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# Biosystematic studies on Agromyzidae from India

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**Abstract.** Pure systematics of Agromyzids attracted the attention of many entomologists quite early in the century, but investigations on their biosystematics is still to gain the necessary attention and recognition from entomologists. Their life history and feeding habits being so closely interrelated with the chemical nature of their host plant, investigations into their capability to select the right host plant become all the more important. It has become very essential to critically reassess their systematic position and the characters governing this sensitive interspecific relationship. Factors which require special attention in this regard are: (i) the organs and devices responsible for host recognition and host selection, (ii) correlation between the structure of these organs and the behaviour of these flies, (iii) recognition of special features in their biology and (iv) the study on the interrelationship between ecological factors and the special features in their biology.

Though agromyzid infestation causes damage to varied plant parts such as root, stem, leaf and seed etc there is striking structural similarity in the organs and devices responsible for host selection. This is mainly due to the fact that in all cases it is the adult fly which is responsible for choosing the host. As very little information is available on the correlations between structural adaptations for host recognition, selection and the behaviour of Agromyzids, an attempt has been made to highlight these aspects.

**Keywords.** Agromyzidae; generic composition; distribution; economic impact; parasitism.

## 1. Introduction

The Agromyzidae, popularly known as leaf miners, are one of the important Dipteran families of economic importance in the world. Studies on them during the past decade in the Gangetic plains show an increasing rate of infestation on quite a few important crop plants and a variety of ornamentals, very often reaching 100% plant infestation especially during the months of February and March.

The investigations in India on their systematics gathered momentum in the mid sixties whereas research on their ecology and biology started in the early seventies. A synopsis of oriental Agromyzidae by Spencer (1961) is perhaps the first attempt on their systematics in India followed by publication of a Monograph on the Agromyzidae from India by Singh and Ipe (1971). This publication includes descriptions of 97 species new to science. Sasakawa's Catalogue of Oriental Diptera records a total of 156 species from India without taking into account many of the accepted synonyms. As a family Agromyzids show a high degree of host specificity but unfortunately many of the records from India are without host linkage.

The present information on the group is in no way complete and many species still await exploration, and already known one, a more critical appraisal. An attempt has been made here to analyse their faunal composition, factors influencing their distribution along with the salient features of their life history, and interspecific relationship viz parasites etc. The biosystematic studies of Agromyzids from India will definitely be deficient in many ways with only limited information being available on

them. This presentation, therefore, should be considered only in the light of the fact that faunistic explorations of Diptera on the whole from India is far from complete.

## 2. Generic composition and seasonal variations

A total of 140 species belonging to 20 genera, viz *Agromyza* Fallen, *Japanagromyza* Sasakawa, *Melanagromyza* Hendel, *Hexomyza* Enderlein, *Tropicomyia* Spencer, *Epidermomyia* Ipe, *Ophiomyia* Brashnikov, *Phytobia* Lioy, *Cerodontha* Rondani, *Calycomyza* Hendel, *Amauromyza* Hendel, *Liriomyza* Mik., *Phytoliriomyza* Hendel, *Phytagromyza* Hendel, *Paraphytomyza* Enderlein, *Pseudonapomyza* Hendel, *Napomyza* Westwood, *Indonapomyza* Singh and Ipe, *Chromatomyia* Hardy and *Phytomyza* Fallen are recorded from India so far. There is a profound influence of vegetation on their distributional pattern and definite ecoregions are recognisible on the basis of their distribution. Their population can be divided into two major groups viz (i) Genera with palaearctic affinities dominant during winter months, and (ii) genera with tropical (monsoon) affinities dominant during summer months.

There is a distinct overlapping of these two populations (figure 1) in the Gangetic plains during the successive seasons closely interrelated with the seasonal vegetation. Dominant summer genera are *Melanagromyza*, *Tropicomyza* and *Epidermomyia* while *Chromatomyia*, *Phytomyza* and *Liriomyza* dominate during the winter months. Major Agromyzid groups and faunal regions recognisible are:

| | |
|---|---|
| (i) Agromyzids with palaearctic affinity (dominant during winter months): | Northern elevations of Himalayan belt, higher elevations of western ghats and the Gangetic plains in winter months. |
| (ii) Tropical forms (dominant during monsoon season): | Peninsular India, including western coastal belt, north eastern border lands and the Gangetic plain in summer months. |

Genera with palaearctic affinities *Chromatomyia* and *Liriomyza* are totally absent during the summer months in the Gangetic plains but they dominate during winter

