Entomology

Association of the aphids (Insecta: Homoptera: Aphididae) with pteridophytes and gymnosperms of India

Rajendra Singh[1*] and Abhilasha Srivastava[1]

Department of Zoology, Deen Dayal Upadhyay Gorakhpur University, Gorakhpur, Uttar Pradesh, India

Correspondence Author: Rajendra Singh

Received 24 Aug 2022; Accepted 5 Oct 2022; Published 29 Oct 2022

Abstract

The paper deals with the association of aphids with two major groups of plants, pteridophytes and gymnosperms in India. Of the 597 species grouped into 10 families of the pteridophytes, 30 species of plants are colonised by 20 species of aphids under 16 genera. Among them, the Pteridaceae are more vulnerable to aphid attack (17 species of plants infested by 11 species of aphids). Similarly, of the 104 species grouped into 5 families of the gymnosperms, 24 species of plants are colonised by 42 species of aphids under 13 genera. Among them, the Pinaceae are more susceptible to aphid attack (12 species of plants infested by 32 species of aphids). Out of 61 species of the aphids recorded on pteridophytes and gymnosperms, 58 species are almost monophagous. Highly polyphagous species are *Micromyzodium filicium* David (12 plant species belonging to 8 genera and 4 families), followed by *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu (6 plant species belonging to 6 genera and 3 families) and *Cinara (Cinara) atrotibialis* David & Rajasingh (6 plant species belonging to 3 genera and 2 families). Most of the pteridophytes are associated with the aphids belonging to the subfamily Aphidinae while the gymnosperms are infested by the aphids belonging to the subfamily Lachninae.

Keywords: aphids, aphididae, checklist, gymnosperms, host-plant association, lycophytes, pteridophytes

Introduction

The tracheophytes, also known as vascular plants, have lignified tissues, the xylem, for conducting water and minerals throughout the plant; and also have a specialized non-lignified tissue, the phloem, to conduct products of photosynthesis. These plants include the lycophytes and ferns (Group: Pteridophyta); conifers, cycads, Ginkgo, and gnetophytes (Group: Gymnospermae); and flowering plants (Group: Angiospermae). The pteridophytes are free-sporing vascular plant neither producing flowers nor seeds and include ferns and lycophytes. They have a life cycle with alternating, free-living gametophyte and sporophyte phases (well differentiated into adventitious roots, stem and leaves) that are independent at maturity. The pteridophytes include two separate but related classes: Lycopodiopsida (include clubmosses, spikemosses, quillworts, scale trees) and Polypodiopsida. Lycopodiopsida (lycophytes) comprises three extant orders and families: Isoetales (Isoetaceae), Lycopodiales (Lycopodiaceae) and Selaginellales (Selaginellaceae). In India, the lycophytes are represented by several species distributed throughout the country, e.g. Isoetaceae (23 species) [1], Lycopodiaceae (52 species) [2], and Selaginellaceae (62 species) [3]. The class Polypodiopsida includes all ferns under 48 families. The gymnosperms unlike pteridophytes are a group of naked seed-producing vascular plants that comprise conifers, cycads, Ginkgo, and gnetophytes. The seeds of gymnosperms develop either on the surface of scales or leaves, which are often modified to form cones, or solitary. The gymnosperms also have a dominant diploid sporophyte phase and a reduced haploid gametophyte phase which is dependent on the sporophytic phase. The extant gymnosperms comprise 12 main families and 83 genera which contain more than 1000 known species [4].

The aphids (Hemiptera: Aphididae) are small, soft-bodied, plant sap-sucking insects. They are cosmopolitan in distribution but most abundant in temperate climates. More than 250 species of aphids are agricultural and horticultural crop pests [5]. They are injurious to the plants by sucking their nutrients, by secreting high amount of honeydew that blocks stomata hampering normal plant physiology, and by transmitting hundreds of viral diseases [6]. Small size, thelytokous parthenogenetic viviparity, complex life-cycles with alternation of sexual and asexual generations, host plant alternation, polymorphism, short and telescopic generations are the major traits that make aphids highly prolific in reproduction [7]. At present all true aphids belong to a single family Aphididae which consists of 23 subfamilies, and 5109 species under 527 genera [8]. In India, 794 species of aphids under 208 genera are reported out of which about 385 are endemic [9].

The cataloguing of aphid and its host plants is essential as several aphid species are known to destroy the agricultural and horticultural crops in India and abroad not only by sucking their saps but also by transmitting several viral diseases [10]. Raychaudhury [11] was the first to catalogue the food plants of Indian aphids updated by Chakrabarti and Sarkar [12]. Later on, Singh & Singh [13-24] updated the food plant catalogue of Indian species of aphids (aphid family-wise) in series of articles. The present paper deals with the association of aphids with the plants belonging to the Lycopodiopsida, Polypodiopsida and gymnosperms of India.

Materials and Methods

The aphid and host plant records in this checklist are taken from a wide variety of resources such as books, journals, proceedings and a few authentic theses and websites up to September 15, 2022, unavoidably including some percentage of misidentifications, both of aphids and their host plants. Some aphid species may also be vagrant individuals. In older literature, several errors crept in the scientific names of both the aphids and plants and even in the recent ones as such contents become outdated quickly and, due to their perceived comprehensiveness, authors often overlook newer sources of data. The names of aphids, as well as plants that were misspelt in the original records have been corrected where we logically ascertain the intended species. Also, the research on aphid taxonomy as well as their host plants is continuous with the description of new taxa, the modified status of others, and the publication of other nomenclatural decisions [25]. In the present checklist, attempts have been made to provide the valid scientific names of the aphids following [8], and of the plants, following [26]. In the first inventory of plant names, their synonyms recorded in India are also provided. Only 1-2 references of each record were cited.

Results and Discussion

Of the 597 species grouped into 10 families of the pteridophytes, represented in India, 30 species of plants are colonised by 20 species of aphids under 16 genera. Among them, the plants belonging to the family Pteridaceae are more vulnerable to aphid attack (17 species of plants infested by 11 species of aphids), followed by Aspleniaceae (4 species of plants infested by 9 species of aphids) (Table 1). Similarly, of the 104 species grouped into 5 families of the gymnosperms, represented in India, 24 species of plants are colonised by 42 species of aphids under 13 genera (Table 1). Among them, the plants belonging to the family Pinaceae are more susceptible to aphid attack (12 species of plants infested by 32 species of aphids), followed by Cupressaceae (8 species of plants infested by 7 species of aphids).

Table 1: Number of plant species belonging to the different orders/families of the pteridophytes and gymnosperms infested by different species of aphids in India

Clades/Divisions	Orders	Families	Plants		Aphids	
			Genera	Species	Genera	Species
Pteridophytes						
Lycopodiopsida	Selaginellales	Selaginellaceae	1	1	1	1
Polypodiopsida	Gleicheniales	Gleicheniaceae	1	1	1	1
	Polypodiales	Aspleniaceae	1	4	8	9
		Athyriaceae	1	1	3	5
		Dennstaedtiaceae	1	1	1	1
		Nephrolepidaceae	1	1	1	1
		Polypodiaceae	1	1	1	1
		Pteridaceae	6	18	11	12
		Thelypteridaceae	1	1	1	1
	Salviniales	Salviniaceae	2	2	1	1
	Total		16	30	17	20
Gymnosperms						
Pinophyta	Cupressales	Araucariaceae	1	1	1	1
		Cupressaceae	6	8	4	7
		Podocarpaceae	1	1	1	1
		Taxaceae	1	1	3	3
	Pinales	Pinaceae	5	12	13	32
Gnetophyta	Gnetales	Ephedraceae	1	1	1	1
	Total		15	24	17	42
	Grand Total		32	54	32	62

Out of 62 species of the aphids recorded on pteridophytes and gymnosperms, 58 species are almost monophagous, feeding on 1-4 plant species belonging to 1-2 families, and the remaining 3 species are polyphagous, feeding on 6-12 plant species belonging to 3-4 families. Highly polyphagous species are *Micromyzodium filicium* David (12 plant species belonging to 8 genera and 4 families), followed by *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu (6 plant species belonging to 6 genera and 3 families) and *Cinara (Cinara) atrotibialis* David & Rajasingh (6 plant species belonging to 3 genera and 2 families) (Table 2).

