

FIRST RECORD ON *ZEA MAYS* L. (POACEAE) OF *CHILOPHAGA TRIPSACI* (FELT) (DIPTERA: CECIDOMYIIDAE), REDESCRIPTION OF THE SPECIES, AND REVIEW OF *CHILOPHAGA*

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Abstract.—*Chilophaga tripsaci* (Felt) was recently discovered damaging maize, *Zea mays* L., in western Mexico. The species was previously known only from a collection made in 1909 on *Tripsacum dactyloides* (L.) L., eastern gamagrass, in Plano, Texas. *Chilophaga* Gagné and *C. tripsaci* are redescribed and a lectotype is designated for the species. It is distinguished from its five congeners by female and larval characters that are illustrated and included in a key to species.

Key Words: gall midges, Lasiopteridi, Alycaulini

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Chilophaga was described in Gagné (1969) for three species of the tribe Alycaulini. Two of the species were associated with stems of grasses. The host of the third was unknown. Three further species, all reared from grass stems were subsequently separately described in the genus (Table 1). *Chilophaga* and the entire tribe Alycaulini are comprised of species known only from the New World (Gagné and Jaschhof 2021). The collective host and distribution ranges shown in Table 1 suggest that the six species are but a small part of a group whose bounds we can only suppose. This is the general rule with cecidomyiids, whose species are usually described singly, dependent on local or immediate economic interest.

Recently a species of *Chilophaga* was found in Mexico destroying tillers of maize, *Zea mays* L. (Figs. 1–4). Larvae were gregarious in the stems and found in great numbers in individual plants. Affected plants, more frequently found along field margins, were stunted, wilting and showed discoloration of the leaf margins. This species is identified here as *Chilophaga tripsaci* (Felt). It was previously known from a single collection of two females and a larva collected in 1909 on eastern gamagrass, *Tripsacum dactyloides* (L.) L., in Plano, Texas (Felt 1910). The plant is native to the Americas and ranges from Brazil and Paraguay north to the United States as far as Nebraska and east to the Atlantic coast (Wikipedia contributors 2021). The genera *Tripsacum*

Table 1. *Chilophaga* species, geographical ranges, and hosts with their subfamily and tribal assignments (plant classification from Flora North America 2021).

<i>Chilophaga</i> Species	Geographical Range	Hosts
<i>C. coloradensis</i> (Felt, 1918)	Colorado, USA	unknown
<i>C. colorati</i> (Felt, 1918)	northern Great Plains, USA	<i>Muhlenbergia</i> sp. (Chloridoideae, Cynodonteae)
<i>C. gyrantis</i> Gagné in Gagné and Stegmaier, 1971	Florida, USA	<i>Aristida gyrans</i> Chapm. (Aristidoideae, Aristideae)
<i>C. setariae</i> Plakidas, 2016	Pennsylvania, USA	<i>Setaria parviflora</i> (Poir.) Kerguélen (Panicoideae, Paniceae)
<i>C. tripsaci</i> (Felt, 1910)	Texas, USA Michoacán, Mexico	<i>Tripsacum dactyloides</i> (L.) L. <i>Zea mays</i> L. (Panicoideae, Andropogoneae)
<i>C. virgati</i> Gagné in Boe and Gagné, 2011	northern Great Plains	<i>Panicum virgatum</i> L. (Panicoideae, Paniceae)

and *Zea* comprise the subtribe Tripsacinae (Soreng et al., 2015).

Specimens were initially identified as *Chilophaga* sp., then compared to the type series of each of the six known species, all of which presently reside in the National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM). The series from maize is identical to *Chilophaga tripsaci* (Felt). This species was only superficially described originally with characters that are of no use in species discrimination. It is redescribed here, the male for the first time, and separated from its congeners by means of keys to larvae and females. The genus is also redescribed.

MATERIALS AND METHODS

On 6 September, 2019, in San Rafael, Contepec, Michoacán, Mexico, gregarious cecidomyiid larvae were found inside young stems of *Z. mays* (Figs. 3-4). Samples of infested plants were brought to the laboratory of the Instituto de Investigaciones Agropecuarias y Forestales, Universidad Michoacana de San Nicolás de Hidalgo (IIAF-UMSNH) and placed in a cage covered with fine mesh. Flies that emerged in the cage shortly afterwards were sent to RJG for identification.