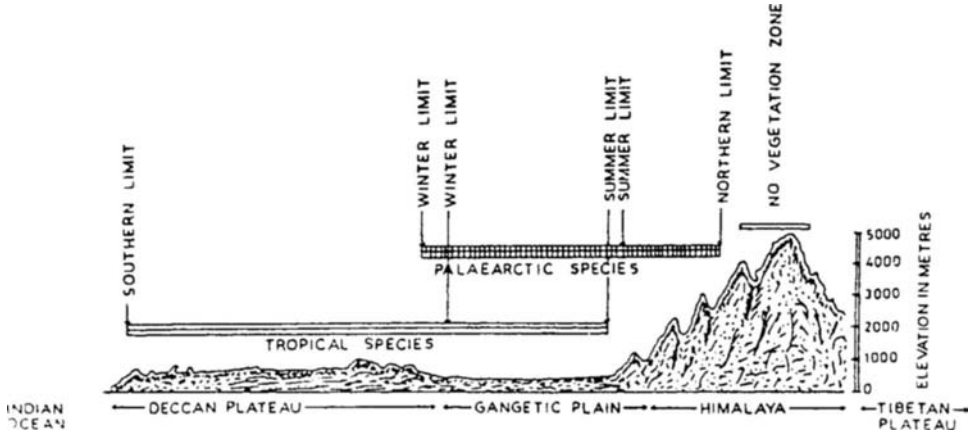


**Figure 1.** Summer and winter limits of palaearctic and tropical species.

months with infestation rate often reaching as high as 100% during February. However, it is interesting to note that the tropical genera *Melanagromyza* and *Epidermomyia* also manage to withstand the cold winter climate prevalent in the Gangetic plains to a considerable extent, the former reaching a maximum population level almost at the same time as that of *Chromatomyia*. However, their northern limits of distribution are very rarely over 240 m above MSL in the Himalayan foot hills (table 1).

Species like *M. obtusa*, *M. atomella*, *E. polyphaga*, *O. phaseoli*, *C. horticola* and *L. brassicae* are widespread in distribution (also seen extending into Rajasthan desert and Deccan plateau in winter months). Palaearctic genera like *Cerodontha*, *Liriomyza* and *Chromatomyia* were found in good numbers in the north eastern border lands. This region is climatically closer to the palaearctic region with lower temperature and higher humidity and hence the presence of these palaearctic genera in good numbers.

Two areas where palaearctic elements dominate (identified as rich in Agromyzids) are: (i) the Northern elevated Himalayan belt including north east India and (ii) the higher elevations of the western slopes of western ghats in the peninsular India.

Though both these areas are wide apart latitudinally they do have moderate to colder temperatures due to higher altitude and reasonably high humidity owing to comparative abundance of rain. The tropical plains as well as the Andaman and Nicobar Island chains are comparatively poor in variety of Agromyzids. This

**Table 1.** Distribution of Agromyzidae in Indian faunal limits.

| Genera | Northern elevation | Gangetic plain | Rajasthan desert | Tropical west coast | Deccan plateau | North eastern border lands | Andaman and Nicobar Islands | Total |
|---|---|---|---|---|---|---|---|---|
| Agromyza | 2 | 5 | | 2 | — | — | — | 9 |
| Japanagromyza | 3 | 3 | | 2 | — | (2) | — | 8 |
| Melanagromyza | 4 | 16 | (2) | 6 | (2) | (1) | (2)* | 26 |
| Hexomyza | — | 1 | | (?) | — | — | — | 2 |
| Tropicomyia | 3 | — | | — | — | — | — | 3 |
| Epidermomyia | 2 | 4 | (2) | 3 | (2) | (1) | — | 9 |
| Ophiomyia | 1 | 6 | | 1 | 1(1) | — | — | 9 |
| Phytobia | 1 | 1 | | 1 | — | 1 | — | 4 |
| Cerodontha | 15 | 1 | | 5 | (1) | (2) | — | 21 |
| Calycomyia | 1 | — | | — | — | — | — | 1 |
| Amauromyza | 1 | — | | — | — | — | — | 1 |
| Liriomyza | 8 | 3 | (1) | 1 | (1) | (3) | — | 12 |
| Phytoliriomyza | 4 | — | | 1 | — | 1 | — | 6 |
| Phytagromyza | 3 | — | | 3 | — | — | — | 6 |
| Paraphytomyza | 1 | — | | 1 | — | — | — | 2 |
| Pseudonapomyza | 1 | 4 | | 2 | (1) | — | — | 7 |
| Napomyza | 1 | — | | — | — | — | — | 1 |
| Indonapomyza | — | 1 | | — | — | — | — | 1 |
| Chromatomyia | 7 | 2 | (1) | — | (1) | — | — | 9 |
| Phytomyza | 1 | — | | 1 | — | — | — | 2 |

