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Aphids and their Host Affinity-VIII: *Schizaphis* spp.

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ABSTRACT

Species of the genus Schizaphis (Aphidinae: Aphidini) are highly restrictive in host plant selection. Out of 40 species, sixteen (40%) showed monophagy, twelve (30%) oligophagy and another twelve (30%) polyphagy. S. chaenometicola hosted only on Rosaceae (Chaenomeles speciosa) in dicotyldons and fifteen species were monophagous in monocotyledons – one on Typhaceae (Typha capensis) in corolliferae and rest fourteen in glumiflorae (Cyperaceae and Poaceae). The GAI values in most of the cases were close to 1.000. In all polyphagous species of Schizaphis host plants from glumiflorae were part of the host range and their GAI values ranged 0.667-1.682. Generalized view of host affinity to taxonomic groups revealed that Schizaphis spp. selected host plants from all the divisions of dicotyledons (5.23%) and monocotyledons (94.77%). However, host species from glumiflorae (Cyperaceae and Poaceae) in monocotyledons alone demonstrated their distinct affinity (87.11%). The most important species was S. graminum which feed on 109 host species belonging to 54 genera and six families. Evolutionary pattern manifested that all the host families in monocotyledons of S. graminum evolved from Liliales stock. No host species was found representing primitive orders like Butomales, Alismatales and Commelinales and their advanced orders.

Key words: *Aphids, Schizaphis spp., Dicotyledons, Monocotyledons, General Affiliation Index (GAI).*

INTRODUCTION

Species in the genus *Schizaphis* (Aphidinae: Aphidini) are highly consistent in their host plant relationships. Probably half of the species live all year on Poaceae and most of the rest (subgenus Paraschizaphis) on Cyperaceae and Typhaceae[1]. About 36 species of *Schizaphis* are of Palaeactic origin and rest Nearctic species. They are related to *Rhopalosiphum* but differentiated on the basis of tapering siphunculi and media of forewing only once branched[1]. The most important species of the genus is *S. graminum* which is commonly known as greenbug. Thorsteinson[2] opined that host selection in most of the phytophagous insects is made from taxonomically grouped plant species. The above view was supported by Rathore and Lal[3] in pod borer, *Maruca vitrta*.

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Recently, similar observations were made by Rathore ant Tiwari[4,5] in *Bemisia tabci* and 42 *Bemisia* spp., respectively and also by Rathore and Tiwari[6] in three species of aphids (*Hyadaphis, Uroleucon* and *Viteus* spp.). In the present paper host plant relationships of *Schizaphis* spp. was investigated.

MATERIALS AND METHODS

Literature on host plants of different species of *Schizaphis* was reviewed from extensive work of Blackman and Eastop [1,7,8,9] . Host plant species thus reported were aligned with the families and orders as described by Hutchinson[10] and evolutionary pattern described therein. Hutchinson[10] in his taxonomic classification divided angiosperms into subphyla dicotyledons and monocotyledons. Dicotyledons were further divided into lignosae (primarily woody plants) and herbaceae (primarily herbaceous plants). Monocotyledons were partitioned into calyciferae (with distinct calyx and corolla), corolliferae (calyx and corolla are more or less similar) and glumiflorae (perianth are more or less reduced or represented by lodicules). To observe the closeness of relationships, various ratios were worked out and a GAI was calculated as reported by Rathore and Tiwari[11]. Degree of host preference was categorized as mono-, oligo- and polyphagous following the terminology of Bernays and Chapman[12]. For further details readers are referred to first publication "Aphids and their host affinity-I: *Acyrthosiphon* spp."[13]

