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Bees of the genera *Dufourea* and *Dieunomia* of Michigan (Hymenoptera: Apoidea: Halictidae), with a key to the *Dufourea* of eastern North America

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Abstract. The halictid bees of the genera *Dufourea* Lepeletier de Saint Fargeau (Rophitinae) and *Dieunomia* Cockerell (Nomiinae) occurring in Michigan are reviewed. Two new records for Michigan are provided: *Dufourea harveyi* (Cockerell), new status, and *Dieunomia heteropoda* (Say). This is also the first published record of *D. harveyi* in the eastern United States. The occurrence of *Dieunomia* in southwest Michigan is the first record of the subfamily Nomiinae for the state. Information on the biology and distribution of each species is summarized. An identification key to the *Dufourea* of eastern North America is provided.

INTRODUCTION

The bee family Halictidae is biologically diverse, including species with a variety of social behaviors and floral preferences (Michener, 1974, 2007). Four subfamilies of halictid bees are recognized (Michener, 2007; Danforth *et al.*, 2008). The subfamilies Rophitinae and Nomiinae are the first two clades to branch off in the phylogeny (Danforth *et al.*, 2008; Hedtke *et al.*, 2013). The genus *Dufourea* Lepeletier de Saint Fargeau is the sole representative of the subfamily Rophitinae in eastern North America. *Dufourea* is composed of solitary ground-nesters which specialize on a limited number of host plants (Torchio *et al.*, 1967; Eickwort *et al.*, 1986; Rozen, 1993; Rozen & Özbek, 2008; Patiny *et al.*, 2008). Individuals are uncommonly collected, but can sometimes be captured in long series in areas where host plants are found (Stevens, 1919; Eickwort *et al.*, 1986; J.G., pers. obs.). Three species were included in Mitchell's (1960) revision of the genus for the eastern United States (*i.e.*, for states east of the Mississippi River).

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Figure 1. Face of female *Dufourea maura* (Cresson). Modified from Dumesh & Sheffield (2012). Scale bar = 1 mm.

Only one of these, *Dufourea novaeangliae* (Robertson), was recorded from Michigan, although all three were known from the Midwest. A fourth species for the eastern United States, *D. maura* (Cresson), was subsequently recorded from northern Michigan (Arduser, 1986). *Dufourea monardae* (Viereck) has also been identified from the state (Bouseman, 1976). Here we report the occurrence of a fourth species of *Dufourea* in Michigan, and the first record of *D. harveyi* (Cresson) in the eastern United States. We discuss all five species occurring in eastern North America, providing available records for Michigan.

The subfamily Nomiinae includes both solitary and communal nesting species (Batra, 1966; Wcislo, 1993; Wcislo & Engel, 1996). Some nomiine bees are oligolectic (Minckley *et al.*, 1994) while others are not (Wcislo, 1993). The subfamily is diverse in the Old World tropics (Pauly, 1990, 2009), but is less so in North America, where only two genera are known, *Nomia* Latreille and *Dieunomia* Cockerell. The species *Dieunomia heteropoda* (Say) is highly distinctive, remarkable for its large size relative to most other halictid bees. We report the first record of the genus *Dieunomia* and the subfamily Nomiinae occurring in Michigan.

MATERIAL AND METHODS

We surveyed the literature for published records of *Dufourea* and *Dieunomia* in Michigan and the eastern United States (*e.g.*, Mitchell, 1960; Evans, 1986; Gardiner *et al.*, 2010; Tuell *et al.*, 2009) and gathered museum records as part of an earlier study on *Dufourea* in Canada (Dumesh & Sheffield, 2012), for ongoing studies of the Michigan bee fauna (J.G., unpubl. data), and continued study of *Dufourea* systematics (T.L.G., unpubl. data). Taxonomy of floral host records was updated using the USDA Plants Database (www.plants.usda.gov). We examined material from two major collec-

tions for Michigan, the A.J. Cook Arthropod Collection at Michigan State University (MSUC), including the research collections of Rufus Isaacs and Doug Landis (MSU Department of Entomology), and the Museum of Zoology, University of Michigan; additional specimens were found in the Snow Entomological Collection, Division of Entomology, University of Kansas Natural History Museum (SEMC), and U.S. National Pollinating Insects Collection, USDA-ARS (BBSL). Historical specimen records were geo-referenced using Google Earth (Google Inc.). County records without a specific locality were geo-referenced to the county centroid. Points were mapped using ArcMap 10.1 (ESRI).

SYSTEMATICS

Family Halictidae Thomson
 Subfamily Rophitinae Schenck
 Genus *Dufourea* Lepeletier de Saint Fargeau

Dufourea can easily be recognized among bees of the eastern United States by the following characters: two submarginal cells, a single subantennal sulcus below each antennal socket, short clypeus, and antennal sockets below middle of the face (Fig. 1). For generic-level keys see Mitchell (1960), Michener *et al.* (1994), and Michener (2007).

Dufourea harveyi (Cockerell), **new status**
 (Figs. 3, 5, 16–18)

Halictoides Harveyi Cockerell, 1906: 223 (♀).

