FREYCINETIA GAUDICH
(PANDANACEAE : FREYCINETOIDEAE)
IN SULAWESI

BY:
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NRP. G351060411

THE GRADUATE SCHOOL
BOGOR UNIVERSITY OF AGRICULTURE
2009
LETTER OF STATEMENT

I express that thesis entitling:

FREYCINETIA GAUDICH (PANDANACEAE : FREYCINETOIDEAE)
IN SULAWESI

Is true represent result of my research and have never been published. All information and data that used have been expressed clearly and can be checked its truth.

Bogor, August 2009

Endang Wahjuningsih
NRP G351060411
Studies on the genus Freycinetia Gaudich (Pandanaceae: Freycinetoideae) in Sulawesi Island were conducted based on morphological characters. Thirteen species are recognized: *Freycinetia amboinensis* Martelli, *Freycinetia beccarii* Hemsl, *Freycinetia celebica* Solms, *Freycinetia devriesei* Solms, *Freycinetia funicularis* Merr, *Freycinetia inermis* Ridl, *Freycinetia kostermansii* B.C Stone, *Freycinetia koordersiana* Martelli, *Freycinetia minahassae* Koord, *Freycinetia ob lanceolata* Martelli, *Freycinetia polystachya* Martelli, *Freycinetia rigidifolia* Hemsl and *Freycinetia sarasinorum* Warb respectively. A determination key to species is presented including their description. A phylogenetic analysis was undertaken using Paup vers. 4. Ob. Swofford Programs was performed with *Pandanus nitidus* Kurz and *Sararanga sinuosa* Hemsl appointed as outgroups. The result of the analysis suggest that Freycinetia in Sulawesi is a monophyletic genus and divided into two clade and supported by the high bootstrap value of 70 % and belong to six section there are Auriculifoliae, Lateriflorae, Polystachyae, Devriesella, Oligostigma, Hemsleyella. One interesting discovery is that despite the fact that *F. oblanceolata* is placed in the same section as *F. beccarii* which is Oligostigma but the tree does not suggest a close relationship. In the first clade showing that *F. devriesei* Solms is sister species to *F. funicularis* Merr and *F. koster mansii* B.C Stone are suggested to have a close relationship and supported by the bootstrap value of 52 %. *F. funicularis* Merr to have a close relationship with *F. koster mansii* B.C Stone to have a close relationship and supported by the high bootstrap value of 79 %. In the second clade *F. inermis* Ridl and *F. koordersiana* Martelli are suggested to have a close relationship and supported by the high bootstrap value of 82 %. This current study also suggests that species of Freycinetia in Sulawesi has stronger affinity with the eastern part of Malesia rather than with the western part.

Key word: Freycinetia, Pandanaceae, Sulawesi, Taxonomy
ABSTRAK

ENDANG WAJUNINGSIH. *Freycinetia* Gaudich (Pandanaceae : Freycinetoideae) di Sulawesi. Dibimbing oleh SRI SUDARMIYATI TJITROSOEDIRDJO dan ARY PRIHARDHYANTO KEIM.


Kata kunci : *Freycinetia*, Pandanaceae, Sulawesi, Taxonomy
ENDANG WAHJUNINGSIH. Freycinetia Gaudich (Pandanaceae: Freycinetoideae) in Sulawesi. Supervised by SRI SUDARMIYATI TJITROSOEDIRDJO and ARY PRIHARDHYANTO KEIM.

Freycinetia is the only liana or climber in Pandanaceae and all of the member have auricle on the leaf, the have numerous seeds in one locul (multiovulate). Although there is a species from the genus Pandanus which known to possess auricle, such as Pandanus pectinatus, however auricle is still a good field identification for the genus. Stone (1972) suggested Freycinetia as the most advance genus within Pandanaceae. His statement is supported by its habit (liana/climber) and infructescence structure.

Freycinetia consist of approximate 200 species which spreads from Srilangka, Indochina, a whole Malesia until Australia (North Queensland) and Pasific (New Zealand). Althouth they are close to each other, Freycinetia is never found on India.

Sulawesi is an island that has never joined Sunda to either or Sahul shelves (Metcalfe, 1996; Hall, 1998; Halloway & Hall, 1998). In other words, Sulawesi is composed of many parts that have always been independent as Oceanic islands. This study is based on herbarium specimens collected from Sulawesi and adjacent Islands. The total number of 62 specimens deposited in the Herbarium Bogoriense (BO) were examined. See materials were studied and their morphological characters were examined with 10 x 40 binocular microscope. A phyllogenetic analysis was conducted to clarify the relationships between Freycinetia species in Sulawesi using PAUP vers. 4.0b (Swoffort, 2000)

The recent study indicated that there were thirteen species of Freycinetia in Sulawesi. From thirteen species have been identified, Freycinetia devriesei Solms, Freycinetia minahassae Koord and Freycinetia koordersiana Martelli are wideles spread in Sulawesi, from North side to South Sulawesi. Freycinetia oblaceolata Martelli, Freycinetia beccarii Hemsl and Freycinetia rigidifolia Hemsl are species which have limited distribution. Thus arrange of its habitat are secondary forest and slope mountain. Species of Freycinetia have bracts of varied coloration, Freycinetia amboinensis Martelli having yellow colour bracts, Freycinetia minahassae Koord having white with red to purple colour bracts, Freycinetia sarasinorum Warb having white to pale yellow bracts.

