

## **DIVERSITY IN HOST PREFERENCE OF *ROTYLENCHUS* SPP.**

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**Abstract:** Species of the genus *Rotylenchus* are ecto- or semi-endo parasites and feed on roots of their host plants. In the study it was found that 50% species of *Rotylenchus* were monophagous and mostly on plants in the clade Rosids followed by monocots, Asterids and gymnosperms. In general, Rosids and Asterids combined parasitized more than 50% host species followed by monocots. Though food preference was species specific but by and large woody plants were preferred from very primitive families like Magnoliaceae and Lauraceae to representatives of advanced families. Woody plants like pines and others made a substantial contribution in the host range of *Rotylenchus*. Maximum number of *Rotylenchus* species harboured plants in families Poaceae (monocots), Rosaceae (Rosids) and Oleaceae (Asterids) followed by Fabaceae, Fagaceae, Asteraceae and Pinaceae. It is, therefore, suggested that agricultural crops should be grown far away from wild vegetation and forest plantations.

**Keywords:** *Rotylenchus*, Magnoliids, Rosids, Asterids, Gymnosperms, Host preference.

### **INTRODUCTION**

Species of the genus *Rotylenchus* (Nematoda: Haplolaimidae) are migratory ectoparasites and browse on the surface of roots. The damage caused by them is usually limited to necrosis of penetrated cells (1). However, species with longer stylet penetrate to tissues more deeply and killing more cells and called as semi-endoparasites (2,3). The genus contains 97 nominal species which parasitize on a wide range of wild and cultivated plants worldwide (3). Studies have revealed that generally nematodes prefer to parasitize host plants from selective taxonomic groups or some similar nature (4,5,6,7). It was, therefore, thought to be appropriate to find out the host preference of *Rotylenchus* species in relation to taxonomic groups of plant species.

### **MATERIALS AND METHODS**

Host plants of *Rotylenchus* species were downloaded from Nemaplex (8) and other reported in the literature were added. All the plant species were aligned and classified according to APG IV system(9)(Fourth version of modern, mostly molecular based system of plant taxonomy of flowering plants developed by Angiosperm Phylogeny Group). Here families are grouped into different clades. Host species were numerically categorized in each clade.

To observe the superiority of one clade over the other or one species over the other, Specific Affiliation Index (SAI) and General Affiliation Index (GAI) were computed following the method of Rathore and Tiwari (5). Certain ratios viz., species: genus, species: family and species: order were calculated to observe the contribution of particular group(s) towards the preference of host species. The terms monophagous, oligophagous and polyphagous were adopted from Barneys and Chapman (10).

## RESULTS AND DISCUSSION

A general bird-eye picture evolved from Table 1 revealed that majority of plants were preferred from Rosids, Asterids and monocot clades from angiosperms followed by gymnosperms. Rosids and Asterid clades had 29.371 and 28.671% plants, respectively followed by monocots (18.881%). Rosids and Asterids combination resulted in more than 50% plants of the total. Although, *Rotylenchus* species parasitized very primitive Magnoliid plants (2.098%) and gymnosperms (11.189%). The Specific Association Index (SAI) did not indicate better preference between prominent clades. Their values demonstrate high polyphagy and wide distribution of host species in genera, families and orders. Contribution of aforesaid parameters was better in gymnosperms as evident by species: family and species: order ratios which were 2.000 and 2.667, respectively. In general, gymnosperms were preferred better than angiosperms in spite of angiosperms had bigger host range.

<b>Table 1. Association of <i>Rotylenchus</i> spp. to different host parameters</b>					
<b>Taxonomic clades</b>	<b>Host species</b>	<b>Genera</b>	<b>Families</b>	<b>Orders</b>	<b>SAI</b>
Magnoliids	3 (2.098)*	2 (1.550)	2 (1.942)	2 (2.174)	0.833
Monocots	27 (18.881)	26 (20.155)	19 (18.447)	17 (18.498)	0.468
Eudicots	3 (2.098)	3 (2.326)	3 (2.913)	3 (3.261)	0.556
Superrosids	3 (2.098)	3 (2.326)	3 (2.913)	3 (3.261)	0.556
Rosids	42 (29.371)	36 (27.907)	30 (29.126)	28 (30.435)	0.468
Superasterids	6 (4.196)	5 (3.876)	5 (4.854)	3 (3.261)	0.615
Asterids	41 (28.671)	40 (31.008)	31 (30.097)	28 (30.435)	0.434
COM Clade	2 (1.399)	2 (1.550)	2 (1.942)	2 (2.174)	0.667
Gymnosperms	16 (11.189)	12 (9.302)	8 (7.767)	6 (6.522)	0.692
*Figures in parentheses are percent values					

