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MEASUREMENT OF DIVERSITY INDICES OF TROPHIC GUILDS OF INSECTS ASSOCIATED WITH THE THORN FOREST COMMUNITY AT HARAPPA ARCHAEOLOGICAL SITE

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ABSTRACT

Insects are dominant component of biodiversity in the terrestrial ecosystems which play important roles in mediating the relationship between the plants and various ecosystem. Shannon-Weaver diversity index, Simpson index, Hill diversity index and Sorenson similarity index were used to explain the diversity of various insect guilds of old groves and rehabilitated stands of the thorn forest community at Harappa. The resemblance in the insect trophic guilds-plant association was found by the cluster analysis. A total of 2419 insects belonging to 147 insect species representing various trophic guilds were present in old groves while a total of 1238 insects belonging to 85 insect species of various trophic guilds were present at restored site. Mean numbers of herbivore, predator and visitor insect species were significantly lower ($p<0.05$) at the restored site while pollinators, scavengers and pests showed no significant difference ($p>0.05$) between both sites. According to Shannon index, herbivores showed no significant difference in diversity among both sites as they showed 100% similarity while predators, pollinators, scavengers, visitors and pests showed significantly less diversity ($p<0.05$) at the restored site. *Salvedora oleoides* and *Tamarix aphylla* had similar trophic guild-plant associations according to the cluster analysis. Both the sites showed 72% similarity regarding various functional guilds so it is expected that with the increasing age and plant diversity of the restored community the diversity of insect guilds species will also increase.

Keywords: Diversity indices, Harappa, Insect Trophic guilds, thorn forest

INTRODUCTION

Insect communities have a diverse range of niches due to their diverse feeding habits i.e., plant herbivores, predators, scavengers and microhabitat requirements (Barkley, 2009). Insects can act as providers, facilitators and eliminators in the ecosystem. Various insects act as providers by being used as food or as the hosts for predacious animals and parasites. Insects play the role of eliminators in the form of decomposers, herbivores and carnivores. Insects play a vital role as pollinator and microhabitat development in case of facilitator (Miller, 1993). They are the major decomposers of the non-living tissue such as leaf litter and wood. Insects act as the regulators of ecosystem processes by consumption of living tissue. The consumption of foliage of an ecosystem by the insect herbivores has great impact on the nutrient cycling and productivity of the plant communities (Hunter, 2001). A large number of beneficial insects depend on plants for the nectar, pollen and shelter. In the maintenance of natural plant communities, pollinating insects play an important role. They also play a critical role in the pollination of various crop plants. Some insects act as biological predators by eating other insects and provide a natural control of pests in farms and gardens. Flowering plants attract many predators from where they get nectar and pollen which help to increase their life span and laying eggs (Fiedler *et al*., 2007). Only a small number of insects of over one million known insect species are pests. Functional guilds help us to simplify the long lists of

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insect species into few manageable units. This simplification helps in the assistance of restoring the structural and functional characteristics of various communities and ecosystems. This also helps in the comparisons among different ecosystems (Brown, 2004).

The dominant vegetation of tropical thorn forest community consists of *Tamarix aphylla* (L.) Karst, Prosopis cineraria L., *Salvadora oleoides* Decne and *Capparis decidua* (Forsk.) Edgew. A total of 2568 mature trees of the thorn forest community were found at the Harappa mound. Total area of Harappa mound is 53.4 hectares.The four thorn forest species are salt tolerant (Sharif and Khan, 2009) so a vegetation restoration programme was initiated by Government College University Lahore with the cooperation of Department of Archaeology and WWF-Pak in 2001 by planting these species on a salt-affected land (14.8 ha) at Harappa mound. Approximately 2600 plants of the four species are now present on the 12 years old restored site.

The aim of this study was to categorize the diverse insect fauna of site into the functional guilds based on their role in the ecosystem associated with the thorn forest community and to compare the diversity of trophic guilds with the rehabilitated site.

