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**Diversity, Bioecology and Biosystematics of Aphids (Hemiptera: Aphididae) in Darjeeling
Himalaya**

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Abstract

Darjeeling Himalaya with its foot hill has a diverse flora and fauna. Aphids with their host plants have shown a great remark in aphidological studies. Altitudinal variation is very important in case of aphid diversity. Predators are also important natural enemies of aphids in this area. There are endemic aphid species found in this region.

Keywords: Aphid, association, hemiptera, distribution.

Introduction

Aphids are the small soft-bodied phytosuccivorous insects drawing phloem-sap, thus are ectoparasites of plants. They infest economical, cultivated and or wild plants. Such insects cause damages to their host plants by several ways: by devitalizing the plant; by affecting the normal development of seedlings, inflorescence, fruits etc.; by hampering the normal physiology of plants, such as transpiration and photosynthesis through occlusion of stomatal openings with heavy secretion and deposition of honey dew on the leaf surface.

Life cycle of aphids shows great variations. Some species lead different patterns of life

cycle (Dixon, 1973). Two types of life cycle are seen in aphids such as Anholocycly (reproduction is only by parthenogenetic viviparity) and Holocycly (parthenogenetic viviparity is intervened by sexual reproduction). Mostly polymorphic presenting five or six morphs, such as male, female, fundatrices, apterous and alate virginoparae or parthenogenetic forms, apterous and alate gynopare which give rise to only ovipare.

A significant feature in evolution of aphid life cycle is host alternation (heterocy). That is several aphids show a regular seasonal migration between two host plants, often with distant taxonomic relation, one of which is termed primary host used for sexual relation

and the other is called secondary host used for parthenogenetic reproduction.

The Darjeeling himalaya which is diverse with its foothill is situated in the northern region of West Bengal, a state in the north-east of India, that lies between 26°31' and 27°14' north latitude and 87°59' and 88°53' east longitude. It is bounded in the north by Sikkim and Bhutan and in the west by Nepal. On the south lie the district of Purnea and West Dinajpur while in the east, Bangladesh and the Jalpaiguri district bound it. The district is labyrinth of ridges and valley densely covered with a wide range of vegetation.

The Darjeeling hill area is formed of comparatively recent rock structure that has a direct bearing on landslides. Heavy monsoon precipitation contributes to the landslides. Soils of Darjeeling hill areas are extremely varied, depending on elevation, degree of slope, vegetative cover and geolithology. The geographic position, topography climate and the extensive vegetation of the region have all added towards an ideal environment complex to promote the assemblages to a very rich and diverse aphid fauna (Agarwala et al., 1987; Blackman and Eastop, 2008). Systematics aphidological studies have been attempted and significant exploration of aphids in India were made since 1960 (Raychaudhuri and Chatterjee, 1980; Ghosh and Raychaudhuri, 1977, 1980 & 1982; Chakrabarti, 2006; Chakrabarti et al., 2012). At Present 823 aphid species under 222 genera are known from India (Chakrabarti, 2006). In northeast India (Agarwala and Das, 2012) reported 212 species under 191 genera of aphids.

Here information on the diversity of aphids, their hosts, some hitherto not known species were recorded, altitude variation and seasonal incidence and their predators also recorded.

Accordingly, an attempt has been made here to provide an up- to-date consolidate account of aphid their distribution and host associations from Darjeeling. Predators mainly coccinellid, Syrphids, Neuroptera predators are associated with aphids. Aphids shows a symbiotic association with ants whereby ants use their excrements (honeydew) as food source.