Larvae and adults were mounted for study in Canada balsam using techniques outlined in Gagné (1989). A glossary of adult morphological terms can be found in Gagné (2018). Anatomical terminology of the larval stage follows Gagné (1989). Drawings were made by RJG with the use of a camera lucida attached to a Wild phase contrast microscope. Most of the scales and setae were lost in the mounting process, but enough remained to observe that setae are associated with larger sockets and scales with smaller sockets. The line illustrations show these sockets in their actual size, placement, and number. The specimens of *C. tripsaci* reported here from maize are deposited in the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM) except for a male, a female, and three larvae in the IIAF-UMSNH. Unique attributes of *Chilophaga* and of *C. tripsaci* among its congeners are in italics in the descriptions.

RESULTS AND DISCUSSION

Chilophaga Gagné 1969: 1358. Type species, *Lasioptera colorati* Felt (orig. des.).

Redescription.—*Adult. Head:* Eye facets circular, closely approximated



Figs. 1–4. 1, Field of maize in San Rafael, Mexico, at time of infestation by *C. tripsaci*. 2, Stunted and discolored maize tillers. 3, Larvae of *C. tripsaci* in maize. 4, Same, mature larvae.

throughout, including at vertex. Palpus with 3 or 4 segments, occasionally both in a species (*C. tripsaci*), with a few robust setae, comparable to those on labella, occasional scales, the surface microtrichose. Labellum with several stout setae, surface microtrichose. Antenna with 11–21 flagellomeres, variable within a species, each with two rings of horizontal circumfila connected by 2 longitudinal strands, the dorsal part of the distal ring between the connectives usually not developed in male.

Thorax: Pleura mostly covered with setae and or scales. Wing: R_5 about half total wing length, covered with dark scales except white apically.

Male abdomen: Tergites: first through seventh subrectangular, sixth and seventh each successively somewhat smaller than the one preceding, all with anterior pair of widely separated trichoid sensilla; first through third with several rows of short setae posteriorly, elsewhere covered with scales; fourth through seventh with addition of long, strong setae along posterior

margin except medially; eighth tergite evident from short, pigmented posterior margin and anterior pair of trichoid sensilla. Sternites: quadrate, sixth through eighth each shorter than preceding, eighth only about one-third length of seventh, all setose posteriorly and laterally, elsewhere covered with scales, all except eighth with anterior pair of closely-set trichoid sensilla. Terminalia: cerci convex in caudal view, laterally curved toward venter, with many dorsal and ventral setae; hypoproct ovoid, convex to slightly concave at caudal margin, with 2 posterodorsal setae; articulated part of gonocoxite covered with setae, covered with scales at least laterally and ventrally, and with *large-setose apicomedial bulge* (Fig. 9); gonostylus tapered from base, dorsally asetose and ridged, elsewhere with scattered setae and covered with setulae; medial extension of gonocoxite bilobed, dorsal lobe short, convex, ventral lobe longer, blunt or convex apically with several short apical setae, both lobes long-microtrichose; aedeagus tapered to convex apex.

