

Morphogenesis of galls induced by *Pauropsylla depressa* Crawford (Hemiptera-Psyllidae) on *Ficus glomerata* Roxb. leaves

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Abstract

Pauropsylla depressa Crawford (Homoptera : Psyllidae) infests *Ficus glomerata* Roxb. and produces galls on its leaves, causing extensive damage to the foliage of the plant. The gall formation by *Pauropsylla depressa* causing the changes in the histomorphology of the host plant.

Galls are pathologically developed cells, tissue and organs of plants, which have risen mostly by hypertrophy and hyperplasia (excessive cell division) usually under the influence of parasitic organism. Galls are epiphyllous, simple, globular, sessile, per foliate unilocular. Usually also in large fleshy, multilocular agglomerate masses. The physiology of gall formation is still obscure and it is generally believed that a secretion from nymph emerges out of the gall and moults into adult. Thickness of wall depending upon the size of gall and gall cavity. External surface of gall is shiny greenish, brown or pinkish developing upon the depending stage of *P. depressa* inside the gall. Outer layer is made of cuticle.

Newly formed galls are green in colour, but as the gall grows due to the metaplasia induced by the feeding of instars in it, gall colour changes pale green. Later on, it develops brownish spots. The colour of galls changes with the development of instars (from 1st instar nymph to 5th instar) inside the galls. After some time, greenish colour turns brown. During winter, mature gall turns pinkish due to the formation of some phenolic compounds. Mature gall contains a lacerated opening on the lower surface (ventral side) of the gall from which fifth instar nymph escapes out for moulting into imago. With the development of instar, the size of the galls also increases (Plate 1). As the size of the nymph increase, subsequently size of the gall also increases. Newly formed gall (young gall) measures 1.5 to 2.0 mm in diameter mature gall measures 10 to 12 mm in diameter and all gall measures 11 to 13 mm in diameter. Attains maximum size of 20 to 30 mm in diameter. However whenever entire leaf turned gallinaceous, then agglomerated mass measured 8 to 12 cm. Agglomerated masses may reach up to 14 to 53 mm in diameter.

Keywords: *Pauropsylla depressa*, *Ficus glomerata*, galls colour, size of galls, morphology

1. Introduction

Pauropsylla depressa Crawford (Homoptera : Psyllidae) Dhiman and Vinay (1983) [6], infests *Ficus glomerata* Roxb. and produces galls on its leaves, causing extensive damage to the foliage of the plant, Mani (1973) [8]. Galls are abnormal growth on the plant leaves which provide hinderances in photosynthetic activities of the plant. In heavy infestations, the leaves turn entirely glomerated with numerous galls. Hence, galls are always injurious to plant and its growth is adversely affected or stunted. One or two galls on a leaf do not interfere much in the photosynthesis but when entire leaf turns gallinaceous and badly distorted this activity is greatly affected. Leaves are factories for photosynthesis which synthesize carbohydrates for plant growth as well as respiratory activities and transpiration etc. On become gallinaceous the leaves become unfit for these activities. In heavy infestations, the leaves turn entirely glomerated with numerous galls (Fig. 5). Many changes morphologically (shape, size and colour) are induced in the leaves due to gall formation. *Pauropsylla depressa* form galls on different parts of host plants.

Galls are pathologically developed cells, tissue and organs of plants, which have risen mostly by hypertrophy and

hyperplasia (excessive cell division) usually under the influence of parasitic organism. Galls are epiphyllous, simple, globular, sessile, per foliate unilocular, usually also in large fleshy, multilocular agglomerate masses (Fig. 4). The gall formation by *Pauropsylla depressa* causing the changes in the histomorphology of the host plant. The physiology of gall formation is still obscure and it is generally believed that a secretion from nymph stimulates gall formation. When insect emerges out of the gall and moults into adult. Newly formed galls are green in colour, but as the gall grows due to the metaplasia induced by the feeding of instars in it, gall colour changes pale green. Later on, it develops brownish spots. After some time, greenish colour turns brown. During winter, mature gall turns pinkish due to the formation of some phenolic compounds. Mature gall contains a lacerated opening on the lower surface (ventral side) of the gall from which fifth instar nymph escapes out for moulting into imago. Hence, to know all these changes present investigation on "Morphogenesis of leaf galls of *Ficus glomerata* Roxb. induced by *Pauropsylla depressa* Crawford" have been taken up.

