Taxonomic Analysis and Host Preference of Tea Mistletoe [*Scurrula atropurpurea* (Blume) Danser], a Hemiparasitic Species

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Abstract - Parasitic and hemiparasitic infections of trees inhibit water and nutrient uptake, cause severe yield reductions, and eventually lead to the mortality of their hosts. This infection significantly reduces productivity and eventually leads to economic losses for farmers and commercial growers. This study taxonomically identified the hemiparasitic plant and its host and investigated the distribution and infection rate of Mistletoe at the Adventist University of the Philippines campus. Taxonomic identification revealed that the hemiparasitic plant (*Scurrula atropurpurea*) belongs to the family Loranthaceae. The host plants of *S. atropurpurea* were identified as Avocado (*Persea americana*), Acacia (*Samanea saman*), Narra (*Pterocarpus indicus*), Paper Tree (*Gmelina arborea*), and Banaba (*Lagerstroemia speciosa*), all belonging to the class Magnoliopsida. The findings revealed a moderate level of infection, with 40% of the 35 trees infected. Dye uptake analysis using safranin demonstrated xylem connectivity between the host and the Mistletoe, highlighting the hemiparasitic nature of the relationship between the *S. atropurpurea* and its hosts. The results of the study are integral to understanding hemiparasite-host interactions, which can aid in managing hemiparasites in natural and agricultural systems, leading to fewer infections and increased productivity.

Keywords: hemiparasitism, taxonomy, host plants, spatial analysis, distribution

INTRODUCTION

Due to their photosynthetic ability, hemiparasitic plants are peculiar in that they can exist as either perennial plants or parasites (Senthilkumaran et al., 2015). Holoparasitic plants attack both the xylem and phloem of their hosts, unlike hemiparasites, which specifically target the xylem, accessing mineral nutrients and water but receiving little carbon (Těšitel et al., 2010). Specialized structures called haustoria, which penetrate the host's tissues and form vascular connections, enable them to attach to host plants, such as shrubs or trees (Kokla & Melnyk, 2018). A member of the family of the family, Lorantheceae, *Scurrula atropurpurea* is a woody, blossoming hemiparasite distinguished by its red tubular flowers and dense covering of dendritic hairs that range from pale gray to yellowish brown (Wu, Raven, & Hong, 2013). Its leaves are typically rounded to elliptical, oppositely arranged with short petioles; the undersides of its leaves and its branchlets are densely covered in a mix of short and long, branched hairs. The hemiparasite is known to parasitize a wide range of hosts from various families, including Lauraceae, Malvaceae, Lamiaceae, Rutaceae, and Moraceae (Del Rosario, 2022).

With a significant role in ecosystems, hemiparasitic plants like *S. atropurpurea* influence the constitution and diversity of plant communities by selectively choosing hosts, which subsequently affects community interactions (DiGiovanni et al., 2017). While the ecological importance of *S. atropurpurea* and its interactions with host plants are recognized, further research is needed to fully comprehend its taxonomy, morphology, physiology, and ecology, which are crucial for understanding its significance in ecosystem dynamics, plant communities, and nutrient cycling.

Moreover, examining the parasitism mechanisms, host specificity, and host range of *S. atropurpurea* is vital to assess its influence on host plants and ecosystem functioning. By identifying and characterizing the infection rates and interactions between *S. atropurpurea* and its hosts, this study addresses a research gap that can contribute to the existing literature on hemiparasitism, including impact, host growth, and distribution. Understanding these interactions can help develop tactics for managing parasitic plants and mitigating their effects on agricultural and natural systems.

This study intended to identify and characterize *S. atropurpurea* (Bl.) Danser by inspecting its taxonomic characteristics, local distribution, and adaptations related to penetration, attachment, and dye uptake. Additionally, the study sought to identify the taxonomy of the host species of *S. atropurpurea* and determine the percentage of infection among those hosts.

I. LITERATURE REVIEW

S. atropurpurea (Blume) Danser, a species of Mistletoe, is a bushy parasitic shrub with distinctive morphological features. Its woody, sprawling stems branch widely, giving host trees a dense, bushy appearance. The leaves are opposite, leathery or papery, and ovate to elliptic in shape, with smooth margins and a thick texture. The plant's haustoria, specialized roots, pierce the host tree's tissues to obtain water and nutrients. The tiny, tubular flowers are pale grayish, yellowish, or greenish and are found in clusters of two to five blooms, measuring about 1.2 to 2.5 cm in length. The plant produces berries that birds disperse to spread their seeds. The overall morphology of *S. atropurpurea*, including its attachment to host trees and nutrient extraction, indicates adaptation to a parasitic lifestyle. Taxonomically, *S. atropurpurea* is classified within the domain Eukaryota, and its lineage includes: Eukaryota; Viridiplantae; Streptophyta; Magnoliopsida; Santalales; Loranthaceae; and the genus Scurrula (National Center for Biotechnology Information, 2024).

