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Thysanoptera host-plant associations, with an account of species living on *Tamarix*, and a new species of *Lissothrips* (Phlaeothripidae)

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Abstract

Eight unrelated Thysanoptera species are known to be associated with the arid zone plant genus *Tamarix* [Tamaricaceae]. One new species, *Lissothrips hemingi* **sp.n.,** is described from Iran based on specimens collected on branches of *Tamarix*. *Liothrips jazykovi* Moulton, described from specimens taken on *Tamarix*, is considered a **new synonym** of *Liothrips reuteri* (Bagnall), a widespread species on the foliage of this plant.

Key words: Biological associations, thrips radiations, plant diversity, Iran, *Tamarix*

Introduction

Almost all species of the insect Order Thysanoptera are dependent in some way on higher plants, but there is a remarkable asymmetry between the evolutionary radiation among thrips and the radiation among plants. Although about 400 families of higher plants are recognized, remarkably few of these have a demonstrated association with any thrips species. But any attempt to consider evolutionary relationships between the lineages of thrips and plants must bear in mind that some published "host records" for thrips are no more than "finding places". For example, Berzosa (1994) lists many different plant families as providing hosts for *Chirothrips* species, a genus in which all species breed only in the inflorescences of Poaceae. Here we consider the Thysanoptera species that appear to be associated only with plants of the genus *Tamarix*, although we do not include records of a few polyphagous species listed by zur Strassen (2003).

Many thrips species breed only in the flowers of plants in the families Asteraceae and Fabaceae (Minaei & Mound 2008, Mound *et al*. 2018). Similarly, Poaceae leaves support specific radiations of *Aptinothrips*, *Limothrips* and *Stenchaetothrips* (Palmer 1975; Bhatti 1982), and Poaceae inflorescences support the radiation of *Chirothrips* and *Arorathrips* (Nakahara & Foottit 2012). Moreover, members of the genus *Dichromothrips* are known to live only on Orchidaceae (Mound 1976), members of the *Odontothrips* group of genera breed almost exclusively in the flowers of Fabaceae (Zhang *et al*. 2020), and *Dendrothrips* species are particularly associated with the leaves of Oleaceae (Marullo 2003). These associations have a strong evolutionary component, with each thrips genus radiating almost exclusively on members of its adopted plant family.

More precise host-associations, involving thrips radiation on any single plant genus, are less common. The most extensively researched such association is on the genus *Acacia* [Fabaceae] in Australia (Crespi *et al*. 2004), where this involves in excess of 250 thrips species in 30 genera. Similar, but far less extensive thrips radiations, are also recorded on the plant genera *Geijera* [Rutaceae] (Mound 1971), *Casuarina* [Casuarinaceae] (Mound & Crespi 1992), *Piper* [Piperaceae] (Mound 2020), and *Ficus* [Moraceae] (Ananthakrishnan & Raman 1989), also *Holarthrothrips* species breed only in the inflorescences of *Phoenix* date palms (ThripsWiki 2020). As with the family level associations mentioned above, such radiations clearly involve an evolutionary component, with the thrips genera on *Acacia*, *Casuarina* and *Geijera* in Australia comprising species that have radiated only on those plant genera.

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In contrast, the various species of *Liothrips* recorded from the leaves of *Piper* are probably not all closely related but represent two or more independent invasions (Mound 2020). Similarly, structural variation among the species associated with *Ficus* leaves and currently listed under *Gynaikothrips* suggests the possibility that these species do not constitute a single lineage. This article concerns the very different assemblage of Thysanoptera species that have been found only on the plant genus *Tamarix* [Tamaricaceae], including a new species in the genus *Lissothrips* that appears to feed on lichens on the branches of this tree, and is the first record of this genus from the Palearctic Region.

Thysanoptera species on *Tamarix*

Tamarix is an Old World plant genus that includes about 50 species of trees or shrubs native to the semi-arid areas of the Sahel zone, although with some species introduced to other countries. The eight species considered here are known only from *Tamarix* plants, there being no available evidence that any of them also live on any other plant. However, this is an assemblage of unrelated genera and does not comprise a single lineage. These thrips are representatives from three different families and eight different genera. Four of the species apparently feed on leaves, one is flower-living, two are probably predatory on other small arthropods, and one is a fungus-feeder. Presumably, this assemblage is ecologically driven with little or no evolutionary significance. *Tamarix* lives in a dry and hostile environment, where it is often one of the most important plants available providing food and shelter to phytophagous insects. The absence of Thysanoptera radiation among these *Tamarix*-associated thrips is itself interesting, in that it contrasts with the situation on *Geijera* (Mound 1971). This Australian shrub similarly grows in scattered stands in semi-arid country, but a single lineage of Phlaeothripidae has radiated on it to produce at least 10 host-specific species.