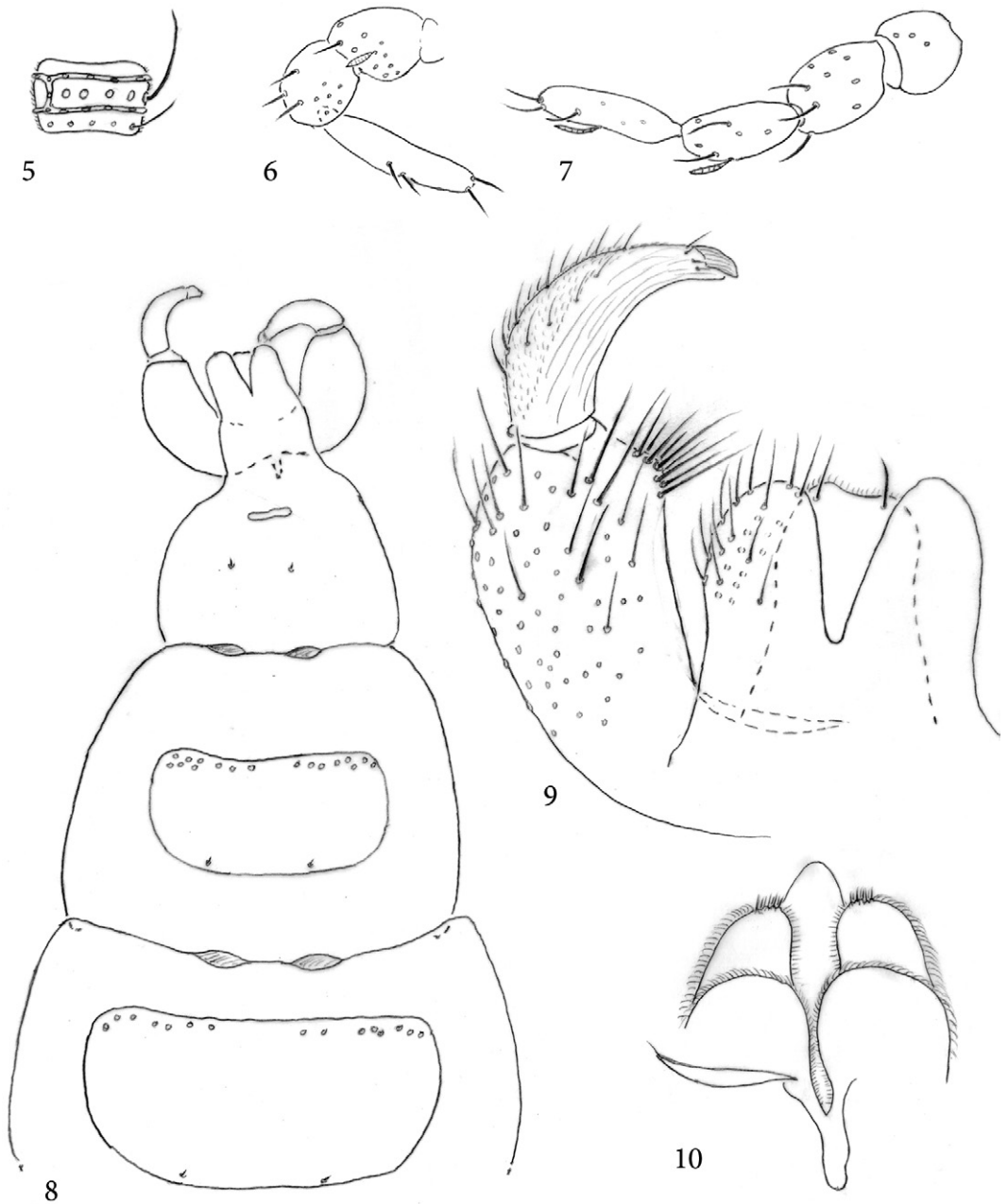
Female abdomen: Tergites: first through seventh rectangular, setation as for male, except seventh with 2 or 3 rows of large posterior setae; eighth tergite nearly or completely divided into 2 elongate sclerites, each with trichoid sensillum situated near anterior third and several short setae along posterior half. Sternites: as for male, except seventh slightly narrower than preceding and eighth evident only from short, narrow sclerite without pair of trichoid sensilla or other setation. Protrusible part of ovipositor 3–6 times length of seventh tergite, with many elongate caudoventral setae. Fused cerci ovoid and slightly dorsoventrally compressed to elongate-cylindrical, covered with setae, *those on distal half of 2 interspersed kinds, about half of them long, thickened and blunt tipped, the remaining pointed, less than half as long* (Fig. 13), setae on basal half longest, pointed, the entire surface covered with setulae.

Hypoproct ovoid to narrow-elongate (cf. Figs. 11, 12), less than one-fourth to nearly half length of cerci, with 2 apical setae.

Pupa: Body elongate-cylindrical, broadly rounded anteriorly, bilobed posteriorly. Base of antenna without conspicuous anterior projection. Cephalic sclerite with short seta on each side. Frons without papillae, with prominent posterolateral bulge on each side lying just anterior to palpal sheath. Prothoracic spiracle horizontal. Abdominal first tergum without spicules, second to eighth terga and all sterna evenly spiculose.

Larva: Spindleform, posterior end with two prominent conical lobes or simply convex (*C. setariae* only). Integument entirely, evenly and minutely pebbled. Antenna about twice as long as wide. Cephalic apodeme about half as long as head capsule. *Spatula present but diminutive, with or without shaft* (Figs. 17–19); *if without shaft then elliptical and in some species pigmented*. Papillae short-setose if setae present, following basic pattern for Alycaulini (Gagné 1989) *except lateral papillae reduced to a diffused single set of 3* on each side of thoracic midline, 2 of each set with setae shorter than papillar diameter, the third without seta, and with 6 (*C. tripsaci* only) or 8 setose *terminal papillae situated ventrally and ventrolaterally on the segment and basad of or on the lobes*.