The same for the species Freycinetia on Sulawesi with Moluccas, Philippines and New Guinea is the shown there is close relation of floristic like what have been Postulated by Lam (1945a; 1945b). Freycinetia are rarely used by public. Seeing
from the interest colour of bract, even it has to be used as decorative plants and spathe catching red colour used material colour alcoholic drink in China (Heyne, 1987). Roots to be used to make rope, stem from Freycinetia celebica Solms to be used to make for rope of a bird and other animal trap. The leaves of F. koordersiana Martelli are used as medicinal for after birth treatment in which the leaves are boiled than given to the mother after labour (childbirth) to clear the womb.

The phyllogenetic analysis was result one parsimonious trees with 87 tree length, Consistency index (CI) of 0.6897, Homoplasy index (HI) of 0.3103, Retency index (RI) of 0.5909 and Rescaled Consistency index (RC) of 0.4075. The result of this current study suggest that the F. funicularis Merr and F. kostermansii B.C Stone united only by one very informative morphological character there is both species have lateral infructescence.

In accordance with Stone (1968) in placing the two species into the same section, Lateriflorae. F. devriesei Solms is suggested to be the closest sister species to the clade that unites F. funicularis Merr and F. kostermansii B.C Stone. The section Lateriflorae is suggested to have a nearness relationship with the section Devriesella. However this result is still preliminary, thus further study with more taxa involved is needed. F. beccarii Hemsl is regarded as the sister species to the clade that unites F. funicularis Merr, F. kostermansii B.C Stone, F. devriesei Solms.

This can also be interpreted that Stone’s section of Oligostigma is regarded to have a close relationship with both section Lateriflorae and Devriesella. This is also a preliminary result, further study is essensial. One interesting discovery is that despite the fact that F. oblanceolata Martelli is placed in the same section as F. beccarii Hemsl in Stone’s infrageneric classification, which is Oligostigma but the tree does not suggest a close relationship.

This current study also suggests that species of Freycinetia in Sulawesi has stronger affinity with the eastern part of Malesia rather than with the western part. In other words, the biogeographical pattern of Freycinetia in Malesia is confined to Huxley’s line rather than Wallace’s line. Thus, the biogeographic patterns in Freycinetia in Sulawesi are explained better with Huxley’s line.

Key word: Freycinetia, Pandanaceae, Sulawesi, Taxonomy
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FREYCINETIA GAUDICH
(PANDANACEAE : FREYCINETOIDEAE) IN SULAWESI

ENDANG WAHJUNINGSIH

Thesis submitted
As partial fulfillment requirement for the Master Degree
In plant Taxonomy

THE GRADUATE SCHOOL
BOGOR UNIVERSITY OF AGRICULTURE
2009
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INTRODUCTION

Pandan and Pandanaceae.

The word “pandan” comes from Malay and is used to name all species of the pandan family or Pandanaceae (Rumphius, 1743; Warburg, 1900; St John, 1963; Keng, 1978; Stone 1982; Hyam & Pan Khurst, 1995).

Pandanaceae belongs to the class Monocotyledoneae that is a group of plant families, which include palms, grasses, banana, orchids and gingers (Dahlgren and Clifford, 1982; Heywood, 1993; Zomlefer, 1994), the sole member of the order Pandaniflorae (Dahlgren and Clifford, 1982) and include more than 900 species divided into four genera: Freycinetia, Pandanus, Sararanga, and Martellidendron (Stone, 1972; Callmander et al, 2003).

Pandan can be found in wide ranging areas from tropical rainforests to areas with four-season, some can even be found in subtropical areas. They spread from West Africa, Madagascar, India, Sri Lanka, Indochina, Malesia, Australia, New Zealand to Pacific (Stone, 1982; 1983).

Pandan grows on many places from sandy beaches and coral estuaries (mangrove), riverside until highland with highest altitude recorded around 3500 m alt (Stone, 1982). They can also be found in secondary forests (savannah) and dry sands (Keim, 2007).

Pandanus is the genus within the family that possesses the largest spreading areas from Africa, Madagascar, India, Sri Lanka, mainland Southeast Asia, Malesia, Australia to Pacific.

Freycinetia spreads from Sri Lanka, Indochina, Malesia until northern part of Australia (Queensland) and New Zealand. Despite the relatively close distant between Sri Lanka and mainland India, Freycinetia has so far never been found in mainland India.

Sararanga spreads from the Philippines, New Guinea and adjacent islands (Keim, 2009 in press) to Solomon Islands (Stone, 1982).
Martellidendron has the narrowest spreading areas in the family, which covers only Madagascar and Seychelles (Callmander et al, 2003).

Figure 1: Distributions of Pandanaceae (Stone 1982; 1983)

Important distinctive morphological characters in the three main genera of Pandanaceae can be seen in Table 1.

Table 1. Some morphological character differences between three genus on Pandanaceae (Stone, 1982; 1983).

