FSCA — Florida State Collection of Arthropods, Gainesville, FL  
 GERP — Global Eucnemid Research Project, UW-Madison, Madison, WI  
 GSPC — Gareth S. Powell Collection, West Lafayette, IN  
 KESC — Kyle E. Schnepf Collection, Gainesville, FL  
 MCZ — Museum of Comparative Zoology, Harvard University, Cambridge, MA  
 RHTC — Robert H. Turnbow Collection, Fort Rucker, AL  
 SEMC — Snow Entomology Museum Collection, University of Kansas, Lawrence, KS  
 WIRC — University of Wisconsin Insect Research Collection, UW-Madison, Madison, WI

## Systematics

### Subfamily Melasinae Fleming, 1821

#### Tribe Dirhagini Reitter, 1911

#### Genus *Microrhagus* Dejean, 1833

**Diagnosis.** Characters of Dirhagini, with apical margin of frontolclypeal region trilobed and more than twice as wide as the distance between antennal sockets; well-developed notosternal antennal grooves present, usually with smooth surfaces; male prothoracic tarsomere I simple, with apical sex combs; metathoracic coxal plates medially 3.0–6.0 times wider than laterally; last visible ventrite either rounded or truncated; poorly defined deep hypomeral pits near prothoracic coxae; interrupted lateral pronotal ridges; lateral surfaces of mesothoracic and metathoracic tibiae with setae only; male aedeagus dorsoventrally compressed; lateral lobes bilobed and directed dorsocaudad; median lobe simple, deeply and widely bifurcate apically; flagellum complex and tubular.

#### Checklist of the species of Nearctic *Microrhagus* Dejean

##### *Microrhagus*

- pectinatus species group
  - pectinatus* LeConte, 1866
- subsINUATUS species group
  - subsINUATUS* LeConte, 1852
- audax species group
  - audax* Horn, 1886
  - opacus* Otto, **new species**
- brunneus species group
  - breviangularis* Otto, **new species**
  - brunneus* Otto, 2013
- carinicollis species group
  - carinicollis* Otto, **new species**
- triangularis species group
  - lecontei* Otto, **new species**
  - triangularis* (Say, 1823)

#### Key to the species of Nearctic *Microrhagus* (Adults)

1. Anterior lateral pronotal ridge elongate, longer than 1/3 the length of pronotum (Otto 2013a, Fig. 1) ..... **2**
- Anterior lateral pronotal ridge short, shorter than 1/3 the length of pronotum (Otto 2013a, Fig. 2) ..... **3**

2. Posterior lateral pronotal ridge short, shorter than 1/2 the length of pronotum (Muona 2000, Fig. 51) (pectinatus species group) ..... ***M. pectinatus* LeConte**  
 — Posterior lateral pronotal ridge elongate, longer than 1/2 the length of pronotum (Muona 2000, Fig. 54) (subsINUATUS species group) ..... ***M. subsINUATUS* LeConte**
3. Posterior lateral pronotal ridge short, up to 1/3 the length of pronotum (Muona 2000, Fig. 62) (audax species group) ..... **4**  
 — Posterior lateral pronotal ridge elongate, up to 3/4 the length of pronotum (Muona 2000, Fig. 58) ..... **5**
4. Pronotum finely punctate, shiny; lateral side of hind angles narrowly rounded apically; scutellum not elevated; anterior lateral pronotal ridge sinuous, ventrally bent (Fig. 3) ***M. audax* Horn**  
 — Pronotum coarsely punctate to rugose, dullish; lateral side of hind angles broadly rounded apically; scutellum slightly elevated; anterior lateral pronotal ridge directed posteriorly (Fig. 29) ..... ***M. opacus* new species**
5. Pronotal hind angles small (Fig. 4) (brunneus species group) ..... **6**  
 — Pronotal hind angles moderately sized (Fig. 5) ..... **7**
6. Antennae weakly to moderately serrate, usually dark brown to blackish .....  
 ..... ***M. breVIANGULARIS* new species**  
 — Antennae moderately to asymmetrically serrate, medium brown ..... ***M. brunneus* Otto**
7. Vertex without short median carina (triangularis species group) ..... **8**  
 — Vertex with short median carina (Fig. 6) (carinicollis species group) .....  
 ..... ***M. carinicollis* new species**
8. Antennomere IV shorter than V (Fig. 7) ..... ***M. lecontei* new species**  
 — Antennomere IV as long as V (Fig. 8) ..... ***M. triangularis* (Say)**

#### Key to the known larvae of Nearctic *Microrhagus*

1. Each side of head capsule with five lateral projections (Fig. 16); spiracular collar caudally pointed (Fig. 9) ..... **2**  
 — Each side of head capsule with four lateral projections (Fig. 26); spiracular collar rounded (Fig. 10) ..... **3**
2. Microtrichial patches narrowed; prothoracic scleromes larger, triangular (Fig. 15, 17) (pectinatus species group) ..... ***M. pectinatus* LeConte**  
 — Microtrichial patches larger; prothoracic scleromes smaller (Fig. 20, 22) (subsINUATUS species group) ..... ***M. subsINUATUS* LeConte**
3. Areoles placed near base of each abdominal segment (Fig. 11) (brunneus species group) ..... **4**  
 — Areoles placed near center of each abdominal segment (Fig. 12) ..... **5**
4. Areoles elongate, transverse; prothoracic microtrichial patch sub-triangular (Fig. 38, 40) .....  
 ..... ***M. breVIANGULARIS* new species**  
 — Areoles oval, transverse; prothoracic microtrichial patch rectangular (Fig. 43, 45) .....  
 ..... ***M. brunneus* Otto**
5. Areoles placed approximate to microtrichial patches (Fig. 13) ..... **6**  
 — Areoles placed distally from microtrichial patches (Fig. 14) (audax species group) .....  
 ..... ***M. audax* Horn**



6. Basal lateral projection of head capsule often enlarged (Fig. 62, 67) (triangularis species group) ..... 7  
 — Basal lateral projection of head capsule shorter (Fig. 53) (carinicollis species group) .....  
 ..... *M. carinicollis* new species
7. Areoles variably sized, often enlarged, largest on segments II–VI on both surfaces, smallest on segments I, VII, and VIII, circular (enlarged) to oval-shaped (smaller) (Fig. 61) .....  
 ..... *M. lecontei* new species  
 — Areoles variably sized, largest on segments II–VI on both surfaces, smallest on segments I, VII, and VIII, oval-shaped (Fig. 66) ..... *M. triangularis* (Say)

### **Pectinatus species group**

A single species within the group is distinguished by adult characters of elongate anterior lateral pronotal ridge, shorter posterior lateral pronotal ridge, moderately sized pronotal hind angles, presence of median carina on frons and wide metathoracic episternum which is slightly widened caudally. Larvae are characterized with five lateral projections along each side of head capsule as well as uniform sized, transverse, oval-shaped areoles and a caudally pointed spiracular collar.

### ***Microrhagus pectinatus* LeConte, 1866**

#### **Fifth instar**

(Fig. 15–19)

**Diagnosis.** Larger, triangular prothoracic scleromes and narrowed microtrichial patches will distinguish *M. pectinatus* from *M. subsinuatus*.

**Specimens Examined.** Forty-nine larvae collected at **USA: WISCONSIN:** Dane County, Festge Park, 1 October 1994, in soft, moderate wet white rotten deciduous wood, Robert L. Otto (4 larvae); Shawano County, Navarino State Wildlife Area, N44° 38.9', W-88° 37.4', 14 April 2009, Robert L. Otto, in white rotten northern pin oak log (4 larvae); Forest County, along State Highway 55, N45° 49.360', W-88° 49.247', 12 April 2010, Robert L. Otto, in rotten maple log (4 larvae); Dane County, Picnic Point, 13 March 2012, Robert L. Otto, in rotten oak log (1 larva); Fond du Lac County, Northwoods Park, 3.2 km N. Rosendale, 13 March 2012, Robert L. Otto, in rotten oak log (3 larvae); Dane County, LWRSWA–Mazomanie unit, 19 March 2012, Robert L. Otto, in rotten maple stump (1 larva); Dane County, Turville Point Preserve, 3 October 2012, 7 October 2012, 16 October 2012, 25 October 2012, Robert L. Otto, in rotten *Quercus* and basswood logs (30 larvae); Dane County, McDaniel Park, N43° 01.676', W-89° 18.600' 27 September 2013, in rotten *Acer* log (2 larvae). Larvae are deposited in GERP and WIRC.

**Description.** Length 9.0–13.0 mm. Width 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either indistinct or absent. Legs absent. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 15).

**Head** (Fig. 16): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular with a median carina. Venter simple. Ventral lateral sides of head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule consists of five projections. Basal lateral projections enlarged. Lateral side of second projections weakly sinuate out and then back towards the tip. Second through fifth lateral projections directed anterolaterally. Antennae minute, arising between fourth and fifth lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 17–18): Sub-equal to subsequent two thoracic segments. Tergum with pair of triangular-shaped scleromes extending from base up three-fourths the length of the segment then divergent toward lateral sides and arching to point of origin. Oblong trapezoidal-shaped microtrichial patch present between scleromes. Sternum with pair of internally bent sub-triangular-shaped scleromes extending from base up three-fourths the length of segment then divergent towards lateral sides and converge above point of origin, leaving a short tail at the caudal end of sclerome. Circular-shaped microtrichial patch present between ventral scleromes. Both surfaces with areoles.

**Meso- and metathorax:** Terga and sterna with oval microtrichial patch; oblonged areole present near each base. Posterior end of each microtrichial patch tricarinate. Sterna with longitudinal plicae and carinae between caudal end of microtrichial patch and areole. Mesothorax without spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga I–VIII with microtrichial patches that successively change from small and oval on segment I to circular on segment VIII. Sterna I–VIII with oval microtrichial patch. Terga and sterna I–VIII with small areole beneath patch near each base. Segment IX laterally constricted caudally. Tergum IX without microtrichial patch and areole; sternum (Fig. 19) heavily sclerotized at caudal half with prominent, wide, semicircular circumanal asperities. Mediocaudal end of segment IX cleft. Urogomphi absent on segment IX. Spiracles annular-biforous, with caudally pointed spiracular collar.

**Distribution.** *Microrhagus pectinatus* is known from **CANADA:** British Columbia, New Brunswick, Nova Scotia, Ontario, Québec; **USA:** Georgia, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Michigan, Missouri, New Hampshire, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Texas, Virginia, West Virginia, and Wisconsin (Muona 2000; Majka 2007). All specimens used in this study came from Wisconsin.

**Biology.** *Microrhagus pectinatus* is a widespread, although uncommonly collected species. Some biological information is available. Dury (1888) collected the species on dead beech (*Fagus grandifolia* Ehrhart; Fagaceae). Blatchley (1910) observed adults occurred in partially rotten elm (*Ulmus* sp.; Ulmaceae) and other logs. Knull (1947) reared adults from a badly decayed beech log. Muona (1993b) wrote that *M. pectinatus* was reared from sycamore (*Platanus* sp.; Platanaceae) in Maryland. Muona (1996) also wrote the hosts for the species were beech and elm. Majka (2007) collected several specimens by a flight intercept trap placed in an old red spruce (*Picea rubens* Sargent; Pinaceae) forest in Nova Scotia.

*Microrhagus pectinatus* were found in a variety of forest systems. In Wisconsin, I collected adults and larvae in floodplain forests, northern dry-mesic forest, northern hardwood swamp, northern mesic forest, northern wet forest, northern wet-mesic forest, oak barrens, oak woodlands, southern hardwood swamp, and southern mesic forest. I found one adult in 1995 by sweeping through maple foliage in southern Wisconsin. Twenty adults were reared from a white rotten northern pin oak (*Quercus ellipsoidalis* Hill; Fagaceae) log on 30 April 2009. I extracted five larvae from a rotten maple stump and rotten oak logs during 2012. Many larvae were also extracted from white rotten, moist maple, oak and basswood logs during 2009 through 2012.

Several species of Eucnemidae were observed tunneling in the same area of the *Quercus* log. *Isarthrus rufipes* (Melsheimer) and *M. pectinatus* were both tunneling in moist, softer, separate sections of the log closest to the soil. A third species, *Dirrhagofarsus ernae* Otto, Muona and McClarin was burrowing in moist, firmer section of the same log. Searching in conifers has yielded no larvae, which may indicate the species is a deciduous specialist.

Larvae were observed tunneling along the wood grain, leaving no trails behind them. Many larvae were extracted at least 2.5–3.0 cm beneath the surface. Like many other observed species (Otto 2012a, 2012b), *M. pectinatus* larvae construct a pupal chamber near the surface and assume a U-shaped position. Larvae overwinter in their pupal chamber and continue their development in the following spring. Pupation requires about two to three weeks. Many adults in recent history were collected from purple prism traps (Synegy Semiochemicals Company, British Columbia) while monitoring for the adventive Emerald Ash Borer (EAB) (*Agrilus planipennis* Fairmaire; Buprestidae) in northeastern Wisconsin during late June through late August.

Collectors in Wisconsin have found *M. pectinatus* in Malaise traps, sweeping through grass, in moderately wet, white rotten deciduous wood, at mercury vapor light trap, collected on girdled ash



trees, and in wood crevices. As previously observed, adults are capable of snapping into the air when placed on their backs. Adults were also observed to quiver their extended antennae while in captivity.

### **Subsinuatus species group**

A single species within the group is characterized by adult features of elongate anterior lateral pronotal ridge, elongate posterior lateral pronotal ridge, moderately sized pronotal hind angles, variably presence of median carina on frons, very narrow metathoracic episternum which are slightly widened caudally. Larvae are characterized with five lateral projections along each side of head capsule as well as uniform sized, transverse, narrowed areoles and a caudally pointed spiracular collar.

### ***Microrhagus subsinuatus* LeConte, 1852**

#### **Fifth instar**

(Fig. 20–24)

**Diagnosis.** Smaller, triangular prothoracic scleromes and larger microtrichial patches will distinguish *M. subsinuatus* from *M. pectinatus*.

**Specimens Examined.** Six larvae collected at USA: WISCONSIN: Oconto County, N. Bayshore County Park, N44° 57.847', W-87° 47.042', 13 April 2011, Robert L. Otto, in rotten elm log (2 larvae); Dane County, LWRSWA–Mazomanie unit, 16 September 2012, Robert L. Otto, in rotten *Betula nigra* log (3 larvae); Dane County, McDaniel Park, N43° 01.707', W-89° 18.639', 22 September 2013, Robert L. Otto, in rotten oak log (1 larva). Larvae are deposited in GERP and WIRC.

