ADAPTIVE STRATEGIES IN CECIDOGENOUS THYSANOPTERA

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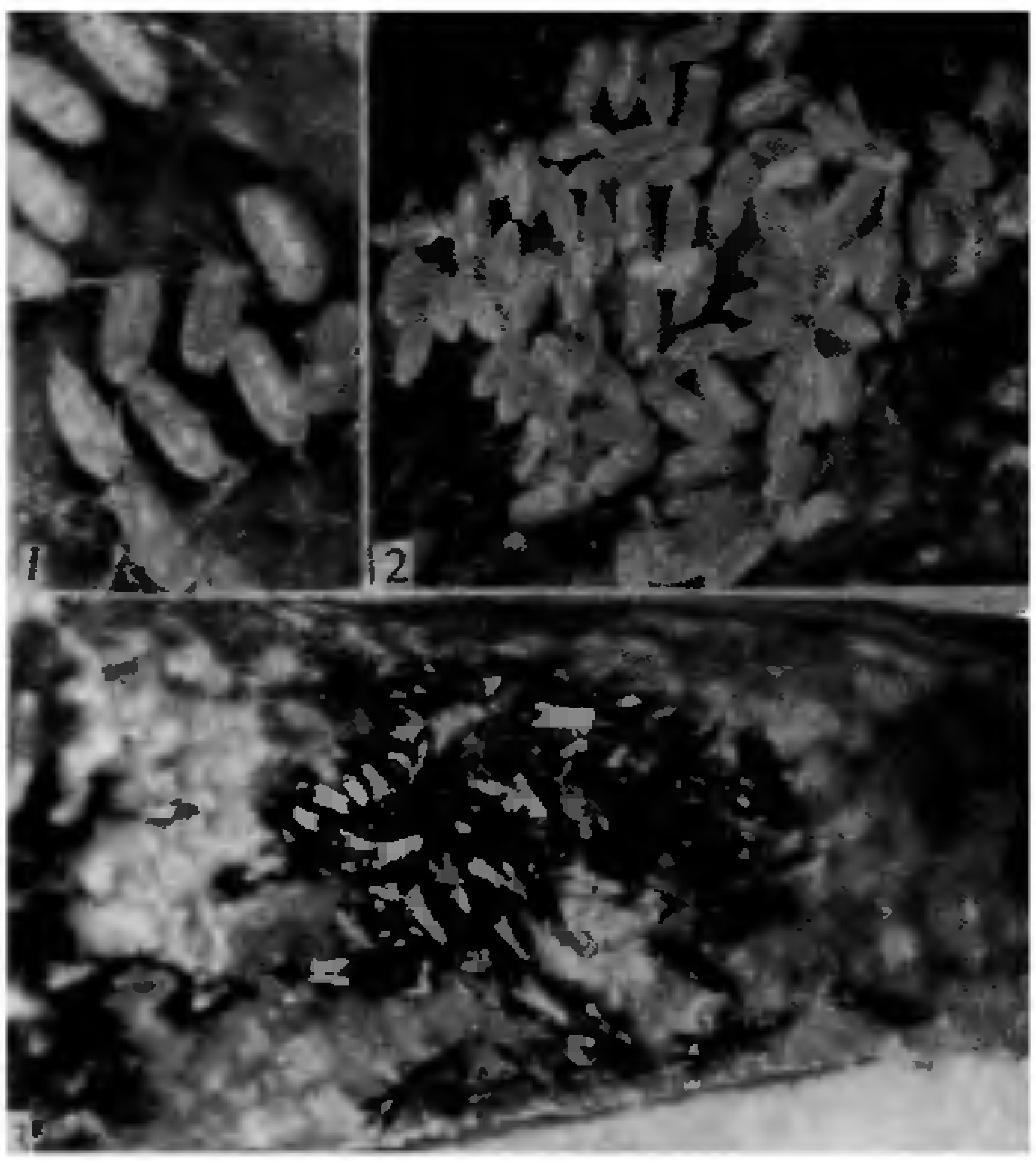
GROWTH abnormalities, recognizable through excessive cell growth and multiplication or hyperplasy and hypertrophy, resulting in various degrees of disorganisation of tissues, depending upon their responses to insect feeding stimuli are typical of galls, provide striking instances of a more intimate biological association between the insect and the host plant. The production of galls necessarily involves the redirection by the insect of plant growth into abnormal cells and tissues. Malformation resulting from such interactions are generally localised around the feeding spots, though in many cases the effect is also evident farther away, extending beyond the feeding region, the impact depending upon the ability of the gall to act as 'metabolic sinks', by utilising the plant resources for gall production from areas outside the feeding zone[1]. Cecidogenesis is therefore a complex phenomenon, often involving one or more compounds released by the insects which in turn induce the secretion of several plant substances. With the diversification and establishment of higher plants, specialised trends culminating in gall production occurred and the wide array of thrips galls induced by several species belonging to the Phlaeothripinae[2] reflects also, the association of thrips generic complexes with specific plant generic complexes, paving the way for a remarkably high degree of host specificity, very typical of thrips galls. This specificity is invariably coupled with the reciprocal action of the plant, forming different types of galls involving various patterns of morphogenetic phenomena. In view of the consistent appearance of 'form' in thrips galls, it is surmised that thrips are capable of soliciting 'genetic expression' in the concerned host plant, consequent to the application of the needed stimulus. This altered differentiation of the host is naturally the effect of changed metabolism in response to the chemical stimulus, the thrips inducing specific cellular and metabolic environment around the feeding area resulting in the characteristic type of differentiation in the host[3]. In particular, an increase in carbohydrates and lipids in galled tissues enables the thrips to maintain their life activities for a considerable period and it is also surmised that there is a antisenescence factor a special adaptation for mainnaining active metabolism on plants.