Six of the eight species here considered associated with *Tamarix* are known to exhibit particularly unusual character states, although it is not known if this is coincidence or induced in some way by this plant. The antennae of *Aeolothrips naderi* are no more than 7-segmented, instead of the 9-segmented condition found in the other members of Aeolothripidae. In all known species of *Eremiothrips* antennal segment V bears near its inner apex a sense cone that is longer than the apical width of this segment, but in *E. tamaricis* this sense cone is much shorter. Similarly, in *Haplothrips tamaricinus* the inner sense cone on antennal segment III is much smaller than the external sense cone, a condition that is particularly unusual in this genus. *Scirtothrips hafezi* is almost unique within the genus *Scirtothrips* in having long setae on the head and pronotum, and *Tamaricothrips tamaricis* appears to be a typical species of the genus *Anaphothrips* apart from having one pair of pronotal posteroangular setae slightly elongate. Finally, *Liothrips reuteri* is exceptional within the species-rich genus *Liothrips* in producing micropterous adults.

Material and methods

Information about seven of the species discussed in this paper is extracted from literature, including publications by the current authors. The specimens of the new species discussed in this paper were collected by beating branches of tamarisk onto a plastic tray. The specimens then were macerated in 2% NaOH solution for 6–8 hours and mounted onto slides in Canada balsam after dehydration through a series of ethanols using a form of protocol described by Mound and Kibby (1998). An Olympus BX51 phase-contrast microscope was used for observations. Photomicrographs and measurements were made using this microscope with DP27 digital camera and CellSens software. The holotype of the new species is deposited in the Natural History Museum, London, United Kingdom (NHM). Most of the other specimens are deposited in the Department of Plant Protection, College of Agriculture, Shiraz University, Shiraz, Iran (PPSU). The following abbreviations are used for pronotal setae: am - anteromarginals; aa - anteroangulars; ml - midlaterals; epim - epimerals; pa - posteroangulars.

AEOLOTHRIPIDAE

Although 24 genera are recognized in this family, slightly more than half of the 216 known species (ThripsWiki 2020) are members of the single genus *Aeolothrips*. In Iran, this genus is particularly species-rich, with at least 30

known species (Alavi & Minaei 2018). All members of the family Aeolothripidae have 9-segmented antennae, apart from the single species discussed below. Many Aeolothripidae species are predators, although flower-living species probably have a mixed diet, and such species may be found on the flowers of various plants. A few *Aeolothrips* species seem to be associated with the flowers of particular plants, such as the European *A. ericae* that is usually found on *Erica* and *Calluna* [Ericaceae] and *A. propinquus* on *Echium* species [Boraginaceae] (Mound *et al*. 2018).

Aeolothrips naderii Minaei & Mound

Aeolothrips naderii Minaei & Mound, 2019: 447.

This species was described from 25 females taken from *Tamarix* sp., in Kohgiluyeh and Boyer-Ahmad Province, Yasouj, Iran. These females are remarkable in having the number of antennal segments reduced to seven or even six. Initially the possibility was considered that they might be aberrant individuals. However, although the specimens were all taken at the same site, they were collected on four different occasions over a period of 12 months during 2017 and 2018. They are at present considered to represent an unusual species that is host-limited to *Tamarix* foliage, although whether phytophagous or predatory on other small arthropods is not known.

THRIPIDAE

With almost 2000 species in about 300 genera this is one of the two largest families of Thysanoptera (ThripsWiki 2020). Members of this family are found worldwide, and sometimes represent a high proportion of the Thysanoptera fauna of semi-arid areas. Of the genera of the three species discussed here in association with *Tamarix* the first two are commonly associated with such ecosystems, and the third genus is a member of the *Anaphothrips* complex in which many species have been described from semi-arid areas of Australia (Mound & Masumoto 2009).

Eremiothrips tamaricis (zur Strassen)

Ascirtothrips tamaricis zur Strassen, 1975: 260.