Table 2: Number of orders, families, genera and species of plants belonging to the pteridophytes and gymnosperms infested by different species of aphids in India

Subfamily/Aphid species	Plants infested by aphids			
	Orders	Families	Genera	Species
Subfamily: Aphidinae				
1. *Amphorophora (Amphorophora) ampullata ampullata*	1	1	1	1
2. *Amphorophora (Amphorophora) ampullata bengalensis*	2	3	6	6
3. *Aphis (Aphis) gossypii*	2	2	2	2
4. *Aphis (Aphis) spiraecola*	1	1	2	2

5. *Aphis (Aphis) verbasci*	1	1	1	1
6. *Aphis (Toxoptera) aurantii*	1	1	1	1
7. *Brachycaudus (Brachycaudus) helichrysi*	1	1	1	1
8. *Ephedraphis ephedrae*	1	1	1	1
9. *Hyperomyzus (Hyperomyzus) lactucae*	1	1	1	1
10. *Macromyzella polypodicola*	1	3	3	3
11. *Macromyzus (Anthracosiphoniella) maculatus*	1	2	2	2
12. *Macromyzus (Macromyzus) manoji*	1	1	1	1
13. *Macromyzus (Macromyzus) woodwardiae*	1	2	3	3
14. *Macrosiphum (Macrosiphum) rosae*	1	1	1	1
15. *Megoura dooarsis*	1	1	1	1
16. *Micromyzella judenkoi*	1	2	3	4
17. *Micromyzodium dasi*	1	1	2	2
18. *Micromyzodium filicium*	1	4	8	12
19. *Micromyzus niger*	1	1	2	2
20. *Myzakkaia verbasci*	1	1	1	1
21. *Myzus (Nectarosiphon) persicae*	1	1	1	1
22. *Myzus (Myzus) ornatus*	1	1	1	1
23. *Neomyzus circumflexus*	1	1	1	1
24. *Pentalonia nigronervosa*	1	1	1	1
25. *Rhopalosiphum nymphaeae*	1	1	2	2
26. *Rhopalosiphum rufiabdominale*	1	1	1	1
27. *Shinjia orientalis*	1	1	3	3
28. *Sinomegoura citricola*	1	1	1	1
29. *Taiwanomyzus himalayensis*	1	1	1	1
Subfamily: Lachninae				
30. *Cinara (Cinara) atroalbipes*	1	1	3	3
31. *Cinara (Cinara) atrotibialis*	2	2	3	6
32. *Cinara (Cinara) chaetorostrata*	1	1	1	1
33. *Cinara (Cinara) comata*	1	1	2	2
34. *Cinara (Cinara) confinis*	2	2	3	4
35. *Cinara (Cinara) curvipes*	1	1	1	1
36. *Cinara (Cinara) eastopi*	1	1	1	1
37. *Cinara (Cinara) lachnirostris*	1	1	2	3
38. *Cinara (Cinara) maculipes*	1	1	1	2
39. *Cinara (Cinara) nr. schimitscheki*	1	1	1	1
40. *Cinara (Cinara) pinea*	1	1	1	1
41. *Cinara (Cinara) takahashii*	1	1	1	1
42. *Cinara (Cinara) tenuipes*	1	1	2	2
43. *Cinara (Cinara) tistaensis*	1	1	1	1
44. *Cinara (Cupressobium)asishghoshi*	1	1	1	1
45. *Cinara (Cupressobium) cupressi*	1	1	1	1
46. *Cinara (Cupressobium) himalayaensis*	1	1	1	1
47. *Cinara (Cupressobium) tujafilina*	1	1	4	4
48. *Cinara (Schizolachnus) orientalis*	1	1	1	1
49. *Eulachnus pumilae*	1	1	1	1
50. *Eulachnus rileyi*	1	1	1	1
51. *Eulachnus thunbergii*	1	1	1	3
52. *Lachnus tropicalis*	1	1	2	2
53. *Nippolachnus bengalensis*	1	1	1	1
54. *Nippolachnus piri*	1	1	1	1
55. *Pseudessigella brachychaeta*	1	1	1	1
56. *Stomaphis (Stomaphis) mordvilkoi*	1	1	1	1
Subfamily: Eriosomatinae				
57. *Eriosoma longipilosum*	1	1	1	1
58. *Pemphigus* sp.	1	1	1	1
59. *Prociphilus (Prociphilus) taxus*	1	1	1	1
60. *Prociphilus (Stagona) himalayaensis*	1	1	1	1
Subfamily: Mindarinae				
61. *Mindarus abietinus*	1	1	2	2
62. *Mindarus japonicus*	1	1	2	2

It is interesting to note that the aphid species infesting pteridophytes are almost different species of those infesting gymnosperms because of nutritional quality of these plants. Most of the pteridophytes are associated with the aphids

belonging to the subfamily Aphidinae while the gymnosperms are infested by the aphids belonging to the subfamily Lachninae. Two species of aphids, *Aphis (Aphis) gossypii* Glover (513 species of plants belonging to 110 families) [24, 27] and *Aphis (Aphis) spiraecola* Patch (278 species of plants belonging to 68 families) [14] infesting gymnosperms; and *Myzus (Nectarosiphon) persicae* (Sulzer) (293 species of plants belonging to 64 plant families) [28] infesting pteridophytes are highly polyphagous species.

The updated checklist of aphids infesting the plants belonging to the abovementioned groups/class/orders/families are given below:

Group: Pteridophytes (Polypodiophyta)

The pteridophytes include two classes: Lycopodiopsida and Polypodiopsida.

A. Class: Lycopodiopsida: Lycopodiopsida is a group of herbaceous vascular plants, commonly called as lycopods, lycophytes or clubmosses, firmosses, spikemosses and quillworts. The lycopods include three monotypic orders, Isoetales, Lycopodiales, and Selaginalles, each having single family. In India, the aphids are associated with only one family Selaginellaceae.

I. Order: Selaginellales, Family: Selaginellaceae:

The order Selaginellales is a montypic order containing single family Selaginellaceae and the members are commonly called as spikemosses or lesser clubmosses. In India, Selaginellaceae is represented by 66 species [3, 29, 30] out of which only one unidentified species of *Sellaginella* P. Beauv. was recorded as host plant of a single species of aphid, *Pentalonia nigronervosa* Coquerel, 1859 [31, 32].

B. Class: Polypodiopsida: All the ferns belong to the class Polypodiopsida comprising four subclasses: Equisetidae, Marattiidae, Ophioglossidae and Polypodiidae, however, in India, aphids are associated with only 3 orders of Polypodiidae (Gleicheniales, Polypodiales and Salviniales) out of 7 orders of this subclass as mentioned below.