**Description.** Length, 11.5–12.0 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either indistinct or absent. Legs absent. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 20).

**Head** (Fig. 21): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular with a median carina. Venter simple, without any furrows. Ventral lateral sides of head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule consists of five projections. Basal lateral projections enlarged. Second lateral projection blunt, directed anterolaterally. Lateral side of second projections weakly sinuate out and then back towards the tip. Third through fifth lateral projections directed anterolaterally. Antennae minute, arising between the fourth and fifth lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum sub-equal in length. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 22–23): Sub-equal to subsequent two thoracic segments. Tergum with pair of sub-triangular-shaped scleromes extending from base up three-fourths the length of the segment then diverge towards lateral sides and arches to point of origin. Rectangular-shaped microtrichial patch present between scleromes. Sternum with pair of triangular-shaped scleromes extending from base up three-fourths length of segment then diverge towards lateral sides and converge above point of origin, leaving a short tail at the caudal end of sclerome. Barrel-shaped microtrichial patch present between scleromes. Both surfaces with areoles.

**Meso- and metathorax:** Terga with oval microtrichial patch. Sterna with broadly oval microtrichial patch. Terga and sterna with longitudinal plicae and carinae between caudal end of microtrichial patch and areole; areole present near each base. Mesothorax without spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga I–VIII with microtrichial patches that successively change from small and oval on segment I to alluvial on segment VIII. Sterna I–VIII with circular microtrichial patch. Terga and sterna with small areole beneath patch, near each base. Tergum IX without microtrichial patch and areole; sternum (Fig. 24) heavily sclerotized at caudal

half with prominent, semicircular circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with caudally pointed spiracular collar.

**Distribution.** *Microrhagus subsinuatus* is known from **CANADA:** Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Québec; **USA:** Colorado, Connecticut, District of Columbia, Florida, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee (**New State Record**), Vermont, Virginia, West Virginia, and Wisconsin (Bousquet 1991; Muona 2000; Majka 2007; Ferro et al. 2012; Webster et al. 2012). All specimens used in this study came from Wisconsin.

**Biology.** Although *M. subsinuatus* is a widespread species, very little is known about its biology. Blatchley (1910) obtained one of the specimens on milkweed (*Asclepias* sp.; Apocynaceae) leaves. Knull (1946) reared the species from moist, decayed logs of American beech in Ohio. Muona (1993b, 2000) wrote that *M. subsinuatus* were taken on *Alnus serrata* Newberry (not Hortulanorum ex. Lavallée); Betulaceae. However, the information provided may be in reference to smooth alder (*Alnus serrulata* (Aiton) Willdenow) instead. *Alnus serrata* is an extinct North American alder species once abundant in western United States during the late Pleistocene Epoch (Peabody Museum of Natural History 2011).

Majka (2007) took one specimen on shoreline vegetation along a pond in Nova Scotia. Webster et al. (2012) collected 23 adults during June, July, and August during their survey work in New Brunswick. One specimen was swept from foliage in a mature hardwood forest. Twenty-two remaining specimens were taken by Lindgren funnel traps placed in various forest systems. They found adults in a mature hardwood forest with American beech, sugar maple (*Acer saccharum* Marshall; Aceraceae) and ash, old silver maple forest with green ash, red spruce forest with red maple (*Acer rubrum* Linnaeus) and balsam fir (*Abies balsamea* (Linnaeus) Miller; Pinaceae), an old northern hardwood forest, old-growth white spruce (*Picea glauca* (Moench) Voss; Pinaceae) and balsam fir forest, and old-growth eastern white cedar (*Thuja occidentalis* Linnaeus; Cupressaceae) forest. Ferro et al. (2012) reared a number of adults from decay class 3-4 coarse woody materials using emergence chambers. Specimens were reared from materials collected at two locations; both from Sevier County, Tennessee.

*Microrhagus subsinuatus* was found in a variety of forest systems. In Wisconsin, I collected adults and larvae in northern dry-mesic forest, northern hardwood swamp, northern mesic forest, northern wet forest, northern wet-mesic forest, oak barrens, southern dry-mesic forest, and southern mesic forest. Two adults were reared from a badly decayed elm log in 2010. Several larvae were found less than 1.0 cm beneath the surface of the moist white rotten sapwood of a river birch log (*Betula nigra* L.; Betulaceae) in 2012. Searching in conifers has yielded no larvae, which may indicate the species is a deciduous specialist. Larvae were observed tunneling along the wood grain, leaving no trails behind them. Most larvae were extracted at least 1.0–3.0 cm beneath the surface. Pupation requires about two to three weeks. Many adults in recent history were collected from purple prism traps in northeastern Wisconsin from late June through late August. Collectors in Wisconsin have found *M. subsinuatus* in Malaise traps, at UV lights, on saplings/herbaceous understory, swept through vegetation, in Lindgren funnel traps, in unbaited Townes Malaise trap, and on girdled ash trees.

### Audax species group

The two species within the group are characterized by adult features of shorter anterior lateral pronotal ridge, shorter posterior lateral pronotal ridge, moderately sized pronotal hind angles, absence of median carina on vertex and caudally widened metathoracic episternum. The known larvae of one species is distinguished by four lateral projections along each side of the head capsule, areoles placed distally from microtrichial patches, areoles placed near center of each abdominal segment, uniformly sized abdominal areoles, and a rounded spiracular collar.

***Microrhagus audax* Horn, 1886****Fifth instar**

(Fig. 25–29)

**Specimens Examined.** Two larvae collected at **USA: WISCONSIN:** Oconto County, N. Bayshore County Park, N44° 57.847', W-87° 47.042', 13 April 2011, Robert L. Otto, in rotten elm. Larvae are deposited in GERP.

**Description.** Length, 8.0–9.0 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae distinct. Legs absent. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 25).

**Head** (Fig. 26): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular with a median carina. Venter with two shallow furrows diverging from anterior portion of the head capsule below the mandibles. Center of the ventral disc with single shallow furrow. Lateral sides of the head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule consists of four projections. Basal lateral projections enlarged. Lateral sides between basal and second lateral projections strongly sinuate. Second through fourth lateral projections directed laterally. Antennae minute, arising between the third and fourth lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 27–28): Sub-equal to subsequent two thoracic segments. Tergum with pair of triangular-shaped scleromes extending from base up three-fourths the length of the segment then diverges towards lateral sides and converges to point of origin; caudal and lateral sides with undefined edges. Rectangular microtrichial patch present between scleromes. Sternum with pair of internally bent sub-triangular shaped scleromes present converging towards median of segment. Sub-triangular-shaped microtrichial patch present between scleromes. Both surfaces without areoles.

**Meso- and metathorax:** Terga with alluvial-shaped microtrichial patch. Sterna with kidney-shaped microtrichial patch. Terga and sterna with small circular areole beneath patch, near middle of each segment. Mesothorax without spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga and sterna I–VIII with relatively narrowed, oblonged transverse microtrichial patch near anterior. Small circular areole present beneath patch, near middle of each segment. Tergum IX without microtrichial patch and areole; sternum (Fig. 29) heavily sclerotized at caudal half with prominent, campaniform circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with rounded spiracular collar.

**Distribution.** *Microrhagus audax* is known from **USA:** Alabama, District of Columbia, Georgia, Illinois, Indiana, Iowa, Maryland, Michigan, Missouri, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Texas, Virginia, West Virginia, and Wisconsin (Muona 2000). Both specimens used in this study came from Wisconsin.

**Biology.** *Microrhagus audax* is an uncommon species most frequently collected in southeastern areas of the United States, yet little is still known about its biology. Muona (2000) wrote *M. audax* were taken at UVCC-light and window traps. In Wisconsin, I found *M. audax* in two different forest systems including northern mesic forest and a degraded southern hardwood swamp. All encountered adult specimens were taken from purple prism traps placed in ash trees. Collectors in Wisconsin have found *M. audax* in Malaise traps, on a log, and swept from grass.

***Microrhagus opacus* Otto, new species****Adults**

(Fig. 30–33)

**Diagnosis.** Within the group, *M. opacus* is distinguished by its duller, coarsely, deeply punctate to rugose pronotal surfaces, as well as presence of slightly elevated scutellum, anterior lateral pronotal ridge directed posteriorly and lateral side of pronotal hind angles with broadly rounded apices. Whereas, *M. audax* is characterized by finely punctate, shiny pronotal surface, flattened scutellum, anterior lateral pronotal ridge sinuous, directed ventrally as well as lateral sides of pronotal hind angles with narrowly rounded apices.

**Description. Male holotype:** Length, 3.25 mm. Width, 1.25 mm. Body subcylindrical, moderately elongate and tapering towards the elytral apex; uniformly black; antennae brownish-black, except antennomere I–II infusate reddish-brown; femur and tibiae dark brown; tarsi yellowish-brown; head, pronotum and elytra clothed with yellow recumbent setae (Fig. 30).

**Head:** Very closely punctate, subspherical with convex frons; surface somewhat dullish; apical margin of frontolclypeal region feebly trilobed, about 2.5 times wider than base; mandibles stout, bidentate, densely punctate.

**Antennae:** Moderately serrate from antennomeres IV–X, reaching almost three-fourths the length of the body, setose. Antennomere III longer than IV; antennomeres IV–X each subequal, longer than wide; antennomere XI longer than X.

**Pronotum:** Coarsely, deeply punctate; surface dullish; longer than wide, with moderate hind angles; basal two-third parallel-sided, apical third arcuate; disc with shallow median groove extending from base up three-fourths the length; base sinuous, with short, median carina above scutellum; sides (Fig. 31) with two lateral ridges; anterior lateral pronotal ridge short, obliquely bent, directed posteriorly, about one-fourth the length of pronotum; posterior lateral pronotal ridge extending up to third the length of pronotum; lateral sides of pronotal hind angles broadly rounded apically.

**Scutellum:** Slightly elevated, punctate, longer than wide, triangular and distally rounded.

**Elytra:** Striae absent; surfaces densely punctate to rugose.

**Legs:** First tarsomere as long as the combined lengths of the remaining four on mesothoracic and metathoracic tarsi; tibiae rounded in cross section; lateral surfaces of mesothoracic and metathoracic tibiae with single spines; metathoracic tarsomeres I–III simple; metathoracic tarsomeres IV truncate and excavated; metathoracic tarsomere V elongate with simple claws.

**Venter** (Fig. 32): Deeply punctate, with recumbent yellowish setae; hypomeron with notosternal antennal grooves; metathoracic episternum caudally widened; elytral epipleurae sulcate; metathoracic coxal plates medially 2.0 times as wide as laterally.

**Male aedeagus** (Fig. 33): Basal piece wide, oblong, somewhat elliptical; remaining aedeagus about twice as long as basal piece, basally narrowed, apical three-fourths widened; lateral lobes short, simple, apically narrowed; secondary lateral lobes fused with lateral lobes; median lobe widened, elongate, apically bilobed.

**Female allotype:** 3.75 mm long; antennae weakly serrate, reaching half the length of the body; frons with pair of circular foveae; legs and antennae dark reddish-brown; pronotum parallel-sided.

**Variation.** Seven paratypes were examined. Three female paratypes range in size 3.75–4.25 mm long. Four male paratypes range in size 3.50–3.75 mm long. Antennae and legs in one of the paratypes are completely reddish-brown, lighter than holotype and allotype. Two other paratypes have darker reddish-brown antennae and legs, similar to the allotype. One female paratype lacks a pair of circular foveae on the frons. Exoskeletal structures are similar to both holotype and allotype.

**Type material. Holotype**, male, with label data: “Ala. Dale Co., Ft. Rucker Mil. Res., 16 May 2003, R. Turnbow” / “**HOLOTYPE**”, *Microrhagus, opacus*, Otto, det. R.L. Otto, 2014” (♂ handwritten behind species name on label)[red printed label]. **Allotype**, female, with label data: “N.Y.” / “**TYPE NO. 3399**” (3399 handwritten) [red card] / “*M. audax*, Horn” (handwritten) / “M.C.Z., Holotype, 33718” (33718

handwritten) [red card] / “NOT Syntype, Muona - 96” (handwritten) [pink card] / “Aug-Dec 2004, MCZ Image, Database” (small picture of camera on left side of label) / “**ALLOTYPE:**, *Microrhagus, opacus*, Otto, det. R.L. Otto 2014” (♀ handwritten behind species name on label)[yellow printed label]. Holotype is transferred from GERP to WIRC. Allotype is at the MCZ.

Paratypes. 7, from the following locality: 2, **ALABAMA: Dale Co.:** Ft. Rucker Mil. Res., 4–20 June 2011, 13 May 2013, R. Turnbow (RHTC); 1, **FLORIDA: Leon Co.:** Tall Timbers Research Station, 4–11–V–1993, M. Lara (FSCA); 1, **GEORGIA: Wheeler Co.:** V–VI/00, R. Morris (GERP); 1, **INDIANA: Morgan Co.:** April 7–July 14, 2012, Kyle E. Schnepf (KESC); 1, **KANSAS: Douglas Co.:** 3.2 km N Baldwin, Breidenthal Reserve, 7–14 June 1996 (SEMC); 1, **Jefferson Co.:** The Falin Property, 1.5 km N jct. 94th Street and Kingman Rd., 39° 13.38'N, 95° 24.24'W, 7–10–VI–2005 (SEMC). Each specimen labeled: “**PARATYPE:**, *Microrhagus, opacus*, Otto, det. R.L. Otto, 2014” (either ♂ or ♀ handwritten behind species name on label) [yellow printed label]. All paratypes are deposited in GERP, KESC, RHTC, SEMC and WIRC.

**Distribution.** The species is known from **USA:** Alabama, Florida, Georgia, Indiana, Kansas, and New York.

**Biology.** In Alabama, one beetle was taken from a Manuka/Phoebe Oil baited Lindgren funnel trap. One beetle was taken from a clear bottle trap baited with rotting fruit in Indiana. In Florida, a single specimen was taken from a Malaise trap. In Kansas, each specimen was taken from either a Malaise trap or a flight intercept trap in 1996 and 2005.

**Etymology.** The name of the new species is derived from its dull or opaque luster of the pronotum in relation to the elytra.