Distribution and Dispersal

Tea mistletoe, belonging to the family Loranthaceae, has a wide distribution across tropical and subtropical regions of Asia. *Scurrula atropurp*urea, in particular, is native to several countries, including Thailand, Vietnam, Java, the Philippines, Bali, Sumbawa, and the Moluccas. This plant primarily inhabits wet tropical biomes, thriving in environments with sufficient moisture and host trees for its parasitic lifestyle. Studies have shown that parasitic plants like *S. atropurpurea* tend to have a wide range of hosts and can occupy extensive areas, producing a high number of propagules. However, their distribution among host populations is often irregular, influenced by environmental circumstances, prior land utilization, and dispersal mechanisms. Within the Loranthaceae family, Scurrula species exhibit a generalist pattern, with the most number of host species (Del Rosario, 2022; Watson, 2009; Hoffmann et al., 1994). Within the family Loranthaceae, *Scurrula* species had the most number of host species, showing a generalist pattern.

Scurrula atropurpurea, also known by its synonym *Loranthus philippensis,* is widely distributed across several countries and is native to the tropical and subtropical regions of Asia (Del Rosario, 2022). This plant can be found across a wide range of countries, including Thailand, Vietnam, Java, the Philippines, Bali, Sumbawa, and the Moluccas (WFO, 2025). It primarily inhabits wet tropical biomes, thriving in environments that provide sufficient moisture and host trees that support its parasitic lifestyle (Forest Restoration Research Unit, 2005).

Devkota and Kunwar (2006) state that mistletoes, including *S. atropurpurea*, have a mutualistic relationship with birds that plays a crucial role in both pollination and seed dispersal. The feeding behaviors and foraging strategies of mistletoe-associated bird species significantly influence the reproductive success and distribution of mistletoes. Members of the Loranthaceae family, including *S. atropurpurea*, produce fleshy, single-seeded fruits that rely on animals for dispersal. Mistletoe birds are particularly effective dispersers, distributing seeds more evenly compared to other animals, which tend to deposit seeds in clusters. Successful seed germination requires the seed to land on a suitable branch of a host tree, making seed dispersal crucial for mistletoes. Birds facilitate the spread of *S. atropurpurea* by ingesting its seeds and depositing them in new locations, often on suitable host plants.

Host Specificity and Range

S. atropurpurea is a generalist parasite that can attach to and absorb nutrients from a broad range of host trees. Its haustoria, specialized root structures, allow it to penetrate host plant tissues and extract necessary nutrients and water for growth. This broad host range enables *S. atropurpurea* to parasitize various tree species and thrive in diverse forest ecosystems (Lim et al., 2016). The plant's adaptability to different host trees and habitats contributes to its wide distribution. However, this adaptability also allows *S. atropurpurea* to severely impact forest health by weakening or killing host plants through the depletion of nutrients and water. (Le et al., 2023). Interestingly, despite being generalist parasites, hemiparasitic plants like S. atropurpurea often exhibit preferences for specific host species, which can alter competitive interactions and lead to changes in vegetation structure and diversity within plant communities (Hodžić, 2021).

Phytochemical Components

S. atropurpurea is rich in flavonoids and phenolic compounds, which contribute to its antioxidant properties. Studies have identified various bioactive compounds in the plant, including hexadecanamide, octadecanamide, tetradecanamide, and 9-octadecanamide, which exhibit medicinal properties (Bunchalee et. al., 2024). The plant also contains active flavonoids like theobromine, quercetin, kaempferol, epicatechin, catechin, caffeine, rutin, and aviculin, which have potential anti-inflammatory properties (Yuniwati, 2018). Furthermore, the hemiparasite also contains tannins, monoterpoids, steroids, quinones, and triterpenoids (Mustarichie, Runadi, & Ramdhani, 2017). A study by Ohashi et al. (2003) found that octa-8,10,12-triynoic acid, an alkynic fatty acid, effectively inhibited cancer cell invasion in vitro.

Recent research by Bunchalee et al. (2024) revealed the presence of kaempferol, quercetin, and casticin in the plant's stems and leaves, which are associated with cardiovascular benefits, antioxidant activity, and potential management of metabolic conditions like diabetes and osteoporosis. The plant's leaves are rich in essential oils, flavonoids, tannins, and other bioactive constituents, making them suitable for traditional medicinal uses, such as herbal teas, extracts, and poultices. A GC-MS analysis by Aditiyarini et al. (2022) identified 12 distinct compounds in the leaf extract, primarily fatty acid esters and sugars, reflecting the plant's complex phytochemical profile. The leaves are notably rich in essential oils, flavonoids, tannins, and various other bioactive constituents. Due to this composition, they are traditionally utilized in the preparation of herbal teas, extracts, and poultices for medicinal and therapeutic purposes.

Host-Plant Interaction

S. atropurpurea is a hemiparasite that can photosynthesize but relies on its host for essential nutrients and water. This dual ability enables it to survive and thrive while drawing resources from the host plant. The parasitic relationship begins when the mistletoe seed germinates and forms a haustorium, a specialized organ that connects the host and parasite (Westwood, 2015). This specialized organ acts as a physical and physiological connection between the host and parasite. The haustorium serves as a physical and physiological bridge, enabling the siphoning of nutrients and water through the host's vascular tissues and bark (Teixeira-Costa, 2021; Saucet & Shirasu, 2016).

This adaptation enables *S. atropurpurea* to parasitize its host and obtain necessary resources (Yoshida et al., 2016; Kuijit, 1969). While parasitic angiosperms, including mistletoes, rarely kill their hosts, they often alter the physiological function of their hosts, leading to decreased growth, reproduction, and competitive ability in infected hosts (Nickrent & Musselman, 2004).

