LIFE-CYCLE OF A SPIRAL GALL APHID, *PEMPHIGUS SPIROTHECAE* (HOMOPTERA: APHIDIDAE), ON POPLAR IN BRITISH COLUMBIA[1]

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ABSTRACT

Pemphigus spirothecae Pass. was inadvertently introduced into North America only recently. Upon hatching in spring on lombardy poplar, the fundatrix feeds on a leaf petiole, which bends and then spirals into a spiral gall. The fundatrix produces about 100 fundatrigeniae within the gall. These produce winged sexuparae which leave the gall and settle on the poplar bark, where they produce up to eight progeny, males and females. Each female lays a single large egg which overwinters on the bark. This aphid is thus monoecious and holocyclic.

INTRODUCTION

The gall aphid, *Pemphigus spirothecae* Pass., was studied on lombardy poplar, *Populus nigra* L. var. *italica*, on the campus of the University of British Columbia during 1973 and 1974. This aphid produces unique spiral galls (Fig. 1) on the petioles of the leaves. *P. spirothecae* is apparently common in Europe but was found only recently in North America in Quebec (Alleyne & Morrison 1974) and at about the same time in British Columbia. Its life-cycle in Europe has been described by Tóth (1939). The present stydy was undertaken to determine the life-cycle of the aphid in British Columbia and to describe the aphid-host plant interaction.

DEVELOPMENT OF THE GALL

In general, the formation of a gall has an early phase, a trophic phase, and a post-trophic phase (Mani 1964). In the spiral gall of *P. spirothecae* the early phase can be sub-divided into three stages: bending, spiralling and swelling (Gerhardt 1922); swelling of the gall continues through the trophic phase. Upon emerging from the egg, the fundatrix or stem mother, begins to feed on the petiole of a leaf producing first bending (Fig. 2b) then spiralling until three loose spirals have been produced (Fig. 2, c & d). Subsequent swelling of the gall seals the gall cavity and increases its size (Fig 2, e, f & g).

The time taken to produce the three coils on petioles of lombardy poplar outdoors at Vancouver was 3-4 weeks, considerably longer than the 6 days reported by Dunn (1960) for attaining the same stage in the laboratory. If the first instar stem mother dies while the gall is forming, no further development takes place and incomplete galls result with one or two coils. Subsequent feeding by the newly enclosed fundatrix stimulates the coils of the gall to grow laterally, sealing the walls. Increase in length of the coils expands the gall and increases the size of the cavity.

The galls reach maturity in late August and September, gradually changing from green to orange-red or brown. When mature, the galls measure about 15 x 13 x 9 mm. The gall cavity is lined by numerous short, papillate unicellular hairs, with some longer multicellular ones among them. When the gall is mature, one or two ostioles develop (Fig. 3) between the coils to serve as emergence holes for the aphids, or sometimes the coils loosen, producing a long slit in the gall, allowing a mass escape of the inhabitants. In this post-trophic stage, the galls deteriorate and fall from the tree with the leaves. The total life of a gall is from 20-25 weeks.

We could find no evidence that the presence of a gall on a leaf weakened the leaf or reduced its size. Galled leaves, however, fell from the tree sooner than non-galled ones.

LIFE CYCLE OF THE APHID

In late March or April at Vancouver the fundatrix emerges from the overwintered egg, at a time when the young poplar leaves begin to appear. The first instar fundatrix (Fig. 4) is small, brownish green, and has very well developed hind legs, 4-segmented antennae (Fig. 4a) and normally developed labium and stylets (Fig 5). In fact, its stylets are very much like those of *Myzus persicae* (Sulzer) (Forbes 1969) with each madibular stylet innervated by two dendrites. The fundatrix settles to feed on a leaf petiole, initiating the formation of the gall. The fundatrix moults for the first time as soon as the spiralling of the petiole has been completed, or almost completed i.e., about 3-4 weeks after hatching. After the fourth moult the fundatrix is mature and starts to reproduce parthenogenetically. The mature