MATERIALS AND METHODS

Study Area

Harappa is situated near Sahiwal in northeast of Pakistan. It lies between 30°37´N latitude and 72°51´ longitude about 165 meters above sea level near the modern Harappa town. The climate of Harappa is that winters are being mild and summers are hot. In summer season, temperature rises over 38°C while in winters temperature varies from 10°C to 21°C.

Sampling Techniques

Old groves (reference site) and restored site of thorn forest of Harappa have been explored for enumeration the diversity of insect trophic guilds.These explorations have been conducted in old groves and restored site for one year. Normally insect samples were taken once in each month but its frequency was doubled in the flowering and fruiting seasons. For sampling purpose twenty spots were selected in old groves while in the restored site seven spots were selected for the collection of insects. These spots were selected on the basis of having a dense vegetation cover.

Various traps were used for the collection of insect fauna present on old groves and rehabilitated stands of thorn forest at Harappa (Schauff, 2005).

Sweep net

A sweep net of 32 cm diameter was used for the capturing of insects. One sample consists of ten sweeps. In the selected site areas, the network was swept in the figure eight. The collected insects were stored in killing trap for killing purpose and then were preserved in 70% ethyl alcohol for later identification. The hard bodied insects are stored in the wooden boxes by pinning method.

Light trap

A bucket type light trap was used for the collection of nocturnal flying insects. The light trap consisted of 60 watt electric bulb and at the bottom bucket was filled with ethyl acetate as a killing agent. The traps were operated at selected spots of both sites and adjusted according to the height of tree.

Pitfall trap

Pitfall traps were used for the collection of terrestrial insect species. Pitfall trap consisted of a wide mouth jar of 12 cm deep and 8.5 cm in diameter and this jar was introduced in another plastic jar which were permanently buried on both sites. Twenty traps were installed on the selected spots of both sites at the interval of 10 feet. The bottom of traps was filled with the 95% ethylene glycol with few drops of detergent to kill and preserve the insects.

Insect preservation

The collected hard bodied insect specimens were sorted and pinned in the wooden boxes while the soft bodied insects were preserved in glass vials having 70%ethyl alcohol for the preservation. Naphthalene balls were kept in the wooden boxes for the preservation of insects. The collected insect specimens were identified under stereo-zoom microscope by using available literature and the keys.

Guild classification

All the collected insect species were categorized into the functional guilds on the basis of their roles in the ecosystem and with the help of available literature. The six major insect trophic guild categories were identified at the thorn forest of Harappa as follows

1. Herbivores
2. Predators
3. Pollinators
4. Scavengers
5. Visitors(insects which just visit the ecosystem for various purposes)
6. Pests

Statistical analysis

Shannon-Weaver index was used to evaluate the insect trophic guilds diversity by using formula,

$H' = - [\Sigma Pi \ln Pi]$

Where,

H' = diversity index,

Pi = proportion of each species in sample,

lnPi = natural logarithm of this proportion(Shannon and Weaver, 1949).

Evenness was calculated by dividing H by Hmax

$E = H/Hmax = H/ \ln S$

Where $Hmax = \ln S$

Independent sample t-test was used to compare the diversities of two sites as given by formula (Hutcheson, 1970)

$t = H^{1`} - H^{2`} / (Var\ H^{1`} + Var\ H^{2`})^{1/2}$

Simpson index measures the probability that twospecies randomly selected from a site will belong to the same species. *Simpson index (λ or D)* gives important information about rarity of species present on site. The formula is

$D = 1 - \{\Sigma n (n?1) / N (N - 1)\}$

n = total number of insects of particular species

N = the total number of insects of all species (Simpson, 1949).

Hill diversity index was used to find out thenumber of abundant species and the species maximum in abundance present in site. The formula is:

$$NA = \sum_{i=1}^{S} (pi)^{1/(1-4)}$$

where pi is individualsproportion of i^{th} species.

A=0, 1 and 2.

Hills diversity numbers are N0, N1 and N2.

Where N0 = number of all species on the site irrespective of the abundance and

N1= number of abundant species present at site

N2 = number of species maximum in abundance at site (Hill, 1973).

