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Aphids and their Host Affinity-VII: *Rhopalosiphum* spp.

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ABSTRACT

Seventeen species of Rhopalosiphum (Aphidinae: aphidini) were examined for their host plant relationships and their affinity to plant taxonomic groups. Out of 17 species, 29.41% were monophagous (R. arundinariae, R. chesqueae, R. dryopterae, R. laconae, R. sanguinarium), 11.76% oligophagous (R. padformis, R. parvae) and 58.82% polyphagous. Species R. arundinariae, R. laconae and R. chesqueae were feeding only on monocotyledons; R. sanguinarium on dicotyledons and R. dryopterae on ferns in gymnosperms. In general, taxonomic affinity (across Rhopalosiphum species) revealed that monocotyledons (70.41%) were more preferred than dicotyledons (28.49%) and gymnosperms-ferns (1.10%). In highly polyphagous species, contribution of monocotyledons was greater in R. maidis (90.36%), R. padi (87.72%), and R. rufiabdominale (51.14%). In all the aforesaid cases share of host species in Poaceae (glumiflorae) was maximum. However, in R. nymphaeae more host plants were infested in dicotyledons (53.80%) as compared to monocotyledons (41.77%) and ferns (4.43%). Here plant species in calyciferae and corolliferae were colonized in greater numbers than in glumiflorae. Various ratios and General Affiliation Index values distinctly showed that Rhopalosiphum species tended to prefer monocotyledonous plant species. However, preference was species specific. Acceptance of host species in abundance from gymnosperms and very primitive orders from dicotyledons, especially in herbaceae (Ranales), and monocotyledons (Alismatales and Butamales) indicates ancient association of some of the Rhopalosiphum species with these groups of plants.

Key words: *Rhopalosiphum spp., angiosperms, dicotyledons, monocotyledons, General Affiliation Index*

INTRODUCTION

Number of species in the genus *Rhopalosiphum* (Aphidinae: Aphidini) are quite limited as compared to other species in the family. Approximately 15 species are classified in this genus[1,2,3] associated primarily with Rosaceae and other host plants in Cyperaceae and Poaceae served as secondary hosts. *Rhopalosiphum* and the viruses they transmit probably originated from North America[4] with a subsidiary centre in Asia.

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Species *R. arundinariae, R. cerasifoliae, R.engimae, R. laconae, R. nigrum* and *R. padiformis* are exclusively of Nearctic distribution and four Nearctic species viz., *R. parvae, R. rufulum, R. musuae* and R. *oxycanthae* have been introduced in other parts of the world[5]. Some of the species in the genus are widely distributed and have wide host range. Thorsteinson[6] described that most phytophagous insects select their host plants from taxonomic groups while others feed indiscriminately. Rathore and Lal[7] observed similar feeding behaviour in pod borer, *Maruca vitrata*. Recently, similar observations were made by Rathore and Tiwari[8,9] in *Bemisia tabaci* and 42 species of *Bemisia*, and Rathore and Tiwari[10] in three species of aphids (*Hyadaphis, Uroleucon, Viteus* spp.). In the present appraisal, authors tried to investigate the host-plant relationships of the genus *Rhopalosiphum*.

MATERIALS AND METHODS

Information on 17 species of *Rhopalsiphum* was extracted from the publications of Blackman and Eastop[3,11,12,13] and others. Host plant species reported in various publications were grouped and aligned with the families and orders following the taxonomic classification of Hutchinson[14] and evolutionary pattern described there in. He divided angiosperms into dicotyledons and monocotyledons. Lignosae (primarily woody plants) and herbaceae (primarily herbaceous plants) formed two divisions in dicotyledons. Monocotyledons were divided into calyciferae (with distinct calyx and corolla), corolliferae (calyx and corolla are more or less similar) and glumiflorae (perianth are much more reduced or represented by lodicules). To account the closeness of relationships various ratios were worked out and a General Affiliation Index (GAI) was employed as described by Rathore and Tiwari [15]. On the basis of host acceptability, *Rhopalosiphum* species were categorized as monophagous, oligophagous and polyphagous following the terminology of Bernays and Chapman[16]. For other details readers are referred to first part of the publication "Aphids and their host affinity-I: *Acyrthosiphon* spp." By Rathore and Tiwari[17].