<table>
<thead>
<tr>
<th>Characters</th>
<th>Freycinetia</th>
<th>Pandanus</th>
<th>Sararanga</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit</td>
<td>Climber or low bushes</td>
<td>Bushes or trees, rarely epiphyte</td>
<td>Trees</td>
</tr>
<tr>
<td>Roots types</td>
<td>Clasping/creeping roots</td>
<td>Prop-roots is doesn’t exist in some species and never on palms roots</td>
<td>Like roots on palms family</td>
</tr>
<tr>
<td>Growth roots</td>
<td>Growth from leaf axis</td>
<td>Growth from stem basis or leaf axis</td>
<td>Only growth from part of stem basis</td>
</tr>
<tr>
<td></td>
<td>Rarely</td>
<td>absent</td>
<td></td>
</tr>
<tr>
<td>Leaves arrangement</td>
<td>Spiro-tetrastichous</td>
<td>Spiro-tristichous</td>
<td>Spiro-tetrastichous</td>
</tr>
<tr>
<td>Spines on leaf margin</td>
<td>Present, but generally, it’s only on the apex, bellow and upper part.</td>
<td>Present along the leaf margin (there are some species)</td>
<td>Always present on leaf margin</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Pandanoideae</td>
<td>Freycinetoidae</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Recurved spines</td>
<td>Absent</td>
<td>There are some species</td>
<td>Absent</td>
</tr>
<tr>
<td>Auricle</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Sexuality</td>
<td>Dioecious, but sometimes Poligamodioecious on some species</td>
<td>Dioecious</td>
<td>Dioecious</td>
</tr>
<tr>
<td>Inflorescence</td>
<td>3 or more cephalia, rarely only with 1 cephalium</td>
<td>1 cephalium or spike which consist of some cephalia</td>
<td>Panicles in the apex (terminal) and has many branches</td>
</tr>
<tr>
<td>Spathes</td>
<td>Present, the colours are different for every species</td>
<td>Present, the colours are different for every species</td>
<td>absent</td>
</tr>
<tr>
<td>Flower stalk shape from inflorescence or infructescence</td>
<td>Cylinder</td>
<td>Cylinder</td>
<td>Square</td>
</tr>
<tr>
<td>Fruit</td>
<td>Berry with 1 or more ovules</td>
<td>Drupe or phalange</td>
<td>Berries with a lot of ovules</td>
</tr>
<tr>
<td>Carpels</td>
<td>Multiovulate</td>
<td>Uniovulate</td>
<td>Uniovulate</td>
</tr>
<tr>
<td>Pollinators</td>
<td>Vertebrate, especially bat and bird</td>
<td>Wind and possibility insect</td>
<td>Insect</td>
</tr>
</tbody>
</table>

Pandan male flowers are rarely found due to the short anthesis, which is one to three days (Stone, 1983). However, the fruit development can take obviously longer time. Based on this phenomenon the classification of the pandan family is basically based on pistillate (female) individuals.

**Freycinetoidae**

Based on the structure of pistillate sex organs (most particularly the carpels, see Table 2), the family is classified into two subfamilies: Pandanoideae and Freycinetoidae.

Freycinetoidae is monogeneric consisting only one genus, *Freycinetia* with approximately 200 species (Callmander *et al*, 2003).

Table 2. Morphological differences between the subfamily Pandanoideae and Freycietoidea (Stone, 1972; Callmander *et al*, 2003).
<table>
<thead>
<tr>
<th>Sub family</th>
<th>Carpel</th>
<th>Genus</th>
<th>Total species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pandanoideae</td>
<td>Uniovulate</td>
<td>Pandanus</td>
<td>± 700 species</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sararanga</td>
<td>± 2 species</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Martellidendron</td>
<td>± 7 species</td>
</tr>
<tr>
<td>Freycinetoideae</td>
<td>Multiovulate</td>
<td>Freycinetia</td>
<td>± 200 species</td>
</tr>
</tbody>
</table>

**Freycinetia**

*Freycinetia* is characterised by at least three distinctive characters: The liana habit (i.e. climber), obvious and well-developed auricles, and one locule with numerous seeds. Despite the possession of auricle in *Pandanus pectinatus* (the only species in the genus *Pandanus* known so far to have it), it is still a good distinctive field character for *Freycinetia*. Stone (1972) regard *Freycinetia* as the most advanced member of Pandanaceae based on the liana habit and complex structure of the infructescences.

In contrast to *Freycinetia*, *Sararanga* is regarded by Stone (1972) to retain many primitive characters such as tree habit, palm-like roots, and massive-branched paniculate infructescence structure. This opinion is supported by Dahlgren *et al.* (1985) that suggested the simple inflorescence arrangement in *Sararanga* represents its primitive nature.

The results of the cladistic analyses proceeded by Cox (1990) and Cox *et al.* (1995) suggest Pandanaceae as a monophyletic family. The results also suggest that *Sararanga* and *Pandanus* are close each other rather than each to *Freycinetia*. The result of DNA analysis done by Callmander *et al.* (2003) also suggests Pandanaceae as a monophyletic family.

**Malesia and pandan’s flora**

Malesia is an important distribution area for Pandanaceae because only in this area the three important genera (*Freycinetia, Pandanus and Sararanga*) can found cohabitant (Stone, 1983). Furthermore, Malesia has the highest number species. There are two genera so far recorded in Sulawesi: *Freycinetia* and *Pandanus* (Stone, 1983; Table 3).
Table 3. Number of known species of Pandanaceae in Malesia (Stone, 1982 & 1983).

<table>
<thead>
<tr>
<th>Regions</th>
<th>Freycinetia</th>
<th>Pandanus</th>
<th>Sararanga</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malay-Peninsula</td>
<td>8-10</td>
<td>ca 50</td>
<td>-</td>
</tr>
<tr>
<td>Sumatra</td>
<td>5-7</td>
<td>ca 15-20</td>
<td>-</td>
</tr>
<tr>
<td>Java</td>
<td>5-6</td>
<td>ca 16</td>
<td>-</td>
</tr>
<tr>
<td>Borneo</td>
<td>25-30</td>
<td>&gt;60</td>
<td>-</td>
</tr>
<tr>
<td>Philippines</td>
<td>24-25</td>
<td>&gt;50</td>
<td>1</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>6-7</td>
<td>ca 5-10</td>
<td>-</td>
</tr>
<tr>
<td>Lesser Sunda Islands (Nusa Tenggara)</td>
<td>1-3</td>
<td>ca 2-3</td>
<td>-</td>
</tr>
<tr>
<td>Moluccas</td>
<td>5-10</td>
<td>ca &gt; 20</td>
<td>-</td>
</tr>
<tr>
<td>New Guinea</td>
<td>60-90</td>
<td>&gt; 100</td>
<td>1</td>
</tr>
</tbody>
</table>

