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# Phenetic Study on Clustered *Pinanga* of Java and Bali

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**ABSTRACT**

The objective of the study was to know relationships of clustered *Pinanga* of Java and Bali based on morphological characters. Observation was done to 115 clustered *Pinanga* specimens (*P. coronata*), 18 of which were assigned as *Operational Taxonomic Units (OTUs)*. The morphological characters noted, analyzed using versions of *the numerical taxonomy system / NTSYS version 1.80, 1993.* The phenogram presents that clustered *Pinanga* of Java and Bali divided into two groups (clusters): specimens from lowland forest (0-750 m asl) and specimens from montane forest (750 m asl or more). The cluster division is not dependent on the geographical distribution of the OTUs, but rather altitudes.



**Key words:** Java, Bali, NTSYS, OTUs, clustered *Pinanga,* phenetic study.

## INTRODUCTION

Indonesia has the richest *Pinanga* in the world. This genus consists of about 120 species, 40 species of which are represented in Indonesia (Uhl and Dransfield, 1987; Mogea, 1991). In Java and Bali, there are 3 species of *Pinanga* namely *P. javana, P. arinasae*, and *P. coronata*. *P. javana* and *P. arinasae* are single stemmed. A third species, *P. coronata* is clustered. *P. coronata* is found throughout Java and Bali, occuring on very steep hillsides in montane forest and flat areas in lowland forest, from sea level 10 1800 m asl (Witono *et al.,* 2002).

Clustered palms is what Holttum (1955) referred to as a sympodial habit, which he considered characteristic of monocotyledones. Each new shoot develops from an axillary bud, which in palms is usually located near the base of the stem. As each short then subsequently produces a new axillary shoot, a clustered habit results (Uhl and Dransfield, 1987). Clustered *Pinanga* usually has many small and short stems.

Classification has been defined as the ordering of organisms into groups on the basis of their relationships. The relationships may be genetic, evolutionary (phylogenetic), or may simply refer to similarities of phenotype (phenetic) (Dunn and Everitt, 1982). Phenetic classification is a construction relationships based on overall similarity of taxa (Sneath and Sokal, 1973) or presence and absence of characters. The phenetic arrangement of the taxa is developed with numerical procedures applied to the