Host plants of individual *Rotylenchus* species are listed in Table 2. They are grouped in each clade along with the families. It was observed that out of 28 *Rotylenchus* species, 50% were

Table 2. Host taxonomic affinity of <i>Rotylenchus</i> spp.					
S.No.	<i>Rotylenchus</i> spp.	Host species with taxonomic groups	No. host species	GAI	Status
1	<i>R. agnetis</i>	<b>Mono</b> -Asparagaceae (1) <i>Ruscus aculeatus</i>	1	1	Monophagous
2	<i>R. boocki</i>	<b>Mono</b> -Araceae (1) <i>Anthurium andraeanum</i>	1	1	Monophagous
3	<i>R. breviglans</i>	<b>Magnoliids</b> -Lauraceae (1) <i>Persea americana</i> ; <b>Superrosids</b> -Grossulariaceae (1) <i>Ribes speciosum</i> ; <b>Superasterids</b> -Cactaceae (1) <i>Opuntia</i> spp.; <b>Asterids</b> -Lamiaceae (1) <i>Salvia leucophylla</i>	4	0.6	Polyphagous
4	<i>R. buxophilus</i>	<b>Mono</b> -Asparagaceae (3) <i>Cordyline</i> sp., <i>Ruscus hypophyllum</i> , <i>Sansevieria</i> sp.; Araceae (1) <i>Anthurium</i> sp., Araceae (1) <i>Palmaceae</i> sp.; Poaceae (1) <i>Secale cereale</i> ; Strelitziaceae (1) <i>Strelitzia</i> sp. <b>Eudicots</b> -Berberidaceae (1) <i>Berberis thunbergii</i> ; Buxaceae (1) <i>Buxus sempervirens</i> ; <b>Superrossids</b> -Paeoniaceae (1) <i>Paeonia</i> sp.; <b>Rosids</b> -Begoniaceae (1) <i>Begonia</i> sp.; Fabaceae (1) <i>Phaseolus lunatus</i> ; Moraceae (1) <i>Ficus carica</i> ; Myrtaceae (3) <i>Eucalyptus</i> sp., <i>Eucalyptus terecornis</i> , <i>Psidium guajava</i> ; Rosaceae (3) <i>Fragaria x ananasa</i> , <i>Pyrus communis</i> , <i>Spiraea</i> sp.; <b>Superasterids</b> -Cactaceae (1) <i>Cactaceae</i> sp.; <b>Asterids</b> -Apocynaceae (1) <i>Vinca major</i> ; Ericaceae (1) <i>Erica arborea</i> ; Oleaceae (2) <i>Ligustrum</i> sp., <i>Ligustrum vulgare</i> ; Solanaceae (1) <i>Solanum lycopersicum</i> ; Theaceae (1) <i>Camellia</i> sp.; <b>COM clade</b> -Celastraceae (1) <i>Euonymus</i> sp.; <b>Gymnosperms</b> -Pteridaceae (1) <i>Adiantum</i> sp.	28	0.448	Polyphagous
5	<i>R. cazorlaensis</i>	<b>Rosids</b> -Fagaceae (2) <i>Quercus faginea</i> , <i>Quercus rotundifolia</i>	2	1.333	Monophagous
6	<i>R. cretensis</i>	<b>Asterids</b> -Oleaceae (1) <i>Olea</i> sp.	1	1	Monophagous
7	<i>R. cypriensis</i>	<b>Asterids</b> -Oleaceae (1) <i>Olea</i> sp.; Solanaceae (1) <i>Solanum tuberosum</i>	2	0.667	Polyphagous
8	<i>R. dalikhaniensis</i>	<b>Mono</b> -Asparagaceae (1) <i>Ruscus hyrcanus</i>	1	1	Monophagous
9	<i>R. eximius</i>	<b>Rosids</b> -Rosaceae (1) <i>Prunus dulcis</i> ; Sapindaceae (1) <i>Pistacea lentiscus</i> ; <b>Asterids</b> -Oleaceae (1) <i>Olea europaea</i> sp. <i>sylvestris</i>	3	0.556	Polyphagous
10	<i>R. goodeyi</i>	<b>Mono</b> -Iridaceae (1) <i>Iris</i> sp.; <b>Rosids</b> -Fabaceae (1) <i>Medicago sativa</i> ; Moraceae (1) <i>Ficus</i> sp.; Rosaceae (2) <i>Fragaria chiloensis</i> , <i>Fragaria x ananasa</i> ; <b>Asterids</b> -Asteraceae (1) <i>Chrysanthemum leucanthemum</i> ; Oleaceae (1) <i>Olea europaea</i> sp. <i>sylvestris</i> ; <b>COM clade</b> -Violaceae (1) <i>Viola</i> sp.	8	0.588	Polyphagous
11	<i>R. graecus</i>	<b>Mono</b> -Poaceae (1) <i>Arundo donax</i> ; <b>Asterids</b> -Araliaceae (1) <i>Hedera helix</i>	2	0.883	Polyphagous
12	<i>R. helenae</i>	<b>Mono</b> -Poaceae (1) <i>Triticum aestivum</i> ; <b>Asterids</b> -Ericaceae (1) <i>Erica cinerea</i>	2	0.883	Polyphagous
13	<i>R. incognitus</i>	<b>Gymnosperms</b> -Pinaceae (1) <i>Pinus pinaster</i>	1	1	Monophagous
14	<i>R. incullus</i>	<b>Rosids</b> -Vitaceae (1) <i>Vitis vinifera</i>	1	1	Monophagous
15	<i>R. iranicus</i>	<b>Rosids</b> -Fagaceae (1) <i>Fagus orientalis</i>	1	1	Monophagous
16	<i>R. jaeni</i>	<b>Rosids</b> -Fagaceae (1) <i>Quercus suber</i>	1	1	Monophagous

