Identification of ground cover which are potential as ornamental plants in the teaching forest of Hasanuddin University

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Abstract. Understorey vegetation is community of plants that consisting of shrubs, herbs, ferns, grasses and creeping plants. This research aimed to determine the species of ground plants which were potential as ornamental plants in the Teaching Forest of Hasanuddin University. This research was expected to provide information of some species of ground plants that are potentially developed as ornamental plants and become a reference for the community and related parties for development in the economic sector and the development of a green environment forward. Data retrieval was done by using crown diameter method to measure the width of ground plants cover closure. After the observation and scoring were done, the next step was to identify the species which are potentially as ornamental plants. Based on observation from 10 paths spread over four forest type in Hasanuddin University Educational Forest, 139 ground plants species were found. After those species were scored, 62 species that could be used as ornamental plants, five of those species were classified as very potential with value of 70, named *Hoya carnosa*, *Cissus discolor*, *Coleus sp.*, *Drocera burmanii* and *Amorphopalus paeonifolius*, while 52 others included into potential category with value range from 35 to 65.

1. Introduction

Ground vegetation are plant communities consisting of shrubs, herbs, ferns, grasses and creeping plants. Lower plants are grouped into two, namely understorey and non-woody plants or known as herbaceous plants. Herbs are all plants that generally reach a height of less than two meters except for seedlings and lower plants [1]. A number of understorey plants show interesting shapes, colors, flowers and leaf surface structures [2], so they have the potential to become ornamental plants. Ornamental plants are plants that are grown or cultivated because of the quality of their ornaments, often called ornamental plants.

Teaching Forest of Hasanuddin University is a Special Purpose Forest Area (KHDTK) in which there are secondary forest stands and several plantations [3]. Based on the results of field observations, there are many understorey species that thrive in several stands in the Teaching Forest of Hasanuddin University. As one of the biodiversity, undergrowth has been widely used so that many studies have been conducted and some species have been known to be mainly used as medicine, but there are still
many unknown species and used as ornamental plants. Therefore, it is necessary to conduct research to
determine the species of understorey which have the potential to be used as ornamental plants in
Teaching Forest of Hasanuddin University.

This study aims to determine the types of understorey that have the potential to be used as ornamental
plants in the Teaching Forest of Hasanuddin University. The results of this study are expected to provide
information about the types of understorey that have the potential to be developed as ornamental plants
and become a reference for the community and related parties for development in the economic sector and
future green environmental development.

2. Research method

2.1. Time and location of research

This research was conducted from October 2018 to January 2019. The research location was located in
secondary natural forest, pine forest (*Pinus mercusii*), acacia forest (*Acacia auriculiformis*), and
mahogany forest (*Swietinia macrophylla*) which are in the Teaching Forest of Hasanuddin University
Area, Kec. Cenrana, Kab. Maros, South Sulawesi Province.

2.2. Method of implementation

2.2.1. Field orientation. This orientation activity was carried out for two days. This activity includes an
initial introduction to the condition of the forest where the observation path will be placed, such as
uniformity of forest cover (the path was placed in the middle of a forest stand which was covered by
tree species which are forest types: natural forest vegetation, pine forest stands, Acasia plantations,
auriculiformis, and *Swietinia macrophylla* plantations).

2.2.2. Observation variables. The variables observed in this study were the characteristics of several
understorey organs which were used as the basis for determining whether a species had the potential to
be used as an ornamental plant or not, including the overall leaf color, color hue (if the leaves are
colorful), shape / texture leaf, flower size or panicle size, flower color, aroma, fruit color, fruit shape
and crown area

2.2.3. Determination of the Path of Observation. The observation path was 5 m wide and 100 m long.
Path placement was carried out purposively by considering the representation of forest types (natural
forest, pine plantation, acacia plantation, mahogany plantation). To make it easier for recording the data
in the field and process data, the 100 m line was divided into plots measuring 5 m x 5 m, so that in total
there were 20 plots in one lane. For each forest type, 3 lanes were placed, except for mahogany
plantations, which, due to their limited size, could only made one lane.

2.2.4. Retrieval of Data. Data were collected by measuring the canopy area of each understorey by using
the Crown Diameter Method [4]. The Crown Diameter Method is a method for measuring the crown
area of the understorey which is carried out by measuring the crown diameter from four directions, then
the measurement results. See diameter averaged below (Figure 1).