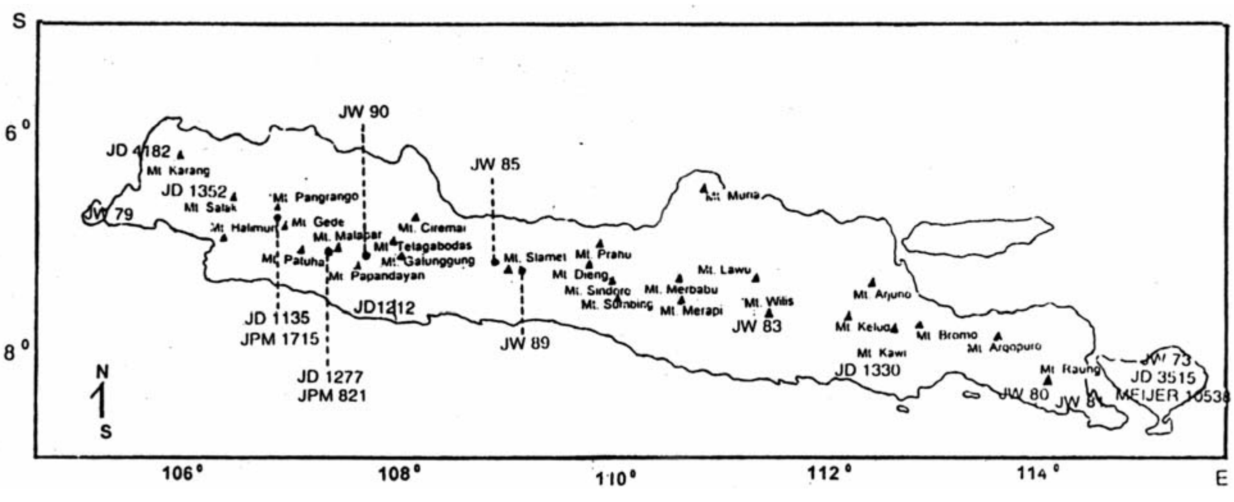


**Figure 1.** Geographical localities of clustered *Pinanga* of Java and Bali used in this study.

**Table 1.** Specimens, localities, and altitudes of the clustered *Pinanga* used in this study.

| No. | Collector | Locality | Altitude (m) |
|---|---|---|---|
| 1. | JW 79 | Cibunar, Ujung Kulon National Park, Pandeglang, West Java | 40 |
| 2. | JD 1212 | Cibalanak, Cipatujah, Tasikmalaya, West Java | 30 |
| 3. | JW 80 | Bande Alit, Meru Betiri National Park, Jember, East Java | 340 |
| 4. | JW 81 | Pantai Penyu, Meru Betiri National Park, Sukamade, Banyuwangi, East Java | 60 |
| 5. | JD 1330 | Ngliyep, south of Malang, East Java | 2 |
| 6. | JD 4182 | Mt. Pulasari, Mandalawangi, Pandeglang, West Java | 500 |
| 7. | JW 90 | Bukit Himalaya Nature Reserve, Sukamulya, Garut, West Java | 1,300 |
| 8. | JD 1135 | Rawah Denok, Gede Pangrango National Park, Cibodas, West Java | 1,800 |
| 9. | JPM 1715 | Kandang Badak, Gede Pangrango National Park, Cibodas, West Java | 1,700 |
| 10. | JD 1352 | Mt. Salak, above Ciomas, Bogor, West Java | 1,500 |
| 11. | JD 3515 | Bukit Tapak, Batukahu Nature Reserve, Bedugul, Bali | 1,000 |
| 12. | Meijer 10538 | Bratan Lake, Bedugul, Bali | 1,000 |
| 13. | JW 73 | Bukit Tapak, Batukahu Nature Reserve, Bedugul, Bali | 1,100 |
| 14. | JD 1277 | Situ Patengang, Ciwideuy, Bandung, West Java | 1,400 |
| 15. | JPM 821 | Cadas Panjang, Cimanggu, Bandung, West Java | 1,750 |
| 16. | JW 83 | Alas Tiwang, Mt. Wilis, Kediri, East Java | 1,200 |
| 17. | JW 85 | Pancuran Tujuh, Mt. Slamet, Purwokerto, Central Java | 750 |
| 18. | JW 89 | Goa Lawa, Mt. Slamet, Purbalingga, Central Java | 800 |

**Table 2.** Morphological characters used in phenetic study.

| No. | Characters |
|---|---|
| | *Vegetative Structures* |
| 1. | Colour of crownshaft: green brownish **(2)**, green yellowish **(1)**, green **(0)** |
| 2. | Petiole and rachis surface silvery indumentum: present **(1)**, absent **(0)** |
| 3. | Number of leaflets on each side of rachis: 21 leaflets or more **(2)**, 11 – 20 leaflets **(1)**, 0 – 10 leaflets **(0)** |
| 4. | Ratio length to width of basal leaflets: 41 or more **(2)**, 26 – 40 **(1)**, 0 – 25 **(0)** |
| 5. | Ribs number of basal leaflets: 3 or more **(2)**, 2 **(1)**, 1 **(0)** |
| 6. | Ratio length to width of middle leaflets: 21 or more **(2)**, 13 – 20 **(1)**, 0 – 12 **(0)** |
| 7. | ribs number of middle leaflets: 4 or more **(2)**, 3 **(1)**, 1 – 2 **(0)** |
| 8. | Ratio length to width of topmost leaflets: 12.6 or more **(2)**, 7.6 – 12.5 **(1)**, 0 – 7.5 **(0)** |
| 9. | ribs number of topmost leaflets: 7 or more **(2)**, 5 – 6 **(1)**, 1 – 4 **(0)** |
| | *Inflorescence Structures* |
| 10. | Growth form of inflorescence: pendulous **(1)**, erect then pendulous **(0)** |
| 11. | Order branches at basal rachillae: 2 orders **(1)**, 1 order **(0)** |
| 12. | Sepal form of female flower: orbicularis **(1)**, broad orbicularis **(0)** |
| 13. | Petal form of female flower: orbicularis **(1)**, broad orbicularis **(0)** |
| 14. | Fruit form: ellipsoid **(2)**, ovoid **(1)**, obovoid **(0)** |

character states of organisms under study. Sneath and Sokal (1986) mentioned this method as numerical taxonomy or taxometrics (Stace, 1989).