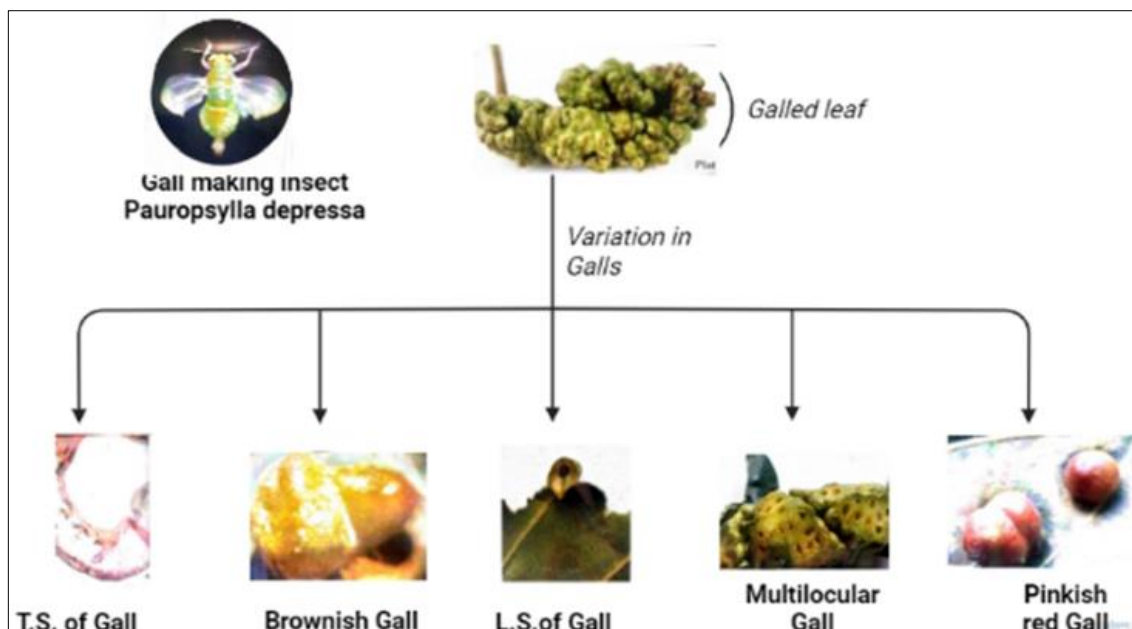


Plate 1: Diagrammatic representation of variation in galls

2. Materials and methods

2.1 Procurement of plant material

Field observations were confined in Saharanpur district and adjacent area where the main host plant of *F. glomerata* Roxb. are found in good number. Fresh leaf galls of *Ficus glomerata* were collected from Saharanpur district and adjacent area of Uttar Pradesh. Following materials and methods were employed for different studies.

2.2 Preparation of plant material

For noting gall formation, a healthy twig of *F. glomerata* was selected having young leaves. These leaves were covered by fine muslin cloth and inside it a freshly mated *P. depressa* female were released for egg laying. After oviposition the female were removed. Now, at regular interval gall size and colour was noted till the emergence of mature 5th instar from the gall through lacerated opening. The shape and size of gall was noted under binocular microscope. Healthy and gall infested leaves of *F. glomerata* were also collected from different localities of Saharanpur district and were fixed in different fixative for histomorphological studies.

