Chapter - 5

ECOLOGY

Ecological studies pertaining to insect galls developed on plant tissues are of paramount significance. Various ecological factors influence gall formation. Following ecological parameters are studied in relation to *Ficus glomerata* leaf galls induced by the feeding of *P. depressa* (Plate – 1&4).

(5.1) DISTRIBUTION OF GALL ON HOST PLANT:
- Distribution of galls was recorded under following heads –

(A) On the host plant (*Ficus glomerata* Roxb.):- For the study of distribution of galls on the host plant, *Ficus glomerata* tree has been divided horizontally into three parts, top, middle and bottom in relation to photoperiod. Direction wise the host plant was also divided into east, west, north and south directions. On the mature tree, maximum galls were found in the middle area of the tree foliage while minimum galls on the bottom and canopy of the tree (Plate - 1). Further, direction wise maximum galls have been observed in east, west and south parts of the tree foliage because these sides of the plant get proper sunlight which is necessary for photosynthesis and development of foliage on the tree. It also maintains proper temperature indirectly within the galls necessary for development of nymphal instars. However, very few galls have been observed in north direction of the tree.
because foliage of this part receives minimum exposure of light. Galls are of two types monolocular and multilocular. Two or more galls situated nearby combined with each other to form multilocular galls. Heavy infestation on a single leaf results in turning the leaf distorted and complete agglomerated mass. In many cases multilocular galls formed on the leaf and entire leaf developed ugly appearance. *P. depressa* makes galls on the dorsal side of the leaves because upper part gets proper sunlight necessary for photosynthesis (Plate - 3).

(5.2) **CAUSATIVE AGENT OF GALL** :- Nearly a million species of insects have been described, so far, and many more are yet to be discovered. They from the largest group of animals, far exceeding in number of species and of individuals, than all the other groups of animals put together. Among these, a good number of insect are gall forming. There has been always difference of opinion regarding causitive agent for gall formation. After copulation, female’s *P. depressa* laid eggs singly near the midrib or side veins on the ventral side of the leaf and sometime, female laid eggs on the upper surface of the gall (top portion (Fig – 5 and Plate - 22). After hatching, first instar nymph starts sucking plant sap from the leaf at one spot and in doing so injects saliva which stimulate gall formation due to the presence of some enzymes or chemicals which induces controlled metaplasia in the leaf tissue surrounding the nymph (Plate - 24). Size of the gall grows by the feeding with the advancing stages of the nymph (i.e. 1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}, 4\textsuperscript{th} and 5\textsuperscript{th} instars (Fig - 8 and Plate - 23). Hence,
saliva injected into the leaf tissue, having metaplacia inducing enzymes, is the causative agent for gall development.

(5.3) SEASONAL VARIATION IN THE GALL: -
Seasonal cycle was mainly studied in the field area of Saharanpur district and adjacent areas where the host plants of Ficus glomerata are found in good number, (Fig - 11). Different plants were randomly selected from the field area and marked for studies. Infected leaves were plucked from the plants in different months and infestation percentage and number of galls was noted. Number of adults was also calculated per five sweeps during different months and correlated with temperature and relative humidity. Maximum infestation occurs from August to October at temperature ranging form 19ºc to 32ºc and relative humidity 55 to 93%. Minimum infestation was seen during March to June. In these months, range of temperature was 13ºc to 39ºc. The decrease in temperature affected the survival of the pest, although, the pest stage occurs within the galls throughout the year. But, the number of galls was reduced during unfavorable condition (winter months, November to mid February). No adults were seen during December to February as they hibernate in winter. Eggs laid in November under go for diapause and hatch in mid February and begins next cycle of population. Though, all stages of the pest occur during March to November but maximum eggs of P. depressa occur during mid July to mid October, 1\textsuperscript{st} instars nymph from July last to mid October, 2\textsuperscript{nd} instars nymph from August to October, 3\textsuperscript{rd} instars from August to October and 4\textsuperscript{th} and 5\textsuperscript{th} instars in September to mid October. Temperature has direct influence on population built up to P. depressa and galls formation.
However, R.H. does not much interfere in the life cycle of this Psyllid as nymphs occur within the galls where host tissue provides enough moisture. Higher numbers of eggs were seen on the ventral side of the leaf margin of the midrib and side veins as well as near the ventral projection of the galls (Plate - 22). Eggs were also observed on the upper surface of the gall, on the dorsal side of the leaf. In the months from November to February as the temperature decreased, number of galls also decreased. Only older galls were seen on the leaves during winter. Duration of each life cycle stage was prolonged. Longevity of adults increased from 1 to 4 days in winter. From March to June, temperature starts increasing and in May and June temperature reaches to peak level and R.H. remained low, which influenced gall formation and number of galls decreased. During July to October, due to rains, the environmental condition becomes suitable for the survival of pest. The temperature remained 19ºc to 32ºc and R.H. 55 to 93% which provides the best condition for multiplication of this Psyllid (Table - 4).