Ecological Implications

S. atropurpurea, as a parasitic mistletoe, has significant ecological implications that affect both its host plants and the broader ecosystem. By parasitizing host plants, it can alter nutrient cycling, leading to localized nutrient redistribution when the Mistletoe or affected branches fall and decompose (Mudgal et al., 2022). *S. atropurpurea* can alter plant community dynamics and composition by stressing host plants, rendering them less competitive, and potentially disrupting species balance (Lim et al., 2016). However, mistletoes can also enhance structural diversity in forests and woodlands by generating complex growth forms and microhabitats, supporting a higher diversity of organisms and increasing overall biodiversity (Watson, 2022). Ultimately, *S. atropurpurea* plays a multifaceted role in its ecosystem, having both adverse effects on individual host plants and positive effects on ecological interactions, habitat complexity, and biodiversity

II. MATERIALS AND METHODS

Research Design

This study utilized fieldwork, laboratory, and spatial analyses. The combination of quantitative and qualitative procedures enabled an encompassing understanding of the characteristics and distribution of *S. atropurpurea* (Shorten & Smith, 2017). The fieldwork involved gathering *S. atropurpurea* samples and cataloging their locations using a Global Positioning System (GPS) to map the distribution of the samples within the campus of the Adventist University of the Philippines. A purposive sampling technique, combined with an exploratory approach, was used to survey the area (Fadliyah et al., 2019).

Mapping and Sampling

The selection of sampling locations was determined using purposive sampling. Each sampling area had a total of 400 m^2 (20 m x 20 m) per quadrat, providing a sufficient and manageable area for data collection (Anitha et al., 2009). The standard criteria for measuring Diameter at Breast Height (DBH, 1.37m above the ground) were utilized. Only mature trees (DBH ~20 cm) in each sampling area were included in the analysis.

The mobile Global Positioning System (GPS) was utilized in mapping the hemiparasitic plant and its hosts within the campus of the Adventist University of the Philippines (Nowak et al., 2020). Tea mistletoe with its hosts were found in five different sites: Two (2) Avocado Trees at 223 Nayong Masaya Street (N 14°12'51.19200", E 121°2'2.59010"), (N 14°12'51.01200", E 121°2'2.94000"), one (1) Acacia Tree in front of the Korean Church (N 14°12'45.22260", E 121°2'5.14450"), seven (7) Queen's Crape Myrtle Trees along Roda's Park (N 14°12'49.14360", E 121°2'13.36920"), (N 14°12'49.04280", E 121°2'13.47000"), (N 14°12'48.77640", E 121°2'13.94160"), (N 14°12'48.54960", E 121°2'14.25480"), (N 14°12'48.39840", E 121°2'14.99640"), (N 14°12'48.32640", E 121°2'15.11520"), (N 14°12'49.14720", E 121°2'15.48600"), two (2) Paper Trees near Chrysanthemum Dormitory (N 14°13'11.42950", E 121°2'25.61480"), (N 14°13'11.20800", E 121°2'25.22400"), one (1) Narra Tree near the Old Gate (N 14°13'9.22540" E 121°2'10.04080"), and one (1) Acacia Tree in the Driving Field (N 14°13'11.91720", E 121°2'15.20520").

Tea Mistletoe (*S. atropurpurea)* (Bl.) Danser and their hosts were collected from the Adventist University of the Philippines (AUP) to examine their distribution. With the use of a plant grabber, the researchers collected five samples of Tea Mistletoe and its hosts, specifically at the site where the haustorium had attached to the host plant. The accrued samples were conscientiously organized and dried between newspapers and parchment paper using a plant press (100 cm x 40 cm) to maintain structural cohesion. The plant press was reinforced with bolts to ensure successful drying, allowing the samples to be placed on herbarium paper for long-term preservation and study. Following standard herbarium practices, the herbarium samples were categorized with the necessary information, including the collection code number, location, date, coordinates, collector's name, scientific name, and plant description (University of Florida Herbarium, 2023).

Identification and Classification

The collected samples of Tea Mistletoe were documented and verified by the Museum of Natural History, University of the Philippines, Los Baños, Laguna, Philippines.

Infection Rate Analysis

The infection rate (IR) of the infected host within the 20 m x 20 m quadrat area was analyzed and calculated using the following equation (Del Rosario et al., 2022; Anitha et. al., 2009).

$$\text{\% Percentage of Infection} = \frac{\text{No. of affected plants}}{\text{Total number of plants observed}} \times 100$$

Dye Uptake Analysis

S. atropurpurea samples attached to its host (*Lagerstroemia speciosa*) were collected to observe the dye uptake of the hemiparasite from the host plant. This specific host species was chosen to minimize variability and to standardize the observations (Haryono, Aditiyarini, & Restiani, 2024). A cut was made on the haustorium, and the host branch was soaked in a solution of 500 mL tap water and 10 mL safranin red for 24h (Seeger & Weiler, 2023). The use of safranin red, which adheres to plant xylem (Bond et al., 2008), allowed for the visualization of dye uptake. Cross-sections and longitudinal sections were then examined to document the dye's movement.

