

SHORT COMMUNICATION

Discovery of a Gall-Forming Midge, *Asphondylia pilosa* Kieffer (Diptera: Cecidomyiidae), on Scotch Broom (*Cytisus scoparius* (L.) Link) (Fabaceae)

GEORGE P. MARKIN AND CAROL J. HORNING

USDA Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory,
1648 S. 7th, MSU, Bozeman, Montana 59717-2780
e-mail: gmarkin@fs.fed.us

Scotch broom (*Cytisus scoparius*: (L.) Link), a native European perennial shrub, was introduced to the U.S. before the turn of the century as an ornamental for its bright yellow, pea-like flower. The plant found the western U.S. maritime zone to be an ideal habitat, thus it soon escaped from cultivation, and became an invasive weed now widely distributed from northern California to British Columbia. The massive monocultures that Scotch broom forms replace desirable species and cause allergy problems when flowering in spring. This has elevated it to one of the most important weeds in the northwest coast of the U.S.A. (Parker *et al.*, 1994; Radtke and Davis, 2000).

In an effort to control this weed, the USDA Agricultural Research Service (ARS) in Albany, California targeted this plant in the 1960's for biological control and subsequently introduced and released two biocontrol agents, a seed-feeding weevil, *Apion fuscirostre* Fabricius (Coleoptera: Apionidae), and a small stem-mining moth, *Leucoptera spartifoliella* Hubner (Lepidoptera: Lyonetidae) (Andres and Coombs, 1995; Goeden, 1978; Julien, 1992). Both readily established, but it was discovered soon after the introduction of *L. spartifoliella* that it had been previously accidentally introduced and was already established in the northern part of the range of this weed (Frick, 1964).

Neither of these agents provided effective control of Scotch broom. Therefore, in the mid-1990's, U.S. Forest Service and the Oregon Department of Agriculture joined an on-going program with New Zealand (Landcare Research, Lincoln) and Australia (CSIRO, Canberra); two countries in which Scotch broom is also a major weed (Syrett *et al.*, 1999). Between 1996 and 2000, a major effort of this program was to support research at CABI Bioscience at Silwood Park, England to conduct surveys of the natural enemies of Scotch broom and identify and study those that had potential as biocontrol agents.

To prevent a repeat of the earlier program in which the agent, *L. spartifoliella*, had been selected, tested, and introduced only to find out afterwards it was already present, the new program included a survey to determine if any other European natural enemies were already present and attacking Scotch broom on the North American West Coast. A technician (C. J. Horning) was stationed at Florence, Oregon at the headquarters of the U.S. Forest Service's Mapleton Ranger District to conduct this survey. The first discovery occurred when the gall mite, *Aceria genistae* (Nalepa) (Acarina: Eriophyidae), one of the agents being evaluated in Europe, was discovered by acarologists in California after they had become aware of the new program (Chan and Turner, 1998).

The second agent, which we discovered already established on the West Coast, was the small gall-forming midge, *Asphondylia pilosa* Kieffer which was very closely related to a second species, *A. sarothamni* Loew, which was being tested in Europe as a potential biocontrol agent. The remainder of this paper reviews what we have learned of the biology, distribution, and taxonomy of this insect.

Description of the Gall

Phenology studies of Scotch broom at Florence, Oregon indicated that reproductive buds formed the previous summer begin swelling in early April. They begin flowering in early May and continue through mid-June, with fully formed pods present by mid-July. Dehiscing of pods occurs in August and early September. *A. pilosa* galls first become obvious as a deformity in the swelling reproductive bud in early May. By mid-May at peak flowering, the galls are still small and developing and do not reach full size until late May or early June. At maturity, the gall is approximately 1 cm long with the basal half an oval-shaped chamber 4 to 5 mm long and 2 to 3 mm in diameter (Fig. 1a). The chamber is topped by a slender,

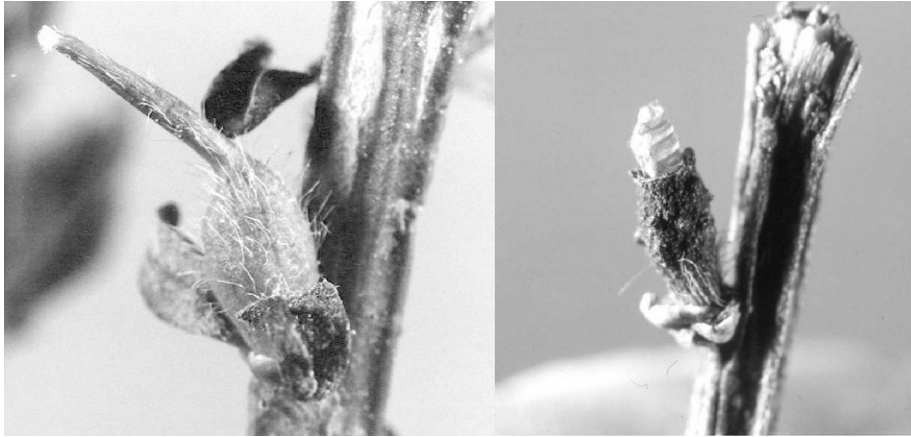


Fig. 1. Galls of *Asphondylia pilosa*. **Left.** Fully formed new gall in June. Light green in color, length 10 mm. **Right.** Open gall in September with empty pupal case, length 5 mm.

tapering, slightly curved tail that projects upward another 4 to 5 mm. The surface of the gall is smooth, light green in color, and covered by scattered, slender, white hairs or filaments. The base of the gall is enclosed by several small bracts. The small size, bright green color, and screening by surrounding foliage make finding the gall at this stage difficult without some searching experience.

