Application of Principal Component Analysis in distinguishing three species of ‘jernang’ (Daemonorops spp.)

R Andini¹, L A Yanti¹, S Rasnovi², M I Sulaiman³, R Moulana³, M Muzaifa³, S N Putri⁴ and A Widiastuti⁵

¹ Forestry Department, Faculty of Agriculture, Universitas Syiah Kuala (USK), Jalan Tgk. Hasan Krueng Kalee No. 3, Darussalam-Banda Aceh 23111, Indonesia
² Biology Department, Faculty of Mathematics and Natural Sciences, USK, Jalan Syech Abdurrauf No. 3, Darussalam-Banda Aceh 23111, Indonesia
³ Department of Agricultural Product Technology, Faculty of Agriculture, USK, Jalan Tgk. Hasan Krueng Kalee No. 3, Darussalam-Banda Aceh 23111, Indonesia
⁴ Forestry Department at the Program Studi di Luar Kampus Utama (PSDKU) Gayo lues, Faculty of Agriculture, USK, Provinsi Aceh, Indonesia
⁵ Faculty of Agriculture, Universitas Gadjah Mada (UGM), Jl. Flora No.1, Bulaksumur, Yogyakarta, Indonesia

E-mail: ikhans.sulaiman@unsyiah.ac.id

Abstract. The province of Aceh at the northern tip of Sumatra has a total area of 5.75 million hectares. Its forest resources are considerably extensive as 60% of its total land area is still considered as ‘forest area’. Non-Timber Forest Products (NTFP) are defined as any wild plant and animal products harvested from forests, e.g., ‘jernang’ or dragon blood (Daemonorops spp.). It is classified as one of the valuable NTFP’s harvested from the forests in Aceh. Its morphological features resemble that of rattan (Calamus spp.), both of which belong to Aracaceae. The red resin of Daemonorops spp. is highly valued in Chinese medicine and possesses anti-inflammatory, anti-tumor, and anti-hemostatic properties. Almost 112 species of Daemonorops spp. exist. However, only 10% produces the red resin. Daemonorops draco, D. mattenensis, D. didymophylla are considered to have significant economic values. Over the past decade, a farmer living in central and western Aceh has cultivated dragon blood plants in small farms and sold the seedlings. In this study, the morphological variations of dragon blood (N=11) from Kuta Panang in central Aceh were assessed, and the Principal Component Analyses (PCA) were applied in order to distinguish the three species. Up to 92% of total variations were significantly explained with PC1, while the remaining were explained with PC2. Among the three species measured with PCA, Daemonorops draco or known as super ‘jernang’, appeared to have more distinctive morphological characteristics, e.g., fruit-, and stem diameter, as well as a number of fruit per trunk. These characteristics would contribute to better yield and field performance.

1. Introduction
The province of Aceh at the northern tip of Sumatra (latitude 4°41’43” North and longitudes 96°44’58” East) has a total area of 5.75 million hectares, with the majority of its regions located approximately 125 m. above the sea level (a.s.l.). Some hilly- (above 1,000 m. a.s.l.) and mountainous regions (higher than 2,500 m. a.s.l.) are extended in the middle of Aceh up to the border of the North Sumatra province. Aceh...
was considered the second most resourceful region of Indonesia due to its oil and gas reservoir in the late 1970s after Papua, although it has seemingly become depleted since 2000.

The forest resources in Aceh, on the other hand, are still considerably extensive as 60% of its total land area is still considered as forest, which is regarded as the last frontier of tropical (rain) forest in Sumatra [1], particularly owing to its Non-Timber Forest Products (NTFP) have not been further exploited. Thus, such untapped resources could be targeted to improve the livelihood of the middle to low-income farmers [2] and, in a broader perspective, contribute to the whole development of Indonesia. In fact, Reim et al. [3] highlighted the necessity to explore the economic feasibility and a successful model shift towards bio-economy in the forestry sector by slowly reducing the utilization of wood-based products, e.g., sawn timber, round wood for buildings, housing, infrastructure, solid wood, plywood, and other wood products’ derivatives.

Non-Timber Forest Products are generally defined as any wild plants (e.g., wild fruits, vegetables, honey, nuts, edible roots, medicinal plants) or animal products and their derived products collected or harvested from forests [2]. Four types of plants in this world produce deep red resin, namely *Dracaena* (Dracaenaceae), *Daemonorops* (Arecales), *Croton* (Euphorbiaceae), and *Pterocarpus* (Fabaceae). Of these, *Daemonorops* be endemic in western Southeast Asia, particularly on the Sumatran Island. The dragon blood plant, also known as ‘jernang’ (*Daemonorops* spp.), is considered one of the valuable NTFPs harvested from Sumatran tropical rain forests. The genus *Daemonorops* with almost 112 species has been classified as the second largest rattan genus after *Calamus* spp. Some of its morphological features also resemble *Calamus*. Both belong to Arecales [4].