Materials and Methods

This account is mainly based on the records made on the studies on aphid species, their host plant, altitudinal ranges, parasites and predators. Some aphid species were collected from different localities of Darjeeling by hand picking with the help of a haired brush or by beating the plant surface on a plate and subsequently collected by brush and preserved in 70% ethyl alcohol. For microscopical study, they were passed through following procedure:

- A) Specimens were boiled in absolute ethyl alcohol for 5 minutes.
- B) After decanting alcohol, insects were boiled in 5-10% KOH solution till the specimen appeared somewhat transparent.
- C) KOH solution was decanted off and the specimens were again rinsed in 95% ethyl alcohol.
- D) After removing absolute alcohol, they were heated in saturated chloral phenol to make them transparent (macerated).
- E) The material then transferred to a glass cavity block and mounted on a glass slide in a gum-chloral mounting medium. The slides with mounted aphid material were then dried on a hot plate, after which the cover slip was sealed with DPX mounting media.

Result and Discussion

Study of Aphid in taxonomical feature is very interesting from Darjeeling Himalaya. It has been observed that 92 species under 61 genera in 6 subfamilies. In world perspective it is 1.37% and in India 78.02%. A list on such aphid species and their host plant from these areas have been provided in Appendix 1. It shows that 70 species under 45 genera are in Aphidinae, 7 species under 5 genera in Greenidinae, 6 species under 5 genera in Hormaphidinae, 6 species under 3 genera in Lachninae, 1 species under 1 genus in Calaphidinae, 2 species under 2 genera in Drepanosiphinae. The maximum aphid diversity shows in the subfamily Aphidinae. It is 64.02% in total aphids found in Darjeeling Himalaya. So, Darjeeling Himalaya shows a great abundance of aphid diversity.

Altitudinal and Seasonal Variation

The population of aphids is very much influenced by the abiotic and biotic factors (Raychaudhuri and Chatterjee, 1980; Ghosh and Raychaudhuri, 1982; Agarwala and Das, 2012; Nandda and Joshi, 2015). Fig.1 shows the association of aphid at different altitudes. This indicated that the species of aphid in the vegetation Zone between 600-3000m. Out of them the subfamily Aphidinae present in between 600-2100m, Calaphidinae upto 2000m, Greenidinae 900-2000m, Hormaphidinae 1000-1500m and Lachninae 1500-2500m. In the field the abundance of predators is positively correlated with the numbers of aphids on the vegetation.

Endemism

There are a large number of endemic species of aphid in Darjeeling district. Among of the aphid species 26% are endemic to Himalaya. Ten species are endemic to here.

Host association

According to the host range of aphids they can be grouped under 3 categories monophagous (feeding of plants of a single plant) that is shown only in Calaphidinae subfamilies, oligophagous (feeding of plants of related genera) that is shown in Drepanosiphinae and Hormaphidinae and polyphagous or pantophagous (feeding on distantly related or unrelated genera). Subfamily Aphididae shown polyphagous nature. Non-availability of usual host plants due to various factors necessitates the adaptation of new plants as hosts to giving to rise new clone.

Conclusion

In conclusion it may be said that the aphids are a group of most defenseless yet destructive insects. Showing a high degree of polymorphism are still obscure. Aphids begin an obligatory group of polyphagous insects, floral abundance & diverse ecological conditions in the hilly terrains may be regarded as important contributing factors in the origin of aphid fauna.

Acknowledgements

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Conflict of interest:

Authors declare that there is no conflict of interest.

Table 1. Distribution of Aphids, their host plants and their locality in Darjeeling.

