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Scientific Note

A Note on Host Choice Vs. Plant Taxonomic Relationships in *Cactodera* spp.

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Cyst forming nematodes are serious pathogens of various agriculture and horticulture crops as well as of forest vegetation. *Cactodera* spp. (Tylenchida:Heteroderidae) are among the plant parasitic nematodes and their host range reported from single to several plant species. Rathore and Ali [1], Rathore and Tiwari [2], Rathore [3-5] reported that nematode species *Meloidogyne incognita*, *Aphelenchoides spp., Xiphinema americanum, Pratelenchoides* spp. and *Rotylenchulus* spp., respectively, select their hosts from taxonomic group (s) of plants and in some cases showed sufficient evidence for phylogenetic relationships on evolutionary scale. In the present study an attempt was made to find out whether such relationships do exist for *Cactodera* spp.

Host plants of 17 *Cactodera* spp. were downloaded from Nemaples [6]. *C. chenopodiae* parasitizing *Chenopodium album* was reported from China by Feng., *et al* [7]. Host plants of *Cactodera* spp. were aligned to families and orders following the APG IV system [8] of flowering plants (classification is fourth version of modern, mostly molecular based system of plant taxonomy being developed by Angiosperm Phylogeny Group). To make numerical differentiation between the affiliation of various taxonomic groups (clades) of plants, Specific Association Index (SAI) and between nematode species General Association Index (GAI) were computed following the method of Rarthore and Tiwari [9]. In support of this, various ratios viz., species/genera, species/families and species/orders were calculated. Host based classification of Berneys and Chapman [10] was employed to differentiate the status of each species.

Host plants of *Cactodera* spp. fall in four clades of APG IV system of classification viz., Monocots, Rosids, Superasterids and Asterids (Table 1). The greater percentage of host species were preferred from Superasterids (48.372%) followed by Rosids (24.651%), Asterids (15.813%) and monocots (11.763%). The SAI value was highest for Superasterids which indicated greater affinity to plants of this clade. SAI values for host plants in Monocots and Asterids were similar while the same was slightly inferior in Rosids (Table 1). The ratios calculated between species/genera, species/families and species/orders further supported the greater affinity with Superasterids as the ratios were 2.000, 4.952 and 7.429, respectively and indicated more host species in less genera, families and orders. The affinity was greater at the level of families and orders than with genera. These ratios were similar for Monocots and Asterids but much less for Rosids.

Taxonomic clades	Host species	Host genera	Host families	Host orders	SAI
Monocots	24 (11.163)	23 (15.972)	8 (13.333)	6 (12.245)	0.703
Rosids	53 (24.651)	40 (27.778)	20 (33.333)	19 (38.776)	0.696
Superasterids	104 (48.372)	52 (36.111)	21 (35.000)	14 (28.571)	1.218
Asterids	34 (15.813)	29 (20,139)	11 (18.333)	10 (20.408)	0.72

Table 1: *Association of Cactodera species to different host parameters.*

Figures in parentheses are percent values; SAI: Specific Association Index.

Taxonomic association of host plants of *Cactodera* spp. presented in table 2 revealed that 70.588% species of *Cactodera* were monophagous (*C. acnidae, C. amaranthi, C. chaubattia, C. chenopodiae, Cestonica, C. evansi, C. johanseni, C. rosae, C. salina, C. thornei, C. torreyanae, C. weissi),* 5.888% oligophagous (*C. cacti*) and 23.529% polyphagous (*C. betulae, C. eremica, C. galinsogae, C. milleri*) (Table 2). Among monophagous species of *Cactodera* 5.882% were on Poaceae (*C. rosae*), 11.764% on Rosids (*C. chabauttia, C. johanseni*) and 52.941% on Superasterids (*C. acnidae, C. amaranthi, C. chenopodiae, C. estonica, C. evansi, C. salina, C. thornei, C. torreyanae, C, weissi*). It is interesting to note that more than half monophagous species (29.412%) were on Amaranthaceae, 11.714% Polygonaceae and each 5.882% on Caryophyllaceae and Montiaceae, again revealing strong affinity to Amaranthaceae and Superasterids. The Oligophagous species, *C. cacti,* exclusively parasitze Superasterids and no other host is known outside this clade. No monophagous species was found on Asterids. The GAI values ranged 1.000 - 1.667, 2.864 and 0.589 - 0.804 for mono-, oligo- and polyphagous species. Values of monophagous species were around one polyphagous less than one. Oligophagous species usually have the same GAI value as in monophagous species but in *C. cacti* it was observed much higher because this nematode parasitizes 61 host plants from a single family. However, this again revealed the strong affinity to plants of this clade.