Despite a huge number of species within *Daemonorops*, only less than 10% of these species produce red resin. *Daemonorops draco* (Willd.) Blume, *D. mattanensis*, and *D. didymophylla* are the three most commercial species. *Daemonorops draco* is referred to as ‘jernang’ super due to its higher quality resin than the other two species. Their distribution is relatively large and extended from the northern part of Sumatra up to Lampung, with a small percentage scattered on Gunung Gede Pangrango National Park and Gunung Halimun National Park in Java [5]. However, most publications have mainly covered ‘jernang’ inhabiting their natural habitats in the Bukit Tiga Puluh National Park (BTNP) - tropical rain forests sanctuary stretched within a triangle between three provinces: Jambi, Riau, and Bengkulu [6,7]. Members of indigenous tribes, e.g., ‘Suku Anak Dalam’ or ‘Orang Rimba’ (literally translated into English as indigenous people inhabiting the forests) and ‘Talong Mamak’ has been collecting these mature fruits implying a high dependency on forest resources [8]. They have also been harvesting rubber (*Hevea brasiliensis*), honey that is produced from various wood tree flowers belong to ‘jelutung’ (*Dyera costulata*), ‘keruing’ (*Dipterocarpus* spp.), and ‘kayu kendur’ (*Xeropsernum* spp.) for their livelihoods. Additional income can be earned from selling ‘jernang’ fruits, i.e., IDR 450,000-600,000 for a whole bunch of mature fruits or IDR 700,000-1,400,000/kg in powder form by farmers. The economic benefit of the plant has also attracted not only the member of traditional tribes but also local farmers. These farmers have also been collecting and cultivating the plant’s seedlings for commercial purposes over the past decades. The powdered form of the red resin is priced up to IDR 1,800,000/kg at the exporter’s level, and it is mainly used as a dye or coloring agent in varnishes, lacquers, painting industries, or even as highly valued Chinese medicine, which is believed to possess anti-inflammatory, anti-tumor, and anti-hemostatic properties [4]. Some concerns have been raised regarding the post-harvest techniques and activities employed by the traditional tribes as this might have influenced the quality determinant of the resin powder, namely the content of ‘*dracorhodin*’ and its purity [4].

Morphological variations in *Daemonorops* spp. have been solely based on one single source published by Rustiiami et al. [5]. The species under the genus are usually 8 to 15 m high, length of internodes of 20 cm, leaf length up to 3 m, and stem diameter of 10 mm to 30 mm. Fruits of *Daemonorops* spp. have scaly skin resembling *Salacca* fruit but with a smaller diameter. The plants are distinctly covered with densely arranged spiny leaf sheaths, with varying lengths of throne ranging from a few millimeters to over 10 centimeters (cm). It is a dioecious plant in which the male and female flowers are produced in different rattan clumps. Each clump or cluster usually consists of 5 to 20 individual stems. Interestingly, the plants usually need another supporting tree - referred to here as ‘host
plants’- at the left and right sides that enable them to climb up horizontally [9]. This kind of adaptability is possible with the special morphology attributed to the leaves, in which their whole leaf surfaces are covered with small thorns with a size less than 2 mm [10].

However, the natural habitat and the host plants of dragon blood plants have been classified as critically endangered due to a massive illegal logging and forest encroachment on the Sumatran island since 2009, particularly in the BTNP area and in Sepintum (Jambi) [7,11]. Another threatening issue is the low genetic diversity of the plants due to the particular harvest habits employed by the local people or tribes where male plants of D. draco are being cut down as they presume it as ‘useless’. This kind of activity from an in-situ conservation perspective is incorrect [8]. The cultivation of dragon blood plants has been thriving since 2013\(^1\) as this could serve as a kind of alternative source of income. Usually, local people manage farms ranging from one to five hectares. However, such commercialization of the seedlings has not yet been accompanied by ex-situ conservation efforts.

