DIVERSITY OF ANT ATTENDED SCALE INSECTS IN SELECTED AREAS OF THE ANURADHAPURA DISTRICT

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Scale insects are phytophagous arthropods of order Hemiptera, found worldwide and including about 6000 species belonging to 21 families. Scale insects produce honeydew that serves as the food for ants. Even though the scale insects have been identified, the diversity of plants and ants that they are associated with is poorly studied in this country. This study intends to identify the scale insects in home gardens in selected areas of the Anuradhapura District and the ant and plant species associated with them. Fifty (50) home gardens were selected as ten home gardens per five divisional secretariats, Mihinthale, Rambewa, Thirappanaya, Kahatagasdigiliya and Puliyankulama. In each home garden, a circular area (radius 50m) was examined to collect ant associated scale insects. The diversity and the abundance of scale insects were assessed. Scale insects, ants and plants were identified at least up to the family level using appropriate keys. The species diversity was analyzed using Simpson's and Shannon indices. From the 50 home gardens 17 species of scale insects were identified from 32 plant species interacting with 5 ant species. Families Coccidae and Pseudococcidae were found to feed on many plant families whereas members of families Diapsidae and Monophlebidae were only found in Apiaceae and Moraceae respectively. The dominant ant species attended scale insects was *Oecophylla smaragdina*. Abundance of the scale insects was recorded highest in Kahatagasdigiliya and the lowest in Thirappanaya whereas the highest species diversity was reported in Kahatasdigiliya and the lowest in Thirappanaya. From this study it can be stated that scales belonging to families Coccidae and Pseudococcidae are more generalized feeders whereas the members of families Diapsidae and Monophlebidae are specialized feeders. The species level identification of the scale insects are continuing. It is recommended to expand this study to cover a wider geographical area to identify this Tritrophic interaction to see the temporal and special variations of the populations along with varying climatic conditions.

Keywords: *Sri Lanka, Hemiptera, Scale insects,* Tritrophic interactions, Phytophagouse

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DIVERSITY STUDY OF ANT ATTENDED SCALE INSECTS: A CASE STUDY IN SELECTED AREAS IN ANURADHAPURA DISTRICT

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INTRODUCTION

The tripartite interaction of plants, ants and scale insects occur throughout evolutionary history. Symbiotic partnership between plants, ants (Hymenoptera: Formicidae) and scale insects (Hemiptera) have evolved due to the need to simultaneously exploit and protect oneself against exploitation (Ueda et al., 2008). This interaction among plants, ants and scale insects can vary according to the species (Davidson & McKey 1993). These relationships provide benefits as well as harmful effects to each member. The moisture of plants attracts the scale insects as they need plenty of moisture around them and the droplets of honeydew attract ants (Hank and Denno, 1993).

Scale insects (Hemiptera) are usually small phytophagous arthropods, so they can be widely distributed in various ecosystems around the world. There are about 6000 species of scale insects in 21 families worldwide. Soft scales are well represented in Sri Lanka, with 71 species in 28 genera (Ben-Don et al. 2016). A recent study conducted by Sirisena et al. (2016) covering 16 agro-ecological zones in Sri Lanka has identified 14 species belonging to eight genera where *Ceroplastes sinensis* and *Pulvinaria urbicola* were recorded for the first time in Sri Lanka. Soft scale insects mainly feed on almost any part of perennial plants and are large wax coted insects. There are also hard scale insects and mealybugs present on plants that are counted as scale insects. There are more than 20 families of scale insects and the most diverse families are Diaspididae (armoured scale insects), Pseudococcidae (mealybugs), and Coccidae (soft scale insects) (Kondo et al., 2008). These insects are found on various parts of their hosts, and may infest leaves, twigs, branches, and roots, and some live inside plant domatia (Kondo et al., 2008).

Some researchers have studied the scale insects in the world and also Sri Lanka. (Kondo et.al., 2008; Kondo and Watson, 2022; Madhushani & Sirisena, 2021; Sirisena et al., 2016; New, 2017; Wijesekara & Wijesinghe, 2003). But when it comes to the symbiotic interaction of ants, scale insects and plants there is little research (Ueda et al., 2008) and none have been traced in the Sri Lankan context. Therefore, this research will be an important study to update the knowledge and

identify diversity of scale insects, plants and ant species that are in symbiosis in selected areas of the Anuradhapura district. Further this study documented the host range of identified scale insects with the respective ant species.

