

# From Dusty Drawers to Verdant Woodlands: New Records of Three Leaf-Mining Sawflies (Hymenoptera: Tenthredinidae) from Northern Europe, with Particular Reference to the Danish Fauna

*Nye fund af tre arter af minerende bladhpvæse (Hymenoptera: Tenthredinidae) fra Nordeuropa, med særlig vægt på den danske fauna*

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## Abstract

We review the diversity and distribution in Denmark of selected genera of the Fenusini, a group of leaf-mining sawflies. Three species of *Metallus*, two of *Parna*, and one each of *Hinatara* and *Scolioneura* are now known in the country. Three species are recorded for the first time in Denmark: *Hinatara recta* on *Acer platanoides*, *Metallus albipes* on *Rubus idaeus*, and *Parna apicalis* on *Tilia* spp. *Parna apicalis* is also recorded as new to Sweden and Lithuania. The Danish data were obtained by combining recent field observations with examination of voucher specimens of pinned adult specimens and mines, of mostly older collection date. With the inclusion of the new records presented in this study, 31 species of leaf-mining sawflies are known to occur in Denmark.

## Sammendrag

Artiklen præsenterer en revision af diversiteten og udbredelsen i Danmark af udvalgte slægter af Fenusini, en gruppe af minerende bladhpvæse. Tre arter af slægten *Metallus*, to arter af slægten *Parna*, samt en art fra hver af slægterne *Hinatara* og *Scolioneura* er kendt fra landet. Tre arter rapporteres for første gang fra Danmark: *Hinatara recta* på spids-løn (*Acer platanoides*), *Metallus albipes* på hindbær (*Rubus idaeus*) og *Parna apicalis* på lind (*Tilia* sp.). *Parna apicalis* er også ny for den svenske og litauiske fauna. De danske funddata stammer fra en kombination af feltstudier samt museumsundersøgelser af voksne individer og herbariebelæg, primært af ældre dato. Som følge af resultaterne præsenteret i artiklen kendes nu 31 arter af minerende bladhpvæse fra Danmark.

## Introduction

Leaf-mining is a specialized form of herbivory occurring in several insect orders, i.e. Coleoptera, Diptera, Lepidoptera and Hymenoptera. Tenthredinidae is the most speciose family within the monophyletic superfamily Tenthredinoidea (Vilhelmsen, 2015), usually referred to as true sawflies. The feeding habits of their larvae, all of which are herbivorous, can be divided into four main categories: most species are external feeders, whereas a minority are specialized gall-inducers (nearly all of these belong to *Euura*, and have *Salix* spp. as hosts; Liston et al. 2017), leaf-miners, or feed "hidden" in other plant organs, particularly fruits and flowers (see, for example, Zinovjev & Vikberg (1998)). Around 50 leaf-mining tenthredinids are known in Europe, of a family total of about 1070 (Taeger et al. 2006). The majority of leaf-mining species belong to the tribe Fenusini of the subfamily Blennocampinae (see Malm & Nyman (2015) on phylogenetic position), and the others to the genera *Endophytus* and *Pseudodineura* of the Nematinae.

In Denmark, 28 species of leaf-mining sawflies were recorded prior to this study. The first major work devoted to the Danish sawfly fauna was published early last century (Nielsen & Henriksen, 1915) and provided an overview of the species known to occur in Denmark at that time, including several leaf-miners. The species descriptions are, however, inadequate in comparison with today's knowledge and the publication is mostly of historical value. Two 1930's publications mentioned Danish records of sawfly leaf-miners: Buhr (1933) reported on mines from Bornholm, and Hering (1935) described a new species from *Populus* (later

considered to be a junior synonym of a previously described species), based on Danish material. The authoritative work, however, was written by H. P. S. Sønderup (1949), a Danish amateur entomologist, who was fascinated by all sorts of leaf-mining insects and studied them over several decades (1920's – 1940's). He took a special interest in sawflies and made many important faunistic contributions, with the majority of records being from or around Maribo on the southern island of Lolland. He sometimes collected the mines and reared adult specimens from them, and some of these specimens (mines and/or adults) are deposited in the Natural History Museum of Denmark (NHMD). Later studies on Tenthredinidae in Denmark have primarily focused on non leaf-mining pest species in forestry and agriculture (e.g. Bejer-Petersen, 1963 and subsequent papers; Bejer & Esbjerg, 1981 and subsequent papers). Taeger et al. (2006) compiled a list of the sawfly species recorded in Denmark, based on the literature known to them, but overlooked the publication by Sønderup (1949). Recently, Haarder (2017) gave an account of the leaf-mining sawflies found on the island of Bornholm, with a few new records.

This study examines the status in Denmark of species in selected genera of the Fenusini. These are the three species of *Metallus*, two *Parna*, and one each of *Hinatara* and *Scolioneura* currently known in the country. First records of *Parna apicalis* from two other northern European countries are included as a matter of convenience. The Danish data is based on a combination of recent field observations, and examination of voucher specimens, of mostly older collection date, of pinned adult specimens and mines conserved in herbaria.

## Methods

Abbreviations used for collections referred to:

LPS Landbohøjskolens Plantepatologiske Samling, Glostrup, Denmark

MZLU Lund University Zoological Museum, Lund, Sweden

NHMD Natural History Museum of Denmark, Copenhagen University, Copenhagen, Denmark

SDEI Senckenberg Deutsches Entomologisches Institut, Müncheberg, Germany

Parts of the Tenthredinidae collection in the Natural History Museum of Denmark (NHMD) were examined and revised by S. Haarder (*Parna*) or A. Liston (*Metallus*). *Parna* specimens from MZLU were studied by A. Liston. Relevant specimens from the mine herbaria at NHMD and LPS were examined by S. Haarder. Mines of *Metallus lanceolatus* and *Scolioneura betuleti* in these collections were not examined, as there is no obvious risk of confusing these with mines of the other species mentioned in this study. Field surveys in Denmark (2014-2017) were primarily conducted by S.H., and larvae of *Hinatara recta*, *Metallus albipes* and *Parna apicalis* are deposited as vouchers in NHMD. Field work in Sweden and Lithuania was carried out by A.L. and A. Taeger (vouchers in SDEI). Distribution maps for all the investigated species (except *Scolioneura betuleti* / *vicina*) were generated using the online mapping tool Simplemapp. For the maps, GPS-coordinates were approximated for the historical records (i.e. for adult museum specimens and herbarium specimens) whereas precise coordinates were used for plotting the field survey records.

## Results

*Hinatara recta* and *Metallus albipes* are reported for the first time from Denmark, and *Parna apicalis* from Denmark, Sweden and Lithuania. The Danish field survey yielded records of leaf-mines of all three species. The revision of specimens (adult/mine herbarium) in the NHMD collection revealed that *M. albipes* and *P. apicalis* were already represented by misidentified

specimens, and *H. recta* by a previously unidentified mine. Further, some specimens of *M. lanceolatus* and *Scolioneura betuleti* were incorrectly identified as *Metallus pumilus*.