Subfamily: Aphididae

| Aphid sp | Host | Locality |
|--|-------------------------------------|------------|
| <i>Acyrtosiphon rubi elliptici</i> Stroyan and Nagaich | <i>Rubus</i> sp. | Mirik |
| <i>Akkaia bengalensis</i> Basu, A.N | <i>Polygonum</i> sp. | Kalimpong |
| <i>Amphicercdus indicus</i> Basu, A.N | <i>Lonicera glabrata</i> | Darjeeling |
| <i>Amphorophora ampullata bengalensis</i> Basu, A.N | Ferns | Kalimpong |
| <i>Amphorophora ampullata bengalensis</i> Basu, A.N | Ferns | Darjeeling |
| <i>Anthracosiphoniella maculatum</i> Basu, A.N | Fern | Darjeeling |
| <i>Aphis citricola</i> v.d.G | <i>Capsicum frutescens</i> | Kalimpong |
| <i>Aphis craccivora</i> Koch | <i>Ipomia balsamina</i> | Kalimpong |
| <i>Aphis craccivora</i> Koch | <i>Solanum arvensis</i> | Kalimpong |
| <i>Aphis craccivora</i> Koch | <i>Artemisia vulgaris</i> | Kalimpong |
| <i>Aphis craccivora</i> Koch | <i>Dolichos lablab</i> | Kalimpong |
| <i>Aphis craccivora</i> Koch | <i>Vicia faba</i> | Darjeeling |
| <i>Aphis fabae solanella</i> Theobald | <i>Solanum niagrum</i> | Kalimpong |
| <i>Aphis gossypii</i> Glover | <i>Ageratum conyzoides</i> | Darjeeling |
| <i>Aphis gossypii</i> Glover | <i>Capsicum frutescens</i> | Kalimpong |
| <i>Aphis gossypii</i> Glover | <i>Galinsuga parviflora</i> | Kalimpong |
| <i>Aphis gossypii</i> Glover | <i>Tagetes patula</i> | Kalimpong |
| <i>Aphis kurosawai</i> Takahashi | <i>Artemisia vulgaris</i> | Kalimpong |
| <i>Aphis ruborum longisetosus</i> Basu, A.N | <i>Rubus lineatus</i> | Darjeeling |
| <i>Aphis spiraecola</i> Patch | <i>Bidens pilosa</i> | Kalimpong |
| <i>Aulacorthum dendrobii</i> Basu, A.N | <i>Dendrobium</i> sp. | Darjeeling |
| <i>Aulacorthum (Perillaaphis) perillae</i> (Shinji) | <i>Perilla frutescens</i> | Kalimpong |
| <i>Aulacorthum anthraxoni</i> (Takahashi) | Grass | Kalimpong |
| <i>Aulacorthum dicentrae</i> Basu, A.N | <i>Dicentra thalictifolia</i> | Darjeeling |
| <i>Aulacorthum magnoliae</i> (Essing and Kuwana) | <i>Sechium edule</i> | Kalimpong |
| <i>Aulacorthum magnoliae</i> (Essing and Kuwana) | <i>Cucarbita moschata</i> | Kalimpong |
| <i>Aulacorthum nipponicum</i> (Essing and Kuwana) | <i>Paederia foetida</i> | Kalimpong |
| <i>Aulacorthum solani</i> (Kaltb.) | <i>Poa</i> sp. | Kalimpong |
| <i>Aulacorthum solani</i> (Kaltb.) | <i>Solanum tuberosum</i> | Kalimpong |
| <i>Aulacorthum solani</i> (Kaltb.) | <i>Oxalis</i> sp. | Kalimpong |
| <i>Brachycaudus helichrysi</i> (Kaltb) | <i>Prunus persica</i> | Kalimpong |
| <i>Brachycaudus helichrysi</i> (Kaltb.) | <i>Gynura angutosa</i> | Kalimpong |
| <i>Brachycaudus</i> sp. | <i>Crotolaria saltiana</i> | Kalimpong |
| <i>Brachymyzus jasmini</i> Basu, A.N | <i>Jasminum humile</i> | Darjeeling |
| <i>Brachysiphoniella montana</i> (van der Goot) | <i>Eleusine</i> sp., <i>Poa</i> sp. | Kalimpong |
| <i>Cavariella nigra</i> Basu, A.N | <i>Salix elegans</i> | Darjelling |

