The Great Lakes Entomologist

Volume 54
Numbers 3 & 4 - Fall/Winter 2021 *Numbers 3 & 4 - Fall/Winter 2021*
Article 9

December 2021

New Records of aphids (Hemiptera: Aphididae) on Industrial Hemp in the US Midwest

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Cover Page Footnote

We thank the North Central Soybean Research Program, United Soybean Board and United States Department of Agriculture-Agricultural Research Service for financial support of the suction trap network, and collaborators in the Midwest for checking and maintaining traps. Dr. Bill Ravlin, Michigan State University Department of Entomology, provided the high-quality photographs of aphids on industrial hemp in the field.

New Records of Aphids (Hemiptera: Aphididae) on Industrial Hemp and Monitoring for *Phorodon cannabis* in the US Midwest Suction Trap Network

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Abstract

Industrial hemp (*Cannabis sativa* L.) production in the USA is increasing, and with it the list of insects colonizing the crop. In this article, we report new records of *Aphis craccivora* Koch and *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) on industrial hemp in East Lansing, Michigan in fall 2020. In addition, between 2017 and 2020, the number of suction trap sites detecting *Phorodon cannabis* Passerini increased, and as well as the number of sites with multiple weeks of detections. The timing of detection changed from only late season (fall migrants) in 2017 to catches spanning spring, summer, and fall in 2019 and 2020. These changes likely reflect the increase in industrial hemp production in the landscape in the Midwestern US.

Keywords: Aphids, hemp, *Cannabis sativa*, suction traps

Industrial hemp (*Cannabis sativa* L.) production in the USA is increasing (Freese 2019), and with it the list of insects colonizing the crop. Records of aphids (Hemiptera: Aphididae) that feed on hemp include *Aphis fabae* Scopoli (black bean aphid), *Ap. gossypii* Glover (cotton-melon aphid), *Aulacorthum solani* (Kaltenbach) (glasshouse-potato aphid), *Myzus persicae* (Sulzer) (green peach aphid), *Phorodon cannabis* Passerini (cannabis aphid) (Blackman and Eastop 2021), and *Rhopalosiphum rufiabdominale* (Sasaki) (rice root aphid) (Lagos-Kutz et al. 2018, Cranshaw and Wainwright-Evans 2020). These species are highly polyphagous and distributed worldwide, except for *P. cannabis*, a *Cannabis* specialist recently introduced into North America (Cranshaw et al. 2018). In 2017, *P. cannabis* was detected for the first time in the Midwest Suction Trap Network (STN) (Lagos-Kutz et al. 2018). The STN has operated in nine states across the Midwest USA since 2005 with the initial intent to capture winged migrants of aphids of agricultural importance and other insect species (Lagos-Kutz et al. 2020). In this article, we report additional and new records of aphids in late season on industrial hemp in the Midwest USA as well as changes of counts of *P. cannabis* in the STN between 2018 and 2020.

Materials and Methods

Collections from industrial hemp. In late September 2020, mixed colonies of *P. cannabis* and a dark aphid visually identified as *Ap. fabae* were noted on many plants in bulk planting of industrial hemp (var. Grandi) on the Michigan State University campus in East Lansing, Michigan. Infested leaves were collected, and hundreds of aphids were removed, placed into 70% ethanol on 5 and 13 October 2020. The preserved specimens were sent to the first author for identification. Archival microscope slides were prepared using the technique described by Pike et al. (1991). Photographs of slide-mounted specimens were taken using a Leica DM 2000 digital camera and SPOT Software 4.6 (Diagnostic Instruments, Inc., Michigan, USA). Archival slides were deposited in the Illinois Natural History Survey Insect Collection Museum.

Monitoring *P. cannabis* in suction trap samples. The STN is made up of ~30 traps operating in multiple states (Lagos-Kutz et al. 2020). Individual traps consist of a PVC pipe with a motor at the bottom end to suck in air. The intake at the top of the PVC pipe is 5.8 m above the ground; the motor is 0.46 m above the ground. The electric fan draws 60 m^3 of air per minute. Winged insects drawn in by the suction are captured in a 250 ml polypropylene jar filled with 85 ml of a mixture of 50% water and