**Sulawesi**

Geologically Sulawesi is a unique major island in Malesia as it has never joined either Sunda or Sahul shelves (Metcalfe, 1996; Hall, 1998; Halloway & Hall, 1998). In other words, the island that is know now as Sulawesi is actually composed of many fragments that each was oceanic island. This is in contrast with other major islands in Malesia such as Sumatra, Java, Borneo, and New Guinea. In the geological past these islands had been parts of either Sunda or Sahul shelves; thus they are continental islands. Biogeographically the island is also unique as it is located in the heart of Wallacea area, an area that is in between the two continents, Asia and Australia. As the result this area is high with floristic and faunal endemism (Whitten et al. 1987)

**Sulawesi and pandan’s flora**

The first report about the pandan flora of Sulawesi was by Solms-Laubach based on collections made by Beccari (1883; see Beccari, 1924).

Koorders (1898) collected some specimens from Minahassa (North Sulawesi) and published a new species of *Freycinetia, F. minahassae* Koord. Although he suggested the possibility of other new species of *Freycinetia* and *Pandanus* but had never been validly published.
After Beccari and Koorders, the addition of pandan Sulawesi collections was
done by Sarasin brothers (Sarasin and Sarasin, 1906; Warburg, 1900) and Kjelberg
(Fagerlind, 1941). Many of their specimens became types for some species of
Freycinetia and Pandanus.

Warburg (1900) resumed and published the known information of
Pandanaceae in a monograph. In fact this is the only monograph on the family has
been written. Four new species of Freycinetia from Sulawesi are proposed in the
monograph, in which three were proposed by Warburg himself, namely: F.
candeliformis, F. latispina, and F. sarasinorum. The other was Koorders’ F.
minahassae, in which Warburg mentioned that it probably identical with his F.
latispina.

After Warburg, the studies on pandan flora in Sulawesi were proceeded by
Martelli (1910a) and Stone (1982a). Martelli was basically reviewed the pandan
flora of Sulawesi in term of the Philippines, while Stone published two new species,
F. micrura BC. Stone and P. sulawesicus BC. Stone.

The most recent study on the pandan flora of Sulawesi was done by Keim &
Rustiami (2007). Four species of Freycinetia (F. celebica, F. minahassae, F.
oblanceolata, and F. polystachya) and two species of Pandanus (P. gladiator and P.
sarasinorum) were recorded in Doda-Lempe valley and adjacent areas of Central
Sulawesi.

There were 6 to 8 species of Freycinetia in this studies and 5 to 6 species of
Pandanus recognized in Sulawesi (Warburg, 1900; Martelli, 1910a; 1910b; 1910c;
Stone, 1983a). The pandan flora of Sulawesi is poorley understood comparing with
other areas in Malesia, such Borneo and New Guinea (Table3).

There are only 20 collections of Freycinetia from Sulawesi deposited at the
Herbarium Bogoriense, three of them are type specimens. However there are 67
type specimens from Philippines, Mollucas, New Guinea and there adjacent areas
which can be use to support the morphological studies.

In Java F. funicularis with its pinkish purple bracts is cultivated as
ornamental plants. In Moluccas the prop-roots of F. javanica and F. scandens are
used as sources of ropes. The spadix from inflorescence is eaten as vegetable. In
China, the bright red coloured bracts are used in colouring the alcoholic beverages (Heyne, 1987).

**Aims**

The aims of this study are to produce an up to date revision of *Freycinetia* in Sulawesi, to describe the relationships among the species within the genus in using the phylogenetic analysis, and try to explain the links between the species in Sulawesi and adjacent areas such as the Philippines, Moluccas, and New Guinea to understand the pattern of distribution of the genus in Sulawesi and Eastern Malesia.

**MATERIALS AND METHODS**

This study was conducted at the Herbarium Bogoriense (BO) from January 2008 to April 2009 based on 62 specimens collected from Sulawesi. Several
distinctive morphological characters (Table 4) were recorded and observed followed by identification and constructing new descriptions and identification key. The data from morphological observation were analysed for phylogenetic study implementing PAUP vers. 4.0b (Swofford, 2000).

Table 4. The distinctive morphological characters extracted from herbarium specimens.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem</td>
<td>- Shape</td>
</tr>
<tr>
<td></td>
<td>- Diameter</td>
</tr>
<tr>
<td></td>
<td>- Internode</td>
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<tr>
<td></td>
<td>- Surface</td>
</tr>
<tr>
<td></td>
<td>- Colour</td>
</tr>
<tr>
<td>Leaf</td>
<td>- Shape</td>
</tr>
<tr>
<td></td>
<td>- Measure (length and wide)</td>
</tr>
<tr>
<td></td>
<td>- Surface</td>
</tr>
<tr>
<td></td>
<td>- Basis</td>
</tr>
<tr>
<td></td>
<td>- Apex</td>
</tr>
<tr>
<td></td>
<td>- Main nerve/Mid rib</td>
</tr>
<tr>
<td></td>
<td>- Vein nerve system</td>
</tr>
<tr>
<td></td>
<td>- Account of vein nerve</td>
</tr>
<tr>
<td></td>
<td>- Distance of vein nerve</td>
</tr>
<tr>
<td></td>
<td>- Spines of margin</td>
</tr>
<tr>
<td>Auricle</td>
<td>- Type</td>
</tr>
<tr>
<td></td>
<td>- Measure (length and wide)</td>
</tr>
<tr>
<td></td>
<td>- Margin</td>
</tr>
<tr>
<td></td>
<td>- Colour</td>
</tr>
<tr>
<td>Inflorescence</td>
<td>- Position</td>
</tr>
<tr>
<td></td>
<td>- Account of bract</td>
</tr>
<tr>
<td></td>
<td>- Colour</td>
</tr>
<tr>
<td>Infructescence</td>
<td>- Account of cephalia</td>
</tr>
</tbody>
</table>

