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Identification of Leaf Miner Pests and Parasitoids of The Sembalun Lombok Arabica Coffee Variety

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Abstract*:* Arabica coffee (*Coffea arabica* L.) is an important plantation commodity cultivated in the Sembalun Highlands, Lombok. However, leaf miner infestations can reduce plant productivity by damaging leaf tissues and disrupting photosynthesis. This study aimed to identify leaf miner pests and associated parasitoids on several Arabica coffee varieties and to evaluate infestation intensity. The research used a quantitative desriptive approach with field survey methods. Sampling was conducted using systematic random sampling on five Arabica coffee varieties: Yellow Caturra, Red Caturra, Typica, Kobra, and Lini-S. Leaves showing leaf miner symptoms were collected weekly, reared in the laboratory, and identified morphologically. Infestation intensity was calculated using the Natawigena method and analyzed decriptively. The result showed that the leaf miner belonged to the order Lepidoptera, family Gracillariidae, genus *Phyllocnistis*, while the parasitoid belonged to the family Eurytomidae. The average infestation intensity was catagorized as moderate, with the highest infestation on Yellow Caturra dan the lowest on Lini-S. The presence of parasitoids indicates their potential role as biological control agents in sustainable Arabica coffee pest management.

Keywords: Arabica coffee; Highlands; Leaf miner; Varieties.

Pendahuluan

Coffee is a high-value agricultural commodity that has been widely cultivated in Indonesia. Globally, Indonesia ranks among the leading coffee-producing countries after Brazil, Vietnam, and Colombia. This commodity plays a strategic role in the national economy, serving as a source of foreign exchange, a provider of employment, and a source of income for farmers (Baso et al., 2018). Data from the Central Statistics Agency (BPS) indicates that Indonesia's coffee production has fluctuated in recent years and has even shown a downward trend during certain periods (BPS Indonesian Coffee Production, 2024). This decline in productivity is influenced by several factors, one of which is the infestation of plant pests.

Arabica coffee (Coffea arabica) is a high-value agricultural commodity that is widely cultivated in highland areas, including the Sembalun region of Lombok. However, Arabica coffee productivity often declines due to pest attacks, one of which is the leaf miner (International Coffee Organization, 2021; Indonesian Ministry of Agriculture, 2015). This pest belongs to a group of endophagous insects that live and develop within leaf tissue, making it difficult to control. Larval activity within the leaf mesophyll tissue causes the formation of mines, which leads to a reduction in chlorophyll content and disrupts the plant's photosynthesis process (Karp et al., 2018).

Leaf miner pests on coffee plants generally belong to several orders, such as Lepidoptera, Diptera, and Coleoptera. These pests have larvae that live and develop within the leaf tissue. These pest infestations can cause significant damage to leaves, even to the point of reducing crop productivity (Dantas et al., 2021). Additionally, the distribution and severity of leaf miner pest infestations are also influenced by environmental factors such as temperature, rainfall, and agroecosystem landscape conditions (Zhang et al., 2023).

On the other hand, the presence of natural enemies such as parasitoids plays a crucial role in maintaining ecosystem balance and naturally suppressing pest populations. Parasitoids are known to reduce populations of leaf miner pests through parasitism at the larval or pupal stage. The diversity and abundance of parasitoids are significantly influenced by habitat conditions, pesticide use, and the complexity of the agricultural landscape (Wulandari et al., 2022). In fact, within certain agroecological systems, parasitoids and natural predators can help suppress pest populations to levels below the economic threshold (Marques et al., 2023).

Interactions between parasitoids and leaf miner pests indicate the potential for natural control that can reduce pest infestation levels on host plants (Sari et al., 2016). Habitat management and the conservation of natural enemies are key strategies for enhancing the effectiveness of biological control against leaf miner pests (Dorra et al., 2021). Therefore, identifying the pest and parasitoid species associated with coffee plants is a crucial first step in supporting the implementation of integrated pest management (IPM).

Although the Sembalun region is known as a major center for Arabica coffee cultivation, with a supportive highland agroecosystem, information regarding the identification of leaf miner pests and their associated parasitoids on various Arabica coffee varieties in this region remains limited. Yet the presence of various coffee varieties has the potential to influence pest infestation levels as well as the presence of their natural enemies. Given these conditions, a study was conducted on "Identification of Leaf miners and Their Parasitoids on Several Varieties of Arabica Coffee (*Coffea arabica*) in the Sembalun Highlands of Lombok."

Materials and Methods

Research Methods

This research employed a quantitative descriptive method with field observation techniques. The survey method was chosen because it provides a direct picture of the actual presence of leafminer pests and parasitoids on various Arabica coffee varieties in the field.