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|--|---------------------------------|------------|
| <i>Cryptosiphum artemisiae</i> Buckton | <i>Artemisia vulgaris</i> | Kalimpong |
| <i>Dysaphis multisetosa</i> Basu, A.N | <i>Pyrus communis</i> | Kalimpong |
| <i>Haythurstia atriplicis</i> (Linnaeus) | <i>Chenopodium album</i> | Kalimpong |
| <i>Hillerislambersia darjeelingi</i> Basu, A.N | <i>Lonicera</i> sp. | Darjeeling |
| <i>Hyalomyzus</i> sp. | <i>Rubus</i> sp. | Mirik |
| <i>Hyalopterus pruni</i> (Geoffroy) | <i>Aurondo donox</i> | Sukna |
| <i>Impatientinum smilaceti</i> (Agarwala et al) | <i>Salix macrophylla</i> | Kalimpong |
| <i>Indiaphis crassicornis</i> Basu, A.N | <i>Rhododendron</i> sp. | Darjeeling |
| <i>Indiaphis setosum</i> Basu, A.N | <i>Pentapterygium serpens</i> | Permaguri |
| <i>Indomasonaphis anaphalidis</i> Basu, A.N | <i>Anaphalis triplinervis</i> | Darjeeling |
| <i>Kurisakia indica</i> Basu, A.N | <i>Engelhardtia spicata</i> | Kalimpong |
| <i>Liosmaphis himalayensis</i> Basu, A.N | <i>Berberis umbellate</i> | Darjeeling |
| <i>Lipaphis erysimi</i> (Kaltenbach) | <i>Brassica nigra</i> | Kalimpong |
| <i>Macrosiphonella pseudoartemisiae</i> Shinji | <i>Chrysanthemum coronarium</i> | Kalimpong |
| <i>Macrosiphoniella kikungshana</i> Takahashi | <i>Artemisia vulgaris</i> | Kalimpong |
| <i>Macrosiphoniella sanborni</i> Gil | <i>Chrysanthemum</i> | Darjeeling |
| <i>Macrosiphoniella spinipes</i> Basu, A.N | <i>Artemisia vulgaris</i> | Kalimpong |
| <i>Macrosiphum rosae</i> (L.) | <i>Rosa</i> sp. | Kalimpong |
| <i>Macrosiphum rosae</i> (L.) | <i>Rosa</i> sp. | Darjeeling |
| <i>Megoura abnormis</i> Basu, A.N | <i>Unidentified leguminosae</i> | Kalimpong |
| <i>Megoura pallipes</i> Basu,A.N | <i>Indigofera teysmanni</i> | Mirik |
| <i>Megoura pallipes</i> Basu,A.N | <i>Indigofera teysmanni</i> | Darjeeling |
| <i>Metopolophium (Microlophium) darjeeligenese lacheni</i> | <i>Rubus</i> sp. | Darjeeling |
| <i>Micromyzus kalimpongensis</i> Basu, A.N | <i>Hedychium coronarium</i> | Kalimpong |
| <i>Myzackaia himalayensis</i> Basu, A.N | <i>Polygonum</i> sp. | Darjeeling |
| <i>Myzackaia himalayensis</i> Basu, A.N | <i>Polygonum</i> sp. | Kalimpong |
| <i>Myzackaia polygonicola</i> Basu, A.N | <i>Polygonum runcinatum</i> | Dajeeling |
| <i>Myzus (Sciomyzus) cymbalariae</i> Stroyan | <i>Solanum</i> sp. | Darjelling |
| <i>Myzus brevisiphon</i> Basu, A.N | <i>Polygonum capitatum</i> | Darjeeling |
| <i>Myzus ornatus</i> Laing | <i>Cineraria</i> sp. | Darjeeling |
| <i>Myzus ornatus</i> Laing | <i>Dahlia</i> sp. | Kalimpong |
| <i>Myzus ornatus</i> Laing | <i>Gladiolus</i> sp. | Mirik |
| <i>Myzus ornatus</i> Laing | <i>Fragaria</i> sp. | Mirik |
| <i>Myzus ornatus</i> Laing | <i>Solanum aurantiacum</i> | Darjeeling |
| <i>Myzus ornatus</i> Laing | <i>Viola tricolor</i> | Kalimpong |
| <i>Myzus persicae</i> (Sulzer) | <i>Solanum niagrum</i> | Kalimpong |
| <i>Myzus persicae</i> (Sulzer) | <i>Foeniculum vulgare</i> | Kalimpong |
| <i>Myzus persicae</i> (Sulzer) | <i>Gynura angutosa</i> | Kalimpong |