2.3 Morphological studies

Macro-morphological features of the plant leaf were observed under magnifying lens and simple microscope Tyler *et. al.*, (1977) [14]. Morphology of the gallinaceous and healthy leaves were carried out by observing external feature, internal structure, size, variation and shape etc. of different phages of gall i.e., young, mature and old gall under binocular microscope. Structure of monolocular and multilocular gall was seen by plucking the infested leaves of *F. glomerata* having all stages of the gall.

3. Results

3.1 Macroscopic and microscopic examination

a) Structure and type of gall

Pauropsylla depressa makes pouch galls on the leaves of *Ficus glomerata*. There are two types of galls monolocular and multilocular (Fig. 3). Monolocular galls having one cavity and

multilocular cause having more cavities (Fig. 2). The galls are of open type usually having a cone on ventral site of the leaf. The psyllid galls as a whole are highly diverse in gall shape and galling position, but they are specific for each species. Galls maybe as simple as small bits on a leaf blade to several deep pits close together forming a complex large pit. It may show up as a slide curling of leaf edges to profuse rolling up to certain areas of the edges of a leaf, forming a specific purse like gall or it can appear as various enclosed type of galls, such as spherical, conical and crown like shapes. External surface of gall is shiny greenish, brown or pinkish developing upon the depending stage of *P. depressa* inside the gall. Outer layer is made of cuticle. Thickness of wall measures 0.10 to 0.15 mm depending upon the size of gall and gall cavity measures 3.6 to 3.9 mm in diameter (Table-1).

b) Shape and size of young, mature and old gall

It varies upon the growth and stage of nymph harbouring in it. With the developing stage of *P. depressa* nymph size of the gall also increases. After the nymph approaches third instar stage, a very slight increase in the size of gall takes place. This increase in size occurs up to 4th instar stage. Minimum size was noted with the first instar nymphs and maximum with 4th and 5th instar nymphs (Fig. 1). Newly formed gall (young gall) measures 1.5 to 2.0 mm in diameter mature gall measures 10 to 12 mm in diameter and all gall measures 11 to 13 mm in diameter. Attains maximum size of 20 to 30 mm in diameter. However whenever entire leaf turned gallinaceous, then agglomerated mass measured 8 to 12 cm (Table-1).

Gall size increases gradually with that development stage of the *P. depressa* nymph inside the gall. Newly formed gall appears like a small pimple on the leaf and it measures hardly 1.5 to 2 mm in diameter. Medium size gall appears like granule and it measures 6 to 8 mm in diameter. Mature gall is fully globular in shape and smooth externally with fine cracks. It measures 10 to 12 mm in size. Old gall develops more wrinkles externally. Mouth of ventral conical projections opens forming lacerated opening through which fifth instar nymph emerges out for mounting into adult. An empty gall develops more wrinkles,

shrinks slightly due to drying and death of all tissue. It measures 3 to 5 mm in diameter. When viewed laterally, a gall appears globular top having a cone.

c) Change in colour of developing gall

It was observed that the nymph of *P. depressa* makes galls on the tender leaves of *F. glomerata*. Only one instar develops with in the gall, but rarely two instars may also develop together inside the gall.

First instar nymph just after hatching from the egg of *P. depressa* starts feeding on the leaf sap and its saliva having some enzymes and other chemicals induce gall formation. Newly formed gall having first and second instars are green in

colour but as the gall grows due to the metaplasia induced by the feeding of instar in it, gall colour changes pale green. Later on, it develops brownish spots. Then the greenish colour turns brown in 4th and 5th instar stage. During winter mature gall turns pinkish due to formation of some phenolic compounds which help in trapping sun heat to warm the gall. Mature gall contains a lacerated opening or aperture on the lower surface (ventral side) of the gall from which fifth instar nymph escapes out from for mounting into imago (Fig. 1). The empty gall become brown in colour which gradually changes into brownish black and become hard and woody (Table-1). Sometimes empty galls develop fungus. Such leaves having empty galls turn pale and drop down early.