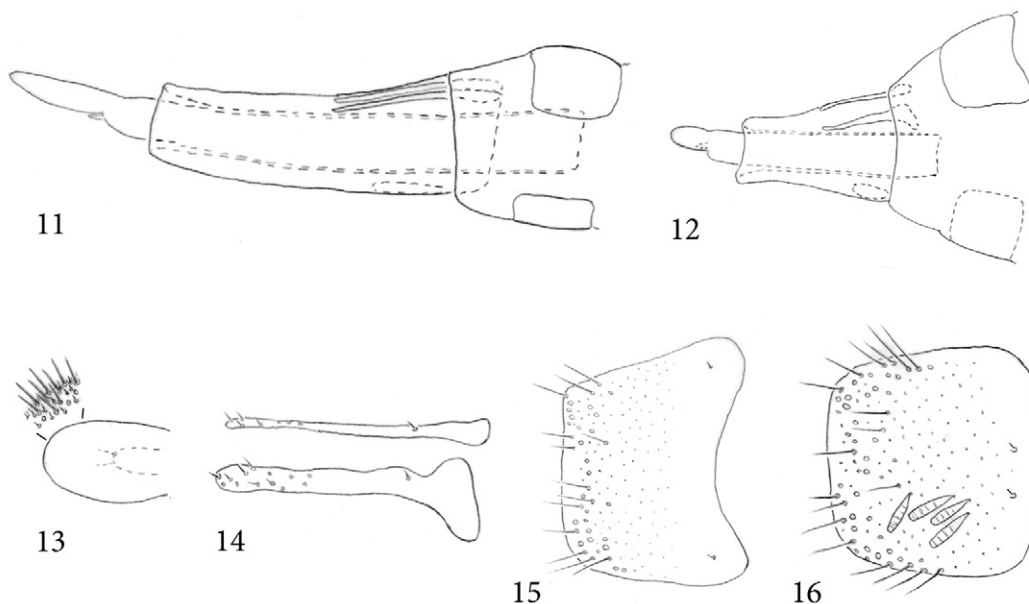
Remarks.—Adults of *Chilophaga* can be separated from other Alycaulini with use of the key in Gagné (2018). Male terminalia of all *Chilophaga* species are generally similar to those illustrated here for *C. tripsaci* (Fig. 9) except for those of *C. gyrantis*, which have a foreshortened gonostylus and a conical, bare apex on the medial extension of the gonocoxite. The setation of the distal half of the female fused cerci is unique in this genus: it bears setae of two intermixed sizes, one thick and elongate, the other tapered and barely longer than their sockets. Another unique feature of this genus is the reduction of lateral larval papillae to three



Figs. 5–10. *Chilophaga tripsaci*. 5, Female fourth flagellomere (ventral). 6, Three-segmented palpus (dorsal). 7, Four-segmented palpus (dorsal). 8, Male abdomen, sixth segment to end (dorsal). 9, Male terminalia (dorsal). 10, Medial extension of gonocoxite and aedeagus (dorsal).

from the usual number of four found in other Alycaulini. When counting the larval lateral papillae, one must distinguish between them and the close-by inner ventral papilla (Fig. 17). The latter papilla

has a longer seta than do the laterals, easily twice as long as the width of the papillar socket, whereas the setae of the lateral papillae are shorter than the width of their sockets.



Figs. 11–16. *Chilophaga* spp. adult characters. Fig. 11, *Chilophaga colorati*, female abdomen, seventh segment to end (lateral). Figs. 12–16, *Chilophaga tripsaci*, female abdomen with details. 12, seventh segment to end (dorsolateral). 13, fused cerci and hypoproct, with detail of cercal vestiture. 14, Eighth tergite. 15, Seventh tergite. 16, Seventh sternite.

Chilophaga tripsaci (Felt)

Figs. 3–10, 12–17, 20

Lasioptera tripsaci Felt, 1910: 10.

Chilophaga tripsaci (Felt): Gagné, 1969: 1358.