RESULTS AND DISCUSSION

Perusal of Table 1 revealed that out of 17 species of *Rhopalosiphum*, 29.41% were monophagous, 11.76% oligophagous and 58.82% polyphagous. Out of five monophagous species, *R. arundinariae, R. chasqueae, R. laconae* were feeding on monocotyledons, *R. sanguinarium* on dicotyledons and *R. dryopterae* on ferns. Two oligophagous species, *R. padiformis* and *R. parvae* were infesting plants in families Cyperaceae and Poaceae in glumiflorae of monocotyledons. Among polyphagous species, *R. maidis, R. nymphaeae, R. padi* and *R. rufiabdominale* encompass a large host range and infest different agricultural and horticultural plant species. GAI values for monophagous and oligophagous species of *Rhopalosiphum* ranged 1.000-1.333, whereas those of polyphagous were either less or more than 1.000.

Table 1: Host taxonomic relationships with *Rhopalosiphum* species

***Rhopalosiphum* spp.**	**Host plants with taxonomic group**	**No. of host species**	**GAI**	**Status**
R. arundinariae	**Monocot-glumiflorae:** Poaceae (2) (*Arundinaria* sp., *A. gigantean* var. *tecta*)	2	1.333	Monophagous
R. cerasifoliae	**Dicot-lignosae:** Rosaceae (3); **Monocot-glumiflorae:** Cyperaceae (5), Juncaceae (1)	9	0.917	Polyphagous
R. chasqueae	**Monocot-glumiflorae:** Poaceae (1) (*Chasquea tomentosa*)	1	1.000	Monophagous
R. dryopterae	**Others:** Dryopteridaceae (1) (*Dryopteris filixmas*)	1	1.000	Monophagous
R. enigmae	**Monocot-calyciferae:** Musaceae (1); **Monocot-corolliferae:** Typhaceae (3)	4	0.857	Polyphagous

R. laconae	**Monocot-corolliferae:** Typhaceae (1) (*Typha* spp.)	1	1.000	Monophagous
R. maidis	**Dicot-lignosae :**Ericaceae (1), Loganiaceae (1), Rosaceae (3); **Dicot-herbaceae:** Amaranthaceae (1), Asteraceae (1), Brassicaceae (1), Cabonaceae (1), Caryophyllaceae (1), Lamiaceae(1), Oxalidaceae (1), Plantaginaceae (1), Polygonaceae (1), Solanaceae (2); **Monocot-calyciferae:** Alismataceae (1), Commelinaceae (2), Musaceae (1), Zingiberaceae (1); **Monocot-corolliferae:** Dioscoreaceae (1), Iridaceae (1), Typhaceae (1); **Monocot-glumiflorae:**Cyperaceae (6), Poaceae (136)	166	1.425	Polyphagous
R. musuae	**Dicot-lignosae:** Rosaceae (3); **Monocot-calyciferae:** Musaceae (2), Strelitziaceae (1); **Monocot-glumiflorae:** Cyperaceae (1), Poaceae (1)	8	0.667	Polyphagous
R. nigrum	**Dicot-lignosae:** Rosaceae (1); **Monocot-calyciferae:** Butomaceae (1); **Monocot-glumiflorae:** Poaceae (2)	4	0.600	Polyphagous
R. nymphaeae	**Dicot-lignosae:** Actinidiaceae (1), Apocynaceae (1), Cucurbitaceae (1), Euphorbiaceae (1), Lythraceae (1), Rosaceae (16), Rubiaceae (1), Symplocaceae (1), Urticaceae (1); **Dicot-herbaceae:** Apiaceae (4), Asteraceae (5), Brassicaceae (4), Cabomaceae (1), Callitrichceae (3), Ceratophyllaceae (1), Droseraceae (1), Holoragidaceae (4), Lentibulariaceae (1), Menyanthaceae (3), Nymphaceae (16), Plantaginaceae (1), Polygonaceae (2), Primulaceae (1), Ranunculaceae (6), Saururaceae (1), Saxifragaceae (1), Scrophulariaceae (3), Solanaceae (1), Trapaceae (2); **Monocot-calyciferae:** Alismataceae (7), Apocynaceae (2), Butomaceae (1), Cannaceae (1), Hydrocharitaceae (7), Juncaginaceae (1), Musaceae (1), Potamogetonaceae (5), Zingiberaceae (1); **Monocot-corolliferae:** Araceae (8), Lemnaceae (6), Liliaceae (2), Orchidaceae (2), Ponteridaceae (5), Typhaceae (7); **Monocot-glumiforae:** Juncaceae (2) Cyperaceae (3), Poaceae (5); Others: Marsileaceae (2), Salviniaceae (5)	158	0.894	Polyphagous
R. oxyacanthae	**Dicot-lignosae:** Rosaceae (26); **Monocot-glumiflorae:** Cyperaceae (1), Juncaceae (2), Poaceae (14)	43	1.667	Polyphagous
R. padi	**Dicot- lignosae:** Oleaceae (1), Thymelaeaceae (1), Rosaceae (12); **Dicot-herbaceae:** Amaranthaceae (1), Asteraceae (4), Boraginaceae (1), Brassicaceae (3), Caryophyllaceae (1),Papaveraceae (1), Polygonaceae (1), Ranunculaceae (1), Solanaceae (2); **Monocot-calyciferae:** Butomaceae (1), Cannaceae (2), Juncaginaceae (1), Strelitziaceae (1); **Monocot-corolliferae:** Agavaceae (2), Amaryllidaceae (1), Araceae (3), Haemodoraceae (2), Iridaceae (2), Liliaceae (3), Typhasae (5);	236	1.597	Polyphagous

