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Characteristic Exploration of Family Fabaceae Leaf Trichomes

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Abstract: This research aims to explore the characteristics of trichomes from the Fabaceae family. This type of research is exploratory descriptive research. Direct exploration and laboratory observation methods were used in the research. This research was carried out from March 2022 to January 2023. This research was carried out at the UMM Malabar City Forest and Biology Laboratory. Observation of trichomes using SEM. The research data obtained were analyzed using descriptive statistics. The results of the research show that there are variations in the characteristics of Fabacea family trichomes in the Malabar forest of Malang City. There are two varieties of trichomes, there are three forms of trichomes, namely subulate, osteolate and globular, the highest average number is *Bauhinia purpurea* leaf trichomes and the fewest are *Albizia chinensis* and *Senna siamea*, the trichomes with the longest size are *Delonix regia* and the shortest are Erythrina trichomes variegata, the narrowest trichomes are *A. chinensis* and the widest are *E. Variegata*. The results of the research can be used by stakeholders to become a consideration for selecting plant species in city parks by using plants that can help improve air quality in addition to considering aesthetics.

Keywords: Exploration; Family Fabaceae; Malabar; Trichomes

Introduction

Malabar forest is a forest with a wide variety of species composed of various types and families of plants, both trees and shrubs. Plants in Malabar forest consist of 101 plants which come from various genera and families with various amounts (Latifa et al., 2019). The Malabar forest becomes one of the Green Open Spaces (RTH) in Malang City, in which it has function as a protected forest and conservation of some plants that are classified as rare (Santoso et al., 2022). It is located in the middle of downtown Malang. Existing plants are dominated by tree species that grow tall and large. The Family Fabaceae is one of the plant families that generate the Malabar forest.

Family Fabaceae is a group of plants used as road protectors. According to Duro et al. (2013) most of the city road protection plants are dominated by the Fabaceae group which is based on their ability to absorb pollutants, apart from the beauty aspect. Some of the family Fabaceae plants that have an effective ability to absorb pollutants include Leucanea leucocephala, Paraserianthes falcataria, Erythrina crista, Tamarindus indica, Pithecellobium dulce variegate, Peltophorum pterocarpum dan Leucaena leucocephala (Rahmawaty et al., 2017; Susilowati et al., 2022). The ability of plants to absorb pollutants affects the physical characteristics of plants (Amulya et al., 2015).

Trichome is a derivative of epidermal tissue which is found in almost all parts of the plant. According to Kim (2019) Trichomes are plant epidermal cells that grow into hairs with different shapes, structures, and functions. Trichomes play a role in reducing the evaporation process that occurs in plants in water-deficient environmental conditions (Busta et al., 2017). In addition to reducing evaporation on the leaves, trichomes function to regulate the temperature of the leaves (Abu-Nassar et al., 2022). In line with this Bennewitz et al. (2018) and Wang et al. (2021) said that trichomes also play a role in reducing the rate of

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transpiration in plants that lack water and as a means of protection from herbivores, pathogens, ultraviolet light, homeostasis, and storage of metabolic products.

The characteristics and number of trichomes in the leaves are influenced by several factors, such as internal and external factors. Extreme environmental conditions at high light intensity, low humidity, abiotic stress, and high and extreme temperatures are external factors that affect the characteristics of trichomes in plants (Samiyarsih et al., 2020; Toriq & Puspitawati, 2023). In addition to external factors, other factors that cause changes in the anatomical structure are internal factors, namely genes, RNA and hormones (Wang et al., 2021). According to Wahyuni & Chatri (2021) stated that the group and type of plant in the differences between varieties were quite significant in influencing the number of stomata and trichomes as well as cell size. The diversity that exists in plants which include differences in families will also determine the characteristics of leaf trichomes.

There are many topics that can be studied related to trichomes in plant leaves, some of which are related to structure and characteristics which include type, type, size, shape, number, and density of trichomes where each plant has different characteristics. Research data on trichomes in the family Fabaceae already exists regarding shape and type but studies on type, number, density, and size are still not many reports and publications so further studies are needed. Exploration of the anatomy of trichomes in the fabaceae family in the Malabar City Forest has not been widely studied, whereas the Malabar City Forest is one of the City Forests in the middle of Malang City. In addition to exploring the anatomy of trichomes in the Fabaceae family, this research uses a substitute for Xylol to reduce research costs and uses Scanning Electron Microscope (SEM) to get clearer results. Based on the description and facts available, trichomes in plants are very important for the plant itself as protection, and regulate evaporation, besides that, it also plays a role in the environment, namely its relationship with pollutant absorption. The aim of this research was to explore the characteristics of the trichomes of the family Fabaceae including their type, type, size, shape, and density.