RESULTS AND DISCUSSION

Perusal of results presented in Table 1 and 2 revealed that in general *Schizaphis* spp. preferred host species from monocotyledons (94.77%) as compared to dicotyledons (5.23%). Out of 40 *Schizaphis* species reported in Table 1, 40% were monophagous, 30% oligophagous, and rest 30% polyphagous. Among 16 monophagous species, one restricted feeding on Rosaceae (*Chaenomeles speciosa*) in dicotyledons and 15 showed monophagy in monocotyledons, i.e., one in corolliferae- Typhaceae (*Typha capensis*) and other 14 on glumiflorae (Poaceae and Cyperaceae) (Table 1). GAI in monophagous species was 1.000 except in *S. nigra* (1.333) and *S. pilipes* (1.667) because of more host species of the same genus. Twelve *Schizaphis* species (30%) were oligophagous and all in monocotyledons, i.e., eight on Poaceae and six on Cyperaceae. Their GAI values ranged from 1.000 to 2.500 but in most cases close to 1.000. Monophagous and oligophagous species together contributed 70% of the total (Table 1). In all polyphagous *Schizaphis* species, host plants from glumiflorae were always part of the host range. GAI values ranged from 0.667 – 1.682 (Table 1).

Table 1: Species of *Schizaphis* in relation to their host taxonomy

***Schizaphis* spp.**	**Host plants with taxonomic group**	**No. of host species**	**GAI**	**Status**
S. acori	**Monocot-corolliferae:** Araceae (1) (*Acoruscalamus*); **Monocot- Glumiflorae:** cyperaceae (1) (*Cyperusdifformus*)	2	0.667	Polyphagous
S. agrostis	**Monocot-glumiflorare:** Poaceae (4) (*Agrostiscapillaris, A. stolonifera, Elymu ssp., Poaannua*)	4	1.200	Oligophagous
S. aurea	**Monocot-glumiflorae:** Poaceae (1) (*Pennisetumalopeculoides*)	1	1.000	Monophagous
S. borealis	**Monocot-glumiflorae:** Poaceae (1) (*Phleumpratense*)	1	1.000	Monophagous
S. brachytarsus	**Monocot-glumiflorae:** Cyperaceae (1) (*Scirpus* spp., *Carexcurta*)	2	1.000	Oligophagous
S. caricis	**Monocot-glumiflorae:** Cyperaceae (8) (*Carex* spp.(7), *Scirpus* sp.)	8	2.500	Oligophagous
S. chaenometicola	**Dicot-lignosae:** Rosaceae (1) (*Chaenomeles speciosa*)	1	1.000	Monophagous