III. RESULTS AND DISCUSSION

Taxonomic Classification of Tea Mistletoe [*Scurrula atropurpurea* (Blume) Danser]

Five host species were identified, including Avocado (*Persea americana*), Banaba (*Lagerstroemia speciosa*), Acacia (*Samanea saman*), Paper Tree (*Gmelina arborea*), and Narra (*Pterocarpus indicus*).

Figure 1. Morphological characteristics of *S. atropurpurea*. a) Leaf b) Leaf venation c) Tubular flower and mature flower d) leaf arrangement e) bush

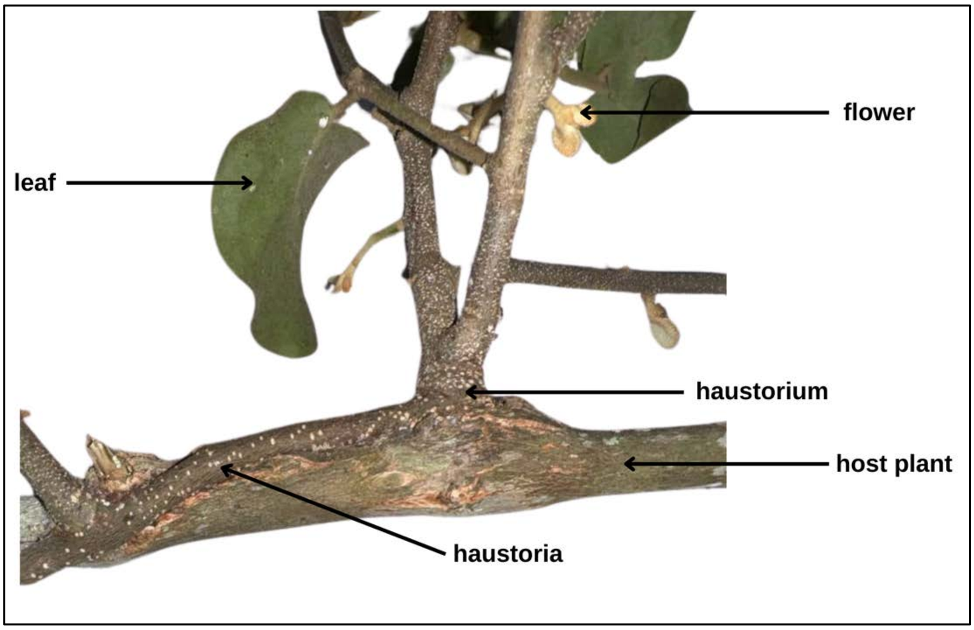

Figure 2. The labeled parts of *S. atropurpurea* and its host

S. atropurpurea (Blume) Danser, a hemiparasitic plant species, was identified and verified at the Museum of Natural History Science (Botanical Herbarium) of the University of the Philippines-Los Baños, Laguna, Philippines (Figures 1 and 2). This species is taxonomically synonymous with *Loranthus philippensis* and is widely distributed across several countries in Asia, including Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Taiwan, Malaysia, Indonesia, China, and the Philippines (Del Rosario, 2022). Notably, *S. philippensis* is now considered to be a synonym of *S. atropurpurea*, reflecting a consolidation in its taxonomic classification based on morphological and geographical data (Barlow, 1992).

The leaves of *S. atropurpurea* are oppositely arranged along the stem, with elliptic to obovate leaf blades measuring 5-10 cm in length and 2.3-5 cm in width (Figures 1 and 2). The leaf base is cuneate to slightly cordate, tapering into a 0.6-1.2 cm long petiole, with rounded leaf apices and largely inconspicuous venation except for the prominent midrib and primary lateral veins on the adaxial surface. The plant produces raceme inflorescences, often clustered at nodes, with 4-6 flowers per raceme. The fruit is relatively small, measuring 0.8-0.9 cm in length, with a thick stipe and a slightly contracted apex. *S. atropurpurea* belongs to the following taxonomic hierarchy: Kingdom Plantae, Phylum Streptophyta, and Class Magnoliopsida, Order Santalales, Family Loranthaceae, Genus *Scurrula*, and Species *Scurrula atropurpurea* (Blume) Danser. These morphological characteristics contribute to the identification and classification of *S. atropurpurea* within the *Loranthaceae* family, providing insight into its adaptive features as a hemiparasitic plant.

Taxonomic Classification of Host Plants

S. atropurpurea was found to parasitize several host plant species, including *Persea americana*, *Lagerstroemia speciosa, Samanea saman*, *Gmelina arborea*, and *Pterocarpus indicus* (Table 1). Notably, *Lagerstroemia speciosa* was the most infected host species across the identified sites, suggesting a potential preference or susceptibility to S. *atropurpurea* infestation. These hosts share key traits, such as well-developed vascular tissues, making them suitable for the hemiparasitic plant to attach, penetrate, and grow for long-term survival.

Table 1. Common name, scientific name, family, and location of host species.

Common Name	***Scientific Name***	***Family***	***Location***
Avocado	*Persea americana*	Lauraceae	223 Nayong Masaya
Banaba	*Lagerstroemia speciosa*	Lythraceae	Along Jerusalem Road and Student Park
Acacia	*Samanea saman*	Fabaceae	Front of Korean Church (Site 1) Driving field (Site 2)
Paper Tree	*Gmelina arborea*	Lamiaceae	Front of Chrysanthemum Dorm
Narra	*Pterocarpus indicus*	Fabaceae	AUP Old Gate

Persea americana

P. americana, commonly known as avocado, is an evergreen tree belonging to the family Lauraceae. Native to the western hemisphere, its origins are traced back to Mesoamerica. The name "avocado" is derived from the Nahuatl word "ahuacatl," meaning "testicle," likely due to the fruit's distinctive shape. Historical records suggest that the avocado was first discovered in Mexico around 291 BC. The species is classified into three horticultural races—Mexican, Guatemalan, and West Indian—each with distinct characteristics, and is adapted to various climatic conditions (Nandwani, 2014).