**Fig. 1.** Adult females of *Metallus lanceolatus* (1A), *M. pumilus* (1B), *M. albipes* (1C) and *Parna apicalis* (1D).

### Keys to adult north-west European *Metallus* and *Parna* species

*The genera can be identified using the key by Smith (1976)*

#### *Metallus*:

1. Abdomen and sometimes posterior dorsal parts of thorax yellow. ....  
 ..... *M. lanceolatus* [in part] female (Fig. 1A) [Male: rare?  
 Recorded by Koch (1989), but we have seen no males amongst 58 specimens examined]  
 - Abdomen and posterior dorsal parts of thorax completely black. .... 2
2. Bases of all femora, all coxae except extreme apices, and trochanters partly, blackened.  
 ..... *M. pumilus* female and male (Fig. 1B)  
 - At least middle and hind femur entirely pale. Front coxa entirely pale, or slightly infuscate. .  
 ..... 3
3. Front and middle coxa entirely white (same colour as femur); hind coxa basally black,  
 apically white; rest of legs entirely white. Smaller: body length 2.5-3.8 mm. ....  
 ..... *M. albipes* (Fig. 1C) [male unknown]  
 - Front, middle and hind coxa slightly infuscate (darker than femur); pale parts of legs  
 yellowish white. Larger: body length 3.5-4.0 mm. ....  
 ..... *M. lanceolatus* [in part] female (Fig. 1A) [male: not seen by us]

#### *Parna*:

1 Base of femur and the entire trochanter and coxa black [colours sometimes faded], tegula pale..... *P. apicalis* (Fig. 1D) [males are unknown and the species is probably entirely parthenogenetic in Central and Northern Europe]

- Only coxa black and the rest of the leg pale, tegula black. ....  
..... *P. tenella* [males quite frequent]

### Results of revision (adult specimens and mine herbarium) and field survey

Below, each species representing a new country record (marked with an asterisk, \*) is presented with an introductory section on biology and distribution followed by details concerning the findings, divided into three sections: adult specimens, historical records and mine herbarium specimens, and field survey. For species already sufficiently documented – *Metallus lanceolatus*, *M. pumilus* and *Scolioneura betuleti* – the field survey section is shortened to a descriptive summary of the results.

Records of adult museum specimens are listed under faunistic districts (for district demarcations see Enghoff & Nielsen, 1977 (Denmark) and Hedqvist, 2003 (Sweden); for Lithuania, the province is listed), specimen data, and verbatim label data where relevant (in quotation marks). The herbarium, literature and field survey records are listed as follows: Faunistic district, locality, date, finder, GPS coordinates / reference (if applicable) and a short description of the habitat, if recorded. Comments by the authors are enclosed in brackets.

#### *Hinatara recta* (Thomson, 1871) (Fig. 2, 6)

Mines are found on young leaves of *Acer platanoides* in late spring, always on the tip of the leaf and often on saplings. The frass – larval excrement – is characteristically rod-shaped and abundant in the mine. A distinct pattern of dark sclerotized flecks is found on the dorsal side of the thorax whereas the corresponding ventral side is uncharacteristically marked. The larval period of this strictly univoltine sawfly is considered to be from May to June (Hering, 1957), however, fully-grown feeding larvae have been recorded from Belgium and Hungary already at the end of April (Ravoet & Ellis, 2010; Edmunds, 2016). The larva leaves the mine to spin a cocoon in the soil whereupon the empty mine shrivels. The species is widespread in Europe; from Sweden and Norway to Russia and Bulgaria (Lønnve 2009, Taeger et al. 2006). Earlier published records of *H. recta* indicate that the species can be found in a variety of habitats, from (sub)urban environments to protected natural reserves (Lønnve, 2009; Ravoet & Ellis, 2010; Edmunds, 2016).

Material examined, and validated records of mines:

**Denmark\*:** adult museum specimens: none. **Historical records of leaf-mines and herbarium specimens:** Nordøstsjælland (NEZ): Roskilde, 12.06.1939, Carolsfeld-Krause (Sønderup, 1949): 4 vacated mines on *Acer platanoides* (NHMD). Listed as *Phyllotoma* sp. on page 162 in Sønderup (1949) and characterized as very rare (“meget sjælden”). **Field survey records:** Fyn (F): Lærkedal, 13.06.2015, leg. S. Haarder and others (55°15'38.1"N 10°10'47.9"E): around 10 vacated mines on *Acer platanoides* along a forest path. Nordøstsjælland (NEZ): Nivå, 22.05.2015, leg. S. Haarder. Several occupied mines on *Acer platanoides* at two localities: near Nivå train station (55°56'09.7"N 12°30'26.0"E) and Laveskov (55°56'30.0"N 12°31'18.7"E). Asminderød, 08.06.2015, leg. S. Haarder & S. J. A. Nielsen (55°58'14.7"N 12°25'10.8"E): 3 vacated mines on *Acer platanoides* in an urban environment. Frederiksberg Garden, 15.06.2016, leg. S. Haarder (55°40'27.4"N 12°31'28.9"E): 1 vacated mine on *Acer platanoides* adjacent to footpath. Helsingør, 01.07.2015, leg. S. Haarder (56°01'36.7"N 12°34'06.8"E): 2 vacated mines on *Acer*

*platanoides* in small forested patch in the outskirts of the city. Myreholm, 04.06.2016, leg. L. Kjær-Thomsen (56°03'54.2"N 12°21'35.0"E): 1 vacated mine on *Acer platanoides* in a commercial bird park - Fugleparken Zoo. Nødebo Holt, 13.06.2016, leg. L. Kjær-Thomsen (55°58'20.9"N 12°20'45.5"E): 2 vacated mines on *Acer platanoides* in mixed deciduous forest. Marienlyst, 01.08.2017, leg. S. Haarder (56°02'46.2"N 12°36'07.8"E): 1 vacated, withered, mine on *Acer platanoides* in a small forest patch near the beachline. **Nordvestsjælland (NWZ)**: Dalby Strand, 20.07.2016, leg. S. Haarder (55°31'08.5"N 11°08'55.5"E): 1 vacated, somewhat withered mine on *Acer platanoides* in a summer cottage area. **Sydsjælland (SZ)**: Næstved, 29.05.2016, leg. S. Haarder (55°13'47.9"N 11°45'58.7"E): around 50 mines on *Acer platanoides*, all vacated, in Munkebakken park near Næstved train station. Tystrup Sø, 23.08.2016, leg. S. Haarder (55°22'16.4"N 11°34'56.5"E): 1 quite withered (yet still identifiable) mine on *Acer platanoides* near the river bank. Stensved, 15.06.2017, leg. S. Haarder (54°59'44.0"N 12°01'01.7"E): 1 vacated mine on *Acer platanoides* along forest edge. Ringsted, 25.05.2018, leg. S. Haarder (55°25'45.8"N 11°47'03.2"E): 3 vacated mines on *Acer platanoides*, high school campus area.