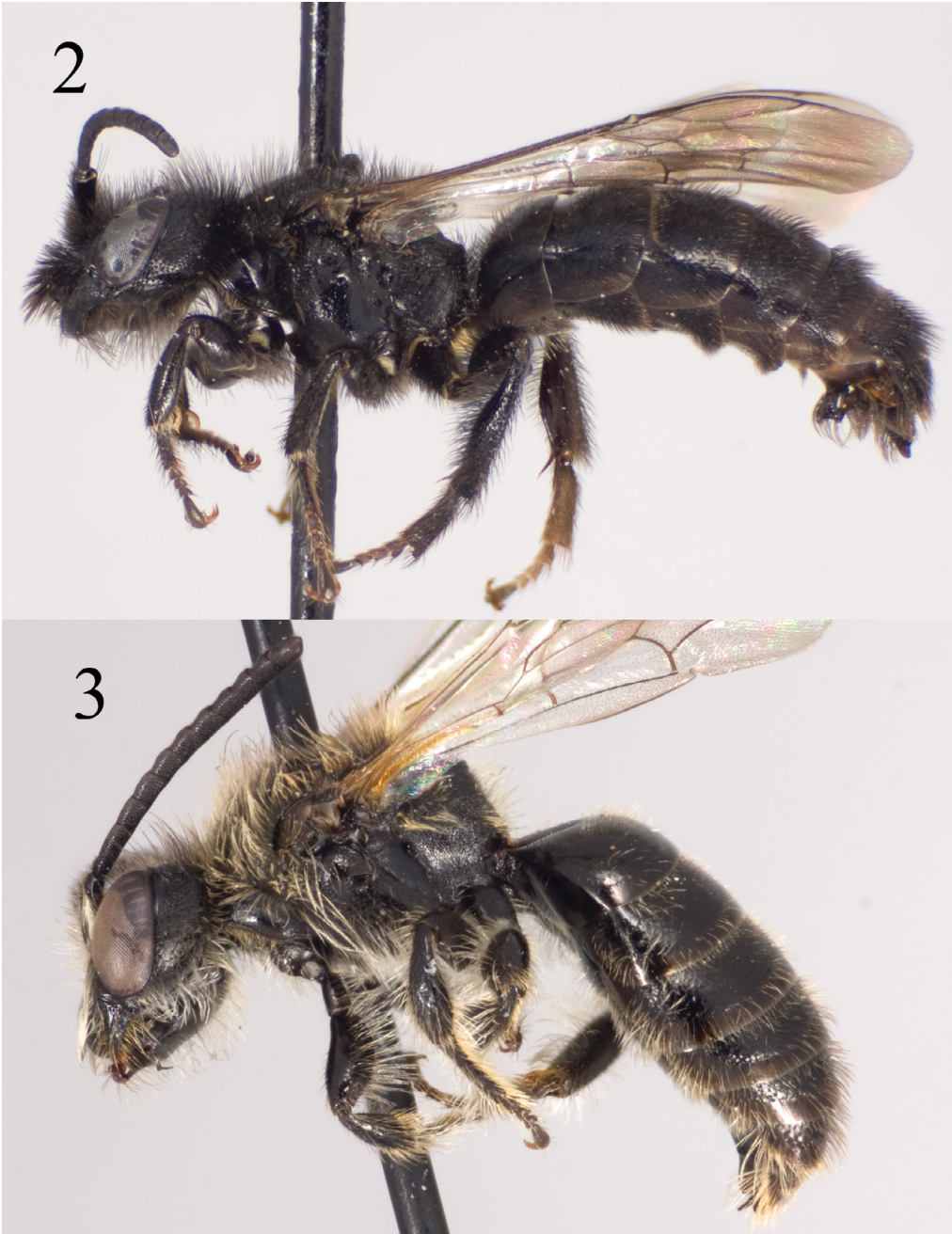
Dufourea (Halictoides) fimbriata fimbriata (Cresson): Michener, 1951: 1131 (catalog, synonym by G.E. Bohart); Hurd, 1979: 1935 (catalog); Moure & Hurd, 1987: 19 (catalog).

Dufourea fimbriata (Cresson): Dumesh & Sheffield, 2012: 15 (♀♂ redescription [in part]).

This species has commonly been understood to be *D. fimbriata* (Cresson, 1878), based on a synonymy proposed by G.E. Bohart in Michener (1951) and subsequently used by later authors (Hurd, 1979; Moure & Hurd, 1987; Dumesh & Sheffield, 2012). This concept is in error based on study of the Cresson type by one of us (T.L.G.). *Dufourea fimbriata* is more closely related to *D. marginata* (Cresson).

