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Profile

The First North American Record of the Allium Leafminer

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Abstract

The invasive species *Phytomyza gymnostoma* (Loew) (Diptera: Agromyzidae), also know as the Allium Leafminer, is reported from the United States for the first time. The first specimens were collected in Lancaster County, PA, USA in December 2015. An additional 19 counties in Pennsylvania and two states were confirmed in 2016. The species' North American distribution, pest implications, and observations on their biology in the New World are reviewed.

Key words: *Phytomyza gymnostoma*, *Allium*, North America, distribution, Allium Leafminer

The initial report of 'unidentified insect (Leafminer spp.) on *Allium*' was submitted to the Pennsylvania Department of Agriculture (PDA) Entomology Division on 21 December 2015, by the author (T.E.E.). A grower in Lancaster County, PA contacted the author after experiencing total loss of a leek (*Allium porrum* Lambinon et al. [Liliales: Liliaceae]) crop due to leafminer damage. The grower had also experienced a complete loss of an onion crop (*Allium cepa* L. [Asparagales: Amaryllidaceae]) that year. Infestation and damage, at a lower level of approximately half, was noted on green onions (*Allium fistulosum* L. [Asparagales: Amaryllidaceae]) in a greenhouse setting, and some infestation in chive plantings (*Allium schoenoprasum* L. [Asparagales: Amaryllidaceae]). The grower had also experienced damage the previous year to the leek crop, but it was still marketable after removal of the damaged outer layers.

Twenty-five pupae and one larva were submitted to the PDA Entomology laboratory for identification, which was tentatively identified by Sven-Erik Spichiger (PDA) as Diptera: Agromyzidae: *Phytomyza* sp. nr. *gymnostoma* Loew, based on pupal morphology and damage. Samples were sent for verification to the USDA-APHIS-PPQ Area Identifier laboratory. Additional samples were collected from the same location on 23 December 2015 by S. Spichiger and L. Donovall, USDA-APHIS-PPQ, and the author (TEE) from planted leeks, onions, and chives. Multiple pupae were reared out during late December and early January at room temperature settings in an office to obtain adult male specimens to confirm the identity using morphological features. The first reared specimens from collected pupae were obtained on 4 January 2016. Data for the reared specimens are housed in the Entomology Division of the Pennsylvania Department of Agriculture (PADA).

Origin and Distribution

P. gymnostoma Loew, also as allium leafminer (ALM), is a European species of Diptera: Agromyzidae described from Poland in 1858. The species is widespread across Continental Europe reaching from Spain to Ukraine, north to Denmark and the United Kingdom. ALM is also present in Asia with records in Turkey and Turkmenistan (USDA APHIS 2016).

The pathway for introduction into the United States is unclear and most risk assessments assume that bulbs and stems of host plants with eggs, pupae, or larvae are the vector (USDA APHIS 2016). The pathway of introduction and spread throughout Europe is also unknown (MacLeod 2007, Smith et al. 2007). Given the current known distribution of ALM in Pennsylvania, New York, New Jersey, and possibly other mid-Atlantic states, and the high level of damage at certain sites, the initial detection was not near the original introduction(s), and likely occurred several years prior to detection.

Following survey in Pennsylvania by PDA, Penn State University, and Penn State Cooperative Extension, ALM is established in Pennsylvania in 20 counties. Populations have also been confirmed from specimens from New York (verified by PDA) and New Jersey (J. Mahar, personal communication). Reports from extension personnel and growers in New Jersey imply that ALM's presence in the state is at least 3–4 yr old. Given the distribution of southern counties in Pennsylvania (York, Lancaster, Chester, Delaware), it is likely ALM is also present in at least Maryland and Delaware.

Trapping for ALM using traditional collection methods has had limited success for PDA. At one site, for example, using yellow or blue sticky cards produced low counts (1–5 every 2 wk), while hand collection and netting in the same fields produced greater number of adults (30+ individuals per collection event) (Fig. 1). Successful

Fig. 1. A field of *Allium* sp. with sticky cards used for detection. The field has four colors of sticky cards (red, black, blue, and yellow).

collection and detection of ALM directly from foliage can be facilitated by targeting collection times to cooler weather or early in the morning (T.E.E., S.E.S., personal communication).