Table 4 (continued)
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedicel</td>
<td>- Account of stigma</td>
</tr>
<tr>
<td></td>
<td>- Measure (length and wide)</td>
</tr>
<tr>
<td></td>
<td>- Surface</td>
</tr>
<tr>
<td>Peduncle</td>
<td>- Length</td>
</tr>
<tr>
<td></td>
<td>- Surface</td>
</tr>
<tr>
<td>Berry</td>
<td>- Measure (length and wide)</td>
</tr>
<tr>
<td>Seed</td>
<td>- Measure (length and wide)</td>
</tr>
<tr>
<td></td>
<td>- Colour</td>
</tr>
<tr>
<td></td>
<td>- Shape</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSIONS

Biogeography
The result of this study indicates that there are thirteen species of *Freycinetia* found in Sulawesi namely: *F. amboinensis* Martelli; *F. beccari* Hemsl; *F. celebica* Solms; *F. devriesei* Solms; *F. funicularis* Merr; *F. inermis* Ridl; *F. kostermansii* B.C Stone; *F. koordersiana* Martelli; *F. minahassae* Koord; *F. ob lanceolata* Martelli; *F. polystachya* Martelli; *F. rigidifolia* Hemsl., and *F. sarasinorum* Warb.

*Freycinetia devriesei* Solms, *F. minahassae* Koord and *F.koordersiana* Martelli are commonly found inhabiting swampy forests throughout Sulawesi.

*Freycinetia oblanceolata* Martelli, *F. beccarii* Hemsl, and *F. rigidifolia* Hemsl are less distributed than the previous three species. They are found in secondary forests and montane forests.

Keim (2005) and Keim & Rustiami (2007) mentioned *F. minahassae* Koord as the widest spread species in Sulawesi. Furthermore, *F. oblanceolata* Martelli and *F. polystachya* Martelli are also reported in Sulawesi. Prior to those researches, *F. oblanceolata* Martelli was known from the Moluccas to New Guinea and *F. polystachya* Martelli from the Philippines. The result of this study is in accordance with the previous two studies, thus strengthening the floristic link (in this case in *Freycinetia*) between Sulawesi and both Moluccas and Philippines (Table 5).

<table>
<thead>
<tr>
<th>Species</th>
<th>Sulawesi</th>
<th>Philippines</th>
<th>Moluccas</th>
<th>New Guinea</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>F. amboinensis</em> Martelli</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>F. beccari</em> Hemsl</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>F. celebica</em> Solms</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>F. inermis</em> Ridl</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>F. kostermansii</em> B.C Stone</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>F. koordersiana</em> Martelli</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>F. minahassae</em> Koord</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>F. oblanceolata</em> Martelli</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>F. polystachya</em> Martelli</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>F. rigidifolia</em> Hemsl</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>F. sarasinorum</em> Warb</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Distribution of *Freycinetia* in the places in East Malesia (Stone, 1968; 1969; Merrill, 1917; 1925; Keim, 2005; Warburg, 1900).
Furthermore, the result of this study also shows that *F. rigidifolia* Hemsl is the only species that is also found in the western part of Malesia. Three species of *Freycinetia* are now also known to be existed in both Sulawesi and the Philippines (*F. devriesei* Solms, *F. minahassae* Koord, and *F. polystachya* Martelli; for the presence of *F. devriesei* Solms and *F. minahassae* Koord in the Philippines (Stone 1969). Based on these findings this current study suggests that species of *Freycinetia* in Sulawesi has stronger affinity with the eastern part of Malesia rather than with the western part. In other words, the biogeographical pattern of *Freycinetia* in Malesia is confined to Huxley’s line rather than Wallace’s line. Thus, the biogeographic patterns in *Freycinetia* in Sulawesi are explained better with Huxley’s line.

This is not completely new information in monocotyledonous plants of Malesia as Keim (2003) has observed the phenomenon in the palm genus *Orania* in Malesia. For more general flora the floristic link between Sulawesi, Philippines, Moluccas, and New Guinea itself has been postulated by Lam (1945a; 1945b). Nevertheless, the result of this study is undoubtedly new information for *Freycinetia*.

**Morphological Character**

**Habit**

Almost all species of *Freycinetia* are climbers or lianas. The Hawaiian species *F. arborea* is the only non climbing habit species.

**Stem**

**Climbing roots**

Climbing roots develop from the stem nodes and opposite the leaves. Root with diameter 2 to 3 mm can be seen in *F. funicularis* Merr and *F. minahassae* Koord.