Research Time and Location

This research was conducted from September to November 2025. It took place at two locations: the Sangkabira coffee plantation in Sembalun Village and a smallholder coffee plantation in Sembalun Village, Sembalun District, East Lombok Regency, West Nusa Tenggara.

Research Tools and Materials

The tools used in this study included plastic containers (100-200 ml), cotton swabs, test tubes, clear plastic, label paper, tweezers, a small brush, a permanent marker, a camera for visual documentation, a microscope, coffee plants of various varieties (Yellow Caturra, Red Caturra Typica, Cobra, and Lini-S), and 70% alcohol.

Observation Site Determination

The location for this study was determined using a survey technique. The study population included all Arabica coffee plants at two research sites: Yellow Caturra, Red Caturra, and Typica. The first site, the Sangkabira coffee plantation in Sembalun Village, covers 4 hectares and consists of approximately 50 coffee trees, approximately 7 years old, planted at a spacing of 2 m x 2 m. The second site, a smallholder coffee plantation in Sembalun Village, Sembalun District, covers 0.4 hectares with a spacing of 1.8 m x 2.5 m.

Area Plotting and Leaf Miner Sampling

Area plotting is a technique for determining sample plants used as observation objects. Determination of sample units is carried out using systematic random sampling, referring to Sugiyono (2019). The plant populations of each variety were: Yellow Caturra (30 trees), Red Caturra (20 trees), Typica (13 trees), Cobra (15 trees), and Lini-S (15 trees). Twenty percent of the plants from each variety were used as observation samples.

Leaf Miner Pest Sampling

From each sample plant, 25 leaves showing symptoms of leaf miner infestation were collected and placed in clear plastic bags. The leaf samples were taken to the Protection Laboratory, Faculty of Agriculture, University of Mataram, for rearing. Morphological characteristics were then observed under a microscope, species identification was carried out using the Global Biodiversity Information Facility (GBIF), and the number of insects collected was counted.

Research Procedure

The study began with a site survey to determine the observation area and available coffee varieties. Next, plots and sample plants were determined using systematic random sampling. Leaves showing symptoms of leaf miner infestation were taken from coffee plants, with all plant populations eligible for sampling and placed in labeled clear plastic bags. The leaf samples were then taken to the Protection Laboratory, Faculty of Agriculture, University of Mataram, for rearing, until the larvae developed into adults. The rearing results were observed under a microscope and identified based on morphological characteristics, using literature and the Global Biodiversity Information Facility (GBIF) database.

Observation Parameters

Observation parameters included the morphological characteristics of leafminer pests, parasitoid morphology, leafminer attack symptoms, larval population size, number of infested leaves, and attack intensity. Pest population observations were conducted using a sampling technique with an in situ counting system, where the number of pests attacking each leaf had different symptoms. The intensity of pest attacks or the extent of damage to each plant was calculated using the formula used by Natawigena (1993) in (Maharani et al., 2019) as follows:

$$IS = \frac{\Sigma(n\ x\ v)}{Z\ x\ N} \text{ X } 100\%$$

Information:
IS = Intensity of attack,
n = Number of leaves showing scale (v),
v = Leaf score (0 - 4)
Z = Highest score (4),
N = Number of leaves observed,

The damage scale can be assessed using the following scores:

0: No leaf damage
1: Leaf damage reaches ≤25%
2: Leaf damage reaches >25% to ≤50%
3: Leaf damage reaches >50% to ≤75%
4: Leaf damage reaches >75%

Results and Discussion

Identification of Arabica Coffee Leafminer Pests in the Sembalun Highlands

A leafminer pest species was found in Arabica coffee plantations in the Sembalun Highlands, identified as an insect from the family Gracillariidae, genus Phyllocnistis, order Lepidoptera. Previous research in Probolinggo reported coffee leafminer incidents and potential parasitoids in Arabica plantations, but that study focused more on surveys of pest incidence and did not describe variations in attack intensity among coffee varieties (Anisa et al., 2025).