**Note.** Otto (2013a) figured *Microrhagus audax* (Fig. 8–9); unaware the eucnemid actually belongs to this new species. The specimen deposited in MCZ was thought to be the type of *M. audax*. In 1996, Muona added a label indicating the specimen was not a syntype. The actual holotype of *M. audax* is deposited in the Ulke collection at the Carnegie Museum. The MCZ specimen was compared against images of the holotype provided by Dr. Robert Davidison and surmised the specimen is quite different, based on these four characteristics.

### **Brunneus species group**

The two species within the group are distinguished by adult characters of shorter anterior lateral pronotal ridge, elongate posterior lateral pronotal ridge, usually shorter pronotal hind angles, absence of median carina on vertex, and a caudally widened metathoracic episternum. Larvae of both species have four lateral projections along each side of head capsule, areoles placed distally from microtrichial patches, areoles placed near base of each abdominal segment, uniformly sized abdominal areoles and rounded spiracular collar.

### ***Microrhagus breviangularis* Otto, new species**

#### **Adults**

(Fig. 34–37)

**Diagnosis.** Simply serrate, darker colored antennae will distinguish the species from *M. brunneus*. Whereas *M. brunneus* is distinguished by its lighter colored, strongly serrate to asymmetrically serrate antennae.

**Description. Male holotype:** Length, 3.0 mm. Width, 1.0 mm. Body subcylindrical, moderately elongate and tapering towards the elytral apex; uniformly black; antennae dark brownish-black, except



antennomeres I–II reddish; femur dark brown; tibiae and tarsi medium brown; head, pronotum and elytra clothed with yellow recumbent setae, more apparent on pronotal base and elytra (Fig. 34).

**Head:** Closely punctate, subspherical with convex frons; surface shiny; apical margin of frontoclypeal region feebly trilobed, about 2.5 times wider than base; mandibles stout, bidentate, densely punctate.

**Antennae:** Moderately serrate from antennomeres V–X, reaching almost three-fourths the length of the body, setose. Antennomere III longer than IV; antennomeres IV–X each subequal, slightly longer than wide; antennomere XI slightly longer than X.

**Pronotum:** Closely, shallowly punctate; surface shiny; longer than wide, with short hind angles; laterally parallel-sided, slightly wider apically; disc simple; base sinuous, with short, median carina above scutellum; sides (Fig. 35) with two lateral ridges; anterior lateral pronotal ridge short, obliquely bent, about one-third the length of pronotum; posterior lateral pronotal ridge extending up to half the length of pronotum.

**Scutellum:** Punctate, short, wider, triangular and distally rounded.

**Elytra:** Indistinctly striate; interstices flattened; surfaces densely punctate to transversely rugose at basal third, closely punctate in remaining two-third.

**Legs:** First tarsomere longer than the combined lengths of the remaining four on mesothoracic and metathoracic tarsi; tibiae rounded in cross section; lateral surfaces of mesothoracic and metathoracic tibiae with single spines; metathoracic tarsomeres I–III simple; metathoracic tarsomeres IV truncate and excavated; metathoracic tarsomere V elongate with simple claws.

**Venter** (Fig. 36): Punctate, with recumbent yellowish setae; hypomeron with notosternal antennal grooves; metathoracic episternum caudally widened; metathoracic coxal plates medially 2.5 times as wide as laterally.

**Male aedeagus** (Fig. 37): Basal piece oblong, narrow, rectangular, about as long as remaining aedeagus; remaining aedeagus short, narrow, as wide as basal piece; lateral lobes short, simple, apically narrowed; secondary lateral lobes fused with lateral lobes; median lobe widened, elongate, apically bilobed.

**Female allotype:** 4.0 mm long; antennae strongly serrate, reaching two-third the length of the body; legs and antennae slightly darker; pronotum parallel-sided.

**Variation.** Twenty-two adult paratypes were examined. Thirteen male paratypes varied in length from 3.0–3.75 mm. Nine female paratypes varied in length from 3.5–4.0 mm. Females are on average slightly larger than the males. Pronotal basal carina above the scutellum shows some degree of structural variation, ranging from near absent to more pronounced. All paratypes except for one female lack the infuscate brownish coloration along the elytral suture. Antennal coloration showed some variability. In four specimens, antennae are brownish, most likely attributed to their slightly teneral state at the time of preservation. In general, antennae are similar to the holotype, that being brownish-black with reddish antennomere II. The posterior lateral pronotal ridge is slightly longer in all paratypes, reaching as long as two-thirds the length of the pronotum, shorter in the holotype.

### Fifth instar

(Fig. 38–42)

**Diagnosis.** Sub-triangular prothoracic microtrichial patch, enlarged basal lateral projection and transverse areoles will distinguish *M. breviangularis* from *M. brunneus*.

**Description.** Length, 9.0–11.0 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either absent or indistinct. Legs reduced to simple setae. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 38).

**Head** (Fig. 39): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular. Very weak median carina present on dorsal cephalic disc. Venter unmodified, without furrows or ridges. Base and lateral sides of the head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule consists of four projections. Basal lateral projections enlarged. Lateral sides between basal and second lateral projections weakly sinuate. Second



through fourth lateral projections directed anterolaterally. Antennae minute, arising between the third and fourth lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi extremely small, segmented. Ligula, mala, lacinia, and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 40, 41): Sub-equal to subsequent two thoracic segments. Tergum with pair of sub-trapezium-shaped scleromes extending from just above the base up near the cranial end of the segment, extending towards each lateral side, down a short distance along the lateral side and converge to point of origin. All sides of scleromes with defined edges. Sub-triangular shaped microtrichial patch present between scleromes. Sternum with pair of internally bent sub-trapezium-shaped scleromes. Each sclerome with short, basal extension. Sub-circular-shaped microtrichial patch present between scleromes. Both surfaces without areoles.

**Meso- and metathorax:** Terga with elliptical-shaped microtrichial patch. Sterna with kidney-shaped microtrichial patch. Terga and sterna with transverse areole beneath patch, near base of each segment. Metathorax with reduced spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga and sterna I–VIII with small, oval to elliptical-shaped microtrichial patch. Terga and sterna I–VIII with transverse areole beneath patch, near base of each segment. Tergum IX without microtrichial patch and areole; sternum (Fig. 42) heavily sclerotized at caudal half with prominent, sub-triangular-shaped circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with rounded spiracular collar.

**Distribution.** *Microrhagus breviangularis* is known from **USA:** Florida, Indiana, and Wisconsin.

**Biology.** In Florida two specimens have been taken by Malaise trap placed in an unburned scrub oak/saw palmetto ecosystem. One beetle was taken in a clear bottle trap baited with rotting fruit in Indiana. In Wisconsin, I found *M. breviangularis* in a variety of forest systems including northern hardwood swamp, northern mesic forest, southern hardwood swamp, and southern mesic forest. Nine specimens were taken from a Malaise trap placed in a deciduous forest in Ozaukee County. One larva was found in a moist, white rotten *Quercus* log in 2012. Other larvae were found in a rotten shagbark hickory (*Carya ovata* (Miller) K. Koch; Juglandaceae) and another undetermined rotten log. Searching in conifers has yielded no larvae, which may indicate this species is a deciduous specialist.

I observed larvae tunneling along the wood grain, leaving no trails behind them. Many larvae were extracted at least 2.5–3.0 cm beneath the surface. Larvae construct a pupal chamber near the surface and assume a U-shaped position. I observed no noticeable difference between previous instars and the prepupal larval form. Pupation requires about two to three weeks. Most recently, a few adults were collected from purple prism traps while surveying for the presence of Emerald Ash Borer beetle during mid-July through mid-September in northeastern Wisconsin.

Two adults emerged from separate pieces of rotten oak wood on 26 February 2013. Two other adults emerged on 8 February 2014. These adults were placed in a vial to observe their behavior. Adult *M. breviangularis* are capable of snapping into the air when placed on their backs. Adults were also observed to quiver their extended antennae while in captivity.

**Type material.** **Holotype**, male, with label data: “U.S.A.: WI: Ozaukee Co., UW-Mil. Field Station, 43.38567°N/88.02638°W, WGS84, 02–09 July 2013, Daniel K. Young” / “**HOLOTYPE:** *Microrhagus breviangularis*, Otto, det. R.L. Otto, 2014” (♂ handwritten behind species name on label)[red printed label]. **Allotype**, female, with label data: “WI: Shawano Co., along Carroll Road, N44.78156°, W-88.34259°, EABT013113, 11 August 2010, Robert L. Otto” / “**ALLOTYPE:** *Microrhagus breviangularis*, Otto, det. R.L. Otto, 2014” (♀ handwritten behind species name on label) [yellow printed label]. Holotype and allotype are in WIRC.

Paratypes. 22 adults and 10 larvae, from the following localities: 2 adults, **FLORIDA: Seminole Co.:** Econ Wild. Area, IV–15–2000, Trevor Smith (FSCA); 1 adult, **INDIANA: Montgomery Co.:** Shades State Park, May 30–July 6, 2011, Kyle E. Schnepf (KESC); 2 adults, 3 larvae, **WISCONSIN: Dane Co.:** Festge Park, 18 September 2012, 1 October 2013, Robert L. Otto (GERP); 1 larva, LWRWSA–

Mazomanie Unit, 23 September 2012; 2 adults, 6 larvae, Turville Point Preserve, 14 September 2013, Robert L. Otto (GERP, WIRC); 2 adults, **Door Co.:** N45.08352122°, W087.16285209°, September 21 2009, September 22 2009, Robert L. Otto (WIRC); 1 adult, **Forest Co.:** along Windsor Dam Road, 1 September 2009, Robert L. Otto (GERP); 1 adult, along Spur Ln., 9 September 2009, Robert L. Otto (WIRC); 1 adult, along Ross Lake Rd., 9 September 2009, Robert L. Otto (WIRC); 7 adults, **Ozaukee Co.:** UW-Mil. Field Station, 43.38567°N/-88.02638°W, WGS84, 02–09 July 2013, 16–22 July 2013, 06–13 August 2013, Daniel K. Young (WIRC); 1 adult, UW-Mil. Field Station, 43.38295°N/-88.02534°W, WGS84, 09–16 July 2013, Daniel K. Young (WIRC); 1 adult, **Shawano Co.:** along Hazel Road, 9 August 2010, Robert L. Otto (GERP); 1 adult, along Old WI-22, 19 July 2010, Robert L. Otto (WIRC). Each specimen labeled: “**PARATYPE:**, *Microrhagus, breviangularis*, Otto, det. R.L. Otto, 2014” (either ♂ or ♀ handwritten behind species name on each label)[yellow printed label] placed beneath the top label or inside the alcohol vial with the larval specimen. Larvae are of indeterminate sex. Adult paratypes deposited in FSCA, GERP, KESC and WIRC. Larval paratypes are deposited in GERP and WIRC.

**Etymology.** The name of the new species is derived from the shorter hind angles of the pronotum.

### *Microrhagus brunneus* Otto, 2013

#### Fifth instar

(Fig. 43–47)

**Diagnosis.** Rectangular-shaped prothoracic microtrichial patch, shorter basal lateral projection and oval, slightly transverse areoles will distinguish *M. brunneus* from *M. breviangularis*.

**Specimens Examined.** One larva collected at **USA: WISCONSIN:** Richland County, Lower Wisconsin River State Wildlife Area–Lone Rock, N43° 11.548', W-90° 13.580', 20 April 2013, Robert L. Otto, in rotten *Quercus* log. Larva is deposited in GERP.

**Description.** Length, 6.0 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either absent or indistinct. Legs reduced to simple setae. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 43).

**Head** (Fig. 44): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular. Very weak median carina present on dorsal cephalic disc. Venter unmodified, without furrows or ridges. Base and lateral sides of the head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule consists of four projections. Basal lateral projections short. Lateral sides between basal and second lateral projections weakly sinuate. Second through fourth lateral projections directed anterolaterally. Antennae minute, arising between the third and fourth lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 45–46): Sub-equal to subsequent two thoracic segments. Tergum with pair of triangular-shaped scleromes extending from just above the base up near the cranial end of the segment, extending towards each lateral side and converge to point of origin. All sides of scleromes with well-defined edges. Rectangular-shaped microtrichial patch present between scleromes. Sternum with pair of internally bent sub-rhombus-shaped scleromes. Each sclerome with short, basal extension. Sub-circular microtrichial patch present between scleromes. Both surfaces without areoles.

**Meso- and metathorax:** Terga and sterna with oval-shaped microtrichial patch. Terga and sterna with oval-shaped areole beneath patch, near center of each segment. Metathorax with reduced spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga and sterna I–VIII with small, oval to elliptical-shaped microtrichial patch. Terga and sterna I–VIII with oval-shaped areole beneath patch, near base of each segment. Tergum IX without microtrichial patch and areole; sternum (Fig.

47) heavily sclerotized at caudal half with prominent, sub-triangular-shaped circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with rounded spiracular collar.

**Distribution.** *Microrhagus brunneus* is known from **USA:** Arkansas, Indiana, Kentucky, Louisiana, North Carolina, Oklahoma, and Wisconsin (Otto 2013a). A submitted image of a male specimen collected during the annual BugGuide Gathering at VCU Rice Center represents Virginia as a **New State Record** to the list for the species (Mike Quinn; BugGuide.net 2014). Single specimen used in this study came from Wisconsin.

**Biology.** Otto (2013a) wrote that *M. brunneus* were primarily taken by EAB purple prism traps deployed in Wisconsin. The eucnemid species has also been taken from sticky trap on a girdled ash tree, flight intercept traps, Lindgren funnel trap, hanging sugar trap, blacklight, combination mercury vapor and blacklight, Malaise Trap, and U.V. trap. In Wisconsin, during my collections, I found *M. brunneus* in a variety of forest systems including floodplain forest, northern hardwood swamp, northern mesic forest, northern wet-mesic forest, southern hardwood swamp, and southern mesic forest. A single larval specimen was taken in a rotten *Quercus* log in a southern mesic forest. The larval type was found within a few millimeters beneath the surface, positioned along the grain, leaving no trail behind it. No additional larval specimens were found in the surrounding section of the log, indicating the single specimen may have arrested its development while the rest completed their development in the previous season.