Superasterids also contributed substantially (21.323%) in the host range of polyphagous species (*C. betulae, C. eremica, C. galinsogae, C. milleri*) and Amaranthaceae involved to the tune of 9.559% on combined basis (Table 2).

Sl. No.	*Cactodera* spp.	Host species	No. of host	GAI	Status
1	*C. acnidae*	Superasterids: Amaranthaceae (1) *Amaranthus tuberculatus*	1	1	Monophagous
2	*C. amaranthi*	Superasterids: Amaranthaceae (2) *Amaranthus viridis, Amaranthus* sp.	2	1.333	Monophagous
3	*C. betulae*	**Monocot**s: Poaceae (14) *Avena sativa*, *Briza maxima, Bromus inermis, Coix lachryma, Dactylis glomerata, Fistula elator, Hordeum vulgare, Paspalum dilatatum, Poa pratensis, Setaria* sp., *Sorghum halepense, Sorghum vulgare, Triticum aestivum, Zea mays*; **Rosida**: Betulaceae (7) *Alnus glutinosa, Betula lenta, Betula nigra, Betula pendula, Betula populifolia, Betula sp., Corylus americana*; Brassicaceae (4) *Brassica juncea, Brassica oleraceae, Lobularia maritima, Raphanus sativus;* Cleomaceae (1) *Cleome spinosa*; Cucurbitaceae (5) *Cucumis melo, Cucumis sativus*, *Cucurbita maxima, Cucurbita moschata, Cucurbita pepo*; Euphorbiaceae (1) *Euphorbia* sp.; Fabaceae (15) *Albizia julibrissin, Amorpha fruticosa, Canavalia ensiformis, Dolichos lablab*, Glycine *max, Lespedeza stipulaceae, Lupinus albus, Lupinus luteus, Melilotus officinalis, Phaseolus coccineus, Phaseolus vulgaris, Robinia pseudoacacia, Trifolium pratense, Trifolium repense, Vigna unguiculata*; Geraniaceae (1) *Geranium maculatum*; Malvaceae (1) *Abelmoschus esculentus*; Onagraceae (1) *Oenothera laciniata*; Rosaceae (1) Geum sp.; **Superasterids:** Amaranthaceae (5) *Amaranthus tricolor, Beta vulgaris, Chenopodium album, Chenopodium amaranticolor*, Spinaciaoleracea: Cactaceae (3) *Disocactus flagelliformis, Opuntia basilaris, Selenicereus* sp.; Caryophyllaceae (1) *Dianthus armerea*; **Asterids**: Acanthaceae (1) *Thunbergia* sp.; Apiaceae (2) *Apium graveolens, Daucus carota;* Asteraceae (6) *Ambrosia artemisiifolia, Helianthus annuus*, *Lactuca sativa, Vernonia* sp., *Xeranthemum annuum, Zinnia* sp.; Caprifoliaceae (1) *Valerianella locusta*; Plantaginaceae (4) *Antirrhinum majus, Linaria canadensis, Penstemon* sp., *Veronica spicata*; Solanaceae (6) *Capsicum frutescens, Nicandra physalodes, Nicotiana tabacum, Physalis alkekengi, Solanum lycopersicum, Solanum melongena*	80	0.804	Polyphagous