Numbers in parentheses indicate overlapping species.
*Empty mines only.

conforms to the observations of Spencer (1973) about the poverty of Agromyzid species in the rain forests in East Africa, Ceylon, Philippines and New Guinea.

### 3. Altitudinal distribution

A study on their altitudinal distribution reveal that Genera *Cerodontha*, *Liriomyza*, *Phytoliriomyza* and *Chromatomyia* have emerged as cold loving genera with close affinities to their palaearctic counterparts. Majority of the known species are found at an elevation above 1000 m MSL (figure 2). In the case of *Phytoliriomyza* all the 6 known species are from areas above this elevation whereas in *Cerodontha* 18 out of the 21 species, in *Liriomyza* 6 out of 12 species and in *Chromatomyia* 6 out of 10 species are from above this elevation. *Melanagromyza* and *Ophiomyia* have got just one species respectively above this elevation and *Tropicomyia*, *Phytagromyza*, *Pseudonapomyza* and *Napomyza* have got none at all. The only *Melanagromyza* species is in all probability an introduced species.

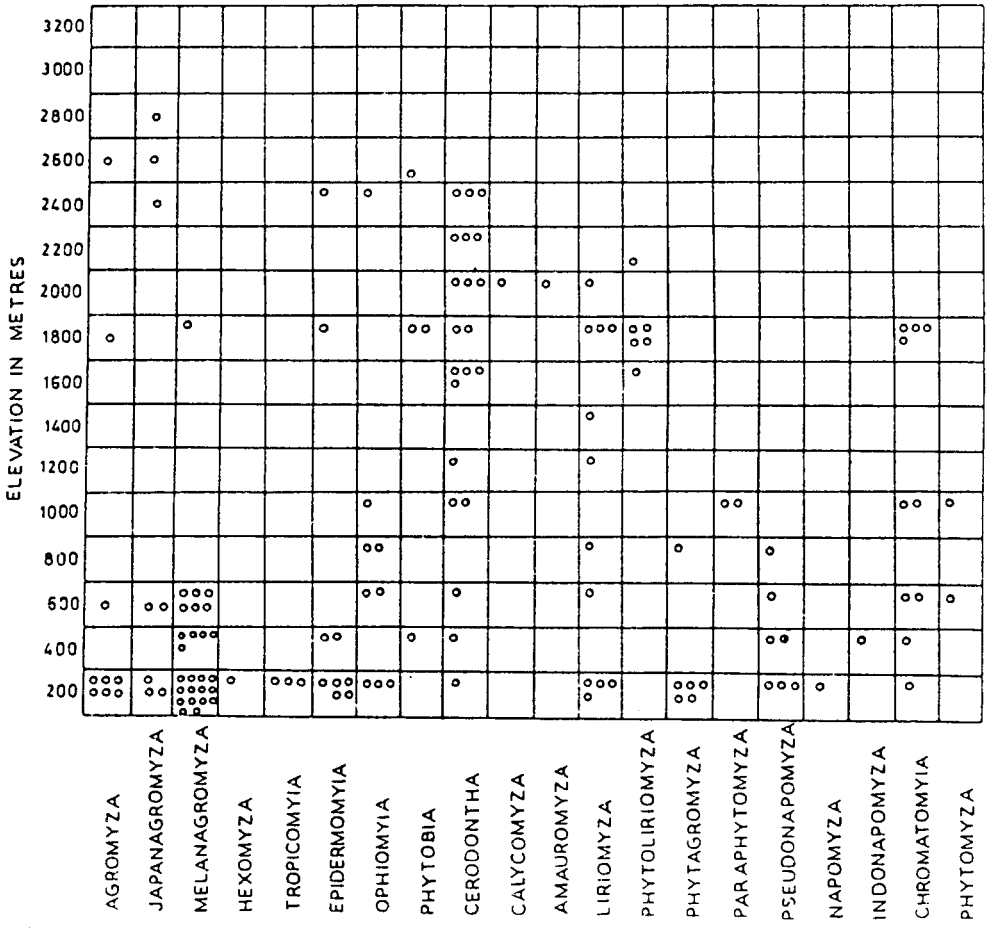


**Figure 2.** Altitudinal distribution of Agromyzids.

A few species that are widespread in distribution in the Indian faunal limits are *M. obtusa*, *C. horticola*, *L. brassicae*, *E. polyphaga* and *E. atomella*. Some areas identifiable as very rich in Agromyzids are Valley of Flowers in the Garhwal Himalaya, Darjeeling-Lebong-Tiesta area in the eastern elevations of Himalaya, and Periyar-Kumili areas of western ghats. *Liriomyza*, *Cerodontha* and *Chromatomyia* are the predominant genera in these regions.

## 4. Economic impact

The impact of Agromyzidae on economy is felt much more in the developing countries of the tropical belt where species like *M. obtusa*, *C. horticola* and *O. phaseoli* are pests on economically important crop plants while in the temperate zone, though the Agromyzid population is high, they are more of a green house problem (as they are pests on vegetables and ornamental plants in green houses). In India where majority of Indians especially of the lower income groups are dependent on leguminous crops for their protein intake, economic impact due to the infestation of various Agromyzids is considerable. Almost all the leguminous crops have an Agromyzid pest and some of them are of major pest status. The major oil seed of the Gangetic plain, *Brassica campestris* (Sarson) too has a major Agromyzid pest infesting it. Few important pests and their host plants are given in table 2.

In the case of seed borers like *M. obtusa* the loss is direct due to the larva feeding on the seeds. In the case of stem borers like *O. phaseoli* or *M. sojae* the feeding by their immature stages in the internal part of the stem causes external browning of the stem leading to death of plants in extreme cases. The leaf miner infestation is quite