Considering these challenges, i.e. concerning their utilization and economic importance, sustainable harvesting, and genetic conservation, the conservation of Daemonorops spp. has become more relevant and important, especially concerning the in-situ activity [Tantowi (one jernang farmer and seller in west Aceh), pers. comm.]. The dimensionality of the large set of morphological traits of Daemonorops spp. [5,6] were reduced with ‘Principal Components Analyses’ (PCA) in order to construct predictive models and distinguish these species by using John’s Macintosh Project (JMP) statistical analysis software [12]. Therefore, the aims of this study were: 1) to assess the morphological variations of three species of dragon blood cultivated in ‘Weh Nongkal Tua’ village located in central Aceh, Indonesia; 2) to distinguish the three species of Daemonorops. Updating and publishing the morphological variations of Daemonorops spp. would enable the farmer communities in middle Aceh to value their NTFPs.

2. Materials and methods
Eighty (N= 80) individual plants representing the three species: D. draco or D. draco (Willd.) Blume also known as super ‘jernang’, D. mattanensis (elephant ‘jernang’), D. didymophylla (peanut ‘jernang’) were assessed in this study. They were planted on one hectare land in Weh Nongkal Tua village in Kuta Panang sub-district in middle Aceh. The work was conducted from September to October 2019.

The main work was the morphological variation assessment. All images were captured with a personal handphone camera (Oppo A5s, 2019), and detailed field documentation was collected. A measuring tape with max. length of 20 m was used. The major morphological characters, i.e., stem, leaves, fruit, and the thorn of Daemonorops spp., were examined. Twenty (N= 20) parameters were assessed, divided into qualitative and quantitative data (table 1). The descriptions of the measurements were based on previous publications [5].

For each trait, three measurements were made, and the average was calculated. The averages were then further calculated for the t-test and F-test (data are not published here). A biplot graph of the PCA was made based on the multivariate analyses and calculation via JMP analysis Pro.12, SAS Inc., USA [12]. The average values of each morphological character were applied in the multivariate analyses to distinguish the three species.

3. Results and discussion
The assessment of the morphological characteristics of the three species was divided into two aspects: qualitatively and quantitatively (table 1). In terms of qualitative data, some similarities, e.g., growth habit, leaf color, fruit composition, thorn availability at the initial stem and leaf branch, were found among them. Slight differences were also observed, e.g., stem color, fruit color, thorn color, and the form of scaly located at the outer part of the fruit. The form of a scale of Daemonorops didymophylla was relatively flatter compared to that of D. draco.

In the earlier report, D. draco was initially incorrectly defined and referred to as Palmijuncus draco of Rumphius in the early 19th century. Its basic morphology was systematically explained by Rustiami [5], where the presence of transverse veinlets has served as an important key identification indicator. On the other hand, the leaflets in pairs were an essential identification feature of D. didymophylla.

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\(^1\) dated since the year 2013 in middle Aceh.
Unfortunately, there were no ‘key’ morphological characteristics noted in D. mattanensis. Based on the PCA results, we found out that the morphological characteristics of D. draco was more distinctive and had features that suit for cultivation as compared to the other two species, although its characteristics, e.g., number of leaves (B.7) and the length of the shortest (B.10) and longest thorn (B.11) were less distinctive compared to the other two species (figure 2.).

### Table 1. Morphological characteristics of the three species of Daemonorops.

| No. | Parameter                                      | D. draco* | D. mattanensis** | D. didymophylla*** |
|-----|-----------------------------------------------|-----------|------------------|-------------------|
| A.  | Qualitative                                   |           |                  |                   |
| 1.  | Growth habit                                  | in a cluster | in a cluster | in a cluster     |
| 2.  | Stem color                                    | yellow | greenish-brown  | green             |
| 3.  | Leaf color                                    | green  | green            | green             |
| 4.  | Fruit composition                             | grouping | grouping | grouping |
| 5.  | Fruit color                                   | dark brown | light brown | light brown |
| 6.  | Scaly form of fruit skin                      | concave | concave         | flat              |
| 7.  | Thorn availability at the initial stem /above the soil surface | available | available | available |
| 8.  | Thorn at the initial leaf branch               | available | available | available |
| 9.  | Thorn color                                   | yellowish-brown | brown | green |

B. Quantitative

|     | Parameter                                      | No. | Stem diameter (cm) | 7.0 | 2.0 |
|-----|-----------------------------------------------|-----|-------------------|-----|-----|
| 1.  | Main stem height (m)                          | 5.0 | 2.0               |
| 2.  | No. of stems per cluster (unit)               | 10.0 | 6.0               |
| 3.  | No. of leaves per unit (unit)                 | 6.50 | 6.50              |
| 4.  | Fruit diameter (cm)                           | 5.0  | 2.5               |
| 5.  | Length of internode (cm)                      | 27.5 | 19.0              |
| 6.  | Length of internode (cm)                      | 37.5 | 28.0              |
| 7.  | No. of fruits per trunk (unit)                | 30.0 | 23.0              |
| 8.  | No. of fruits per trunk (unit)                | 1.5  | 1.5               |
| 9.  | Length of the longest thorn (cm)              | 3.0  | 1.5               |

*The morphological performance of D. draco can be seen in figure 1 at the left column. **D. mattanensis in figure 1 at the middle one, and *D. didymophylla on figure 1 at the right one.