I. Order: Gleicheniales, Family: Gleicheniaceae: The aphids are associated with its type family Gleicheniaceae, also known as the forked ferns family. It includes six genera and about 176 known species [26]. However, only a single species of aphid, *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu, 1966 is associated with an unidentified species of the genus *Gleichenia* Sm. [33] out of 7 species known [34].

II. Order: Polypodiales

The order Polypodiales includes the majority (26 families) of polypod ferns, and mostly distributed in tropical, semitropical and temperate region of the world. However, only following members of 7 families, Aspleniaceae, Athyriaceae, Dennstaedtiaceae, Nephrolepidaceae, Polypodiaceae, Pteridaceae and Thelypteridaceae are associated with several species of aphids as stated below.

1. Family: Aspleniaceae: The Aspleniaceae, commonly called as spleenworts, is worldwidely distributed both in tropical and temperate regions; more-or-less equal numbers of terrestrial and epiphytic species; and less often they are aquatic, growing in moving water [35]. It includes 3 genera and more than 1200 species globally [26]. However, in India, out of 81 species of *Asplenium* L. [36], only 4 species are associated with 9 species of aphids as mentioned below.

1. *Asplenium adiantum-nigrum* L.

- *Macromyzus (Macromyzus) woodwardiae* (Takahashi, 1921) [37, 38]

2. *Asplenium auriculatum* Sw.

- *Macromyzus (Macromyzus) woodwardiae* (Takahashi, 1921) [38]

3. *Asplenium dalhousieae* Hook.

- *Taiwanomyzus himalayensis* (Chakrabarti & Banerjee, 1989) [39]

4. *Asplenium trichomanes* L.

- *Megoura dooarsis* (Ghosh & Raychaudhuri, **19**69) [40]
- *Micromyzodium filicium* David, 1958 [41, 42]

5. *Asplenium* spp.

- *Amphorophora (Amphorophora) ampullata ampullata* Buckton, 1876 [41]
- *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu, **19**66 [37, 40]
- *Macromyzella polypodicola* (Takahashi, 1921) [37]
- *Macromyzus (Macromyzus) woodwardiae* (Takahashi, 1921) [37, 42]
- *Micromyzella judenkoi* (Carver, 1965) [37]
- *Myzakkaia verbasci* (Chawdhuri, Basu, Chakrabarti & Raychaudhuri, 1969) [40]

b. Family: Athyriaceae: The Athyriaceae includes the ladyferns and allies with a cosmopolitan distribution. They are terrestrial or lithophytic, less commonly aquatic. Out of more than 500 hundred species described under 3 genera in the family [26], 67 species and hybrids are known in India [43]. Among them, only one species of a single geneus *Diplazium* Sw. was recorded as host plant by 4 species of aphids as mentioned below.

1. *Diplazium esculentum* (Retz.) Sw. (syn. *Asplenium esculentum* (Retz.))

- *Macromyzella polypodicola* (Takahashi, 1921) [38, 44]
- *Macromyzus (Anthracosiphoniella) maculatus* Basu, 1969 [37, 42]
- *Macromyzus (Macromyzus) manoji* Raha & Raychaudhuri, 1978 [44]
- *Macromyzus (Macromyzus) woodwardiae* (Takahashi, 1921) [37, 44]

c. Family: Dennstaedtiaceae: Dennstaedtiaceae comprises 10 genera with about 290 known species [26]. They are either terrestrial or scrambling over rocks or stones or occasionally over other vegetation (epiphytic). In India, among the 60 species described under 7 genera [36], only one species, *Hypolepis polypodioides* Hook. was reported as host plant of a single species of aphid, *Amphorophora (Amphorophora) ampullata* Buckton, 1876 [45].

d. Family: Nephrolepidaceae: *Nephrolepis* Schott. is a monotypic genus of the family containing about 60 species of ferns commonly known as macho ferns or Boston ferns [26] and distributed in tropical to subtropical regions around the world. However, Among them, only one unidentified species of *Nephrolepis* was recorded as host plant by a single species of aphid, *Micromyzodium filicium* David,

1958 [42, 46], though 6 species are known from India [47].

e. Family: Polypodiaceae: The family Polypodiaceae includes common ferns comprising about 32 genera and over 2000 species [26]. Almost all species are epiphytic, only few are terrestrial in the tropical and subtropical evergreen and semi-evergreen forests. The family is represented in India by 27 genera and 106 species [48]. However, only one species, *Goniophlebium argutum* J. Sm. in Hk. (syn. *Polypodium argutum* Wall.) is known as host plant of a single species of aphid, *Aphis (Toxoptera) aurantii* Boyer de Fonscolombe, 1841 [49].

f. Family: Pteridaceae: The maidenhair fern family Pteridaceae comprises some 1150 known species in about 45 genera [4]. In India, it is represented by 11 genera and 126 species [36], out of which 17 species under 6 genera are associated with 11 species of aphids belonging to 10 genera. *Micromyzodium filicium* David, 1958 alone infests 10 species of plants of this family as mentioned below.

1. *Adiantum capillus-veneris* L.
- *Aphis (Aphis) gossypii* Glover, 1877 [50]

2. *Adiantum caudatum* L.
- *Micromyzella judenkoi* (Carver, 1965) [12]
- *Micromyzodium dasi* Verma, 1970 [51]
- *Micromyzodium filicium* David, 1958 [12]

3. *Adiantum cordatum* Maxon
- *Myzus (Nectarosiphon) persicae* (Sulzer, 1776) [52]

4. *Adiantum raddianum* C. Presl (syn. *Adiantum cuneipinnulum* N.C.Nair & S.R.Ghosh)
- *Micromyzodium filicium* David, 1958 [53]

5. *Adiantum raddianum* C. Presl (syn. *Adiantum tinctum* T. Moore)
- *Micromyzodium filicium* David, 1958 [41, 42]

6. *Eriosorus* sp.
- *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu, 1966 [52]
- *Macromyzus (Anthracosiphoniella) maculatus* Basu, 1969 [52]
- *Micromyzodium filicium* David, 1958 [41]
- *Micromyzus niger* van der Goot, 1917 [52]
- *Shinjia orientalis* (Mordvilko, 1929) [52]

7. *Hemionitis decomposita* (M.Martens & Galeotti) Christenh.
- *Micromyzella judenkoi* (Carver, 1965) [37, 44]

8. *Hemionitis farinosa* (Forssk.) Christenh. (syn. *Cheilanthes farinosa* (Forssk.) Kaulf.)
- *Macromyzella polypodicola* (Takahashi, 1921) [54]
- *Micromyzus niger* van der Goot, 1917 [54]

9. *Hemionitis marginata* (Kunth) Christenh. (syn. *Cheilanthes marginata* Kunth)
- *Micromyzodium filicium* David, 1958 [55]

10. *Hemionitis michelii* (Christ) Christenh. (syn. *Cheilanthes argentea* (S.G.Gmel.) Kunze)
- *Micromyzella judenkoi* (Carver, 1965) [56]

11. *Hemionitis* sp.
- *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu, **19**66 [37, 41]
- *Macrosiphum (Macrosiphum) rosae* (Linnaeus, 1758) [53]
- *Micromyzella judenkoi* (Carver, 1965) [41, 42]
- *Micromyzodium dasi* Verma, 1970 [12, 51]
- *Micromyzodium filicium* David, 1958 [12]