Host Range

The agricultural impacts of *P. gymnostoma* threatens the production of *Allium* crops (Liliaceae), particularly *A. cepa* (onion), *A. gygantheum*, *A. porrum* (leek), *A. sativum* (garlic), *A. schoenoprasum* (chive), and ornamental *Allium spp.* (Coman and Rosca 2011a,c; Mesic et al. 2009). Other members of the *Allium* group are also at risk including wild Alliums, which can act as refuges outside of managed systems (Table 1), and one species (*A. munzii*) in California is endangered. Feeding damage on wild *A. vinaela* (wild garlic) and *A. tuberosum* (garlic chives) has already been documented in Pennsylvania. Within the first year of recognizing the presence of ALM, feeding damage has been documented on 9 of 13 allium species reported in Pennsylvania (Biota of North America Program, www.bonap.org).

Table 1. All *Allium* species in Pennsylvania, New Jersey, and New York with denotation of feeding injury by ALM

Allium species	Common name	Damage documented
Allium cepa	Onion	Yes
Allium gygantheum	Giant Onion	Yes
Allium porrum	Leek	Yes
Allium sativum	Garlic	Yes
Allium schoenoparasum	chive	Yes
Allium vineale	Wild garlic	Yes
Allium tuberosum	Garlic chives	Yes
Allium canadense	Wild Onion	Yes
Allium cernuum	Nodding Onion	Yes
Allium oleraceum	Field garlic	
Allium tricoccum	Ramps	
Allium sphaerocephalon	Round-headed leek	
Allium paniculatum	Mediterranean Onion	

Species presence based on Biota of North America Program (www.bonap.org).

Biology and Phenology

ALM has two generations per year, with adults present in the spring and again in the fall (Collins and Lole 2005, Coman and Rosca 2011b). The first generation adults emerge in the spring from overwintered pupae in the plant or nearby soil, with emergence in Pennsylvania in mid to late April based on 2016 and 2017 collections. Adults will feed on inflicted wounds on *Allium*, typically planted onions and wild alliums, overwintered garlic, and leeks, leaving characteristic damage (caused by the female flies) of lightened puncture wounds in a distinctive linear pattern, described in more detail in the damage section. We have also recorded characteristic puncture wounds in onion transplants (Fig. 2). Eggs are laid on or in the plant, after which hatching larvae will feed in the tissue, later migrating towards the base of the plants to pupate, either in the bulb, between leaves, or in the adjacent soil.

The spring generation pupa aestivates before emerging as second generation adults in late September and persisting into early November based on trapping data in Pennsylvania in 2016. The second generation will overwinter within the host plants or in adjacent soil as pupa. In farmscapes with a succession of various allium species, we have observed feeding to be concentrated on species in their vegetative growth stages.

Adult phenology from recorded populations in Austria appear similar to those we have recorded to date in Pennsylvania. Kahrer 1999 monitored ALM adult emergence in Fuschsenbigl, Austria and saw adult populations on 16 April, peaking on 28 April, and lasting 26 d. Fall populations emerged on 10 September, peaked on the 16th, and lasted 3–6 wk. A comparison of climatic and photoperiod data of Fuschsenbigl, Austria and Topton, PA, a town located in an area confirmed for ALM, show similar phenology (Fig. 3). Fuschsenbigl and Topton share similar elevations (550 ft vs 479 ft, 167.6 M vs 146 M), hardiness zones (7a–7b vs 8a), and average temperatures (49.1 F vs 50.4 F, 9.5 C vs 10.2 C). The Romanian populations have an earlier spring phenology, while the fall population is active for about the same period and length (Coman and Rosca 2011b).