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|---|-------------------------------|-------------|
| <i>Oedisiphum soureni</i> Basu, A.N | <i>Anaphalis triplinervis</i> | Darjelling |
| <i>Pentalonia nigronevosa</i> Coquerel | <i>Musa</i> sp. | Kalimpong |
| <i>Pseudoacyrthosiphon holsti</i> (Takahashi) | <i>Rhododendron</i> sp. | Darjeeling |
| <i>Rhodobium porosum</i> (Sanderson) | <i>Rosa</i> sp. | Kalimpong |
| <i>Rhopalosiphum maidis</i> (Fitch) | <i>Zea mays</i> | Kalimpong |
| <i>Rhopalosiphum maidis</i> (Fitch) | <i>Hordeum vulgare</i> | Kalimpong |
| <i>Schizaphis graminum</i> (Rondani) | Unidentified grass | Darjeeling |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Chegra |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Kalimpong |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Pedong |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Plungdung |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Pokhriabong |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Darjeeling |
| <i>Shinjia pteridifoliae</i> (Shinji) | Unidentified ferns | Lebong |
| <i>Sinomegoura photinae</i> Takahashi | <i>Photinia integrifolia</i> | Darjeeling |
| <i>Sitobion indicum</i> Basu, A.N | <i>Cymbidium</i> sp. | Darjeeling |
| <i>Sitobion luteum</i> (Buckton) | <i>Cymbidium</i> sp. | Kalimpong |
| <i>Sitobion luteum</i> (Buckton) | <i>Dendrobium</i> sp. | Kalimpong |
| <i>Sitobion miscanthi</i> Takahashi | <i>Hordeum vulgare</i> | Darjeeling |
| <i>Sitobion rosaeformis</i> (Das) | <i>Rosa cania</i> | Darjeeling |
| <i>Stobion rosaeformis</i> (Das) | <i>Rosa</i> sp. | Kalimpong |
| <i>Subovatomyzus leucosceptri</i> Basu, A.N | <i>Turnera</i> sp. | Kalimpong |
| <i>Subovatomyzus leucosceptri</i> Basu, A.N | <i>Leucosceptrum canum</i> | Darjeeling |
| <i>Toxoptera aurantii</i> (B.D.Fonscolombe) | <i>Schima wallichii</i> | Kalimpong |
| <i>Tricaudatus polygoni tuberculatus</i> (Narzykulov) | <i>Polygonum molle</i> | Darjeeling |
| <i>Tricaudatus polygoni tuberculatus</i> (Narzykulov) | <i>Spiraea corymbosa</i> | Darjeeling |
| <i>Trichosiphoniella polygoniformosanas</i> (Takahashi) | <i>Polygonum perfoliatum</i> | Kalimpong |
| <i>Trichosiphoniella sasaki</i> (Matsumura) | <i>Artemisia vulgaris</i> | Kalimpong |
| <i>Uroleucon tanacetii indica</i> Basu, A.N | Unidentified plant | Darjeeling |
| <i>Vesiculaphis caricis</i> (Fullaway) | <i>Cyperus rotundus</i> | Kalimpong |
| <i>Vesiculaphis grandis</i> Basu, A.N | <i>Rhododendron</i> sp. | Darjeeling |
| <i>Vesiculaphis pieridis</i> Basu, A.N | <i>Pieris ovalifolia</i> | Darjeeling |