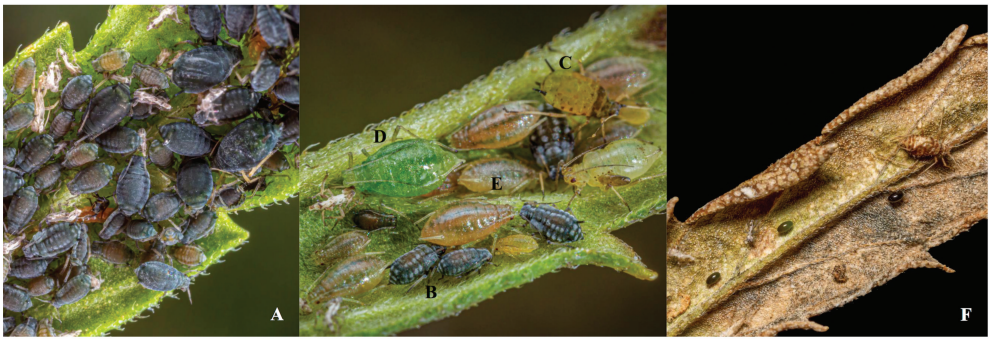

Figure 1. Aphids and eggs on industrial hemp, in East Lansing, Michigan, fall 2020. A) Colony of *Aphis craccivora*. B) Nymphs of *Ap. craccivora*. C) Apterous vivipara of *Ap. gossypii*. D) Apterous vivipara of *Myzus persicae*. E) Ovipara of *Phorodon cannabis*. F) Eggs of *P. cannabis* eggs on a senescing industrial hemp leaf. (Photos courtesy of Bill Ravlin).

50% antifreeze (propylene glycol). Suction trap samples were collected weekly between mid-May and mid- to late-October. Details of locations and sample management can be found in Lagos-Kutz et al. (2020). All aphids caught in the suction traps were identified by the first author and stored (in 95% ethanol) at the at the USDA-ARS Laboratory located in Urbana, Illinois.

Results

Collections from industrial hemp. On 5 October 2020, *P. cannabis* gynoparae, oviparae, males, and eggs were identified in mixed colonies (Fig. 1) with gynoparae and apterous viviparae of *Ap. gossypii*, *M. persicae*, and *Ap. craccivora* Koch. The dark colonies of *Ap. craccivora* were first visually field identified as *Ap. fabae* (Fig. 1A-B), but after microscopic examination of slide-mounted specimens, the morphological characters for both morphs matched those for *Ap. craccivora*. This is the first report of *Ap. craccivora* colonizing hemp.

Morphological characters to discriminate the seven species reported on hemp are summarized in Table 1 for apterous viviparae and in Table 2 for alate viviparae or gynoparae. Photographs of the antennae and dorsal abdomens of these species are presented in Figure 2 and 3. For additional comparative morphometric data and photographs of the species see Voegtlin et al. (2003), Lagos-Kutz et al. (2014, 2021), Cranshaw et al. (2018) and Blackman & Eastop (2021). Archival slides of aphids were deposited in the Illinois Natural History Survey (INHS) Insect Collection. (First collection: 5 Oct 2021, East Lansing, Michigan, 42.6911°N, –84.4928°W. *Ap. craccivora*: 819,442 to 819,446; *Ap. gossypii*: 819,432 to 819,435; *M. persicae*: 819,436 to 819,441; 819,454 to 819, 458; *P. cannabis*: 819,425 to 819,431; 819,452 to 819,453. Second collection: 13 Oct 2021, same location: *Ap. gossypii*: 819,447; *M. persicae*: 819,448; *P. cannabis*: 819,451).

Monitoring cannabis aphid in suction trap samples. *Phorodon cannabis* was first detected in the STN in 2017 (Lagos-Kutz et al. 2018). In 2018, there were multi-week catches of this species in 11 of the 33 traps located either in Kansas, Iowa, Minnesota or Wisconsin. The earliest catches were at the end of July, but most specimens were caught between August and the third week of September; the highest single catch in summer (n = 17) was in Sutherland, IA, and the highest catch in the fall (n = 15) was in Manhattan, KS (Fig. 4A). There were single-week records in Antigo, WI and Monmouth, IL in August, and one aphid caught in Monroe, MI on 5 October 2018.

In 2019, *P. cannabis* migrants were collected for the first time in the spring, between May and June, in Freeport, IL and Kanawha, IA (Fig. 4B). Compared to 2018, there was more activity in June and July, although the greatest catches still occurred in August and September. There were multi-week catches in 10 of the 33 traps in the network. The trap in Concord, NE had the highest catch on 23 August 2019 (n = 15). Also, there were single-week records in August or September from Columbia, MO; Monmouth IL; Urbana-Champaign, IL (two traps); Rosemount, MN; Wanatah and Lafayette, IN; Nashua, IA; Hickory Corners, MI; and Hancock, WI. A total of 20 out of 33 traps in the network caught *P. cannabis* in 2019 with multiweek catches at 10 sites.