The genus *Eremiothrips* comprises 21 species and is found in areas of the Palaearctic that are usually dry between Morocco, Iran, Kazakhstan and inner Mongolia. This species was described from Morocco on 22 females collected from *Tamarix balansae* and *T. articulata*. Both sexes of this species have subsequently been collected on tamarisk from Kohgiluyeh and Boyer-Ahmad province, south west of Iran, and the first description of the male was provided recently by Minaei and Aleosfoor (2020). Members of this genus are currently not known to show specificity to either flowers or foliage.

Scirtothrips hafezi Minaei & Mound

Scirtothrips hafezi Minaei & Mound, 2018: 289.

Over 100 species are recognized in the genus *Scirtothrips*, and each of these seems to feed on young leaves or very young fruits. They are found in a wide range of habitats, and the range of host plants is very considerable, with some species being crop pests and a few breeding on young fern fronds. This species was collected from *Tamarix* sp. in Fars province, Iran. It is unusual among *Scirtothrips* species in having two pairs of long pronotal posteroangular setae, and ocellar setae III unusually long (Minaei & Mound 2018), character states that it shares only with a single species from South Africa. Although some *Scirtothrips* are highly polyphagous, many species are host-specific, but with diverse host associations including tree ferns, cycads and several unrelated angiosperms.

Tamaricothrips tamaricis (Bagnall)

Anaphothrips tamaricis Bagnall, 1926: 645.

This species is recorded from Iran, Italy, Bulgaria, Egypt, France, Jordan, Israel, Morocco and Spain on flowers of *Tamarix*, and is possibly more widespread in association with *Tamarix* species (zur Strassen 2003). Based on field observations in Iran, the species is one of the first thrips species to occur on tamarisk in the spring. The genus *Tamaricothrips* comprises this single species, and apart from the presence of one pair of slightly longer pronotal posteroangular setae it shares most character states with members of the genus *Anaphothrips*.

PHLAEOTHRIPIDAE

With 450 genera and almost 4000 species this is the largest Thysanoptera family. Members of this family exhibit a wide range of different biologies, as evidenced by the four species discussed here from *Tamarix*. The first species is flower-living, whereas the second is leaf-living. The third is a member of a large series of taxa that are fungus feeders, although this particular species is probably associated with a lichen. The fourth species is a member of a group that are presumed to be predatory on other small arthropods.

Haplothrips tamaricinus Priesner

Haplothrips tamaricinus Priesner, 1939: 125.

This species was described from Egypt in *Tamarix* flowers (Priesner 1939). Both sexes have been reported subsequently from *Tamarix* bushes in Iran (Guilan Province) (zur Strassen 1971). *Haplothrips* members are associated particularly with the flowers of Poaceae and Asteraceae, but some are predatory on small arthropods (Mound & Minaei 2007). Although some species are currently known from a single plant species, most species seem to be oligophagous at some level.

Liothrips reuteri (Bagnall)

Compsothrips reuteri Bagnall, 1913: 295.
Liothrips jazykovi Moulton, 1946: 56. **Syn. n.**

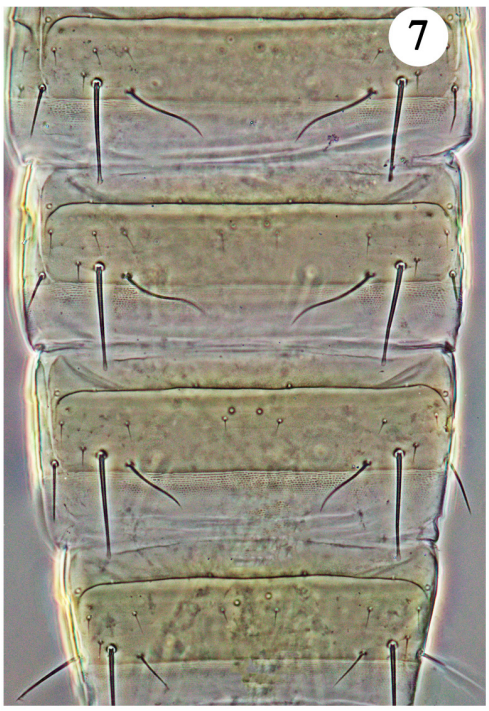
Described originally from Egypt, but with five synonymic names from Turkmenistan, Albania and Yemen (Thrips Wiki 2020), this species has also been recorded from the Canary Islands and India. Apparently a specific foliage feeder on *Tamarix* species, it has been reported from this plant in the southern and central parts of Iran by various authors (Mortazawiha & Dern 1977; Barkhordari *et al*. 1981; Kheyrandish Koshkoei 2000). The macropterous form was described by Minaei and Mound (2014) as being apparently most common in spring. Moulton described *L. jazykovi* based on one female and one male from Tashkent, Uzbekistan, on *Tamarix*. He considered it comparable with *L. reuteri* although the latter "has a protruding vertex and a lighter colored antenna". Considering the host and collecting locality of this species, also the variation in *L. reuteri*, these two are here considered to represent the same species. Specimens that are available in PPSU show variation in colour of antennal segments (Figs 11–14). With over 260 species, the members of this leaf-feeding genus have been taken from a wide range of unrelated plants. However, as most species are known from very small samples, the level of host-specificity remains unclear.