Description

P. gymnostoma Loew 1858 is in the order Diptera, family Agromyzidae, and subfamily Phytomyzinae. *Phytomyza* Fallén contains over 530 described species (Zlobin 1994) and can be separated from other Agromyzidae by the combination of the following characters: (i) fronto-orbital setae proclinate, (ii) costa extending only to the vein R_{4+5}, and (iii) cross vein dm-cu usually absent (Winkler et al. 2009). *P. gymnostoma* was moved into the genus *Napomyza* (Spencer 1976) and later moved back into *Phytomyza* (Zlobin 1994, Collins and Lole 2005). Much of the work after Zlobin's revision did not recognize this taxonomic change and were published under *Napomyza gymnostoma*.

Fig. 2. Onion transplant with ALM feeding damage.

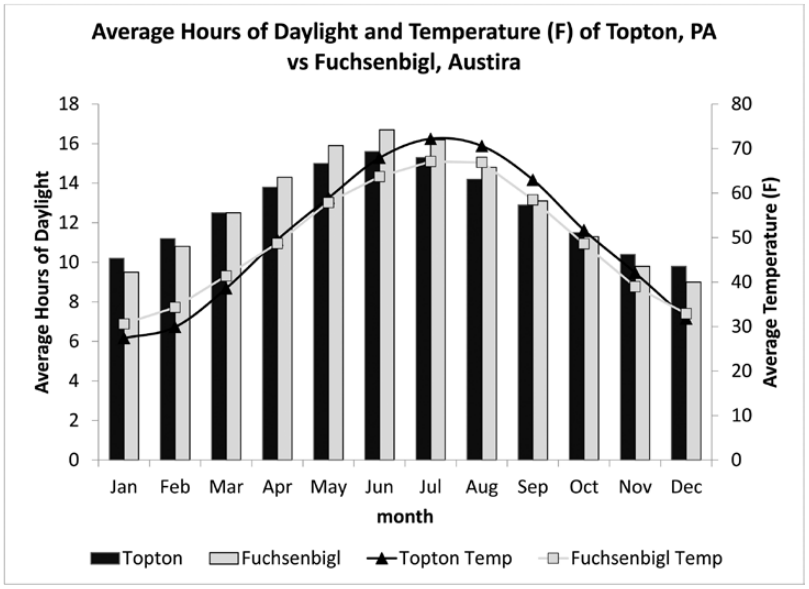

Fig. 3. Comparison of climatic and daylight conditions between Fuchsenbigl, Austria, and Topton, PA, USA.

Fig. 4. Ventral, lateral, and dorsal view of ALM adults. ALM has a set of features that distinguish it from other onion pests and similar *Phytomyza*. Characters of diagnostic value include the gena with yellowish-orange marking, front coxae all black, and femora tipped in yellowish-orange.

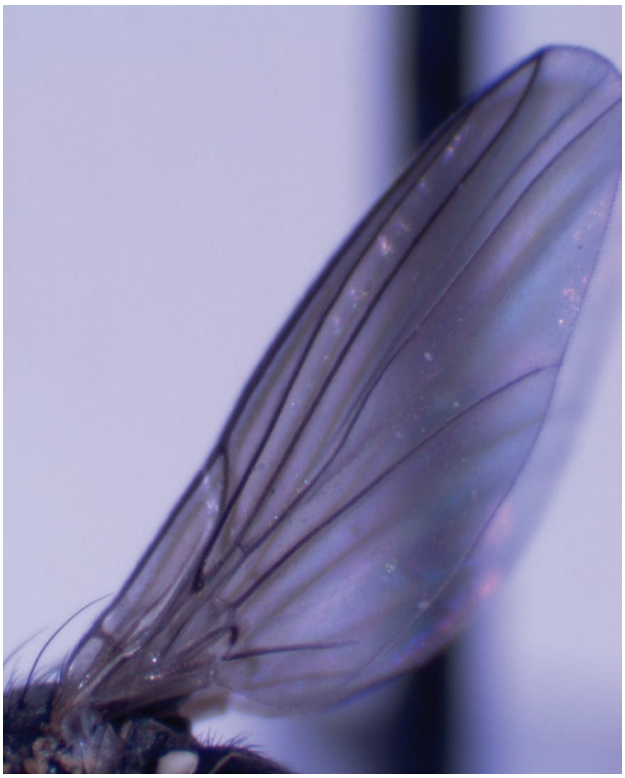

Fig. 5. Wing of *P. gymnostoma* showing the elongated rectangular basal cell.