12. *Pityrogramma chrysophylla* Link
- *Micromyzodium filicium* David, 1958 [37]

13. *Pityrogramma ebenea* (L.) Proctor (syn. *Gymnogramma peruviana* Desv., *Pityrogramma peruviana* Maxon)
- *Micromyzodium filicium* David, 1958 [42, 46]

14. *Pteridium aquilinum* (L.) Kuhn (syn. *Pteris aquilina* L.)
- *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu, **19**66 [37, 41]
- *Shinjia orientalis* (Mordvilko, 1929) [41, 57]

15. *Pteridium* sp.
- *Shinjia orientalis* (Mordvilko, 1929) [58]

16. *Pteris cretica* L.
- *Micromyzodium filicium* David, 1958 [41, 42]

17. *Pteris longifolia* L.
- *Micromyzodium filicium* David, 1958 [12]

18. *Pteris ovalifolia* ?
- *Shinjia orientalis* (Mordvilko, 1929) [57, 59]

19. *Pteris* sp.
- *Amphorophora (Amphorophora) ampullata bengalensis* Hille Ris Lambers & Basu, 1966 [52]
- *Eriosoma longipilosum* Chakrabarti & Raychaudhary, 1975 [57]
- *Shinjia orientalis* (Mordvilko, 1929) [12, 37]

g. Family: Thelypteridaceae: It is a family of marsh ferns containing 4 genera and more than known 1250 species [26]. Most of these frns are terrestrial, and most occur in moist or wet habitats in tropical and temperate regions of the world. In India, 73 species are recognized [36], among them only one unidentified species of the genus *Thelypteris* (syn. *Lastrea* sp.) is used as host by a single species of aphid, *Micromyzodium filicium* David, 1958 [41, 42].

III. Order: Salviniales

The order Salviniales consists of only two families, Marsileaceae and Salviniaceae.

a. Family: Salviniaceae: The family Salviniaceae commonly known as heterosporous ferns contain only 2 genera *Azolla* (7 species) and *Salvinia* (16 species) [26]. In India, 2 species of *Azolla* and 3 species of *Salvinia* are recorded in aquatic habitat [60], out of which one species of each are infested by a single aphid species as given below.

1. *Azolla pinnata* R. Br.
- *Rhopalosiphum nymphaeae* (Linnaeus, 1761) [61]

2. *Salvinia molesta* D. Mitch.
- *Rhopalosiphum nymphaeae* (Linnaeus, 1761) [62, 63]

Group: Gymnosperms

The superdivision Spermatophyta of the clade Tracheophytes includes gymnosperms and angiosperms, the former is a relatively small and highly distinct group of naked seed-producing plants unlike the latter (angiosperms, seeds and ovules are enclosed within an ovary). It includes conifers, cycads, Ginkgo, and gnetophytes and have very ancient lineage. Their seeds develop either on the surface of scales or leaves, which are often modified to form cones, or solitary. The gymnosperms have great ecological and economical importance. The extant forms are grouped into 4 divisions, Pinophyta (conifers), Ginkgophyta (Ginkgo), Cycadophyta (Cycads) and Gnetophyta (*Gnetum*, *Ephedra*, *Welwitschia*), however, in India, aphids are associated with plants belonging to only Pinophyta and Gnetophyta.

A. Division: Pinophyta

Members of this division of Gymnospermae are commonly called as conifers and comprise a single extant class, Pinopsida. They are perennial woody plants with secondary growth. It includes cedars, Douglas-firs, cypresses, firs, junipers, kauri, larches, pines, hemlocks, redwoods, spruces, and yews. The conifers are ecologically and economically important as they provide us bulk of timber, pencil wood, paper pulp, resin, oil, tar, turpentine, medicine, food and are even used for tanning [64]. Hence, the aphid infestation of these plants is a matter of concern for silviculture also. The Pinophyta includes 2 orders, Cupressales and Pinales [26] and plants belonging to both orders are associated with aphids as stated below.

I. Order: Cupressales

It includes 5 families, Araucariaceae, Cupressaceae, Podocarpaceae, Sciadopityaceae, and Taxaceae. However, in India, members of only three families as mentioned below are associated with aphids.

a. Family: Araucariaceae: Araucariaceae is an extremely ancient family of coniferous trees largely confined to the Southern Hemisphere. Plants of this family are typically extremely tall evergreen trees. Only 41 species under 3 genera are known [65]. In India, an unidentified species of *Araucaria* sp. was recorded as host plant of a single species of aphid, *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [52, 66].

b. Family: Cupressaceae: Cupressaceae, also known as the cypress family, includes the junipers and redwoods, with most widely distribution among gymnosperms. The family includes 25 genera (13 monotypic) globally [65]. The heartwood of many species of Cupressaceae is used for furnitures, wooden pencils and roofing houses. Other plants are used to make houses, canoes, baskets, boxes and even clothing from their bark, wood and roots. Several plants of the family are of horticulture importance and hence information regarding their association with aphid pests is very important. In India, 8 species under 6 genera serve as host plant of 7 species belonging to 4 genera as stated below.

1. *Austrocedrus chilensis* (D. Don) Pic. Serm. & Bizzarri (=*Thuja chilensis* D. Don*)*

- *Cinara (Cupressobium) tujafilina* (del Guercio, 1909) [67]

2. *Cryptomeria japonica* (Thunb. ex L.f.) D.Don

- *Brachycaudus (Brachycaudus) helichrysi* (Kaltenbach, 1843) [52]

3. *Cupressus* sp.

- *Aphis (Aphis) gossypii* Glover, 1877 [52]
- *Cinara (Cupressobium) tujafilina* (del Guercio, 1909) [68]

4. *Juniperus recurva* Buch.-Ham. Ex D. Don

- *Cinara (Cupressobium) cupressi* (Buckton, 1881) [69, 70]

5. *Juniperus rigida* Siebold & Zucc. (syn. *Juniperus communis* Thunb.)

- *Cinara (Cinara) confinis* (Koch, 1856) [71]

6. *Juniperus squamata* Buch-Ham ex D. Don

- *Cinara (Cupressobium) asishghoshi* Chakrabarti, Medda & Kanturski, 2020 [66]

7. *Platycladus orientalis* (L.) Franco (syn. *Biota orientalis* (L.) Endl.; *Thuja orientalis* L.)

- *Lachnus* sp. [72, 73]
- *Cinara (Cupressobium) tujafilina* (del Guercio, 1909) [66, 71]

8. *Thuja occidentalis* L.

- *Cinara (Cupressobium) tujafilina* (del Guercio, 1909) [66, 74]

9. *Thuja* sp.

- *Cinara (Cupressobium) tujafilina* (del Guercio, 1909) [66, 71]

c. Podocarpaceae: Podocarpaceae comprises about 200 species of evergreen trees and shrubs (WFO). However, in India, only two species of a single genus *Nageia* Gaertn. are reported and only one species, *Nageia nagi* Kuntz. (=*Myrica nagi* Thunb.) was reported as host plant of a single polyphagous aphid species, *Myzus (Myzus) ornatus* Laing, 1932 [33].

d. Family: Taxaceae: Taxaceae, also known as the yew family, includes six extant genera, and 34 species of plants distributed worldwide [26]. However, in India, only one species is associated with 3 species of aphids as mentioned below, among 4 species of 3 genera are known [75].

1. *Taxus baccata* L.