3.2 Tables

Table 1: Shape, size and colour of gall of *Ficus glomerata* leaves induced by *Pauropsylla depressa*

S. No.	Days	Stage of instar in the gall	Types of gall	Shape of gall	Size of gall (mm)						Lacerated opening	Colour of gall
					Mini, Maxi, Av. Diameter (mm)			Mini, Maxi, Av. Height (mm)				
1.	1 st and 2 nd	1 st instar nymph	Newly formed	Pimple like elevation	1	2	1.4	1	1.6	1.2	Absent	Green
2.	4 th	2 nd instar nymph	Young	Small globular	2	3.5	2.5	1.5	2.5	1.8	Absent	Green
3.	6 th	2 nd instar nymph	Young	Globular and with smooth surface	2	4	2.6	1.5	3.0	1.9	Absent	Pale green
4.	10 th	3 rd instar nymph	Medium	Globular and with fine lines	6	8	6.2	3	6	4.1	Absent	Pale green
5.	14 th	4 th instar nymph	Medium	Globular with slight wrinkle	8	10	8.5	4	7	5.0	Elevation of opening	Pale green with brownish spot
6.	18 th	5 th instar nymph	Mature	Globular with slight wrinkle	10	12	10.7	4	8	5.1	Lacerated opening before emergence	Brownish
7.	26 th	Empty gall	Old	Globular wrinkle with cracks	9.5	11	9.8	4	7	5.0	Opened	Brown

Average has been taken of 50 observations.

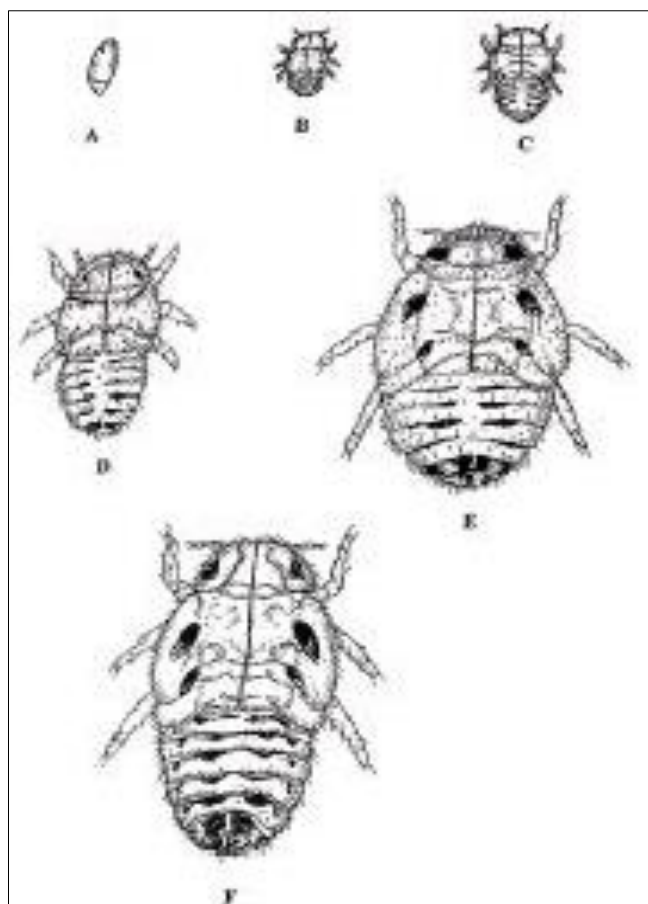
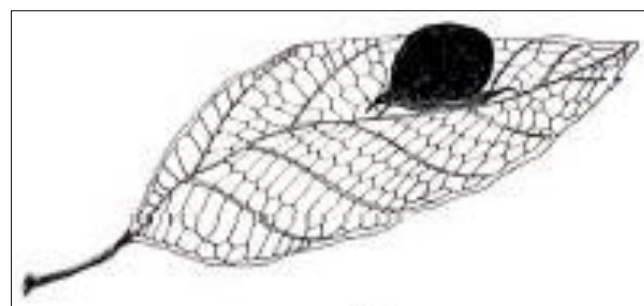
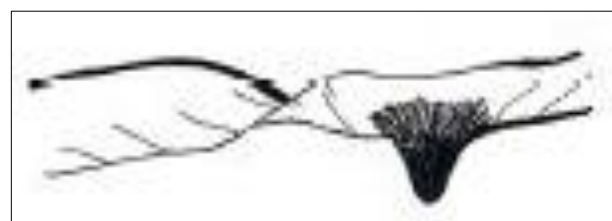