METHODOLOGY

Study site

A field survey was carried out from October 2022 to January 2023 in five divisional secretaries (Mihinthale, Tirappane, Puliyankulama which belongs to Nuwaragampalatha East, Rambewa and Kahatagasdigiliya) in the Anuradhapura district (Figure 1). When selecting the home gardens the area (more than ½ acre) and the diversity of plant species were considered. The laboratory work was carried out at the Zoology Laboratory, Department of Biological Sciences, Faculty of Applied Sciences and Plant Sciences Laboratory at the Faculty of Agriculture, Rajarata University of Sri Lanka.

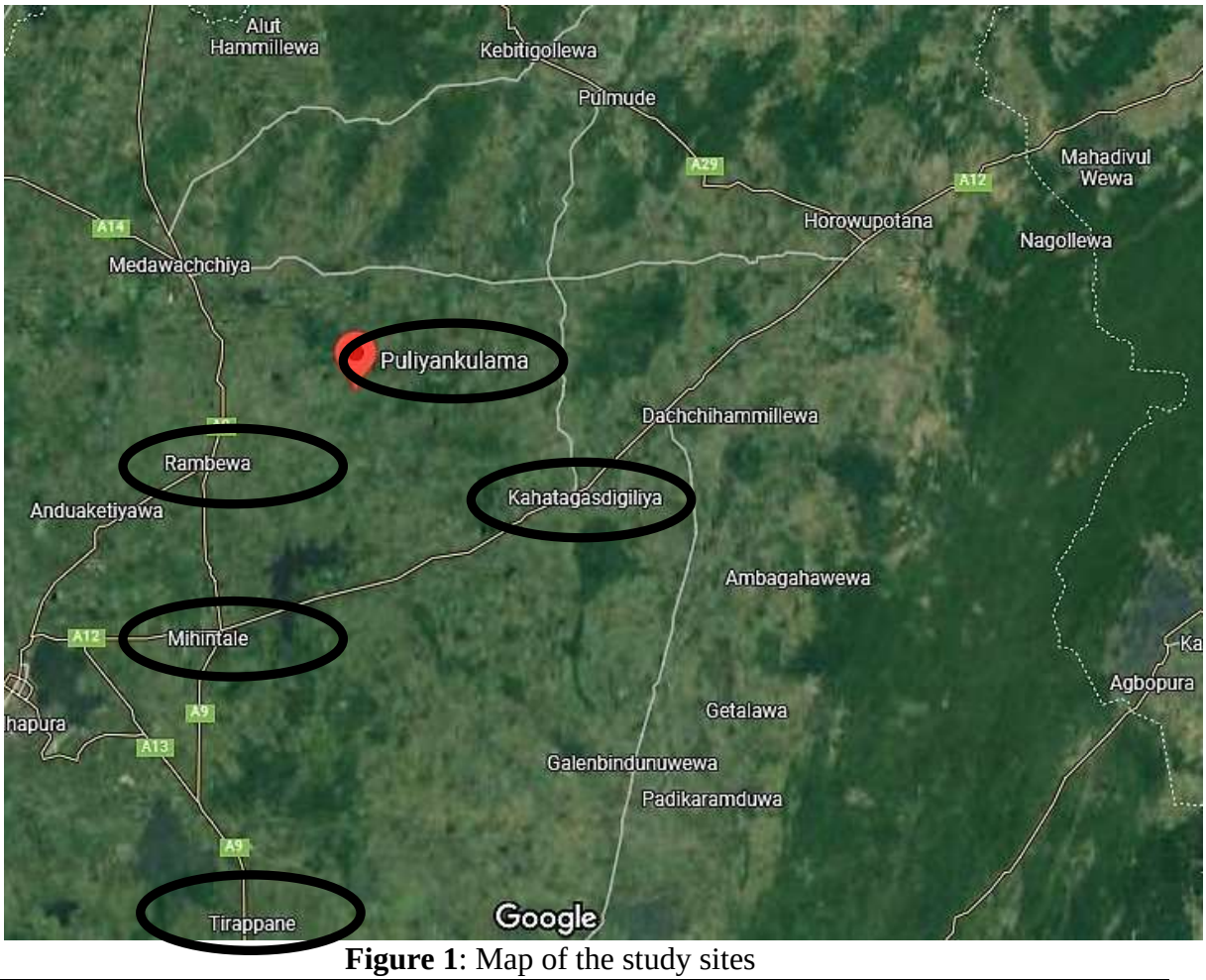

Figure 1: Map of the study sites

Field work

Sampling was done from 0800 h to 1100 h by visual inspection of plants. All the vegetation, including trees, shrubs and weed species that might carry scale insect infestations within the 50m radius of circular area in each home garden were examined. The sampling method was varied according to the size of the host plant/tree. In the case of trees, twenty infested leaves per tree and four infested shoots were collected as five leaves and one branch per direction (30 cm in length and 1.0-1.2 mm in diameter) from the four cardinal directions (North, East, South and West) (Hendawy et al., 2013) nearest to the perimeter of the canopy were examined at all possible times. In the case of shrubs, five to ten leaves or three (30cm length/twig) twigs were examined. In the case of small plants/weeds, the whole plant was examined. The presence or absence status of scale insects and ants was recorded. If they were present, they were collected with the pieces of infested plant material and placed in labelled Ziploc polythene bags (15crn x 20cm). The information related to the collected sample (sample number, locality, date of collection and host plant and its habitat, name of the owner, address) was recorded. The abundance of the scale insect was assessed by counting their number per unit area ($inch^2$). The host of each collected scale insect species and any visible damage (if any) caused to the plants by scale insects were recorded. Geo-position coordinates were recorded with a hand-held GPS unit.