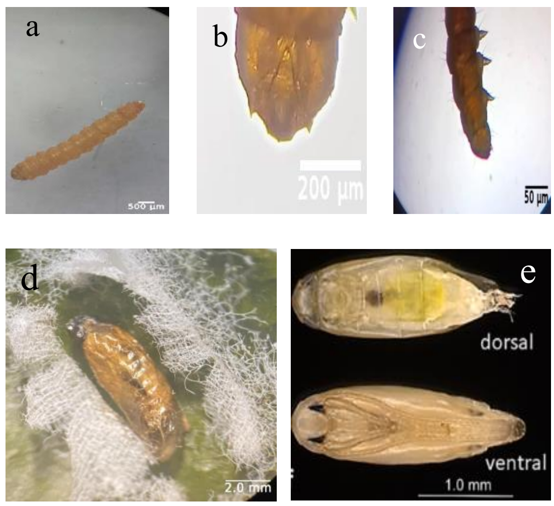

Figure 1. Development stages of Phyllocnistis larvae. (a) Larvae; (b) head; (c) proleg; (d) pupa; (e) dorsal and ventral forms (Dantas et al., 2021)

Leafminer pests have distinctive morphological characteristics. In the larval stage, they have a slender, flexible, and transparent body measuring 3-5 mm, with very small or even invisible legs. Larvae are equipped with chewing mouthparts that function to create mines on the leaf surface, and have prolegs on the anterior portion that play a role in movement within the leaf tissue. Larvae vary in color, ranging from striking colors to colors that resemble the leaves or plant tissue where they live. Furthermore, during the growth phase, Lepidoptera larvae undergo several molts, allowing them to increase in size until they reach the next stage of development (Cerdena et al., 2020). In the pupal stage, they are generally found on the edges, tips, and bases of leaves, with a brownish color, oval to cylindrical shape, and protected by a white cocoon.

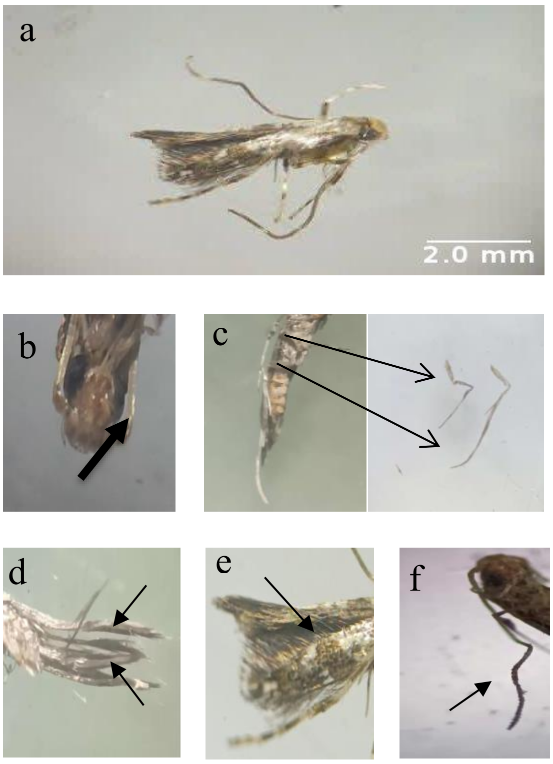

Figure 2. Phyllocnistis Imago (a) Imago; (b) compound eyes of imago, (c) legs, (d) wings, (e) scales, (f) antennae

The imago of the leafminer is relatively small, with a slender body and narrow wings. This insect is characterized by wings covered with fine scales on their surfaces. These scales not only provide a distinctive pattern and color to the wings but also play a protective role and aid in camouflage against the surrounding environment. The head is small and round, with compound eyes that are dark to brown in color. The antennae are long, composed of approximately 48 segments, and have structures that resemble hairs or fine incisions. It has six legs used for movement and interaction with its surroundings. This leafminer belongs to the order Lepidoptera and the family Gracillariidae. Larvae in this family are generally very small with slender, cylindrical bodies and live as leafminers. The head of the larva is relatively developed compared to the rest of the body and is equipped with mouthparts used to feed on the leaf mesophyll tissue and create tunnels on the leaf surface (Bhat et al., 2024). The larval body consists of several segments equipped with thoracic legs and additional legs in the form of prolegs that aid movement within leaf tissue.

Observed morphological characteristics also indicate conformity with the genus Phylllocnistis, which belongs to the family Gracillariidae. Insects in this genus are generally very small with a slender, elongated body shape measuring 2-6 mm. Adults typically have narrow, elongated forewings (wingspan <5 mm) with a relatively simple color pattern, silvery white, dark with black spots (Brito et al. 2017). The forewings are longer than the narrow, elongated hindwings, and are covered with fine hairs along the edges.