**Fig. 2.** *Hinatara recta*: material from the mine herbarium at NHMD (2A, 2B), leaf mines with larvae on *Acer platanoides* (2C, 2D)

***Metallus albipes*** (Cameron, 1875) (Fig. 3, 7)

Phenology, distribution, and mine morphology similar to *M. pumilus*, but *M. albipes* is stated in the literature to feed only on *Rubus idaeus*, and the larva of *M. albipes* is without a dark spot on the sternum of the first abdominal segment.

Material examined, and validated records of mines:

**Denmark\*:** **adult museum specimens:** [formerly placed in collection under *M. pumilus*]  
**Nordøstsjælland (NEZ):** [abdomen missing] 1 [?] female "Kb" [Copenhagen] "Danmark ex coll. Schiödte" (NHMD); 1 female [labels as for previous specimen, but with an undecipherable

handwritten label]. **Sønderjylland (SJ)**: 1 female ""Sondbg 30.V.91" [Sønderborg] "Coll. Wüstnei." [with a second, undecipherable, label in pencil]. **Historical records of leaf-mines and herbarium specimens: Nordøstsjælland (NEZ)**: Jyderup, 21.09.1910, leg. J. Lind (Sønderup, 1949) (LPS): numerous mines on *Rubus idaeus*, but identifiable larvae only in a few. **Nordstjylland (NEJ)**: Skagen, 02.08.1920, leg. K. L. Henriksen (NHMD): around 40 mines on *Rubus idaeus*, most containing larvae. **Field survey records: Bornholm (B)**: Bodilsker Plantage, 18.09.2016, leg. K. Nielsen (55°04'56.6"N 15°03'19.7"E): many occupied mines on *Rubus idaeus* in summer cottage area. **Østjylland (EJ)**: Gram, 14.10.2015, leg. M. Holm (56°03'18.2"N 9°59'58.8"E): five occupied mines on *Rubus idaeus* at edge of coniferous forest; Enemærket, 20.10.2015, leg. M. Holm (56°06'N 9°51'E, approximated): one occupied mine on *Rubus idaeus*; Staksrode Skov, 28.06.2016, leg. S. Haarder (55°41'20.2"N 9°52'09.2"E): three occupied mines on *Rubus idaeus* in undergrowth of coniferous forest. Grund Skov, 28.06.2016, leg. S. Haarder (55°41'29.0"N 9°45'09.5"E): one occupied mine on *Rubus idaeus* in mixed deciduous forest. **Fyn (F)**: Gærup Skov, 03.07.2016, leg. S. Haarder (55°07'17.6"N 10°18'54.7"E): two occupied mines on *Rubus idaeus* in mixed deciduous forest. **Lolland-Falster-Møn (LFM)**: Møns Klint, 06.08.2017, leg. S. Haarder (54°57'55.8"N 12°32'53.4"E): two occupied mines on *Rubus idaeus* in chalk-rich beech forest. **Nordøstsjælland (NEZ)**: Rusland, 05.10.2014, leg. S. Haarder (56°05'00.0"N 12°24'28.5"E): two occupied mines on *Rubus idaeus* in primarily deciduous forest with element of conifers. Esrum Lund 10.10.2014, leg. L. Kjær-Thomsen (56°02'42.4"N 12°22'04.6"E): two occupied mines on *Rubus idaeus* in mixed deciduous forest. Holte, 20.09.2016, leg. M. Kofoed-Hansen (55°48'57.1"N 12°27'39.5"E): one occupied mine on *Rubus idaeus* in hedgerow adjacent to train tracks. Knurrenborg Vang, 20.10.2016, leg. S. Haarder (55°57'39.7"N 12°25'29.9"E): several occupied mines on *Rubus idaeus* in beech-dominated forest. Rude Skov, 04.10.2016, leg. M. Kofoed-Hansen (55°50'27.4"N 12°28'12.6"E): two occupied mines on *Rubus idaeus* in mixed deciduous forest. Pernille Sø, 05.07.2017, leg. K. Nielsen (56°03'56.2"N 12°32'34.8"E): one occupied mine on *Rubus idaeus* at lakeside in wooded area (Teglstrup Hegn). **Sydsjælland (SZ)**: Ornebjerg, 01.11.2015, leg. S. Haarder (55°01'55.7"N 11°55'54.8"E): three occupied mines on *Rubus idaeus* in mixed forest. Langebæk Skov, 24.09.2016, leg. S. Haarder (54°58'44.8"N 12°04'55.0"E): two occupied mines on *Rubus idaeus* in mixed deciduous forest. Søskov, 26.07.2016, leg. S. Haarder (54°58'38.8"N 12°01'14.3"E): one occupied mine on *Rubus idaeus* in mixed deciduous forest. Knudsskov, 03.09.2017, leg. S. Haarder (55°03'21.4"N 11°44'28.7"E): many occupied mines of *Rubus idaeus* in (primarily) old growth forest.

Two records could be attributed to *M. albipes* based on larval characters (no dark spot on first ventral segment), but the host plants were identified as other than *Rubus idaeus*: **Østjylland (EJ)**: Illerup Ådal, 28.09.2014, leg. M. Holm, (56°03'25.1"N 9°55'34.0"E): one occupied mine on *Rubus saxatilis* at forest edge. **Nordøstsjælland (NEZ)**: Hammermøllen, 31.07.2017, leg. K. Nielsen (56°03'58.8"N 12°33'08.0"E): 1 occupied mine on *Rubus spectabilis* adjacent to forest trail near small train station (Hellebæk station). Finally, several vacated *Metallus*-mines on *Rubus idaeus* were recorded near Lohals at forest edge on the island of Langeland (**F**), 25.09.2015, leg. A. L. Nielsen (55°07'26.3"N 10°54'41.3"E).

The following historical findings cannot be attributed satisfactorily to *M. albipes* or *M. pumilus* because they are 1) literature records without plant host records, or corresponding specimens in the mine herbarium, or 2) mine specimens from the mine herbarium at NHMD in which the larvae are not preserved in the mines, or are dried beyond identification: **Bornholm (B)**: Rønne, 08.1942, leg. Herbert Buhr (Buhr, 1933): mines on *Rubus idaeus*. **Østjylland (EJ)**: Frijsendal, 06.1942, leg. A. Jøker (Sønderup, 1949; NHMD): 4 empty mines on *R. idaeus*;



Himmelbjerget, 08.07.1935, leg. H. V. Rævskjær (NHMD): 2 mines, one of them occupied, on *R. idaeus*. **Lolland-Falster-Møn (LFM)**: Maltrup Skov, 21.7.1937, leg. H. P. S. Sønderup (Sønderup, 1949): mines on *Rubus* sp. **Nordøstsjælland (NEZ)**: Geelskov, 12.09.1920, leg. J. P. Kryger (Sønderup, 1949; NHMD): 9 mines, most without larvae, on *R. idaeus*.



**Fig. 3.** *Metallus pumilus* (3A-C) and *M. albipes* (3D-G): leaf mines on *Rubus* spp. (3A-B, 3D-E), larvae in ventral view (3C, 3F; note the missing spot on the first abdominal segment of *M. albipes*; 3F), a dried larva of *M. albipes* in a leaf mine on *Rubus idaeus* - Skagen, 1920 - from the mine herbarium at NHMD (3G).