In 2020, *P. cannabis* migrants were again collected in the spring, on 29 May 2020 (Fig. 4C). There were multi-week catches in

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DOI: 10.22543/0090-0222.2406

Table 1. Morphological characters of apterous viviparae of aphids that feed on hemp.

Morphological characters	*Aphis craccivora*	*Aphis fabae*	*Aphis gossypii*	*Aulacorthum solani*	*Myzus persicae*	*Phorodon cannabis*	*Rhopalosiphum. rufiabdominale*
Antennal tubercles (AT)	Weakly-developed	Weakly-developed	Weakly-developed	Strongly-developed, inner faces parallel	Strongly-developed, inner faces convergent	Strongly-developed	Weakly-developed
Number of antennal segments	6	6	5 (summer dwarf morphs) or 6	6	6	6	Usually 5
Dorsal hairs on head	pointed	pointed	pointed	pointed	pointed	capitate	pointed
Marginal tubercles on abd. segments I and VII *	Present	Present	Present	Absent	Absent	Absent	Present
Shape of Siphunculi *	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Slightly and asymmetrically swollen	Slightly swollen	Cylindrical
Cauda color *	Dark	Dark	Pale or dusky	Pale	Pale	Pale	Dark
Caudal setae *	5–8	11–24	4–7	7–9	5–6	8–9	4 (2 on each side)
Caudal shape *	Oblong	Slightly spoon-shaped	Slightly spoon-shaped or tongue-shaped	Finger-like	Tongue-shaped	Triangular	Subtriangular, slightly longer than wide

* Indicates that these characters are similar on apterous and alate viviparae.

Table 2. Morphological characters of alate viviparae of aphids that feed on hemp.

Morphological characters	***Aphis craccivora***	***Aphis fabae***	***Aphis gossypii***	***Aulacorthum solani***	***Myzus persicae***	***Phorodon cannabis***	***Rhopalosiphum. rufiabdominale***
Antennal tubercles (AT)	Weakly-developed	Weakly-developed	Weakly-developed	Strongly-developed, inner faces parallel	Strongly-developed, pronounced, converging distally	Strongly-developed AT bearing finger-like processes	Weakly-developed
Number of antennal segments	6	6	6	6	6	6	Usually 5
Longest seta on ANT III (mm) *	0.01–0.021	0.023–0.049	0.006–0.012	—	—	—	—
Arrangement of secondary sensoria	Single row	Scattered	Single row	Single row	Single row	Scattered	Scattered
Number of sensoria	III 3–8	III 6–23 IV 0–3 V 0	III 4–10	III 6–20	III 7–16	III 25–32 IV 9–18 V 4–6	III 12–30 IV 0–4 V 0–4
Caudal setae	5–8	11–24	4–7	7–9	5–6	8–9	4 (2 on each side)

* Indicates that these characters are similar on apterous and alate viviparae.

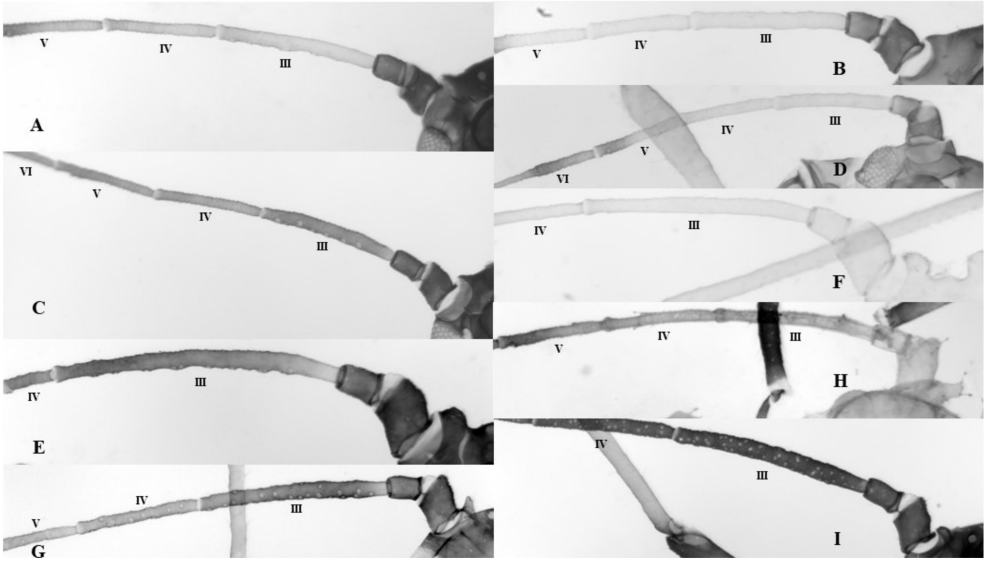

Figure 2. Antennae of gynoparae and apterous viviparae of aphids collected on industrial hemp in East Lansing, Michigan in fall 2020. A) Gynopara and B) Apterous of *Aphis craccivora*. C) Gynopara and D) Apterous of *Ap. gossypii*. E) Gynopara and F) Apterous of *Myzus persicae*. G) Gynopara. H) Ovipara and I) Male *Phorodon cannabis*. Images were magnified to 141.4x. (Photos courtesy of D. Lagos-Kutz).

