Distribution and association pattern of pasak bumi (*Eurycoma longifolia*) in Batang Lubu Sutam District, Padang Lawas, North Sumatra

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Abstract. Pasak bumi (*Eurycoma longifolia*) is a medicinal plant with various benefits and has long been used to cure various diseases such as cancer, gingivitis, intestinal worms, and anti-inflammatory anti-malarial, and tonic after childbirth. The root has high economic value leading to unsustainable harvest and drastic population decline. As initial data in conservation activities, information regarding the association of pasak bumi in Batang Lubu Sutam natural forest has not been obtained. Therefore, this research was conducted to determine the pasak bumi distribution and its association within their natural habitat in Batang Lubu Sutam forest. The study was conducted by using the vegetation analysis method using a plotted path determined by purposive sampling. Data analysis was performed by calculating association indices, including the Ochiai index (Oi), Dice index (Di), and Jackard index (Ji). The results showed that pasak bumi were found in the seedling and sapling stage in the research location and form a degree of association with several plants. The species that formed the highest degree of association with the pasak bumi at both levels of regeneration was *Shorea leprosula* with an Ochiai index value of 0.85 at the seedling level and 0.94 at the sapling level.

1. Introduction

*Eurycoma longifolia* or pasak bumi is a species that grows in Indonesian tropical rainforests, especially in Sumatra and Kalimantan Island [1]. This species has never been reported on the island of Java [2]. Besides in Indonesia, this plant can also be found in various Asian countries, including Malaysia, Cambodia, Laos, South Burma, and Vietnam [3]. Pasak bumi is a herbaceous plant from the Simaroubaceae family [4]. This plant has odd-pinnate compound leaves, small reddish flowers, round and smooth stems, and a bitter taste [5]. Pasak bumi is often found living in groups at the seedling level and grows on soils that contain a lot of sand and like soil with good aeration and sloping [6]. Pasak bumi is generally found in the primary forest [7], but this species has also been found growing in secondary forests at an altitude of 170-200 meters above sea level [8,9].
Pasak bumi has long been known as one of the plants with various health benefits. This plant has long been used as traditional medicine in curing various diseases such as fever, intestinal worms, gingivitis, as a tonic after childbirth [6], mouth sores, syphilis, male stamina enhancer, increases appetite [3], anti-malarial, and anti-cancer [10,11]. The chemical compound of pasak bumi is reported to have many functions in curing various diseases. Several chemical compounds found in pasak bumi include quassinoids, biphenyl neolignan squalene derivatives, tricullan-type triterpenes, alkaloids [12], and aphrodisiac properties which are primarily found in the roots [13]. The dominant aphrodisiac content in the roots causes this species to be harvested destructively and causes a significant population decline. More than 200 herbal products are processed into various forms such as capsules, herbal teas, and powders that use pasak bumi root as the main ingredient circulating in the market [14]. This is one of the triggers for the increasing illegal hunting of pasak bumi in natural habitats. Although pasak bumi has not been listed as an endangered species in the International Union for Conservation of Nature (IUCN), Indonesian researchers have categorized this species as a rare plant [15].

As one of the initial references in determining conservation actions, information regarding this species and the environment preferences of the Pasak Bumi must be known. The presence of species is affected by environment factor and the another species in the habitat [16]. One of the natural habitats of Pasak Bumi in North Sumatra is at Batang Lubu Sutam Natural Forest. Information regarding the association of pasak bumi with other species in the natural forest of Batang Lubu Sutam has not been obtained yet. Therefore, this research was conducted to determine pasak bumi distribution and association in Batang Lubu Sutam forest. Another section of your paper.

2. Research Methods

2.1. Research location
This research was conducted in Batang Lubu Sutam natural forest, Padang Lawas Regency, North Sumatra, Indonesia (figure 1). The location is classified into the limited production forest area of Tor Sipara-para, Register 40, and the border area of Riau Province and North Sumatra Province. The remaining natural forest area is only 500 ha, located at an altitude of 250-700 m.asl with temperatures ranging from 27-30 °C. The research location has a relatively high relative humidity, which is in the range of 65-90%.

Figure 1. Research location in Batang Lubu Sutam forest

2.2. Data collection
This research was conducted by vegetation analysis method using transects accompanied by sampling plots with different sizes, 2 x 2 m, 5 x 5 m, 10 x 10 m, and 20 x 20 m for seedlings, saplings, poles, and trees (figure 2). The path is determined based on the presence of pasak bumi plants with varying
distances between paths. The existence of pasak bumi is known based on the knowledge of the local community and searches conducted by researchers. The variables recorded included the number of individuals of all species in each growth stage in each plot and height and dbh at the pole and tree levels. Characteristics of individual growth rates included seedling level (height 1.5 m), sapling level (height > 1.5 m, DBH < 10.0 cm), pole level (DBH 10.0-199 cm) and tree (DBH 20.0 cm). Species growing at a radius of 5 meters from the individual pasak bumi were recorded to analyze plants that have associations with the pasak bumi.