17	<i>R. jagatpurensis</i>	<b>Mono-Poaceae</b> (2) <i>Festuca pseudovina</i> , <i>Zea mays</i> ; <b>Asterids-Asteraceae</b> (1) <i>Artemissia maritima</i>	3	0.719	Polyphagous
18	<i>R. labiodiscus</i>	<b>Asterids-Asteraceae</b> (2) <i>Brachyglottis repanda</i> , <i>Cyathia</i> sp.	2	0.667	oligophagous
19	<i>R. landii</i>	<b>Gymnosperms-Pinaceae</b> (1) <i>Pinus pinaster</i>	1	1	Monophagous
20	<i>R. laurentinus</i>	<b>Asterids-Apiaceae</b> (1) <i>Daucus carota</i>	1	1	Monophagous
21	<i>R. magnus</i>	<b>Rosids-Fagaceae</b> (1) <i>Quercus suber</i> ; <b>Asterids-Aquifoliaceae</b> (1) <i>Ilex aquifolium</i>	2	0.667	Polyphagous
22	<i>R. montanus</i>	<b>Rosids-Rosaceae</b> (1) <i>Malus domestica</i>	1	1	Monophagous
23	<i>R. pumilus</i>	<b>Mono-Poaceae</b> (1) <i>Poa pratensis</i> ; <b>Gymnosperms-Cupressaceae</b> (1) <i>Juniperus monosperma</i> ; <b>Pinaceae</b> (2) <i>Pinus edulis</i> , <i>Pinus pinaster</i>	4	0.75	Polyphagous
24	<i>R. robustus</i>	<b>Mono-Alstroemeriaceae</b> (1) <i>Alstroemeria</i> sp.; <b>Araceae</b> (2) <i>Zantedeschia aethiopica</i> , <i>Philodendron</i> sp.; <b>Arecaceae</b> (2) <i>Washingtonia</i> sp., <i>Cocos nucifera</i> ; <b>Asparagaceae</b> (2) <i>Convallaria majalis</i> , <i>Lilium speciosum</i> ; <b>Bromeliaceae</b> (1) <i>Ananas comosus</i> ; <b>Iridaceae</b> (1) <i>Gladiolus</i> sp.; <b>Poaceae</b> (2) <i>Lolium perenne</i> , <i>Saccharum officinarum</i> ; <b>Eudicots-Buxaceae</b> (1) <i>Buxus sempervirens</i> ; <b>Superrossids-Saxifragaceae</b> (1) <i>Huachera</i> sp.; <b>Rosids-Fabaceae</b> (1) <i>Pisum sativum</i> ; <b>Geraniaceae</b> (1) <i>Pelargonium</i> sp.; <b>Malvaceae</b> (1) <i>Fremontodendron</i> sp.; <b>Myrtaceae</b> (2) <i>Eucalyptus</i> sp., <i>Eucalyptus tereticornis</i> ; <b>Rosaceae</b> (3) <i>Fragaria</i> sp., <i>Malus sylvestris</i> , <i>Rosa</i> sp.; <b>Rutaceae</b> (2) <i>Citrus sinensis</i> , <i>Citrus</i> sp.; <b>Vitaceae</b> (1) <i>Vitis vinifera</i> ; <b>Superasterids-Amaranthaceae</b> (1) <i>Beta