Similarity between two sites was calculated bythe Sorensen's similarity index by using formula

$C_S = 2C/A+B$

Where,

C_S = similarity coefficient,

C = common species present in two sites,

A and B = the total species present in site A and B, respectively (Sorenson, 1948).

Cluster analysis was used to find out the resemblance of insect plant associations. STATISTICA 8 version was used for this analysis by chord distance, which is a measure of the dissimilarity by Ward's method (Ward, 1963).

RESULTS

The present study showed that a total of 2419 individuals belonging to 147 insect species of various trophic guilds were present in old groves while at restored site a total of 1238 individuals belonging to 85 insect species of various trophic guilds were present. Overall the Shannon diversity value of guild structure established on old groves was high and Simpson index value was low as compared to restored site (Table 1). In a comparison of trophic guilds of old groves and restored site, it was evident that in case of trophic guilds both the sites have 73% similarity. Herbivores showed highest similarity index (100%) followed by pollinators (86%), scavengers (74%), pests (77%), predators (70%) and visitors (67%). The values of Species richness indicated that in old groves, maximum number of insect species became the part of the ecosystem as visitors (S=52) followed by predators (S=37), scavengers (S=29), pollinators (S=16), pests (S=8) and herbivores (S=5). Similar trend was found at the restored site with maximum number of insects as visitors (S=26) and least number of species acting as both herbivores and pests (S=5) (Table 1).

Overall, there was no significant difference (p> 0.005) between the two sites with regard to mean number of species (Table 2). The mean number of insect species belonging to herbivores, predators and visitors were in significantly less numbers at the restored site while pollinators, scavengers and pests showed no significant difference among both sites (p> 0.05). According to the Shannon diversity index, overall there was significantly less (p<0.05) diversity in guild structure on the restored site (Table 3). Only herbivores showed non-significant difference in diversity and 100% similarity index on the restored site while predators, pollinators, scavengers, visitors and pests showed significantly less diversity on the restored site (Table 3). On the basis of guilds composition, 100 % herbivores, were found to be associated with *S. oleoide s*and *C. decidua* while 80% herbivores were found to be associated with *T. aphylla* and *P. cineraria* (Table 4). Association of predators was found to be, *S. oleoides* 43%, *T. aphylla* 67%, *C. deciduas* 89% and *P. cineraria* 35%. In case of pollinators the association of 62% insect species was with both *S. oleoides* and *P. cineraria* while 81% and 87% insect species were associated with *T. aphylla* and *C. decidua*, respectively. In case of scavengers, *S. oleoides* possessed 52% insect species, *T. aphylla* possessed 65% insect species, C. deciduas possessed 76% insect species while 38% insect species were found to be associated with *P. cineraria.* Insect visitors association with different tree species was found to be, *S. oleoides* 65%, *T. aphylla* 58%, *C. decidua* 90% and *P. cineraria* 19%. Both *S. oleoides* and *C. decidua* exhibited association of 75% of the total pest species while this value for *T. aphylla* and *P. cineraria* was found to be 62% and 37%, respectively. Cluster analysis showed that *S. oleoides* and *T. aphylla* had similar Trophic guild-plant associations while *P. cineraria* and *C. deciduas* had different insect guilds-plant associations (Fig. 1).

DISCUSSION

In the current study overall the high value of Shannon index indicated the high diversity of functional guilds in old groves as compared to the restored site. Overall old groves had more number of abundant species (N1=75) due to high diversity in which 27 insect species of guild structure showed maximum abundance while restored site had less number of abundant species (N1=36) due to less diversity in which only 13 species were in maximum abundant (N2=13). Simpson index explained that overall in old groves less number of rare species (D= 0.038) were present due to the high diversity on the old groves as compared to the restored site (D= 0.077).Value of evenness was high on the old groves due to the presence of less rare species (86%) as compared to the restored site (81%). Sorenson similarity index showed high species composition similarity between the two sites. Herbivores, predators and visitors were significantly less on the restored site on the basis of mean number of species because the restored site consisted of less vegetation, less availability of prey and less food and shelter so the herbivores, predators and visitors were less on the restored site. On the basis of Shannon index, herbivores showed no significant difference in their diversity on the restored site. This showed that herbivores were as well established on the restored site as on the old groves. According to enemies hypothesis, a diverse matrix of flowering plants offers prey food i.e., pollen and nectar, and shelter for predators and parasitoids which increase the abundance and functional diversity of natural enemies resulting in effective biological control of herbivores species (Sobek *et al.,* 2009) but on restored site due to less