A major approach to analyzing similarities and dissimilarities in this study is cluster analysis. There are three widely applied agglomerative clustering methods, but only one of them is employed in this study. The three methods are: single-linkage clustering, complete-linkage clustering, and group-average clustering (Dunn and Everitt, 1982). Group-average clustering analysis will be the applied agglomerative clustering method employed in this study.

This phenetic study is to provide a natural classification for the clustered *Pinanga* of Java and Bali based on morphological characters. The result of this study is phenogram or relationship of the clustered *Pinanga* of Java and Bali from many localities, altitudes, and habitats.

## MATERIALS AND METHODS

*Plant materials*

In this study, all herbarium specimens of clustered *Pinanga* at Herbarium Bogoriense were observed. The number of collection of clustered *Pinanga* of Java and Bali are 115 specimens, 18 of which were assigned as Operational Taxonomic Units (OTUs) which are shown in Table 1 and the geographical localities of these specimens used in phenetic study are shown on Figure 1.

*Procedures*

The Morphological characters used in this study include vegetative structures (stem and leaves) and inflorescence structures. Fourteen morphometric characters (Table 2.) were chosen. These included seven qualitative and seven quantitative characters.

Nine characters were recognized from vegetative structures and five from the inflorescence structures. While qualitative characters were ordered and assigned numerical codes, quantitative characters were entered directly as raw data.

Data processing was carried out using versions of *the numerical taxonomy system* / NTSYS. NTSYS is a system of programs that is used to find and display structure in multivariate data. This system can be used to compute various measures of similarity or dissimilarity between all pairs of objects and then summarize the information either in terms of noted sets of similar objects (Rohlf, 1993).

The results are expressed in an OTU by OTU dissimilarity or similarity matrix. In the following stage, SAHN (Sequential, Agglomerative, Hierarchical, and Nested) clustering program was used to construct the phenogram. In this study used to UPGMA (unweighted pair-group method using averages).

## RESULTS AND DISCUSSIONS

The raw data were converted to a matrix (Table 3.). The numerical taxonomy system produces value of correlation coefficients (Table 3.) and a phenogram (Figure 2.) which shows a relationship among the specimens of clustering *Pinanga* in Java and Bali with the specimens observed arrangement as shown in Table 1.

The phenogram presents that there are 16 levels of correlation coefficients, from tle lowest (0.289) to the highest (1.000)(Matrix 2.). The lowest correlation coefficient indicates the less similar, and the highest is the closests similarity.

Whitmore (1985) divided the forest formations of the tropical Far East into three types: lowland forest (1-750 m asl), lower montane forest (750-1500 m asl), and upper montane forest (1500 m asl or more). The phenogram presents that clustered *Pinanga* from Java and Bali consists of two groups (clusters): specimens from lowland forest (JW 79, JD 1212, JW 80, JW 81, JD 1330, and JD 4182) and specimens from montane forest (JW 90, JD 1135, JPM 1715, JD 1352, JD 3515, MEIJER 10538, JW 73, JD 1277, JPM 821, JW 83, JW 85, and JW 89).

The second cluster are divided into two subclusters based on a value correlation coefficient 0,375, there are specimens from the altitude 1000 m asl or more (JW 90, JD 1135, JPM 1715, JD 1352, JD 3515, MEIJER 10538, JW 73, JD 1277, JPM 821, and JW 83) and specimens from the altitude 1000 m or less (JW 85 and JW 89). Specimens JW 85 and JW 89 have different subcluster with the other specimens from montane forest, because part of their characters have similar to first cluster. There are number of leaflets on each side of rachis 11-20, rib number of basal leaflets 3 or more (JW 85) and 2 (JW 89), rib number of the middle leaflets 4 or more (JW 85) and 3 (JW 89), and rib number of apical leaflets 7 or more. The correlation coefficients between OTUs, subclusters, and clusters of clustered *Pinanga* are shown in Table 4.