(5.4) EFFECT OF TEMPERATURE IN FIELD ON THE GALLS AND DEVELOPING STAGE OF PAUROPSYLLA DEPRESSA CRAWFORD: -

Temperature has direct effect on the population built up of *P. depressa*. It acts on the nymphs indirectly through the gall wall. In field minimum temperature occurs during November to February as 4ºc to 25ºc. At this temperature range, due to poikelothermaol nature of the *P. depressa*. adults hibernate and eggs undergo to diapause. When temperature begins to raise from March onward, diapause of eggs is broken and adults come out of their hide outs.
Hence, during March to June, though, temperature remains 13ºc to 39ºc but minimum infestation of gall on the leaves occurs, having upto, 1st and second nymphal stages (Plate – 23C). Humidity of the environment decreases to low level as 13 to 78%. As rain fall occurs during July and continued upto September in this region. Humidity rises to 55 to 90% and temperature almost stabilized 19c to 30c which is optimum temperature for reproduction of \textit{P. depressa}. Hence, gall infestation increases to many folds (Fig - 9).

Eggs on the leaves and all nymphal stages within the gall as well as adults on the plant are available in good number. During October, temperature beings to decline. Hence, in October and November gall infestation gradually decreases, being minimum in November when temperature becomes 13c to 20c. During winter, only few galls are found formed by 1st nymphs, hatched during early November. These instar prolonged their development within gall. Eggs laid late in November underwent to diapause and adults proceeded for hibernation.

\textbf{(5.5) EFFECT OF GALL ON HOST PLANT:} - Gall formation causes extensive damage to the foliage of the plant (Plate - 1). The leaves are factories of photosynthesis due to which growth in different parts of plant occurs. The leaves not only manufacture food for the plant, but also perform respiration as stomata are found in the leaves. Hence, gall formation affects these two activities of the plant. One or two galls do not interfere much in the photosynthesis but when entire leaf turns gallinaceous and badly distorted this activity is greatly affected (Fig - 10 and Plate - 17). The leaves become unfit for photosynthesis activity and growth of
the twig is stunted. When the entire plant is infested by galls, then the vegetative growth of the plant seen was adversely affected. The plant growth was stunted, when it was entirely gallinaceous. In comparison to it, healthy plant growth was seen normal. Initial development of gall does not interfere in plant activities. Premature leaf fall occurs of gallinaceous leaves. As the leaves also used as fodder for cattle, hence, gallinaceous leaves become unfit to be used as fodder.

(5.6) HIBERNATION OR DIAPAUSE IN GALL CAUSING INSECT: - Hibernation is a time when insects ‘sleep’ through cold weather. This sleep is not like human sleep where loud noises can wake up. With true hibernation, the insect appear dead. There is no movement and it takes a long time for it to wake up. Many insects overwinter in a dormant state. They can be in any stage of development such as – egg, larva, pupa or adult. These insect pass the winter in soil or under host leaf plant material.

Diapause is a dynamic process consisting of several successive phases. It is not only common among insects but is also widespread throughout the world. In case of P. depressa, no true diapause occurs as the nymphs reside within the gall. They are indirectly affected through gall tissue by the cold weather only. Cold weather occurs in this region during winter. Adults hibernate during winter months, November to mid February in crevices of tree trunk, under the bark or under fallen leaves. As soon as warm weather sets in after mid of February, these come out of their hide outs. During winter colour of the galls changes from greenish to purple or
reddish brown as said earlier. This is a device to get more temperature within the gall as dark colour are good absorbent of the sun heat (Table - 2). However, eggs laid just prior to winter undergo for diapause to pass winter. Like that adult’s, diapause in eggs is broken as the temperature rises during late February.

(5.7) MIGRATION IN INSECT (P. depressa):-
Migration is a universal phenomenon in most of animals and insects. All insects move to some extent. The range of movement can vary from few centimeters for some sucking insects and wingless aphids to thousands of kilometers in the case of other insects such as butterflies and dragonflies. This occurs for obtaining better feeding and climatic localities. Migration occurs from one locality to other and from one food plant to other. Long range insect migration occurs in relation to climate and weather. The distance can vary from species to species, but in most cases, these movements involve large numbers of individuals. Migration is a key process in the population dynamics of many insects, including some of the most damaging pests.

Longest migration for an insect goes to the desert locust that travels about 2800 miles yearly. In P. depressa following different types of migratory behaviours are noted –

(A) From one locality to other: - The migration of P. depressa was studied in Saharanpur district and adjacent areas where host plants, Ficus glomerata exist in good number in nature (Fig - 11). The adult P. depressa are true flier, hence, they can migrate to long distance but generally local flights are
observed within the territory in different seasons (Fig - 11). However, when the climatic conditions become unsuitable or host plants are chopped off for fodder, the bug takes long flight in search of other host plant for the purpose of feeding, sheltering and breeding. The bug can take flight for few minutes to hours and during this period it can travel a distance from few meters up to kilometers. The adults have wing coupling device in both the wings which helps in taking efficient flight (Plate - 4).

(B) From one place to other on the same host plant: -

*Ficus glomerata* is a fully developed tree having many branches, side branches and good height. Hence, to reach up to the trip of branch having tender leaves, it performs local flights on the same plant. Leaves are used for oviposition and feeding which are full of sap and their tissue are soft and easy for penetration. On the same plant *P. depressa* takes flight from one twig to other, from lower side upto canopy of the plant and thus entire plant is explored for oviposition or feeding (Plate - 4). Flight efficiency is increased by efficient wing coupling device found is both the wings.