### Carinicollis species group

The single species within the group is distinguished by adult characters of shorter anterior lateral pronotal ridge, elongate posterior lateral pronotal ridge, moderately sized pronotal hind angles, presence of short median carina on vertex and caudally widened metathoracic episternum. Larvae are characterized with four lateral projections along each side of head capsule, shorter basal lateral projection, areoles placed approximate to microtrichial patches, areoles placed near center of each abdominal segment; uniform sized abdominal areoles and rounded spiracular collar.

### *Microrhagus carinicollis* Otto, new species

#### Adults

(Fig. 48–51)

**Description. Male holotype:** Length, 3.0 mm. Width, 1.0 mm. Body subcylindrical, moderately elongate and tapering towards the elytral apex; uniformly black; antennae dark brown, except pedicel and scape reddish; femur dark brown; tibiae and tarsi reddish-brown; head, pronotum and elytra clothed with short, yellow recumbent setae (Fig. 48).

**Head:** Very closely punctate, subspherical with convex frons; vertex with slightly elevated short median carina; surface somewhat shiny; apical margin of frontolclypeal region feebly trilobed, about 2.5 times wider than base; mandibles stout, bidentate, densely punctate.

**Antennae:** Moderately serrate from antennomeres IV–X, reaching about three-fourths the length of the body, setose. Antennomere III longer than IV; antennomeres IV–X each triangular, subequal and longer than wide; antennomere XI longer than X.

**Pronotum:** Closely, shallowly punctate to almost rugose; surface shiny; slightly longer than wide, with moderate hind angles; lateral sides sub-parallel-sided, apically widened; arcuate anteriorly; disc simple, without median impressions; base sinuous, with short, median carina above scutellum, slightly impressed on both sides of the median carina; sides (Fig. 49) with two lateral ridges; anterior lateral hypomeral ridge short, obliquely bent, less than one-fourth the length of pronotum; posterior lateral hypomeral ridge extending up to three-fourths the length of pronotum.

**Scutellum:** Punctate to rugose, slightly oblong, triangular, and distally rounded.

**Elytra:** Very weakly striate; interstices slightly elevated; surfaces closely punctate to rugose.

**Legs:** First tarsomere longer than the combined lengths of the remaining four on mesothoracic and

metathoracic tarsi; tibiae rounded in cross section; lateral surfaces of mesothoracic and metathoracic tibiae with single spines; metathoracic tarsomeres I–III simple; metathoracic tarsomeres IV truncate and excavated; metathoracic tarsomere V elongate with simple claws.

**Venter** (Fig. 50): Punctate, with recumbent yellowish setae; hypomeron with notosternal antennal grooves; metathoracic episternum caudally widened; metathoracic coxal plates medially 2.5 times as wide as laterally.

**Male aedeagus** (Fig. 51): Basal piece oblong, somewhat elliptical; remaining aedeagus a little more than twice as long as basal piece, basally narrowed, apical three-fourths widened; lateral lobes short, simple, apically narrowed; secondary lateral lobes fused with lateral lobes; median lobe widened, elongate, apically bilobed.

**Female allotype**: 3.5 mm long; antennae dark brown, weakly serrate, reaching almost two-thirds the length of the body; legs and antennae slightly darker.

**Variation.** One hundred thirty-five adult paratypes were examined. One hundred male paratypes varied in lengths from 2.75–3.75 mm. Thirty-five female paratypes varied in lengths from 3.0–3.5 mm. Females are on average slightly larger than males. Female antennae are weakly serrate and stouter, with antennomeres VI–X slightly longer than wide. Female antennae reach almost two-thirds the length of its body. Some paratypes have lighter colored antennae compared with the holotype, perhaps attributed to their slightly teneral state at the time of collection. Some paratypes have a more consistent reddish-brown coloration of the femur, tibiae and tarsi. Posterior lateral pronotal ridge in both sexes are consistent with the holotype, extending up to three-fourth the length of the pronotum. Pronotal basal median carina above the scutellum shows some degree of structural variation and overall lengths. Some specimens have weaker carina, while others have a more pronounced basal carina. Basal median carina is shorter in some specimens. Base of the pronotum showed some variations in the depth of impressions at both sides of the median carina. Some specimens have deeper basal impressions than others. Carina at the vertex exhibits some variability. Some specimens have a shallower, finer carina; while others are almost absent. Many specimens exhibit a well-defined, short carina. Overall lengths also varied greatly among these specimens. Many specimens have a shorter carina, consistent with the holotype. Other specimens have a rather elongate carina, extending farther down the frons, just above the base of the frontoclypeal region.

### **Fifth instar**

(Fig. 52–56)

**Description.** Length, 8.0–10.0 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either indistinct or absent. Legs reduced to simple setae. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 52).

**Head** (Fig. 53): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular. Very weak median carina present on dorsal cephalic disc. Venter unmodified, without furrows or ridges. Base and lateral sides of the head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule with four projections. Basal lateral projections short. Lateral sides between first and second lateral projections sinuate. Second lateral projection short. Second through fourth lateral projections directed laterally. Antennae minute, arising between the third and fourth lateral projections. Scape not visible. Pedicel elongate. Sensorium and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi indistinct. Ligula, mala, lacinia, and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 54–55): Sub-equal to subsequent two thoracic segments. Tergum with pair of triangular scleromes extending from base up three-fourths the length of the segment then diverges towards lateral sides and converges to point of origin; caudal and lateral sides with undefined edges. Rectangular-shaped microtrichial patch present between scleromes. Sternum with pair of internally bent sub-triangular-shaped scleromes present converging towards median of segment. Pentangular-shaped to circular-shaped microtrichial patch present between scleromes. Both surfaces without areoles.



**Meso- and metathorax:** Terga and sterna with elliptical-shaped microtrichial patch. Mesothorax without areoles on both surfaces. Metathorax variable, with or without very small circular areole beneath patch, near middle of each segment on both surfaces. Metathorax with reduced spiracles.

**Abdomen:** Segments II–X sub-equal in length and width. Terga and sterna I–VIII with microtrichial patch that successively change from oval on segment I to a small circle on segment VIII. Areoles variably sized, largest on segments II–VI on both surfaces, smallest on segments I, VII and VIII, oval-shaped; positioned beneath patch, near middle of each segment. Tergum IX without microtrichial patch and areole; sternum (Fig. 56) heavily sclerotized at caudal half with prominent, semicircular circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with rounded spiracular collar.

**Distribution.** *Microrhagus carinicollis* has been collected from **USA:** Alabama, Florida, Indiana, Kansas, and Wisconsin.

**Biology.** In Alabama, beetles were taken from a window traps and Berlese samples of oak stump and branch debris. One beetle was taken from a Lindgren funnel trap baited with *Persea* in Florida. One beetle was taken at light in Indiana. In Kansas, five beetles were collected either from a flight intercept trap or a canopy trap deployed in 2005 and 2006. In Wisconsin, *M. carinicollis* were found in a variety of plant communities including northern hardwood swamp, northern mesic forest, northern wet-mesic forest, and mesic to wet-mesic brush prairie. Many larvae were extracted from white rotten, moist maple logs during 2007 through 2009. Searching in conifers has yielded no larvae, which may indicate this species is a deciduous specialist.

I observed larvae tunneling along the wood grain, leaving no trails behind them. Many larvae were extracted at least 2.5–3.0 cm beneath the surface. Larvae of *M. carinicollis* construct a pupal chamber near the surface and assume a U-shaped position. I also observed no noticeable difference between previous instars and prepupal larval form. Pupation requires about two to three weeks. Most recently, many adults were collected from either purple prism traps from mid-June through mid-September in northeastern Wisconsin or Malaise Traps placed in Ozaukee County during early July through early September. Collectors found *M. carinicollis* in Malaise traps during the mid to late 1970s in much of Wisconsin.

Two adults emerged on 19 and 21 May 2007. Both adults were placed in a vial with a piece of wood to observe their behavior and attempt to induce mating. No eggs or first instars were observed following completion of adult observations. Like other eucnemid species, *M. carinicollis* are capable of snapping into the air when placed on their backs. Adults were also observed to quiver their extended antennae while in captivity. Adult beetles are short lived, lasting about one to two weeks in captivity before dying. It is likely *M. carinicollis* completes its development in one year under optimal conditions, but may have longer development under less optimal conditions.

**Type material. Holotype**, male, with label data: “U.S.A.: WI: Ozaukee Co., UW-Mil. Field Station, 43.38567°N/-88.02638°W, WGS84, 16-22 July 2013, Daniel K. Young, *Fagus-Acer* Forest” / “**HOLOTYPE**:, *Microrhagus, carinicollis*, Otto, det. R.L. Otto, 2014” (♂ handwritten behind species name on label) [red printed label]. **Allotype**, female, with label data: “WI: Forest Co., along Conner Farm Rd., N45.56501°/W88.69402°, 13 August 2009, Robert L. Otto” / “Taken from EAB Prism Trap baited w/ manuka oil” / “**ALLOTYPE**:, *Microrhagus, carinicollis*, Otto, det. R.L. Otto, 2014” (♀ handwritten behind species name on label) [yellow printed label]. Holotype and allotype are in WIRC.

Paratypes. 135 adults and 8 larvae, from the following localities: 1, **ALABAMA: Blount Co.:** Oneonta, 8.v.2012, T. King (FSCA); 9, Highland Lake, 10.vi–29.vii.2012, 15.vii–2.vii.2012, T. King (FSCA); 1, **FLORIDA: Santa Rosa Co.:** Milton, 20–VIII–2008, R. Robinson (FSCA); 1, **INDIANA: Montgomery Co.:** Shades State Park, July 3, 2012, Kyle E. Schnepf (KESC); 1, **KANSAS: Bourbon Co.:** 9 mi SW Ft. Scott, 37° 46.98'N, 94° 49.42'W, 14–28–VI–2005 (SEMC); 1, **Cherokee Co.:** 2 mi S Galena, 37° 2.64'N, 94° 31.64'W, 6–15–VI–2006 (SEMC); 2, **Jefferson Co.:** The Falin Property, 1.5 km N jct 94th St. and Kingman Road, 39° 13.38'N, 95° 24.24'W, 8–19–VII–2005, 2-9-2005 (SEMC); 1, **Sedgwick Co.:** 0.5 mi S Derby, 37° 31.64'N, 97° 16.03'W, 19–26–VII–2005 (SEMC); 2, **WISCONSIN: Bayfield Co.:** T46N R9W sec. 16, 29 July–5 August 1975, 22 June–6 July 1977 (WIRC); 1, **Door Co.:**

N45.11035387°, W087.21469416°, 21 September 2009, Robert L. Otto (WIRC); 1, **Florence Co.:** along County Road N, 15 July 2011, Robert L. Otto (GERP); 1, **Forest Co.:** along McArthur Pine Rd., 30 July 2009, Robert L. Otto (WIRC); 2, along W. Shore Ln., 10 August 2009, Robert L. Otto (GERP); 1, along Johnson Rd., 12 August 2009, Robert L. Otto (GERP); 1, along Stark Settlement Rd., 13 August 2009, Robert L. Otto (WIRC); 1, along County Hwy T, 17 August 2009, Robert L. Otto (WIRC); 1, along Goodman Park Rd., 17 August 2009, Robert L. Otto (WIRC); 1, along Old Hwy 8, 18 August 2009, Robert L. Otto (WIRC); 2, along S. Tower Ln., 19 August 2009, 9 September 2009, Robert L. Otto (WIRC); 2, along Spur Ln., 19 August 2009, Robert L. Otto (WIRC); 1, along Scott Lake Rd., 20 August 2009, Robert L. Otto (WIRC); 1, along Belunes Rd., 26 August 2009, Robert L. Otto (WIRC); 1, along Pine River Rd., 27 August 2009, Robert L. Otto (WIRC); 1, along Thrasher Rd., 27 August 2009, Robert L. Otto (WIRC); 1, along Stevens Lake Rd., 27 August 2009, Robert L. Otto (WIRC); 1, along Windsor Dam Rd., 1 September 2009, Robert L. Otto (WIRC); 1, along Calm Bay Ln., 2 September 2009, Robert L. Otto (WIRC); 2, **Grant Co.:** T6N R6W sec. 17, 26 July–9 August 1976, 15–22 June 1977 (WIRC); 2, **Iowa Co.:** T6N R5E sec. 1, 29 June–6 July 1976, 12–21 July 1976 (WIRC); 1, **Jackson Co.:** T21N R4W sec. 27, 21–28 July 1975 (WIRC); 4, T21N R4W sec. 33, 6–12 July 1976, 20–27 July 1976 (WIRC); 3, **LaCrosse Co.:** environs west of West Salem, 21 June–10 July 2010, Anne Marie Shorter (WIRC); 1, **Langlade Co.:** along State Hwy 55, 10 August 2009, Robert L. Otto (WIRC); 1, **Marinette Co.:** along High Falls Road, 14 July 2011, Robert L. Otto (GERP); 1, **Milwaukee Co.:** Root River Parkway, 1 July 2012, Kyle E. Johnson (WIRC); 6 adults and 8 larvae, **Oconto Co.:** Ruckert's private property, 13 April 2007, 21 April 2007, 22 April 2007, 26 March 2009, Robert L. Otto (GERP, WIRC); 27, **Oneida Co.:** T35N R11E sec. 17, 29 July–5 August 1975, 5–12 August 1975, 6–13 July 1976, 13–20 July 1976, 20–27 July 1976, 27 July–2 August 1976, 9–16 August 1976, 16–25 August 1976 (WIRC); 21, T46N R9W sec. 16, 20–27 June 1977, 27 June–6 July 1977, 5–12 July 1977, 12–19 July 1977, 19–26 July 1977, 2–8 August 1977 (WIRC); 12, **Ozaukee Co.:** 43.38567°N/-88.02638°W, WGS84, 16–22 July 2013, 27 August–3 September 2013, Daniel K. Young (WIRC); 8, 43.38295°N/-88.02534°W, WGS84, 02–09 July 2013, 09–16 July 2013, 16–22 July 2013, 30 July–6 August 2013, 6–13 August 2013, Daniel K. Young (WIRC); 1, **Sauk Co.:** Leopold Reserve, 8–10.VII 1987, EX: Malaise trap (WIRC); 1, **Shawano Co.:** along Strause Road, 18 June 2010, Robert L. Otto (WIRC); 1, along Industrial Drive, 15 July 2010, Robert L. Otto (WIRC); 1, along County Road H, 19 July 2010, Robert L. Otto (WIRC); 1, along Carroll Road, 20 July 2010, Robert L. Otto (WIRC); 1, **Sheboygan Co.:** Kohler-Andrae SP, 21 July 2013, Jeffrey P. Gruber (WIRC). Each specimen labeled: “**PARATYPE:**, *Microrhagus, carinicollis*, Otto, det. R.L. Otto, 2014” (either ♂ or ♀ handwritten behind species name on each label)[yellow printed label] placed beneath the top label or inside the alcohol vial with the larval specimen. Larvae are of indeterminate sex. Adult paratypes are deposited in FSCA, GERP, KESC, SEMC, and WIRC. Larval paratypes are deposited in GERP and WIRC.