Adults

ALM is 2.5–3.5 mm long, with a dark, matte colored body (Fig. 4). The head has extensive yellow markings on the frons, down onto the clypeus and wrapping around on the gena. A stripe of lighter yellow continues along the posterior margin of the compound eye, narrowing dorsally. On the thorax, a yellow stripe runs along the notopeural suture. The legs are black with the femurs tipped in yellow to orange color distally. The wings are clear with the basal cell narrow and rectangular (Fig. 5).

Pupa

Pupa are 3.2–3.7 mm long, ovate to barrel shaped with a ferruginous color. The spiracles are projected slightly on short stalks.

Larvae

Larvae are white to yellowish maggots, headless, up to 8 mm long at final instar. The spiracles are borne on elongate lobes, with lobes containing multiple small oval openings. These openings are distributed irregularly along the C-shaped lobe (Figs. 6 and 7).

Eggs

Eggs are white, 0.5 mm long, and slightly curved.

Similar Flies or Flies That also Infest Alliums

Phytomyza plantaginis

Phytomyza plantaginis (Robineau-Desvoidy) (Diptera: Agromyzidae) is similar in appearance to ALM. This fly often overlaps ALM

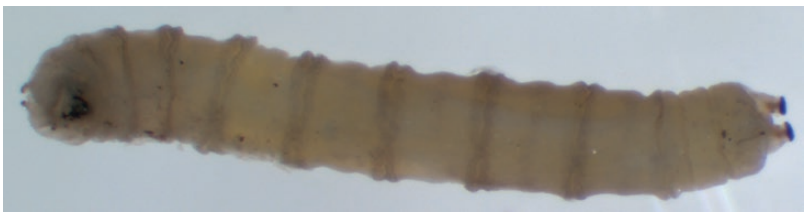

Fig. 6. Larva of ALM showing spiracles on elevated platform.

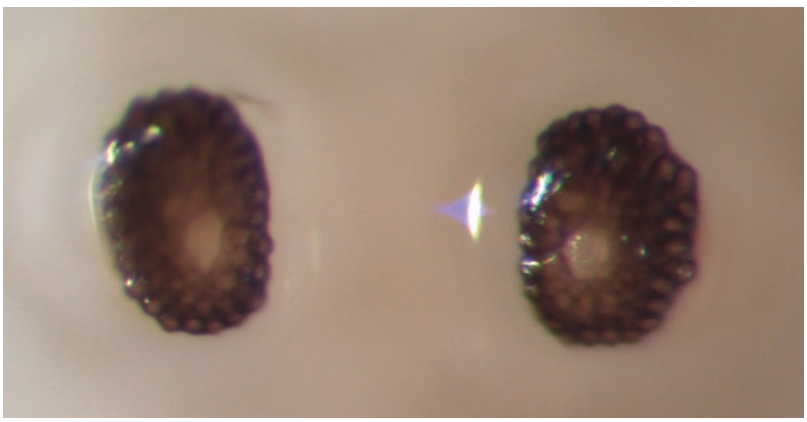

Fig. 7. Ventral view of spiracles showing C-shaped arrangement of spiracular openings.