14 of the 33 traps in the network. In addition to flights in August and September, activity extended into October at multiple locations. The highest count was in Concord, NE (n = 45) on 21 August 2020. Also, there were single-week records in August or September from Champaign-Urbana and Monmouth IL; Hickory Corners, MI; Crookston, MN; and Arlington, WI. A total of 19 out of 33 traps in the network caught *P. cannabis* in 2020 with multiweek catches at 14 sites.

Discussion

This is the first report of *Ap. craccivora* on hemp, which visually can be misidentified

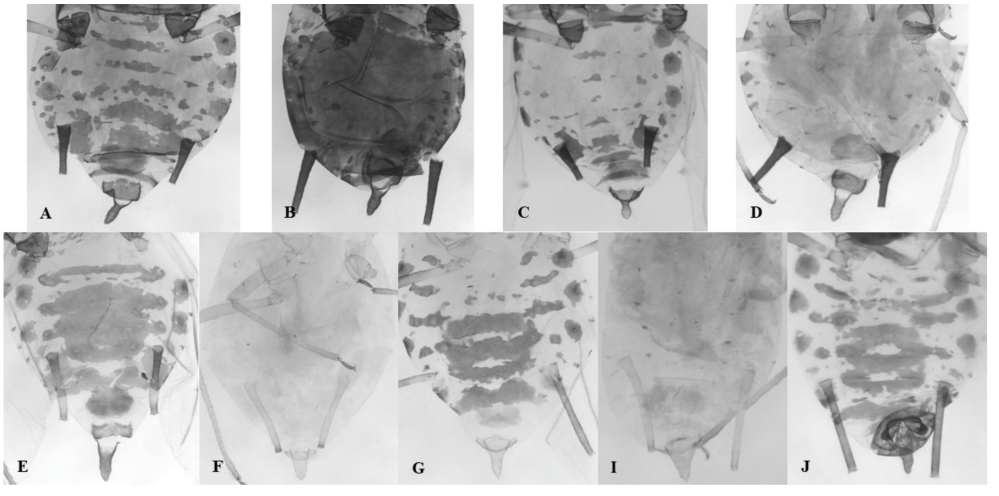

Figure 3. Dorsal abdomens of gynoparae and apterous viviparae of aphids on industrial hemp, in East Lansing, Michigan in fall 2020. A) Gynopara and B) Apterous of *Ap. craccivora*. C) Gynopara and D) Apterous of *Ap gossypii*. E) Gynopara and F) Apterous of *M. persicae*. G) Gynopara, I) Ovipara and J) Male *P. cannabis*. Images were magnified to 64.9x. (Photos courtesy of Doris Lagos-Kutz).