***Metallus lanceolatus*** (Thomson, 1870) (Fig. 4, 8)

Mines are found on *Geum* spp.: in semi-natural vegetation most often on *G. urbanum* and *G. rivale*, but also on many species cultivated in gardens (Buhr 1941). Individual mines are initiated as short corridors, but soon develop into large blotch mines. Pattern of larval sclerotization much like *Metallus pumilus*, but with weaker coloring. Frass in grains which are scattered in the mine. Larvae occur from June to November in two generations. The species is widely distributed in Europe and also occurs in the Nearctic (Canada and USA). It was considered very common ("Meget almindelig") in Denmark by Sønderup (1949).

Material examined, and validated records of mines:

**Denmark\*:** adult museum specimens: [all NHMD, some formerly placed under *M. pumilus*]

**Lolland-Falster-Møn (LFM):** 3 females "Fenusa pumila Kl. ex l. Maribo 28.7.33 Betula 7.7.1933"; 4 females mounted together "Entodecta gei Bri. ex l. Maribo 12.8.1935 H.P.S.S."; 1 female "Entodecta gei ex l. Maribo 28.7.1936 H.P.S. Sønderup "; 2 females "Entodecta gei ex l. Maribo 23.8.1935 H.P.S. Sønderup "; 1 female "Entodecta gei ex l. Maribo 8.8.1936 H.P.S. Sønderup "; 1 female "Entodecta gei ex l. Maribo 18.6.1936 H.P.S. Sønderup "; 1 female "Entodecta gei Bri. ex l. Maribo 10.8.1935 Geum urb. [Geum urbanum] H.P.S. S. "; 1 female "Fa" "Falster Schiödte" "Danmark ex coll. Schiödte"; 1 female "Entodecta gei Bri. ex l. Maribo 14.8.1935 H.P.S.S.". **Bornholm (B):** [abdomen missing] 1 [?] female "Bo" "Bornholm Schiödte" "Danmark ex coll. Schiödte". **Unknown locality:** 2 females mounted together: no data; 1 female "fem. Schiödte" "Danmark ex coll. Schiödte". **Historical records of leaf-mines and herbarium specimens: Lolland-Falster-Møn (LFM):** Aahaven [Maribo], 8.11.1931, leg. H. P. S. Sønderup (Sønderup, 1949). Bangshave [Maribo], 14.7.1935, leg. H. P. S. Sønderup (Sønderup, 1949). Kidnakke [Maribo], 17.9.1932, leg. H. P. S. Sønderup (Sønderup, 1949). **Nordøstsjælland (NEZ):** Lejre, 19.10.1938, leg. J. P. Kryger. (Sønderup, 1949). Klampenborg, 21.7.1937, J. P. Kryger (Sønderup, 1949). Sandkroen [Asserbo], 15.10.1920, J. P. Kryger (Sønderup, 1949). **Nordvestjylland (NWJ):** Lemvig, 1.10.1946, leg. H. P. S. Sønderup (Sønderup, 1949). **Field survey records:** Mines have been found throughout Zealand, with the majority of findings from districts NEZ and SZ (18 records in total). Outside Zealand, records are scattered from Lolland-Falster-Møn (LFM, 3 records) to Funen (F, 2 records) and Eastern Jutland (EJ, 2 records).



**Fig. 4.** *Metallus lanceolatus*: Leaf mines on *Geum urbanum* (4A-B); photos by Linda Kjær-Thomsen, larva in ventral view (4C).



***Metallus pumilus*** (Klug, 1816) (Fig. 3, 9)

Mines are found in leaves of *Rubus* spp. (including *Rubus idaeus*), usually off-centre. The mine is initially a corridor, but soon forms a large, transparent blotch-mine; the frass is loosely distributed as grains. The larva is slender and whitish, with dark, well-developed thoracic legs. The first sternal segment bears a large, somewhat rectangular sclerotisation followed by an elongated dark spot on each of the second and third segments. Additionally, there is a spot on the ventral side of the first abdominal segment – a key character separating the larva of *M. albipes* from *M. pumilus*. Occupied mines can be encountered from June to July and again in autumn. Pupation is external. A widely distributed species, recorded from Scandinavia to southern Europe, and eastwards to Russia (Taeger et al. 2006) ; also from Iran (Khayrandish et al. 2017), the Russian Far East (Zhelochovtsev & Zinovjev 1996) and Japan (Lacourt 1999).

Material examined, and validated records of mines:

**Denmark: adult museum specimens:** [all NHMD] **Lolland-Falster-Møn (LFM):** 2 females "ex I. Maribo 30.6.36 Af *Rubus frutic.* H. P. S. Sønderup"; 1 male, "Entodecta pumilus Kl. ex I. Maribo 13.7.36 *Rubus* H.P.S.S." "Sønderup 16.10.36"; 1 male "Maribo 1936 Sønderup leg."; 1 female, "Entodecta pumilus ex larva Maribo 23.6.1936 *Rubus* H.P.S. Sønderup "; 1 female, "Entodecta pumilus Kl. ex larva Maribo 20.5.1936 *Rubus caesius* 13.7.1935 H.P.S. Sønderup"; 1 female, "Entodecta pumilus Kl. ex larva Maribo 16.5.1936 *Rubus caesius* H.P.S. Sønderup " 1 female, "Entodecta pumilus Kl. ex larva Maribo 9.8.1935 *Rubus* H.P.S.S."; 1 female, "Entodecta pumilus ex larva Maribo 19.5.1936 paa *Rubus* H.P.S. Sønderup ". SJ: 1 female "Sonderburg 1.6.01" "Coll. Wüstnei."; 1 male "Sondbg 21.VII.81" "Coll. Wüstnei."; 1 female "Sondbg 18.6.81" "Coll. Wüstnei.". Unknown locality: 1 female "[?] Mels" "Coll. Wüstneii" [presumably Sønderborg]. **Historical records of leaf-mines and herbarium specimens: Bornholm (B):** Rønne, 08.1932, leg. H. Buhr (Buhr, 1933; Sønderup, 1949). Mines on *Rubus fruticosus* s. la. ("Brambeeren"). **Lolland-Falster-Møn (LFM):** Maltrup, 23.10.1924, leg. H. P. S. Sønderup (NHMD): Two empty mines on *Rubus fruticosus* s. la.; Maribo, 2.10.1932, leg. H. P. S. Sønderup (NHMD): one vacated mine on *Rubus caesius*; Strangeshave, 29.8.1935, ex. 18.5.1936, leg. H. P. S. Sønderup (Sønderup, 1949). The date attributed to the reared specimens is, in our opinion, most likely corresponding to the "... Maribo 19.5.1936..." entry (see above); the locality, Strangeshave, is near Maribo. **Nordøstsjælland (NEZ):** Asserbo Ruin, 15.08.1920 & 08.1942, leg. J. P. Kryger & A. Jøker (NHMD). Five and two vacated mines, respectively, on *Rubus parviflorus*; a dried larva was found outside the mine, on the leaf disc, in one of the herbarium specimens from 1942. **Field survey records:** Widely distributed in Zealand (NEZ, NWZ, SZ) and Lolland-Falster-Møn (LFM), with a handful of records from Eastern Jutland (EJ) and Funen (F), and one record each from Western Jutland (WJ) and Bornholm (B). Host predominantly *Rubus fruticosus* sensu lato, but also *Rubus caesius* and, in rare cases, *R. idaeus*.