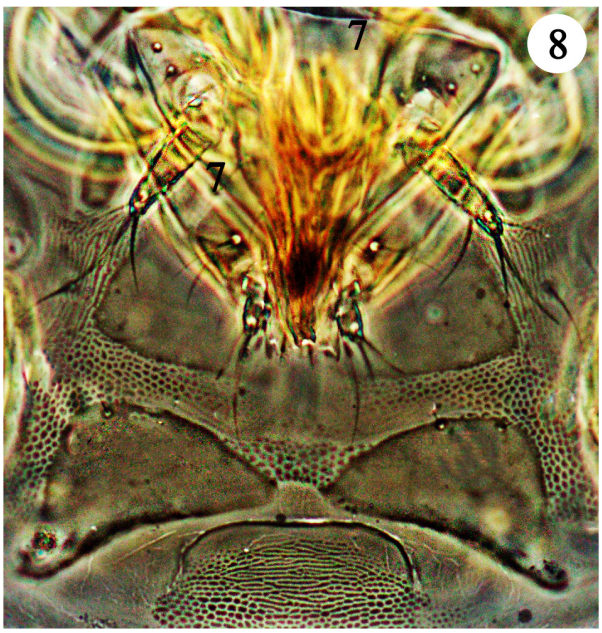
Lissothrips hemingi sp. n.
(Figs 1–10)

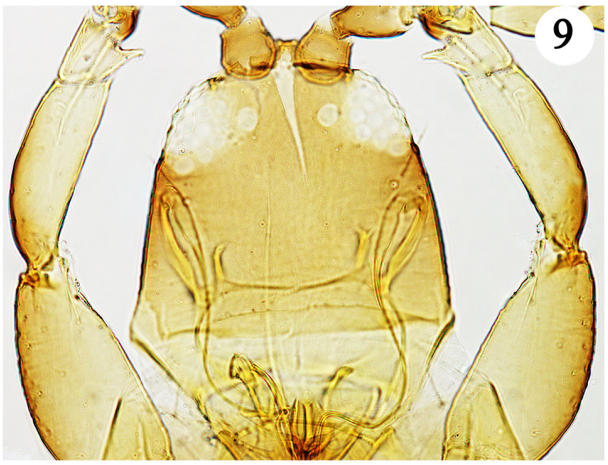
Female aptera. Body light brown, tarsi and antennal segment III paler, tube darker (Fig. 1), major setae brown yellowish. Head nearly as long as wide, not reticulate (Fig. 3); compound eyes small, about 12 facets dorsally, not prolonged ventrally; post ocular setae long and blunt apically, extending beyond posterior margin of