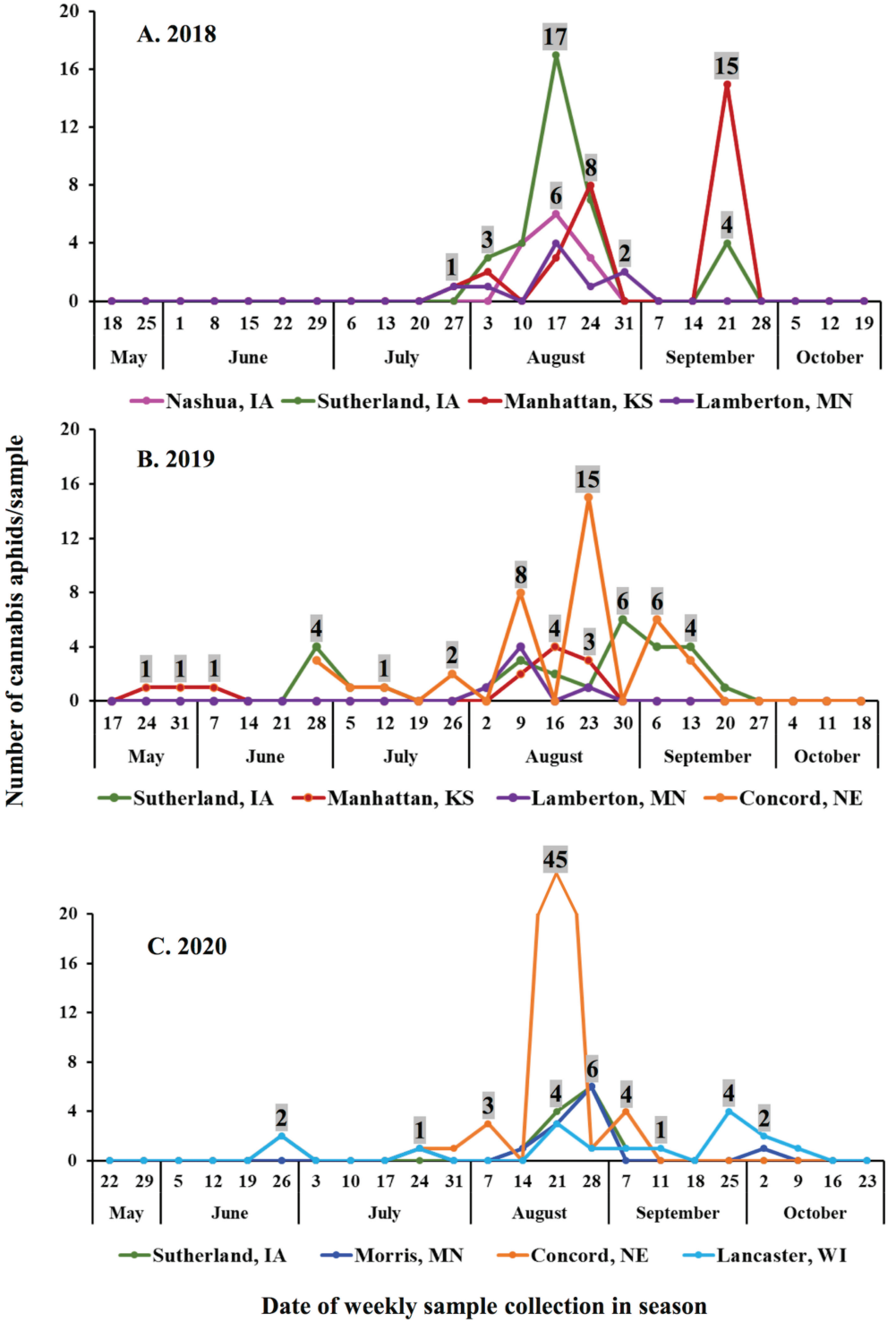

Figure 4. Seasonal collections of *Phorodon cannabis* from selected locations with multi-week catches in the Midwest Suction Trap Network in 2018 (A), 2019 (B) and 2020 (C).

as *Ap. fabae* since it is the only black aphid previously reported on hemp (Blackman and Eastop 2021) and it is widely distributed in the Midwest USA (Lagos-Kutz et al. 2021). Although this is not a surprise because this species and the other new records of aphid species (*Ap. gossypii* and *M. persicae*) found on industrial hemp have been reported as highly polyphagous species (Blackman and Eastop 2021).

It is interesting that many individuals of *Ap. craccivora*, *Ap. gossypii* and *M. persicae* were found on hemp in October, since this is not their overwintering or primary host plant (Blackman and Eastop 2021). Morphological keys to distinguish gynopara (alate females that produce oviparae that lay eggs on the primary host plant) of these species are not available and it is hard to distinguish them from the summer alate viviparae. For example, fall collections are assumed to be gynoparae. So, the morphological characters presented in Table 2 correspond to alate viviparae obtained from multiple references (Voegtlin et al. 2003, Lagos-Kutz et al. 2014, Cranshaw et al. 2018, Blackman and Eastop 2021). Future work needs to be done to monitor the aphids that feed on hemp throughout the field season (Spring through Fall) to get a better idea of the phenology of the aphids that populate industrial hemp.

The number of suction trap sites detecting *P. cannabis* increased between 2017 (Lagos-Kutz et al. 2018) and 2020, as well as the number of sites with multiple weeks of detections. The highest individual catch on the network also increased, from 2 in 2017 to 45 in 2020. Thus, the timing of detection changed, from only late season (fall migrants) in 2017, to catches spanning spring, summer, and fall in 2019 and 2020. These changes likely reflect the increase in industrial hemp production in the landscape in the Midwestern US (Freese 2019). We will continue using suction traps to monitor *P. cannabis* and other aphids that were collected on industrial hemp.

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