Method

This research was descriptive quantitative. This research aimed at exploring the variety, types, shapes, numbers, density, and trichome size of family Fabaceae leaf in Malabar forest of Malang City and describing its abiotic factors. This research was carried out on March 2022 to January 2023. This research was conducted in Malabar City forest of Malang and Biology Laboratory of UMM to implement the observation of leaf trichome characteristics, including the variety, types, numbers, and sizes of the trichomes by means of binocular microscope and SEM. Research implementation included research implementation included data collection on family Fabaceae plants, sampling the leaves of each plant and richome observation (Figure 1).

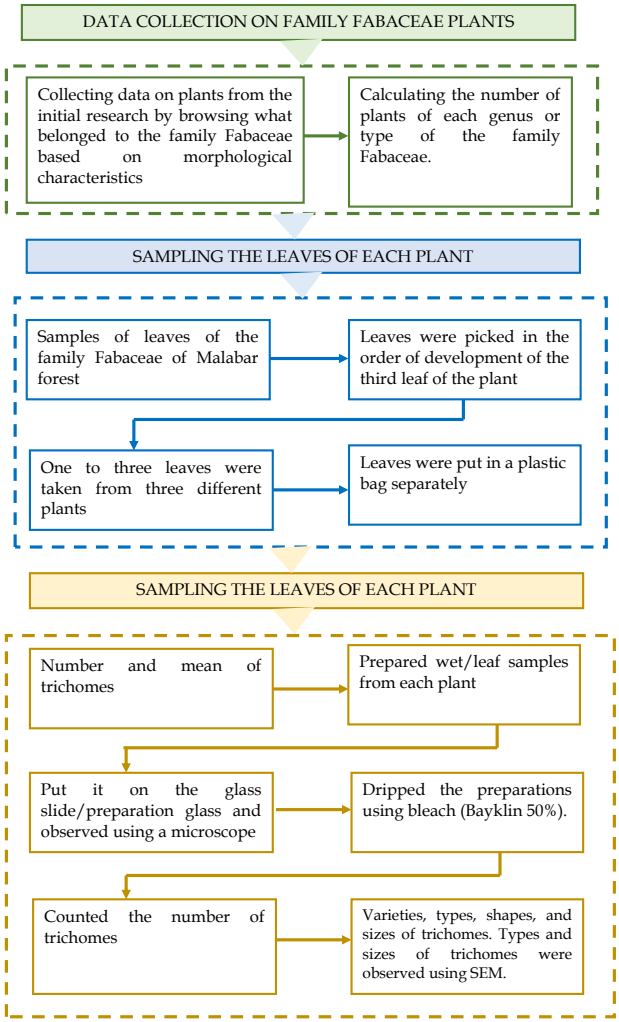

Figure 1. Research Procedure

The samples were put and observed the stomata types and the stomata sizes using the SEM. Noted the results of each leaf trichome. The results data of this research were obtained by calculating the numbers of plants and varieties, types, shapes, numbers, sizes, and density of each leaf trichome. Types and variety of trichomes were obtained from the observation results and those would be matched with relevant literature from the articles and books; the numbers, density, and sizes of trichomes were obtained from the value of the number of observations using SEM. Descriptive statistics was used to analyze the data.

Result and Discussion

The observation results on the leaf trichome characteristics indicate that there are variations in the variety and other characteristics. Trichomes can be broadly divided into two categories: glandular and non-glandular trichomes (Figure 2). Glandular trichomes are glandular trichomes characterized by the presence of cells that can secrete or store large quantities of secondary metabolites and contribute to improving the plant's suitability to the environment (Huchelmann et al., 2017). In general, the structure of the glandular trichomes is divided into three, namely the glands responsible for the secretion of metabolites, the stalk, the part of the structure that contains glands, and the base connecting the stalk with the surrounding epidermal cells (Chalvin et al., 2020). In contrast to glandular trichomes, non-glandular trichomes are trichomes that cannot produce and store secretions. Nonetheless, non-glandular trichomes are responsible for protecting plant organs from various biotic and abiotic stresses (Karabourniotis et al., 2020). There is both more than one type of trichome and only one type of trichome in one variety of plants. There are differences in trichome type and shape; however, there are generally two types: unicellular and multicellular. Trichomes can have three different sorts of characteristics: subulate, osteolate, and globular. There is just one variety of trichomes present in one type of plant, and it is accompanied by other trichome types as well. Table. 1 presents the observational findings.