plant diversity, availability of natural enemies of herbivores were less which helped the herbivores to be well represented on the restored site. Predatory insect diversity is expected to increase with increasing plant diversity because it offers a great amount of resources in terms of production of biomass and resource heterogeneity to the consumers (Schuldt *et al.,* 2011). On the restored site due to less plant diversity, availability of prey was less so predatory species were less in diversity on that site. Due to the less vegetation cover of plant species, availability of food (pollen, nectar) was less for pollinators so their diversity was less on restored site. Scavengers are an integral part of all ecosystems and decompose dead organic matter and circulate nutrients. Less availability of microhabitats and biomass due to less ground cover, mulch and woody debris on the restored site was the reason of the presence of less number of scavengers in the restored stands of thorn forest community (Crane and Baker, 2011).

Maximum number of herbivorous insect species were associated with *S. oleoides and P. cineraria* because the whole life cycle and food of lepidopterous species (*C. amata. C. danae, E, hecabe* and *P. brassicae)* are dependent on *S. oleoides* (Larsen, 1988). Maximum numbers of insect Pest species were found to be associated with *S. oleoides.* Maximum number of insect predator, pollinator, visitor and scavenger species were associated with *C. decidua,* that is a part of the sub climax community and is a small leafless branched tree with red conspicuous nectar full flowers and pink fleshy fruits. These flowers and fruits are attractive to insects so this is the reason of having more numbers of associated pollinator and visitor species resulting in an increased number of associated predators and scavengers which are an important part of food chain of forest ecosystems. Cluster analysis indicated that *S. oleoides* and *T. aphylla* have more resemblance in the composition of guilds structure. Although *S. oleoides* and *P. cineraria* form the typical bi-climax community of thorn forests (Khan, 2009) but at Harappa site because of very few numbers of *P. cineraria* on the mound the dominant association is between *S. oleoides* and *T. aphylla*. That could be the reason for these trees having similar insect guilds associations while *P. cineraria* is different from them in this respect.

CONCLUSION

On the basis of the results of this study it is concluded that 72% similarity regarding various functional guilds existed between both the sites. It is expected that with the passage of time with increasing age and diversity of the restored community, the productivity and stability of the restored forest will also increase and that will support more diverse insect assemblages.

Table 1
Analysis of insect trophic guilds of old groves and restored site on basis of different diversity indices.

Trophic guilds	Community	Richness	Abundance	Shannon index	Simpson Index	Evenness	Hill diversity number(N1)	Hill diversity number (N2)	Sorenson Similarity index
Overall	Old groves	147	2419	4.314	0.038	0.864	75	27	0.733
	Restored site	85	1238	3.596	0.077	0.810	36	13	
Herbivores	Old groves	5	115	1.567	0.216	0.974	5	5	1.000
	Restored site	5	68	1.592	0.206	0.989	5	5	
Predators	Old groves	37	503	3.450	0.036	0.955	32	28	0.702
	Restored site	20	197	2.898	0.060	0.967	18	17	
Pollinators	Old groves	16	244	2.528	0.091	0.912	13	11	0.857
	Restored site	12	123	2.327	0.105	0.936	10	9	
Scavengers	Old groves	29	346	3.144	0.051	0.934	23	20	0.739
	Restored site	17	159	2.705	0.072	0.955	15	14	
Visitors	Old groves	52	514	3.790	0.026	0.959	44	39	0.667
	Restored site	26	189	3.103	0.051	0.953	22	20	
Pests	Old groves	8	697	1.192	0.390	0.573	3	3	0.769
	Restored site	5	502	0.980	0.433	0.609	3	2	

Table 2

Comparison between old groove and new rehabilitated thorn forest community at Harappa archeological site regarding mean number of species in each trophic guild.