**Etymology.** The name of the new species is derived from its very short median carina present on the vertex.

**Note.** Otto (2013a) figured *M. carinicollis* as *M. triangularis* (Fig. 10–11), unaware the specimen represented an undescribed species.

### Triangularis species group

The two species within the group are characterized by adult features of shorter anterior lateral pronotal ridge, elongate posterior lateral pronotal ridge, moderately sized pronotal hind angles, absence of median carina on vertex and caudally widened metathoracic episternum. Larvae of both species are distinguished with four lateral projections along each side of head capsule, moderately sized basal lateral projection, areoles placed approximate to microtrichial patches, areoles placed near center of each abdominal segment, variably sized abdominal areoles, and rounded spiracular collar.



*Microrhagus lecontei* Otto, new species**Adults**

(Fig. 57–60)

**Diagnosis.** Within the species group, shorter antennomere IV in relation to antennomere V (Fig. 7) will distinguish *M. lecontei* from *M. triangularis*. Whereas, *M. triangularis* is distinguished by antennomere IV being as long as V (Fig. 8).

**Description. Male holotype:** Length, 3.0 mm. Width, 1.0 mm. Body subcylindrical, moderately elongate and tapering towards the elytral apex; uniformly black; antennae dark brown, except pedicel and scape reddish; femur, tibiae and tarsi dark brown; head, pronotum and elytra clothed with short, yellow recumbent setae, more apparent on pronotal base and basal third of elytra (Fig. 57).

**Head:** Closely punctate, subspherical with convex frons; surface shiny; apical margin of frontoclypeal region feebly trilobed, about 2.5 times wider than base; mandibles stout, bidentate, densely punctate.

**Antennae:** Moderately serrate from antennomeres IV–X, reaching about three-fourths the length of the body, setose. Antennomere III longer than IV; antennomere IV slightly shorter than V; antennomere V slightly shorter than VI; antennomeres VI–X each triangular, subequal and longer than wide; antennomere XI longer than X.

**Pronotum:** Evenly, shallowly punctate; surface shiny; as long as wide, with moderate hind angles; lateral sides parallel-sided; arcuate anteriorly; disc simple, without median impressions; base sinuous, with elongate, median carina above scutellum, deeply impressed on both sides of the carina; sides (Fig. 58) with two lateral ridges; anterior lateral hypomerical ridge short, obliquely bent, less than one-fourth the length of pronotum; posterior lateral hypomerical ridge extending up to three-fourths the length of pronotum.

**Scutellum:** Punctate, slightly oblong, triangular, and distally rounded.

**Elytra:** Indistinctly striate; interstices flattened; surfaces evenly punctate.

**Legs:** First tarsomere longer than the combined lengths of the remaining four on mesothoracic and metathoracic tarsi; tibiae rounded in cross section; lateral surfaces of mesothoracic and metathoracic tibiae with single spines; metathoracic tarsomeres I–III simple; metathoracic tarsomere IV truncate and excavated; metathoracic tarsomere V elongate with simple claws.

**Venter** (Fig. 59): Punctate, with recumbent whitish setae; hypomeron with notosternal antennal grooves; metathoracic episternum caudally widened; metathoracic coxal plates medially 2.5 times as wide as laterally.

**Male aedeagus** (Fig. 60): Basal piece oblong, narrow, rectangular, nearly as long as remaining aedeagus; remaining aedeagus short, narrow, as wide as basal piece; lateral lobes short, simple, apically narrowed; secondary lateral lobes fused with lateral lobes; median lobe delicate, inconspicuous.

**Female allotype:** Length 3.5 mm; antennae weakly serrate, reaching two-thirds the length of the body; antennomere IV distinctly shorter than V; femur dark brown, tibiae and tarsi medium brown; pedicel and scape slightly darker; basal impressions on both sides of median carina shallower.

**Variation.** Twenty-four adult paratypes were examined. Seventeen male paratypes varied in length from 2.5–3.25 mm. Seven female paratypes varied in lengths from 2.5–3.5 mm. Females are slightly larger than males. Female antennae are generally weakly serrate, stouter with antennomeres VI–X slightly longer than wide. Antennomeres IV and V each distinctly shorter than remaining antennal segments in females. Some male paratypes have lighter colored antennae than the holotype. Darker brown colored femora are present in some male paratypes. In those same specimens, tibiae and tarsi are medium brown in color. A few males have a uniformed light medium brown coloration, perhaps owing to their slightly teneral state at time of collection. In both sexes, most specimens have a posterior lateral pronotal ridge consistent with the holotype, extending up to three-fourths the length of the pronotum. Only a few specimens however, have a shorter posterior lateral pronotal ridge, extending up to half the length of the pronotum. The anterior lateral pronotal ridge in some female paratypes is oblique and flatter, lacking that archness as it extends downward, compared with the male paratypes. Some degree of variation is present at the basal pronotal median carina above the scutellum. The median

carina ranges from being weaker in some specimens to more pronounced in other specimens. The basal median carina is shorter in some specimens. The pronotal base showed some impression variations at both sides of the median carina. Some specimens have deeper impressions at the base than other specimens in the series.

### Fifth instar

(Fig. 61–65)

**Diagnosis.** Trapezoidally-shaped prothoracic microtrichial patch and variably shaped, often enlarged, areoles will distinguish *M. lecontei* from *M. triangularis*.

**Description.** Length, 7.0–8.5 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either indistinct or absent. Legs reduced to simple setae. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 61).

**Head** (Fig. 62): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular. Very weak median carina present on dorsal cephalic disc. Venter unmodified, without furrows or ridges. Base and lateral sides of the head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule with four projections. Basal lateral projections somewhat enlarged. Lateral sides between first and second lateral projections strongly sinuate. Second lateral projection short. Second through fourth lateral projections directed laterally. Antennae minute, arising between the third and fourth lateral projections. Scape not visible. Pedicel elongate. Sensorium and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi extremely small, segmented. Ligula, mala, lacinia, and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 63–64): Sub-equal to subsequent two thoracic segments. Tergum with pair of triangular-shaped scleromes extending from base up three-fourths the length of the segment then diverge towards lateral sides and converge to point of origin; caudal and lateral sides with undefined edges. Trapezoidally-shaped microtrichial patch present between scleromes. Sternum with pair of internally bent sub-triangular-shaped scleromes present converging towards median of segment. An extra short, basal extension is present near the center of the sclerome. Sub-circular-shaped microtrichial patch present between scleromes. Both surfaces without areoles.

**Meso- and metathorax:** Terga and sterna with large oval-shaped microtrichial patch. Mesothorax without areoles on both surfaces. Metathorax with very small circular areole beneath patch, near middle of each segment on both surfaces. Metathorax with reduced spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga I–VIII with microtrichial patch that successively change from small oval on segment I to a small sub-triangular-shape on segment VIII. Sterna I–VIII with narrowed microtrichial patch that successively change from oblong oval-shaped on segment I to a small circle on segment VIII. Areoles variably sized, often enlarged, largest on segments II–VI on both surfaces, smallest on segments I, VII and VIII, circular (enlarged) to oval-shaped (smaller); positioned beneath patch, near middle of each segment. Tergum IX without microtrichial patch and areole; sternum (Fig. 65) heavily sclerotized at caudal half with prominent, semicircular circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with rounded spiracular collar.

**Distribution.** *Microrhagus lecontei* has been taken in **USA:** Indiana, Kansas, and Wisconsin.

**Biology.** Two beetles were taken from a Lindgren funnel trap set in Tippecanoe County, Indiana. One beetle was taken from a black panel trap baited with EtOH in Morgan Co., Indiana. In Kansas, beetle specimens have been taken from a Malaise trap and a canopy trap. In Wisconsin, I found *M. lecontei* in a variety of forest systems including floodplain forest, northern hardwood swamp, northern mesic forest and northern wet-mesic forest. All larvae were extracted from a very wet, grey rotten *Quercus* (Fagaceae) log in 2013. The heavily rotten log was located 6.06 meters from the shoreline of Lake Waubesa

at McDaniel Park in McFarland. The plant community was classified as a floodplain forest dominated with green ash (*Fraxinus pennsylvanicus* Marshall; Oleaceae) with silver maples (*Acer saccharinum* Linnaeus; Aceraceae), basswood (*Tilia americana* Linnaeus; Tiliaceae) and oaks as associates. Searching in conifers has yielded no larvae, which may indicate this species is a deciduous specialist.

I observed larvae tunneling along the wood grain, leaving no trails behind them. Many larvae were extracted near the surface, no more than 2.5 cm beneath the surface. Fourteen larvae, ranging from third to fifth instars were extracted from very wet pieces of wood. The striking feature observed in some larvae were enlarged areoles present on some abdominal segments. These enlarged areoles may be attributed to an adaptive strategy of boring into a wetter log as they constantly regulate water between themselves and the surrounding wet wood fibers. Some of the younger larvae have smaller areoles, compared to some of the fifth instars. Like many other observed species, larvae of *M. lecontei* construct a pupal chamber near the surface and assume a U-shaped position. I also observed no noticeable difference between previous instars and prepupal larval form. Pupation requires about two to three weeks. Most recently, many adults were collected from purple prism traps from late-June through mid-September in northeastern Wisconsin. During the mid to late 1970's, collectors in Wisconsin have found *M. lecontei* in Malaise traps deployed in much of Wisconsin during their survey work on Gypsy Moths (*Lymantria dispar* Linnaeus; Erebidae).

Eight adults emerged on 8 February 2014. All adults were placed in a small Ziploc® bag to observe their behavior. Like other eucnemid species, adult *M. lecontei* are capable of snapping into the air when placed on their backs. Adults were also observed to quiver their extended antennae while in captivity.

**Type material.** **Holotype**, male, with label data: "WI: Forest Co., along State Highway 55, N45.69989°/W88.86191°, 28 July 2009, Robert L. Otto" / "Taken from EAB prism trap baited w/ manuka oil" / "**HOLOTYPE**:", *Microrhagus, lecontei*, Otto, det. R.L. Otto, 2014" (♂ handwritten behind species name on label)[red printed label]. **Allotype**, female, with label data: "WI: Forest Co., along Double Bend Road, N45.74162°/W88.76381°, 20 August 2009, Robert L. Otto" / "Taken from EAB trap baited w/ manuka oil" / "**ALLOTYPE**:", *Microrhagus, lecontei*, Otto, det. R.L. Otto, 2014" (♀ handwritten behind species name on label) [yellow printed label]. Holotype and allotype are in WIRC.

Paratypes. 24 adults and 14 larvae, from the following localities: 1, **INDIANA: Morgan Co.:** July 11–Aug. 3, 2010, Kyle E. Schnepf (KESC); 2, **Tippecanoe Co.:** Ross Hills, Lindgren, June 7–28, 2013, col. Gareth S. Powell (GSPC); 1, **KANSAS: Douglas Co.:** 2 mi NW Baldwin, 38° 48.586'N, 95° 12.560'W, 12–26–VI–2006 (SEMC); 1, **Jefferson Co.:** The Falin Property, 1.5 km N jct. 94th Street and Kingman Rd., 39° 13.38'N, 95° 24.24'W, 10–25–VII–2004 (SEMC); 8 adults and 14 larvae, **WISCONSIN: Dane Co.:** McDaniel Park, 22 September 2013, 27 September 2013, Robert L. Otto (GERP, WIRC); 1, **Fond du Lac Co.:** T46N R9E sec 16, 2–8 August 1977 (WIRC); 1, **Forest Co.:** along Borske Rd, 17 August 2009, Robert L. Otto (WIRC); 1, along Ross Lake Rd, 19 August 2009, Robert L. Otto (WIRC); 1, along Old Hwy 55, 24 August 2009, Robert L. Otto (WIRC); 1, **Iowa Co.:** T6N R5E sec. 1, 6–12 July 1976 (WIRC); 1, **Jackson Co.:** T21N R4W sec. 33, 6–12 July 1976 (WIRC); 1, **Oconto Co.:** along Mosling Rd, 22 June 2010, Robert L. Otto (WIRC); 1, **Oneida Co.:** T46N R9W sec. 16, 12–19 July 1977 (WIRC); 1, **Ozaukee Co.:** 43.38295°N/-88.02534°W, WGS84, 09–16 July 2013, Daniel K. Young (WIRC); 1, 43.38567°N/-88.02638°W, WGS84, 27 August–3 September 2013, Daniel K. Young (WIRC); 1, **Shawano Co.:** along State Highway 32, 21 July 2010, Robert L. Otto (WIRC). Each specimen labeled: "**PARATYPE**:", *Microrhagus, lecontei*, Otto, det. R.L. Otto, 2014" (either ♂ or ♀ handwritten behind species name on each label)[yellow printed label] placed beneath the top label or inside the alcohol vial with the larval specimen. Larvae are of indeterminate sex. Adult paratypes are deposited in GERP, GSPC, KESC, SEMC and WIRC. Larval paratypes are deposited in GERP and WIRC.

**Etymology.** The name of the new species is dedicated to John LeConte, the father of American Coleopterology.

*Microrhagus triangularis* (Say, 1823)**Fifth instar**

(Fig. 66–70)

**Diagnosis.** Rectangular-shaped prothoracic microtrichial patch and oval shaped, somewhat enlarged areoles will distinguish *M. triangularis* from *M. lecontei*.

**Specimens Examined.** Eight larvae collected at **USA:** WISCONSIN: Dane County, Marshall Park, N43° 05.533', W-89° 28.975', 16 September 2013, Robert L. Otto, in rotten log (2 larvae); Oconto County, Rueckert's private property, T29N R17E sec 16, 10 April 2007, 16 April 2007, Robert L. Otto, in white rotten maple log (2 larvae); Oconto County, Quartz Hill Trail, N45° 22.449', W-88° 37.765', 16 April 2010, Robert L. Otto, in rotten aspen log (4 larvae). Larvae are deposited in GERP and WIRC.