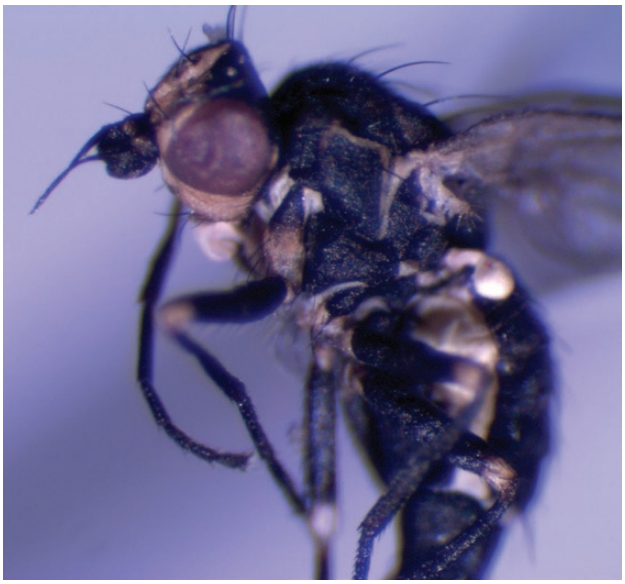

Fig. 8. Photo of *P. plataginis,* a similar looking agromyzid to ALM. The bicolor procoxae and narrow notopleural stripe can be used to distinguish this species in addition to its smaller size.

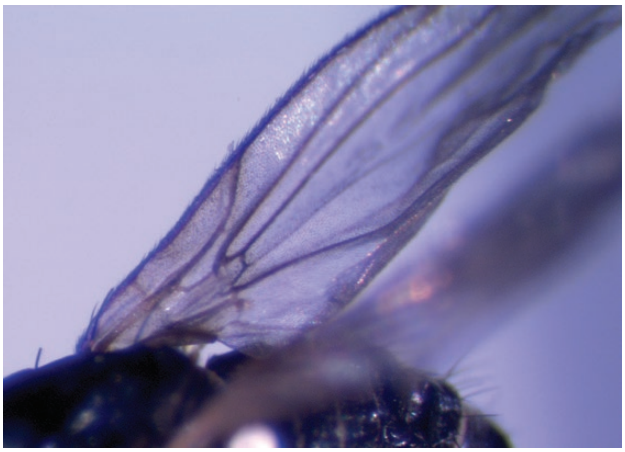

Fig. 9. Wing of *P. plataginis* showing the smaller, pentagonal basal cell.

distribution as its host *Plantago* spp. (Plantaginaceae) is common in areas where wild alliums are present. *P. plantaginis* adults are smaller (1.8–2.2 vs 3–3.5 mm), the fore coxa is bicolored with the distal portion yellow to orange and the basal portion black, and the basal cell is smaller and roughly pentagonal (Figs. 8 and 9).

Onion Maggot

Adult Onion maggot flies, *Delia antiqua* Meigen (Diptera: Anthomyiidae) can be distinguished as adults by the all black appearance of the body, head, and legs (Figs. 10 and 11). Larva can be distinguished by spiracles not on elevated stalks with three circular oval spiracular openings.

Tritoxa flexa

Known as the black onion fly in some literature, *Tritoxa flexa* (Wiedemann) (Diptera: Ulidiidae) can be distinguished as adults by the all black body, legs, and head. Furthermore, black onion fly wings are mostly black with three white stripes diagonally on the wings (Fig. 12). Larva can be distinguished by spiracles not on elevated stalks with three circular oval spiracular openings.

Fig. 10. Dorsal view of *D. antiqua* (Onion Maggot Fly).

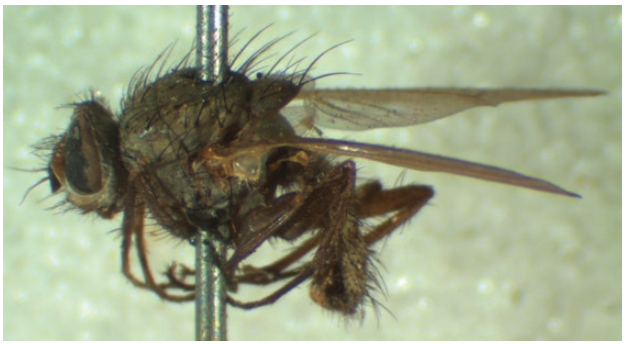

Fig. 11. Lateral view of *D. antiqua* (Onion Maggot Fly).