	Site	N	Mean	SD	SE	t-value	Sig.
Overall	Old groves	147	16.46	35.08	2.89	0.40^{NS}	0.690
	Restored site	85	14.56	34.45	3.74		
Herbivores	Old groves	5	23.00	7.18	3.21	2.74*	0.041
	Restored site	5	13.60	2.70	1.21		
Predators	Old groves	37	13.59	7.87	1.29	2.29*	0.026
	Restored site	20	9.85	4.49	1.00		
Pollinators	Old groves	16	15.25	10.55	2.64	1.62^{NS}	0.118
	Restored site	12	10.25	5.51	1.59		
Scavengers	Old groves	29	11.93	8.30	1.54	1.35^{NS}	0.184
	Restored site	17	9.35	4.64	1.13		
Visitors	Old groves	52	9.89	5.91	0.82	2.26*	0.027
	Restored site	26	7.27	4.17	0.82		
Pests	Old groves	8	87.10	135.50	47.91	0.18^{NS}	0.859
	Restored site	5	100.40	121.30	54.25		

NS = Non-significant (P>0.05), * = Significant (P<0.05)N = Number of species , SD = Standard deviation
SE = Standard error archeological site regarding mean number of species in each trophic guild.

Table 3

Comparison of Shannon diversity index for old groves and restored sites for different guild structures.

	Old groves		Restored site		
Trophic guilds	Shannon index(H)	Var(H)	Shannon index(H)	Var(H)	t-value
Overall	4.314	0.00081	3.596	0.00190	13.79**
Herbivores	1.567	0.00057	1.592	0.00024	0.89 NS
Predators	3.450	0.00052	2.898	0.00078	15.29**
Pollinators	2.528	0.00135	2.327	0.00151	3.75**
Scavengers	3.144	0.00106	2.705	0.00110	9.45**
Visitors	3.790	0.00054	3.103	0.00130	16.00**
Pests	1.192	0.00142	0.980	0.00116	4.16**

NS = Non-significant (P>0.05); ** = Highly significant (P<0.01)

Table 4

Insect Trophic guilds associated with four plant species of thorn forest community at Harappaa rcheological site regarding mean number of species in each trophic guild.

Insects Trophic guilds	**Insect species**	***S***	***T***	***C***	***P***	**Insects Trophic guilds**	**Insect species**	***S***	***T***	***C***	***P***
Herbivores	*Phyllotreta exclamitionis* Thurnberg	+	-	+	-		*Prionyx sp*	-	+	+	-
	Colotis amata Fabricius	+	+	+	+		*Vespa eumenes*	-	+	+	-
	Colotis danae Fabricius	+	+	+	+		*Vespa orientalis* Linnaeus	-	+	+	+
	Eurema hecabe Linnaeus	+	+	+	+		*Chrysoperla carnea* Stephens	-	+	+	+
	*Pieris brassicae*Linnaeus	+	+	+	+		*Dendroleonsp*	-	+	+	+
		5	4	5	4		*Crocothemissp*	-	+	+	+