Laboratory work

Bagged samples were taken to the laboratory for identification using a dissection microscope. Small pieces of infested plant materials and ants were isolated separately. They were placed in 70% ethyl alcohol in labeled plastic bottles (3- or 5-ml capacity, as appropriate) to kill and preserve them. The labeled vials of freshly killed material were sealed. Permanent slide preservation was conducted using standard methods for the scale insect samples for identification. The scale insects were identified using standard keys (Kondo and Watson, 2022; Sirisena et al., 2016) while observing under the light microscope. The ants were also identified using keys and plants were identified using morphological characteristic features using herbarium specimens at the Rajarata University and verified it using standard keys.

Data Analysis

Species diversity was assessed using Shannon and Simpson's indices (Shannon and Weaver, 1949).

RESULTS AND DISCUSSION

After investigating fifty home gardens from five divisional secretariats in the Anuradhapura District, 17 scale insects were identified including *Paracoccus margintus, Coccus hesperidum, Ceroplastes rubens,* and *Icerya seychellarum,* belonging to four families. Most collected scale insects belonged to Family Coccidae, Family Pseudococcidae and Family Diaspididae and a few belonged to Family Monophlebidae. Most of the scale insects were present in Pseudococcidae family which includes mealybugs. Most of the scale insects were identified up to species level and others into family level. The identification is still under progress.

According to Simpson's diversity index the highest species diversity is present in the Kahatagasdigiliya area (0.79) and lowest in the Thirappanaya area (0.14). The Shannon diversity shows that the highest abundancy of species in the Kahatagasdigiliya area (1.96) and lowest in Thirappanaya (0.32).

The following table represents the species that were identified during this survey (Table 1) and it was aligned to show the plant families and the ant family that are associated with different scale insect families (Figure 2 and Figure 3).