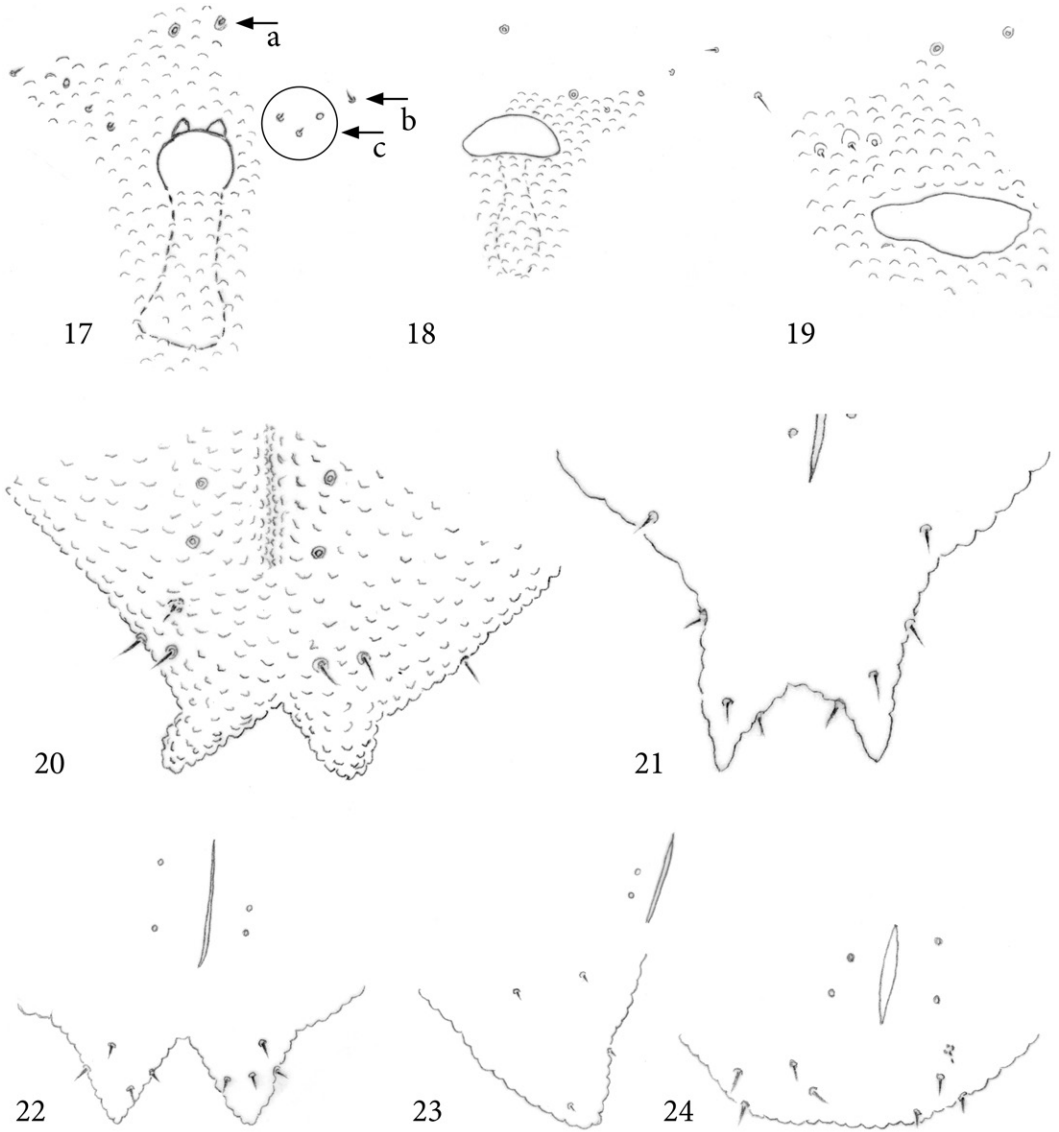
Redescription.—*Adult. Head:* Palpus variable (Figs. 6, 7), 3 or 4 segmented, which may occur on the same specimen, with a few robust setae, comparable to those on labella, and occasional scales and covered with setulae. Labellum with several stout setae, surface microtrichose. Antenna with 16 or 17 flagellomeres in male ($n = 3$) and 18 or 21 in female ($n = 4$).