The morphological characteristics of ‘jernang’ that was previously described at the conservation area of Bukit Tigapuluh National Park (BTNP) and its surrounding were slightly different from those planted in Kuta Panang; especially in terms of plant height. Most of those plants described in the BTNP possessed a taller stature with almost 8 m in height, longer leaves up to 32 cm in length, and thicker diameter of stem between 8 to 14 cm was reported. In terms of criteria for trade, it seemed that stem diameter does not play an important role with respect to showing yield characteristics in rotan ‘jernang’ or Daemonorops. Contrastingly, it plays a significant role in the other ‘common’ rattan (Calamus spp.) by the international trade because their stems are the major commodity and are used to make baskets, cords, and furniture in most South East Asian countries. From this, we can presume that the Daemonorops in Kuta Panang was a more cultivated type rather than the natural ones that grow in wild or natural habitats in the forest. These are shown with more advantageous characteristics, such as shorter leaf length than the other groups (see figure 1 at the top).

The color, form, and sizes of ‘jernang’ fruits were also notably different among the three species (table 1). In an earlier report, the size of fruits in Daemonorops negatively correlates with the amount of resin yield [13]. The resin is exudated to the surface of the fruits. The smaller the fruit size is the larger the surface area per weight unit of the fruit; therefore, the more the resin is yielded.

Interestingly, the spiny length varies from 1.5 to 3.0 cm long (table 1). Notably, the existence of ‘the knee’ marked as swelling and situated just below the petiole or leaf rachis in each plant was also found (figure 1). Based on field observation and then confirmed with a reference, thorn morphology in
Daemonorops spp. was found to vary from species to species. The existence of rachis, particularly the thorn or spine arrangement on the leaf sheath on Daemonorops, might be applied as the ‘key morphological determinant’ in distinguishing its interspecific variations [5]. These were also confirmed in our results (figure 1).

**Figure 1.** The morphological characteristics of *D. draco* (left column), *D. mattanensis* (middle), *D. didymophylla* (right); second row (from top) = leaf length and color, third row= the whole plant appearance, fourth row= fruit morphology, fifth row= the thorn or spine morphology as ‘the most obvious characteristics’ to distinguish the three species according to [5].
The use of PCA in distinguishing the biochemical compounds in life science studies, e.g., metabolomic studies [14,15], and species variation in *Amaranthus* spp. [16] has been reported in the past. PCA can be applied as one of the most effective methods in simplifying the multi-trait or diverse variables into clusters or groups in a two-dimensional form. Here, we used a similar approach with the JMP and had succeeded in distinguishing the collected morphological data (N= 11).

Figure 2 shows that the three species (*D. draco, D. mattanensis, D. didymophylla*) were grouped or clustered in three regions on the biplot based on 11 morphological characters (see table 1, section B). As highlighted earlier, PCA has the ability to simplify and reduce the dimensionality of measurement data. Eigenvalue that indicates the importance of the certain behavior of a data system showed a value of over 80%. Principle Component 1 or ‘PC1’ explained almost 92% of the total variation, where most morphological data were more densely gathered at the right side (see figure 2, right side). ‘PC2’ was only 8.35%. The graph confirmed that *D. draco* holds agronomical characteristics, particularly in the number of fruits, stem height, branch length, number of stems, and length of the longest thorn compared with the other two species (figure 2).

We presumed that artificial selection might have been applied in the past. Therefore, *D. draco* has more morphological advantages that will facilitate their propagation and field nursery. Contrastingly, *D. didymophylla* compared to *D. draco* has a 50% smaller fruit diameter, 70% smaller stem diameter, and 30% less in terms of the number of fruits per trunk. All these would not allow the species to produce high yield fruits. As complementary to the current findings, further investigation should be made on the molecular and biochemical compounds of *Daemonorops* spp.