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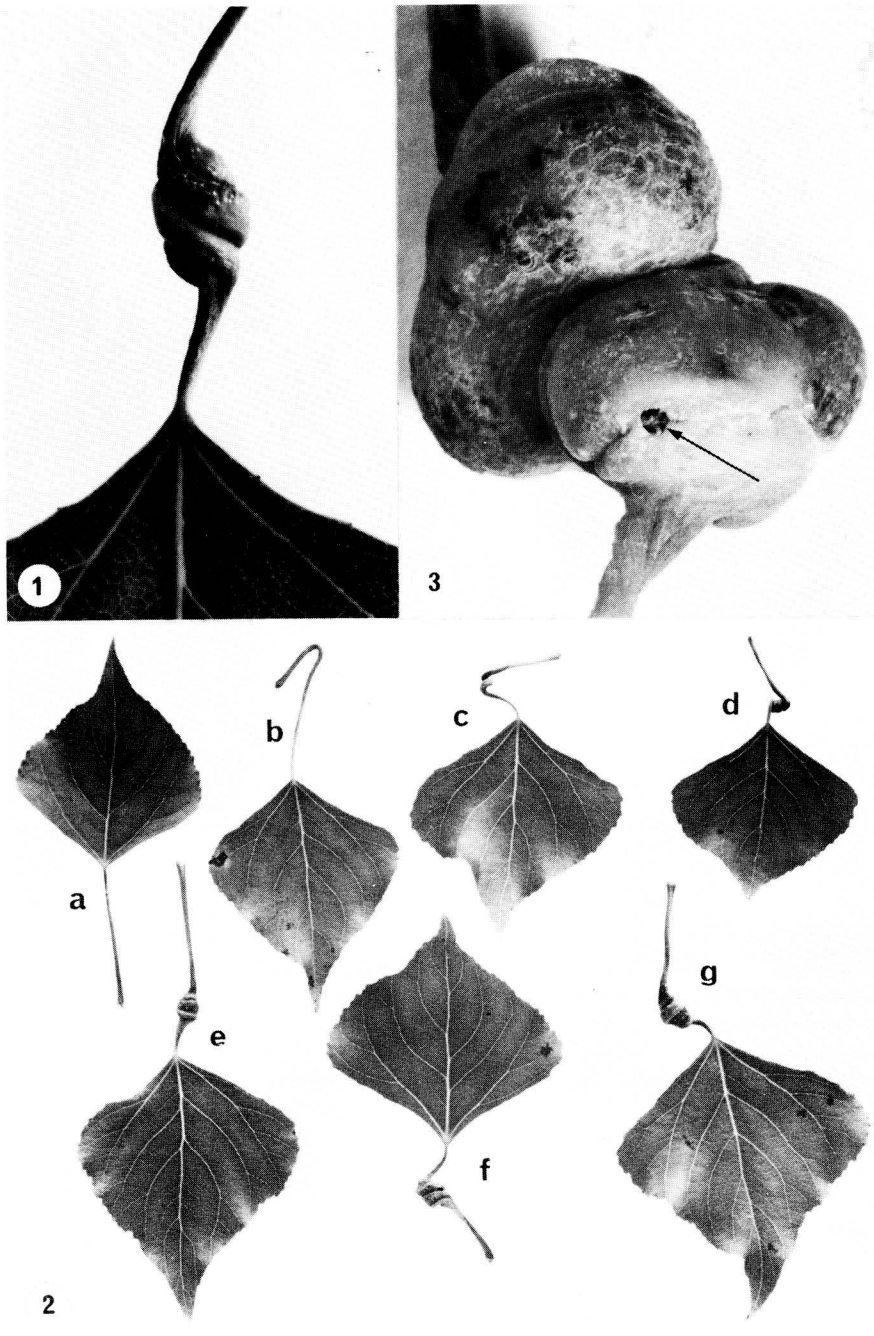
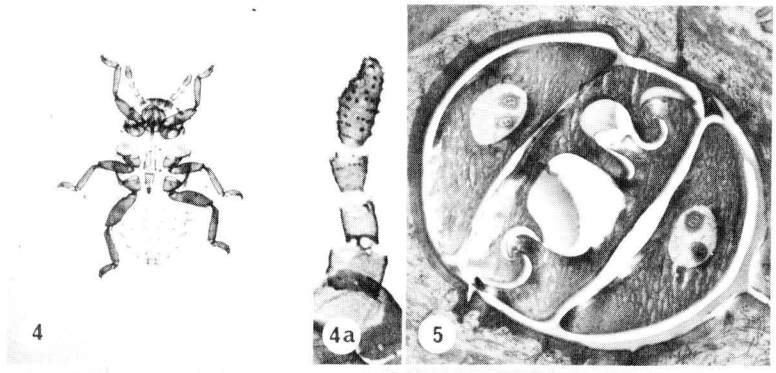
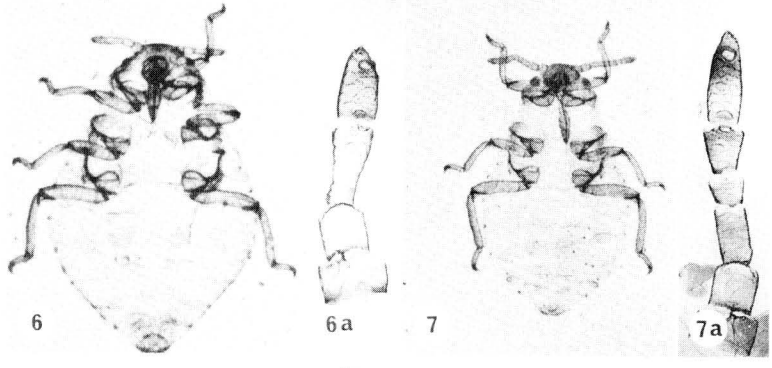


Fig. 1. Fully formed spiral gall of **Pemphigus spirothecae** Pass. on the petiole of a leaf of lombardy poplar.