	Monocot-glumiflorae: Juncaceae (10), Cyperaceae (24), Poaceae (150)			
R. padiformis	**Monocot-glumiflorae:** Poaceae (2) (*Poapratensis, Triticum aestivum*)	2	1.000	Oligophagous
R. parvae	**Monocot-glumiflorae:** Cyperaceae (2) (*Carex* spp., *Scirpus lacustris*)	2	1.000	Oligophagous
R. rufiabdominale	**Dicot-lignosae:** Caprifoliaceae (1), Ericaceae (1), Fabaceae (1), Malvaceae (4), Melastomataceae (1), Rosaceae (12); **Dicot-herbaceae:** Apiaceae (2), Asteraceae (6), Berberidaceae (1),Caryophyllaceae (3), Orobanchaceae (1), Papaveraceae (1),Solanaceae (9); **Monocot-calyciferae:** Bromeliaceae (1), Musaceae (1); **Monocot-corolliferae:** Agavaceae (1), Alstromeriaceae (1), Araceae (2), Iridaceae (1); **Monocot-glumiflorae:** Cyperaceae (7), Poaceae (31)	88	0.849	Polyphagous
R. rufulum	**Dicot-lignosae:** Rosaceae (1); **Monocot-corolliferae:** Araceae (1), Arecaceae (1); **Monocot-glumiflorae:** Poaceae (1)	4	0.500	Polyphagous
R. sanguinarium	**Dicot-lignosae:** Rosaceae (1) (*Crataegus pubescens*)	1	1.000	Monophagous

A generalized picture of taxonomic affinity of *Rhopalosiphum* species presented in Table 2 indicated that 28.49% host species were infested in dicotyledons as compared to 70.41% in monocotyledons. Share of non-angiosperms (others-ferns) was to the tune of 1.10%.. For further evaluation of taxonomic affinity ratios between host species: host genera, families and orders were worked out. In lignosae, herbaceae, calyciferae, corolliferae and others, these ratios were less than 4, whereas in glumiflorae species: family and order ratio in each case was 17.78 as compared to generalized ratio of 5.00, revealing greater affinity of plant species of families Juncaceae, Cyperaceae and Poaceae. This further revealed confamilial relationships of host species to *Rhopalosiphum*.

Table 2: Relationships between *Rhopalosiphum* species and host taxonomic groups

Parameters	**Host plants**						**Total**
	Dicotyledons		**Monocotyledons**			**Others***	
	Lignosae	**Herbaceae**	**Calyciferae**	**Corolliferae**	**Glumiflorae**		
Species	98 (13.42)	110 (15.07)	43 (5.89)	62 (8.49)	409 (56.03)	8 (1.10)	730
Genera	42(10.97)	76(19.84)	35 (9.14)	43 (11.23)	183 (47.78)	4 (1.04)	383
Families	27 (18.49)	46 (31.51)	23 (15.75)	24 (16.45)	23 (15.75)	3 (2.05)	146
Orders	27 (20.45)	40 (30.30)	17 (12.88)	22 (16.67)	23 (17.42)	3 (2.27)	132
Total	**194 (13.95)**	**272 (19.55)**	**118 (8.48)**	**151 (10.86)**	**638 (45.87)**	**18 (1.29)**	**1391**