Every type of malformation does not necessarily result in gall formation, true galls being always positive, directional responses of plant tissues to the cecidogen of thrips, so as to result in disharmonic growth effects, with the polarity related to the insects rather than the rest of the plant. As a result of such a growth activity, thrips become partially or completely enclosed, so that they grow, mature and reproduce within them. Whether the nature of the gall is partial or complete, is however determined by the time of initiation of the gall, the population of thrips within it, as well as the degree of intraspecific diversity of the concerned species. Different types of tissue reorganisation and realignment that ensue from their activity, contribute to the dynamics of gall tissues[4,5]. Besides the varied genetic expressions evident in the exhibition of form as well as patterns of galls, there also occurs a convergence of external form, coupled with divergence in internal structure, so that galls of several highly host specific species such as those of *Liothrips*, Karny, *Gynaikothrips* Zimmerman, *Mesothrips* Karny *Liophlaeothrips* Priesner etc, reveal a strikingly identical pattern of galling, mostly as rolls, their subtle variation being revealed only by their internal structure. The opposite condition is shown by different species belonging to one genus as in *Crotonothrips* Ananthakrishnan which show striking complexities of patterns of gall morphology in plant species belonging to the genus *Memecylon* L. (family Melastomaceae), so that the form of the gall would necessarily indicate the species involved.

An overall analysis of thrips galls reveals that they are mostly open gall systems communicating with the exterior aiding in the migration as well as the ingress of inquilines and predators, which exert considerable influence on gall thrips populations. Closed gall systems are equally characteristic of thrips galls, as is evident in the galls of *Terminalia chebula* Retz. and *Calcopteris floribundus* Lam. Hyperplasy and hypertrophy are necessarily adaptive phenomena and in particular, hypertrophy of the mesophyll cells show cellular realignments in the early stages of feeding, towards the establishment of a 'form', so that specificity of gall morphology is characteristic of thrips galls. Transformation of primordial tissues to meristematic tissue is another adaptive trend noticeable in thrips galls, there being a precise regulatory mechanism, involving proliferation of epidermal and hypodermal cells, the cell divisions being periclinal or anticlinal, the regulatory processes acting only at the levels of individual cells and cellular groups, so that there is a manifestation of partial autonomy which is responsible for the variations in the division centres of the gall system. Of equal adaptive significance is the organization of a zone of nutritive cells existing as isolated patches along the lamina and extending deeper in the leaf tissue as a result of sustained feeding by thrips

Examining from an ecological angle, adaptive strategies in relation to the ability of some gall thrips to switch over to the formation of leaf galls and inflorescence gall, on the same plant with accompanying changes in the duration of life cycles, appear striking. A typical example is afforded by *Thilakothrips babuli* Ramakrishna the rosette gall thrips among *Acacia leucophloea* Willd. where the same species forms the rosette galls on leaves, as well as the inflorescence galls. With the drying of the rosette galls some of the apterous adults undergo diapause and with *Acacia* Willd. subsequently sprouting flower buds, they leave the diapausing site, migrate to flowers to form the floret galls within which both the macropterous and apterous populations develop. What is of significance from the view point of the strategy adopted by the thrips species, is a shorter life cycle in the inflorescence galls (12–14 days) as compared to that of the rosette galls (20-28 days), in view of the comparative short life of inflorescence[6].