These clusters are morphologically closely related. The cluster division is not dependent on the geographical distribution of the OTUs, but rather altitudes. So, the adaptation of clustered *Pinanga* in Java and Bali is vertically.

The species concept that continues to be used in describing palms is not only based on morphological similarities, but other factors such as ecology and geography are so important. In clustered *Pinanga* in Java and Bali, the main factors that caused display a wide variability in morphological characters is ecology, primarily temperature and light intensity.

**Table 3.** Morphological characters specimens of clustered *Pinanga* used in this study.

| No. | Specimens | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | JW 79 | 2 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| 2. | JD 1212 | 2 | 1 | 1 | 0 | 2 | 0 | 2 | 0 | 2 | 1 | 1 | 0 | 1 | 0 |
| 3. | JW 80 | 2 | 1 | 2 | 2 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 1 | 1 | 0 |
| 4. | JW 81 | 2 | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 2 | 1 | 0 | 1 | 1 | 0 |
| 5. | JD 1330 | 2 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 1 | 0 | 1 | 1 | 2 |
| 6. | JD 4182 | 2 | 1 | 0 | 1 | 0 | 1 | 2 | 0 | 2 | 1 | 1 | 0 | 1 | 2 |
| 7. | JW 90 | 1 | 0 | 2 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 2 |
| 8. | JD 1135 | 1 | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 9. | JPM 1715 | 1 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 10. | JD 1352 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| 11. | JD 3515 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 12. | MEIJER 10538 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 13. | JW 73 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 1 |
| 14. | JD 1277 | 2 | 0 | 2 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| 15. | JPM 821 | 2 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 16. | JW 83 | 1 | 0 | 2 | 2 | 1 | 2 | 0 | 2 | 0 | 1 | 0 | 1 | 1 | 2 |
| 17. | JW 85 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 1 | 1 | 1 | 2 |
| 18. | JW 89 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 1 | 0 | 2 |