Others* host plants other than angiosperms; Figures in parentheses are % values

Among the serious polyphagous *Rhopalosiphum* species, *R. maidis* has been one of them. Blackman and Eastop[18] reported this aphid feeding on cereals and grasses of more than 30 genera. We found that it infests 166 plant species belonging to 22 families, both from dicotyledons and monocotyledons. Out of these, number of host species from Poaceae was the highest (136). Also the contribution of host species from monocotyledons was over 90%. Species: families ratio was 1.23 and 16.67 in

dicotyledons and monocotyledons, respectively again indicated greater affinity to cereals and grasses. *R. maidis* belongs to host alternating group of aphids and supposedly sexual phase should be completed by migrating to rosaceous, primary host plants. However, no such evidence of occurrence has been reported[19]. All population seem to be entirely parthenogenetic. Nevertheless, five parthenogenetic lineages were identified and described as biotypes on the basis of their differing ability to colonize on barley and maize [20,21]. Genotypically distinct form of *R. maidis* occurs on barley, does not colonize on sorghum spp. or maize and viceversa[19]. Blackman and Eastop[22] and Chattopadhyay et al[23] reported differences in karyotypes in the population of this aphid. Brown and Blackman[19] showed that *R. maidis* population on barley in the northern hemisphere had ten-chromosome karyotypes, whereas on maize, sorghum and Johnson grass from all parts of the world 2n=8. Samples with other karyotypes (2n=9, 2n=11 and 2n=8 heterozygous for an interchange between the X chromosome) occur less frequently on these and other species of Gramineae. However, Loxadale and Lushai[24] reported that in northern hemisphere, *R. maidis* has karyotype forms specific to barley and sorghum spp. (2n=10) and maize (2n= usually 8)[12,19]. This may have very serious implications on host acceptability and host affinity per se.

R. maidis is cosmopolitan in distribution throughout the tropics, subtropics and warmer temperate zones. Besides feeding on young leaves, tassels and other parts of plants, it excrete copious amount of honeydew which attracts attending ants, serves as media for sooty mould and provides food for corn earworm moths and other pests. It is vector of many virus diseases such as Barley yellow dwarf, Maize leaf fleck, Maize dwarf mosaic, Millet red leaf, Abaca mosaic, Cucumber mosaic, Onion yellow dwarf, Papaya ringspot, and Sugarcane mosaic[18,25].

The bird cherry-oat aphid, *R. padi*, is often considered as a major pest of cereals in temperate cereal crops worldwide [18]. The aphid alternates host between bird cherry (*Prunus padus*) as the primary host in Europe and common chokecherry (*Prunus virginiana*) in North America and various grasses, cereals and sedges as the secondary hosts. Some population reproduces parthenogenetically all year on the grasses [18]. Molecular studies of Simons et al[26] revealed that cyclic parthenogenetic lineage possessed differing mtDNA and plasmid haplotype than obligatory asexual clones.

We observed bird cherry aphid infesting all kinds of angiosperms. Host species in lignosae and herbaceae were to the tune of 5.93 and 6.36%, respectively, whereas in monocotyledons the same were 2.12% in calyciferae, 7.63% in corolliferae and 77.97% in glumiflorae. Combined figure for dicotyledons was 12.29% and for monocotyledons 87.72% indicated that this aphid feeds both dicotyledonous and monocotyledonous plants, however, the greater preference was for host species in the family Poaceae (63.56%). Blackman and Eastop[18] also reported feeding on numerous species of Poaceae and can colonize on many other plants of monocotyledons and some dicotyledons. Observation on species: family ratio further strengthened the view. This ratio was 2.42 for dicotyledons and 147.86 for monocotyledons. But for glumiflorae alone (Juncaceae, Cyperaceae, Poaceae), the same was 61.33. The GAI value of 1.597 confirmed its polyphagy and different ratios its affinity to monocotyledons particularly for host species in Poaceae.

R. padi besides feeding also harms plants by transmitting several viruses. It is a vector of Barley yellow dwarf, Cereal yellow dwarf. Filaree red leaf, Aba mosaic, Onion yellow dwarf [18]and Maize leaf fleck and Oat yellow disease.