Identification of Leafminer Parasitoids

Based on morphological identification results, the parasitoid associated with leafminer pests on Arabica coffee plants in the Sembalun Highlands, according to the Biodiversity and Classification of Wasps (Natashi, 2023), belongs to the Eurytomidae family. The presence of this parasitoid demonstrates the important role of natural enemies in maintaining pest population stability in coffee agroecosystems, as parasitoids can suppress host populations through natural parasitism. Ecologically, parasitoids function as population control factors, helping maintain the balance between herbivores and their natural enemies in the field (Hendrival et al., 2023).

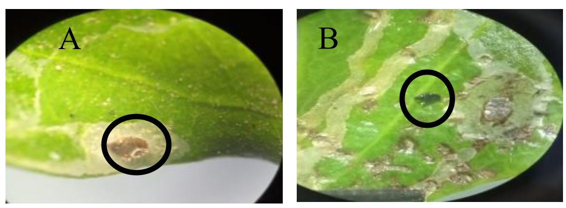

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Figure 2. Morphology of parasitoids (A) Pupa; (B) Exuvia; (C) Legs; (D) Antenna; (E) Wings; (F) Imago

This family has distinctive morphological characteristics, particularly the head, which resembles a worm or slug larva. The head is relatively large and round, with a pair of compound eyes protruding anteriorly. The antennae are long and slender, composed of 12 to 16 segments, and function as sensory organs for touch and taste. The thorax is composed of the prothorax, mesothorax, and metathorax, with three pairs of short legs for locomotion. Furthermore, Eurytomidae have a pair of thin, transparent wings, relatively larger than those of striped insects (Gumovsky et al. 2013).

The parasitic mechanism in parasitoids generally begins with host discovery, followed by egg laying on or inside the host's body. After hatching, the parasitoid larvae develop by exploiting the host's body tissue for nutrition, thus disrupting the host's growth and ultimately dying before reaching adulthood. In leafminer pests, this process is particularly relevant because the larval and pupal stages are the most vulnerable to parasitoid attack. Previous research results show that leaf miner parasitoids can provide significant levels of parasitization and have the potential to suppress pest populations in the field (Rahmawila, et al., 2014).

From an application perspective, the discovery of Eurytomidae parasitoids holds significant potential for biological control programs in Arabica coffee plantations. The presence of parasitoids can be utilized as a component of IPM through supporting vegetation that supports the survival of natural enemies. Therefore, the parasitoids discovered in this study are not only taxonomic in value but also have practical implications for more sustainable pest management.

Intensity of Attacks and Larval Population

Based on observations in Table 1, the intensity of leafminer attacks on several Arabica coffee varieties in the Sembalun Highlands showed significant variation. The highest attack intensity was found on the Yellow Caturra variety, while the lowest was found on the Lini-S variety. The average attack intensity indicates that leafminer attacks at the study site were classified as moderate. According to Dantas et al. (2021), leafminer attacks on coffee plants can significantly reduce photosynthetic area, especially under conditions of high populations and widespread infestation of young leaves.

Table 1. Intensity of Leaf Miner Pest Attacks

Variety	Total population	Number of infected leaves	Attack intensity (%)
Yellow Caturra	32	229	42,72
Red Caturra	22	107	25,03
Typica	35	293	31,96
Cobra	21	204	16,97
Lini-S	19	189	9,28
Total	129	1022	125,96
Average	25,8	204,4	25,192
SD	±7,19	±67,42	±12,98

Differences in attack intensity between varieties can be influenced by plant morphological and physiological characteristics, such as leaf thickness, nutrient content, and leaf tissue structure. Varieties with softer leaf tissue tend to be more susceptible to leafminer attacks because they facilitate the formation of holes in the mesophyll tissue. This is in line with the statement by Zhang et al. (2023) that the level of plant susceptibility to leafminers is influenced by plant physiological conditions and environmental factors such as temperature and humidity.

The pest population numbers found also showed variation between varieties. The highest total population was found in the Typica variety, followed by Yellow Caturra, while the lowest population was found in the Lini-S variety. However, high populations do not always correlate directly with attack intensity, as intensity is also influenced by the number of infested leaves and the extent of leaf lesions. This indicates that the dynamics of leafminer attacks are complex and influenced by the interaction of various biotic and abiotic factors (Paredes et al., 2021).

The number of infested leaves in each variety also showed significant differences. The Typica variety had the highest number of infested leaves, while the Red Caturra variety had the lowest. This difference indicates a pest preference for certain varieties, likely related to the quality of the leaves as a food source. Furthermore, the availability of young leaves for oviposition is also an important factor in determining the level of leafminer infestation (Dantas et al., 2021).