Fig. 2. Stages in the formation of the gall: a, a non-galled leaf; b, bending of the petiole; c & d, spiralling of the petiole; e, f, & g, swelling of the gall.

Fig. 3 Mature gall with an ostiole (arrow).





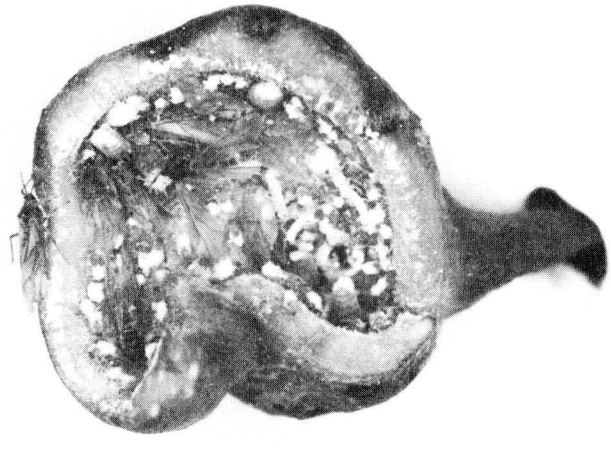


Fig. 4. First instar fundatrix of P. spirothecae with an enlargement of an antenna (4a).
Magnification: whole aphid ⊢——⊣ = 0.5 mm
antenna ⊢——⊣ = 0.1 mm

Fig. 5. Transmission electron micrograph of a cross section of the stylets of a first instar fundatrix. ⊢——⊣ = 1 u

Fig. 6. Mature fundatrix with an enlargement of an antenna (6a).
Magnification: whole aphid ⊢——⊣ = 1 mm
antenna ⊢——⊣ = 0.1 mm

Fig. 7. Mature fundatrigenia with an enlargement of an antenna. Magnification as for Fig. 6.

Fig. 8 Sexuparae inside an opened gall.