**Table 4.** The correlation coefficients between OTUs, subclusters, and clusters of clustered *Pinanga.*

| Cc. | Value | Notes |
|---|---|---|
| 16 | 1,000 | Similar character between JD 3515 and Meijer 10538 |
| 15 | 0,929 | Colour of crownshaft green yellowish, sepal form of female flower broad orbicularis (JPM 1715) vs colour of crownshaft green, sepal form of female flower orbicularis (JD 1352) |
| 14 | 0,927 | Ratio length to width of middle leaflets 13-20, ratio length to width of topmost leaflets 12.6 or more (JW 73) vs ratio length to width of middle leaflets 21 or more, ratio length to width of topmost leaflets 7.6-12.5 (JD 3515, MEIJER 10538) |
| 13 | 0,857 | Number leaflets on each side of rachis 21 or more, ribs number of middle leaflets 3, fruit obovoid (JW 81) vs number leaflets on each side of rachis 10-20, ribs number of middle leaflets 4 or more, fruit ellipsoid (JD 1330) |
| 12 | 0,823 | Ratio length to width of basal leaflets 41 or more, fruit ovoid (JD 1135) vs ratio length to width of basal leaflets 26-40, fruit ellipsoid (JPM 1715, JD 1352) |
| 11a | 0,786 | Ratio length to width of basal leaflets 41 or more, ribs number of basal leaflets 1 (JW 80) vs ratio length to width of basal leaflets 0-25, ribs number of basal leaflets 2 (JW 81, JD 1330) |
| 11b | 0,786 | Number leaflets on each side of rachis 0-10, basal rachillae 1 order, petal form of pistillate flower broad orbicularis (JW 79) vs number leaflets each side of rachis 11-20, basal rachillae 2 orders, petal form of pistillate flower orbicularis (JD 1212) |
| 10 | 0,738 | Ratio length to width of topmost leaflets 7.6-12.5, ribs number of topmost leaflets 5-6 (JW 90) vs ratio length to width of topmost leaflets 0-7.5, ribs number of topmost leaflets 1-4 (JD 1135, JPM 1715, JD 1352) |
| 9 | 0,714 | Ratio length to width of basal leaflets 41 or more, ratio length to width of middle leaflets 21 or more, ratio length to width of topmost leaflets 7.6-12.5 (JD 1277) vs Ratio length to width of basal leaflets 26-40, ratio length to width of middle leaflets 13-20, ratio length to width of topmost leaflets 0-7.5 (JPM 821) |
| 8 | 0,708 | Colour of crownshaft green yellowish, sepal form of pistillate flower broad orbicularis (JW 90, JD 1135, JPM 1715), fruit ellipsoid (JW 90, JPM 1715, JD 1352) vs colour of crownshaft green, sepal form of pistillate flower orbicularis, fruit ovoid (JD 3515, JW 73, MEIJER 10538) |
| 7 | 0,622 | Petal form of female flower orbicularis (JW 90, JD 1135, JPM 1715, JD 1352, JD 3515, MEIJER 10538, JW 73) vs petal form of female flower broad orbicularis (JD 1277, JPM 821) |
| 6 | 0.619 | Ribs number of middle leaflets 4 or more, sepal form of pistillate flower broad orbicularis (JW 79, JD 1212) vs ribs number of middle leaflets 3 (JW 80, JW 81), sepal form of pistillate flower orbicularis (JW 80, JW 81, JD 1330) |
| 5 | 0.571 | Ribs number of basal leaflets 1, growth form of inflorescence erect then pendulous (JW 90, JD 1135, JPM 1715, JD 1352, JD 3515, MEIJER 10538, JW 73, JD 1277, JPM 821) vs ribs number of basal leaflets 2, growth of inflorescence pendulous (JW 83) |
| 4 | 0.543 | Ratio length to width of middle leaflets 0-12 (JW 79, JD 1212, JW 80, JW 81, JD 1330) vs ratio length to width of middle leaflets 13-20 (JD 4182) |
| 3 | 0.500 | Ratio length to width of basal leaflets 0-25, ribs number of basal leaflets 3 or more, ratio length to width of middle leaflets 0-12, ribs number of middle leaflets 4 or more, ratio length to width of topmost leaflets 0-7.5, basal rachillae branches 1 order, petal form of female flower orbicularis (JW 85) vs Ratio length to width of basal leaflets 26-40, ribs number of basal leaflets 2, ratio length to width of middle leaflets 13-20, ribs number of middle leaflets 3, ratio length to width of topmost leaflets 7.6-12.5, basal rachillae branches 2 orders, petal form of female flower broad orbicularis (JW 89) |
| 2 | 0.375 | Number leaflets on each side of rachis 21 or more (JW 90, JD 1135, JPM 1715, JD 1352, JD 3515, MEIJER 10538, JW 73, JD 1277, JPM 821, JW 83), ribs number of topmost leaflets 1-4 (except JW 90) vs number leaflets on each side of rachis 11-20, ribs number of topmost leaflets 7 or more (JW 85, JW 89) |
| 1 | 0.289 | Petiole and rachis surface silvery indumentum, growth of inflorescence pendulous (JW 79, JD 1212, JW 80, JW 81, JD 1330, JD 4182) vs petiole and rachis surface silvery indumentum: absent (JW 90, JD 1135, JPM 1715, JD 1352, JD 3515, MEIJER 10538, JW 73, JD 1277, JPM 821, JW 83, JW 85, JW 89), growth of inflorescence erect then pendulous (except JW 83) |