Damage

Feeding damage by adults is a result of punctures by females with their ovipositor on leaves for feeding on the exudates and oviposition (Fig. 13. Males have also been observed feeding on these exudates, but do not pierce the leaves (Coman and Rosca 2011b) (Figs. 14–17). More damaging are the losses from larval feeding and mining, which causes softened tissue in the plant, increasing risk of fungal and bacterial infections, as well as decreasing marketability (Agallou et al 2004, Coman and Rosca 2011a). In some crops, we have observed that leaves become highly distorted, exhibiting a curled and wavy pattern. Densities of up to 20 pupae per leek stem have been recorded in Europe (Spasic and Mihajlovic 1997), and leeks in Pennsylvania have been observed with multiple pupae per bulb.

Fig. 12. Dorsal view of *T. flexa* (Black Onion Fly).

Fig. 14. Allium damaged by ALM, showing signs of stunted growth and wilting.

Fig. 13. ALM female oviposition activity on Simply Sweet onion variety.

Fig. 15. Allium leaf with oviposition scars and tunneling damage by larvae.

Storage of alliums crops, typically done with onions, is also impacted by ALM feeding. Onions affected by ALM have a lower successful storage rate, causing the crop to rot from the inside (personal communication). Seemingly intact onions can have internal damage not visible on inspection, delaying assessment of ALM damage to growers. Ornamental alliums have also seen significant damage, with such high value varieties as Allium Globemaster (*Allium giganteum* Regel [Asparagales: Amaryllidaceae]) having substantial foliage damage in the spring (L.E.B., personal communication).

The risk to production in the United States could have significant impact on $1 billion worth of onions and $279 million worth of garlic production (NASS 2016). *P. gymnostoma* has been considered one of the most impactful pests of Allium production in Europe (Đuric´ and Hrnčic´ 2014), but the damage concerns may be strongly influenced by the degree of synchrony between insect, crop, and other *Allium* host plants.

Natural Enemies

Multiple parasitoids have been identified for ALM in Europe. Spasic and Mihajlovic (1997) reported 23% parasitism of *P. gymnostoma* by *Halticoptera circulus* (Walker) (Hymenoptera: Pteromalidae). A further seven hymenopteran parasitoids from four genera were

Fig. 16. Allium bulb with ALM larva feeding on tissue below surface. The larva's position was below the soil level.

Fig. 17. ALM pupa (red ovals) overwintering in leeks.

identified by Sionek and Weich (2004). These five genera have representatives in North America already, raising the possibility that some form of biocontrol may already be present. To date, however, no records of parasitism have been recorded.

Management

The threat of ALM has been most problematic for farmscapes and cropping systems that provide a relatively continuous supply of *Allium* hosts. The literature from Europe suggests organic production and market garden production systems tend to be most at risk, perhaps due to synchrony of adult flight activity with a continuous host supply, and/or to lack of insecticidal controls used in conventional production systems. ALM is also able to take advantage of host refuges outside of managed systems, which may allow them to avoid certain control strategies such as tilling and spraying.

Previously developed and in place commercial spray control methods have been successful in limiting ALM effects in some systems (Talotti et al. 2004). Delayed planting of spring crops till after first generation adult flight can minimize the chance of infestation (Agallou et al. 2004, Sionek 1999). Crop rotation and netting can also be useful techniques to limit infestation in organic systems (Agallou et al. 2004, MacLeod 2007). This may have limited effect based on surrounding levels of infestation and areas with wild allium.

Backyards and homeowner growers are limited in their options for dealing with ALM. As most pesticides that are able to reach ALM in the plant are of restricted use, these are not a viable option. Delayed plantings till after adult flight and covering crops in barriers or netting during the adult flight period are currently the suggested options given to growers. Also, creating a host-free period may be a viable option if wild alliums are not in the landscape.

Summary

In summary, *P. gymnostoma*, or the ALM, is an important pest in several European countries, and is now confirmed in three states with prospects to significantly impact both agricultural production and ornamental plantings of *Allium*. Native alliums, also at risk, can provide a refuge outside of managed systems. Their close association with their host, overwintering habits, and damage to commercial and ornamental crops will make future detections likely as ALM expands its geographic range in North America. We provide this information in hopes of slowing this geographic expansion.

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