**Description.** Length, 8.0–10.0 mm. Width, 1.0 mm. Orthosomatic, elateriform. Body cylindrical, sides parallel, cream-yellow with head, prothoracic sclerome patches and caudal end of abdominal segment IX dark brown. Setae either indistinct or absent. Legs reduced to simple setae. Dorsal and ventral microtrichial patches slightly darker in color compared to their surrounding areas (Fig. 66).

**Head** (Fig. 67): Strongly flattened, prognathous and inserted into prothorax. Dorsal cephalic disc sub-circular. Very weak median carina present on dorsal cephalic disc. Venter unmodified, without furrows or ridges. Base and lateral sides of the head capsule unsclerotized. Anterior portion of head capsule heavily sclerotized. Each lateral side of head capsule with four projections. Basal lateral projections enlarged. Lateral sides between first and second lateral projections strongly sinuate. Second through fourth lateral projections directed laterally. Antennae minute, arising between the third and fourth lateral projections. Scape not visible. Pedicel elongate. Sensorium and flagellum sub-equal in length. Sensory papillae indistinct. Mandibles minute, resting in the mesal acumination of the head capsule. Each mandible heavily sclerotized, oval with two outwardly projecting teeth. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

**Prothorax** (Fig. 68–69): Sub-equal to subsequent two thoracic segments. Tergum with pair of triangular-shaped scleromes extending from base up three-fourths the length of the segment then diverge towards lateral sides and converge to point of origin; caudal and lateral sides with undefined edges. Rectangular-shaped microtrichial patch present between scleromes. Sternum with pair of internally bent sub-triangular-shaped scleromes present converging towards median of segment. Sub-circular-shaped microtrichial patch present between scleromes. Both surfaces without areoles.

**Meso- and metathorax:** Terga with elliptical-shaped microtrichial patch. Sterna with semicircular-shaped microtrichial patch. Mesothorax variable; either with small, circular areole or absent altogether on both surfaces. Metathorax with small circular areole beneath patch, near middle of each segment on both surfaces. Metathorax with reduced spiracles.

**Abdomen:** Segments I–IX sub-equal in length and width. Terga I–VIII with microtrichial patch that successively change from oval on segment I to a small triangle on segment VIII. Sterna I–VIII with microtrichial patch that successively change from elliptical on segment I to a small oval on segment VIII. Areoles variably sized, largest on segments II–VI on both surfaces, circular to oval-shaped; positioned beneath patch, near middle of each segment. Tergum IX without microtrichial patch and areole; sternum (Fig. 70) heavily sclerotized at caudal half with prominent, semicircular circumanal asperities. Urogomphi absent on segment IX. Spiracles annular-biforous, with rounded spiracular collar.

**Distribution.** *Microrhagus triangularis* is known from **CANADA:** New Brunswick, Nova Scotia, Ontario, Québec; **USA:** Alabama, Arkansas, Connecticut, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia and Wisconsin (Muona 2000; Majka 2007; Webster et al. 2012). All specimens used in this study came from Wisconsin.



**Biology.** *Microrhagus triangularis* is one of the most common species found in eastern North America and some biological information is now known. Muona (2000) wrote *M. triangularis* was found on dogwood (*Cornus* sp.; Cornaceae). Majka (2007) took the species using a car net in Nova Scotia. Webster et al. (2012) collected seven specimens in July and August. One specimen was taken by beating foliage in a mixed forest. The remaining six specimens were taken from Lindgren funnel traps placed in an old red pine forest, a mature hardwood forest with American beech, sugar maple, and ash, an old-growth eastern white cedar forest, and an old red oak forest.

In Wisconsin I found *M. triangularis* in a variety of forest systems including floodplain forest, northern dry-mesic forest, northern hardwood swamp, northern mesic forest, northern wet-mesic forest, Pine Barrens, southern hardwood swamp, and southern mesic forest. I collected one adult specimen on goldenrod (*Solidago* sp.; Asteraceae) in 1994. Another adult specimen was swept through understory at Lone Rock in 1994. Many larvae were extracted from white rotten, moist maple and aspen (*Populus* sp.; Salicaceae) logs from 2007 through 2009. Searching in conifers has yielded no larvae, which may indicate this species is a deciduous specialist. I observed larvae tunneling parallel with the wood grain, leaving no trails behind them. Many larvae were extracted at least 2.5–3.0 cm beneath the surface. Like many other observed species, larvae of *M. triangularis* construct a pupal chamber near the surface and assume a U-shaped position. I observed no noticeable difference between previous instars and prepupal larval stage. Pupation requires about two to three weeks. Most recently, many adults were collected from purple prism traps during mid-June through the end of August in northeastern Wisconsin. Collectors in Wisconsin found *M. triangularis* in Malaise traps, sweeping grass and herbaceous understory, in Lindgren funnel traps, and on girdled ash trees.

Seven adults emerged on 5 June, 2010. Adults were placed in a vial with a piece of wood to observe their behavior and attempt to induce breeding. No eggs or first instars were observed following completion of adult observations. Like other eucnemid species, *M. triangularis* are capable of snapping into the air when placed on their backs. Adults were observed to quiver their extended antennae while in captivity. Adult beetles are short lived, lasting about one to two weeks in captivity before dying. It is likely *M. triangularis* completes its development in one year under optimal conditions, but may arrest its development under less optimal conditions.

## Discussion

Since the start of this project, its intention is to uncover any larval types for the family and record biological observations associated with each encountered species. Its ultimate goal is to uncover as many larval types in hope that someday a diagnostic key can be constructed to identify them in the region. It is a rare moment to witness the existence of four new species through this project, three of which were accomplished through rearing in Wisconsin. Secondly, the project has doubled the specific numbers in the region and potentially exposed their misplacements in the group, based on observed adult and larval morphology during the course of the study. All larval types for eight of the nine species during the course of this study came from Wisconsin, with the exception of *M. opacus*, whose larvae still remain undiscovered.

Larvae of *M. pectinatus* and *M. subsinuatus* are very similar to the European *Microrhagus pygmaeus* (Fabricius). After comparing larvae of both species against illustrations from Burakowski (1991, Fig. 150–151, page 42); *M. pectinatus* and *M. subsinuatus* can be separated from *M. pygmaeus* by the presence of areoles on both prothoracic and abdominal segment VIII. Areoles are absent on both segments in *M. pygmaeus*.

Larval types for these two species are also similar to another European species, *Microrhagus lepidus* (Rosenhauer). Based on illustrations in Burakowski (1991) and Mamaev (1976), shape of dorsal mesothoracic and metathoracic microtrichial patches will separate *M. pectinatus* from *M. lepidus*, those being alluvial-shaped in *M. lepidus* and oval shaped in *M. pectinatus*. *Microrhagus subsinuatus* can be distinguished from *M. lepidus* by its size and the shape of the dorsal microtrichial patches on each abdominal segment. Microtrichial patches are larger in *M. subsinuatus*, smaller in *M. lepidus*. Microtrichial patches are more elliptical on abdominal terga I–V in *M. lepidus*, and more circular in *M. subsinuatus*.

The remaining six known Nearctic *Microrhagus* larval types are very similar to the European *Microrhagus pyrenaeus* Bonvouloir. A number of comparative observations were made while examining these larval types against illustrations in Burakowski (1991, Fig. 53, page 16; Fig. 144–145, page 40). *Microrhagus breviangularis* and *M. brunneus* both differ from *M. pyrenaeus* by its transverse areoles positioned near the base of each abdominal segment; whereas areoles are circular to oval-shaped and positioned near the center of each segment in *M. pyrenaeus*. Presence of areoles on both surfaces of mesothorax and abdominal segment VIII will distinguish *M. audax* from *M. pyrenaeus*. Variably sized areoles on some abdominal segments will distinguish both *M. lecontei* and *M. triangularis* from *M. pyrenaeus*. Based on these illustrations, *M. pyrenaeus* have uniformed areoles, not subjected to wide variations in size. *Microrhagus carinicolis* is very similar to *M. pyrenaeus*, but differs in the presence of areoles on the mesothoracic tergum and abdominal sternum VIII; absent on both surfaces in *M. pyrenaeus*.

*Microrhagus* are one of several large, globally distributed genera in the family. Like *Fornax* Laporte and *Dromaeolus* Kiesenwetter, *Microrhagus* are based on autapomorphic, heterogeneous character states, making the group paraphyletic. Other than larvae of *M. subsinuatus* and *M. pectinatus*, the remaining six examined larval types from this study do not key out through an on-line world-wide larval identification key provided by Muona and Teräväinen (2011). Two character states outlined for *Microrhagus* larvae in the on-line key include the presence of five lateral serrations along each side of the head capsule and caudally pointed spiracular collars. Observations of four lateral projections are present along each side of the head capsule and rounded spiracular collars for these six larval types do not correspond with character states typical of *Microrhagus*. Furthermore, adult examinations for these seven species have uncovered two character traits differing from typical forms of *Microrhagus*. Adult character states include shorter anterior lateral pronotal ridge and metacoxal plates medially 1.2–2.5 times wider than laterally. Typical *Microrhagus* species have an elongate anterior lateral pronotal ridge and medially wider metacoxal plates. Both larval and adult character states observed in *M. audax*, *M. breviangularis*, *M. brunneus*, *M. carinicolis*, *M. lecontei*, *M. opacus*, and *M. triangularis* indicates misplacement for these species in the group. These eucnemid species will remain in *Microrhagus* for the time being, until further phylogenetic analysis can be done in the future.

Further analysis is warranted to ascertain status of different groups currently synonymized in *Microrhagus* (i.e. *Dichodirhagus* Méquignon, *Emyirhagus* Olexa, and *Aulacostenus* Motschulsky), whether these groups are distinct and should be separated from *Microrhagus*, including finding sister-group relationships among other taxa placed in the tribe. Creation of new group names for a number of species have not been ruled out. A potential world revision of *Microrhagus* at the specific level, utilizing both larval and adult morphologies as well as DNA may result in a number of species belonging to smaller, different groups; thereby reducing the size of *Microrhagus* significantly from its current numbers in the future.