Insects Trophic guilds	Insect species	S	T	C	P
Predators	*Chlaenius bimaculatus* Dejean	+	+	+	-
	Cicindela repanda Dejean	+	-	+	-
	Coccinella septempunctata Linnaeus	+	+	+	+
	Labidura sp	+	-	-	-
	Aenictus aratus	+	+	+	+
	Formica exsectoides	+	+	+	+
	Polistes flavus Cresson	+	+	+	+
	*Polistes sp*1	+	+	-	+
	*Polistes sp*2	+	-	+	-
	Ogcogaster tessellata Westwood	+	-	+	-
	Osmylus sp	+	+	+	-
	Ishnura forcipata Morton	+	-	+	-
	Crocothemis erythraea Brulle	+	+	+	-
	Crocothemis Servilia Drury	+	+	+	-
	Orthetrum anceps Schneider	+		+	+
	Pantala flavescens Fabricius	+	+	+	+
	Calosoma maderae Fabricius	-	+	+	-
	Calosoma sp	-	+	+	-
	Pterostichus sp.	-	+	+	-
	Cicindela undulate Dejean	-	+	-	
	Menochilus sexmaculatus Fabricius	-	+	+	+
	Staphylinus xanthocephalus Kratz	-	+		-
	Forficula auricularia Linnaeus	-	+	+	+
	Papilio polytes Linnaeus	+	+	-	-
	Papiliodemoleus Linnaeus	-	-	-	+
		16	25	33	13
Scavengers	*Anthicus sp*	-	+	+	-
	Onthophagus gazelle Fabricius	+	+	+	+
	Adesmia sp	+	+	+	+
	Cryphaeus gazelle Fabricius	+	+	+	+
	Pimelia indica	+	+	+	+
	Pimelia sp	+	+	+	+
	Entomobrya sp	-	+	+	+
	Forficula auricularia Linnaeus	-	+	+	+
	Forficula sp	-	-	+	-
	Myllocerus undatus Marshall	+	-	+	-
	Labidura riparia Pallas	-	-	+	-
	Blatella sp. 1	-	+	+	-
	*Blatella sp.*2	-	+	+	-
	*Periplanata sp.*1	-	+	+	-
	Calliphora vicina Linnaeus	-	+	+	-
	Calliphora sp	+	+	+	-
	Antherigona soccata Rondani	-		+	-
	Antherigona sp	+	+	+	-
	Musca domestica Linnaeus	+	+	+	+
	Chrysomyza demantata Fabricius	-	+	+	-
	Aenictus aratus	+	+	+	+

Insects Trophic guilds	Insect species	S	T	C	P
	Orthetrum pruinosum neglectum Rambur	-	+	+	-
	Coccinella sp 1	-	-	+	-
	Paederus fuscipes Curtis	-	-	+	-
	Forficulasp	-	-	+	-
	*Labidurariparia*Pallas	-	-	+	-
	Formica sp	-		+	-
	Vespa sp	-		+	-
	*Orthetrumsabina*Drury	-		+	-
		15	19	22	11
Pollinators	*Chironomid sp*1	-	-	+	+
	*Chironomid sp*2	+		+	-
	Chironomidsp 3	-	+	+	+
	Anthophorasp	-	+	+	-
	*Apisdorsata*Fabricius	+	+	+	+
	*Apisflorea*Fabricius	+	+	+	+
	*Apismellifera*Linnaeus	+	+	+	+
	Habropodasp	-	+	+	-
	*Xylocopapubescens*Spinola			+	-
	*Danauschrysippus*Linnaeus	+	+	+	-
	*Colotisamata*Fabricius	+	+	+	+
	*Colotis danae*Fabricius	+	+	+	+
	Eurema hecabe Linnaeus	+	+	+	+
	*Pieris brassicae*Linnaeus	+	+	+	+
		10	13	14	10
Visitors	*Agromyza sp*	-	-	+	+
	Aedes albopictus Skuse	-	+	+	-
	Anopheles stephensi Liston	-	-	+	+
	Culex pipiens Linnaeus	-	-	+	-
	Culex quinquefasciatus Say	+	-	+	+
	Cule xtarsalis Coquillett	-	+	+	-
	Creontiades pallidus Ramber	+	-	+	-
	Physopelta gutta Burmeister	+	+	+	-
	Eocanthecona furcellata Wolff	-	+	+	-
	Nezara viridula Linnaeus	+	+	+	-
	Nezara sp	+	+	+	+
	Macrocentrus collaris Spinola	-	+	+	-
	Microplistis demolitor Wilkinson	+	+	+	-
	Netelia sp	-	+	+	-
	Myzinum sp	-	+	+	-
	Utethesia pulchella Linnaeus	+	+	+	-
	Diaphania indica Saunders	-	-	+	-
	Spoladea recurvalis Fabricius	+	+	+	-
	Zizeeria Karsandra Moore	+	+	+	-
	Agrotis ipsilon Hufnagel	+	+	+	-
	Earias insulana Boisduval	+	+	+	-
	Earias vitella Fabricius	-	-	+	+
	Helicoverpa armigera Hubner	+	-	+	+