The Lauraceae family, to which avocado belongs, is a diverse group of dicotyledonous plants comprising approximately 2,850 known species distributed across 45 genera worldwide (Christenhusz, 2016). Most members of this family are aromatic, evergreen trees or shrubs found in warm-temperate to tropical regions.

Avocado trees typically grow 9-18 meters tall, with some wild varieties reaching up to 20 meters, and have a trunk diameter of 30-60 cm. The species is characterized by its periodic growth pattern, influenced by local environmental conditions (Nandwani, 2014). Avocado trees thrive in well-drained, slightly acidic soils rich in organic matter. The leaves exhibit varying shapes, commonly round, oval, or ovate, and measure 7.62-25.4 cm in length (Afzal et al., 2022). The tree produces small, greenish, bisexual flowers, and the fruits display a range of shapes, including round, ovate, and pear-shaped, with varying skin color and texture.

Avocado belongs to the following taxonomic hierarchy: Kingdom Plantae, Phylum Streptophyta, Class Magnoliopsida, Order Laurales, Family Lauraceae, Genus Persea, and Species *P. americana.*

Lagerstroemia speciosa

The genus *Lagerstroemia* was named in honor of Magnus von Lagerström, a Swedish merchant and director of the Swedish East India Company (Orwa et al., 2009). The species epithet "*speciosa*" is derived from the Latin word "speciosus," meaning "showy" or "spectacular," referring to the plant's striking floral display. Common names include "Queen's flower" and "crape myrtle," the latter describing the delicate, crinkled texture of the flowers. *Lagerstroemia speciosa* is native to the Philippines, widely distributed across most islands and provinces, and commonly found in secondary forests at elevations ranging from low to medium. Due to its vibrant and attractive flowers, it is frequently cultivated as an ornamental plant.

L. speciosa, commonly known as banaba, is a deciduous tropical flowering tree that typically grows 5-10 meters tall, with some varieties reaching up to 20 meters. The bark is smooth, gray to cream in color, and peels off in irregular flakes. The leaves are large, smooth, and vary in shape from spatulate to oblong or elliptic-ovate, measuring 12-25 cm in length and 4-8 cm in width. The tree sheds its leaves during the early months of the year as part of its natural growth cycle. The flowers are striking and ornamental, measuring 5-8 cm in diameter, and are typically purplish to lilac to mauve-pink in color. They are arranged in prominent terminal panicles that can reach up to 40 cm in length. The fruit is a large, nut-like capsule, obovoid to ellipsoid in form, measuring 2-3.5 cm in length, and contains pale brown seeds with wings approximately 1.2-1.8 cm long, aiding in wind dispersal (Meerow, Ayala-Silva, & Irish, 2015).

Banaba belongs to the Kingdom Plantae, Phylum Tracheophyta, Class Magnoliopsida, Order Myrtales, Family Lythraceae, Genus Lagerstroemia, and Species *L. speciosa*.

Pterocarpus indicus

Narra, the Philippine national tree, is a grand hardwood tree that can reach up to 33 meters. The bark is smooth, gray to cream in color, and peels off in irregular, flaky pieces. Its leaves are compound and pinnate, measuring 15-30 cm in length, with 7-11 ovate to oblong-ovate leaflets. The tree produces clusters of small, fragrant, yellow flowers, approximately 1.5 cm long. Its fruits are disc-shaped pods with winged edges, which are hairy when young and smoother when mature, measuring 4-5.5 cm in length (Stuart, 2021). The wood of Narra is highly valued for its resilience, vivid reddish color, and resistance to termites. It is frequently used in the manufacture of cabinetry, furniture, and other fine wood products. Due to its economic and ecological importance, the Narra tree is an indispensable part of the Philippines' environment, providing shade and improving the quality of soil through nitrogen fixation.

Narra belongs to Kingdom Plantae, Phylum Magnoliophyta, Class Magnoliopsida, Order Fabales, Family Fabaceae, Genus Pterocarpus, and Species *P. indicus.*

Samanea saman

The *S. saman*, commonly known as the Acacia or Rain Tree, is a large,
evergreen tree that can reach up to 25 meters (82 feet) in height. It has a wide-spreading canopy with a rounded, umbrella-like shape that can extend to 30 meters in diameter. Its bark is rough, and the leaves are bipinnate (feather-like), typically growing 15 to 30 centimeters long with

numerous small leaflets (Saples & Elevitch, 2006). The tree produces large, showy, pink or purple flowers that are clustered together in ball-shaped inflorescences. These flowers bloom during the rainy season, hence the common name "Rain Tree."

Native to tropical America, *S. saman* was introduced to the Philippines around 1860. The tree's bark and seeds contain alkaloids, and its leaves, stems, and pods are rich in tannins and saponins. The pods are also used for their starch and sugar content. The tree has been used to treat conditions like diarrhea, ulcers, and sore throats. These species contribute to the landscape through their dense foliage and are also valued for their timber and environmental benefits.