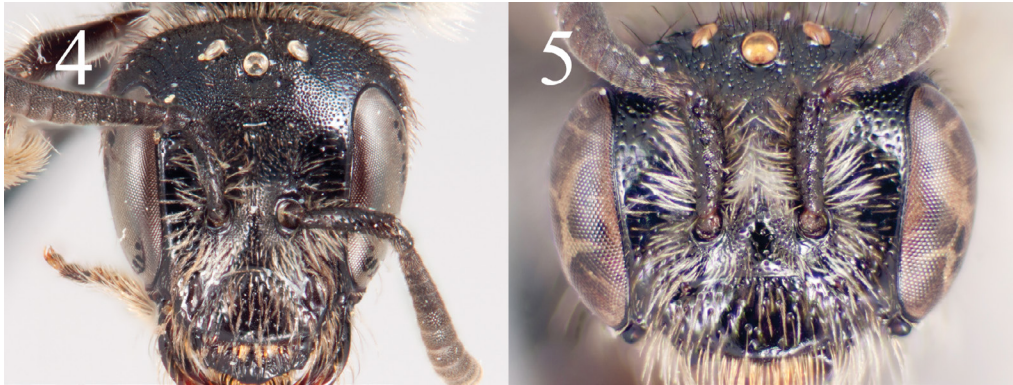
Dufourea harveyi is not previously recorded from Michigan or nearby states. *Dufourea harveyi* is widespread in the western USA and Canada in alpine and boreal areas (Hurd, 1979; Moure & Hurd, 1987; Dumesh & Sheffield, 2012). In the United States it was previously known only as far east as Colorado (Cockerell, 1906; Hurd, 1979; Moure & Hurd, 1987), but has recently been recorded from Ontario, Canada (Dumesh & Sheffield, 2012). New state records for Michigan are as follows: **Barry Co.:** Yankee Springs Game Area, 16 August 1960 [MSUC]; **Jackson Co.:** Liberty, Grand River fen, 4 August 2009, 31 August 2009 [MSUC]; **Kalamazoo Co.:** Gull Lake Biological Station [formally the W.K. Kellogg Biological Station], 19 August 1960 [MSUC] (Fig. 24). These are the first published records of the species in the eastern United States. The easternmost record for the species is from Jackson County, Michigan. An earlier Ontario record (N50.8729, W84.5797) is nearly 940 km due north of Jackson County (Dumesh & Sheffield, 2012).

Dufourea harveyi is believed to be an oligolege on *Potentilla* L. (Asteraceae), including *Potentilla glandulosa* Lindl., but has also been recorded visiting *Achillea millefolium*



Figures 2–3. Lateral habitus of male *Dufourea* Lepeletier de Saint Fargeau. 2. *Dufourea maura* (Cresson). 3. *D. harveyi* (Cockerell). Modified from Dumesh & Sheffield (2012).

L. (Asteraceae), *Dasiphora fruticosa* (L.) Rybd. (Rosaceae), *Penstemon* Schmidel (Scrophulariaceae), and *Polemonium* L. (Polemoniaceae) (Hurd, 1979; Lincoln, 1981; Moure & Hurd, 1987). Species of *Potentilla* have been recorded from all 83 counties in Michigan; but *P. glandulosa* is not one of them (Reznicek *et al.*, 2011). Individuals fly from late June to late August.



Figures 4–5. Faces of female *Dufourea* Lepeletier de Saint Fargeau. 4. *Dufourea novaeangliae* (Robertson). 5. *D. harveyi* (Cockerell). Modified from Dumesh & Sheffield (2012).

Dufourea maura (Cresson)
(Figs. 1–2)

Panurgus maurus Cresson, 1878: 61 (“♀” = ♂).

Halictoides maurus (Cresson): Stevens, 1919: 205 (host records).

Dufourea (*Halictoides*) *maura* (Cresson): Michener, 1951: 1132 (catalog); Hurd, 1979: 1936 (catalog); Moure & Hurd, 1987: 20 (catalog).

Dufourea maura (Cresson): Dumesh & Sheffield, 2012: 20 (♀♂ redescription).

This distinctive species has been recorded from Isle Royale in Keweenaw County (Arduser, 1986), which is the northernmost part of the state. *Dufourea maura* has a boreal/alpine distribution which makes it unlikely to occur in the southern parts of Michigan. The bee is known from Ontario (Dumesh & Sheffield, 2012), but has not been recorded from any of the adjacent US states (e.g., Wolf & Ascher, 2009). Arduser (1986) reported 27 males and four females taken through the month of July (2nd–27th) in various years. Four additional males from Isle Royale, collected on June 30th, 1965 were examined at MSUC (Fig. 24). Two recently collected specimens in the collection of S. Wilson are from the following sites on Isle Royale: Threemile trailhead, 48.122919, -88.531717, 11 July 2013 and Monkey Basin, 48.064075, -88.650183, 24 July 2013.

Dufourea maura is believed to be a specialist on *Campanula rotundifolia* L. (Campanulaceae) (Stevens, 1919; Hurd, 1979; Lincoln, 1981; Arduser, 1986), which is widespread in the state of Michigan, occurring in 68 counties (Reznicek *et al.*, 2011). Flight records range from June to mid August (Stevens, 1919).

Dufourea monardae (Viereck)
(Figs. 8, 9, 13–15)

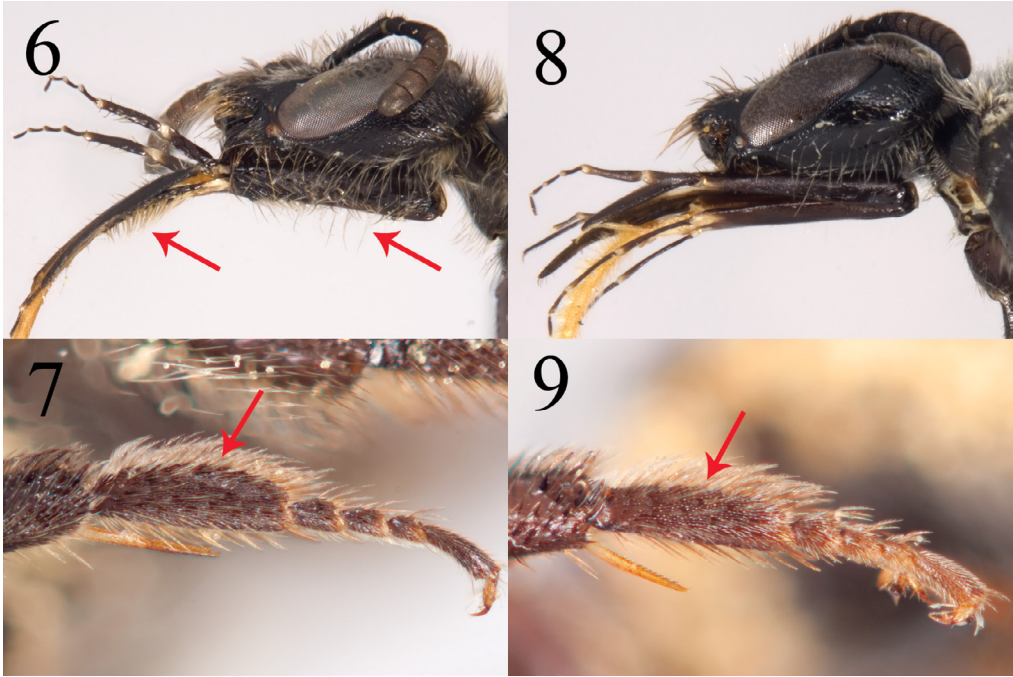
Conohalictoides monardae Viereck, 1924: 14 (♀♂).