## Acknowledgments

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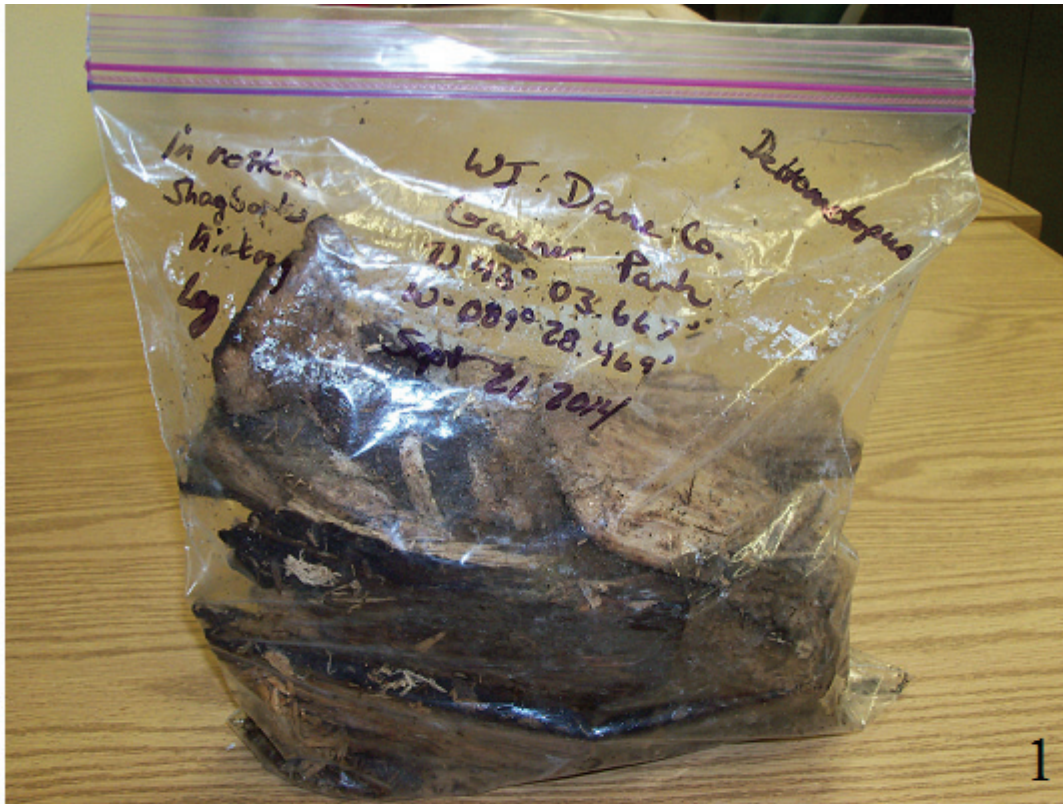
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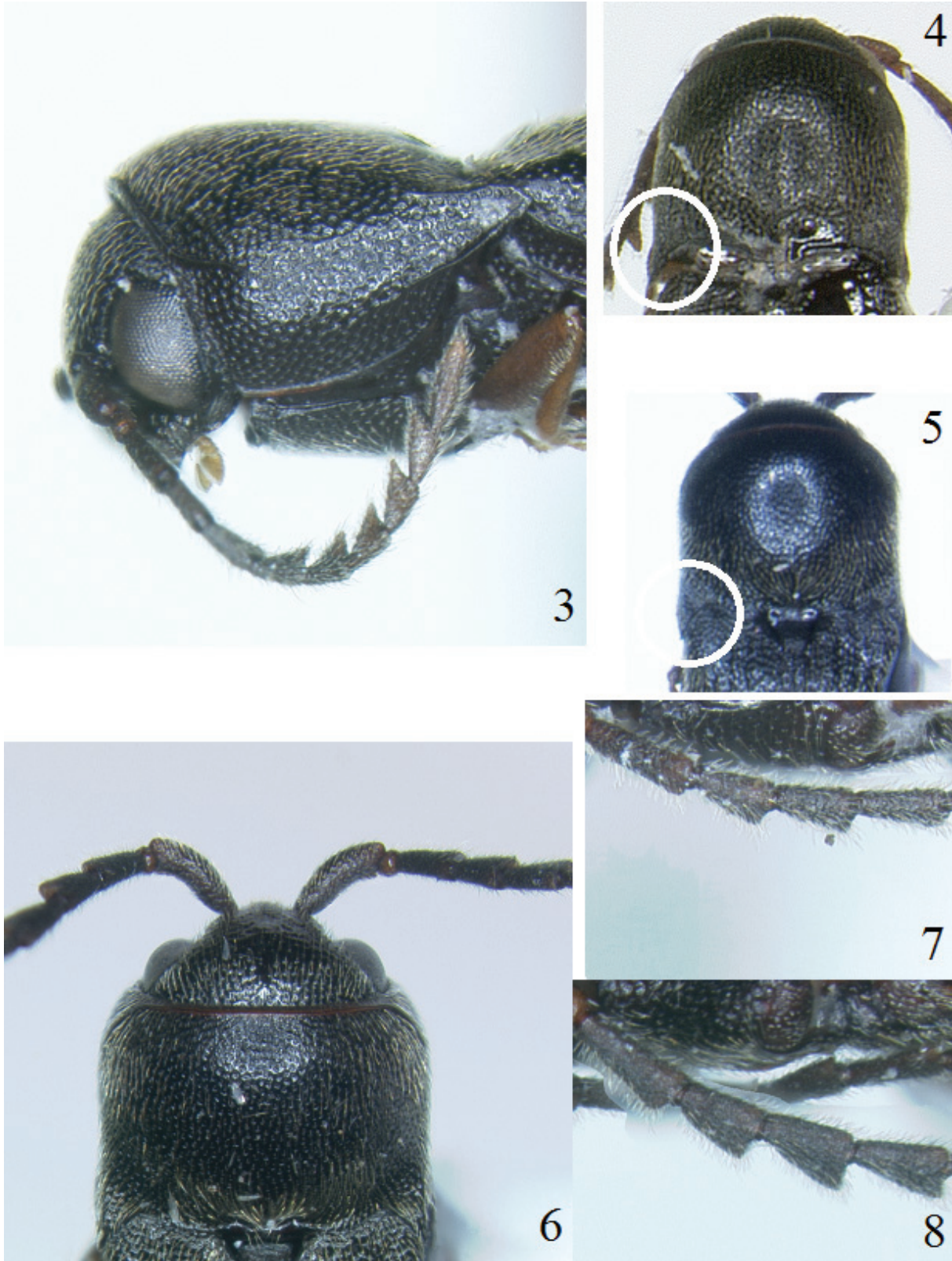
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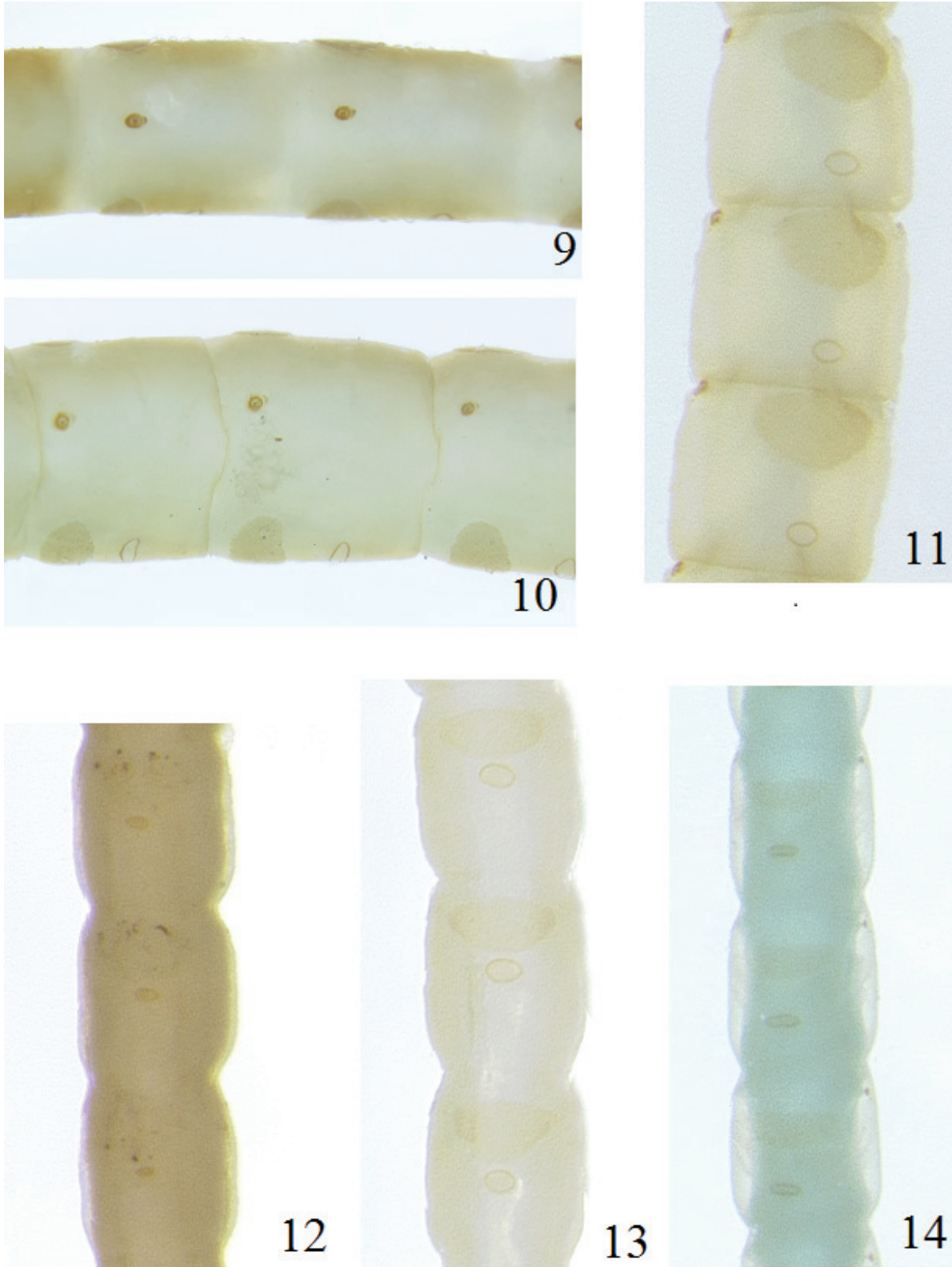


Figures 1-2. Rearing method. 1) Storage bag with rotten wood and data. 2) Examined rotten wood.



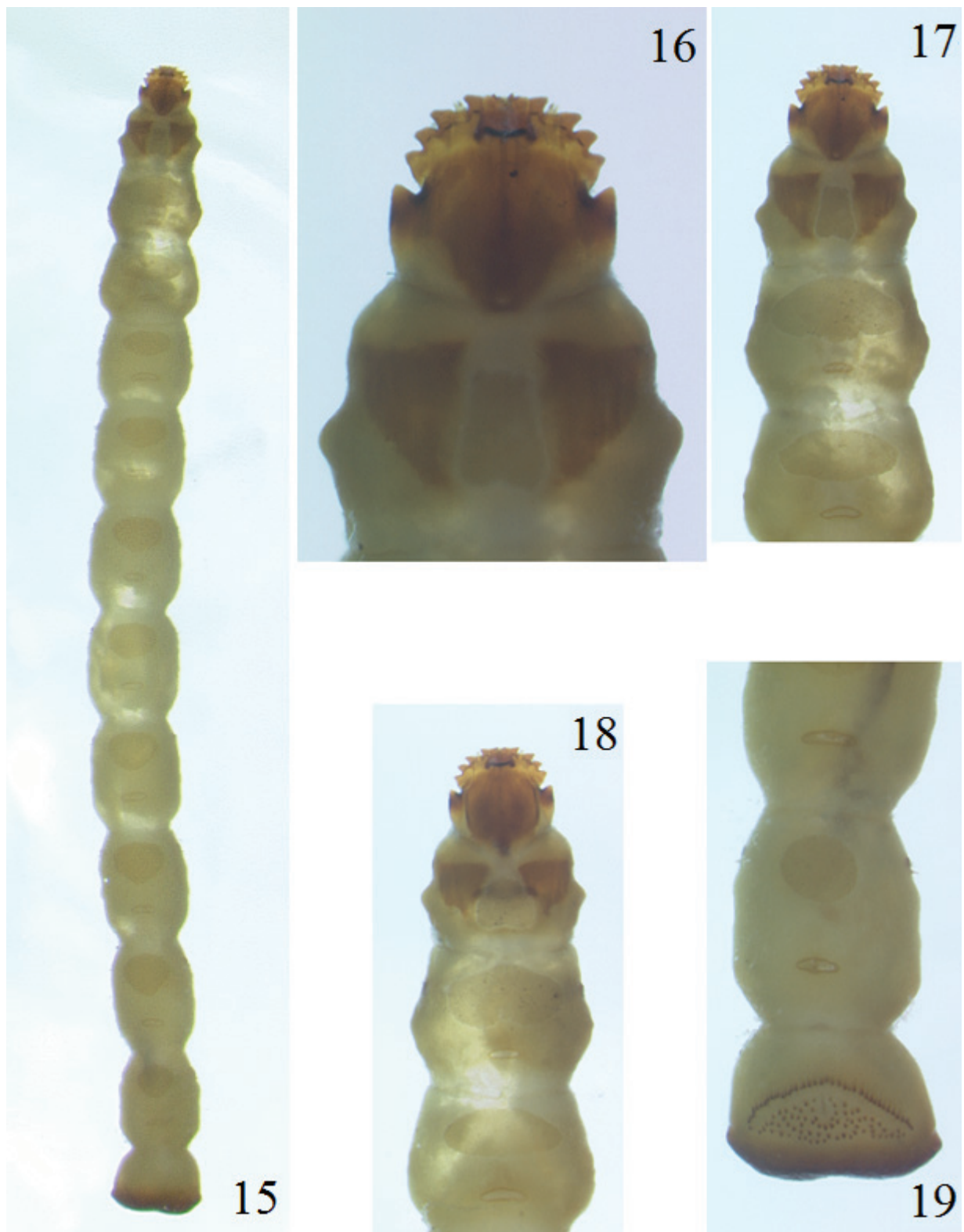


**Figures 3–8.** Nearctic *Microrhagus*. **3)** *Microrhagus audax*, pronotum, lateral side. **4)** *Microrhagus carinicollis*, pronotum, pronotal hind angles circled. **5)** *Microrhagus brunneus*, pronotum, pronotal hind angles circled. **6)** *Microrhagus carinicollis*, vertex. **7)** *Microrhagus lecontei*, antennomeres 3–6. **8)** *Microrhagus triangularis*, antennomeres 3–6.



**Figures 9–14.** Nearctic *Microrhagus*. **9)** *Microrhagus pectinatus*, spiracular collar on abdominal segments 1–3, lateral view. **10)** *Microrhagus breviangularis*, spiracular collar on abdominal segments 1–3, lateral view. **11)** *Microrhagus brunneus*, abdominal segments IV–VI, dorsal view. **12)** *Microrhagus carinicolis*, abdominal segments IV–VI, dorsal view. **13)** *Microrhagus triangularis*, abdominal segments IV–VI, dorsal view. **14)** *Microrhagus audax*, abdominal segments IV–VI, dorsal view.





**Figures 15–19.** *Microrhagus pectinatus*, fifth instar. **15)** Dorsal habitus. **16)** Head, dorsal view. **17)** Head and thoracic region, dorsal view. **18)** Head and thoracic region, ventral view. **19)** Abdominal segments VII–IX, ventral view.



**Figures 20–24.** *Microrhagus subsinuatus*, fifth instar. **20)** Dorsal habitus. **21)** Head, dorsal view. **22)** Head and thoracic region, dorsal view. **23)** Head and thoracic region, ventral view. **24)** Abdominal segments VII-IX, ventral view.

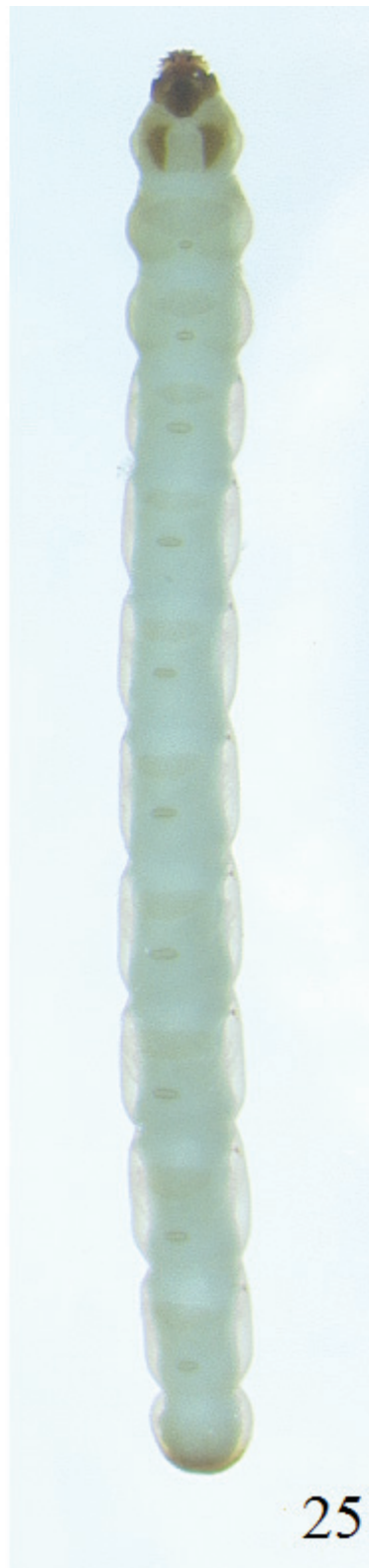


Figure 25. *Microrhagus audax*, fifth instar, dorsal habitus.