The taxonomy of Acacia is as follows: Kingdom Plantae, Phylum Tracheophyta, Class Magnoliopsida, Order Fabales, Family Fabaceae, Genus Samanea, Species *S. saman.*

Gmelina arborea

Commonly known as the paper tree, *G. arborea* is a rapidly growing, deciduous tree indigenous to tropical regions. It can attain imposing heights of 15-25 meters and is appreciated for its functionality in various areas. Simple, large, and oval-shaped, the leaves are arranged oppositely along the branches, with a smooth texture that enhances the tree's aesthetic appeal (Grow Billion Trees, 2025).

This versatile species provides countless economic and ecological benefits, including exceptional coppicing capacity, high biomass production, and a dependable source of forage for livestock. The wood is lightweight yet strong, making it suitable for pulpwood production and furniture. Its robust root system enhances soil richness, and the tree is fire-tolerant, ensuring its adaptability to changing cultivation practices. The Paper Tree can be cultivated smoothly through cuttings and seeds, encouraging productive establishment and germination (Orwa et al., 2009).

Paper tree belongs to the Kingdom Plantae, Phylum Tracheophyta, Class Magnoliopsida, Order Lamiales, Family Lamiaceae, Genus Gmelina, and Species *G. arborea.*

Distribution

S. atropurpurea was found parasitizing five (5) host plant species across different locations within the Adventist University of the Philippines (AUP) campus. Two (2) Acacia trees were infected in two different places, one in front of the Korean Church and one 1 in the Driving Field. Two (2) Avocado trees were infected at 223 Nayong Masaya Street. Seven (7) Banaba trees were infected at Jerusalem Road along Roda's Park. One (1) Narra Tree is infected near the AUP Old Gate. Lastly, two (2) Paper trees were found infected. One of the primary factors influencing the distribution of Tea Mistletoe is the seed dispersal facilitated by avian vectors. Mistletoe seeds exhibit a highly specialized reliance on avian dispersers for successful germination and establishment. These seeds are incapable of germinating unless they pass through the digestive tract of a bird. This digestive process not only facilitates seed viability but also prepares the seed for attachment and growth. Upon secretion, the seed is enveloped in a sticky, viscous coating. To remove the adhesive seed from its feathers, the bird engages in a characteristic behavior– rubbing its cloaca against tree branches in what the researchers have termed a "waggle dance" (Ross). Once attached, the seed quickly initiates haustorial development, penetrating the host tissue to access water and minerals necessary for its growth.

Table 2. Names of host plants, location, and GPS coordinates.

Host Plant	**Location**	**GPS Coordinates**
Acacia (*Samanea saman)*	Driving Field	N 14°13'11.91720" E 121°2'15.20520"
	Front of the Korean Church	N 14°12'45.22260" E 121°2'5.14450"
Avocado (*Persea americana)*	223 Nayong Masaya Street	N 14°12'51.19200" E 121°2'2.59010"
		N 14°12'51.01200" E 121°2'2.94000"
Banaba (*Lagerstroemia speciosa)*	Jerusalem Road along Roda's Park	N 14°12'49.14360" E 121°2'13.36920"
		N 14°12'49.04280" E 121°2'13.47000"
		N 14°12'48.77640" E 121°2'13.94160"
		N 14°12'48.54960" E 121°2'14.25480"
		N 14°12'48.39840" E 121°2'14.99640"
		N 14°12'48.32640" E 121°2'15.11520"
		N 14°12'49.14720" E 121°2'15.48600"
Narra (*Pterocarpus indicus)*	Near AUP Old Gate	N 14°13'9.22540" E 121°2'10.04080"
Paper tree (*Gmelina arborea)*	Front of Chrysanthemum Dorm	N 14°13'11.42950" E 121°2'25.61480"
		N 14°13'11.20800" E 121°2'25.22400"

Percentage of Infection

One (1) Acacia tree located in front of the Korean Church (site 1) is infected, with an infection rate of 100%. Out of four (4) trees in the Driving field, one (1) Acacia tree is infected, representing an infection rate of 25%. Out of five (5) trees near AUP's Old Gate, one (1) Narra tree is infected, corresponding to an infection rate of 20%. Two (2) Paper trees out of the five (5) trees are infected in front of the Chrysanthemum Dormitory, indicating a 40% infection rate. Seven (7) Banaba trees out of thirteen (13) trees are infected, with a percentage of 53.84%. Lastly, out of seven (7) trees in 223 Nayong Masya, two (2) Avocado trees are infected, with a percentage of 28.57%.

Table 3. The percentage of infection of *Scurrula atropurpurea* among its hosts

Scientific name	No. of infected tree/s	No. of non-infected tree/s	Total number of observed tree/s	Percentage of infection
G. arborea	2	3	5	40.00%
L. speciosa	7	6	13	53.84%
P. americana	2	5	7	28.57%
P. indicus	1	4	5	20.00%
*S. saman**	1	0	1	100.00%
*S. saman***	1	3	4	25.00%
Total	14	21	35	40.00%

*Collected from the front of the Korean Church
** Collected from the Driving Field area

Infection Rate of Host Plants

The quadrats containing host plants *P. americana*, *S. saman*, *P. indicus*, *G. arborea*, and *L. speciosa* showed varying infection rates. *P. americana* had a 28.57% infection rate, while *S. saman* had a 100% infection rate in one quadrat and 25% in another. *P. indicus* had a 20% infection rate, *G. arborea* had a 40% infection rate, and *L. speciosa* had a 53.84% infection rate. Overall, out of 35 trees, 14 were infected with the hemiparasite, resulting in a 40% infection rate.