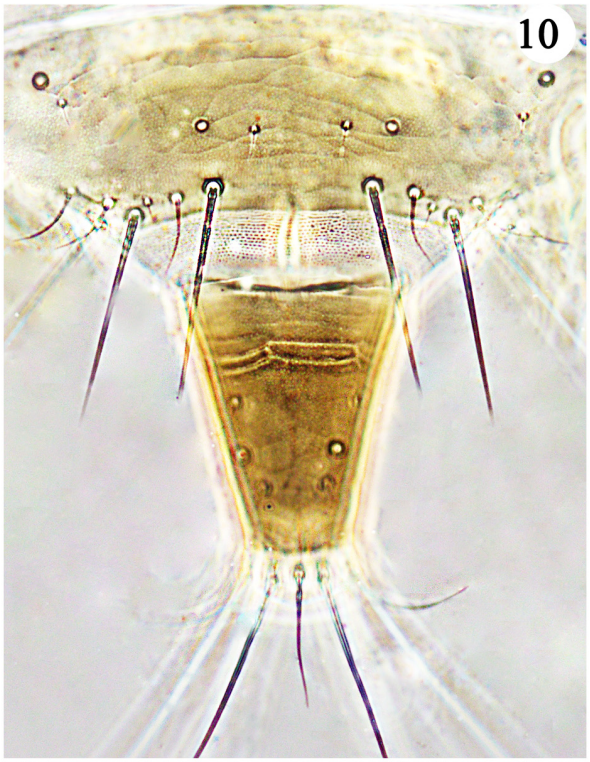
compound eyes (Fig. 3); maxillary stylets at least one-third of head width apart, retracted to postocular setae (Fig. 9). Antennae 8-segmented, III smaller than IV with no sense cone (Fig. 6), IV with 2 stout sense cones, VIII short and slightly narrower at base than VII at apex. Pronotum transverse, with very faint sculpture, notopleural sutures complete; all five major pronotal setae (am, aa, ml, epim, pa) developed (Fig. 3) (ml not developed in holotype); am setae blunt, other setae capitated. Fore tarsal tooth well developed (Fig. 9). Mesonotum transversely reticulate, lateral setae minute; metanotum reticulate, median setae long and acute, arise on the middle of sclerite (Fig. 4). Prosternal ferna distinct, basantra well developed, mesopresternum eroded medially (Fig. 8); metathoracic sternopleural sutures not developed. Abdomen with pelta broadly D-shaped, campaniform sensilla present (Fig. 4); abdominal tergites II–IX with median setae minute, III–VI with one pair of wing- retaining setae (cf. Fig. 7); tergite IX setae a little shorter than tube; anal setae shorter than tube. Sternites with 3–4 minute discal setae.

FIGURES 1–6. *Lissothrips hemingi* sp.n.: **(1)** Adult (female); **(2)** Adult (male); **(3)** Head and pronotum; **(4)** Meso, metanotum and pelta (female); **(5)** Meso and metanotum (male); **(6)** Antenna.









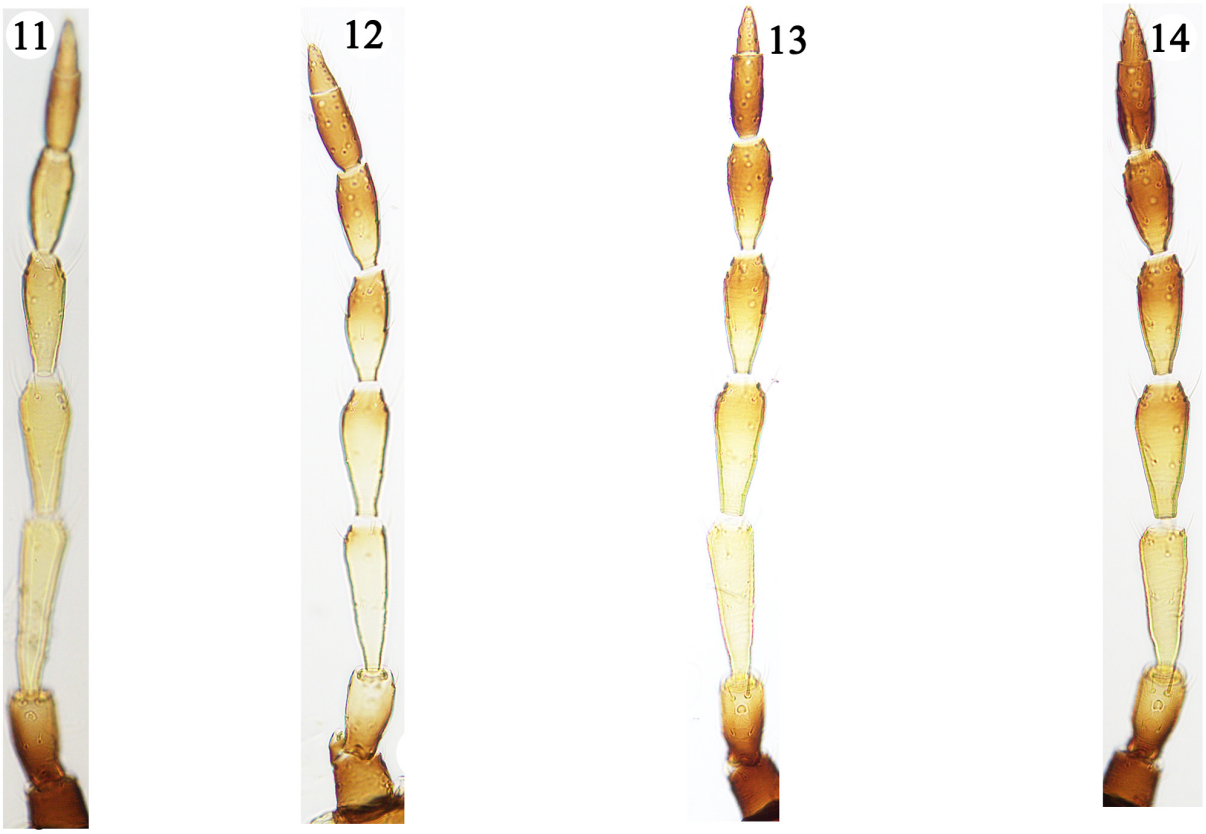
FIGURES 7–10. *Lissothrips hemingi* sp.n.: **(7)** Abdominal tergites IV-VII (male); **(8)** Prostenum; **(9)** Head and fore leg (female); **(10)** Abdominal tergites IX and tube (female).