***Parna apicalis*** (Brischke, 1888) (Fig. 5, 10)

The small to medium sized blotch-mines are found near the leaf margin on *Tilia* spp., often in urban areas. Mines are flat and contain many small grains of frass – both key characters for *P. apicalis*. Usually, the mines are in leaves of the tree crown, not nearer ground level on sucker growth as in *P. tenella* (Edmunds, 2016). The larva bears a characteristic chitinized structure on the first sternal segment, followed by a medial spot on the following two segments; the colour of these structures is dark (except after moulting), another helpful character (pigmentation of corresponding parts of *tenella* much weaker). *Parna apicalis* is univoltine: occupied mines can be found as early as April, but the main larval period is May. Distribution: through much of western and southeastern Europe (Taeger et al. 2006), including

the British Isles, but not known from the Iberian Peninsula or Italy. In northern Europe, the only previous records were from Finland and Estonia (Heidemaa & Viitasaari 1997).

Material examined, and validated records of mines: **Denmark\*:** **adult museum specimens:** [stood formerly under *P. tenella*] **Lolland-Falster-Møn (LFM):** Lindø in Maribo Sø, 28.5.1935, ex. 12.4.1936 and 17.4.1936, leg. H. P. S. Sønderup: 2 and 4 females, respectively; Maribo, ex. 27.4.1939, leg. H. P. S. Sønderup: 4 females; Frejlev Skov, 7.6.1987, leg. H. K. J. (?): 8 females. **Historical records of leaf-mines and herbarium specimens:** [formerly determined as *Parna (Scolioneura) tenella*] **Lolland-Falster-Møn (LFM):** Lindø in Maribo Sø, 27.5.1935, ex. 10.4.1936, leg. H. P. S. Sønderup (Sønderup, 1949; NHMD). One vacated mine on *Tilia x europaea* (*Tilia parviflora* in herbarium). Maribo, 01.06.1934 & 02.06.1934, ex. 14.4.1935 (from latter collection date), leg. H. P. S. Sønderup (Sønderup, 1949; NHMD). Five and one vacated mines, respectively, on *Tilia x europaea* (*Tilia parviflora* in herbarium). **Field survey records:** **Nordøstsjælland (NEZ):** Copenhagen, 11.05.2014, leg. S. Haarder (55°40'13.6"N 12°31'15.5"E): one occupied mined found on *Tilia* sp. in Copenhagen Zoological Garden by the lemur enclosure. **Sydsjælland (SZ):** Næstved, 29.05.2016 & 24.05.2017, leg. S. Haarder (55°13'47.9"N 11°45'58.7"E): vacated and occupied mines (former and latter date, respectively) on *Tilia* sp. in a park – Munkebakken – close to the train station.

The following records are equivocal, and can only be assigned to *Parna* sp.: Knuthenborg Park (LFM), 25.5.1938, ex. 15.4.1939, H. P. S. Sønderup (Sønderup, 1949): neither reared specimens nor mines were located in the NHMD collections. Ebbeskov (NEZ), 11.06.2015, leg. J. Lutz (55°29'44.5"N 11°56'07.8"E) and Stenholt Mølleeng (NEZ), 22.05.2018, leg. L. Kjær-homsen (55°57'48.7"N 12°20'53.0"E): Mines with overall appearance of *Parna apicalis*, but larva weakly sclerotized on the sternum, a diagnostic character of *P. tenella*.

**Sweden\*:** **adult museum specimens:** [formerly placed under *P. tenella*] Skåne (**Sk**): Kullaberg (Malmöhus Län), ex. 19.02.1967, leg. Benander (56°17'45.6"N 12°28'26.4"E): 4 females (MZLU). **Field survey records:** **Gotland (Go):** Tingstäde, 07.6.2017, leg. A. Liston (57°43'51.6"N 18°36'18.0"E), 5 mines with mature larvae on *Tilia x europaea* in small, open, mixed secondary woodland within village.

**Lithuania\*:** **field survey records:** **Panevėžys County:** Panevėžys, 08.06.2015, leg. A. Liston & A. Taeger (55.74°N 24.25°E): 2 vacated leaf-mines on *Tilia* sp. in open, mixed, secondary woodland at edge of village (SDEI).

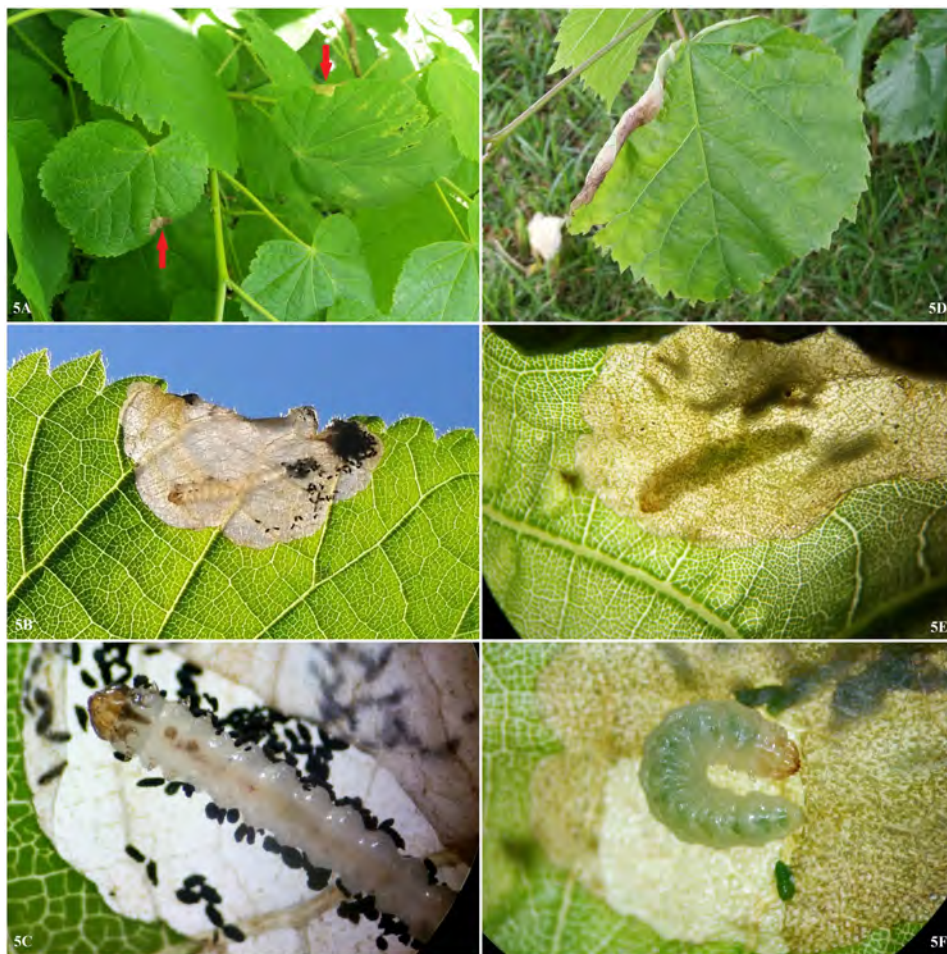
### ***Parna tenella*** (Klug, 1816) (Fig, 5, 10)