4	*C. cacti*	**Superasterid**s: Cactaceae (61) *Borzicactus trollii*, *Cactaceae* sp., *Cereus* sp., *Cereus spaciosus*, *Cereus xantocarpus, Chamaecereus silvesrti, Coryphantha macrothele, Disocardus (Aporocactus) flagelliformis, Echinopsis aurea, Echinopsis* sp., *Epiphyllum* sp., Ferocactus latispinus, Ferocactus pilosus, *Ferocactus setispinus, Ferocactus sp., Gymnocalycium baldianum, Gymnocalycium denudatum, Gymnocalycium joossensianum, Gymnocalycium multiflorum, Gymnocalycium quehlianum, Lobivia pentlandii, Lobivia sp., Mammilaria aurihcornata, M. bravoae, M. confusa, M. elegans, M. gracilis, M. halmiana, M. hidalgensis, M. lenta, M. lloydii, M. longimanma, M. martinezii, M. parkinsoni, M. perbella, M. pringlei, M. prolifera, M. soetigera, M. sempervivi, M. sonorensis, Mammillaria sp., M. spinosissima, M. winterae, M. woodstii, Nopalxochia ackermannii, Notocactus attonis, Notocactus tabularis, Opuntia macdougalina, Opuntia microdasys, Opuntia pailana, Opuntia* sp., *Opuntia srticta, Phyllocactus akkermanni, Pseudoechinopis aurea, Rebutia krainziana, Rebutia kupperama, Rebtia pseudodeminutus, Rebutia* sp., *Schlumbergera truncata, Trichocereus* sp., *Trichocereus spachianus*	61	2.864	Oligophagous
5	*C. chaubattia*	**Rosids:** Rosaceae (2) *Malus domestica, Malus* sp.	2	1.333	Monophagous
6	*C. eremica*	**Rosids**: Ulmaceae (1) Ulmuspumila; **Superasterids:** Amaranthaceae (1) *Atriplex comfotifolia*	2	0.667	Polyphagous
7	*C. estonica*	**Superasterids:** Polygonaceae (3) *Polygonum aviculare, P. nepalense, Polygonium* sp.	3	1.667	Monophagous
8	*C. evansi*	**Superasterids:** Caryophyllaceae (2) *Dianthus caryophyllus, Dianthus* sp.	2	1.333	Monophagous
9	*C. galinsogae*	**Monocots:** Commelinaceae (1) *Tinantia erecta*; Cyperaceae (1) *Cyperus esculentus*; Poaceae (2) *Avena flatua, Hordeum vulgare*; **Rosids:** Brassicaceae (2) *Brassica rapa, Brassica raphanistrum*; Fabaceae (1) *Medicago polymorpha*; Geraniaceae (1) *Erodium cicutarium*; Oxiladaceae (1) *Oxalis jaquiniana*; **Superasterids:** Amaranthaceae (2) *Amaranthus hybridus, Chenopodium berlandieri*; Caryophyllaceae (1) *Spergula arvensis*; Montiaceae (1) *Calandrinia micrantha*; **Asterids:** Asteraceae (7) *Bidens ballsii, Bidens odorata, Bidens serrulata, Cosmos bipinnatus, Galinsoga parviflora, Simsia amplexicaulis, Vilianova achllaeoides*; Plantaginaceae (1) *Veronica persica*	21	0.589	Polyphagous
10	*C. johanseni*	**Rosids:** Brassicaceae (1) *Raphanus sativus*	1	1	Monophagous
11	*C. milleri*	**Monocots:** Amaryllidaceae (1) *Allium cepa*, Asparagaceae (1) *Asparagus officinalis*, Poaceae (3) *Digitaria sanguinalis, Triticum aestivum, Zea mays*; **Rosids**: Brassicaceae (1) *Brassica oleracea*; fabaceae (5) *Glycine max, Lotus corniculatus, Medicago sativa, Phaseolus vulgaris, Trifolium pratense*; Vitacea (1) *Vitis vinifera***; Superasterids:** Amaranthaceae (5) *Amaranthus retrofexus, Beta vulgaris, Chenopodium album, Chenopodium amaranticolor, Chenopodium quinoa*; Cactaceae (5) *Lubivia siylvestrii, Mammillaria elongata, Opuntia rufida, Opuntia vulgaris, Schlambergera truncata*; Caryophyllaceae (1) *Stellaria media*; Polygonaceae (4) *Polygonum convolvulus, Polygonum pennsylvanium, Polygonum persicaria, Rumex crispus*; **Asterids:** Apiaceae (2) *Apium graveolens, Daucus carota;* Lamiaceae (1) *Mentha arvensis*; Solanaceae (3) *Solanum dulcamara, Solanum lycopersicum, Solanum tuberosum*	33	0.729	Polyphagous