S. cuprea	**Monocot-glumiflorae:** Poaceae (1) (*Calamagrostis* spp.)	1	1.000	Monophagous
S. dubia	**Monocot-glumiflorae:** Poaceae (4) (*Agrostis stolonifera, Avena barbata, Bromus arvensis, Calamagrostis canescens*)	4	1.000	Oligophagous
S. eastopi	**Monocot-corolliferae:** Typhaceae (1) (*Typha capensis*)	1	1.000	Monophagous
S. gracilis	**Monocot-glumiflorae:** Cyperaceae (1) (*Carex maritima*)	1	1.000	Monophagous
S. graminum	**Dicot-lignosae:** Fabaceae (1); **Dicot-herbaceae:** Polygonaceae (1) **Monocot-corolliferae:** Iridaceae (1); **Monocot-glumiflorae:** Cyperaceae (4), Juncaceae (1), Poaceae (101)	109	1.682	Polyphagous
S. hierochlorophaga	**Monocot-glumiflorae:** Poaceae (1) (*Cymbopogon sp.*)	1	1.000	Monophagous
S. holci	**Monocot-glumifloriae:** Poaceae (4) (*Holcus lanatus, H. mollis, Holcus sp., Poa annua*)	4	1.500	Oligophagous
S. hypersiphonata	**Monocot-glumiflorae:** Poaceae (14)	14	1.230	Oligophagous
S. jaroslavi	**Dicot-herbaceae:** Menispermaceae (1); **Monocot-glumiflorae:** Poaceae (5)	6	0.889	Polyphagous
S. longicaudata	**Monocot-glumiflorae:** Poaceae (6)	6	1.000	Oligophagous
S. longisetosa	**Monocot-glumiflorae:** Cyperaceae (1) (*Carex rhynchophysa*)	1	1.000	Monophagous
S. mali	**Dicot-lignosae:** Rosaceae (1) (*Malus baccata*); **Monocot-glumiflorae:** Cyperaceae (1) (*Carex aquatilis*)	2	0.667	Polyphagous
S. minuta	**Dicot-herbaceae:** Scrophulariaceae (1); **Monocot-glumiflorae:** Cyperaceae (5)	6	1.000	Polyphagous
S. muhlenbergiae	**Monocot-glumiflorae:** Poaceae (3) (*Leymus arenarius, Poa pratens, Muhlenbergia* sp.)	3	1.000	Oligophagous
S. nigerrima	**Monocot-glumiflorae:** Poaceae(3) (*Alopecurus pratensis, Calamagrostis spp., Fastuca pratensis*)	3	1.000	Oligophagous
S. nigra	**Monocot-glumiflorae:** Cyperaceae (2) (*Carex laxiflora, C. vulpinoidea*)	2	1.333	Monophagous
S. palustris	**Monocot-calyciferae:** Juncajinaceae (2); **Monocot-glumiflorae:** Juncaceae (7), Poaceae (1)	10	1.500	Polyphagous
S. pashtshenkoae	**Monocot-glumiflorae:** Cyperaceae (1) (*Carex* spp.)	1	1.000	Monophagous
S. phlei	**Monocot-glumiflorae:** Poaceae (6)	6	1.143	Oligophagous
S. pilipes	**Monocot-glumiflorae:** Cyeraceae (3) (*Carex acuta, C. lasiocarpa, C. nigra*)	3	1.667	Monophagous
S. piricola	**Dicot-lignosae:** Rosaceae (4); **Monocot-glumiflorae:** Cyperaceae (2)	6	1.000	Polyphagous
S. priori	**Monocot-glumiflorae:** Poaceae (1) (*Leymus arenarius*)	1	1.000	Monophagous
S. pyri	**Dicot-lignosae:** Rosaceae (1), **Monocot-glumiflorae:** Cyperaceae (4)	5	1.000	Polyphagous
S. rosazevedoi	**Monocot-calyciferae:** Strelitziaceae (1); **Monocot—corolliferae:** Typhaceae (4); **Monocot-glumiflorae:** Poaceae (1)	6	0.889	Polyphagous
S. rotundiventris	**Dicot-lignosae:** Ericaceae (1), Fabaceae (1); **Monocot-corolliferae:** Araceae (1), Arecaceae (1), Typhaceae (1); **Monocot-glumiflorae:** Cyperaceae (15), Poaceae (2)	22	1.000	Polyphagous
S. rufula	**Dicot-herbaceae:** Chenopodiceae (2); **Monocot-glumiflorae:** Poaceae (10)	12	0.993	Polyphagous
S. scirpi	**Monocot-corolliferae:** Araceae (2), Iridaceae (1), Typhaceae (6); **Monocot-glumiflorae:** Cyperaceae (14), Juncaceae (1)	24	1.182	Polyphagous

S. scirpicola	**Monocot-glumiflorae:** Cyperaceae (2)	2	1.000	Oligophagous
S. thunbergi	**Monocot-glumiflorae:** Poaceae (1) (*Calamagrostis purpurea*)	1	1.000	Monophagous
S. variegate	**Monocot-glumiflorae:** Cyperaceae (1) (*Carex juncella*)	1	1.000	Monophagous
S. wahlgreni	**Monocot-glumiflorae:** Cyperaceae (2) (*Carex vesicaria, Eleocharis palustris*)	2	1.000	Oligophagous
S. weingaertneriae	**Monocot-glumiflorae:**Poaceae (1) (*Corynephorus canescens*)	1	1.000	Monophagous
S. werderi	**Monocot-glumiflorae:** Poaceae (1) (*Poa alpina*)	1	1.000	Monophagous