Table 1. Varieties, Types, and Shapes of Leaf Trichomes Plants in the *Family Fabaceae*

Leaf Name	Variety	Type	Shape
T. indica	Non-glandular	Unicellular	Subulate
Erythrina variegata	Non-glandular & glandular	Multicellular	Osteolate
			Globular
Erythrina crista-galli	Non-glandular & glandular	Unicellular	Subulate
		Multicellular	Globular
Delonix regia	Non-glandular	Unicellular	Subulate
Gliricidia sepium	Glandular	Unicellular	Subulate
Senna siamea	Non-glandular	Unicellular	Subulate
Senna alata	Glandular	Unicellular	Subulate
Bauhinia purpurea	Non-glandular	Unicellular	Subulate
L. leucocephala	Non-glandular	Unicellular	Subulate
Adenanthera pavonina	Non-glandular	Unicellular	Subulate
Albizia chinensis	Non-glandular	Unicellular	Subulate
Pterocarpus indicus	Glandular	Unicellular	Subulate
Samanea saman	Non-glandular	Unicellular	Subulate

Information: *T. indica* (Judd et al., 2008), *E. variegate* (Cahyono et al., 2022), *E. crista-galli* (Cahyono et al., 2022), *D. regia* (Mărgineanu et al., 2014), *G. sepium* (Judd et al., 2008), *S. siamea* (Begum et al., 2014), *S. alata* (Begum et al., 2014), *B. purpurea* (Cahyono et al., 2022), *L. leucocephala* (Al-Joboury et al., 2017), *A. pavonina* (Partha & Rahaman, 2015), *A.chinensis* (Abdel-Ghani et al., 2015), *P. indicus* (Yuliany et al., 2021), *S. saman* (Al-Joboury et al., 2017).

The results of observing trichomes using SEM in Figure 2, S. alata with a magnification of 600x produced images of trichomes with a subulate shape with a glandular type. Trichomes on T. indica Figure 2 with a magnification of 600x shows the results of subulate trichomes with a non-glandular type. The E. crista-galli trichome in Figure 2 with a magnification of 600x shows the results of subulate and globular trichomes with glandular and non-glandular types. Trichomes on G. sepium in Figure 2 with a magnification of 600x show the results of subulate trichomes with a glandular type. Finally, the P. indicus trichomes in Figure 2 with a magnification of 600x show the results in a subulate shape with a glandular type.

Number/Mean of Trichomes of Family Fabaceae in Malabar Forest

The results of counting the number of trichomes or calculating their mean reveal differences in each observation of a leaf's field of view, from the first to the fifth field of view. The observed data are shown in Table. 2, with *B. purpurea* leaf trichomes having the largest mean number (58), followed by *A. chinensis, S. siamea*, and *L. leucocephala* with the lowest mean number (7).

