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A STUDY OF PLANT-INSECT ASSOCIATIONS OF THORN FOREST COMMUNITY AT HARAPPA, PAKISTAN

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ABSTRACT

Insects and plants have intimate and complex relationships. The present study was conducted to find out the diversity of plant-insect associations of thorn forest community at Harappa. Cluster analysis and Principal Component analysis were used to explain the plant-insect associations at Harappa forest. *Capparis decidua* showed highest numbers of associated insects. Maximum numbers of plant-insect associations were shown by order Coleoptera and Lepidoptera. Analogous plant-insect associations were found between *Salvadora oleoides* and *Prosopis cineraria* in case of orders Diptera, Coleoptera, Dictyoptera, Homoptera, Isoptera Hymenoptera and Thysanoptera. It was concluded that thorn forest community at Harappa exhibits diversity in plant-insect associations providing integrity and strength to the ecological community.

Keywords: Insect diversity, Ecological communities, Multi-trophic interactions, Ecosystem complexity, Bi-species climax.

INTRODUCTION

Ecosystem processes stabilize by increase in biodiversity (Loreau and de-Mazancourt, 2013). Composition of insect species is limited by the host plant species. Plant diversity, distribution and abundance are the factors which are necessary for the presence and absence of insect species (Zou *et al.,* 2013; Curtas-Hernandez and Murillo, 2015; Wappler and Grimsson, 2016). Insects use plants for sharing the key attributes, such as geographical distribution, chemicals and microhabitat preferences (Prado and Lewinsohn, 2004). Insect-plant interactions are ecologically and spatially dynamic which form associations in a complicated pattern (Mello and Silva-Filho, 2002; Grion *et al.,* 2019). A basic set of resources is necessary for the survival of insects. Insect species exploit plants for the sake of food, shelter and egg laying sites. Plant-insects interactions have great importance for plants and insects both in form of pollination, predation and parasitism (Bernays, 1994; Brandle, 2008; Wisz *et al.,* 2013). Harappa forest exhibited of variety of insects because of presence of cultivation lands of sugarcane, cotton, wheat and different vegetables on its three sides while modern Harappa town is situated on its west side. Thorn forest community at Harappais dominated by four plant species *Prosopis cineraria*, *Salvadora oleoides*, *Tamarix aphylla* and *Capparis* deciduas (Sharif, 2011). *Salvadora oleoides* and *Prosopis cineraria*are dominant climax plant species and are often associated with *Tamarix aphylla* and *Capparisdecidua*as subclimax species (Khan, 1995). The height of *S. oleoides* is 6 to 9m *Salvadora oleoides*consists of fleshy, yellow and dark green leaves while flowers are greenish white in color.Height of fast growing and evergreen *T. aphylla*is 18 meter. The leavesof *T. aphylla* are alternate and bluish green while the color of stalkless, tiny flowers is whitish-pink. The height of *P. cineraria* is 6.5 meter and its entomophilies flowers have yellow color. Bushy shrub *C. decidua* has leafless branches and has brightly colored pinkish flowers that attract many insects (Orwa *et al.,* 2009). These plant species have also medicinal values (Saleem *et al.,* 2018). The uniqueness of trees specifies the appropriate surroundings and resources for supporting the spatial and diverse patterns of insect communities.

The main objective of this study was to understand the plant-insect associations of Harappa thorn forest.

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MATERIALS AND METHODS

Study area

Harappa site (30°38´North and 72°52´East) having archaeological significance is present 15 miles west of Sahiwal city. Current Harappa village is located 3.7m from the ancient site. Ancient Harappa was the urban centre of Indus valley civilization. Twenty sampling sites possessing dense vegetation cover were selected at Harappa forest for the collection of insects for three consecutive years. Insects were captured through different traps and were kept in collecting jars. Insect collecting jars were labeled to explore different insect-plant associations.