Halictoides Novae-angliae (Robertson): Graenicher, 1910: 104 (misdet.)

Dufourea (*Halictoides*) *monardae* (Viereck): Michener, 1951: 1132 (catalog); Mitchell, 1960: 518 (♀♂ redescription); Krombein, 1967: 472 (catalog); Hurd, 1979: 1936 (catalog); Moure & Hurd, 1987: 21 (catalog).

Dufourea monardae (Viereck): Dumesh & Sheffield, 2012: 22 (♀♂ redescription).

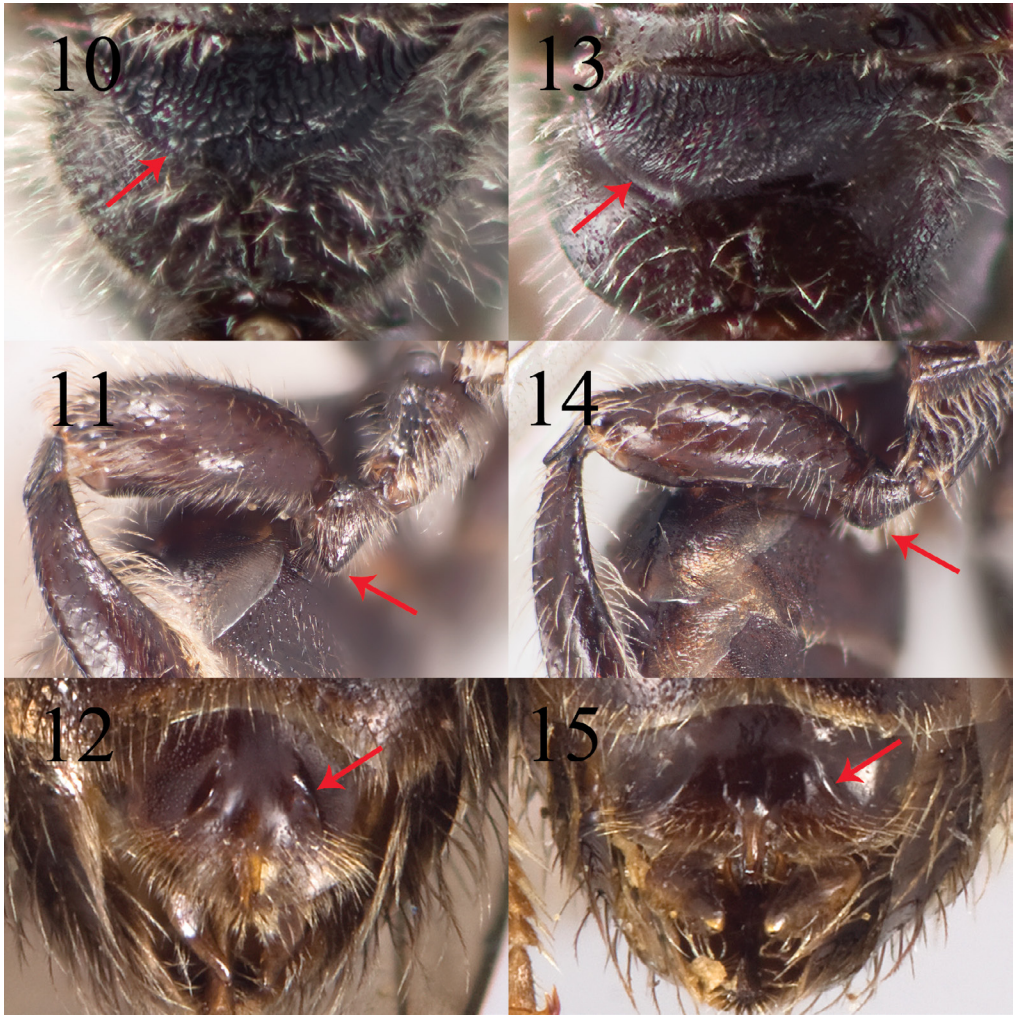
This species is oligolectic on *Monarda fistulosa* L. (Lamiaceae) (Bouseman, 1976). Graenicher (1910) recorded this species (as *Halictoides Novae-angliae*) on *Agastache foe-*



Figures 6–9. Females of *Dufourea novaeangliae* (Robertson) (6, 7) and *D. monardae* (Viereck) (8, 9). **6, 8.** Head and mouthparts in lateral view. **7, 9.** Mesobasitarsi. Modified from Dumesh & Sheffield (2012).

niculum Pursh (Kuntze) (Lamiaceae), additional non-*Monarda* records include: *Arctium minus* Bernh. (Asteraceae) and *Leonurus cardiac* L. (Lamiaceae). Although the floral host is abundant, this species is relatively uncommon in collections. Nevertheless, *D. monardae* is the most commonly collected member of the genus in Michigan. The species is known to occur through parts of the Midwest, northeast and southeast USA, as well as Ontario, Canada (Mitchell, 1960; Bouseman, 1976; Wolf & Ascher, 2009; Dumesh & Sheffield, 2012).