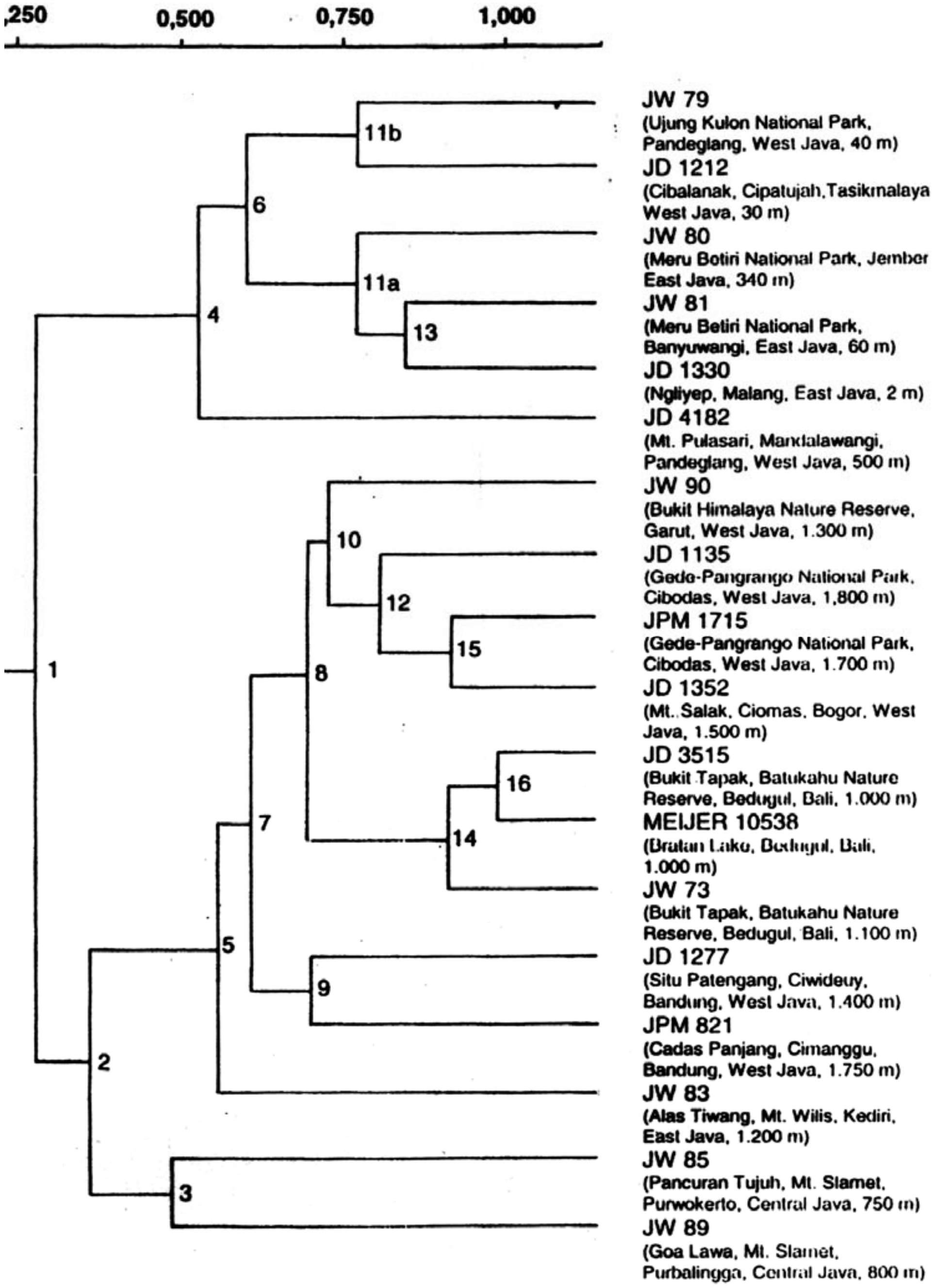


**Figure 2.** Phenogram of clustered *Pinanga* from Java and Bali.

## CONCLUSIONS

Based on phenetic analysis using UPGMA, it can be concluded that the clustered *Pinanga* of Java and Bali which observed divided into two groups (clusters): specimens from lowland forest (0-750 m asl) and specimens from montane forest (750 m asl or more). The second cluster are divided into two subclusters based on a value correlation coefficient 0,375, there are specimens from the altitude 1000 m asl or more and specimens from the altitude 1000 m or less. The cluster division is not dependent on the geographical distribution of the OTUs, but rather altitudes.

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