Sampling techniques

Various types of nets were used in this study for capturing the insects i.e., aerial traps, pitfall traps having 8.5 cm diameter & 12 cm depth wide mouthed jars, beating nets and light traps (60 watt electric bulb). Wooden boxes were used for the pinning of hard bodied insects while the soft bodied insects were preserved in 70% ethyl alcohol in glass vials. These insects preserved in wooden storage boxes carrying naphthalene balls (Schauff, 2005). Stereo-zoom microscope was used for the identification of insect specimens by using available literature and the keys.

Multivariate Statistical analysis

Software STATISTICA Ver. 8 (Stat Soft 2007) was used for statistical analysis. Cluster analysis was carried out by applying Ward's method suggesting the hierarchical cluster method (Ward, 1963)**.**

Principal component analysis (PCA) determined the insect species associations with the plants of Harappa thorn forest community.

RESULTS

Capparis deciduas showed highest insect-plant associations because 115 insect species showed their association with *C. decidua* while 88 insect species had an association with *Tamarix aphylla*. From total 136 insect species, 78 insect species showed their association with *Salvadora oleoides*. Least number of insect species (46) showed their association with *Prosopis cineraria* (Fig. 1). Principal Component Analysis showed the highest diversity in plant-insect associations in case of Coleopterans, Lepidopterans, Dipterans and Hymenopterans while Dictyopterans, Isopterans, Homopterans, Collembollans, Thysanopterans and Neuroperans showed least diversity in plant-insect associations (Fig. 2).In case of Dipterans, Hymenopterans and Dictyopterans two groups were made which showed analogous plant-insect associations between *P. cineraria* and *S. oleoides* and between *C. decidua* and *T. aphylla* (Fig. 3 a,b,c). In case of orders Coleoptera (Fig. 3d), Isoptera,Thysanoptera and Homoptera (Fig. 4 e-g) analogous plant-insect associations could be seen between *P. cineraria* and *S. oleoides* while *Capparis deciduas* and *Tamarix aphylla* showed dissimilar insect-plant associations. Species belonged to order Lepidoptera possessed analogous plant-insect associations between *T. aphylla* and *S. oleoides* whereas dissimilar plant-insect associations were observed by *P. cineraria* and *C. decidua*. Similar plant-insect associations between *Capparis decidua* and *Tamarix aphylla* while dissimilar plant-insect associations between *Prosopis cineraria and Salvadora oleoides* were observed in case of orders Odonata and Neuroptera (Fig. 4.e,f &h). Orthopteran species showed analogous plant-insect associations between *C. deciduas* and *S. oleoides* while *P. cineraria* and *T. aphylla* showed dissimilar plant- insect associations (Fig. 4.i).

DISCUSSION

Present study indicated that 37% insect species showed their association with *C. decidua*, 24% insect species associated with *S. oleoides,* 25% insect species with *T. aphylla* and only 15% insect species showed their associations with *P. cineraria*. *C. decidua* is a small, leafless, crooked spiny branched small tree and is a part of sub climax community (Khan 1995). It possessed brick red conspicuous flowers in groups along the leafless shoots. These flowers are prominent in nature and attractive to insects (Rathee *et al.,*2010; Singh and Singh, 2010). This may be there as one of highest numbers of plant-insect associations of *C. decidua. Prosopis cineraria* showed the lowest numbers of plant-insect associations due to being less in numbers at the site as only six trees of this species were found in Harappa forest. Coleopterans, Dipterans, Hymenopterans and Lepidopteran species showed maximum variety of plant-insect associations in form of predatory, herbivores, pollinators and pests in Harappa thorn forest community. These species were associated with all four plant species of thorn forest i.e., *Prosopis cineraria* and *Salvadora. oleoides*, *Capparis decidua* and *T. aphylla.* Because these orders have maximum number of species and are present in all type habitats (Nazir *et al.,* 2015). Beetles like *Calosoma maderae, Pterostichus* and *Calosoma biaculatus* play predatory role in thorn forest by feeding spiders and insect eggs and larvae (Avgen and Emre, 2010). Staphylinid beetles like (*Paederus fuscipes* and *Staphylinus xanthocephalus* feed on thrips, fruit flies and aphids (Nasir *et al*., 2013). *Coccinella septempunctata, Coccinella transversalis* and *Menochilus sexmaculatus* beetles are major predators of aphids and mites which are the pests of Harappa forest (Zahoor *et al.,* 2013; Perveen *et al.,* 2014) and provide stability and integrity to forest ecosystem. Coleopteran species of family Curculionidae consisted of *Myllocerus undatus, Tanymecus indicus* and *Myllocerus discolor.* These are pests of wheat and cotton crop (Geetha *et al*., 2013) came from nearby agricultural fields, visit the Harappa forest. *Anthicus* beetles play an important role as scavengers in thorn forest (Evans, 2014). Hymenopteran species like *Netelia sp, Microplistis demolitor* Wilkinson, *Cotesia sp* and *Macrocentrus collaris* Spinola, came from nearby agricultural fields of sugarcane, wheat, cotton and maize to visit the Harappa site. These species parasitize the lepidopteran, dipteran and coleopteran larvae (Lewis and Whitfield, 1999). Species of family Nocutidae (Lepidoptera) i.e., *Agrotis ipsilon* Hufnagel,*Helicoverpa armigera* Hubner,*Spodoptera exigua* Hubner *Earias vitella* Fabricius, *Earias insulana* Boisduval, *Agrotis segetum* Denis and Schiffermueller and *Spodoptera litura* Fabricius also visit the forest from agriculture lands due to presence of light traps which were fitted for catching insects (Macleod, 2002; Zahoor *et al.,* 2003). Butterflies like *Pieris brassicae*

