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Gall induction by *Pegomya curticornis* (Stein) (Diptera: Anthomyiidae) within the roots of spurges *Euphorbia virgata* Walkdst. and Kit. *E. esula* L. (Euphorbiaceae)

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Abstract:

The anthomyiid fly *Pegomya curticornis* (Stein), introduced into Alberta from Europe for the biocontrol of leafy spurge (*Euphorbia esula* L.), normally induces simple galls on subterranean stems. Here we describe the anatomy of galls collected in Europe that had been induced by *P. curticornis* on horizontal roots of spurges. Four mature galls were found on the roots of *E. virgata* Waldst. and Kit. and 10 on the roots of *E. esula*. Tissues of the root galls were composed of gall parenchyma that had proliferated from feeding sites near the outside edge of secondary xylem. It is assumed that some larvae inadvertently tunnel beyond the base of stems into the roots and that similar galls will form on Alberta spurges.

Introduction

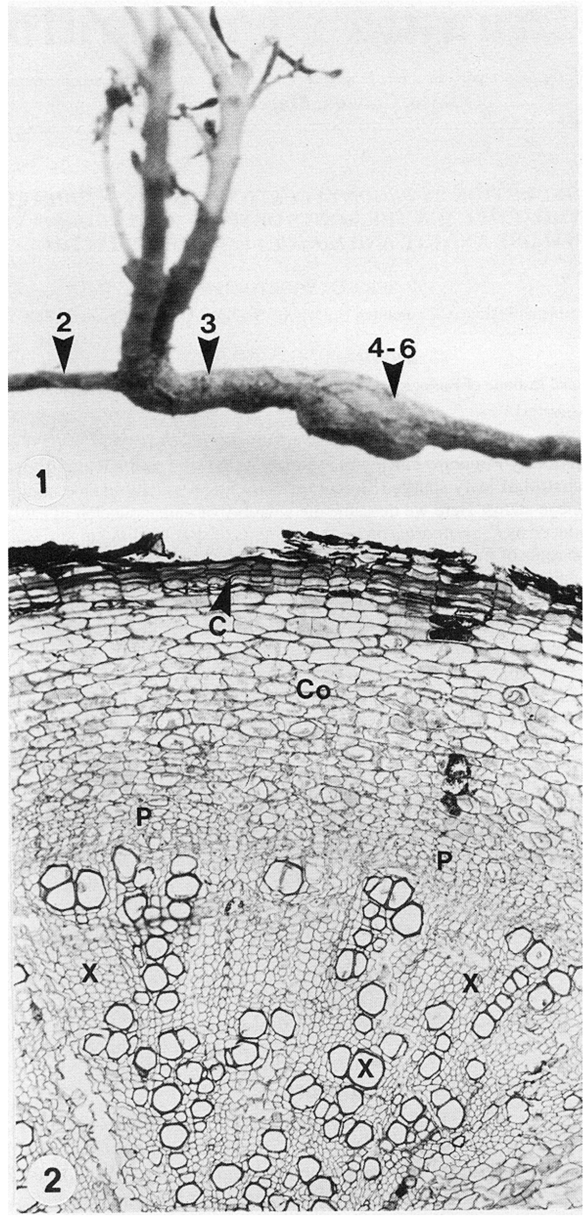
In previous studies (Gassmann and Shorthouse 1990, 1992), we reported on how two species of anthomyiid flies [*Pegomya curticornis* (Stein) and *P. euphorbiae* (Kieffer)] induce simple galls on the subterranean stems of several species of spurge *Euphorbia* (Euphorbiaceae) in Europe. As little is known about the few gall-inducing anthomyiids in the world (Meyer 1987), any information on their biology is of interest. Furthermore, *P. curticornis* recently has been introduced into Alberta for the biological control of leafy spurge (*Euphorbia esula* L.) and, as with all biocontrol programs, additional information on activities of the agents is of value. Here we report on the structural modifications to the roots caused by larvae of *P. curticornis* that had induced galls in horizontal roots instead of subterranean stems.