- *Cinara (Cupressobium) himalayaensis* Chakrabarti, Medda & Kanturski, 2020 [66]
- *Hyperomyzus (Hyperomyzus) lactucae* (Linnaeus, 1758) [76]
- *Prociphilus (Prociphilus) taxus* (Ghosh, Chakrabarti, Chowdhuri & Raychaudhuri, 1969) [66, 76]

2. *Taxus* sp.

- *Prociphilus (Prociphilus) taxus* (Ghosh, Chakrabarti, Chowdhuri & Raychaudhuri, 1969) [77]

II. Order: Pinales

The members of the order Pinales are characterized with its reproductive structure, the cones. In modern classification, it includes only type family Pinaceae.

a. Family: Pinaceae: The Pinaceae is the largest family of conifers comprising 11 genera and 232 species [65] and widely distributed mostly in northern hemispfere with the majority of the species in temperate climates, but ranging from subarctic to tropical. Economically they are very important as its wood is used as timber for construction and furniture and also used for the manufacture of turpentine, rosin, pulp, and paper. Hence, the aphid infestation of these plants is a matter of concern for silviculture also. In India, at least 20 species under 5 genera are known [78], among which 12 species are associated with 32 aphid species. The aphid, *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968, alone infests 6 species of pines as stated below.

1. *Abies pindrow* Royle

- *Cinara (Cinara) atroalbipes* David, Narayanan & Rajasingh, 1971 [66]
- *Cinara (Cinara) confinis* (Koch, 1856) [79]
- *Cinara* sp. [80]
- *Mindarus japonicus* Takahashi, 1931 [80]
- *Pemphigus* sp. [81]

2. *Abies* sp.

- *Cinara (Cinara) confinis* (Koch, 1856) [82]
- *Cinara (Cinara) tenuipes* Chakrabarti & Ghosh, 1974 [41] [40]
- *Cinara (Cinara) tistaensis* Agrawala & Raychaudhuri, 1982 [69]
- *Cinara* sp. [52]
- *Mindarus abietinus* Koch, 1857 [12, 66]
- *Rhopalosiphum rufiabdominale* (Sasaki, 1899) [83, 84]

3. *Cedrus deodara* (Roxb. ex D. Don) G. Don
- *Aphis (Aphis) spiraecola* Patch, 1914 [40]
- *Aphis (Aphis) verbasci* Schrank, 1801 [40]
- *Cinara (Cinara) confinis* (Koch, 1856) [12]
- *Cinara (Cinara) curvipes* (Patch, 1912) [81]
- *Mindarus abietinus* Koch, 1857 [12, 66]
- *Stomaphis (Stomaphis) mordvilkoi* Hille Ris Lambers, **19**33 [83]
- *Stomaphis* sp. [83]

4. *Picea abies* (L.) H. Karst.
- *Cinara (Cinara) lachnirostris* Hille Ris Lambers, 1966 [72]
- *Lachnus tropicalis* (van der Goot, 1916) [72]

5. *Picea smithiana* Boiss. *(=Abies morinda* Loudon; *Picea morinda* Link)
- *Cinara (Cinara) atroalbipes* David, Narayanan & Rajasingh, 1971 [66]
- *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [79]
- *Cinara (Cinara) comata* Doncaster, 1956 [79, 66]
- *Cinara (Cinara) confinis* (Koch, 1856) [12]
- *Cinara* sp. [40]
- *Mindarus japonicus* Takahashi, 1931 [12]

6. *Pinus kesiya* Royle ex Gordon (syn. *Pinus khasya* Royle ex Gord.)
- *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [37, 66]
- *Cinara (Cinara) nr. schimitscheki* Börner, 1940 [85]
- *Cinara (Schizolachnus) orientalis* (Takahashi, 1924) [79]
- *Eulachnus thunbergii* (Wilson, 1919) [66]
- *Neomyzus circumflexus* (Buckton, 1876) [86]
- *Nippolachnus bengalensis* Basu & Hille Ris Lambers, 1968 [33]
- *Nippolachnus piri* Matsumura, 1917 [87]

7. *Pinus kesiya* var. *langbianensis* (A.Chev.) Gaussen ex Bui (syn. *Pinus insularis* Endl.)
- *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [87]
- *Cinara (Cinara) pinea* (Mordvilko, 1895) [88]
- *Eulachnus thunbergii* (Wilson, 1919) [79]

8. *Pinus palustris* Mill. (syn. *Pinus longifolia* Salisb.)
- *Cinara (Cinara) atroalbipes* David, Narayanan & Rajasingh, 1971 [66]

9. *Pinus patula* Schltdl. & Cham.
- *Cinara (Cinara) maculipes* Hille Ris Lambers, 1966 [79]
- *Eulachnus thunbergii* (Wilson, 1919) [37]

10. *Pinus pinaster* Aiton
- *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [71]

11. *Pinus roxburghii* Sarg. (syn. *Pinus longifolia* Roxb. ex Lambert)
- *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [66]
- *Cinara (Cinara) lachnirostris* Hille Ris Lambers, 1966 [89]

12. *Pinus wallichiana A*.B. Jacks. (syn. *Pinus excelsa* Wall. ex Lamb)
- *Cinara (Cinara) eastopi* Pintera, **19**65 [66, 79]
- *Cinara (Cinara) lachnirostris* Hille Ris Lambers, 1966 [50, 72]
- *Cinara (Cinara) maculipes* Hille Ris Lambers, 1966 [90]
- *Cinara (Cinara) takahashii takahashii* Chakrabarti, Medda & Kanturski, 2020 [66]
- *Lachnus tropicalis* (van der Goot, 1916) [80]
- *Prociphilus (Stagona) himalayaensis* Chakrabarti, 1976 [40, 66]
- *Pseudessigella brachychaeta* Hille Ris Lambers, 1966 [91]

13. *Pinus* sp.
- *Aphis (Aphis) spiraecola* Patch, 1914 [52]
- *Cinara (Cinara) atroalbipes* David, Narayanan & Rajasingh, 1971 [79]
- *Cinara (Cinara) atrotibialis* David & Rajasingh, 1968 [92]
- *Cinara (Cinara) chaetorostrata* Ghosh & Raychaudhuri, 1981 [93]
- *Cinara (Cinara) comata* Doncaster, 1956 [66]
- *Cinara (Cinara) lachnirostris* Hille Ris Lambers, 1966 [89]
- *Cinara (Cinara) maculipes* Hille Ris Lambers, 1966 [79]
- *Cinara (Cinara) takahashii takahashii* Chakrabarti, Medda & Kanturski, 2020 [66]
- *Cinara (Cinara) tenuipes* Chakrabarti & [41]
- *Cinara* sp.[40]
- *Eulachnus pumilae* Inouye, 1939 [66]
- *Eulachnus rileyi* (Williams, 1911)? [94]
- *Eulachnus thunbergii* (Wilson, 1919) [66]
- *Lachnus tropicalis* (van der Goot, 1916) [95]
- *Nippolachnus piri* Matsumura, 1917 [33]
- *Prociphilus (Stagona) himalayensis* Chakrabarti, 1976 [96]
- *Sinomegoura citricola* (van der Goot, 1917) [95]

14. *Tsuga dumosa* Eichl. (syn. *Tsuga brunoniana* Carriere)
- *Prociphilus* sp. [88]

B. Division: Gnetophyta

I. Order: Gnetales

Gnetophyta having a single order Gnetales consisting of 3 monotypic families, Gnetaceae, Welwitschiaceae, and Ephedraceae.