![Illustration of the crown diameter method](image)
To assess the potential of understorey as ornamental plants, observations were made on variables that has mentioned above. These variables were qualitative, not measurable and could be subjective depending on the person measuring them. Therefore, to reduce the subjectivity of the measurement, simple criteria and indicators were created which were given a value of 1 if the indicator showed “potential” and given a score of 0 if the indicator led to “no potential” (Table 1). Furthermore, the score was multiplied by the weight value in the range of 5-15 with a total weight value of 100.

**Table 1.** Criteria, indicators, scores and weight of the assessment of the potential of understorey as ornamental plants modified by [5–10]

| Criteria (Characteristics of Organs) | Indicators                                                                 | Score | Quality | Score x Quality |
|-------------------------------------|-----------------------------------------------------------------------------|-------|---------|-----------------|
| General leaf color                  | Beautiful or attractive leaf color (red, white, yellow, purple)              | 1     | 15      | 15              |
|                                     | Regular green leaf color                                                    | 0     | 15      | 0               |
|                                     | Leaf pattern consists of more than one color (white-green, white-purple, red-green, etc.) | 1     | 15      |                 |
| Leaf color hues                     | The color of the leaves is unmatched, even if they are attractive (red, purple, white, etc.) | 0     | 15      | 0               |
|                                     | Unique leaf texture (heart, kidney, incised or wavy edge, or other uniqueness) | 1     | 10      |                 |
| Leaf texture shape                  | General leaf texture form (entire, elliptic, lanceolate, ovate, obovate)    | 0     | 10      | 0               |
|                                     | Large flowers or if the flowers are small but arranged in large panicles    | 1     | 15      |                 |
| Flower Size                         | The flowers are small and not arranged in large panicles so they don’t stand out | 0     | 15      | 0               |
|                                     | The color of the flower stands out from the general colors around it, so it attracts attention (red, ping, yellow, purple, white) | 1     | 15      |                 |
|                                     | Unobtrusive or dull colors include green flowers                            | 0     | 15      | 0               |
| Flower Color                        | Fragrant flowers such as jasmine, tuberose, tongue-in-law or orchid scent  | 1     | 10      |                 |
| Flower scent                        | Flowers do not smell or smell like corpse flowers                           | 0     | 10      | 0               |
|                                     | Unique and artistic header forms: thick or lush leaves, interesting branches or not like understorey plants in general | 1     | 10      |                 |
|                                     | Canopy shape is not unique, thin crown, sparse leaves                       | 0     | 10      | 0               |
|                                     | Unique fruit shape (uncommon), large or clustered in large, striking panicles, such as ornamental eggplant. | 1     | 5       |                 |
| Fruit shape                         | Fruits are small, inconspicuous or clustered in large panicles              | 0     | 5       | 0               |
|                                     | Fruits are small, inconspicuous or clustered in large panicles              | 1     | 5       |                 |
| Fruit color                         | Fruit is not flashy color or does not attract attention                    | 0     | 5       | 0               |
2.3. Data analysis

Each understorey species had an actual maximum value of 100 which was obtained from the sum of the scores multiplied by the weight for each criterion. Furthermore, understorey grouped into 3 categories based on the actual value obtained for each species. The categories of understorey species grouping that had the potential as ornamental plants based on their actual value are as follows:

1. **Less potential.**
   - In the less potential category, each understorey species will have an actual value of 1-33.

2. **Potential**
   - In the potential category, each understorey species will have an actual value of 34-67.

3. **Very potential**
   - In the high potential category, each understorey will have an actual value of 68-100.

Based on the data that has been obtained from the results of species measurements on the existing plots on each path in the field, then the value of the frequency and area of understorey canopy cover was calculated using the following formula [11]:

1. **Frequency**
   \[ F = \frac{\text{Number of plots found of a type}}{\text{Total Plot}} \times 100\% \]

2. **Extent of understorey canopy cover**
   \[ l = \frac{1}{4} \pi d^2, \quad \text{Where} \quad d = \frac{(d1+d2+d3+d4)}{4} \]