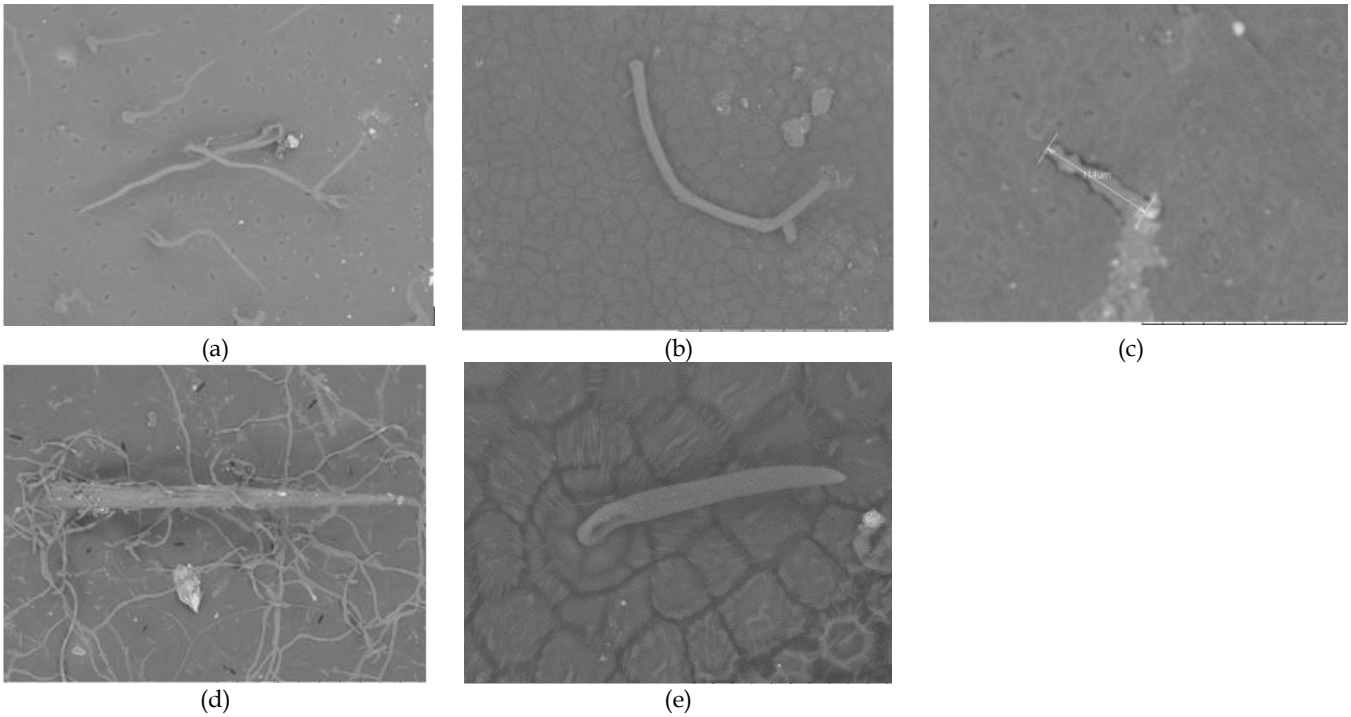

Figure 2. (A) *S. alata* (Begum et al., 2014), (B) *T. indica* (Judd et al., 2008), (C) *E. crista-galli* (Cahyono et al., 2022), (D) *G. sepium* (Judd et al., 2008), and (E) *P. indicus* (Yuliany et al., 2021) observation results of SEM Magnification 600x

Table 2. Number/Mean of Trichomes of Family Fabaceae Leaves in Malabar Forest

Plant	Field of View Observation					Average amount
	S1	S2	S3	S4	S5	
T. indica	10	5	7	8	10	8
E. variegata	38	42	56	52	57	49
E. crista-galli	31	40	33	42	47	39
D. regia	16	8	10	14	17	13
G. sepium	62	48	66	48	46	54
S. siamea	6	11	4	7	7	7
S. alata	38	49	52	40	41	44
B. purpurea	48	62	54	63	63	58
L. leucocephala	4	9	7	6	9	7
A. pavonina	17	27	31	22	23	24
A. chinensis	9	6	7	4	9	7
P. indicus	13	8	6	7	16	10
S. saman	28	38	31	39	44	36