A suture is apparently present on the inside of the upper edge of the larval chamber just below the base of the tail. The gall opens at this suture, and the top cap with the tail falls off, exposing the pupae and allowing the adult to escape (Fig. 1b). Unsuccessful galls or parasitized galls retain their original shape, with the tail remaining in place. As the empty gall dries, it becomes dark brown with a knobby, irregular surface. Galls are strongly attached to the plant. They can easily be found in mid-September but soon begin to deteriorate, and by mid-winter often all that is left is the very base surrounded by its ring of bracts.

Biology of the Midge

Life cycle observations are mostly based on field collections of 10 branches containing galls, carried out monthly from May to September (1999, 2000) at three locations near Florence, Oregon. Branches were shipped to the USDA Forest Service laboratory in Bozeman, Montana, where galls were dissected to determine status of development of larvae, and any associated parasitoids. Larvae were found in galls from late April through May, and the first pupae in early June. Emergence began in early July and extended through early August. Adult emergence occurred after Scotch broom seed pods were fully formed and beginning to harden. Final adult emergence occurred when most pods were hard and beginning to dehisce, an important characteristic for identifying this insect (see below). By August, the current year's flush of foliage was completed and rudimentary new buds that would open the following year had formed. It has been suggested by Waloff (1968) that emerging midge adults mate before locating these developing reproductive buds, in which they oviposit. Accordingly, eggs would be the overwintering stage. According to this scenario, this insect has one generation a year in the Pacific Northwest which is tightly synchronized to the phenology of Scotch broom.

Distribution

Distribution was determined by stopping at large mature stands of Scotch broom opportunistically encountered while working in western Oregon and to a limited extent in southwestern Washington. The method of survey was to visually search ten plants for five minutes, counting all galls found and usually collecting them for later examination in the laboratory. By a rough estimate, galls, even when most abundant, would be found on only 1 out of 10 to 20 of the branches examined. However, when one gall was found, often several more would be located on branches in the vicinity. Galls were found as far south on the Oregon Coast as Bandon (Coos County) and as far north as Aberdeen, Washington, the northern extent of this survey. Galls were found widely distributed in the Willamette Valley. In the Coast Range and

western foothills of the Cascades, galls were found up to 300 m in elevation, and along the Columbia River, inland as far as Hood River, Oregon. Of the over 56 broom sites examined, galls were found at 45 of them and only seemed to be missing at elevations above 300 m in the Coast Range and the Cascades. This survey did not include most of the Washington Coast or the southern range of broom in Oregon and California.

Taxonomic Identification

Obtaining a positive identification of the larvae proved difficult. In 1998 specimens were initially sent to the USDA-ARS Systematics Laboratory in Beltsville, Maryland, which at the time did not have an expert on Cecidomyiidae, so they forwarded the samples to Raymond J. Gagné, their retired taxonomist, who tentatively identified the specimens as *Asphondylia sarothamni* Loew. The biology of the Oregon midge, however, differed from published descriptions of the biology of *A. sarothamni*, which had been documented in the literature as having two generations a year (Parnell, 1964; Waloff, 1968). In Europe the first generation of *A. sarothamni* develop in bud galls and emerge in May. The adults oviposit in the developing broom pods, and the second generation adults emerge in June or July and oviposit in the newly formed, rudimentary buds in which the eggs overwinter. To determine if we were overlooking a second generation of the Oregon *Asphondylia* in the pod, in 1999 we examined 1,002 pods and then another 1,651 pods in 2000 from around Florence, Oregon. In neither year did we find any broom pod deformities that matched the description of *A. sarothamni* in the literature (Parnell, 1964; Waloff, 1968). We therefore concluded that our insect had only a single generation a year and was therefore probably not *A. sarothamni*.

We finally sent samples to the British Natural History Museum. According to Paul Hillyard, Manager of Insect Information Services (pers. comm. 2001) our specimens were examined by Dr. Keith Harris, who disagreed with the USDA Systematics Laboratory and identified them as *A. pilosa* (Harris, 2002). This identification was supported by the published biology in literature wherein *A. pilosa* is described as having a single generation a year (Waloff, 1968), which agrees with our observation of the biology of the Oregon midges.