3. Result

3.1. Composition of understorey species

3.1.1. Species, canopy cover area and frequency in natural forests. Found in this natural forest found as many as 61 species. From the three observation lines in the natural forest, 3 species were found that were spread across the three lines or with a distribution frequency of 100%, namely: *Piper nigrum, Piper sp.*, and *Pandanus sp.* Judging from the canopy cover area of each understorey, the dominant species in Line 1 was *Piper umbellatum* with a crown closure value of 7,823.19 cm², on Line 2 was *Lygodium flexuosum* with a crown closure value of 45,688.56 cm² and on Line 3 namely *Psychotria sp.* with crown closure value of 261,383.30 cm². The highest intra-lane frequency was *Leea indica*, which was 90% and other understorey species had a low distribution frequency of 5%. The average cover area of understorey per lane in natural forest is 239,058.30 cm².

3.1.2. Species, canopy cover area and frequency in mahogany plantation forests. The most common understorey found in the mahogany forest type was *Leea indica* with a total canopy cover value of 668,522.26 cm², followed by *Piper nigrum* with a total canopy cover value of 326,139.83 cm², while the understorey species had the highest total crown cover area was *Gymnopetalium sp.* only 353.64 cm². In line with the basal area, the species that had the highest distribution frequency was *Leea indica* at 85%. Some species only had a distribution frequency of 5%. The average understorey cover area per lane in mahogany forests was 2,750,291 m².

3.1.3. Species, canopy cover area and frequency in acacia plantation forests. There were 6 species of understorey found in all three pathways in acacia plantations. *Lantana camara* had the largest canopy cover area with a value of 466,499.66 cm², while the species with the smallest canopy cover area was *Commelina benghalensis* which is only 79.68 cm². The species with the highest distribution frequency between plots in each line was *Oplismenus compositus*, which was 95%. Most of the other species have a low frequency of only 5%. The average cover area of understorey per lane in acacia forest was 2,583,864.20 cm².

3.1.4. Species, canopy cover area and frequency of pine plantation forest. The results of the measurement of the area of understorey cover in pine forest types found as many as 66 species spread
over three lines. Based on canopy cover area, Stachytarpheta jamaicensis species had the highest total canopy area with a value of 22,904.43 cm² and the Erechtites hieracifolium species had the lowest total canopy area with a value of only 24.10 cm². The highest distribution frequency, 80%, was indicated by the species Leea indica and Piper nigrum, and most other species had a low distribution frequency of 5%. The average cover area of understorey per lane in acacia forest was 43,226.59 cm².

3.1.5. Comparison of number of species and area of canopy cover among forest types. If the average number of species per lane were compared, it was found that the highest mean number of species per lane was found in mahogany forest types with an average number of 42 species per lane. In contrast, the smallest average number of species per lane was found in the acacia forest type, which was 26 species per lane. The highest average canopy cover area was found in acacia plantations with a canopy cover value of 4,350,445.53 cm² and the smallest average crown cover area was found in pine forest types with a canopy cover value of 43,226.59 cm², see table 2.

### Table 2. Comparison of the number of species and the area of understorey cover between different forest types

| Information | Natural Forest | Mahogany Forest | Acacia Forest | Pine forests |
|-------------|----------------|-----------------|--------------|--------------|
| Average Number of Species per Line | 27.33 | 42 | 26 | 32.33 |
| Average Head Cover Area per Lane (cm²) | 239,058.30 | 4,350,445.53 | 2,583,864.20 | 43,226.59 |

3.2. Potential of lower plants as ornamental plants

Determination of the potential of understorey as ornamental plants was done through a scoring system multiplied by weight. The value of the scoring time multiplied by the highest weight (100) was divided by three to determine the potential category of each type: 66.67 - 100 was very potential, 33.33 - 66.67 was potential, 1 - 33.33 was less potential. Through a scoring method like this, the 139 species were found in all the observation paths fall into the score interval between 1 - 70. Thus, the 139 species fall into three potential categories, namely 5 very potential species, a potential category. As many as 57 species, and the remaining 77 species fall into the category of less potential.

Five species that fall into the potential category were *Hoya carnosa*, *Cissus discolor*, *Coleus sp.*, *Drocera burmanii*, and *Amorphopala paeoniifolius* (score = 70). However, each of these species had a prominent score for different criteria. *Hoya carnosa* had a prominent value for the criteria of a beautiful pink flower and gives off a sweet aroma when blooming. *Cissus discolor* had the advantage of its cordate leaf shape and striking red velvet leaf color. *Coleus sp.* had a high enough score mainly because of its appeal to the striking color and pattern of the leaves. *Drocera burmanii* was a small herbaceous plant that had a high score of its uniqueness which is an insectivorous plant. *Amorphopala paeoniifolius* was in the very potential category because it had large ear-shaped flowers that were protected by a sheath of flowers or dark purple protective petals.