**Table 2.** Important Agromyzid pests with their host plants and per cent of infestation.

| Agromyzids (Status as pest—major) | Host plant | Average plant infestation | Maximum infestation |
|---|---|---|---|
| *C. horticola* | *B. campestris* | 67·41 | 98·75 |
| | *Pisum sativum* | 58·24 | 99·05 |
| | *Tropaeolum majus* | 47·75 | 91·15 |
| | *Lathyrus odoratus* | 40·05 | 81·67 |
| *L. brassicae* | *B. campestris* | 57·13 | 83·26 |
| | *P. sativum* | 50·48 | 77·31 |
| | *T. majus* | 35·71 | 58·60 |
| | *L. odoratus* | 24·92 | 34·68 |
| *O. phaseoli* | *Vigna catiang* | 100 | 100* |
| | *Dolichos lablab* | 60·00 | 60·00* |
| | *Glycine max* | 4–5 | 4–5 |
| | *P. sativum* | 33·00 | 39·00 |
| | *Phaseolus mungo* | 37·08 | 48·08 |
| *M. sojae* | *G. max* | 50·00 | — |
| | *Phaseolus radiatus* | 42·02 | 50·00 |
| | *P. mungo* | 84·06 | 90·02 |
| | *P. sativum* | 60·00 | — |
| *M. obtusa* | *Cajanus indicus* | 61·73 | 100 |

*Subject to ecological conditions.

high during peak periods on crops like *B. campestris* and their feeding causes wilting and total loss of the leaves in acute cases of infestation.

## 5. Parasitism

Parasites are the most important factors influencing the Agromyzid populations. Experiments so far have provided conclusive evidence to justify preference of biocontrol methods to chemical control for these pests. Some important parasites reared from the host species are listed below:

| Agromyzid hosts | Parasites |
|---|---|
| *M. obtusa* | *Euderus lividus* |
| | *Diglyphus mandibularis* |
| | *Digliphus funicularis* |
| | *Tetrastichus atomella* |
| | *Euderus agromyzae* |
| | *Ormyrus orientalis* |
| | *Eurytoma* sp. |
| *M. sojae* | *Afrostilba* sp. (Eucoilidae) |
| | *Opius phaseoli* (Braconidae) |
| *C. horticola* | *Chrysocaris horticola* |
| | *Solenotus* sp. (Eulophidae) |
| | *Tetrastichus* sp. (Eulophidae) |
| | *Opius* sp. |
| *C. syngenisae* | *Closterocerus phytomyza* |
| *O. phaseoli* | *Opius phaseoli* |
| | *Trigonogastra rugosa* |
| | *Tetrastichus* sp. |
| | *Eurytomidae* sp. |
| *L. brassicae* | *Diglyphus indicus* |
| *E. atomella* | *Tetracampae indica* |

Biological observations on the parasites are limited. The available information indicates that both *O. phaseoli* and *M. sojae* infestations are kept under control by parasites as the percentage of parasitism reaches appreciable levels every season. But this cannot be said about *M. obtusa* or *C. horticola*, both the pest forms reaching alarming levels of infestation each season with no corresponding effective build up of parasites (table 3).