vulgaris</i> ; <b>Cactaceae</b> (1) <i>Cactaceae</i> sp.; <b>Caryophyllaceae</b> (2) <i>Dianthus barbatus</i> , <i>Dianthus caryophyllus</i> ; <b>Asterids-Adoxaceae</b> (1) <i>Viburnum carlesii</i> ; <b>Apiaceae</b> (1) <i>Daucus carota</i> ; <b>Aquifoliaceae</b> (1) <i>Ilex crenata</i> ; <b>Asteraceae</b> (4) <i>Bellis</i> sp., <i>Dahlia</i> sp., <i>Scorzonera hispanica</i> , <i>Senecio</i> sp.; <b>Cornaceae</b> (1) <i>Cornus florida</i> ; <b>Ericaceae</b> (4) <i>Andromeda</i> sp., <i>Arctostaphylos</i> sp., <i>Pieris japonica</i> , <i>Rhododendron</i> sp.; <b>Hydrangeaceae</b> (1) <i>Hydrangea</i> sp.; <b>Oleaceae</b> (2) <i>Ligustrum</i> sp., <i>Olea europaea</i> ; <b>Plantaginaceae</b> (1) <i>Antirrhinum</i> sp.; <b>Solanaceae</b> (3) <i>Solanum lycopersicum</i> , <i>Solanum tuberosum</i> , <i>Nicotiana tabacum</i> ; <b>Theaceae</b> (1) <i>Camellia</i> sp.; <b>Magnoliids-Magnoliaceae</b> (1) <i>Magnolia soulangiana</i> ; <b>Gymnosperms-Cupressaceae</b> (4) <i>Thuja occidentalis</i> , <i>Juniper</i> sp., <i>Juniper squamata</i> , <i>Sequoia</i> sp.; <b>Pinaceae</b> (5) <i>Picea pungens</i> , <i>Picea sitchensis</i> , <i>Pinus</i> sp., <i>Pinus sylvestris</i> , <i>Pinus radiata</i> ; <b>Pteridaceae</b> (1) <i>Adiantum pedatum</i> ;	59	0.545	Polyphagous
25	<i>R. uniformis</i>	<b>Magnoliids-Lauraceae</b> (1) <i>Persea americana</i> ; <b>Rosids-Fabaceae</b> (1) <i>Glycine max</i> ; <b>Rosaceae</b> (2) <i>Malus sylvestris</i> , <i>Prunus domestica</i> ; <b>Sapindaceae</b> (1) <i>Aesculus</i> sp.; <b>Asterids-Apiaceae</b> (1) <i>Daucus carota</i> ; <b>Theaceae</b> (1) <i>Camellia japonica</i>	7	0.474	Polyphagous
26	<i>R. unisexus</i>	<b>Rosids-Fabaceae</b> (1) <i>Glycine max</i> ; <b>Rutaceae</b> (1) <i>Citrus aurantium</i>	2	0.667	Polyphagous
27	<i>R. urmiaensis</i>	<b>Rosids-Betulaceae</b> (1) <i>Corylus</i> sp.	1	1	Monophagous
28	<i>R. vitis</i>	<b>Rosids-Vitaceae</b> (1) <i>Vitis vinifera</i>	1	1	Monophagous