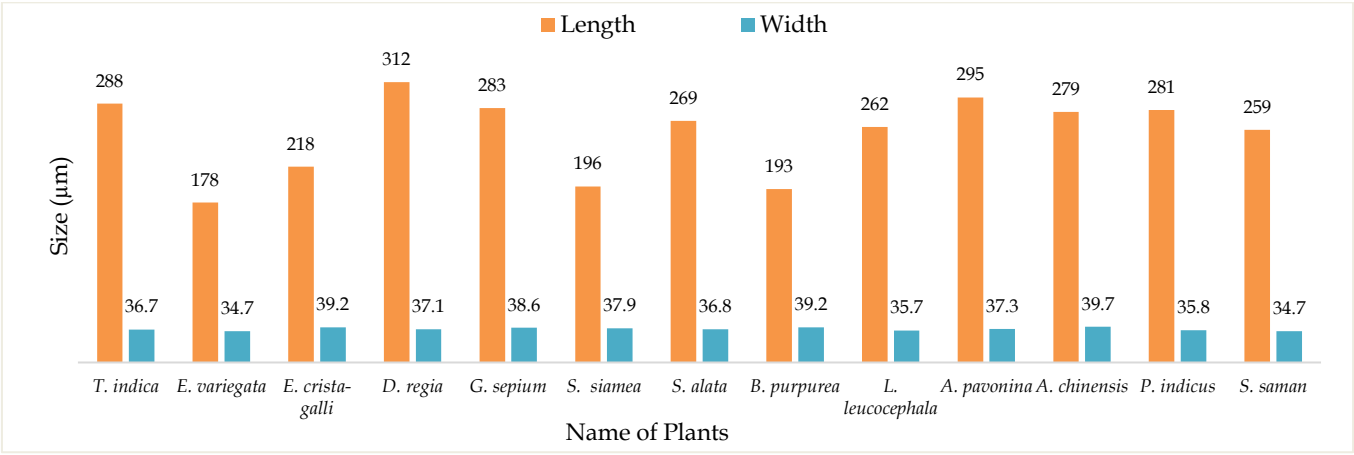

Figure 3. Trichome Size of family Fabaceae Leaf in Malabar Forest

Trichome Size of Family Fabaceae Leaves in Malabar forest

The results of the size observations reveal that the *D. regia* leaf trichome has the longest size (321µm) and the shortest trichomes are the trichomes of *E. variegata* leaves (178 µm), the narrowest trichome is the *A. chinensis* trichome (39.2 µm) and the widest is the *E. variegata* (34.7 µm) Figure 3 elucidate the observation results.

Malabar Forest Abiotic Factor Measurement

Abiotic factor measurements are made for a number of factors, and the results indicate that the wind speed is 3.1 knots, the air humidity is 69%, the soil pH is 6.4, the air is 24°C, the light is 337 Cd, and the air temperature is 24.9°C. Table 5.3. depicts the observation results.

Observing the characteristics of leaf trichomes reveals variations in the variety and other characteristics. Trichomes are classified into two types: glandular trichomes and non-glandular trichomes. There is only one type of trichome in one type of plant and more than one type of trichome in another. Trichomes are found on the outer surface of almost all plant organs, including vegetative organs like leaves, branches, sheaths, and roots, as well as reproductive organs such as sepals, petals, stamens, gynoecium, seeds, and fruit (Giuliani et al., 2020). According to Harisha et al. (2013) trichomes have a diverse structure and morphology that can be used to identify genera, species, subspecies, and varieties of the various families studied. Trichomes have a wide variety of structures within larger and smaller plant groups, but they also have uniform features within a single taxon, which can be used for taxonomic purposes, identifying plant species, and understanding species relationships (Dasti, 2003). Additionally, special epidermal cells are also required to complete taxonomic data as a foundation for taxonomic studies and evolution (Begum et al., 2014).

Table 3. Results of Measurement of Abiotic Factors in Malabar Forest, Malang City

Parameters	Results
Wind velocity	3.1 knots
Humidity	69%
Soil pH	6.4
Soil temperature	24^{o}C
Light intensity	337 Cd
Air temperature	24.9 ^{o}C

Based on the observation results data, it is known that family Fabaceae plants, generally, have non-glandular trichome types, namely trichomes or protector hairs whose trichome cells do not secrete secretory substances. Previous research results indicate that in each plant non-glandular trichomes are found in the form of simple multicellular and glandular trichomes in the form of a plate (Ajuru et al., 2018). Trichomes in roots are non-glandular trichomes that lack secretions and have no secretory function (Akwu et al., 2023). This is in accordance Rashid et al. (2022) with the characteristics of non-glandular trichomes which have multicellular hairs that can be in the form of stars and a sharp end. Thus, it can be concluded that in family Fabaceae, non-glandular trichomes with a variety of shapes that vary greatly between species predominate in the epidermal layer of leaves. Thus, despite being in the same family, each of the same plants exhibits a variety of trichome types and shapes.