The rice root aphid or red rice root aphid, *R. rufiabdominale*, is a pest of rice and many other plants. It completes life cycle on plum (*Prunus domestica*) and apricot (*Prunus americana*) and has been greenhouse pest in various parts of the world[27].It is a palaearctic species probably originated in Eastern Asia[28].

R. rufiabdominale has broad host range and has been reported on plant species of 22 plant families. It is pest of upland rice. In our study we found it colonizing on 88 host species both in monocotyledons (51.14%) and dicotyledons (48.86%) across 21 plant families. Lignosae (22.73%) and herbaceae (26.14%) had almost similar number of host species, whereas the same was much higher in glumiflorae (43.18%) as compared to calyciferae (2.27%) and corolliferae (5.68%). The species: family ratio was 3.31 and 5.63 for dicotyledons and monocotyledons, respectively. The same ratio for glumiflorae alone was 19.00. This strengthened the view that though *R. rufiabdominale* is feeding on wide range of host species but plants in Poaceae (glumiflorae) are the most preferred. Besides its direct feeding, it vectorise several viral diseases like Green leaf dwarf, Barley yellow dwarf, maize mosaic and sugarcane mosaic[27].

The water lily aphid or redish-brown plum aphid, *R. nymphaeae*, is also a heteroceous aphid having around twelve species of *Prunus* as winter hosts[11,18], and feed on many wet-land and water dwelling species in summer including Nymphaea (water lilies), Potamogetan (pondweed), and Sparganium (arrowhead)[29]. We observed it infesting 158 plant species from 59 families and 38 orders, from dicotyledons and monocotyledons as well as gymnosperms. Holman[30] also reported that host list of this aphid includes species of 49 families. Our observations revealed that dicotyledons (53.80%) showed preference over monocotyledons (41.77%) and gymnosperms (4.43%). However, as evident by species: family ratio 2.93 (dicotyledons) and 3.66 (monocotyledons), less families were utilized to provide slightly greater number of host species in monocotyledons. Among dicotyledons, herbaceae shared more number of host species (38.61%) than lignosae (15.19%). Similarly in monocotyledons, the calyciferae, corolliferae and glumiflorae contributed 14.46, 18.99 and 6.33, respectively. The species family: family ratio was also higher in corolliferae (5.00). In host preference study Storey [35] found that *R. nymphaeae* tended to prefer the host plants they were reared on, suggesting familiarity played a role in shaping host preference.

In Poaceae, the aphid infests wheat, maize, sorghum, setaria, rice, etc. But it has been found useful as biological control agent to destroy an annual broadleaf weed, Ducksalad (*Heterenthera limosa*) in rice fields. As mentioned earlier, it also feeds on several water dwelling useful plants and has ability to survive under water by retaining an air film on their bodies using specialized hairs (perhaps by means of circular spinules), trapped air bubbles somehow cover the entire colony[31]. Bernnet and Buckingham[32] found on parts of water plants either on water surface or rising above the surface.

Evolutionary pattern of families as described by Hutchinson[14] suggests that *R. nymphaeae* feeds on plant species across nine orders in lignosae and 14 orders in herbaceae. In lignosae, the primitive order they feed upon was Rosales (which served as the primary host) and is 6th on evolutionary scale, whereas in herbaceae aphid selected most primitive order Ranales (24 host species) and host species in 50% of the orders were infested. The prominent evolutionary lineage in herbaceae was as follows:

Ranales—Saxifragales—Solanales—
Personales =contributed 30 plant species

In monocotyledons, *R. nymphaeae* was reported feeding on plant species from primitive orders Alismatales and Butomales. Feeding on host plants of orders, on evolutionary lineage, originating from Alismatales is rare. Liliales stock, as always, made useful host species contribution. The possible evolutionary lineages were as follows:

1.Alismatales—Juncaginales—
Aponogetonales = contributed 10 host species
2. Alismatales—Potamocetonales = 12
3. Butomales—Liliales—Arales = 29
4. Butomales—Liliales—Typhales = 22
5. Butamales - Liliales—Juncales—Cyperales, Graminales = 25

Hutchinson[14] considered monocotyledons as monophyletic and two orders Butamales and

Alismatales show close relationship with Ranales. Families Butamaceae correspond very closely with Helleboroideae, whilst the Alismataceae resemble the Ranunculoideae of the family Ranunculaceae.

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