A generalized view of affinity to plant taxonomic groups presented in Table 2 showed that *Schizaphis* spp. accepted the host plants from all the divisions of dicotyledons and monocotyledons. However, host species from glumiflorae (Poaceae and Cyperaceae) distinctly dominated their affinity to *Schizaphis* spp. as 87.11% host plant species belonged to this category. Blackman and Eastop[1] also reported that half the species of *Schizaphis* live all year on Poaceae and most of the rest on (subgenus *Paraschizaphis*) on Cyperaceae. The species in subgenus *Paraschizaphis* are viz., *S. acori, S. brachytarsus. S. caricis, S. eastopi, S. logisetosa, S. pashtshenkoae, S. rosazevedoi, S. scirpi, S. scirpicola. S. palustis* belongs to subgenus *Euschizaphis* and showed preference to Juncaceae. A generalized species: family ratio for dicotyledons was 1.36 and of monocotyledons 4.95 again indicating greater affinity to monocotyledons. These ratios separately for calyciferae, corolliferae and glumiflorae in monocotyledons were 1.50, 1.90 and 5.81, respectively further endorsed the affinity of *Schizaphis* species to glumiflorae group of host plants, i.e., from Poaceae and Cyperaceae. No plant species was reported as host of *Schizaphis* from non-angiosperms.

Table 2: Species of *Schizaphis* in relation to their host taxonomy

Parameters	Host plants						Total
	Dicotyledons		Monocotyledons			Others*	
	Lignosae	Herbaceae	Calyciferae	Corolliferae	Glumiflorae		
Species	10 (3.48)	5 (1.74)	3(1.05)	19 (6.62)	250 (87.11)	0	287
Genera	8 (4.60)	4 (2.30)	2 (1.15)	12 (6.90)	148 (85.05)	0	174
Families	7 (10.61)	4 (6.06)	2 (3.03)	10 (15.15)	43 (65.15)	0	66
Orders	7 (10.77)	4 (6.15)	2 (3.08)	10 (15.38)	42 (64.62)	0	65
Total	**32 (5.41)**	**17 (2.87)**	**9 (1.52)**	**51 (8.61)**	**483 (81.59)**	**0**	**592**

The most important and highly invasive species is *S. graminum* and has been recognized as a major pest of small grains for over 150 years[14]. The first North American report of *S. graminum* was on wheat and barley in Virginia about 1882[15].It is a palaearctic species, possibly of Middle Eastern or Central Asian origin, now widely distributed throughout Southern Europe, Asia, Africa and North and South America[16] .In our study it has been found feeding on 109 plant species belonging to 54 genera in 6 families of both dicotyledons and monocotyledons. Among dicotyledons it has been reported on *Trifolium subterraneum* (Fabaceae) and *Fagopyrum esculentum* (Polygonaceae). In monocotyledons *S. graminum* accepted one host species from Iridaceae *(Iris* sp.), four Cyperaceae (*Carex* sp., *Cyperus longus, C. niveus, C. rotundus*), one Juncaceae (*Juncus tenuis*) and 101 from Poaceae (*Aegilops, Agropyron, Agrostis, Alopecurus, Andropogon, Anthoxanthum, Arundo, Avena, Brachiaria, Bromus, Calamagrostis, Cynodon, Dactylis, Danthonia, Digitaria, Distichlis, Echinochloa, Eleusine, Elymus, Eragrostis, Festuca, Hordeum, Lolium, Mormus, Oryza, Panicum, Paspalum, Phalaris, Pleum, Phragmatis, Poa, Secale, Setaria, Sorghum, Sporobolus, Stipa, Trisetaria, Triticum, Zea,*

etc.). Host range of *S. graminum* on grasses and cereals was reported by Nuessly et al,[17] and on weedy hosts by Dahms et al[18] and Michels[19] supports the host range reported herein. GAI value 1.682 manifests polyphagy with restrictive taxonomic variability. Species: family ratio to different categories was 1.00, 1.00, 1.00, 1.00 and 2.08 for lignosae, herbaceae, calyciferae, corolliferae and glumiflorae, respectively further substantiated that Poaceae in glumiflorae is the choicest food and showed greater affinity to this group of plant species. Nevertheless, further investigation at subfamily and tribal levels of host species revealed that all the host genera grouped in two subfamilies, and 14 tribes (Table 3).