![Figure 2. Principal Component Analyses or PCA of the three species of Daemonorops based on the morphological characteristics: 1= *D. draco* indicated in a black square, 2= *D. mattanensis* indicated in a circle, 3= *D. didymophylla* indicated in the black dot.](image)

4. Conclusions
This report identified a potential cash crop; other than oil palm cultivation initiated by some coffee farmers in Kuta Panang in middle Aceh. The findings could support the option of having alternative income for them due to the fluctuating coffee price at the international market over the past decade. It seemed that the environmental condition in middle Aceh, which is classified as mountainous regions with cool temperature and below 20 °C, is still suitable to be planted with *Dae. However*, the species usually require a warm temperature ranging from 24-32 °C and 60-85% humidity [17].

The morphological characteristics of *‘jernang’* or *Daemonorops* spp. cultivated in Kuta Panang in middle Aceh have been examined in detail in this study. We measured a total of 20 characteristics, of which 55% were quantitative data. Three replicates were made for each measurement, and the average values were then further calculated to distinguish the three species: *D. draco, D. mattanensis,* and *D. didymophylla*. *Daemonorops draco* was found to have more distinctive morphological characteristics in
terms of fruit-, and stem diameter and the available number of fruits per trunk, compared to the other two species. These unique characteristics have made it more easily to be cultivated compared to the other two species. Thorn or spine arrangement on the leaf sheath can be applied as the major determinant in distinguishing the interspecific variations within the three Daemonorops.

5. References

[1] Anonymous 2017 Aceh Dalam Angka 2017 (Banda Aceh: Badan Pusat Statistik Provinsi Aceh)

[2] Beukering P Van, Grogan K and Seager D 2009 An Economic Valuation of Aceh’s forests The road towards sustainable development (Amsterdam: Final Report)

[3] Raupelien A 2017 Bio-economy based business models for the forest sector-A systematic literature review the 8th International Scientific Conference Rural Development ed prof. Asta Raupeliene (Lulea: prof. Asta Raupeliené) 775–80

[4] Andini R, Ismullah F, Bakri S, Sulaiman M I A A 2020 Current status of Aceh jernang (Daemonorops sp.) and its traditional conservation efforts IOP Conf. Ser. Earth Environ. Sci. 425 1–7

[5] Rustiami H 2004 Taxonomy and Uses of Daemonorops draco (Willd.) Blume 165–75

[6] Henderson A and Rustiami H 2019 New species of Calamus (Areaceae; Calamoideae; Calaminaceae) from Sumatra Phytotaxa 415 117–29

[7] High S, Urip J, No S, Pura T and Tel J I 2012 The population of Jernang rattan (Daemonorops draco) in Jebak Village, Batanghari District, Jambi Province, Indonesia 13 205–13

[8] Asra R, Syamsuardi, Mansyurdi and Witono J R 2014 Genetic diversity of Daemonorops draco (Palmae) using ISSR markers Biodiversitas 15 109–14

[9] Wahyudi A and Jannetta S 2011 Potensi dan permudahan alam rotan penghasil jernang di Kawasan Taman Nasional Bukit Tigapuluh Riau J. Penelit. Hutan dan Konserv. Alam 8 237–43

[10] Matangaran J R 2012 Potensi dan Pemanenan Buah Rotan Jernang Jurnal Silvikultur Tropika 3 65–70

[11] Förster J 2010 Forest valuation stimulates green development policies in the Province of Aceh, Indonesia (Aceh: The Economists of Ecosystems and Biodiversity)

[12] Anonymous Basic Analysis ed Scintilla (North Carolina)

[13] Sulaiman M I, Nasrianti N, Andini R, Darmadi and Erika C 2020 Effect of fruit size, solvent and extraction methods on resin extractability of Daemonorops sp. (jernang) IOP Conference Series: Earth and Environmental Science 425

[14] McGhie T K and Rowan D D 2012 Metabolomics for measuring phytochemicals, and assessing human and animal responses to phytochemicals, in food science Mol. Nutr. Food Res. 56 147–58

[15] Llorach R, Urpi-sarda M, Jauregui O, Monagas M and Andres-lacueva C 2009 An LC-MS-Based Metabolomics Approach for Exploring Urinary Metabolome Modifications after Cocoa Consumption research articles 5060–8

[16] Andini R, Sulaiman M I, Moulana R, Hmon K P W and Ohsawa R 2020 Application of principle component Analysis in differentiating the three types of Amaranthus based on their photoperiodic flowering response Application of principle component analysis in differentiating the three types of Amaranthus based on their photoperiodic flowering response IOP Conf. Ser. Earth Environ. Sci. 425 1–12

[17] Sahwalita and Herdiana 2019 Budidaya Rotan Jernang, HHHK Unggulan Masyarakat Sumatera ed L Kalima, Turjaman (Palembang)

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