Because this species was mixed up with *Parna apicalis* until recognized as separate by Chevin (1983: but misidentified as *P. kamijoi* Togashi, 1980), previously published records under the name *tenella* cannot be relied upon, unless voucher specimens exist. Host plant choice (*Tilia* spp) is comparable to *P. apicalis*, but *P. tenella* is more widely distributed in Europe and the larval period is mainly from June to July. *Parna tenella* is usually considered to be univoltine (Pschorn-Walcher & Altenhofer 2000). Published records indicate that mines are mainly found on suckers, low on the trees (Edmunds, 2016). The mines of *P. tenella* can be distinguished from those of *P. apicalis* by the strongly rolled leaves and the larger frass grains, and larvae of *tenella* by the more weakly developed sclerotizations on the larval sternum. Mentioned as rare ("sjælden") in Sønderup (1949), but his records may refer to either of the two European *Parna* species.

Material examined:

**Denmark: adult museum specimens:** None (NHMD); see entry for *P. apicalis*. **Historical records of leaf-mines and herbarium specimens:** None (NHMD); see entry for *P. apicalis*. **Field survey records: Sydsjælland (SZ):** Stensved Kirke, 11.07.2017, leg. S. Haarder (54°59'03.2"N 12°01'51.8"E): numerous occupied mines on *Tilia* sp. in graveyard. Glumsø, 31.08.2017, leg. S. Haarder (55°21'11.9"N 11°41'43.1"E): two vacated mines on *Tilia* sp. close to Glumsø train station. Ringsted, 25.05.2018, leg. S. Haarder (55°26'18.5"N 11°47'26.6"E): one inhabited mine on *Tilia* sp. near the train station. Vordingborg, 23.06.2018, leg. S. Haarder (55°00'25.8"N 11°54'36.3"E): around 20 vacated mines on *Tilia* sp. in the Historical-Botanical garden. Madsnedsund, 26.06.2018, leg. S. Haarder (55°00'04.3"N 11°53'33.4"E): eight vacated mines on *Tilia* sp. in a school courtyard. **Lolland-Falster-Møn (LFM):** Marielyst, 28.07.2017, leg. S. Haarder (54°41'36.3"N 11°57'44.6"E): a single vacated mine on *Tilia* sp. in a small park. **Nordvestsjælland (NWZ):** Kalundborg, 02.09.2018, leg. S. Haarder (55°40'52.6"N 11°04'45.0"E): one vacated mine on *Tilia* sp. outside Kalundborg Museum.

**Sweden: adult museum specimens: Skåne (Sk):** Höganäs, Kullaberg, 30.5.1956 & 15.6.1956, leg. P. Benander (56.30°N 12.47°E): respectively 1 male, 1 female. "Fogelsång i Skåne" (Thomson, 1870: as *Blennocampa albida* (Kl.)): 1 male (MZLU)



**Fig. 5.** *Parna apicalis* (5A-C) and *P. tenella* (5D-F): leaf mines on *Tilia* sp. (5A-B, 5D-E; arrows indicate mines), larvae in ventral view (5C, 5D).

### ***Scolioneura betuleti* (Klug, 1816)**

The large mines are found on *Betula* spp., and in the Central European mountains on *Alnus viridis*. The white larva is large and slender, and bears numerous dark sclerotized plates on its body; a genus-characteristic trait is the pattern of small dark spots along the side of the larva. Occupied mines are found in late summer to autumn. Widespread and common in Europe, the distribution extends eastwards to Russia (Siberia) and Mongolia. Also present in Canada where it was first detected in 1983 (Evans et al. 1985). *Scolioneura betuleti* is very common (“Almindelig overalt”) in Denmark according to Sønderup (1949).

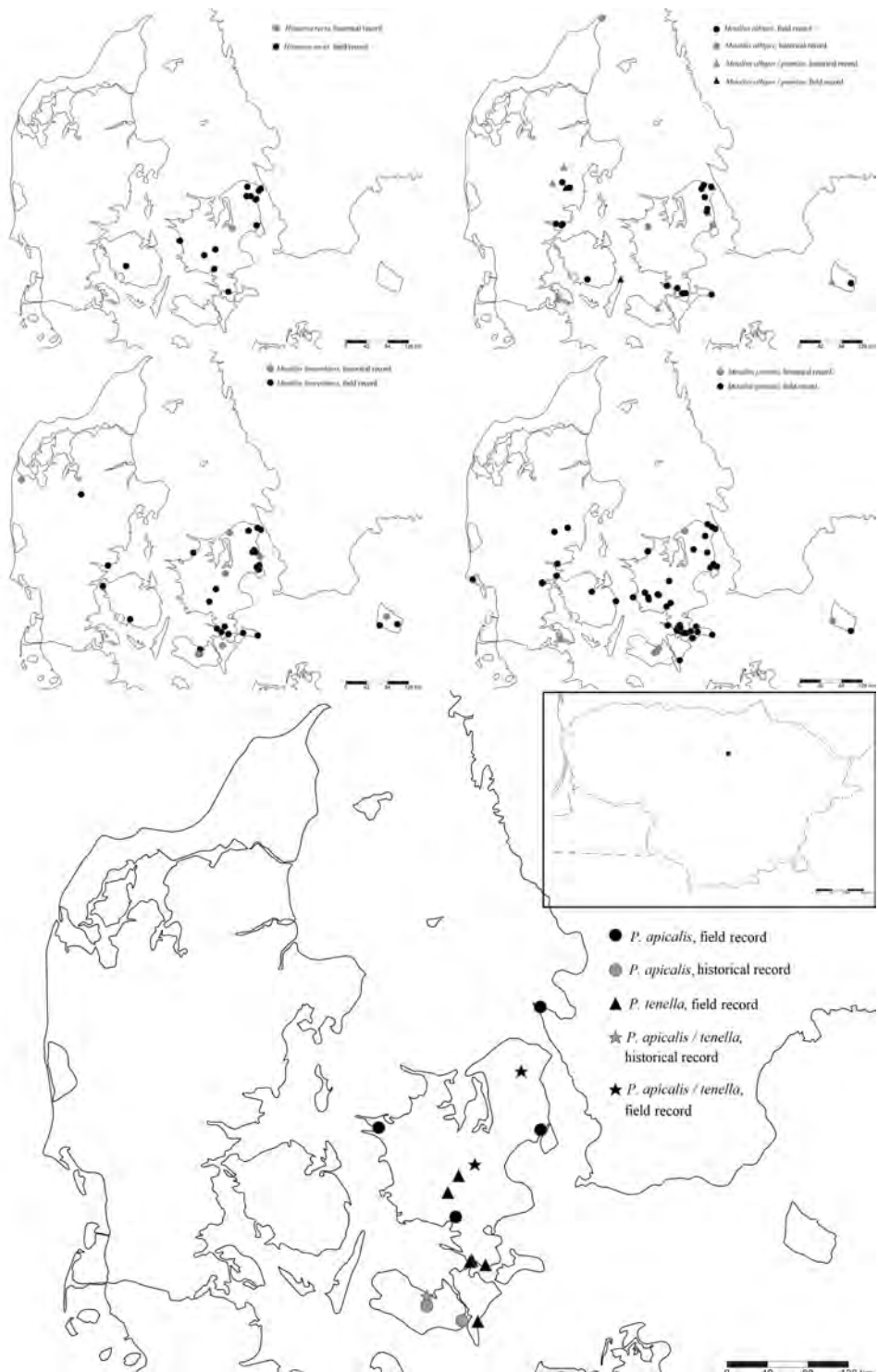
We note that *Scolioneura vicina*, another birch-mining species, has not formally been recorded from Denmark. It is, however, widely believed that this taxon should be considered a synonym of *S. betuleti*, as there are no substantial morphological or molecular differences between the two (Leppänen et al. 2012). The only difference is phenological: mines of *S. vicina* are found in early summer (May – June). Accordingly, early records of mines are listed as *S. vicina* below.