Thorax: Anepisternum covered with scales, katepisternum with scales on upper half, anepimeron covered with setae, additionally with a few scales inside periphery, metapleuron covered with scales. Wing, 2.6–2.7 mm in male ($n = 3$), 2.5–3.2 mm in female ($n = 4$).

Male abdomen (Figs. 8–10): Two pigmented, elliptical eyespots present intersegmentally on both dorsum and

venter following fifth through seventh segments. Terminalia: cerci convex in caudal view, laterally curved toward venter, with many dorsal and ventral setae; hypoproct ovoid, slightly concave at caudal margin, with 2 posterodorsal setae; articulate part of gonocoxite covered with setae, covered with scales laterally and ventrally, with large-setose apicomedial bulge; gonostylus tapered from base, dorsally asetose and ridged, elsewhere with setae and covered with setulae; ventral lobe of medial extension of gonocoxite broadly convex, with several short setae at apex.

Female abdomen (Figs. 12–16): Eighth tergite divided into 2 elongate sclerites about 1.5 times (full length) as long as seventh tergite (measured from anterior trichoid sensilla to posterior setae), each with trichoid sensillum situated near anterior third and several short setae along posterior half. Intersegmental pigmented eyespots as found in male following fifth through seventh segments lacking. Protrusible part of ovipositor



Figs. 17–24. *Chilophaga* spp. larval characters. 17, *Chilophaga tripsaci*, spatula and associated papillae (a = sternal papilla; b = ventral papilla; c, triplet of lateral papillae). 18, *Chilophaga setariae*, spatula and associated papillae shown on one side only. 19, *Chilophaga colorati*, same. 20, *Chilophaga tripsaci*, larval terminal segment (ventral). 21, *Chilophaga colorati*, same (ventral). 22, *Chilophaga virgati*, same (ventral). 23, *Chilophaga gyrantis*, same (lateral). 24, *Chilophaga setariae*, same (ventral).

about 3.5 times length seventh tergite, with many elongate caudoventral setae. *Fused cerci ovoid, slightly dorsoventrally compressed*, covered with setae, those on distal half of 2 intermixed kinds, half long, thickened and blunt tipped, the remaining

setae, pointed, less than half as long, setae on basal half, longest, pointed, the entire surface covered with setulae. Hypoproct ovoid, nearly half length of cerci, with 2 apical setae.

Pupa: Unknown.

Larva (Figs. 3, 4, 17, 20): Color in life, yellow turning to red when fully mature. Spindleform, posterior end with two conical lobes. Spatula present, emergent on anterior third with 2 triangular anterior teeth, with definite shaft. Papillae following basic pattern for Alycaulini (Gagné 1989) except lateral papillae reduced to single set of 3 on each side of thoracic midline, 2 of each set with setae shorter than papillar diameter, 1 without seta, and with 6 setose terminal papillae situated ventrally and ventrolaterally on the segment and basad of the lobes.

Material examined.—Type series of *C. tripsaci*: 2 females (USNMENT01818315 and USNMENT01818316) and 1 larva (USNMENT0188314), each on a separate slide, mounted in Canada balsam and labelled “*Lasioptera tripsaci* Felt, Plano, Texas on *Tripsacum dactyloides*, 1 Aug '09, a2013, USNM Type No. 29286.” As noted in the original description (Felt 1910), Felt received the specimens from F[rancis] M[arion] Webster, who was at the time employed by the U.S. Bureau of Entomology. I am presently designating one of the two females (USNMENT01818315) as the Lectotype. Three males, four females and 11 larvae, from maize tillers, San Rafael, Contepec, Michoacán, Mexico, Sept, 2019, J.I. Figueroa; deposited in the USNM, except male, female and three larvae in IIAF-UMSNH.

Remarks.—*Chilophaga tripsaci* can be separated from its congeners through female and larval characters with use of the keys that follow. It is the only species of the genus with only three instead of four pairs of terminal papillae, none of which are situated on the lobes (Fig. 20). This species and *C. setariae* are the only two species with a complete spatula that includes a shaft. The emergent anterior end of *C. tripsaci* has additionally two triangular anterior teeth. The female

hypoproct is large with comparison to the fused cerci, attaining nearly half the length of the cerci. All other known females of *Chilophaga* have a much shorter hypoproct with respect to the cerci (Fig. 11).