![Figure 2. Plot design on vegetation analysis method](image)

The data obtained were then analyzed using the Ochiai index (Oi), the Dice index (Di), and the Jackard index (Ji) [17] to determine the level of association of the pasak bumi with other species in the vicinity. The association index can be calculated using the formula:

**ochiai index (Oi):**

\[ O_i = \frac{a}{\sqrt{(a+b)(a+c)}} \]

**Dice index (Di):**

\[ D_i = \frac{2a}{2a + b + c} \]

**Jackard index (Ji):**

\[ J_i = \frac{a}{a + b + c} \]

Where the value of a is the number of plots where the two associated species (A and B) are found, b is the number of plots where type A is found but not type B, and c is the number of plots where type B is found but not type A. The calculation results obtained will describe the level of association of pasak bumi with other plants around it. [17] state that the association value is in the range of values 0 to 1. The association relationship can be categorized as high if the value obtained is close to 1. On the other hand, an association value close to 0 indicates that the species association relationship is low.

3. **Result and Discussion**

3.1. **Pasak bumi distribution**

Indonesian forests are one of the largest tropical forest in the world. They are habitats for various types of vegetation that have various benefits, including medicinal plants, wood producers, aesthetic elements, and habitats for various animals [18]. However, various human activities have caused damage to forest lands, thereby disrupting the vegetation population in them [19]. The natural forest of Batang Lubu Sutam is one of the remaining forests in North Sumatra and is one of the natural habitats
of rare medicinal plants, namely Pasak Bumi. The results showed that there had been a significant decline in the population of pasak bumi in the natural forest of Batang Lubu Sutam. This causes the pole to suffer from regeneration constraint making it difficult to increase its population [20].

In the natural forest of Batang Lubu Sutam, pasak bumi only found in the seedling and sapling stage (figure 3). The number of seedling on 180 established plot were only 19 individuals, whereas on sapling only 13 individual (figure 4). This indicates that the pasak bumi regeneration system has experienced severe disturbances. Based on information obtained from the surrounding community, it is known that there has been massive exploitation of pasak bumi in the natural forest of Batang Lubu Sutam in 2015 [19]. The roots of pasak bumi are believed to be the main organ that has the highest efficacy. This causes the roots of pasak bumi to have the highest selling price compared to another part. This also causes the pasak bumi to be harvested destructively by pulling out the roots. The high selling price of pasak bumi at the pole and tree stage also triggers the loss of the pasak bumi at these stage.

![Figure 3. Individual pasak bumi (Eurycoma longifolia): (a) the seedling (b) the sapling.](image)

According to [21], pasak bumi is one of the medicinal plants that has been registered by the Food and Drug Supervisory Agency (BPOM). There has not been any cultivation for this species so the acquisition still relies on harvesting from nature. In addition, [22] also stated that several factors could affect the increase of medicinal plants, including industrial development, prices, stocks in nature, and government policies. The number of products that include pasak bumi as the main ingredient in various medicinal products that BPOM has registered causes this species to be highly hunted. [21] In addition, slow growth and irregular flowering periods also make it difficult for pasak bumi to regenerate and get closer to extinction [23]. The decline in the species number at the pole and tree-level was caused by several factors, including environmental factors and disturbances caused by humans. The research location close to the limited production forest causes the canopy's opening so that the intensity of sunlight entering the forest floor is higher. Some species at the juvenile stage (seedlings and saplings) cannot receive the high intensity of the sunlight, so they die. This then led to the disappearance of several species in the regeneration phase and was not found at the pole and tree level.
Figure 4. The number of pasak bumi at the seedling, sapling, pole and tree stages in Batang Lubu Sutam Forest, Padang Lawas, North Sumatra

3.2. Pasak bumi association
Association is a form of interaction of several types of plants in an environment [24]. According to [25], associations can be characterized by similar floristic compositions, uniform physiognomy, and distinctive distribution habitat. Associations can be divided into two; those were positive and negative associations [26]. A plant species presents simultaneously with other species and will not appear without a species that can be categorized as a positive association. Meanwhile, a plant species that is not present at the same time can be classified as a negative association.