The role of intra and inter specific competition in population regulation within galls appears a significant adaptation considering the phenomenon of resource partitioning. In this connection the reproductive strategies as well as those involved in population regulation within galls, appear important parameters, with each species exhibiting very charac-



Figures 1-3. 1. Enlarged eggs of *Arrhenothrips ramakrishnae*. **2.** A group of Androthrips *flavipes* eggs interspersed with *A. ramakrishnae* eggs **3.** Population of *A. ramakrishnae* within an opened gall of *Mimusops elengi*

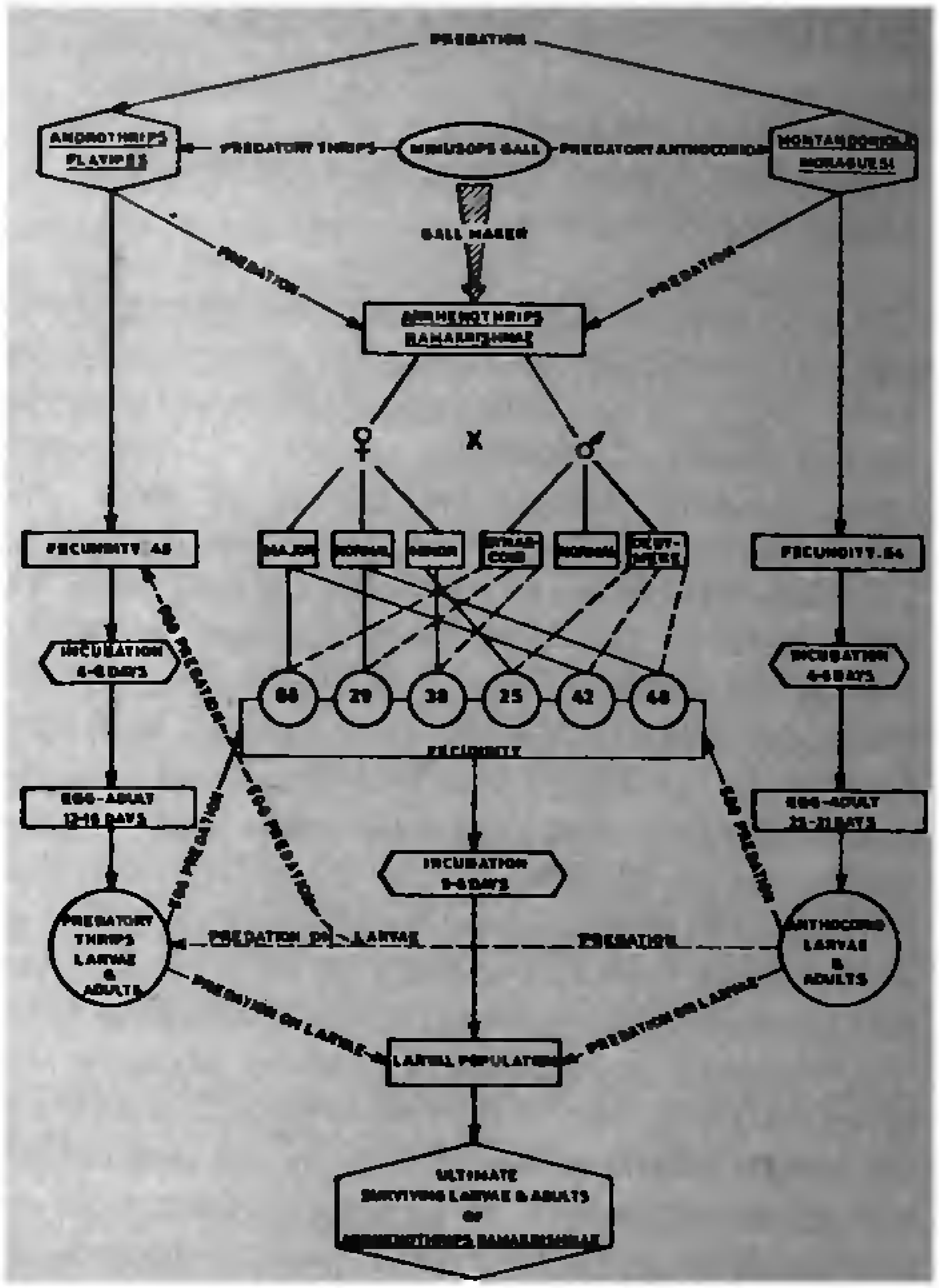


Figure 4. Intra and interspecific interactions within the Arrhenothrips gall of *Mimusops elengi*. (unless, otherwise indicated mere numbers refer to the eggs).