Insects Trophic guilds	Insect species	*S*	*T*	*C*	*P*	Insects Trophic guilds	Insect species	*S*	*T*	*C*	*P*
	Formica exsectoides	+	+	+	+		*Spodoptera exigua* Hubner	+	+	+	-
	Formica sp	-	-	+	-		*Spodoptera litura* Fabricius	-	+	+	+
	Geotrupes orientalis Westwood	+	-	-	-		*Acrida exaltata* Walker	+	+	+	-
	Labidura sp	+	-	-	-		*Acrotylus insubricus* Scopoli	+	+	+	-
	*Labia minor*Linnaeus	+	-	-	-		*Aiolopus thalassinus* Fabricius	-	-	+	-
	Blatella germanica Linnaeus	+	+	-	-		*Aiolopus sp*	+	+	+	-
	Blattid sp.2	+	-	-	-		*Hieroglyphus sp*	-	+	+	-
	Blattid sp.1	-	-	-	+		Total	34	30	47	10
	Locusta migratoria	+	+	+	-	Pests	*Bagrada hilaris* Burmeister	+	-	+	-
	*Oxya velox*Fabricius	+	+	+			*Cicadellid sp*	-	+	+	-
	Sphingonotus balteatus Saussure	+	+	+	+		*Cicadulina bipunctella* Matsumura	+	+	+	+
	Sphingonotus savignyi Saussure	+	+	+	-		*Microtermes obesi* Holmgren	+	+	+	-
	Sphingonotus sp 1	+	+	+	-		*Odontotermes obesus* Rambur	+	+	+	-
	Sphingonotus sp 2	+	-	+	+		*Thrips sp*	+		+	+
	Acheta domestica Linnaeus	+	-	+	-		*Haplothrips sp*	+	+	-	-
	Gryllus bimaculatus DeGeer	+	-	+	-		Total	6	5	6	3
	Gryllotalpa orientalis Linnaeus	+	-	+	-						
	Chrotogonus trachypterus Blanchard	+	+	+	+						
	*Chrotogonus sp*1	+	-	+	-						
	*Chrotogonus sp*2	-	-	+	-						
	Pyrgomorpha conica	+	+	+	-						
	Pyrgomorpha sp 1	+	-	+	-						
	Pyrgomorpha sp 2	-	-	+	-						
	Tanymecus indicus Faust	+	+	-	-						
	Culex sp.	+	-	-	-						
	Agrotis segetum	+	-	-	-						
	Cotesia sp	+	+	+	-						

S= *S. oleoides*, T = *T. aphylla* , C=*C. decidua* , P = *P. cineraria*

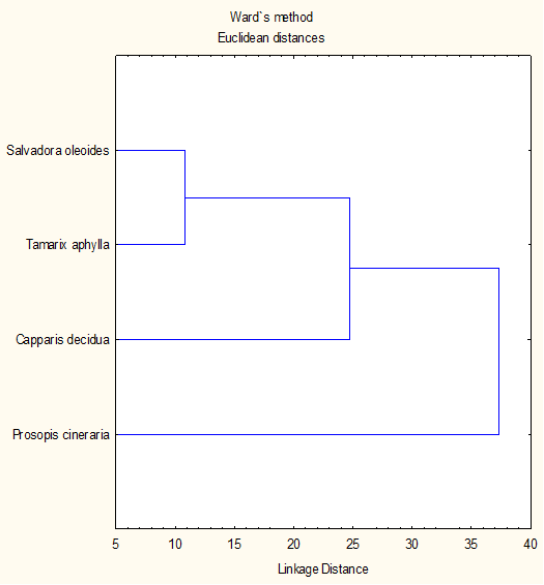

Fig.1
Dendogram showing the relationship of insect plant associations.

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