Host Suitability Factors

These identified hosts shared several traits that make them a suitable host for the hemiparasitic plant. They all belong to the Magnoliopsida class, which includes flowering trees that thrive in tropical and subtropical regions, an ideal environment for *S. atropurpurea* to attach and grow (Lim et al., 2016). More often than not, the connection between *S. atropurpurea* and its hosts is significantly influenced by the type of host plant and its overall well-being. Host suitability is influenced by factors such as age, size, resource allocation strategies, and responses to parasitic infections (Moncalvillo & Matthies, 2023). Other factors that play important roles are host plant traits, seasonal changes, and dispersal patterns (Solikin, 2022).

Mango (*Mangifera indica),* Guyabano (*Annona muricata)*, Malunggay *(Moringa oleifera),* Aratilis *(Muntingia calabura)*, and Mahogany *(Swietenia macrophylla)* are the species of trees that have a defensive physical barrier, such as latex-producing or thick bark,

bark that sheds naturally, and chemical deterrents that make it arduous for *S. atropurpurea* to infiltrate, infect, and create a connection. Guyabano and Malunggay's lack of infection could stem from the Rapid bark shedding or allelopathic compounds, which may also disrupt haustorial attachment (Moncalvillo & Matthies, 2022). Additionally, parasitic species rely on chemical cues from suitable hosts to initiate seed germination and haustorium development (Press & Phoenix, 2005). As a result, *S. atropurpurea* tends to exhibit host preference and attach and grow only on species that emit the appropriate chemical cues, while avoiding those that do not.

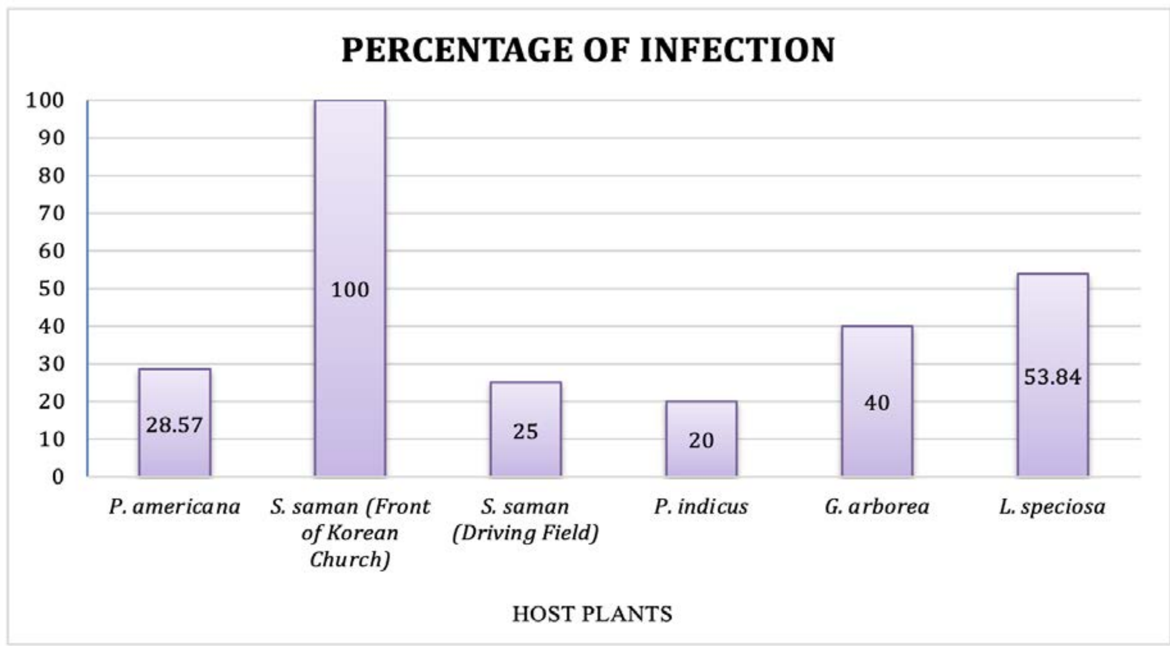

Figure 3. The percentage of infection of *Scurrula atropurpurea* among its hosts

The infection rate of S. *atropurpurea* varied among host species, *with Lagerstroemia speciosa* having the highest rate of 53.84%, followed by *D. arborea* at 40%, *Persea americana* at 28.57%, and *Samanea saman* at 25% in one region and 100% in another. The high infection rate of S. saman in isolated conditions suggests that it is highly susceptible and a preferred host in the absence of competition (Fadliyah et al., 2019 Structural compatibility, physiological defenses, and transpiration rates may influence the haustorial attachment and establishment of the hemiparasite (Rahmad et al., 2014).