Dufourea monardae has been collected in relative abundance at the Edwin S. George Reserve in Livingston County (Bouseman, 1976; Evans, 1986). Additional records of the species are from the following localities: **Allegan Co.:** Allegan State Forest, 30 July 1970 [MSUC]; **Barry Co.:** Yankee Springs Game Area, 13 July 1959 [MSUC]; **Cass Co.:** Edward Lowe Foundation, 22 July 2013 [MSUC]; **Clinton Co.:** Bath, 20 July 1963 [MSUC]; Rose Lake Wildlife Experiment Station, 14 August 1979 [MSUC]; **Dickinson Co.:** T40N R30 Sec. 7, 31 July 1983 [BBSL]; **Huron Co.:** 5 km NE of Gagetown, 30 July 2009 [MSUC]; **Ingham Co.:** no locality, 17 August 1948 [MSUC]; East Lansing, 25 July 1960 [MSUC]; Mason, 1 August 2012 [MSUC]; **Iona Co.:** no locality, 14 July 1957; **Kalamazoo Co.:** Gull Lake Biological Station, 19 July 1965, 23 July 1960, 16 August 1960 [MSUC]; Kalamazoo, 18 August 1963 [MSUC]; Kalamazoo, 4 mi. W, 4 August 1963 [MSUC]; **Livingston Co.:** Gregory State Game Area, Sheets Lake, 26 July 1991 [BBSL]; **Midland Co.:** no locality, 17–27 July 1960 [MSUC]; **Newaygo Co.:** Croton, 4 August 1973 [MSUC]; **Oakland Co.:** Pontiac Recreation Area, 28 July 1972 [MSUC]; **Shiawassee Co.:** Rose Lake Research Area, 29 July 1993 [BBSL]; **Washtenaw Co.:** Mud Lake Bog, 17–20 July 1971 [SEMC] (Fig. 24). The bee is evidently widespread in Michigan. The host plant, *M. fistulosa*, occurs throughout the state, having been record in 75 counties (Reznicek *et al.*, 2011). Flight records range from July to late August (Evans, 1986).



Figures 10–15. Males of *Dufourea novaeangliae* (Robertson) (10–12) and *D. monardae* (Viereck) (13–15). 10, 13. Propodea. 11, 14. Metatrochanters. 12, 15. Metasomal sterna six. Modified from Dumesh & Sheffield (2012).

Dufourea novaeangliae (Robertson)
(Figs. 4, 6, 7, 10–12)

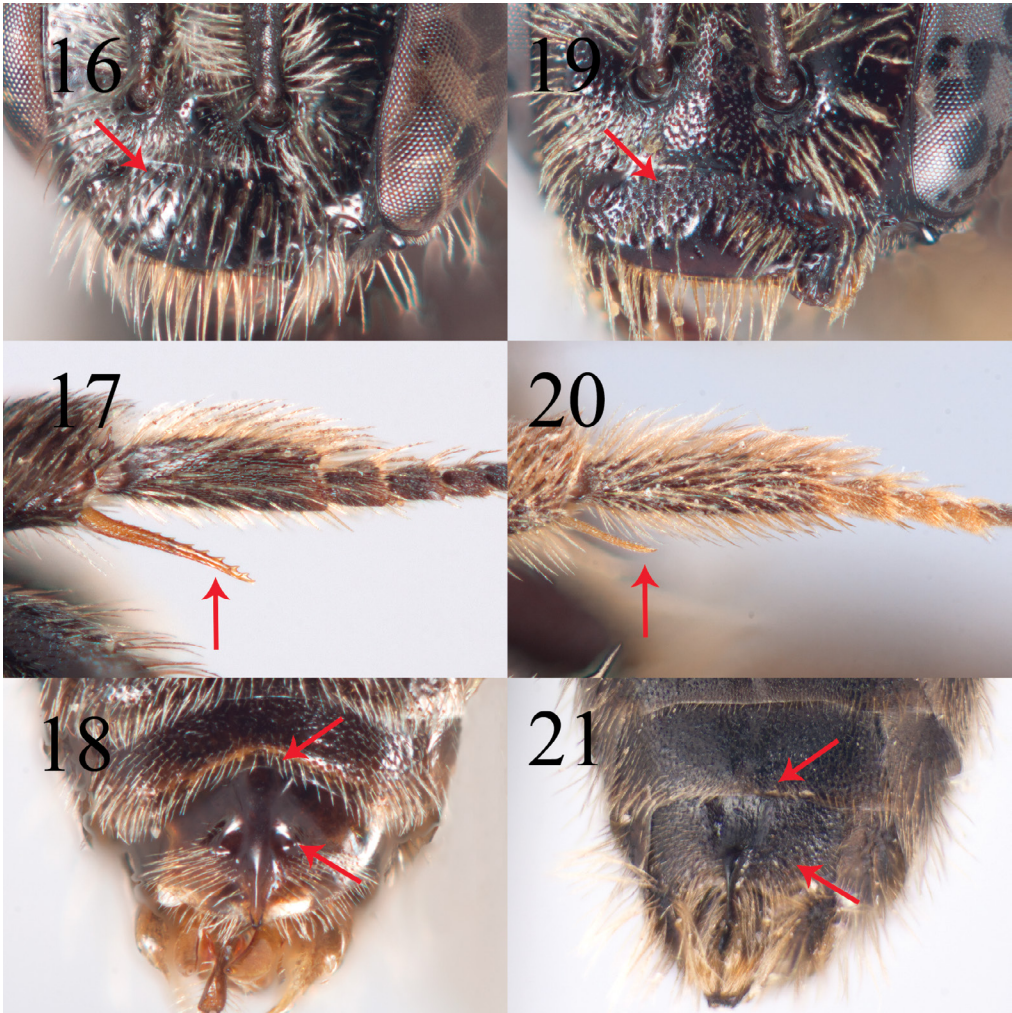
Panurgus novae-angliae Robertson, 1897: 339 (♂).