Table 1: Identified Scale Insects, Ants, and the Plant Species in Symbiosis

Common name of the scale insect	**Scientific Name of Plants**	**Plant Common Name**	**Ant Scientific Name**
Mealybugs	*Bauhinia sp.*	Hong Kong Orchid	*Oecophylla smaragdina*
Papaya mealybugs	*Murraya koenigii*	Curry leaf	*Oecophylla smaragdina*
Mealybugs	*Aglaonemasp.*	Chinese evergreen	*Oecophylla smaragdina*
Armored scales	*Centella asiatica*	Gotu kola	*Oecophylla smaragdina*
Mealybugs	*Mangifera indica*	Mango	*Oecophylla smaragdina*
Soft scales	*Mangifera indica*	Mango	*Oecophylla smaragdina*
Mealybugs	*Citrussp.*	Orange	*Oecophylla smaragdina*
Mealybugs	*Psidium guajava*	Guava	*Anoplolepis gracilipes*

Mealybugs	*Abelmoschus esculentus*	Okra	*Oecophylla smaragdina*
Mealybugs	*Helianthus annuus*	Sun flower	*Oecophylla smaragdina*
Mealybugs	*Annona muricata*	Soursop	*Oecophylla smaragdina*
Mealybugs	*Murraya koenigii*	Curry leaf	*Oecophylla smaragdina*
Mealybugs	*Hibiscus rosainnesis*	Hibiscus	*Oecophylla smaragdina*
Mealybugs	*Solanum melongena*	Egg plant	*Anoplolepis gracilipes/Crematogastersp.*
Mealybugs	*Manihot esculenta*	Bitter cassava	*Oecophylla smaragdina*
Mealybugs	*Annona squamosa*	Custard Apple	*Oecophylla smaragdina*
Mealybugs	*Morinda citrifolia*	Indian Mulbery	*Oecophylla smaragdina*
Mealybugs	*Tectona grandis*	Teak	*Oecophylla smaragdina*
Mealybugs	*Solanum lycopersicum*	Tomatoes	*Crematogastersp.*
Mealybugs	*Citrussp.*	Lime	*Oecophylla smaragdina*
Mealybugs	*Carica papaya*	Pawpaw	*Oecophylla smaragdina*
Mealybugs	*Artocarpus altilis*	Breadfruit	*Lasius niger*
Mealybugs	*Psidium guajava*	Guava	*Oecophylla smaragdina*
Soft scales	*Justicia adathoda*	Malabar nut	*Oecophylla smaragdina*
Soft scales	*Artocarpus heterophyllus*	Jackfruit	*Oecophylla smaragdina*
Soft scales	*Ixora coccinea*	Scarlet jungle flame	*Oecophylla smaragdina*
Soft scales	*Tecoma stans*	Kelanithissa	*Oecophylla smaragdina*
Soft scales	*Mangifera indica*	Mango	*Oecophylla smaragdina*
Soft scales	*Syzygium samarangense*	Java Apple	*Oecophylla smaragdina*
Mealybugs	*Psidium guajava*	Guava	*Oecophylla smaragdina*

Soft scales	*Hibiscus rosa-sinnesis*	Hibiscus	*Lasius niger*
Soft scales	*Annona squamosa*	Soursop	*Lasius niger*
Soft scales	*Mangifera indica*	Mango	*Oecophylla smaragdina*
Soft scales	*Bauhinia forficata*	Brazilian orchid tree	*Oecophylla smaragdina*
Soft scales	*Psidium guajava*	Guava	*Anoplolepis gracilipes/Oecophylla smaragdina*
Soft scales	*Aglaonema sp.*	Chinese evergreen	*Oecophylla smaragdina*
Mealybugs	*Musa paradisiaca*	Banana	*Dolichoderus thorcicus*
Mealybugs	*Musa paradisiaca*	Banana	*Oecophylla smaragdina*
Mealybugs	*Areca catechu*	Betel nut palm	*Oecophylla smaragdina*
Seychelles scale	*Ficus microcarpa*	Malayan Banyan	*Oecophylla smaragdina*
Seychelles scale	*Citrussp.*	Lime	*Oecophylla smaragdina*
Seychelles scale	*Ficus microcarpa*	Malayan Banyan	*Oecophylla smaragdina*
Soft scales	*Ficus microcarpa*	Malayan Banyan	*Oecophylla smaragdina*
Soft scales	*Manihot esculenta*	Bitter cassava	*Oecophylla smaragdina*
Soft scales	*Hibiscus rosa-sinnesis*	Hibiscus	*Oecophylla smaragdina*