Of the 57 species that were included in the potential category, there were several that the score multiplied by the weight is quite high, *Leea rubra* gets the score multiplied by high weight because the leaves have thick crowns, the shape of the leaves was attractive even though they were small in size, and the flowers / fruits were red. *Lantana camara* had a large number of strikingly colored flowers so that if the arrangement of the plants was done properly, this species had a high aesthetic value. *Melastoma malabatriocum*, *Melastoma sp.* had flowers that were similar in shape and color, which was pink with a relatively large / striking size. *Melastoma malabatriocum* had a form of growing small shrubs so it was suitable to be planted in the yard, while *Melastoma sp.* was an herbaceous level plant suitable for planting as a potted plant. *Dendrobium crumenatum* was one of the species of the *Orchidaceae* family, namely the *Psychotria malayana orchid* family, which was a shrub that had a rather
tight canopy, medium leaf size, with clean / fresh and shiny green leaves so it was good to be used as a living fence. *Desmos sinensis* had the potential to be planted as an ornamental plant because it had a striking flower color and produces a fragrant aroma, the flower of this plant was usually used for essential oil. *Geophila repens* got a high score from several advantages, namely the bright red fruit color of orange, besides that this species was a type of vine so it was very suitable to be used as an ornamental plant for ground cover or ground cover. *Rubus rosaeolius* was a vine that is not too big with a heart-shaped leaf with brownish leaf color. If the growth was arranged so as not to wander anywhere, this thorny liana looks attractive. *Viola sp.* was an herbaceous plant that has orchid-shaped flowers that are striking purple in color. This species was perfect for small potted plants to gift to colleagues. *Callycarpa longifolia* was a tall shrub that had small white fruit and could be used as a hedge or understorey in urban forests. *Vernonia cinera* was an herbaceous weed with purple flowers and was usually less suitable as an ornamental plant. *Utricularia aurea* was a small herbaceous plant with small colored flowers that were good for planting in small pots, but unfortunately the flowers fall quickly. *Phaius flavus* was a species of ground orchid that has yellow flowers, but the size of the flowers was small so that its appeal as an ornamental plant was unlike other orchid species. *Habenaria dentate* was an earthen orchid whose flower shape was like a crane in flight. This orchid species was actually quite interesting, but the size was not big, only small herbs. *Curcuma zedoaria* was a white meeting whose flowers grew from the ground red - pink. Unfortunately, this species of encounter only flower seasonally and the flowers quickly appeared old after anthesis. *Cleodendrum japonicum*, which in the local language was often called the pagoda flower, was a species of shrub with red recaime flowers with large panicle sizes.

4. Discussion

4.1. Diversity of understorey plants

Based on the observations, it can be seen that, there were differences in the composition of understorey species between the lines spread over four types of forest stands, namely natural forest, mahogany forest, acacia forest and pine forest. The highest number of species was found in pine forest types (66 species), followed by natural forests (61 species) and acacia plantations (58 species), while the lowest number was found in mahogany plantations (42 species). In mahogany forests can be caused mainly by the number of paths in the mahogany plantation, of which there is only 1 path. The thickness of mahogany canopy cover can also be the cause of the low number of species found under mahogany stands. Only understorey plants that are shade tolerant can survive under mahogany stands [12].

The number of understorey species found in pine forest types is thought to be related to humidity and radiation. Priyono (2002) states that pine stands have the ability to absorb and store large amounts of water in the soil, so that the moisture (moisture) in pine plantations is quite high. In addition, the topography of pine plantations on the upper slopes, as well as the canopy of pine plantations with needle leaves and generally only 1 layer of canopy, causes most of the intensity of sunlight to penetrate it reaching the forest floor. This condition is used by certain understorey species that require sufficient sunlight. According to Gray & Speis (2002), the presence of species that make up the understorey community is closely related to the intensity of incoming light [13]. In contrast to the number of understorey species found, the number of individuals for each species is relatively low, seen from the low average number of canopy cover. This is due to thick pine litter, especially on line 1 (Table 5). It is known that pine contains allelopathic substances that can inhibit the growth of other vegetation underneath including understorey vegetation [14].