Conohalictoides lovelli Viereck, 1904: 245 (♀♂).

Dufourea (*Halictoides*) *novae-angliae* (Robertson): Michener, 1951: 1132 (catalog); Mitchell, 1960: 519 (♀♂ redescription); Krombein, 1967: 472 (catalog); Hurd, 1979: 1936 (catalog); Eickwort *et al.*, 1986: 109 (larva; nesting biology); Moure & Hurd, 1987: 22 (catalog).

Dufourea novaeangliae (Robertson): Dumesh & Sheffield, 2012: 23 (♀♂ redescription).

Dufourea novaeangliae is oligolectic on *Pontederia cordata* L. (Pontederiaceae) (Viereck, 1924; Eickwort *et al.*, 1986; Alves-dos-Santos, 2003), but has also been recorded from *Fagopyrum esculentum* Moench (Polygonaceae), *Verbena hastata* L. (Verbenaceae), *Lythrum salicaria* L. (Lythraceae), and *Prunella vulgaris* L. (Lamiaceae), presumably visiting these plants for nectar (Mitchell, 1960; Eickwort *et al.*, 1986; Payette, 2001). At least



Figures 16–21. Male *Dufourea harveyi* (Cockerell) (16–18) and *D. marginata* (Cresson) (19–21). 16, 19. Clypea. 17, 20. Inner metatibial spurs. 21, 22. Metasomal sternae five and six. Modified from Dumesh & Sheffield (2012).

in certain locations, this species can be collected in large numbers from *Pontederia* L., which grows at the edges of lakes and streams (Eickwort *et al.*, 1986; Reznicek *et al.*, 2011). *Pontederia cordata* is widespread throughout the state of Michigan, occurring in 57 counties (Reznicek *et al.*, 2011). *Dufourea novaeangliae* has been collected across the northeastern USA and eastern Canada (Mitchell, 1960; Bouseman, 1986; Eickwort *et al.*, 1986; Payette, 2001; Wolf & Ascher, 2009; Sheffield *et al.*, 2009; Dumesh & Sheffield, 2012).

Males of *D. novaeangliae* are active by early to mid-July, followed by females approximately a week later (Eickwort *et al.*, 1986; Payette, 2001; J.G., pers. obs.). Peak activity lasts until mid to late August (Eickwort *et al.*, 1986). The nesting biology of *D. novaeangliae* was studied in upstate New York by Eickwort *et al.* (1986). Nests were found in sandy soils in shaded areas adjacent to water (Eickwort *et al.*, 1986). Mate-seeking behavior of males was reported by Kukuk *et al.* (1985).

Mitchell (1960) recorded *D. novaeangliae* from Michigan from unspecified locations. It is recorded here from the following locations: **Allegan Co.:** Allegan State Forest, 22 July 1963 [MSUC]; **Barry Co.:** Guernsey Lake, T2N R9W Sec. 18, no date [MSUC]; no locality, 24 July 1956 [MSUC]; **Clinton Co.:** Bath, 20 July 1963 [MSUC]; **Ingham Co.:** Lake Lansing, 25 August 1979 [BBSL]; **Mecosta Co.:** no locality, 24 July 1941 [SEMC]; **Newaygo Co.:** no locality, 1 August 1943 [MSUC]; **Shiawassee Co.:** Rose Lake Research Area, 21 July 1992 [BBSL] (Fig. 24). Two individuals were collected on *Sagittaria latifolia* Willd. (Alismataceae). One of us (J.G.) collected bees from *Pontederia* in Lake Cadillac (Wexford Co.) and Lake Lansing (Ingham Co.) during August of 2013, but failed to find any *Dufourea* (J.G., pers. obs.).

Dufourea marginata (Cresson)
(Figs. 19–21)

Panurgus marginatus Cresson, 1878: 62 (♀).

Panurgus autumnalis Robertson, 1895: 121 (♀).

Dufourea (*Halictoides*) *marginata* (Cresson): Mitchell, 1960: 516 (♀♂ redescription).

Dufourea (*Halictoides*) *marginata marginata* (Cresson): Michener, 1951: 1132 (catalog); Hurd, 1979: 1936 (catalog); Moure & Hurd, 1987: 20 (catalog).