Material examined, and validated records of mines: **Denmark: adult museum specimens:** [The adult specimens (50 in total) under the name *Scolioneura betuleti* in the NHMD collection have not been examined] **Lolland-Falster-Møn (LFM):** 2 females "[?] Vistnok [=probably] *Entodecta pumilus* Kl. ex larva Maribo 8.8.1935 Rub. caes. H.P.S.S. "; 1 male "Maribo 1936 Sønderup leg." [NHMD, stood under *Metallus pumilus*]. **Historical records of leaf-mines and herbarium specimens: Bornholm (B):** Bornholm [no locality], 08.1932, leg. H. Buhr (Buhr, 1933; Sønderup, 1949). **Lolland-Falster-Møn (LFM):** Nysted, 21.6.1932 [= *S. vicina*], leg. H. P. S. Sønderup (Sønderup, 1949). Maribo, 18.7.1933, leg. H. P. S. Sønderup (Sønderup, 1939). Bøtø, 25.8.1935, ex. 12.5.1936, leg. H. P. S. Sønderup (Sønderup, 1949). Nakskov, 24.6.1936 [= *S. vicina*], leg. H. P. S. Sønderup (Sønderup, 1949). **Nordøstsjælland (NEZ):** København, 17.6.1920, [= *S. vicina*], leg. K. L. Henriksen (Sønderup, 1949). **Nordvestjylland (NWJ):** Sønderby v. Rom Hede, 12.9.1946, leg. H. P. S. Sønderup (Sønderup, 1949). Lemvig, 1.9.1948, leg. H. P. S. Sønderup (Sønderup, 1949). **Field survey records:** Mines of *S. betuleti* have been recorded from the three districts in Zealand (NEZ, NWZ, SZ) and Eastern Jutland (EJ), whereas *S. vicina* is known from all districts except NWZ and NWJ. Perhaps the most common leaf-mining species in Denmark. Details of the records (*S. betuleti* and *S. vicina*) can be seen at the Danish Nature Database (F&N<sup>i</sup>)

### **Discussion**

The new country records of three leaf-mining sawflies in this study - *Hinatara recta*, *Metallus albipes* and *Parna apicalis* – were documented by a combination of examination of, mostly older, museum specimens (pinned adults, and mines in mine herbaria), and recent field surveys. The results obtained indicate the value of this approach, as it leads to a more complete understanding of actual distribution, contributes to better morphologically based keys, and can correct previous wrong identifications.

Historical *Hinatara recta* records from Denmark are restricted to a single herbarium specimen from 1939, whereas the recent field surveys indicated the presence of an established, if perhaps uncommon, species in Denmark. Thus, these records could suggest that the species has increased its range and population levels during the last half century. It is also possible that the species has simply been overlooked in the past, although the mines are rather distinctive and can be identified throughout the summer even though larvae are no longer present. However, *Hinatara recta* was confused in much of the older literature with another leaf-mining sawfly, *Fenusella hortulana*. This could also explain the lack of records. For



**Fig. 6-10.** Distribution map of *Hinatara recta* (top left), *Metallus albipes* and *Metallus albipes / pumilus* (top right), *Metallus lanceolatus* (mid left), *Metallus pumilus* (mid right) in Denmark. Bottom. Distribution map of *Parna* spp. in Denmark and *Parna apicalis* in Sweden and Lithuania. Inserted map in top-right corner depicts locality of *P. apicalis* in Lithuania.



example, Nielsen & Henriksen's (1915) record of *Fenusa hortulana* is difficult to interpret, because the brief characterization of the adult is clearly *Fenusella hortulana* (only hosts: *Populus* spp.), whereas the hosts (seemingly based on observations at Helsingør) are given as *Acer platanoides* and *A. campestre*. The second of these is not a known host of *H. recta*, but is a host of *H. nigripes*. However, *H. nigripes* is a warmth-loving species that is not known to occur further north than Central Germany (where it is very rare), and it would be surprising if it occurred in Denmark. It seems more likely, that Nielsen & Henriksen's mention of *A. campestre*, if based on original observation, arose from a misidentification of mines of *Heterarthrus wuestneii*, a species which is recorded from Denmark. The presence of *F. hortulana* in Denmark is nevertheless certain, based on the description of *Fenusa sønderupi* (a junior synonym of *F. hortulana*), type locality Maribo, by Hering (1935). Sønderup's (1949) subsequent records of *hortulana* mines do not name the *Populus* species involved, so that they may either refer to the other European *Populus*-mining, *Fenusella* species (*F. glaucopsis* (Konow, 1907), not yet recorded in Denmark), or *F. hortulana*. The larvae of these species are said to be distinguishable by differences in the anal ring, and host species: *F. hortulana* is mostly found on *Populus nigra* (and hybrids, e.g. *Populus x canadensis*) whereas *F. glaucopsis* seems mainly to be on *Populus tremula*. However, published information on hosts indicates that their host ranges partly overlap (Pschorn-Walcher & Altenhofer 2000; Altenhofer 2003). 21 adult specimens of *Fenusella hortulana* (as *Messa hortulana*) are deposited in NHMD<sup>ii</sup>. Re-examination of these would be worthwhile.