1. Family: Ephedraceae: The family includes around 70 species of the genus *Ephedra* L. [26] which are widely distributed in many arid regions of the world. They are commonly known as joint-pine, jointfir, Mormon-tea or Brigham tea. Most of the plants contain ephedrine, a medicinal compound. In India, out of 14 species known [97], only one identified and one unidentified apecies of *Ephedra* L. are associated with a single species of aphids as given below.

1. *Ephedra gerardiana* Wall. ex Klotzsch & Garcke
- *Ephedraphis ephedrae* (Nevsky, 1929) [12]

2. *Ephedra* sp.
- *Ephedraphis ephedrae* (Nevsky, 1929) [98]

Conclusion

The present checklist displays that 30 species of pteridophytes are colonised by 20 species of aphids under 16 genera. Maximum 17 species of plants belonging to the family Pteridaceae are associated with 11 species of aphids. Similarly, 23 species of gymnosperms are colonised by 41 species of aphids described under 13 genera. Among them, 12 species of the family Pinaceae are associated with 32 species of aphids. Out of 61 species of the aphids recorded on pteridophytes and gymnosperms together, highly polyphagous species of aphids are *Micromyzodium filicium* (12 plant species) followed by *Amphorophora (Amphorophora) ampullata bengalensis* and *Cinara (Cinara) atrotibialis* (6 plant species each). Most of the pteridophytes are associated with aphidines while the gymnosperms with lachnines.

References

1. Patil SM, Rajput KS. The genus Isoetes from India: an overview. Plant Science Today, 2017; 4(4):213-226. https://dx.doi.org/10.14719/pst.2017.4.4.33

2. Dixit RD. Lycopodiaceae of India. Bishen Singh Mahendra Pal Singh, 2007, p124.
3. Dixit RD. Selaginellaceae of India. Bishen Singh Mahendra Pal Singh, Dehradun, 1992.
4. Christenhusz MJM, Byng JW. The number of known plants species in the world and its annual increase. Phytotaxa, 2016; 261(3):201-217. doi:10.11646/phytotaxa.261.3.1
5. Singh R, Singh G. Aphids and Their Biocontrol. In: Ecofriendly Pest Management for Food Security (Ed. Omkar). Academic Press, 2016, p63-108.
6. Singh R, Singh G. Aphids. In: Polyphagous Pests of Crops (Ed. Omkar). Springer Nature Singapore, 2021, p105-182.
7. Singh R, Singh G. Reproductive strategies in aphids. In: Reproductive Strategies in Insects (Eds. Omkar and Mishra G.), Taylor and Francis Group, LLC, 2022, p259-282.
8. Favret C. Aphid Species File. Version 5.0/5.0. <http//Aphid.SpeciesFile.org> (accessed on October 10, 2022).
9. Singh R, Singh G. Species diversity of Indian aphids (Hemiptera: Aphididae). International Journal of Biological Innovations, 2019; 1(1):23-29. https://doi.org/10.46505/IJBI.2019.1105
10. Ghosh A, Chakrabarti S, Mandal B, Krishna Kumar NK. Aphids as Vectors of the Plant Viruses in India. In: A Century of Plant Virology in India (Eds. Mandal B, Baranwal VK, Rao GP, Jain RK), Springer Nature Singapore Pte Ltd., 2017, p515-536.
11. Raychaudhuri DN. Food Plant catalogue of Indian Aphididae. Graphic Printall, Culcutta, India, 1983, p204.
12. Chakrabarti S, Sarkar A. A supplement to the food-plant catalogue of Indian Aphididae. Journal of Aphidology, 2001; 15:9-62.
13. Singh G, Singh R. Food plant records of aphids (Aphididae: Sternorrhyncha: Hemiptera) in India belonging to subfamilies Aiceoninae, Anoeciinae, Chaitophorinae and Drepanosiphinae. International Journal of Zoological Investigations, 2016; 2(2):281-295.
14. Singh G, Singh R. Distribution of *Aphis (Aphis) spiraecola* Patch 1914 (Aphidini: Aphidinae: Aphididae: Hemiptera) and its food plants recorded in India. International Journal of Recent Advancement & Multidisciplinary Research, 2016; 3(12):2100-2111.
15. Singh G, Singh R. Food plant records of Aphidini (Aphidinae: Aphididae: Hemiptera) in India. Journal of Entomology and Zoology Studies, 2017; 5(2):1280-1302.
16. Singh G, Singh R. Updated checklist of food plants of Macrosiphini (Aphididae: Hemiptera) in India – 1. International Journal of Research Studies in Zoology, 2017; 3(1):6-33. http://dx.doi.org/10.20431/2454-941X.0301002
17. Singh G, Singh R. Updated checklist of food plants of Macrosiphini (Aphididae: Hemiptera) in India – 2. International Journal of Research Studies in Zoology, 2017; 3(1):42-76. http://dx.doi.org/10.20431/2454-941X.0301004
18. Singh G, Singh R. Updated checklist of food plants of Macrosiphini (Aphididae: Hemiptera) in India – 3. International Journal of Research Studies in Zoology, 2017; 3(2):1-31. http://dx.doi.org/10.20431/2454-941X.0302001
19. Singh G, Singh R. Updated checklist of host plants of Calaphidinae (Aphididae: Hemiptera) in India. International Journal of Contemporary Research and Reviw, 2017; 8(2):20171-20190. http://dx.doi.org/10.15520/ijcrr/2017/8/02/111
20. Singh G, Singh R. Updated checklist of Indian Eriosomatinae (Aphidinae: Aphididae: Hemiptera) and their food plants. Journal of Entomology and Zoology Studies, 2017; 5(1):921-936.
21. Singh G, Singh R. Updated checklist of Greenideinae (Aphididae: Hemiptera) and its host plants in India. International Journal of Contemporary Research and Review, 2017; 8(3):20191-20219. http://dx.doi.org/10.15520/ijcrr/2017/8/03/139
22. Singh G, Singh R. Updated checklist of Indian Hormaphidinae (Aphididae: Hemiptera) and their food plants. Journal of Entomology and Zoology Studies, 2018; 6(2):1345-1352.
23. Singh G, Prasad M, Singh R. Updated check-list of Lachninae, Lizeriinae, Mindarinae, Phyllaphidinae, Saltusaphidinae, Taiwanaphidinae and Thelaxinae (Aphididae: Hemiptera) and their food plants in India. Journal of Entomology and Zoology Studies, 2018; 6(2):3157-3166.
24. Singh G, Singh NP, Singh R. Food plants of a major agricultural pest *Aphis gossypii* Glover (Homoptera: Aphididae) from India: an updated checklist. Internal Journal of Life Science, Biotechnology & Pharma Research, 2014; 3(2):1-26. http://www.ijlbpr.com/currentissue.php
25. Singh R, Khan AA. Aphids (Insecta: Homoptera: Aphididae) infesting plants of the order Caryophyllales and Santalales (Eudicots: Superasterids: Angiospermae) in India. International Journal of Entomology Research, 2022; 7(9):34-41.
26. WFO. World Flora Online. http://www.worldfloraonline.org, retrieved on October 10, 2022.
27. Singh R, Agrawal R. Association of the Aphids (Insecta: Homoptera: Aphididae) with monocots flowering plants in India. International Journal of Biological Innovations, 2022; 4(1):252-281. https://doi.org/10.46505/IJBI.2022.4203
28. Singh R, Singh G, Tiwari AK, Sharma A, Patel A, Pratibha. *Myzus (Nectarosiphon) persicae* (Sulzer, 1776) (Homoptera: Aphididae): Updated check list of host plants in India. International Journal of Zoological Investigations, 2015; 1:8-25.
29. Antony R, Kumar ESS, Khan AES. *Selaginella camusii*, a new species of Selaginellaceae from India. Nordic Journal of Botany, 2003; 22:377-340.
30. Singh SK, Srivastava GK, Srivastava M, Shukla PK. *Selaginella crassipes* (Selaginellaceae), a new report from India. Taiwania, 2015; 57(3):283-287.
31. Singh OP, Rawat RR. Abst. Symp. 'Recent trends in Aphidological studies: Bhubaneswar, 1979, p14-15.
32. Ghosh LK. Handbook on hemipteran pests in India, Zoological Survey of India, Kolkata, 2008, 453p.