Trichomes, which are derivatives of the epidermis and serve as protecting leaf organs, come in a variety of kinds and shapes (Ramadhani et al., 2022). In linier with Li et al. (2018) claims that each trichome serves a different purpose for instance, non-glandular trichomes act as a barrier to prevent pathogens from entering through the stomata, whereas glandular trichomes secrete secondary metabolites, Trichomes are frequently carried on stalks of non-glandular cells and have unicellular or multicellular heads made up of secretory-producing cells (Santos Tozin et al., 2016). According to Harisha et al. (2013) in her study, the head of the trichome contains brown pigment but, in this study, it is not known whether it really contains pigment or not since this study only looks at the trichomes from the outside. Febriyani et al. (2022) elucidates that secondary metabolites in the form of alkaloids can be found in the heads of trichomes with brown pigment. Research results by Zarinkamar (2016) showed that glandular trichomes in plants of the family Fabaceae Trigonella foenum-graecum has a high alkaloid accumulation value. Histochemical tests confirmed that secondary metabolites including lipids, mucilaginous polysaccharides and phenolic compounds were present in the glandular trichomes. Next, glandular unicellular triocoma which has a pointed shape Lablab purpureus serves as a form of plant self-protection. These trichomes will cause an itchy sensation when the skin comes into contact with the stem L. purpureus (Jayanti, 2017). Trichomes on leaves E. crista-galli serves as a barrier to the entry of pathogens that pass through the stomata. Next trichomes on B. purpurea are dead trichomes that function as a protective layer when plants lose water in large quantities and the length of trichomes is an adaptation to the environment to reduce evaporation (Cahyono et al., 2022).

Observing the characteristics of leaf trichomes reveals variations in the type and shape of the trichomes, with two types in general, namely unicellular and

multicellular. Unicellular trichomes are single-celled trichomes, whereas multicellular trichomes are multicellular trichomes (Cahyono et al., 2022). There are three shapes of trichome characteristics, namely subulate, osteolate, and globular. There is only one type of trichome in one type of plant, but there are several types of trichomes that accompany it. Trichomes, waxy layers, secondary metabolites, and spines are morphological structures that can act as repellents, poisons, and inhibit the eating process. Plants with these characteristics can avoid or reduce the severity of insect pest damage. The trichome is one of the first plant organs that pests encounter. It is in line with Bennewitz et al. (2018) that the function of trichomes is to protect plants from herbivores, heat and sunlight, also control leaf temperature and water loss. Stomata and trichome types are important in identifying plant species and understanding species relationships (Begum et al., 2014).

According to Pan et al. (2021), trichome is an epidermal protrusion towards the outside of plants that has properties as an additional tool. Figueiredo et al. (2021) claims that trichomes have various kind and non-glandular trichomes, glandular trichomes, branched or unbranched, scales, papillae, and root hairs that can be used for absorption. This is in line with the glandular trichome characteristics which can produce thick and sticky secretions (Balakrishnan, 2011). It takes the form of single-celled secretory trichomes in leaves or scales with large secretory cells at the end of narrow stalks (Hartanto, 2021). Trichomes have a function to absorb water and nutrients, reducing the disturbance caused by plant defenses against herbivores (Pan et al., 2021).

The observation results of numbers or mean of trichomes have a variation; the highest number is B. purpurea leaf trichomes (58) and the least are A. chinensis and S. siamea (7). According to Toriq & Puspitawati (2023), the leaf organ is mostly found in trichomes on the upper, lower, or both surfaces of the leaf. Unlike stomata, which are mostly found on the abaxial side of the leaf, trichomes can be found on both the adaxial and abaxial sides (Gul et al., 2019). The number of trichomes found in the leaves of each plant varies depending on the species (Nurrohman et al., 2022). Soheili et al. (2023) claims that the number of trichomes on the leaves can be assumed as a form of plant adaptation to the surrounding environment. The observation results of size are obtained that the longest size is D. regia leaf trichomes (321µm), and the shortest trichomes are the trichomes of E. variegate leaves (178 µm), the narrowest trichome is the A. chinensis trichome (39.2 µm), and the widest is E. variegate (34.7 µm). Many plants have different shapes, sizes, and functions as a result of the development of different epidermal tissue (trichomes) (Makin et al., 2022). Based on Cahyono et al. (2022), trichomes are often found in leaves that active in doing activity based on its function.