The *Metallus* species are difficult to identify, using only external characters of adults. As discussed by Koch (1989), some of the characters given in earlier keys are too variable to be useful for identification. One of the main problems that caused confusion in the past, as also mentioned by Koch (1989), is that *M. lanceolatus* does not always have a largely pale abdomen: it may rarely be entirely dark, as in the other European species. Very dark *M. lanceolatus* specimens include the syntype (type locality: Sweden, Skåne, Ringsjön) which Koch (1989) wrongly referred to as the holotype. However, the 16 Danish specimens in the NHMD all have the abdomen more or less yellowish. An examination of the reared specimens in the SDEI and NHMD collections lead us to conclude, that the north-west European species can nevertheless be identified using colour characters, as in the key presented in the Results section. Specimens that have faded or become discoloured because of the collection method or sub-optimal conservation, may have to be identified by examining their saws (illustrated by Koch 1989). The two European species of *Parna* are more easily distinguished (see also Liston, 1993: *P. apicalis* treated as *P. reseri* Liston, 1993, a junior synonym). Leg colour is a good character for separating fresh specimens of these species, but the colours of older specimens in museums are often faded. However, although the leg coloration of *P. apicalis* specimens from 1936 (NHMD) seems faded, the dark parts were nevertheless still distinguishable as such, and the clearly pale tegulae, compared to other parts of the thorax, confirmed the identification.

The importance of being able to refer to mine herbaria to check identifications, both of host plants and the leaf-miners themselves, was particularly evident with regard to *Metallus albipes* and *Parna apicalis*. Some mines in the herbarium previously identified as *Metallus pumilus* were found to be *M. albipes*, based on the combination of plant host (*R. idaeus*) and a still-visible character on dried larval skins (no spot on the ventral 1<sup>st</sup> abdominal segment), and yet others were not possible to assign to species. On the other hand, all preserved mines of *P. tenella* in the herbarium turned out to be *P. apicalis*. The latter species was first recognized to be distinct from *tenella* by Chevin (1983), so it is understandable that Sønderup did not consider the possibility of the existence of two leaf-mining sawfly species on *Tilia*.

Interestingly, his description of the leaf-mine incorporates elements from both *P. apicalis* and *P. tenella*: "Stor, noget opblæst, gennemsigtig flademine med Ekskr. Liggende som grove, sorte korn [Large, somewhat inflated, transparent blotch mine with frass in coarse, large grains.]. *P. tenella* is recorded in the literature from Sweden (e.g. Landin, 1971), whereas *P. apicalis* had not been recorded prior to this study. The published records of Swedish *P. tenella* could refer to either species. The information by Landin is almost certainly not based on his own observations, but might be on the authority of Ahlberg (1934) or Wahlgren (1951, 1963), neither of whom provided information on the appearance of the mines. A general problem attached to the data presented by Sønderup (1949), is that he often gave only a genus name of the plant host, without mentioning any species names. This has proven problematic, because several subsequently published revisionary studies of leaf-mining sawflies have indicated that additional species exist, which are often more narrowly host-specific. It was possible to associate some of the earlier literature records with specimens in the mine herbarium or adult specimens, but many others were unaccounted for, and the records hence remain unverified.

Sønderup (1949) mentions a further mine herbarium deposited in the Museum of Natural History in Aarhus (Denmark). It would have been interesting to examine this herbarium, but unfortunately it was discarded some years ago (pers. comm. Morten D.D. Hansen), because the collection was deemed unsuitable for future study after having suffered serious moisture damage.

The field records of *Metallus albipes* mines in Denmark suggest that the species is common and has been overlooked in the past. This correlates with the distribution in Europe, where it is widely distributed. In Scandinavia, it has been found in Sweden and Finland, and more recently in Norway (Heibo et al. 2014). The field findings on *Rubus saxatilis* and *Rubus spectabilis* are intriguing and should be investigated further. Perhaps the presence or absence of the spot on the 1st abdominal segment of the larva should be considered the more significant character, rather than the host. But it is not known whether this character is entirely reliable for distinguishing *M. albipes* from *M. pumilus*. On the other hand, *M. albipes* is only recorded from *R. idaeus*, apart from the mention of *Rubus plicatus* (*R. fruticosus* aggregate) by Kontuniemi (1960) in Finland, and a record from Japan on *R. crataegifolius* (Okutani 1967). But it is not absolutely clear if the sawfly involved in these records really was *M. albipes*. Finally, *M. pumilus* has been recorded independently (e.g. by Kontuniemi 1960, and Kangas 1985) as feeding on *R. saxatilis*. In such ambiguous cases, it would be advisable to rear adults, and base the identification on them.

*Parna apicalis*, on the other hand, is a more rarely occurring species in Denmark. The few field records indicate a strong preference for urban habitats (near train stations, parks, etc.) and while the infested host plants were not identified to species, they were probably hybrids, e.g. *Tilia x europaea*, which are commonly planted in Denmark. Similar habitat-types are noted by Liston (2006) and Halstead (2009), who, in addition, give comprehensive lists of *Tilia* species recorded as hosts in Germany and the UK, respectively. Edmunds (2016) also states that mines are usually found in the leaf canopy – this was true for the finding in Copenhagen Zoo, but not for those in the urban park in South Zealand (Næstved). All field records of *Parna tenella* were from (semi)urban habitats and mines were found in suckers on the base of the tree, as also reported by Edmunds (2016). Curiously, the revision of adult and mine specimens at NHMD resulted in a complete lack of verified Danish records of *P. tenella*. The subsequent field records documented the species' occurrence in Denmark and, while not appearing to be common, it is probably more widespread than these few field records indicate.

The two Danish field findings of an unidentifiable *Parna* mine is interesting: the mines appear very flat, a hallmark of *P. apicalis*, but the larvae are weakly sclerotized and the frass grains are rather large, indicating *P. tenella*. Further, an occupied mine found on June 11<sup>th</sup> 2015 (Ebbeskov) seems phenologically more likely to belong to *P. tenella* than *P. apicalis* as opposed to the May 22<sup>nd</sup> mine from Stenholt Mølleeng which suggests *P. apicalis*. As with *M. albipes* / *M. pumilus*, rearing of adult specimens should elucidate which species is involved.

With the three species mentioned in this study as new to the country, the Danish sawfly fauna now comprises 368 species. Of these, 31 can be considered true leaf-miners. Although the Danish species have been reasonably well studied – largely due to the efforts of H. P. S. Sønderup – additional leaf-mining species might occur in Denmark. These species are distributed in northern and Western Europe and produce mines on hostplants which are common in Denmark; *Fenusula altenhoferi* on *Ulmus laevis* and *U. minor*, *Fenusella glaucopsis* on *Populus tremula*, *Heterarthrus cuneifrons* on *Acer pseudoplatanus* and *H. flavicollis* on *A. platanoides*. Also, a few species might, over time, be expected to extend their range northwards as a result of increasing global temperatures. Examples include *Hinatara nigripes* on *Acer campestre* (see above) and *H. excisa* on *A. pseudoplatanus*, both of which are spring miners with their northernmost distribution currently in Southern and Central Germany, respectively. The remaining European species of leaf-mining sawflies exhibit a distribution limited to southern or easternmost Europe on host plants that are absent from Denmark or very rare, or are associated with habitats not found in Denmark (e.g. the alpine species *Scolioneura tirolensis* from Central Europe that mines leaves of *Salix* spp; Liston, 2007).

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<sup>i</sup> <https://www.fugleognatur.dk/artintro.asp?ID=43118> & <https://www.fugleognatur.dk/artintro.asp?ID=20376>

<sup>ii</sup> <http://www.NHMD.dk/EntoWeb/collections-databaser/Hymenoptera/Heterarthrinae230603.htm>