Fig 1: Different stages of life cycle of *Pauropsylla depressa* Crawford. (A) Egg (B) 1st instar nymph (C) 2nd instar nymph (D) 3rd instar nymph (E) 4th instar nymph (F) 5th instar nymph



(A)



(B)

Fig 2: (A) Dorsal view of monolocular gall (B) Ventral conical projection of the gall

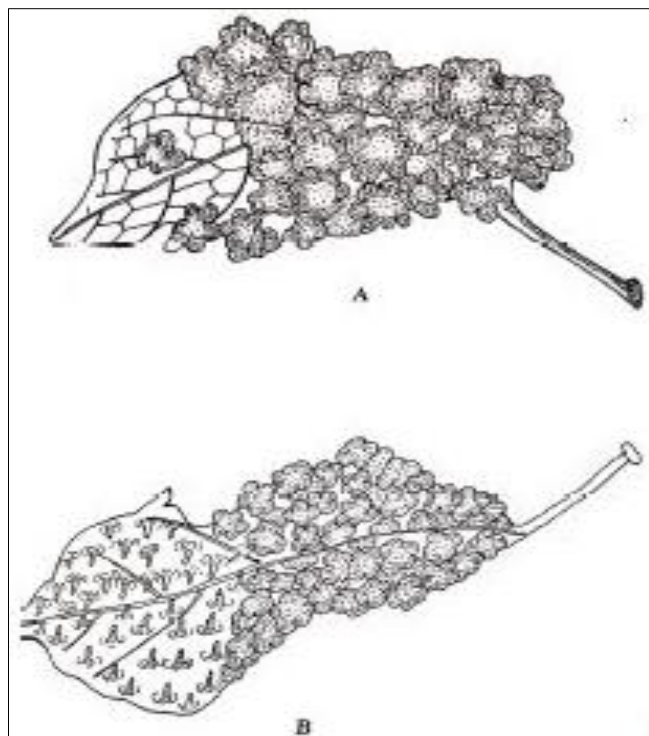


Fig 3: (A) Multilocular galls on the leaf of *Ficus glomerata* Roxb. in dorsal view (B) Multilocular galls on the leaf of *Ficus glomerata* Roxb. in ventral view

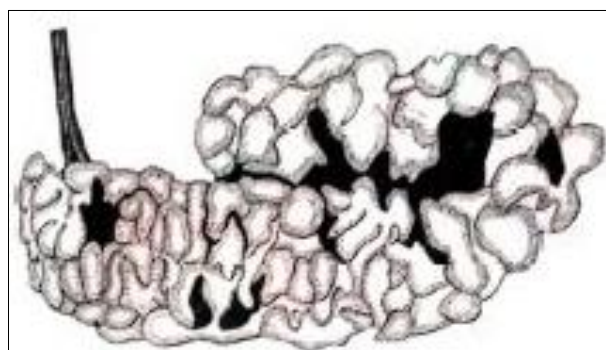


Fig 4: A completely gallinaceous leaf of *Ficus glomerata* Roxb.