**Leaves**

Leaf greatly varies in shape and size. Elliptical shaped leaves (8 to 33 cm long and 0.25 to 4 cm wide) are found in *F. beccarii* Hemsl, *F. celebica* Solms, *F. devriesei* Solms, *F. inermis* Ridl, *F. funicularis* Merr, and *F. rigidifolia* Hemsl. Two species are found with spatheoides leaves (20 to 45.5 cm long and 1.8 to 3.5 cm wide), which are *F. oblaneolata* Martelli and *F. kostermansii* B.C Stone. *Freycinetia amboinensis* Martelli, *F. koordersiana* Martelli, *F. minahassae* Koord., *F. polystachya* Martelli, and *F. sarasinorum* Warb. possess massive and robust lanceolate-elongate leaves (11 to 121 cm long and 0.8 to 6.5 cm wide).

Leafsheath is narrow, truncate, membranous (patch to sliver near the stem), smooth, and the margin is spineless. The colour varies from crème white to whitish green.

Auricle is mostly tapered except for one species, *F. amboinensis* Martelli that possesses lobed auricle, thus a good field distinctive character for the species. The tapered auricles also vary. In most of the species (such as *F. minahassae* Koord) the auricle has flattened and spineless margin (integer), while in *F. polystachya* Martelli and *F. rigidifolia* Hemsl the auricles have spiny-comb like margins.

The leaf margin is generally glabrous and without spines except for robust species like *F. minahassae* Koord

The adaxial surface of the leaf are always glabrous and shiny green. The abaxial surface usually with lighter green coloured and glabrous. Spines are observed in the main nerve of *F. minahassae* Koord, but not in the other species. Recurved spines have never been found in *Freycinetia*. 
The apical part of the leaf can be sharp-pointed (acute) or longer sharp-pointed (acuminate) as can be observed in *F. polystachya* Martelli, *F. amboinensis* Martelli and *F. celebica* Solms. Caudate apical part of the leaf can be seen in *F. ob lanceolata* Martelli and *F. kostermansii* B.C Stone. Minute spines sometimes are found in the apical part of the leaf. Adaxial ventral pleats have never been found in *Freycinetia*.

**Bracts**

Bracts highly vary in size and colour. Bracts usually fall soon after anthesis (i.e. caducous). *Freycinetia funicularis* Merr. is known to have white bracts. *Freycinetia amboinensis* Martelli, *F. koster mansii* B.C Stone, and *F. sarasinorum* Warb. have bright yellow bracts. Other species have yellow or bright white.

The result of this study indicates that the sizes of bracts positively correlate with the habit. Massive species like *F. funicularis* Merr and *F. minahassae* Koord each possesses large size bract, which are 10 to 14 cm long and 2.5 to 3 cm wide. On the contrary, smallest species such as *F. inermis* Ridl has the smallest bract within the Sulawesi species.

Prior to this current study, Keim & Rustiami (2007) explained that the colour of bracts in *F. minahassae* Koord is white with reddish purple on their edges. They also mentioned that the thick-fleshy bracts of *F. minahassae* Koord are often found torn and it is likely done by bats as they recorded that the bracts were in fine condition during the day when they proceeded the observation.

Van der Pijl (1956) stated that bats are the pollinator agents for many species of *Freycinetia* (such as *F. reineckei* Warb. in Samoa and *F. baueriana* Endl. in New Zealand). Indeed, as nocturnal animals, colour is not the main attractor for bats. Apparently it is the odour that plays an important role in attracting bats to *Freycinetia*, in which the thick-fleshy bracts seems to act as rewards for bats. Despite the well known information in Pacific area, it has never been reported in Sulawesi; thus, it is new information. The result of this study is in accordance with them.
The bat species in Samoa is recorded, *Pteropus samoensis* (Cox 1983; Cox 1984; Cox *et al*, 1995) and in New Zealand is *Mystacina robusta* and *M. tuberculata* (Lord, 1991). Unfortunately, there is no record on Sulawesi.

Sulawesi indeed possesses a number of endemic fruit-eating bats such as *Acerodon celebensis, Dobsonia exoleta, Rhinolophus celebensis* and *Styloctenium wallacei*. Any of these species could be the pollinator of *F. minahassae* Koord.

Colour also act as the main attractor for bird (i.e. avifauna) and Sulawesi is home for large species of birds. One of them is the gigantic Celebes hornbill (*Buceros rhinoceros*). This current study suggests that birds (especially hornbills) also play as important pollinators for *Freycinetia* in Sulawesi and this is in accordance with Cox (1982; 1983) and Lord (1991). Further study on the ecology of *Freycinetia* in Sulawesi is essential.

**Inflorescences**

Inflorescences are usually found in the apical part of the stem or terminal. Few species observed with inflorescences develop from the stem or lateral. The result of this present study indicates that there are only two species in Sulawesi with lateral inflorescences, *F. funicularis* Merr and *F. kostermansii* B.C Stone.

There is a strict difference between lateral inflorescences and terminal inflorescences found in the branch. Leaves are not found in lateral inflorescences, just bracts. On the contrary, in terminal inflorescences that are found in the branch leaves are found.

Inflorescences are rarely found in herbarium specimens. Staminate (male) inflorescences are more rarely found than pistillate (female) inflorescences and this is apparently due to the short period of the anthesis in male flowers, which is one to three days only (Stone 1983). Male inflorescences consist of densely packed male flowers, each with mass of stamens.

**Flowers**

Staminate flowers are minute and constituted only perianth. Each flower is composed of numerous stamens. Each stamen is with long filament. Anther usually
has darker colour than filament. Pistillate flowers are not observed in this current study.

**Sexuality**

Although a tendency to monoecious in Freycinetia is observed in *F. reineckei* (Cox 1981; Cox *et al.*, 1984; see Poppendieck 1987), it is not observed in the species from Sulawesi. Thus, species of *Freycinetia* from Sulawesi are strictly dioecious.