Dufourea marginata (Cresson): Dumesh & Sheffield, 2012: 18 (♀♂ redescription [in part]).

There are no records of this species in Michigan. *Dufourea marginata* occurs in Illinois, Wisconsin, and Ontario (Michener, 1951; Wolf & Ascher, 2009; Dumesh & Sheffield, 2012), and so could plausibly extend its range into both the southwest corner and the Upper Peninsula of Michigan. *Dufourea marginata* is a specialist on *Helianthus* L. (Stephen *et al.*, 1969; Hurd *et al.*, 1980), but has also been collected on other Asteraceae, including *Bidens aristosa* (Michx.) Britton, *Cirsium altissimum* (L.) Hill, *Erigeron speciosus* (Lindl.) DC. var. *macranthus* (Nutt.) Cronquist, *Grindelia squarrosa* (Pursh) Dunal, *Oligoneuron rigidum* (L.) Small, and *Rudbeckia hirta* L. (Stephen *et al.*, 1969; Hurd, 1979; Hurd *et al.*, 1980; Moure & Hurd, 1987). *Dufourea marginata* has also been recorded visiting *Convolvulus* L. (Convolvulaceae) for nectar.

Key to species of *Dufourea* in eastern North America
[All species except *D. marginata* have been recorded from Michigan.]

1. Both sexes: Pubescence of body very dark (Fig. 2); compound eyes diverging below (Fig. 1). Male: Metasomal sternum six with strong ventrally-directed keel (Fig. 2) (specialist on *Campanula*; alpine/boreal distribution) *D. maura* (Cresson)
- Both sexes: Pubescence of body light in part (Fig. 3); compound eyes parallel or converging below. Male: Metasomal sternum six with apically-directed keel (Fig. 3) 2
- 2(1). Both sexes: Head longer than wide (Fig. 4) 3
- Both sexes: Head wider than long (Fig. 5) 4
- 3(2). Female: Mouthparts (stipes, first labial palpomere) with abundant setae (Fig. 6); mesobasitarsus bowed posteriorly, width at midpoint distinctly greater than apex (Fig. 7). Male: Posterior margin of propodeal dorsum rugulose (Fig. 10); metatrochanter with ventral angle acute (Fig. 11); metasomal sternum six with oblique submedial swellings carinate (Fig. 12) (specialist on *Pontederia*)
..... *D. novaeangliae* (Robertson)

- Female: Mouthparts bare (Fig. 8); mesobasitarsus parallel-sided, width at mid-point subequal to apex (Fig. 9). Male: Posterior margin of propodeal dorsum imbricate (Fig. 13); metatrochanter with ventral angle obtuse (Fig. 14); metasomal sternum six with oblique submedial swellings acarinate (Fig. 15) (specialist on *Monarda*) *D. monardae* (Viereck)
- 4(2). Both sexes: Mesoscutum shiny, sparsely punctate across disc. Female: Clypeus with coarse punctures evenly distributed across surface (Fig. 16); mesotibial spur long, more than half as long as mesobasitarsus (Fig. 17). Male: Posterior margin of metasomal sternum five concave (Fig. 18); sternum six with low submedial ridge on each side of medial carina (specialist on *Potentilla*) *D. harveyi* (Cockerell)
- Both sexes: Mesoscutum dull, contiguously punctate across disc. Female: Clypeus with fine punctures concentrated basally, clypeus impunctate apicomediaally (Fig. 19); mesotibial spur short, less than half as long as mesobasitarsus (Fig. 20). Male: Posterior margin of metasomal sternum five straight (Fig. 21); sternum six without submedial ridge on each side of medial carina (specialist on *Helianthus*) *D. marginata* (Cresson)

Subfamily Nomiinae Robertson

Genus *Dieunomia* Cockerell

Dieunomia heteropoda heteropoda (Say)

(Figs. 21–22)

Nomia (?) *heteropoda* Say, 1824: 349 (♂).

Andrena valida Say, 1837: 393 (♀).

Nomia heteropoda valida (Say): Cockerell, 1934: 4 (synonymy).

Nomia heteropoda validescens Blair, 1935: 206 (♂).

Nomia heteropoda subvalida Blair, 1935: 206 (♀).

Nomia (*Dieunomia*) *heteropoda heteropoda* (Say): Michener, 1951: 1128 (catalog); Mitchell, 1960: 507 (♀♂ redescription); Hurd, 1979: 1945 (catalog); Moure & Hurd, 1987: 40 (catalog).

This is a highly distinctive species, which is unlikely to be mistaken for any other bee in the state. It can easily be recognized by its large size (>17 mm), andreniform body shape, and dark body, pubescence, and wings (Fig. 22). The first and third submarginal cells are approximately equal in length, and each are much longer than the second cell. A distinctive feature of the male is the enlarged metatibia (Fig. 23), which is used to grasp the female during mating (Wcislo & Buchmann, 1995).