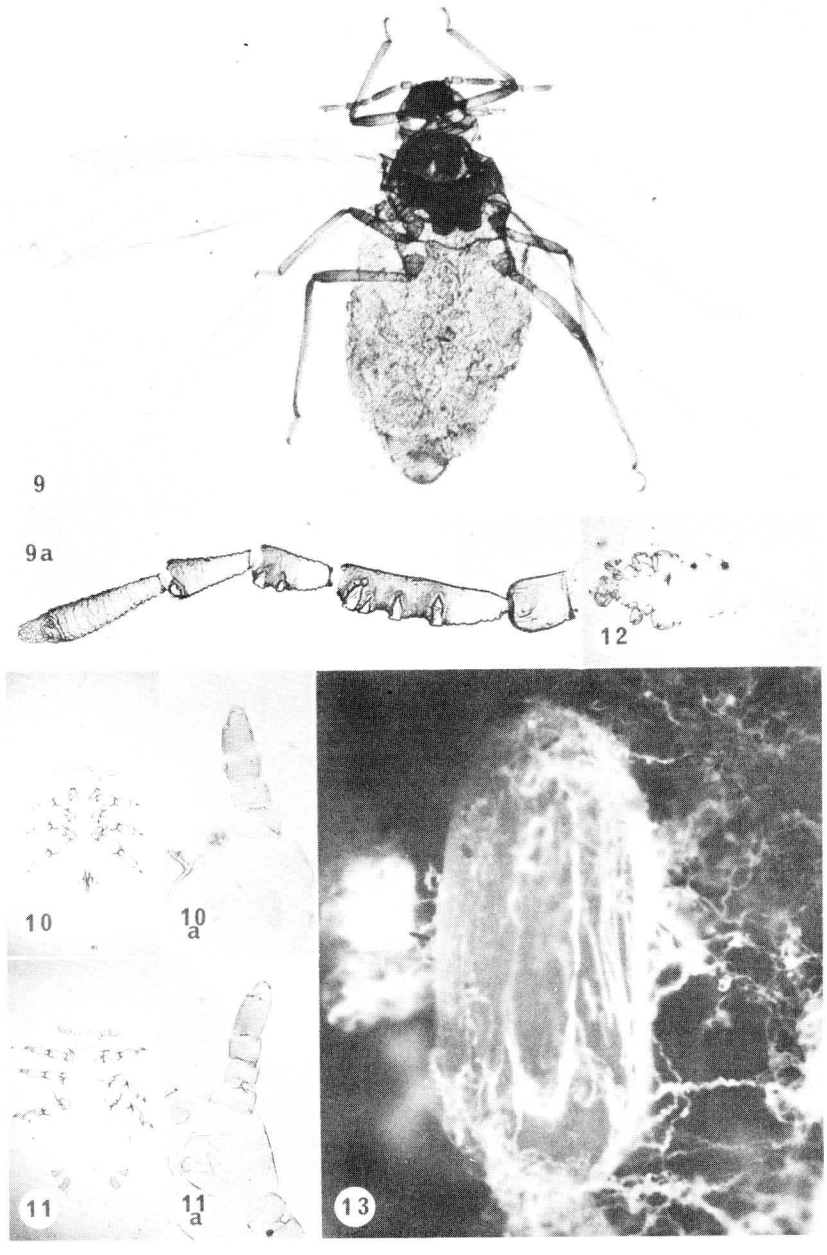


Fig. 9. Mature sexupara with an enlargement of an antenna (9a). Magnification as for Fig. 6.

Fig. 10. Mature male (sexuale) with an enlargement of an antenna (10 a). Note the rudimentary mouthparts. Magnification as for Fig. 6.

Fig. 11. Mature female (sexuale) with an enlargement of an antenna (11a). Note the rudimentary mouthparts. Magnification as for Fig. 6.

Fig. 12. Female laying her egg.

Fig. 13. An egg with wool-like wax.

fundatrix (Fig. 6) is pale yellow and has short 4-segmented antennae, (Fig. 6a) and well-developed labium and stylets.

At Vancouver the fundatrices mature between mid-june and the beginning of July. During July and August each fundatrix produces about 100 progeny, the fundatrigeniae. The mature fundatrigenia (Fig 7) is pale and can be distinguished from the mature fundatrix by its longer, 6-segmented antennae (Fig. 7a). The fundatrigeniae moult four times before they start producing the sexuparae.

The sexuparae are produced in August and September and are present in the galls (Fig. 8) from early August until lat November. The mature sexupara (Fig. 9) is winged and has 6-segmented antennae with transverse secondary sensoria on the third and fourth antennal segments (Fig. 9a). The head and thorax are black and the abdomen is yellow-green. Each sexupara produces a maximum of six females and two males on the bark of the tree and then dies. The females and males moult three times in a period of 36-40 hours and then mate. The male (Fig. 10) is small and pale green with 4-segmented antennae (Fig. 10a). The female (Fig. 11) is also small with 4-segmented antennae (Fig. 11a) but the abdomen is long and contains a single, very large egg (Fig. 12) which is laid in the crevices of the bark or under the lichen (*Cetraria* sp.) often found on the bark. The newly laid egg (Fig. 13) is 0.55 x 0.28 mm and is almost the size of the female's abdomen. It is white and covered by wool-like waxy secretions from the abdominal wax glands. In 3 or 4 days the egg changes to light green and then to a bright yellow-brown. The egg overwinters on the bark.

The sexuales do not feed since they do not have functional mouthparts. The labium is reduced to a small papilla and stylets are absent. The rudimentary condition of the mouthparts can be seen on the heads in the photomicrographs of the antennae in Figs. 10 and 11.

Thus all the morphs of *P. spirothecae* are found on the bark or in the galls on lombardy poplar. The aphid is therefore monoecious and holocyclic.

DISCUSSION

The formation of the spiral gall on the petiole of lombardy poplar is a dramatic example of the way in which aphids can change the growth processes of plants for their own advantage. The plant tissue completely surrounds and encloses the fundatrix and her progeny. Only late in the season does the gall open and release the sexuparae.

Other species of *Pemphigus* living on poplar produce markedly different galls. The form of the gall, therefore must be due to the specific feeding behaviour of the aphid when gall formation is initiated and to chemical substances injected into plants with the aphid's saliva (Miles 1968). The details of the feeding behaviour of the fundatrix of *P. spirothecae* have been described by Dunn (1960).

The spiral gall provides the aphid with an environment protected from parasites, predators and weather conditions; only the sexuales spend their entire life outside of the gall. Probably just as important to the aphid is the fact that the galling apparently supplies the aphid with improved nutrition by changing the physiology of the plant (Forrest 1971).

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