Measurements (holotype female in microns): Body length 1347. Head (a little crashed), length 148; width 150; po setae 75. Pronotum, length 105; width 220; am 15, aa 20, ml apparently not developed in holotype (in one of the paratypes 20), epim 40, pa 25. Tergite IX setae S1 50. Tube length 70. Antennal segments I–VIII length, 26, 37, 37, 44, 40, 38, 28, 16.

Female microptera. Very similar to aptera. Fore wing length 120.

Male aptera. Very similar to female (Fig. 2) but slightly smaller; metanotum less reticulate (Fig. 5); tergite IX setae S2 short and stout; sternites without pore plate.

Measurements (paratype male in microns): Body length 1300. Head, length 125; width 143; po setae 30. Pronotum, length 100; width 200; am 16, aa 23, ml 20, epim 37, pa 28. Tergite IX setae S1 55. Tube length 64.



FIGURES 11–14. *Liothrips reuteri* (female), variation in antenna.

Male microptera. Very similar to aptera. Fore wing length 105.

Material examined. Holotype, female, IRAN, Fars province, Sarvestan (29° 7' 5.63" N 53°17' 17.46" E), *Tamarix* sp., 29.iv.2016 (KM 1435).

Paratypes: 1 male collected with holotype; 1 female, same place and plant, 9.v.2016 (KM 1459). Non paratype specimens: 2 females, 1 male, Kohgiluyeh and Boyer-Ahmad Province, Yasouj, same plant, 5.ix.2019; 1 female, same place and plant, 27.vi.2018; 1 female, same place and plant, 26.vii.2018.

Comments. The fungivorous genus *Lissothrips*, in common with many genera of Phlaeothripidae such as *Apterygothrips*, *Karnyothrips* and *Hoplothrips* (Mound & Tree 2019; Mound *et al*. 2020), is not diagnosed by any single character state. The new species is placed in this genus because of the relatively small size of antennal segment III and the lack of a sense cone on this segment. Moreover, the specimens were taken from branches with lichen. It is distinguished from most members of the genus by the rather short and broadly based eighth antennal segment. Among *Lissothrips* species this condition is found only in *L. dentatus* and *L. dugdalei* from New Zealand, the other members of the genus having antennal segment VIII slender and narrowed to the base. The new species differs from the New Zealand species in lacking a sense cone on the third antennal segment. There are 23 species listed worldwide in *Lissothrips* (ThripsWiki 2020), of which 12 are known only from the Americas, mainly the Neotropics, one is from Fiji, one from Japan, and nine from Australia and New Zealand (Mound & Tree 2015). This species is the first to be recorded from the Palaearctic Region, and it is also unusual in having a fore tarsal tooth well developed in both sexes.

Etymology. The species is named in honor of the late Professor Bruce Sword Heming (1939–2018). He was a morphologist and embryologist with a great interest in thrips, of which group he developed an extensive slide collection at the Strickland Museum, University of Alberta, Canada.

Mesandrothrips caliginosus (zur Strassen)

Xylaplothrips caliginosus zur Strassen, 1966: 26.

Described from a single male taken on *Tamarix anglica* in the Canary Islands, this remains the only known record of this species (zur Strassen 1966). Recently, the genus *Mesandrothrips* was recalled from synonymy with *Xylaplothrips* to include 20 species, including *Mesandrothrips caliginosus* (Mound & Tree 2019).

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