This species has been collected from the following sites in southwest Michigan: **Allegan Co.:** 4.5 km south of Pullman, 17 July 2013 [MSUC], 15 August 2013 [J.G. private collection]; Allegan State Game Area, T2N R14W Sec. 18, 2 August 2003 [MSUC]; **Berrien Co.:** 4 km west of Berrien Springs [MSUC]; **Van Buren Co.:** 4 km north by northwest of Alma 20 July 2011, 08 August 2011, 10 July 2012 [MSUC] (Fig. 24). Although this bee is very distinctive we do not know of any Michigan specimens preceding 2003. There is a single specimen deposited at the University of Guelph Insect Collection collected on 15 July 2007 at Black Oak Heritage Park (C. Sheffield, pers. comm.), which is part of the Ojibway Prairie Complex in Windsor, Ontario. This record suggests that *D. heteropoda* may be present in southern counties across the state of Michigan. It is possible that the lack of earlier records of this distinctive bee are due to a recent range extension, but the lack of thorough collection effort in the state makes this difficult to determine.



Figures 22–23. Lateral habitus of *Dieunomia heteropoda* (Say). 22. Female. 23. Male. Images courtesy of Laurence Packer.

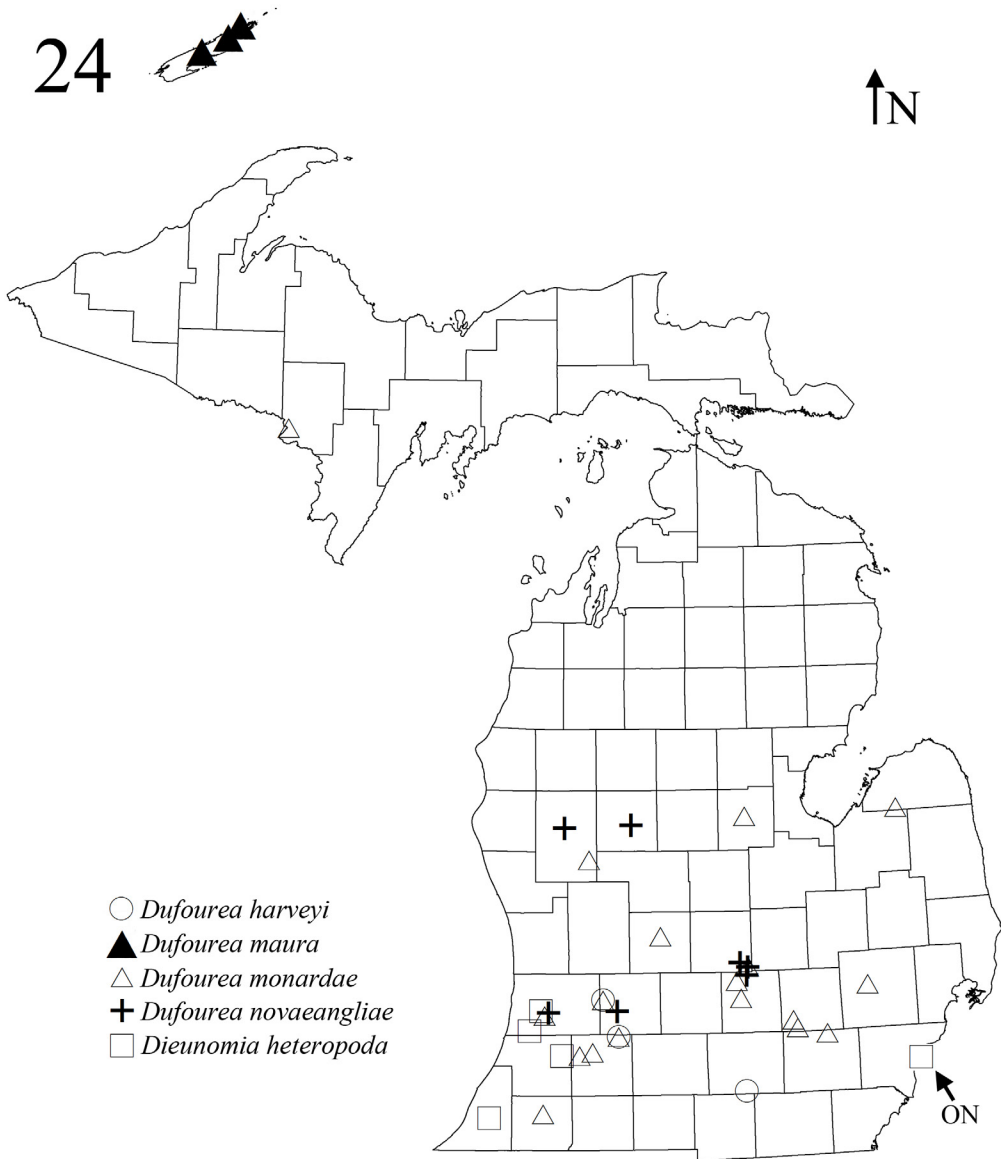


Figure 24. Distribution map of *Dufourea* Lepeletier de Saint Fargeau and *Dieunomia* Cockerell of Michigan. Circle (○) *Dufourea harveyi* (Cockerell); solid triangle (▲) *D. maura* (Cresson); empty triangle (△) *D. monardae* (Viereck); cross (+) *D. novaeangliae* (Robertson); and square (□) *Dieunomia heteropoda* (Say).

Dieunomia heteropoda is primarily an oligolege of *Helianthus* (Hurd *et al.*, 1980). In Michigan, it has been collected from *Helianthus*, *Ratibida pinnata* (Vent.) Barnhart, *Rudbeckia hirta*, and *Centaurea* L. (Asteraceae). Females usually make solitary nests (Parker *et al.*, 1986; Wcislo, 1993), but may sometimes behave as communal nesters (Wcislo, 1993; Wcislo & Engel, 1996).

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