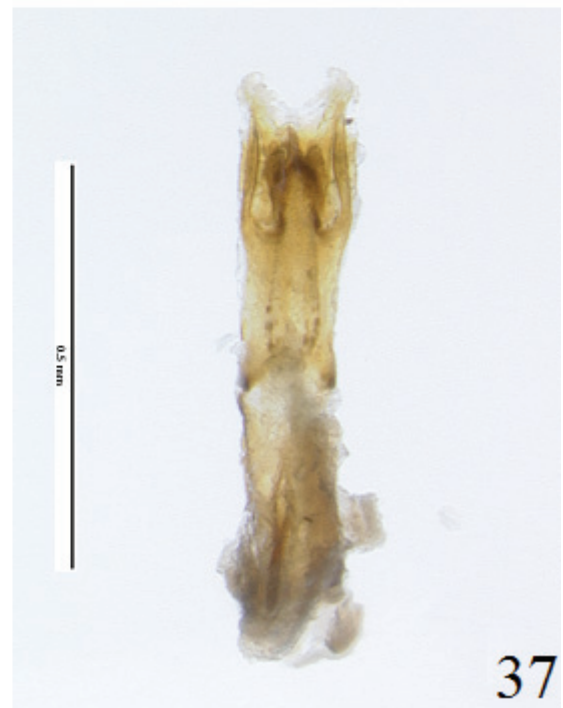
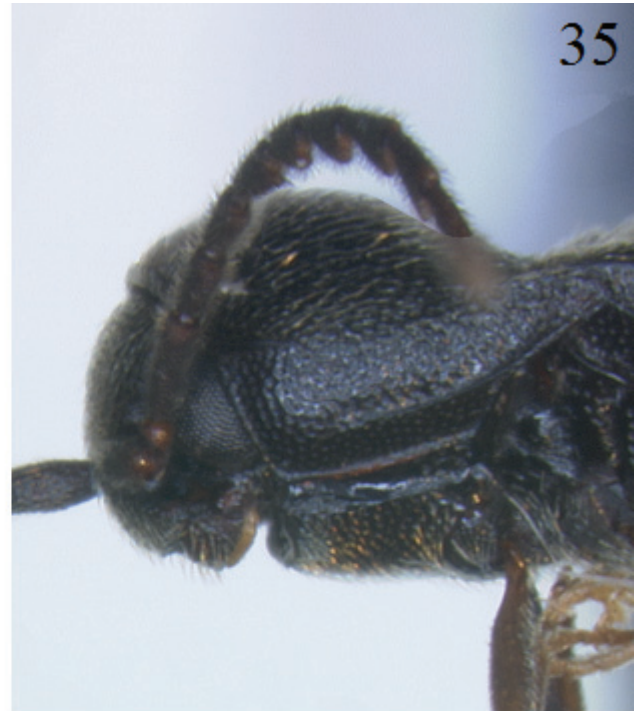
**Figures 26–29.** *Microrhagus audax*, fifth instar. **26)** Head, dorsal view. **27)** Head and thoracic region, dorsal view. **28)** Head and thoracic region, ventral view. **29)** Abdominal segments VII–IX, ventral view.





**Figures 30–33.** *Microrhagus opacus* Otto. **30)** Holotype, dorsal view. **31)** Holotype, lateral view. **32)** Holotype, ventral view. **33)** Aedeagus of paratype. Scale line = 2.0 mm (adult), 0.5 mm (aedeagus).





**Figures 34–37.** *Microrhagus breviangularis* Otto. **34)** Holotype, dorsal view. **35)** Holotype, lateral view. **36)** Holotype, ventral view. **37)** Aedeagus of paratype. Scale line = 0.5 mm.



**Figure 38.** *Microrhagus breviangularis*, fifth instar, dorsal habitus of paratype.



**Figures 39–42.** *Microrhagus breviangularis*, fifth instar. **39)** Head, dorsal view of paratype. **40)** Head and thoracic region, dorsal view of paratype. **41)** Head and thoracic region, ventral view of paratype. **42)** Abdominal segments VII–IX, ventral view of paratype.

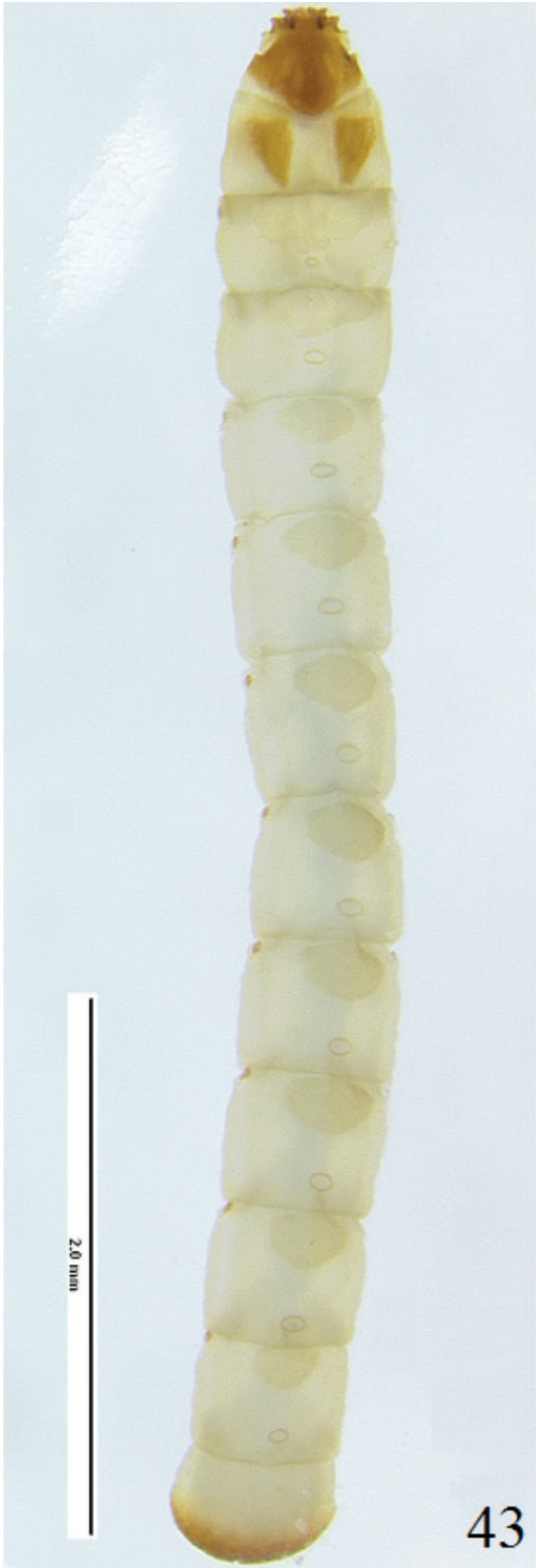
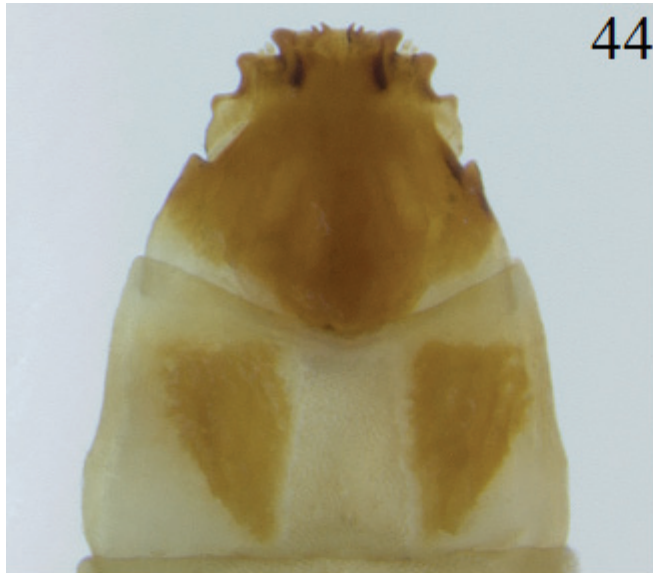


Figure 43. *Microrhagus brunneus*, fifth instar, dorsal habitus. Scale line = 2.0 mm.





**Figures 44–47.** *Microrhagus brunneus*, fifth instar. 44) Head, dorsal view. 45) Head and thoracic region, dorsal view. 46) Head and thoracic region, ventral view. 47) Abdominal segments VII–IX, ventral view.





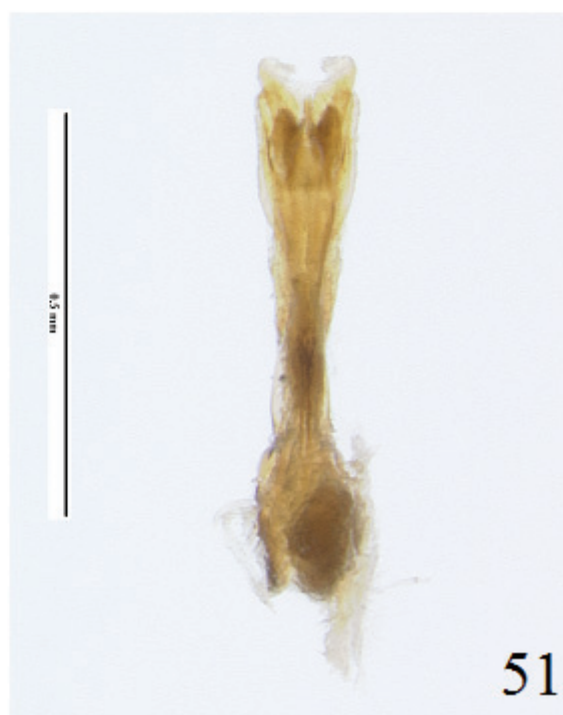
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Figures 48–51. *Microrhagus carinicollis* Otto. 48) Holotype, dorsal view. 49) Holotype, lateral view. 50) Holotype, ventral view. 51) Aedeagus of paratype. Scale line = 0.5 mm.



**Figures 52–56.** *Microrhagus carinicollis*, fifth instar. **52)** Dorsal habitus of paratype. **53)** Head, dorsal view of paratype. **54)** Head and thoracic region, dorsal view of paratype. **55)** Head and thoracic region, ventral view of paratype. **56)** Abdominal segments VII–IX, ventral view of paratype. Scale line = 2.0 mm.



**Figures 57–60.** *Microrhagus lecontei* Otto. **57)** Holotype, dorsal view. **58)** Holotype, lateral view. **59)** Holotype, ventral view. **60)** Aedeagus of paratype. Scale line = 2.0 mm.

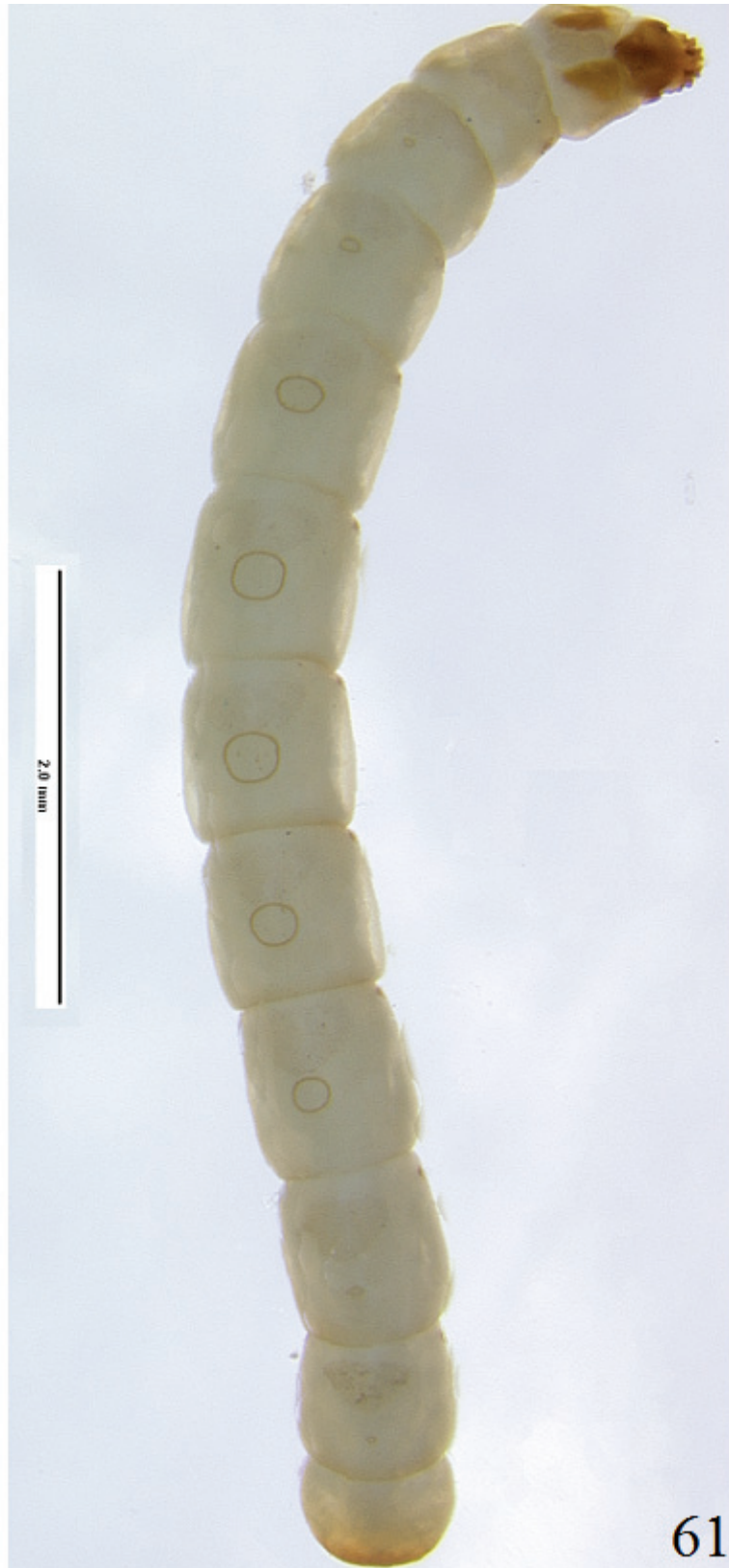


Figure 61. *Microrhagus lecontei*, fifth instar, dorsal habitus of paratype. Scale line = 2.0 mm.





**Figures 62–65.** *Microrhagus lecontei*, fifth instar. **62)** Head, dorsal view of paratype. **63)** Head and thoracic region, dorsal view of paratype. **64)** Head and thoracic region, ventral view of paratype. **65)** Abdominal segments VII–IX, ventral view of paratype.





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Figure 66. *Microrhagus triangularis*, fifth instar, dorsal habitus.



**Figures 67–70.** *Microrhagus triangularis*, fifth instar. **67)** Head, dorsal view. **68)** Head and thoracic region, dorsal view. **69)** Head and thoracic region, ventral view. **70)** Abdominal segments VII–IX, ventral view. Scale line = 0.5 mm.