**Infructescences**

Infructescences are commonly umbel with three (triad) to four (quaternate) spirally arranged cephalia. Less than three cephalia per infructescence can be seen in *F. celebica* Solms, which possesses one (spadix) to two (binate) cephalia. More than four cephalia per infructescence is observed in *F. polystachya* Martelli.

As in inflorescences, infructescences are usually located on the apical part of the stem or terminal. *Freycinetia funicularis* Merr and *F. kostermansii* B.C Stone are two species found in Sulawesi with lateral infructescences, which mean their infructescences appear from the stem. The difference between lateral and terminal infructescences on branches is the same as in inflorescences.

Peduncle is short (usually 1 cm long or less), but robust species like *F. amboinensis* Martelli, *F. funicularis* Merr, *F. minahassae* Koord. are observed with peduncle reach 2 cm long.

The surface of the pedicel can be smooth (glabrous) or with scales (scaly or scabrous) and it is an important distinctive morphological characters. In the species from Sulawesi the length of pedicel is recorded ranging from 2.5 to 5.5 cm, while the width is ranging from 0.5 to 1.2 cm. Pedicel is always longer than peduncle, even in the robust species.

**Cephalium**

The main generative organ in *Freycinetia* is the structure composed of numerous uniloculate-multiovulate densely attached fleshy fruits. This structure is called cephalium (plural cephalia). Cephalia varies in shape, size, and colour.
Rounded (globose) cephalia is found in *F. devriesei* Solms (2.5 cm long and 2 cm wide). Much smaller globose cephalia can be seen in *F. inermis* Ridl.

Actually most species possess elliptical to elongated ellipsoidal cephalia. These cephalia is indicated by the length is more than twice the width. Large ellipsoidal cephalia (usually with 8 to 8.5 cm long and 2 to 4 cm wide) are observed in *F. minahassae* Koord. and *F. polystachya* Martelli, while much smaller size (1.2 to 1.7 cm long and 0.55 to 0.7 cm wide) can be seen in *F. funicularis* Merr. and *F. beccarii* Hemsl.

Based on field notes attached onto the observed specimens data concerning the colour of cephalia can be obtained such as red in *F. inermis* Ridl and yellowish green in *F. polystachya* Martelli. Staminodes are rare or not commonly seen.

**Berries**

The uniloculate-multiovulate fleshy berry is actually the fruit. Numerous berries form the complex fruit known as cephalium. A berry consists of numerous gynaecia, each with 1 to 2 stigmatic remains. Berries vary in form. Needle-like (filiform) berries are observed in *F. minahassae* Koord.

Rostrate berries are found in *F. devriesei* Solms and *F. kostermansii* B.C Stone. *Freycinetia amboinensis* Martelli and *F. sarasinorum* Warb have minute berries (1.5 to 3 mm long and 1 to 2 mm wide), but not needle-like. Apical part of berries is usually hard and stiff, while basal part or pileus usually less hard, fleshy and husky.

**Seeds**

Seeds are small, elliptical to oblong (0.2 to 0.3 mm long and 0.1 to 0.2 mm wide). In this current study, seeds are observed in *F. inermis* Ridl, *F. beccarii* Hemsl, *F. amboinensis* Martelli. The embryo is much smaller with homogenous endosperm.
Uses

The result of this study records that in Sulawesi there are only two species known to be used by the local people, *F. celebica* Solms and *F. koordersiana* Martelli. The stem of *F. celebica* Solms is used for trapping birds and other small animals (Purwanto *et al.* 23, *pers note*) The leaves of *F. koordersiana* Martelli are used as medicinal for after-birth treatment, in which the leaves are boiled then given to the mother after labour (childbirth) to clear the womb (Vogel & Vermenten 6997, *pers note*)

Phylogenetic Analysis

Phylogenetic analysis proceeded in this current study implementing PAUP vers 4.0b as was modified by Swoffort (2000) and involving 30 morphological characters (Table 6). After the first analysis has been completed, seven characters (numbers 7, 11, 14, 15, 21, 23, and 24) turn out to be less informative as the CI values are low (0.25, 0.3, 0.3, 0.4, 0.4, 0.3, and 0.2 respectively). The analysis then was repeated with these seven uninformative characters excluded. Each of the characters was scored and presented in a matrix as can be seen in Table 6. Bootstrap method is implemented.

The result of the second analysis is a tree with length of 87 (i.e. tree length 87), CI value of 0.6897, HI 0.3103, RI 0.5909, and RC 0.4075. The result of this study indicates that the genus *Freycinetia* in Sulawesi is monophyletic as supported by bootstrap supporting value of 70% (Fig.2). This result in someway supports Stone (1974).

Table 6. Morphological characters and character states used for the phylogenetic analysis.