Materials and methods

In the process of collecting over 500 mature galls on the subterranean shoots of various spurges in Hungary, the second author found four mature galls on the roots of *E. virgata* Waldst. and Kit. More recently, 10 additional root galls were found on *E. esula* [for the taxonomy of *E. esula* group see Crompton et al. (1990) and references therein]. Galls were removed from their hosts in early June; the four from *E. virgata* and two from *E. esula* were fixed in Formalin - acetic acid - alcohol (FAA) and sent to the first author for processing. Tissues were dehydrated in a tertiary-butyl alcohol series, embedded in paraffin, sectioned at 8 µm with a rotary microtome, and stained with safranin-fast green (Jensen 1962). Sections from unattacked roots were also made from healthy plants and from near the root galls. Flies from the remaining galls from *E. esula* were reared to adults.

Results and Discussion

All galls contained a mature larva or pupa. Each gall was approximately 1.5 cm long and 0.8 cm wide (Fig. 1) and found on mature roots exhibiting secondary growth (Fig. 2). The anatomy of roots and four galls from *E. virgata* was identical with that of the two galls and roots of *E. esula*; however, all figures discussed here are from *E. virgata*. In contrast to stems of spurge [which consist of pith, radial files of secondary xylem elements surrounded by secondary phloem, and a cortical parenchyma (Gassmann and Shorthouse 1990)], ma-



Figs. 1, 2. 1. Habitus of *Pegomya curticornis* on a horizontal root of *Euphorbiae virgata*; X1.5 Arrows indicate the approximate areas from which sections in Figures 2-6 were taken. 2. Cross section of an undamaged horizontal root; X78, C, cork; Co, cortex; P, phloem; X, secondary xylem.

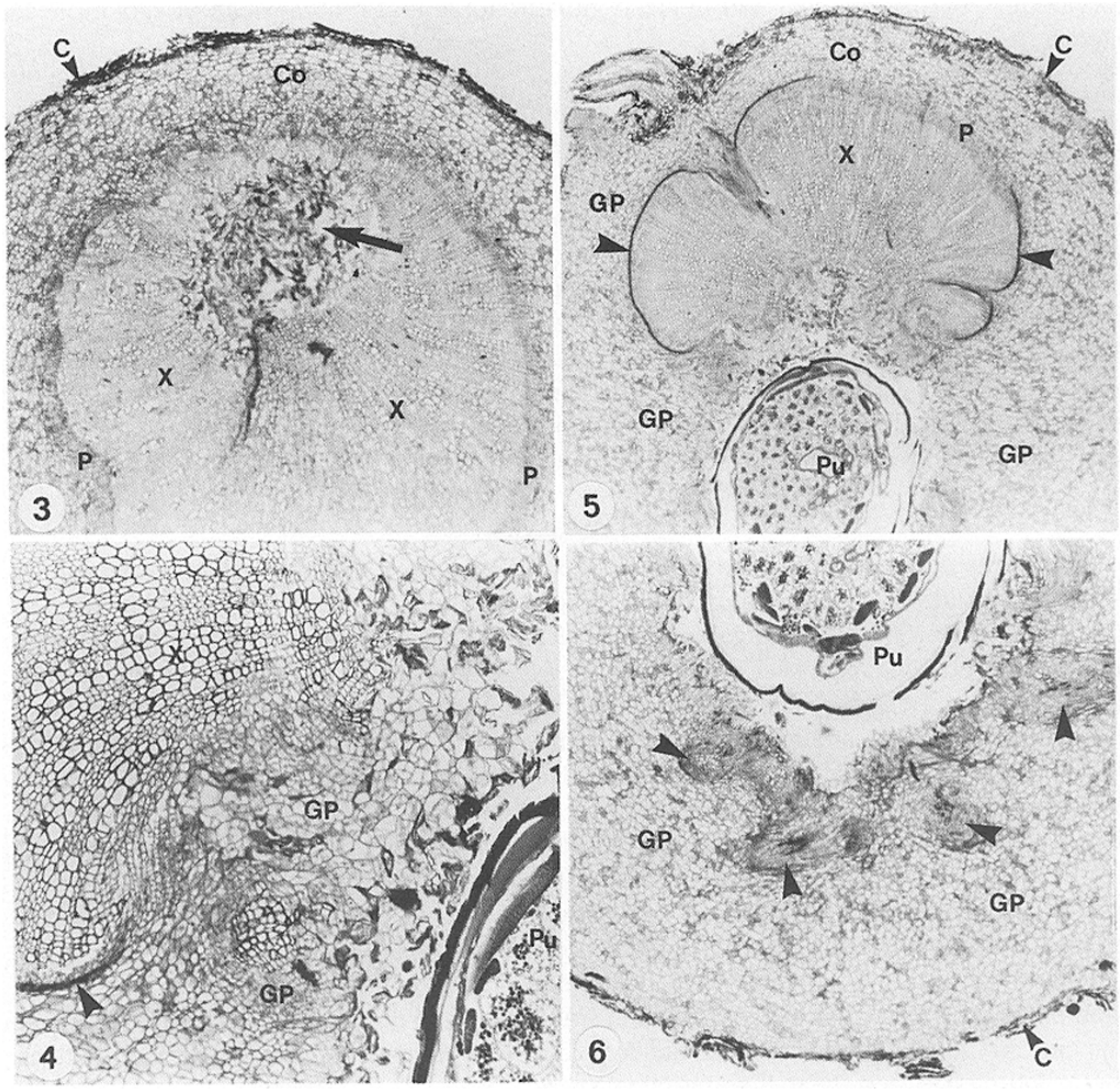
ture roots have a central core composed of secondary xylem arranged in radiating rows, which collectively occupy about two-thirds of the diameter (Raju 1985). There is no pith and the xylem is surrounded by cambium, phloem, and mechanical tissue, which also forms radiating strips. The cortex consists of a few layers of irregular, mostly oval cells. Laticiferous cells occur scattered throughout the cortex (Bakshi and Coupland 1959). In place of the epidermis of stems, the outside margin of roots consists of a thick sheath of cork cells.