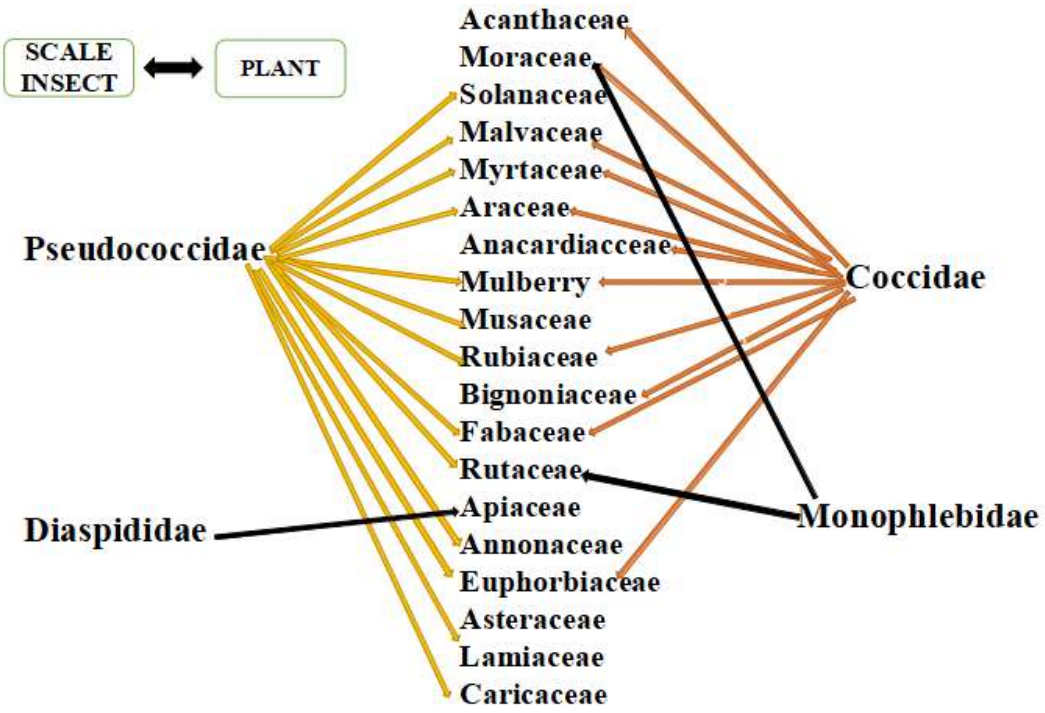

Figure 2 : Interaction of Scale insects and plants considering the Families

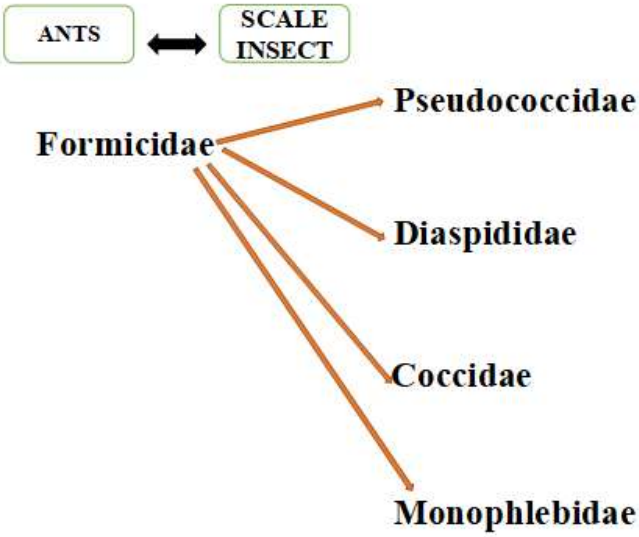

Figure 3 : Interaction of Scale insects and ants considering the Families

CONCLUSIONS AND RECOMMENDATIONS

From the 50 home gardens 17 species of scale insects were identified from 32 plant species interacting with 5 ant species. In all the cases ants and scale insects were found together. Family Pseudococcidae and Coccidae are found with a variety of plant families whereas Family Diaspididae and Monoplebidae are found with a few selected plant families. This might be due to their generalist and specialist nature. During the survey it was identified that weather influences the scale insect existence which needs further investigating. It is recommended to expand this study with more home gardens and also further geographically and seasonally to come up with a more robust and complete list of interactions in the Sri Lankan context.

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