Discussion

There is a good variation in the shape, size and types of the galls induced by psyllids on various host plants. In *Ficus glomerata* Roxb. (Family Moraceae) gall is induced by *P. depressa* Crawford a gallinaceous insect (Homoptera: Psyllidae). These galls are spherical, globular, unilocular or multilocular. Galls are present on the dorsal surface of the leaf and opening of the gall is on ventral side. In *F. glomerata* galls ventral projections of gall is pointed and in case of mature gall it is having a mini-aperture or lacerated opening through which the fifth instar nymph comes out for moulting. Young gall of *F. glomerata* measures, 1.5 to 2 mm in diameter, mature gall measure, 6 to 8 mm in diameter, old gall measure, 10 to 12 mm diameter and agglomerated masses may reach up to 14 to 53 mm in diameter.

Rahman (1932)^[10] described the gall of *P. depressa* as pointed, sphere projection over the leaf surface. Beenson (1941)^[11]

reported large bladder shaped thin-walled galls of *Pnapteran lentiginosum* on the leaves of *Garuga pinnate*. Mani (2000)^[9] recorded, cone like galls induced on the vegetative shoot apical meristems of *Mangifera indica* by *Apsylla cistellata*. Singh (2003)^[12] reported leaf role epiphyllous in rolling of two margins towards the midrid, irregularly swollen twisted gall of *T. hirsute* on *T. tomentosa*. Chen (2005)^[2] reported that most psyllid galls are monolocular, only one instar develop inside the gall. *P. triozyptera* develop conical galls on *Ficus ampelas* and *Ficus irisaria* (Moraceae). Inbar *et. al.*, (2010)^[7] regarded aphid infected galls in the Mediterranean forest as cauliflower shape. The shape size and types of galls produced by insect is variable on different plant species.

In *Ficus glomerata*, leaf galls induced by *P. depressa* are green in colour which provide mechanical support for the formation of food. In winter season, green colour turns pinkish red due to formation of phenolic compounds which helps in trapping sun heat. Some galls may change colour during their development, specially from green to red. Galls also changes colour, with the developmental stage of insect *P. depressa* which is present inside the gall. When first and second instar nymph is present, colour of gall is green, 3rd instar nymph, colour of gall is pale green, 4th instar nymph, colour of gall is pale green with brownish spot and fifth instar nymph, colour of gall is brown and finally to brownish black (when gall is empty, hard and woody. Minimum number of galls per leaf recorded as one and maximum as 145.

Color in galls is due to accumulation of plant derived pigments in their tissues. For example, the red galls of wasp (Cynipidae) induced on oaks contain high levels of carotenoids, Czeczuga (1977)^[4]. Only few authors only mentioned the nature and putative function of gall coloration. Hence, it has been suggested that the red colour of several of oak wasp galls attract parasitoids, Stone *et. al.*, (2002)^[13].

Close and Beadle, (2003)^[3] said that, red and yellow pigments provide protection from photo inhibition and photo oxidation. Singh, (2003)^[12] recorded, in *T. tomentosa*, initially green colour gall, but in winter season these are turned red colour. Dhiman and Arora (2004)^[5] reported maximum 123 galls on a leaf of *Ficus glomerata*. Wool, (2004)^[15] noted that pigmentation in some aphid galls is associated with exposure to light. Russo, (2007)^[11] recorded same finding in colour of galls of *Slavum wertheimae* on *P. atlantica* plant, (bright red and yellow etc.) Inbar *et. al.*, (2010)^[7] discussed a new hypothesis, why do many galls have conspicuous colour of galls in few plant species.

Conclusions

On become gallinaceous leaves (Fig. 5) become unfit for this activity. Thus, so far study on morphology and histology of leaf galls of *Ficus glomerata* Roxb. Induced by *Pauropsylla depressa* Crawford hence looking to the significance of insect *P. depressa*, present investigation has been taken which will arm the economic botanist or entomologists to device a suitable control measure of the insect.



Fig 5: (a) Galled leaf, (b) A twig with gall leaf

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