monophagous (*R. agnetis*, *R. boocki*, *R. cajorlaensis*, *R. cretensis*, *R. dalikhaniensis*, *R. incognitus*, *R. incullus*, *R. iranicus*, *R. jaeni*, *R. landii*, *R. laurentinus*, *R. montanus*, *R. urmiaensis*, *R. vitis*) and one species *R. labiodiscus* showed oligophagy (3.871%). Rest of the *Rotylenchus* species (46.429%) were polyphagous in nature. Large number of monophagous species hosted Rosids (25%) followed by monocots (10.714%), Asterids (7.143%) and gymnosperms (7.143%). This shows that host plants in Rosids have been comparatively of recent origin. Among polyphagous species, *R. buxophilus* and *R. robustus* had wide host range having 28 and 59 species, respectively representing many clades. General Affiliation Index (GAI) was 1.000 for all the monophagous species and the same was less than 1 for polyphagous. Hutchinson (11) divided dicotyledonous angiosperms into two divisions viz. lignosae (trees and shrubs and some herbs clearly derived from and related to other woody plants – a fundamentally woody group) and herbaceae (herbs and rarely shrubby plants related to and derived from herbaceous stocks – a fundamentally herbaceous group).

Since more than 50% host plants fall in Rosids and Asterids clades, and if we compare the families of these host species by placing them in lignosae (Apocynaceae, Araliaceae, Aquifoliaceae, Begoniaceae, Betulaceae, Cornaceae, Ericaceae, Fabaceae, Fagaceae, Hydrangeaceae, Malvaceae, Moraceae, Myrtaceae, Oleaceae, Rosaceae, Rutaceae, Sapindaceae, Theaceae, Vitaceae) and herbaceae (Apiaceae, Asteraceae, Adoxaceae, Geraniaceae, Lamiaceae, Plantaginaceae, Solanaceae) we observed that out of 26 families of Rosids and Asterids – 19 grouped in lignosae and 7 herbaceae. This is enough to indicate that *Rotylenchus* species have greater preference to woody plants. This view gets further support from the plant species belong to Magnoliids, which is entirely a woody group and perhaps the most ancient type of existing. In addition, families Grossulariaceae in Superrosids and Cactaceae in Superasterids were also classified in lignosae by Hutchinson (11) having woody plants. Gymnosperms include timber trees and all are woody in nature. Although the preference is species specific but in general there is strong affinity for host plants of woody nature. It is therefore necessary that agricultural crops should be grown away from forest areas and intercropping of only non-host species is suggested.

Perusal of Table 3 revealed that family Poaceae in monocots, Rosaceae in Rosids and Oleaceae in Asterids harboured maximum number of nematode species having 6 in each case followed by Fabaceae (5), Fagaceae (4), Asteraceae (4) and Pinaceae (4), etc. *R. robustus* was the most prolific feeder and parasitized host species from 33 families and from very primitive to advanced ones.