Linnaeus, *Colotis amata* Fabricius, *Eurema hecabe* Linnaeus and *Colotis danae* Fabricius are associated with *S. oleoides* for the completion of their life cycle and food. These butterflies are also major pollinators of these plants (Haussler *et al.,* 2017).*Anopheles sp*ecies and *Culex sp*of family Culicidae (Diptera) prefer shaded areas in forest for laying eggs. *Aedes albopictus* Skuse prefer tree holes in forest for laying eggs (Amala and Anuradha, 2012). Hymenopteran species like *Vespa crabo, Sceliphron sp*, *Polistes flavus, Polistes metricus* and *Vespa orientalis*have associations with forest plantation as Predators. In Hymenoptera, Ants (Family Formicidae) are scavengers and litter dwelling predators which help in the decomposition of decaying material and provide stability to food web of forest ecosystem (Cerda and Dejean, 2011). Hymenopteran species like *Apis dorsata* Fabricius*, Apis mellifera* Linnaeus and *Apis florae* Fabricius play important role in pollination of Harappa forest plant species. Setting of seeds in many plants cannot possible without bees and they die (Sass, 2011). These bees were increased in number during flowering season of forest. Species related to order Dictyoptera, Isoptera, Homoptera, Collembolla, Odonata, Thysanoptera and Neuropera contributed minimum variations in associations with the plant species because these orders have less number of species and are present in specific habitats. Dragonflies (Odonates) play predatory role to balance the ecosystem functions of Harappa forest. They feed on dipterans i.e.,mosquitoes (Kalita *et al.,* 2014). Net-winged insects (Neuroptera) included *Chrysoperla carnea* Stephens*, Osmylus nubeculosus* Navas, *Ogcogaster tessellate* Westwood and *Dendroleon sp. are predaceous in nature feed on* whiteflies, aphids, mealybugs, thrips, American bollworms, yellow striped armyworm and mites (Hameed et al., 2013). Insect species of family Labiduridae (Dermaptera) are predators and scavengers of Harappa forest ecosystem. Their habitat is moist places having leaf litter and high organic matter. *Labidura riparia* Pallas (Earwig) predates upon caterpillars, maggots, fleas, cutworms, small invertebrates and mealy bugs (Tiar, 2013). Insect species of family Labiidae *Labia minor* act as Scavenger at Harappa forest. Species of order Dictyoptera are nocturnal and act as scavengers at Harappa forest. They come from nearby Harappa town adjacent to Harappa thorn forest community. Only two species of order Isoptera (*Odontotermes obesus* Rambur and *Microtermes obesi* Holmgren) found from Harappa forest showing their associations with only three forest plant species i.e., *Salvadora oleoides, Prosopis cineraria* and *Tamarix aphylla.* These two species are major pests of *T. aphylla, P. cineraria*and *S. oleoides* and created high damage to these trees (Orwa *et al.,* 2009). Thysanoptera species of family Thripidae i.e., *Thrips sp*., family Phlaeothripidae i.e., *Haplothrips sp*and Homopteran species of family Cicadellidae (*Cicadulina sp* and *Cicadellid sp*) are minor pests of Harappa forest because these species contributed less damage to Harappa forest (Parihar and Singh, 1993).