Host Diversity and Environmental Factors

Areas with mixed diversity exhibited varying infection rates, supporting the notion that host diversity influences host transmission by diluting seed dispersion and host compatibility (Albues et al., 2023). Urban stress, such as drought or pollution, may also contribute to the susceptibility of trees, as evidenced by the proximity of infected trees to roads (Kubíček et al., 2018). A 40% infection rate is significant but not extreme, as research has been conducted on a related mistletoe that has ranged from partial to 100% in heavily affected host species (Erhabor, 2022). As for rating scales, it would be classified as "low" compatibility according to the study by Fetch and Steffenson (1999), as there are few to no necrotic lesions and marginal chlorosis. The 40% overall infection rate among 35 trees suggests moderate infection in AUP, with host diversity and species-specific traits influencing susceptibility. These findings align with previous studies on host-parasite interactions, environmental stress, and community diversity (Těšitel et al., 2010).

The infection rate data showed that *S. atropurpurea* is not randomly distributed and varies by host species, suggesting a preference for specific hosts despite its generalist nature (Hodžić, 2021). Mixed infection rates indicate that there is a species-specific susceptibility, which reduces the proliferation of the hemiparasite, as the specificity serves as a barrier for diverse tree communities (Solikin, 2021). GPS mapping also revealed clustered infections, likely due to bird-mediated seed dispersal, supporting a mutualistic relationship between the Mistletoe and avian species (Devkota & Kunwar, 2006).

Host-Parasite Interaction

The hemiparasite's infection process begins with sprouting on the host plant, followed by the growth of its stem and roots, which securely attach to the host. The intrusive cells of the haustoria bypass the host's physical defenses and avoid triggering immediate immune responses to reach the plant's vascular system (Aryal, 2024). The primary haustorium penetrates through the cambium, anchoring itself to the vascular tissue to access water and nutrients (Teixeira-Costa, 2021). A vascular bridge is formed, allowing the hemiparasite to continuously draw nutrients from the host, which may result in reduced growth on the attached branch (Lim et al., 2016). Additionally, the hemiparasite develops photosynthetic leaves to produce its food, reducing its dependence on the host.

As it grows, the plant becomes more intertwined with the host, almost merging into a single branch. The host itself is not unaffected, as it shows swelling at the point of attachment from where the haustorium pierces through to the plant. This swelling results from the Mistletoe's integration into the host's water-conducting tissues, facilitating the transfer of water and nutrients essential for the parasite's growth and development. Furthermore, the hemiparasite develops a shoot system that spreads externally from the host. This far into its maturation, it starts to resemble a shrub, consisting of leaves, racemes with 4-8 flowers, and dark, spotty branches growing on the branches of its chosen host.

Dye Uptake

The dye uptake of *S. atropurpurea* from its host, *L. speciosa,* demonstrates the connection of the hemiparasite to its host. In comparison to the vivid pink of the host plant tissues, where the xylem rings are prominent, the dye in the tissues of the hemiparasite appears lighter in color. Interestingly, the hemiparasite continues to draw water from the container, as the plant did not dry up after the cuts were made. This demonstrates that the host's xylem vessels continue to transport water upward, allowing both the host tissues and the attached hemiparasite access to water (Těšitel, Plavcová, & Cameron, 2010). This also shows that the host is functionally capable of water uptake through the xylem. At the same time, the hemiparasite appears to have a delayed or reduced water uptake due to additional hydraulic resistance at the haustorial interface (McElrone et al., 2013).

The degree of efficiency of transport that limits the rate of water and nutrient uptake depends on factors such as anatomical and biochemical host-parasite compatibility (Athiroh et al., 2014). The lighter, faded color of the dye within the hemiparasite may be attributed to the interaction between antioxidant constituents within the hemiparasite and safranin red dye, which can result in degradation or alteration of the molecules (Haryono et al., 2024). This biochemical activity could obscure the full extent of dye movement between the two plants, complicating the discernible assessment of the experiment. The paler coloration in the hemiparasite tissues, in contrast to the vivid pink of the host tissues, is consistent with our results, implying diminished water uptake due to hydraulic resistance or biochemical fortification within the hemiparasite.

V. CONCLUSION

This study has successfully identified and characterized the hemiparasitic plant, *S. atropurpurea,* and its hosts. The study also found that *S. atropurpurea* parasitizes a broad range of woody plant species within the Adventist University of the Philippines (AUP) campus, including *Persea americana*, *Gmelina arborea*, *Pterocarpus indicus, Samanea saman,* and *Lagerstroemia speciosa*. Among the host species, *Lagerstroemia speciosa* was the most infected host species across the identified sites. Dye uptake analysis confirmed the parasitic relationship between *S. atropurpurea* and its host (*L. speciosa),* exemplifying vascular integration of the parasite's haustorium into the host's vascular system. Further studies on hemiparasite-host interactions, utilizing histological, phytochemical, and molecular analyses, are essential for fully elucidating the hemiparasitic-host interactions and the underlying mechanisms. Understanding hemiparasite-host interactions can aid in managing parasitic plants in both natural and agricultural systems, potentially leading to fewer infections of host plants and increased productivity.

AUTHORS' CONTRIBUTION

OBY conceptualized and provided essential suggestions on the design, implementation, and analysis of the study. HNTI, GLMMM, and RGR conducted the research, while NJV assisted with the experimentation and preparation of reagents. All authors contributed to the finalization of the manuscript.

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