## 6. Some factors influencing population

### 6.1 *Rainfall*

A single factor that has profound influence on Agromyzid distribution is the dominant climatic factor—the monsoons. Rainfall in addition to influencing the

**Table 3.** Yearly pattern of parasitic levels observed in the Gangetic plains and per cent of parasitism.

| Month | *Ophiomyia phaseoli* on *Vigna catiang* | *Melanagromyza sojae* | | *Melanagromyza obtusa* on *Cajanus indicus* | |
|---|---|---|---|---|---|
| | | *Phaseolus mungo* | *Pisum sativum* | Early var. | Late var. |
| Jan. | — | — | 53 | — | 56 |
| Feb. | — | — | — | — | 50·1 |
| March | — | — | — | — | 52·5 |
| April | — | — | — | — | — |
| May | — | — | — | — | — |
| June | — | — | — | — | — |
| July | — | 8·3 | — | — | — |
| Aug. | — | 54·1 | — | — | — |
| Sept. | — | 72·2 | — | 13·2 | — |
| Oct. | 46·2 | 91·7 | — | 22·0 | — |
| Nov. | 94·0 | — | — | 21·7 | — |
| Dec. | — | — | 27·0 | — | 38·3 |

Data for individual parasites are not available.

vegetation has short term impact such as destruction of the adult flies, washing away of pupae of species that fall on the ground and killing of the larvae in mines on the leaves. This physical impact has profound influence on the short term population structures of Agromyzids especially in the tropical peninsular India.

Immediate post monsoon collection trips yielded very poor collection and also large number of dead immature stages inside the mines due to mines getting filled up with water. Thus often it was found that one generation itself gets wiped out due to unseasonal rains.

### 6.2 *Wind*

Wind can also be considered as a physical factor that influences the Agromyzid population. They prefer shady protected area for egg laying. Some of the windy islands of the Andaman and Nicobar island chains are very poor in Agromyzids though their vegetation is very much similar to the western coastal belt with comparatively rich Agromyzid fauna. Presence of hills and peaks on the western ghats provide protective niches and hence though windy western ghats are richer in Agromyzidae.

### 6.3 *Cultural practices*

In the Gangetic plains where farmers have been reluctant in employing modern cultural methods including rotation of crops, and where monoculture has been in practice for many years the population of species like *C. horticola* and *M. obtusa* infesting mustard crop (*B. campestris*) and Arhar crop (*Cajanus indicus* L.) respectively has gone up to unmanageable levels.

### 6.4 *Host selection*

Agromyzids are generally host specific. The chain process of host selection can be split and defined into (i) host habitat finding, (ii) host finding, (iii) host recognition, (iv) host acceptance and (v) host suitability. Very little information is available on habitat finding or host finding by Agromyzids. Ovipositor-labella combination is used for host recognition and acceptance. The female fly makes numerous punctures on the plant tissue with the help of the ovipositor. The exuding plant fluid is tasted with the help of labella by the female flies and eggs are laid singly once the host plant is accepted. Only about 8–10% of punctures are deposited with eggs and become eventually ovipositional punctures, the remaining ones being left as pseudopunctures. Misidentification of host plants by female has been observed but is very rare. Males are incapable of making punctures hence often been sharing the plant exudation from the punctures made by the female. Male life span is shorter than the female.

## 7. Future course of investigations

Investigations into the behaviour of Agromyzids needs much more inputs. The factors requiring special attention are: (i) Organs and devices responsible for host recognition and host selection, (ii) correlation between the structure of these organs and the behaviour of these flies, (iii) recognition of special features in their biology and (iv) study on the interrelationship between special features in their biology and bioecological factors.

Though Agromyzid infestation causes damage to varied plant parts such as root, stem, leaf, seed etc, there is a striking similarity in the organs and devices responsible for host selection. This is mainly due to the fact that in all cases it is the adult fly which is responsible for choosing the host. More investigations are needed into the correlations between structural adaptations for host recognition and selection and the behaviour of Agromyzids.

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