Cluster analysis indicated *S. oleoides* and *P. cineraria* as analogous plant-insect associations in case of orders Diptera, Hymenoptera, Dictyoptera, Homoptera, Isoptera, Coleoptera and Thysanoptera. Orders Dictyoptera, Neuroptera, Diptera, Hymenoptera and Odonata showed analogous plant-insect associations between the *C. decidua* and *T. aphylla* (sub-climax species) of thorn forest at Harappa. This is due to the long history of co-evolution and adaptation between the climax and sub-climax thorn forest species (Khan 2009). Order Lepidoptera showed its analogous plant-insect associations between sub-climax tree species *Tamarix aphylla* and climax species *Salvadora oleoides* at Harappa forest. This is because of the reduced representation of one of the members of bi-species climax association i.e. *P. cineraria* at the site due to overharvesting by the local people resulting in the great abundance of *T. aphylla* (a sub-climax species) forming major association with *S. oleoides*. Orthopteran species get food and shelter from two plant species of thorn forest due to dominance of *S. oleoides* and occurrence of grasses and herbs under *C. decidua.*

Conclusion

Thorn forest community at Harappa exhibited great variations in plant-insect associations where insects were found to play different roles like they were acting as predators, pollinators, herbivores and scavengers in the forest ecosystem. This shows that Harappa forest ecosystem had extensive food chains and food webs which also play effective role in the surrounding ecosystems and provide variety of habitats and niches for the survival of insects and animals. Diversity in plant- insect associations at thorn forest Harappa showed structural complexity and multi-trophic interactions which help in the establishment of species rich communities and provide stability to ecological communities.

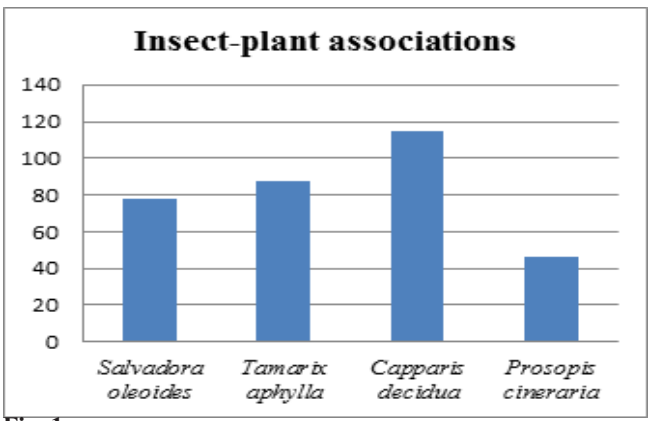

Fig. 1
Insect-plant associations of thorn forest community at Harappa.

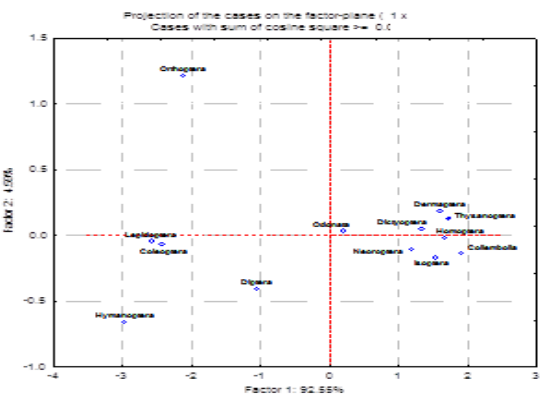

Fig. 2
Diversity of Insect-plant associations at Harappa forest.