http://faunaofindia.nic.in/PDFVolumes/hpg/038/index.pdf
33. Raychaudhuri DN. Taxonomy of the aphids of the Eastern Himalayas. US Pl 480 Project Tech. Report, 1973, p107.
34. Fraser-Jenkins CR. A brief comparison of modern pteridophyte classifications (families and genera in India). Indian Fern Journal, 2009; 26:107-126.
35. Brownsey PJ, Perrie LR. Aspleniaceae. In: Flora of New Zealand - Ferns and Lycophytes. Fascicle 18 (Eds. Breitwieser I, Wilton AD). Manaaki Whenua Press, Lincoln, 2022. http://dx.doi.org/10.7931/B1562D
36. Kholia BS. http://www.sikkimforest.gov.in/Reports and Publications/Biodiveristy-of Sikkim/4 Ferns Kholia_43-64 web.pdf retrieved on October 10, 2022.
37. Raychaudhuri DN. Aphids of North-East India and Bhutan. Zoological Society, Calcutta, 1980, 521p.
38. Ghosh LK, Basu RC. Insecta: Hemiptera: Aphididae. In: Fauna of West Bengal. State Fauna Series, Zoological Survey of India, Kolkata, 1997; 3:125-318.
39. Chakrabarti S, Banerjee PK. *Utamphorophora himalyensis*, a new aphid (Homoptera: Aphididae) infesting ferns in Western Himalaya. Proceedings of the Zoological Society, Calcutta, 1989; 42:39-42.
40. Ghosh LK. A study on the aphids (Homoptera: Aphididae) of Himachal Pradesh in North-West Himalaya, India, Ph. D. thesis, University of Calcutta, India, 1977, p360.
41. Ghosh AK. Fern infesting aphids (Homoptera: Aphididae) in India. Indian Journal of Horticulture, 1974; 31:104-109.
42. Ghosh AK. Floral assemblage and faunal diversity in Aphidoidea (Homoptera: Aphididae) in Eastern India. Bulletin of the Zoological Survey of India, Kolkata, 1980; 2:171-176.
43. Kachhiyapatel RN, Patil SM, Raole VM, Rajput KS. Genus *Athyrium* Roth (Athyriaceae: Pteridophyta) from Gujarat State. Plant Science Today, 2019; 6(1):54-62. https://doi.org/10.14719/pst.2019.6.1.471
44. Ghosh AK, Ghosh MR, Raychaudhuri DN. Studies on aphids (Homoptera: Aphididae) from eastern India. II. Some new species and new records from north Bengal. Oriental Insects, 1970; 4:193-203.
45. Reddy SGE, Kumari A, Lal B. First report of the aphid, *Amphorophora ampullata* (Homoptera: Aphididae) on the fern, *Hypolepis polypodioides* (Hypolepidaceae) from Western Himalayas (India). American Fern Journal, 2013; 103(3):185-187. http://dx.doi.org/10.1640/0002-8444-103.3.185
46. David SK. A new genus and three new species of aphids from India. Indian Journal of Entomology, 1958; 20:175-180.
47. Fraser-Jenkins CR. Taxonomic Revision of the Three Hundred Indian Subcontinental Pteridophytes with Revised Census List. Bishen Singh Mahendra Pal Singh, Dehra Dun.
48. Patnaik SN, Panigrahi G. Cytology of some genera of Polypodiaceae in Eastern India-II. American Fern Journal, 1963; 53(1):40-46.
49. Bera S, Gharai N. Polypodiaceous fern as an alternative host for tea pest *Toxoptera aurantii* Boyer (Aphididae) from Darjeeling Himalaya, West Bengal. Indian Fern Journal, 1995; 12:168-172.
50. Dutta J, Gautam DC. Chromosomes of aphid fauna from north-western Himalayas, India. Cytologia, 1993; 58:367-375.
51. Saha S, Chakrabarti S. New records of aphids (Homoptera: Aphididae) from Garhwal range of Western Himalaya, India. Journal of the Bombay Natural History Society, 1988; 85:633-635.
52. Agarwala BK. Some aspects of aphid (Homoptera: Insecta) studies in Sikkim and Bhutan Ph. D. thesis, University of Calcutta, India, p383.
53. Raychaudhuri DN, Ghosh D, Raychaudhuri D, Agarwala BK. Studies on the aphids (Homoptera: Aphididae) from south India. I. Insecta matsumurana, n. s., 1981; 23:1-20. https://eprints.lib.hokudai
54. Ghosh LK. Additions to the aphid fauna of Bihar with the first record of an aphid sexuale (Homoptera: Aphididae). Journal of the Bombay Natural History Society, 1977; 73:416-418.
55. Maity SP, Chakrabarti S. Aphids (Homoptera: Aphididae) of northwest India. III. Records of new aphids from Garhwal Himalaya. Science & Culture, 1979; 45:160-162.
56. Chakrabarti S. Aphids of north western India with special reference to Kumaon range, Uttar Pradesh, Ph. D. thesis. University of Calcutta, India, 1972, 435p.
57. Chakrabarti S, Raychaudhuri DN. Aphids (Homoptera: Aphididae) from Sundardhunga Valley, Kumaon Himalaya, India. Oriental Insects, 1975; 9:195-211. https://doi.org/10.1080/00305316.1975.10434491
58. Stary P, Ghosh AK. Aphid parasites (Hymenoptera: Aphidiidae) from Meghalaya, India. Oriental Insects, 9, 343-349. https://doi.org/10.1080/00305316.1975.10434504
59. Chakrabarti S, Ghosh AK, Raychaudhuri DN. On some undescribed morphs and new records of aphids (Homoptera: Aphididae) from Kumaon Himalaya, India. Current Science, 1972; 41:70-71.
60. Ghosh R, Özaslan C, Ray P. Invasive alien freshwater hydrophytes: Co-facilitating factors with emphasis on Indian scenario. Indian Journal of Weed Science, 2021; 53(3):216-229.
61. Halder J, Rai AB, Chakrabarti S, Dey D. Distribution, host range and bionomics of *Rhopalosiphum nymphaeae* (Linnaeus, 1761), a polyphagous aphid in aquatic vegetables. Defence Life Science Journal, 2020; 5(1):49-53. https://doi.org/10.14429/dlsj.5.14403
62. John KC, Nair NB. *Rhopalosiphum nymphaeae* (Homoptera: Aphididae), a control agent for *Salvia molesta*. Entomology Monthly Magzine, 1983; 7:381-384.
63. Chakrabarti S, Sarkar S, Debnath M. Diversity, bioecology and biosystematics of aphidophagous predators of eastern Himalaya and northeast India. In: Biodiversitat und Naturausstattung im Himalaya, IV (Eds. Hartmann M, Weipert J.), Naturkundemuseum Erfurt, 2012, p129-147.
64. Dar AR, Dar GH. The wealth of Kashmir Himalaya-Gymnosperms. Asian Journal of Plant Sciences, 2006; 5(2):251-259. http://doi.org/10.3923/ajps.2006.251.259.
65. TGD. The Gymnosperm Database, https://www.conifers.org/ retrieved on October 10, 2022.
66. Chakrabarti S, Medda PK, Kanturski M. Conifer-feeding aphids (Insecta: Hemiptera: Aphididae) of India, Bhutan