The relationship between larval population, number of infested leaves, and attack intensity indicates that the three are interrelated but not always directly proportional. The larval population reflects the number of pest individuals found, the number of infected leaves indicates the extent of the spread of the attack, while the intensity of the attack describes the level of damage to the infested leaves. In this study, the Typica variety had the highest larval population, but its attack intensity was not the highest, while Yellow Caturra showed the highest attack intensity despite its lower population. This indicates that the intensity of the attack is not only determined by the number of larvae, but also by the distribution of larvae on the leaves and the level of damage to each leaf.

The presence of parasitoids from the Eurytomidae family found in this study indicates an ecological interaction that has the potential to naturally suppress pest populations. Parasitoids are known to infect leafminer larvae or pupae, thereby inhibiting development and causing host mortality. According to Wulandari (2022), the presence of parasitoids in an agroecosystem is strongly influenced by host availability and environmental conditions, and can act as effective biological control agents. Furthermore, research by Gurr et al. (2017) also states that the diversity of natural enemies, including parasitoids, can significantly reduce pest populations in sustainable agricultural systems.

Symptoms of Leafminer Attacks

Leafminers are a group of insects that damage leaf tissue by creating tunnels in the mesophyll during the larval stage. Initial symptoms of leafminer attacks on Arabica coffee plants are generally observed on the shoots or young leaves. Leafminer larvae damage plants by feeding on the mesophyll tissue between the epidermis layers, creating tunnels on the leaf surface (Sari et al., 2016). These tunnels generally appear as white lines on the leaf surface, indicating their path of movement as they feed on leaf tissue (Sofianto et al., 2023).

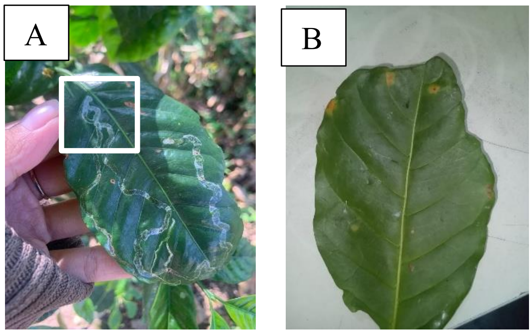

Figure 3. Symptoms of leaf miner attack A) Upper surface of leaf; (B) Lower surface of leaf

Damage caused by leafminer larvae occurs because the mesophyll tissue of the leaf is eaten during the larval development process. As a result, the leaf's ability to photosynthesize is reduced, thus inhibiting plant growth. At high levels of infestation, the leaf lesions can widen and merge, causing the leaf blades to dry out, turn brown, and eventually fall off. In young plants, severe infestation can cause stunted plant growth because young leaves, which play a vital role in photosynthesis, are damaged (Wulandari, 2022). This leaf tissue damage has the potential to reduce the quality and productivity of the affected plants (Dunia Tani, 2024). According to Suhartono (2004), the presence of trichomes on host plants is a form of morphological maintenance mechanism for plants against pest attacks. Plants with a high density of trichomes on their leaves and stems tend to be more able to inhibit insect activity, thereby reducing the level of pest attacks on those plants.

Physiologically, the thickness of the cuticle acts as an initial barrier against the entry of pests. Leaves with thicker cuticles are generally more difficult for pests to penetrate, thus reducing the opportunity for larvae to begin feeding within the leaf tissue. Conversely, leaves with thinner cuticles tend to more easily penetrate the leaf surface and expand their holes (Silva et al., 2025). In addition to physical factors, secondary metabolite content also plays a role in determining coffee plant resistance to pests. Compounds such as phenols, flavonoids, and antioxidants are known to be closely linked to plant defense responses to biotic stresses. In several Arabica coffee clones, secondary metabolite content has been shown to correlate with plant resistance to leaf diseases, and flavonoids have been reported to be useful as indicators for selecting more resistant coffee plants. Other research has also shown that secondary metabolites in coffee leaves are associated with plant defense strategies against biotic disturbances, including in cultivars that are more resistant than susceptible cultivars (Silva et al., 2021).

Conclusion

Based on the research results, one species of leafminer pest was found on several Arabica coffee varieties belonging to the order Lepidoptera, the genus Gracillariidae, and the genus Phylocnistis. Furthermore, one species of parasitoid insect was identified associated with the leafminer pest, which is grouped into the family Eurytomidae. The average attack intensity was categorized as moderate, with the highest attack rate on the Yellow Caturra variety and the lowest on the Lini-S variety. Symptoms of leafminer pest attack on Arabica coffee plants include lesions on the upper surface of the leaves. The presence of parasitoids demonstrates potential as a biological control agent in suppressing leafminer pest populations on Arabica coffee plants.

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