Subfamily: Calaphidinae

| | | |
|---|-------------------------|------------|
| <i>Taoia indica</i> Ghosh & Raychudhuri | <i>Alnus</i> sp. | Darjeeling |
| <i>Taoia indica</i> Ghosh & Raychudhuri | <i>Alnus nepalensis</i> | Kalimpong |
| <i>Taoia indica</i> Ghosh & Raychudhuri | <i>Alnus nepalensis</i> | Chegra |
| <i>Taoia indica</i> Ghosh & Raychudhuri | <i>Alnus nepulus</i> | Mirik |

Subfamily: Drepanosiphinae

| | | |
|---|-----------------------|------------|
| <i>Neobetulaphis pusilla</i> , Basu,A.N | <i>Betula utilis</i> | Darjeeling |
| <i>Tinocalloides montanus</i> Basu,A.N | <i>Prunus cerasus</i> | Kalimpong |

Subfamily: Greenidinae

| | | |
|--|--------------------------|------------|
| <i>Eutricosiphum alnifoliae</i> Basu, A.N | <i>Alnus nepalensis</i> | Kalimpong |
| <i>Eutricosiphum alnifoliae</i> Basu, A.N | <i>Alnus nepalensis</i> | Darjeeling |
| <i>Greenidea (T.) formosanum heeri</i> Rachaudhuri et al | <i>Psidium guajava</i> | Darjeeling |
| <i>Greenidea (T.) formosanum heeri</i> Raychaudhuri et al | <i>Psidium guajava</i> | Kalimpong |
| <i>Greenidea (T.) formosanum heeri</i> Raychaudhuri et al | <i>Psidium guajava</i> | Mirik |
| <i>Greenidea longirostris</i> Basu, A.N | <i>Schima wallichii</i> | Kalimpong |
| <i>Greenidea longirostris</i> Basu, A.N | <i>Schima wallichii</i> | Darjeeling |
| <i>Greenideodia lambersi</i> Basu, A.N | <i>Hymenodictyon</i> sp. | Kalimpong |
| <i>Mollitricosiphum</i> sp. | <i>Alnus nepalensis</i> | Kalimpong |
| <i>Mollitricosiphum (Metatricosiphum) nandii</i> Basu, A.N | <i>Alnus nepalensis</i> | Kalimpong |
| <i>Paratricosiphum javanicum</i> Raychaudhuri | <i>Alnus nepalensis</i> | Darjeeling |
| <i>Pentatricosiphum luteum</i> Basu, A.N | <i>Litsea polyantha</i> | Mirik |

Subfamily: Hormaphidinae

| | | |
|--|----------------------------|-------------|
| <i>Cerataphis orchidearum</i> (Westwood) | <i>Aerides feildeingii</i> | Darjeelling |
| <i>Ceratovacuna sylvestrii</i> (Takahashi) | <i>Bambusa</i> sp. | Coochbehar |
| <i>Ceratovacuna sylvestrii</i> (Takahashi) | <i>Bambusa</i> sp. | Soreang |
| <i>Chitoregma tattakana</i> (Takahashi) | <i>Arundinaria</i> sp. | Darjeelling |
| <i>Pseudoregma alexanderi</i> (Takahashi) | <i>Bambusa</i> sp. | Kalimpong |
| <i>Pseudoregma alexanderi</i> (Takahashi) | <i>Bambusa</i> sp. | Pedong |
| <i>Pseudoregma alexanderi</i> (Takahashi) | <i>Bambusa</i> sp. | Mirik |
| <i>Pseudoregma alexendari</i> (Takahashi) | <i>Bambusa</i> sp. | Darjeeling |
| <i>Pseudoregma panicola</i> (Takahashi) | <i>Panicum</i> sp. | Darjeeling |
| <i>Pseudoregma panicola</i> (Takahashi) | <i>Panicum</i> sp. | Kalimpong |
| <i>Pseudoregma panicola</i> (Takahashi) | <i>Panicum</i> sp. | Pedong |
| <i>Pseudoregma panicola</i> (Takahashi) | <i>Panicum</i> sp. | Soreang |
| <i>Tuberoaphis hydrangeae digitata</i> H.R.L & Basu, A.N | <i>Hydrangea robusta</i> | Darjeeling |