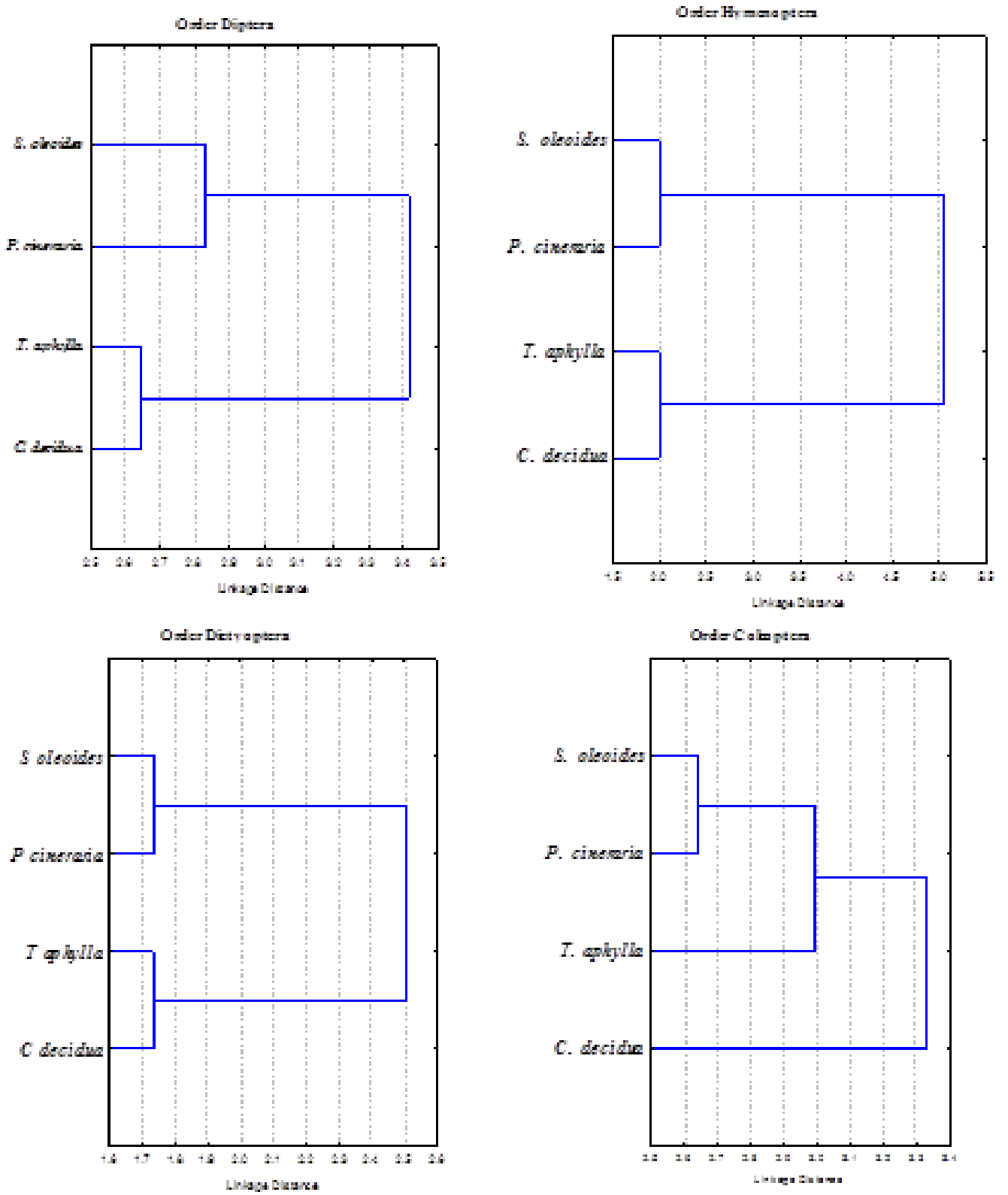

Fig. 3(a,b,c,d)
Plant-Insect associations of thorn forest community at Harappa.