12	*C. rosae*	Monocots: Poaceae (1) *Hordeum vulgare*	1	1	Monophagous
13	*C. salina*	Superasterids: Amaranthaceae (1) *Salicornia bigelovti*	1	1	Monophagous
14	*C. thornei*	Superasterids: Montiaceae (1) *Claytonia (Montia) perfoliata*	1	1	Monophagous
15	*C. torreyanae*	Superasterids: Amaranthaceae (1) *Suaeda torreyane*	1	1	Monophagous
16	*C. weissi*	Superasterids: Polygonaceae (2) *Polygonum pennsylvanium, Polygonum persicaria*	2	1.333	Monophagous
17	*C. chenopodiae*	Superasterids: Amaranthaceae (1) *Chenopodium album*	1	1	Monophagous

Table 2: *Taxonomic position of host plants of Cactodera species.*

Affiliation of various *Cactodera* species to taxonomic groups of host plants is presented in table 3. After avoiding repetition of names from families, the picture reveals that four *Cacodera* species were associated with Monocots, six with Rosids, 14 with Superasterids and three with Asterids. In Monocots*, C. milleri* was predominant parasite on Asparagales while on Commelinales it was *C. galinsoga*e. Poales harboured four *Cactodera* species. Among Rosids-Febids (Cucurbitales, Fabales, Fagales, Rosales) and Malvids (Brassicales, Gereniales, Malvales, Myrtales) both were predominantly parasitized by *C. betulae*. In COM-clade Oxalidale was parasitized by *C. galinsogae* and Malpighiales by *C. betulae*. Superasterids were parastized by maximum number of species. After removing the repetition from families, 14 *Cactodera* species harboured the clade and strong affiliation with Amaranthaceae was evident. Among Asterids both Campanulids (Apiales, Asterales, Dipsacales) and Lamids (Lamiales, Solanales) had common parasites. Polyphagous *C. betulae* dominated the scene. However, plant species from Superasterids tremendously contributed in the host range of *Cactodera* spp. and showed very strong affinity to host plants of this clade.

Clade	Order	Family	*Cactodera* species	No. of species
Monocots	Asparagales	Amaryllidaceae	*C. milleri*	1
		Asparagaceae	*C. milleri*	1
	Commelinales	Commelinaceae	*C. galinsogae*	1
	Poales	Cyperaceae	*C. galinsogae*	1
		Poaceae	*C. betulae, C. galinsogae, C. milleri, C. rosea*	4
Rosids	Brassicales	Brassicaceae	*C. betulae, C. galinsogae, C. johanseni*	4
			C. milleri	
		Cleomaceae	*C. betulae*	1
	Cucurbitales	Cucurbitaceae	*C. betulae*	1
	Fabales	Fabaceae	*C. betulae, C. galinsogae, C. milleri*	3
	Fagales	Betulaceae	*C. betulae*	1
	Gereniales	Geraniaceae	*C. betulae, C. galinsogae*	2
	Malpighiales	Euphorbiaceae	*C. betulae*	1
	Malvales	Malvaceae	*C. betulae*	1
	Myrtales	Onagraceae	*C. betulae*	1
	Oxalidales	Oxiladaceae	*C. galinsogae*	1
	Rosales	Rosaceae	*C. betulae, C. chaubattia*	2
		Ulmaceae	*C. eremica*	1
	Vitales	Vitaceae	*C. milleri*	1

Superasterids	Caryophyllales	Amaranthaceae	*C. acnidae, C. amaranthi, C. betulae, C. enermica, C. galinsogae, C. milleri, C. salina, C. torreyanae, C. chenopodiae*	9
		Cactaceae	*C. betulae, C. cacti, C. milleri*	3
		Caryophyllaceae	*C. betulae, C. evansi, C. galinsogae, C. miller*i	4
		Montiaceae	*C. galinsogae, C. thornei*	2
		Polygonaceae	*C. estonica, C. milleri, C. weissi*	3
Asterids	Apiales	Apiaceae	*C. betulae, C. milleri*	2
	Asterales	Asteraceae	*C. betulae, C. galinsogae*	2
	Dipsacales	Caprifoliaceae	*C. betulae*	1
	Lamiales	Acanthaceae	*C. betulae*	1
		Lamiaceae	*C. milleri*	1
		Plantaginaceae	*C. betulae, C. galinsogae*	2
	Solanales	Solanaceae	*C. betulae, C. milleri*	2

Table 3: *Distribution of Cactodera species to different orders and families.*

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