In all six samples, the larvae had tunnelled (Fig. 3) through the secondary xylem (compared with the pith in the stem) and in some areas had damaged the cambium, phloem, and cortex. Callus proliferated from the damaged areas and was responsible for the irregular root swelling between the gall and vertical stem.

Sections through the pupal chamber of mature galls (Fig. 4) showed that masses of gall parenchyma proliferated from the area where the larvae had chewed through the cambium into the cortex. Gall parenchyma had apparently formed as the larvae were feeding, as thick layers completely surrounded the feeding site (Fig. 5), leaving the once central core of secondary xylem to one side. New vascular bundles were formed within the gall parenchyma peripheral to the circular mass of secondary xylem (Fig. 6).

Galls induced by *P. curticornis* on roots of spurge are similar to those induced on stems. Both are simple galls consisting of callus around sites of tunnelling and gall parenchyma around feeding sites, and are without nutritive and mechanical tissues common in the galls of most other insects (Rohfritsch 1992). Although gall insects are highly organ specific and instances of species inducing galls on the wrong organ are rare (Shorthouse and Lalonde 1986), galls of *P. curticornis* on roots are apparently another such anomaly. It appears that *P. curticornis* has the ability to manipulate growth of both stems and roots. It is possible that the larvae tunnelled beyond the base of the subterranean shoots into the roots because the shoots on which eggs were laid were too immature to allow larval development.

When stems of spurge are galled by *P. curticornis*, further stem growth and flowering is curtailed (Gassmann and Shorthouse 1990). In root galls, it is not known how much shoot growth is affected; however, tunnelling through secondary xylem and induction of calluslike gall parenchyma is bound to cause some drain on the host plant. Thus, even if some *P. curticornis* feeding on Canadian spurge induce root instead of stem galls, they will still be responsible for host damage.



Figs. 3-6

Sections through larval tunnel and mature galls inhabited by pupae of *Pegomya curticornis*. 3. Section of horizontal root between vertical stem and gall showing tunnel (arrow) made by boring larva; X24. 4. Section through mature gall showing proliferation of gall parenchyma along the edge of secondary xylem damaged by feeding larva. Note the layer of dark staining, crushed cells between the secondary xylem and gall parenchyma (arrow); X60. 5 Section through mature gall showing proliferation of gall parenchyma peripheral to the circular zone of secondary xylem. Note the layer of dark staining, crushed cells between secondary xylem and gall parenchyma (arrows); X16. 6. section through mature gall showing masses of gall parenchyma peripheral to the core of secondary xylem. Note the presence of vascular bundles (arrows) in the gall parenchyma; X24. C, cork; Co, corex; GP, gall parenchyma; P, phloem; Pu, pupa; X, xylem.

Acknowledgments

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