The shape, size, and density of the shape and type of trichomes also affect their function in protecting a plant's leaf organs. Trichomes in epidermal tissue are said to have special properties since insect defense power is determined by the presence of glands (glandular) or not (non-secretory), density, length, shape, uprightness and rigidity of trichomes (Qadariyah et al., 2020). A study of Wagner et al. (2004) discovers a trichome in E. crista-galli with a simple unicellular shape with the average length of 0.41mm. According to (Barthlott et al., 2017), trichomes, in general, are between micro to several centimeters in size with various species-specific shapes. Trichomes have secretory cell cavities ranging in size from 10-30µm to 40-60µm (Choi & Kim, 2013).

Wind speed of 3.1 knots, humidity of 69%, soil pH of 6.4, air temperature of 24 oC, light intensity of 337 Cd, and air temperature of 24.9 oC are obtained from abiotic factor measurements on several parameters. Trichomes' response to high temperatures in protecting the surrounding environment by increasing the number of trichomes in each plant organ, particularly leaves. Because of the high density of trichomes and the variety of trichome sizes, road shade plants can respond to environmental conditions such as pollutants and herbivorous animal attacks, allowing them to strengthen their defense mechanisms (Latifa et al., 2021). Hendrick et al. (2016) states that the number of trichomes on the leaves can be interpreted as a form of plant adaptation to its surroundings. A balanced environment will encourage the growth of trichomes in each plant, whereas a damaged or polluted environment will inhibit the growth of trichomes. According to a study conducted by Amulya et al. (2015), vehicle emissions cause plants to change the shape, size, and density of their trichomes. The higher the trichome density, the more polluted the air quality, and vice versa.

The density of trichomes is affected by the availability of sunlight. The findings of this study demonstrate that a decrease in low light intensity affects the density of leaf trichomes as well as plant growth and yield (Zhou et al., 2018). Various environmental conditions, eg full solar radiation or shading increases the density of trichomes on the upper leaf surface while decreasing the total leaf area and the number of primary branches (Martínez-Natarén et al., 2018). According to Koul et al. (2021) proposes that Trichomes are epidermal cells that protect plants from excessive light and reduce evaporation; therefore, trichomes cannot grow in conditions of excessive light intensity since it will affect the growth process and the trichomes' ability to perform their functions.

The findings of this research are expected to provide information for academics, practitioners, and observers who devote themselves to the environment. The trichome characteristics found in family Fabaceae in Malabar forest can be used as one of a recommendation for the selection of plants to be planted, in this case related to the characteristics of the existing trichomes including the shape, type, number, and ability of each trichome in plants to absorb pollutants and in the context of being the beauty of a city. Leaves are bio-indicators of air pollution. Looking at the damage microscopically, such as changes in cell structure, stomata, and trichomes, or changes in physiology and chemistry, such as changes in metabolism, provides evidence that leaves act as bio-indicators of the environment. Tight trichomes function to protect the leaves from plant-toxic pollutants. This information is also beneficial for planning a healthy urban environment and supporting the overall goals of urban development.

There are two overarching goals of urban development: obtaining efficient environmental support and creating a place that is clean, pleasant, comfortable, safe, and attractive (Latifa et al., 2021). The existence of Malabar City Forest in an urban can be used as a source or producer in providing oxygen to other organisms. Hence, it is important to identify the linkages of trichomes with the environment to discover the environmental quality. The presence of balanced trichomes in a plant assists in the plant's survival and protects it from pest attacks, allowing the plant to grow optimally and provide functions for the surrounding environment.

Conclusion

This research concludes that that there are variations in the characteristics of the trichomes of the family Fabaceae in the Malabar forest of Malang city There are two varieties of trichomes, there are three forms of trichomes, namely subulate, osteolate and globular, the highest average number is *B. purpurea* leaf trichomes and the fewest are *Al. chinensis* and *S. siamea*, the trichomes with the longest size are *D. regia* and the shortest are Erythrina trichomes variegata, the narrowest trichomes are *A. chinensis* and the widest are *E. Variegata*. The research results can be used by relevant stakeholders to become a consideration for choosing plant species in city parks or green open spaces to use plants that can help improve air quality in addition to considering aesthetic aspects. So that the plants in city parks or green open spaces can function as the function of city parks or green open spaces. This research is still about trichomes in plants of the family Fabaceae. For further research, more in-depth research can be carried out. This includes studying the stomata, chlorophyll content, and lead in the leaves to complete data on the characteristics of the leaves of the family Fabaceae.

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Author Contributions

R.L.,; Data analysis, Writing original draft, E.R.,; Writing, review and editing original draft, S.H.,; Writing, review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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