Parasitism

While galls were never very abundant, a high percentage (32%, $N = 315$) were parasitized. By August and September, galls that had not opened usually had a distinct, circular hole cut in the side which indicated that a parasitoid had emerged. Galls collected in July and reared in the laboratory produced a small, metallic green wasp, which Dr. Eric Grissell of the USDA Systematics Lab in Beltsville identified as *Pseudocatolaccus guizoti* Girault, (Hymenopterous: Pteromalidae) which he stated is very similar to or the same as *P. nitescens* Walker which is reported to attack *A. sarothamni* on Scotch broom in Europe.

Discussion

The discovery of *A. pilosa* attacking Scotch broom in North America eliminated our interest in further studies in Europe of the closely related *A. sarothamni* as a biocontrol agent. The fact that a very closely related insect that attacks the same plant structure is already present in western North America, but is being suppressed by a parasitoid or other biotic factors would indicate that if a new but closely related species was introduced, it probably would also be suppressed by the same biotic factors or parasitoids. Our interest in supporting research and testing of this insect in Europe has therefore been terminated, although the work was continued by CABI since it is hoped that this insect could also be used in the future in either New Zealand or Australia.

Acknowledgements

We thank the taxonomists who advised us, in particular Eric Grissell at USDA Systematics Entomology Laboratory; Raymond J. Gagné, retired from USDASEL; and Paul Hillyard, Manager, Insect Information Services, Natural History Museum, London. We also thank Quentin Paynter, for providing much unpublished information and for reviewing this manuscript. In particular, we wish to thank Keith Harris for reviewing the numerous series of specimens we sent him and providing us information on the two related species in Europe. We wish to thank the staff of the Mapleton Ranger District, Siuslaw National Forest, Florence, Oregon, particularly Dan Karnes, for the use of space and facilities from which this broom study was conducted, and their support and interest in our overall broom program. For review of this manuscript and their very helpful comments, we wish to thank Simon Fowler, Landcare Research,

New Zealand; CSIRO, Entomology Winnellie Northern Territory, Australia, and Rudiger Wittenberg, CABI Bioscience, Silwood Park, Ascot, Berkshire, United Kingdom and John Hosking, Agricultural Research Centre, Tamworth, New South Wales, Australia.

Literature Cited

- Andres, L. A., and E. M. Coombs. 1995. Scotch broom. In J. R. Nechols, L. A. Andrew, J. W. Beardsly, R. D. Goeden, and C. G. Jackson (eds.). *Biological Control in the Western United States: Accomplishments and Benefits of Regional Research Project W-84*, pp. 303–305. USA: University of California, Division of Agriculture and Natural Resources Publication No. 3361. Berkeley, CA. 356 pp.
- Chan, K. L., and C. E. Turner. 1998. Discovery of the gall mite *Aceria genistae* (Nalepa) (Acarina: Eriophyidae) on gorse and French broom in the United States. *Pan-Pacific Entomologist* 74:55–57.
- Frick, K. R. 1964. *Leucoptera spartifoliella*, an introduced enemy of Scotch broom in the western United States. *Journal of Economic Entomology* 57:589–591.
- Goeden, R. P. (ed.). 1978. Leguminosae. Scotch broom (*Cytisus scoparius* (Linnaeus) Link). In *Introduced Parasites and Predators of Arthropod Pests and Weeds: a world review*, pp. 393–395. USDA Agriculture Handbook No. 480. 545 pp.
- Julien, M. H. 1992. Biological control of weeds. *A World Catalogue of Agents and Their Target Weeds*, 3rd edition. CAB International, Wallingford, UK. 186 pp.
- Harris, K. M. 2002. The gall midge *Asphondylia pilosa* Kieffer (Diptera Cecidomyiidae) on *Cytisus scoparius* (L.) link in Europe and North America. *Cecidology* 17:94–98.
- Parker, B., G. Miller, and L. C. Burrill. 1994. Scotch broom, *Cytisus scoparius* (L.) Link. *Pacific Northwest Weeds Bulletin* No. 103, 4 pp. Revised July 1994. Oregon State University Cooperative Extension Service, Corvallis, OR.
- Parnell, J. R. 1964. Investigations on the biology and larval morphology of the insects associated with the galls of *Asphondylia sarothamni* H. Loew (Diptera: Cecidomyiidae) on broom (*Sarothamnus scoparius* L. (Wimmer). *Ecological Entomology* 116(11):255–273.
- Radtke, H., and S. Davis. 2000. Economic Analysis of Containment Programs, Damage, and Production Losses from Noxious Weeds in Oregon. Technical report prepared for Oregon Department of Agriculture, Salem. 64 pp.
- Syrett, P., S. V. Fowler, E. M. Coombs, J. R. Hosking, G. P. Markin, Q. E. Paynter, and A. W. Sheppard. 1999. The potential for biological control of Scotch broom (*Cytisus scoparius*) (Fabaceae) and related weedy species. *Biocontrol News and Information* 20(1):17–34.
- Waloff, N. 1968. Studies of the insect fauna of Scotch broom *Sarothamnus scoparius* (L.) Wimmer. *Advances in Ecological Research* 5:87–208.