Key to larvae of *Chilophaga*

(That of *C. coloradensis* is unknown.)

1. Spatula prominent, with distinct shaft (Figs. 17, 18) 2
 - Spatula much reduced, elliptical, without shaft, weakly pigmented (as in Fig. 19) ... 3
2. Spatula with two anterior teeth (Fig. 17); terminal segment with prominent lobes (Fig. 20) *C. tripsaci*
 - Spatula without anterior teeth (Fig. 18); terminal segment evenly convex, without lobes (Fig. 24) *C. setariae*
3. Terminal segment constricted basad of lobes (Fig. 21) *C. colorati*
 - Terminal segment not constricted basad of lobes (Figs. 22, 23) 4
4. Terminal lobes conical, terminal papillae situated on lobes (Fig. 22) *C. virgati*
 - Terminal lobes bulbous, some terminal papillae situated basad of lobes (Fig. 23) *C. gyrantis*

Key to females of *Chilophaga*

(That of *C. setariae* is unknown.)

1. Hypoproct more than 1/3 length of fused cerci (Figs. 12, 13) *C. tripsaci*
 - Hypoproct 1/4 or less length of fused cerci (as in Fig. 11) 2
2. Seventh tergite about 1/2 length of eighth *C. coloradensis*
 - Seventh tergite about 2/3 length of eighth ... 3
3. Sclerites of eighth tergite conjoined at base *C. gyrantis*
 - Sclerites of eighth tergite not conjoined at base 4
4. Protrusible part of ovipositor ca. 5 times as long as seventh tergite *C. colorati*
 - Protrusible part of ovipositor ca. 3 times as long as seventh tergite *C. virgati*

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LITERATURE CITED

- Boe, A., and R. J. Gagné. 2011. A new species of gall midge (Diptera: Cecidomyiidae) infesting switchgrass in the Northern Great Plains. *BioEnergy Research* 4: 77–84.
- Felt, E. P. 1910. Two new Cecidomyiidae. *Entomological News* 21: 10–12.
- Felt, E. P. 1918. Appendix: A study of gall midges V, pp. 101–252, 257–268, pls. 3–8. *In* Felt, E. P. ed. 32nd Report of the State Entomologist on injurious and other insects of the State of New York 1916. New York State Museum Bulletin 198. 276 pp., 8 pls.
- Flora of North America Editorial Committee, eds. 1993+. *Flora of North America North of Mexico* [Online]. 22+ vols. New York and Oxford. <http://beta.floranorthamerica.org>. [Last accessed October 5, 2021].
- Gagné, R. J. 1969. A tribal and generic revision of the Nearctic Lasiopteridi (Diptera: Cecidomyiidae). *Annals of the Entomological Society of America* 62: 1348–1364.
- Gagné, R. J. 1989. *The Plant-Feeding Gall Midges of North America*. Cornell University Press, Ithaca, New York. Xi & 356 pp.
- Gagné, R. J. 2018. Key to adults of North American genera of the subfamily Cecidomyiinae (Diptera: Cecidomyiidae). *Zootaxa* 4392: 401–457.
- Gagné, R. J. and M. Jaschhof. 2021. A Catalog of the Cecidomyiidae (Diptera) of the World. 5th Edition. 813 pp. https://www.ars.usda.gov/ARSUserFiles/80420580/Gagne_Jaschhof_2021_World_Cat_5th_Ed.pdf.
- Gagné, R. J. and C. E. Stegmaier, Jr. 1971. A new species of *Chilophaga* on *Aristida* (Gramineae) in Florida (Diptera: Cecidomyiidae). *The Florida Entomologist* 54: 335–338.
- Plakidas, J. D. 2016. The gall midges (Diptera: Cecidomyiidae: Cecidomyiinae) from Allegheny County Pennsylvania. *International Journal of Dipterological Research* 27: 65–176.
- Soreng, R. J., P.M. Peterson, K. Romaschenko, G. Davidse, F.O. Zuloaga, E.J. Judziewicz, T.S. Filgueiras, J.I. Davis and O. Morrone. 2015. A worldwide phylogenetic classification of the Poaceae (Gramineae). *Journal of Systematics and Evolution* 53: 117–137.
- Wikipedia contributors. 2021. *Tripsacum dactyloides*. Wikipedia. The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=Tripsacum_dactyloides&oldid=1845350619. [Last accessed Oct. 20, 2021].