The association index value obtained is used as a reference to determine the degree of association in the pairs of species studied [24]. Based on the study results, *Shorea leprosula* has the highest association index value at the seedling level (Table 1). The association index value in this species is relatively high, those were 0.85 on the Ochiai index and 0.72 on the Jackard index. This indicates that at the seedling level, pasak bumi has a high degree of association with *Shorea leprosula*. In addition to meranti bunga, several species have a high association value (> 0.7). Several tree species that have a high degree of association with pasak bumi are *Garcinia dioica*, *Streblus elongates* and *Shorea multiflora* (table 1).

| No | Scientific name             | Ochiai (Oi) | Dice (Di) | Jackard (Ji) |
|----|------------------------------|-------------|-----------|--------------|
| 1. | *Shorea leprosula*           | 0.85        | 0.41      | 0.72         |
| 2. | *Garcinia dioica*            | 0.81        | 0.4       | 0.66         |
| 3. | *Streblus elongates*         | 0.78        | 0.37      | 0.61         |
| 4. | *Shorea multiflora*          | 0.74        | 0.35      | 0.55         |
| 5. | *Spatholobus littoralis*     | 0.7         | 0.33      | 0.5          |
| 6. | *Dractomelon dao*            | 0.66        | 0.3       | 0.44         |
| 7. | *Blumeodendron kurzii*       | 0.62        | 0.28      | 0.38         |
| 8. | *Dipterocarpus hasseltii*    | 0.52        | 0.21      | 0.27         |
| 9. | *Shorea acuminata*           | 0.58        | 0.25      | 0.33         |
| 10. | *Castanopsis sp.*           | 0.58        | 0.25      | 0.33         |

At the sapling level, the results showed that pasak bumi consistently formed a high degree of association with *Shorea leprosula* with the values 0.94 and 0.88 on the Ochiai index and Jackard index (Table 2). There are more tree species at the sapling level that form a high degree of association with...
the pasak bumi. It can be known based on acquiring a relatively high association index value (> 0.7) in 8 tree species.

Table 2. The ten highest association types of pasak bumi at the sapling level

| No | Scientific name | Association Index |
|----|-----------------|--------------------|
|    |                 | Ochiai (Oi) | Dice (Di) | Jackard (Ji) |
| 1. | Shorea leprosula | 0.94        | 0.47      | 0.88        |
| 2. | Garcinia dioica  | 0.94        | 0.47      | 0.88        |
| 3. | Shorea multiflora| 0.81        | 0.4       | 0.66        |
| 4. | Soleia elongata  | 0.74        | 0.35      | 0.55        |
| 5. | Shorea acuminata | 0.74        | 0.35      | 0.55        |
| 6. | Spatholobus littoralis | 0.74    | 0.35      | 0.55        |
| 7. | Shorea spp       | 0.74        | 0.35      | 0.55        |
| 8. | Dracintomelon dao| 0.74        | 0.35      | 0.55        |
| 9. | Koompassia malaccensis | 0.57  | 0.25      | 0.33        |
| 10.| Aporoso aurita   | 0.57        | 0.25      | 0.33        |

Interaction patterns between species that have mutually beneficial relationships or vice versa can produce specific patterns called interspecific associations [27]. The association index values obtained on the Ochiai index (Oi) and the Jackard index (Ji) show that the association formed on the pasak bumi with the surrounding species tends to be strong. The analysis results also show that pasak bumi has formed associations with *Shorea leprosula* at the juvenile stage (seedlings and saplings). It indicates that there is a close relationship between the two species. The association of pasak bumi with the genus *Shorea* was also found in *Shorea parvifolia* [21] and *Shorea resinosa* [28]. In the same study, [28] added that pasak bumi has an association with the Dipterocarpaceae family. The existence of a strong degree and association relationship between pasak bumi and the genus *Shorea*, indicates that the presence of this species can be an indicator of the presence of other species, such as pasak bumi and plants from the genus *Shorea*.

The field observation found that Shorea species that grow with pasak bumi have varying sizes. It shows that there is a positive relationship between both of species. Pasak bumi was found living under the shade of a meranti tree which had a higher size with seedling and sapling of meranti. The need for a place to grow that is almost the same can lead to strong associations between species. According to [26], the pasak bumi at the regeneration level (seedlings and saplings) require moist growing conditions and loose soil. Humid growing conditions can be obtained by forming a canopy to reduce the intensity of sunlight entering the forest floor. Furthermore, [29] stated that plant associations could occur in addition to species density due to habitat factors such as shade, microclimate, light, and temperature.

4. Conclusion
Pasak bumi population in Batang Lubu Sutam forest only found in seedling and sapling stage and with the distribution pattern of is clumping near the mother trees. The species that formed the highest degree of association with the pasak bumi at both levels of regeneration was *Shorea leprosula* with an Ochiai index value of 0.85 at the seedling level and 0.94 at the sapling level.

Acknowledgement
This research was supported by the Indonesian Directorate of Research and Community Service, Ministry of Research and Technology and National Research and Innovation Agency, Republic of Indonesia (No. 12/E1/KP.PTNBH/2021) through Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) Scheme 2021.
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