teristic egg laying patterns varying from small groups of 4–16 to as many as 60–100, as for instance in the Mimusops gall thrips, *Arrhenothrips ramakrishnae* Hood. The basic cause for this intraspecific variation appears to be the impact of polymorphism, in particular the reproductive behaviour of the major and the minor females as well as the oedymerous and gynaecoid males, which considerably influence fecundity. Such polymorphism also results in patterns of mating leading to recognizable variation in fecundity[7] Resource partitioning is an equally important biological strategy, very evident in the interaction of individuals within the galls, resulting in both intra—as well as interspecific competition. Intraspecific competiton is evident in the competition for mating and egg laying, not to mention that involved in the occupation of feeding sites Interspecific competition is equally characteristic of gall thrips and their associates and is evident among the gall maker, predatory thrips (*Androthrips flavipes* Schmutz) and Anthocorid bugs (*Montandoniola moraguesi* Puton). There is always a tendency for *Androthrips flavipes* to oviposit among the eggs of *Arrhenothrips* Hood enabling the emerging larvae to feed on *Arrhenothrips* eggs, but the larger number combined with the almost simultaneous emergence of *Arrhenothrips* larvae preclude its total mortality at the hands of the thrips predator[8,9]. It has also to contend with the anthocorid bug which besides feeding on all stages of the gall maker, also feeds on the eggs and larvae of *Androthrips flavipes*, incidentally enhancing the chance of survival of the former whose major females also tend to ward off the nymphs of the anthocorids. Figures 1-3 give the details regarding the eggs. Figure 4 indicates in detail, the strategies involved in the interspecific competition among the gall inhabitants of the Mimusops gall.

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VARIATION OF FREE AMINO ACIDS DURING FIGHTING IN *SCHIZODACTYLUS MONSTROSUS* DRURY (ORTHOPTERA, SCHIZODACTYLIDAE)

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ENERGY metabolism in insects during various vital activities has been drawing increasing attention of the insect physiologists. Insects, in addition to sugars and lipids, use free amino acids as the readily available source of respiratory fuels[1-4]. *Schizodactylus monstrosus*, a carnivorous insect shows intraspecific aggressiveness and fighting is thus a characteristic feature of their behaviour. Most of the previous studies, on the variation of energy providing nutrients have considered the fluctuations during flight and there is no report of the patterns of energy metabolism during fighting in insects. The present paper, therefore, attempts to report the variation of free amino acids in leg muscle, fat body and haemolymph during different fighting periods.

Specimens were collected from the river basin of the Damodar and kept separately in jars, with moist sand (80% R.H.) and provided with cockroach nymphs as food. To initiate fighting, two adult males were kept in a large sized glass jars, separated into two compartments by a glass partition. This facilitated visual stimuli for the initiation of their aggressiveness. After 5 min they showed attacking tendency and were brought outside immediately to allow fighting.

Haemolymph and tissues (fat body and leg muscle) for amino acids analysis were collected at 5 min interval upto 20 min. Blood was collected by a calibrated capillary tube from the cut hind femora; dissections were performed in ringer solution. Sample preparation for amino acid analysis was done following the method of Rakshpal[5]. Qualitative separation of free amino acids was carried out by two-dimensional paper chromatography using phenol: water (5:1) and butanol: acetic acid: water (4:1:1) as the two solvents. Quantitative estimation of the respective amino acids was done as previously described[6].

Up to first 5 min of fighting in the fat body, free amino acids (FAA) showed 12.12% decline while in the haemolymph it depicted 29.73% decline. From 5-10 min of fighting, the level presented 32.22% and 25.47% decrease in the fat body and haemolymph respectively. However, the level presented 22.23% and 17.26% decline from 10-15 min of fighting in the fat body and haemolymph respectively. In the rest of the periods, the level, however, presented no significant alterations (table 1). Variation of individual amino acids showed significant utilization of proline in both fat body and haemolymph. However, the percentage of decline up to 10 min of fighting appeared high in the haemolymph in respect of the fat body. Glutamic acid after an initial decrease up to 10 min of fighting, showed 56.07% and 52.63% increased level in the fat body and haemolymph respectively. Among other free amino acid levels, serine and glycine presented slightly higher level towards the end of fighting. Methionine, histidine, alanine, arginine, leucine, aspartic acid and valine contents depicted substantial decline up to the end of fighting in both fat body showed haemolymph. Phenylalanine in the fat body showed gradual decline while in the haemolymph the rate of decline was pronounced up to 10 min of fighting. Threonine in both fat body and haemolymph presented notable rate of decline up to 10 min of fighting