<b>Table 3. Distribution of <i>Rotylenchus</i> spp. to host families and orders</b>				
<b>Clade</b>	<b>Order</b>	<b>Family</b>	<b><i>Rotylenchus</i> species</b>	<b>No. of spp.</b>
Magnoliids	Magnoliales	Lauraceae	<i>R. breviglans</i> , <i>R. uniformis</i>	2
		Magnoliaceae	<i>R. robustus</i>	1
Monocots	Alismatales	Araceae	<i>R. boocki</i> , <i>R. buxophilus</i> , <i>R. robustus</i>	3
	Arecales	Areaceae	<i>R. buxophilus</i> , <i>R. robustus</i>	2
	Asparagales	Asparagaceae	<i>R. agnetis</i> , <i>R. buxophilus</i> , <i>R. dalikhaniensis</i> , <i>R. robustus</i>	4
		Iridaceae	<i>R. goodeyi</i> , <i>R. robustus</i>	2
	Poales	Bromeliaceae	<i>R. robustus</i>	1
		Poaceae	<i>R. buxophilus</i> , <i>R. graecus</i> , <i>R. helenae</i> , <i>R. jagatpurensis</i> , <i>R. pumilus</i> , <i>R. robustus</i>	6
	Zingiberales	Strelitziaceae	<i>R. buxophilus</i>	1
Eudicots	Buxales	Buxaceae	<i>R. buxophilus</i> , <i>R. robustus</i>	2
	Ranunculales	Ranunculaceae	<i>R. buxophilus</i>	1
Superrosids	Saxifragales	Grossulariaceae	<i>R. breviglans</i>	1
		Paeoniaceae	<i>R. buxophilus</i>	1
		Saxifragaceae	<i>R. robustus</i>	1
Rosids	Fabales	Fabaceae	<i>R. buxophilus</i> , <i>R. goodeyi</i> , <i>R. robustus</i> , <i>R. uniformis</i> , <i>R. unisexus</i>	5
	Fagales	Betulaceae	<i>R. urmiaensis</i>	1
		Fagaceae	<i>R. cazorlaensis</i> , <i>R. iranicus</i> , <i>R. jaeni</i> , <i>R. magnus</i>	4
	Geraniales	Geraniaceae	<i>R. robustus</i>	1
	Malvales	Malvaceae	<i>R. robustus</i>	1
	Myrtales	Myrtaceae	<i>R. buxophilus</i> , <i>R. robustus</i>	2
	Rosales	Moraceae	<i>R. buxophilus</i> , <i>R. goodeyi</i>	2
		Rosaceae	<i>R. buxophilus</i> , <i>R. eximius</i> , <i>R. goodeyi</i> , <i>R. montanus</i> , <i>R. robustus</i> , <i>R. uniformis</i>	6
	Sapindales	Rutaceae	<i>R. robustus</i> , <i>R. unisexus</i>	2
		Sapindaceae	<i>R. uniformis</i>	1
Vitales	Vitaceae	<i>R. incullus</i> , <i>R. robustus</i> , <i>R. vitis</i>	3	
Superasterids	Caryophyllales	Amaranthaceae	<i>R. robustus</i>	1
		Cactaceae	<i>R. breviglans</i> , <i>R. buxophilus</i> , <i>R. robustus</i>	3
		Caryophyllaceae	<i>R. robustus</i>	1
Asterids	Apiales	Apiaceae	<i>R. laurentinus</i> , <i>R. robustus</i> , <i>R. uniformis</i>	3
		Araliaceae	<i>R. graecus</i>	1
	Asterales	Asteraceae	<i>R. goodeyi</i> , <i>R. jagatpurensis</i> , <i>R. labiodiscus</i> , <i>R. robustus</i>	4
	Aquifoliales	Aquifoliaceae	<i>R. magnus</i> , <i>R. robustus</i>	2
	Cornales	Cornaceae	<i>R. robustus</i>	1
		Hydrangeaceae	<i>R. robustus</i>	1
	Dipsacales	Adoxaceae	<i>R. robustus</i>	1
	Ericales	Ericaceae	<i>R. buxophilus</i> , <i>R. helenae</i> , <i>R. robustus</i>	3
		Theaceae	<i>R. buxophilus</i> , <i>R. robustus</i> , <i>R. uniformis</i>	3
	Gentianales	Apocynaceae	<i>R. buxophilus</i>	1
	Lamiales	Lamiaceae	<i>R. breviglans</i>	1

		Oleaceae	<i>R. buxophilus</i> , <i>R. cretensis</i> , <i>R. cypriensis</i> , <i>R. eximius</i> , <i>R. goodeyi</i> , <i>R. robustus</i>	6
		Plantaginaceae	<i>R. robustus</i>	1
	Solanales	Solanaceae	<i>R. buxophilus</i> , <i>R. cypriensis</i> , <i>R. robustus</i>	3
COM clade	Celastrales	Celastraceae	<i>R. buxophilus</i>	1
	Malpighiales	Violaceae	<i>R. goodeyi</i>	1
Gymnosperms	Pinales	Cupressaceae	<i>R. pumilus</i> , <i>R. robustus</i>	2
		Pinaceae	<i>R. incognitus</i> , <i>R. landii</i> , <i>R. pumilus</i> , <i>R. robustus</i>	4
	Polypodiales	Pteridaceae	<i>R. buxophilus</i> , <i>R. robustus</i>	2

Molecular studies of Subbotin et al (12) suggested that *R. Goodeyi* and *R. laurentinus* are very closely related or co-specific taxa. Volvas et al (1) reported that nematode presently known as *R. Magnus magnus* and *R. Magnus jaeni* are separate and distinguishable. Tzortzakakis et al (13) observed close molecular relationships between *R. cretensis*, *R. urmiensis* and *R. striaticeps* but all are separate species. In our study all are differing in their host preference.

#### Acknowledgements

Authors are grateful to Mr. Akhilesh Rathore for extending help in retrieving the information.

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