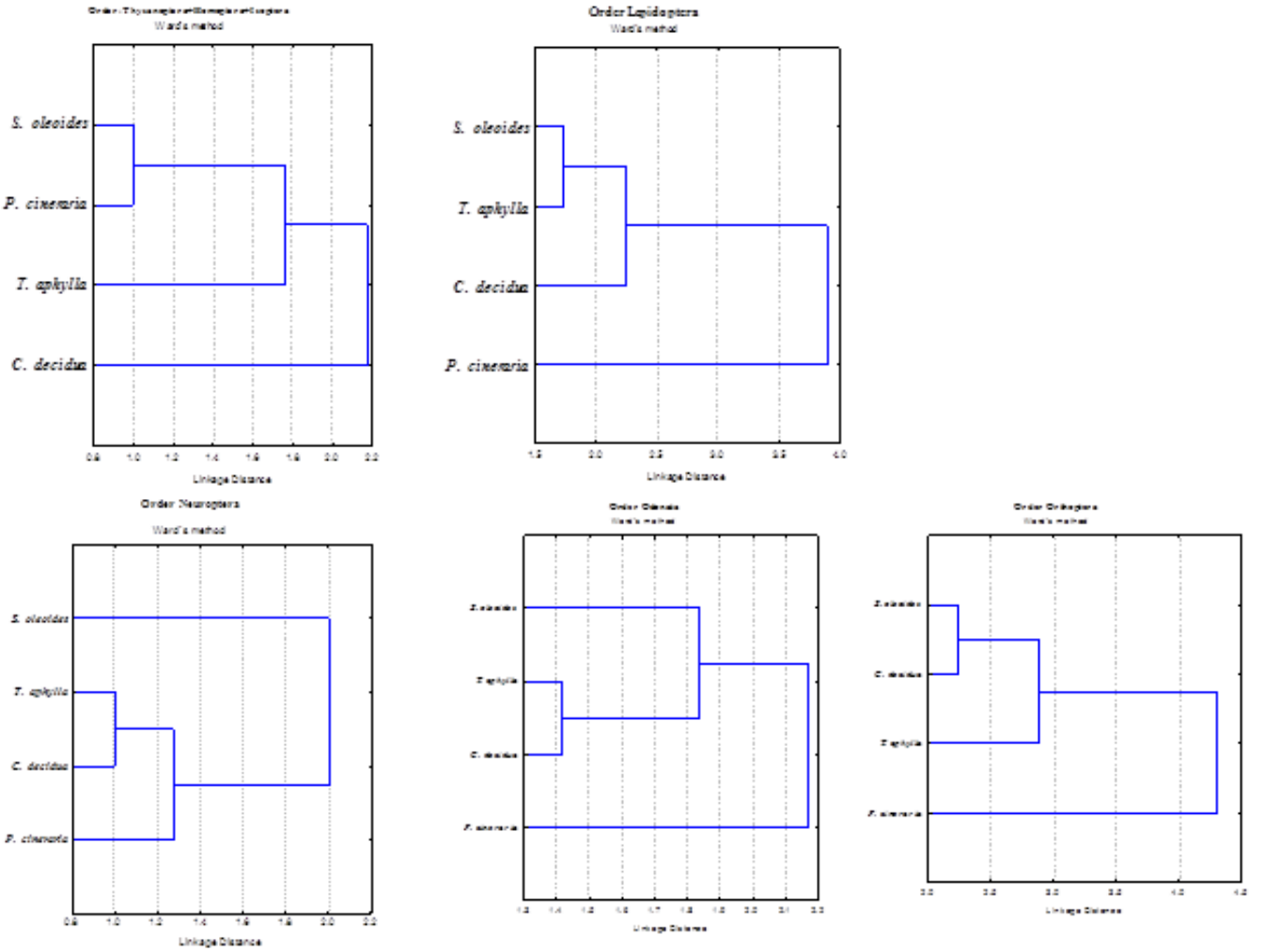

Fig. 4 (e,f,g,h,i)
Plant-insect associations of thorn forest community at Harappa.

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