Table 3: Association of host genera of *S. graminum* to taxonomic subdivisions of family Poaceae

Family	Subfamily	Tribe	Subtribe	Host genera
Poaceae	Pooideae	Festuceae	Festucinae	*Bromus, Dactylis, Festuca, Poa*
			Loliinae	*Lolium, Vulpia*
Poaceae	Pooideae	Hordeae	Triticinae	*Aeigelops, Agropyron, Secale, Triticum*
			Elyminae	*Elymus, Hordeum*
Poaceae	Pooideae	Agrosteae	-	*Agrostis, Alopeurus, Calamagrostis, Phleum*
Poaceae	Pooideae	Phalarideae	-	*Anthoxanthum, Ehrharta, Phalaris*
Poaceae	Pooideae	Arundineae	-	*Arundo, Phragmites*
Poaceae	Pooideae	Aveneae	-	*Avena, Danthonia*
Poaceae	Pooideae	Chlorideae	-	*Bouteloua, Cynodon, Distichlis*
Poaceae	Pooideae	Eragrosteae		*Eleusine, Eragrostis*
Poaceae	Pooideae	Oryzeae	Oryzinae	*Oryza*
Poaceae	Pooideae	Stipeae	-	*Stipa*
Poaceae	Pooideae	Sporoboleae	-	*Sporobolus*
Poaceae	Panicoideae	Andropogoneae	Andropogoninae	*Andropogon, Bothrichloa, Sorghum*
Poaceae	Panicoideae	Paniceae	Panicinae	*Brachiaria, Digitaria, Echinochloa, Panicum, Paspalum, Pennisetum, Setaria, Trisetaria*
Poaceae	Panicoideae	Maydeae	-	*Zea*

Feeding by *S. graminum* initially causes yellow or red spots and continues feeding reduces root and shoot biomass development[20] and can lead to plant death[14]. Saliva of this aphid has enzymatic activity that breaks down the cell wall and chloroplast in the susceptible plants [21]. Ryan et al[22] and Grima et al [23] reported that *S. graminum* feeding results in less chloroplast and carbon assimilation and transpiration[22]. Burd[24]showed that some salivary material translocated in the roots and shoots of wheat seedlings, which plant apparently respond to feeding by increased production of ethylene.

S. graminum has shown great genetic variability as represented by many biotypes and nearly all of them (except D) have been characterized on the basis of specific preference for host species and/or ability to damage specific cultivar [25]. Therefore, with the exception of biotype D (which was characterized on the basis of insecticide resistance), biotypes A-K have been characterized by their ability to damage certain resistant plants[26]. Classification of Diehl and Bush[27] described these biotypes a case of polymorphic variation within populations, host races, or possibly within species.

There are a number of studies that looked into such differences on molecular basis. Black et al[28] showed detectable differences between and within *S. graminum* biotypes. Sequencing of part of COI region of mtDNA has revealed the existence of three clades[29,30], and also confirmed these findings by using RAPD markers[31]. Biotypes C, E, K, I and J grouped in clade I; A, F, G in clade II and B in clade III in American *S. graminum* populations. Clones collected from wheat in Tunisia fell in two clusters; 1st clade including clones from north Tunesia which were clearly associated with agricultural biotypes C, E, I and K while the 2nd clade non-agricultural biotypes F, G and H[32].These trends towards molecular divergence appear to be adaptation of *S. graminum* to host plant groupings. [29,30,33,34]

Evolutionary pattern revealed that order Leguminales of the family Fabaceae was 6th and order polygonales of the family Polygonaceae on 63rd position. On the other hand families in orders Typhales (Typhaceae) and Iridales (Iridaceae) were on 98th and 100th positions, respectively whereas orders Juncales (Juncaceae), Cyperales (Cyperaceae) and Graminales (Poaceae) were on 109th, 110th and 111th position on evolutionary scale, respectively as described by Hutchinson[11]. All the host orders in monocotyledons evolved from Liliales stock. In spite of so many host species in monocotyledons neither primitive progenitors like Butomales, Alismatales and Commelinales nor their advanced orders provided any host species for *S. graminum*. All the host species were virtually grouped in glumiflorae.

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