Subfamily: Lachninae

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|--|----------------------------|------------|
| <i>Cinara cupressi</i> (Buckton) | <i>Juniperus recarva</i> | Kalimpong |
| <i>Cinara tujafilina</i> (Del Guercio) | <i>Cupressus</i> sp. | Kalimpong |
| <i>Nippolachnus bengalensis</i> Basu, A.N | <i>Eribotrya dubia</i> | Darjeeling |
| <i>Nippolachnus himalayensis</i> (Van der Goot,1917) | <i>Eribotrya petiolata</i> | Darjeeling |
| <i>Nippolachnus piri</i> Matsumura | <i>Pyrus communis</i> | Darjeeling |
| <i>Tuberolachnus (Tuberoplachniella) sclerata</i> Basu, A.N. | <i>Eribotrya petiolata</i> | Darjeeling |

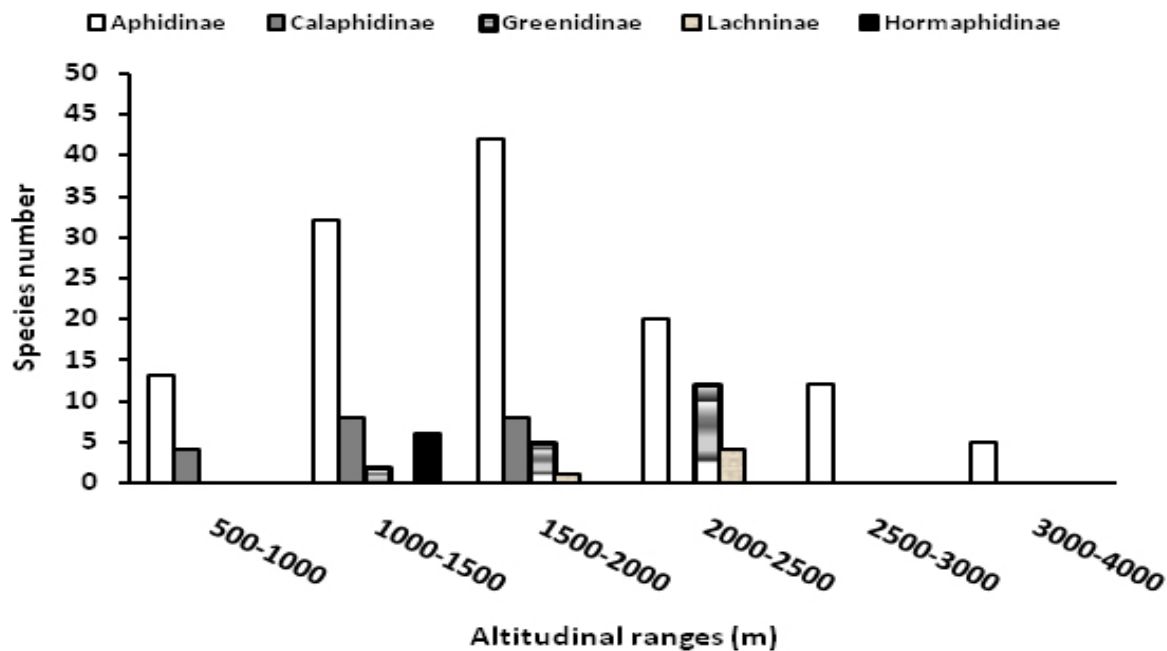


Fig. 1. Association of aphids in different altitudes.

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