A large number of species are also found in natural forest types. Observations in the field indicate that, as in pine forests, the micro-habitat conditions under natural forest stands are also very humid. The canopy layer in natural forest is composed of 2-3 layers [15,16]. This causes understorey which requires high humidity but does not require full light to thrive under natural forests. The three dominant herbaceous species in natural forest types are *Piper nigrum*, *Piper sp.* and *Pandanus sp.*

In acacia plantations, it was found that the number of understorey was less than natural forests and pine plantations, namely 58 species. In general, acacia plantations are located in rocky areas and therefore the stands are generally sparse, the trees are not tall, and the canopy cover is not tight. This
makes the climate of the micro-climatic conditions under acacia stands relatively drier. In addition, the root system of acacia which is dense at the ground surface is also thought to be a barrier for some species of understorey to live. Indriyanto (2010) also reported that acacia trees produce allelopathic litter which can inhibit the growth of other species [17]. The light intensity that is high enough to reach the forest floor causes several species of understorey that require a lot of light to grow well under acacia plantations, but because of the low humidity, the number of species that can grow is not as much as those found under pine forests and natural forests.

4.2. Potential of understorey plants as ornamental plants

Based on the research results, it was known that there were 62 species of understorey that have the potential to become ornamental plants. All these understorey species come from 27 families. The highest number of species found were 14 species from the Orchidaceae family. Other plant species found successively were; There were 6 species of Zingiberaceae family, 5 species of Asteraceae family, 3 species of Fabaceae and Lamiaceae each, 3 species of family Apocynaceae, Vitaceae, Verbenaceae, and Melastomaceae each, while families Aracaceae, Acanthaceae, Annonaceae, Balasaminaceae, Begoniaceae, Commelinaceae, Droceraceae, Hypoxidaceae, Lentibulariaceae, Malvaceae, Marantaceae, Primulaceae, Polygalaceae, Rosaceae, Smilacaceae, Violaceae and Araceae were found 1 species each.

Based on the scoring results, 5 species of understorey from a total of 62 species that had the potential to become ornamental plants had a total value of 70, so they were categorized as having the potential to be used as ornamental plants. The five species include Hoya carnosa, Cissus discolor, Coleus sp., Drocerera burmanii, and Amorphopalus paeoniifolius. The five species had a striking appeal in different parts. In addition, there were 57 species that were included in the potential category with values ranging from 35 to 65.

Of all the species classified as having the potential to be used as ornamental plants, most of them have an appeal to the flower section. One family that has an interest in the flower section is the Orchidaceae family or the orchid family group but has a low value on the leaves. The ornamental orchid plant is one of the priority commodities that have been determined by the ministry of agriculture. Several species of orchids such as Malaxis acuminate and peristylus lacertifer have flowers that are small in size but have beautiful colors and are arranged in large panicles so that they still have the appeal of being used as ornamental plants. There are orchid species that have beautiful leaf shapes such as Nervilia sp. and Nervillitia crociformis.

Drocerera burmanii and Utricularia aurea are unique species that are insectivorous or insectivorous plants. This uniqueness did not add to the score in categorization because this study did not include the uniqueness indicator as an assessment. These species are only found in the acacia forest type.

There are several species of understorey that are unique to their leaves, but these species are not included in the category of potential to be used as ornamental plants. This is because only the leaves have a unique shape, while there are no other parts such as flowers or fruit that can support the assessment. The species that have this unique leaf shape are Ficus pumila, Gymnopedatium sp. and Adiantum philiphense.

5. Conclusion and suggestion

5.1. Conclusion

The conclusions obtained from the research on the identification of understorey species that have the potential as ornamental plants in Teaching Forest of Hasanuddin University are found as many as 62 potential species. There are 5 species included in the very potential category and 57 species included in the potential category. The species of understorey that have the potential to be used as ornamental plants are mostly from the Orchidaceae family, as many as 14 species.
5.2. Suggestions
The research results are expected to become a reference for the community around the forest and related parties in the use of understorey plants as ornamental plants for cultivation. The existence of further research on the factors that influence the growth of understorey in each forest type.

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