and Nepal with descriptions of three new species of the genus *Cinara*. The European Zoological Journal, 2020; 87(1):659-687. https://doi.org/10.1080/24750263.2020.1831086
67. Joshi S, Poorani J. Aphids of Karnataka. http://www.aphidweb.com, retrived on October 10, 2022.
68. Raychaudhuri DN, Dutta S, Agarwala BK, Raychaudhuri D, Raha, S. Some parasites and predators of aphids from northeast India and Bhutan. Entomon, 1978; 3:91-94.
69. Agarwala BK, Raychaudhuri D. Two species of *Cinara* Curtis from India, with description of a new species (Homoptera: Aphididae, Lachninae). Akitu, N.S., 1982; 46:1-4.
70. Debnath M, Chakrabarti S. Diversity, bioecology and biosystematics of aphids (Hemiptera: Aphididae) in Darjeeling Himalaya. International Journal of Experimental Research & Review, 2020; 21:10-18. https://doi.org/10.52756/ijerr.2020.v21.002
71. Kar I, Basu G, Khuda-Bukhsh AR. A check-list of chromosomes in aphids (Homoptera: Aphididae) worked out in India along with the names and families of their host plants. Environment & Ecology, 1990; 8(1):414-428.
72. Bhagat RC. Some new aphid parasitoids (Hymenoptera: Aphidiidae) from Kashmir (India). Oriental Insects, 1981; 15:195-200. https://doi.org/10.1080/00305316.1981.10434855
73. Chakrabarti S, Debnath M. Diversity of aphidophagous parasitoids (Insecta) of northwest and western Himalayas, India. In: Biodiversitat und Naturausstattung im Himalaya, III (Eds. Hartmann M, Weipert J.), Naturkundemuseum Erfurt, 2009, p441-454.
74. Agrawal R, Singh R. New host records of aphids (Homoptera: Aphididae) in northeast Uttar Pradesh. Journal of Aphidology, 2005; 19(1&2):109-111.
75. Bisht S, Singh R. Ethnobotanical notes on a lesser known gymnosperm family Taxaceae of Himalayan regions in India, adjoining countries and in South-East Asia. Pleione, 2020; 14(1):01-16. doi:10.26679/Pleione.14.1.2020.001-016
76. Ghosh AK, Basu RC, Raychaudhuri DN. A new genus and seven new species of aphids (Homoptera) from India. Oriental Insects, 1969; 3(3):245-253. http://doi.org/10.1080/ 00305316.1969.10433913.
77. Ghosh AK. Proceedings of the Symposium on Soil Biology & Ecology, 1979, p224-227.
78. Dar AR, Dar GH. Taxonomic appraisal of conifers of Kashmir Himalaya. Pakistan Journal of Biological Sciences, 2006; 9(5):859-867. doi:10.3923/pjbs.2006.859.867
79. Ghosh AK. The fauna of India and the adjacent countries – Part 2. Subfamily Pemphiginae. Zoological Survey of India, Calcutta, 1982, p167.
80. Bhagat RC. New records of the aphids (Homoptera: Aphididae) from Kashmir (India). Science & Culture, 1981; 47:134-136.
81. Rishi ND. Aphids. Recent trends in aphidological Studies, Bhubaneswar, 1975, 52.
82. Chakrabarti S, Chowdhuri AN, Raychaudhuri DN. Further records of Aphids (Homoptera: Aphididae) from Himachal Pradesh, India.sc, 1974; 40:461-462.
83. Raychaudhuri DN, Ghosh LK, Das SK. Studies on the aphids (Homoptera: Aphididae) from north and northwest India-I. Insecta Matsumurana, New Series, 1980; 20:1-42.
84. Ghosh LK. A Conspectus of Aphididae (Homoptera) of Himachal Pradesh in north-west Himalaya, India. Zoological Survey of India, Technical Monograph, 1986; 16:1-282.
85. Ghosh AK. A list of Aphids (Homoptera: Aphididae) from India and adjacent countries. Journal of the Bombay Natural History Society, 1975; 71(2):201-225.
86. Reddy MV, Alfred JRB, Ghosh AK. First record of *Neomyzus circumflexus* (Buckton) (Homoptera: Aphididae) on young pine seedlings (*Pinus kesiya* Royle). Entomon, 1978; 3:117-118.
87. Ghosh AK, Raychaudhuri DN. A preliminary account of the bionomics and taxonomy of aphids from Assam. Journal of the Bombay Natural History Society, 1962; 59:238-253.
88. Behura BK. Suppliment to aphids of India - a survey of published information. Prakruti - Journal of Utkal University, Science, 1965; 3:40-65.
89. Bhagat RC. On aphids (Homoptera: Aphididae) and their parasitoids (Aphidiidae: Hymenoptera) infesting forest trees in Kashmir valley, India. Indian Forester, 1985; 111:467-474.
90. Chakrabarti S, Chowdhuri AN, Raychaudhuri DN. Further records of aphids (Homoptera: Aphididae) from Himacha Pradesh, India. Science & Culture, 1974; 40:461-462.
91. Kanturski M, Akbar S-A, Favret C. Morphology and sensilla of the enigmatic Bhutan pine aphid *Pseudessigella brachychaeta* Hille Ris Lambers (Hemiptera: Aphididae) - a SEM study. Zoologischer Anzeiger, 2017; 266(1):1-13. doi:10.1016/j. jcz.2016.10.007.
92. David SK, Rajasingh SG. A new species of *Cinara* Curtis (Homoptera: Aphidoidea) from eastern India. Oriental Insects, 1968; 6:35-44. https://doi.org/10.1080/00305316.1968.10433875
93. Ghosh LK, Raychaudhuri DN. A new species of *Cinara* Curtis (Homoptera: Aphididae) from northweast India. Entomon, 1981; 6:173-174.
94. David SK, Rajasingh SG. New records of aphids (Insecta: Homoptera) from Assam, India. Proceedings of the Zoological Society, Calcutta, 1969; 22:151-157.
95. Raychaudhuri D. Taxonomy and biology of aphids (Homoptera: Aphididae) of Manipur. Ph. D. thesis, University of Calcutta, India, 1978, p308.
96. Chakrabarti S. New Aphids (Homoptera: Aphididae) from Northwest India. Entomon, 1976; 1:171-174.
97. Biswas J, Singh R. *Ephedra stipitata* (Ephedraceae), a new species from Ladakh, India. Annales Botanici Fennici, 2022; 59(1):123-129. https://doi.org/10.5735/085.059.0119
98. Bhagat RC. Aphids (Insecta) damaging medicinal and aromatic plants of Jammu and Kashmir state (India): an updated checklist and biodiversity. Indian Journal of Applied & Pure Biology, 2012; 27(1):1-10.