<table>
<thead>
<tr>
<th>No.</th>
<th>Character</th>
<th>Character states</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stem shape</td>
<td>0=terete; 1=trigonal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2.</td>
<td>Stem diameter</td>
<td>0=0,3-0,9 cm; 1= 1-2,5 cm; 2= 2,6-4 cm; 3= &gt; 4 cm</td>
</tr>
<tr>
<td>3.</td>
<td>Stem colour</td>
<td>0= pale yellow to gold yellow; 1= yellowish brown; 2= reddish brown; 3= yellowish brown to reddish; 4. blackish brown</td>
</tr>
<tr>
<td>4.</td>
<td>Internodes</td>
<td>0=0,3-1,35 cm; 1=1,6-2,25 cm; 2=2,95-4 cm</td>
</tr>
<tr>
<td>5.</td>
<td>Leaf shape</td>
<td>0=small ellips; 1=medium ellips; 2=great ellips; 3=small linear; 4=medium linear; 5=great linear; 6=oblanceolate</td>
</tr>
<tr>
<td>6.</td>
<td>Leaf apex</td>
<td>0=acute; 1=acuminate; 2=caudate</td>
</tr>
<tr>
<td>7.</td>
<td>Number of nerves</td>
<td>0= &lt; 20; 1=21-39; 2= &gt; 40</td>
</tr>
<tr>
<td>8.</td>
<td>Distance of the nerves</td>
<td>0= &lt; 1 mm; 1= &gt; 1 mm</td>
</tr>
<tr>
<td>9.</td>
<td>Spines on leaf margin</td>
<td>0= throughout on leaf margin; 1= on basis and apex leaf; 2= only on apex leaf</td>
</tr>
<tr>
<td>10.</td>
<td>Main nerve</td>
<td>0= distinct; 1= less distinct; 2= sharp; 3= thick, sharp on apex</td>
</tr>
<tr>
<td>11.</td>
<td>Spines on main nerve</td>
<td>0= throughout on main nerve; 1= spines on middle and apex of main nerve; 2= only on apex</td>
</tr>
<tr>
<td>12.</td>
<td>Auricle type</td>
<td>0= tapered; 1= lobed</td>
</tr>
<tr>
<td>13.</td>
<td>Auricle margin</td>
<td>0= spines; 1= integer</td>
</tr>
<tr>
<td>14.</td>
<td>Dimension of auricle</td>
<td>0= 1-2,5 cm; 1= 2,6-4 cm; 2= 4,1-5,5 cm</td>
</tr>
<tr>
<td>15.</td>
<td>Colour of auricle</td>
<td>0= transparent; 1= brownish; 2= brown</td>
</tr>
<tr>
<td>16.</td>
<td>Nerve of auricle</td>
<td>0= long line with spot; 1= long line without spot; 2= curve line; 3= without long line(smooth)</td>
</tr>
<tr>
<td>17.</td>
<td>Colour of bracts</td>
<td>0= yellow; 1= white with reddish colour on margin; 2= white; 3=orange to bright red</td>
</tr>
<tr>
<td>18.</td>
<td>Number of stigma</td>
<td>0= 1; 1= 2-3; 2= &gt; 3</td>
</tr>
<tr>
<td>19.</td>
<td>Position of infructescences</td>
<td>0= terminal; 1= lateral</td>
</tr>
<tr>
<td>20.</td>
<td>Type of infructescences</td>
<td>0= spadix; 1= umbella; 2= panicle; 3= racemose</td>
</tr>
<tr>
<td>21.</td>
<td>Number of cephalia</td>
<td>0= 1 or 2 ; 1= 3; 2= &gt; 3</td>
</tr>
<tr>
<td>22.</td>
<td>Cephalia shape</td>
<td>0= globose; 1= ellips/ovalis; 2= oblong; 3= lanceolate (like sausage); 4=reniformis</td>
</tr>
<tr>
<td>23.</td>
<td>Pedicel shape</td>
<td>0= terete; 1= half terete</td>
</tr>
<tr>
<td>24.</td>
<td>Pedicel surface</td>
<td>0= glabrous; 1= scabrid</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>25.</td>
<td>Length of peduncle</td>
<td>0= very short to nearness absent; 1= 0,8-2,5 cm; 2= 2,6-4 cm; 3= &gt; 4 cm</td>
</tr>
<tr>
<td>26.</td>
<td>Peduncle shape</td>
<td>0= terete; 1= tetranguler</td>
</tr>
<tr>
<td>27.</td>
<td>Shape of berries</td>
<td>0= very short; 1= filiformis; 2= elongate (non filiformis); 3= rostrate; 4= obovate</td>
</tr>
<tr>
<td>28.</td>
<td>Type of berries</td>
<td>0= berry; 1= drupa</td>
</tr>
<tr>
<td>29.</td>
<td>Seed shape</td>
<td>0= ellips; 1= linear; 2= moon cresent; 3= obdeltoid; 4= triangular</td>
</tr>
<tr>
<td>30.</td>
<td>Seed colour</td>
<td>0= white; 1= creamy; 2= brown; 3= blackish brown; 4= black; 5= pink</td>
</tr>
</tbody>
</table>
Table 7. Data matrix of morphological characters used for the phylogenetic analysis of the genus *Freycinetia* in Sulawesi

| Taxa               | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |
| *P. nitidus*       | 0 | 1 | 1 | 0 | 5 | 1 | 1 | 0 | 0 | 2 | 0 | - | - | - | - | ? | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 1 | 3 | ? |
| *Sararanga sinuosa*| 0 | 3 | 4 | ? | 5 | 0 | ? | ? | 0 | ? | 0 | - | - | - | - | - | - | 0 | 0 | 2 | ? | 4 | 1 | 0 | 3 | 1 | 2 | 0 | 4 | 1 |
| *F. amboinensis*   | 0 | 1 | 1 | 1 | 4 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 |
| *F. beccarii*      | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 0 | ? | 0 | ? | ? | ? | ? | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 1 | 0 | 3 | 0 | 0 | 2 |
| *F. celebica*      | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | ? | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| *F. devriesei*     | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 2 | ? | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 1 | 1 |
| *F. funicularis*   | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 2 | ? | 2 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 4 |
| *F. inermis*       | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 1 | 4 | ? | 1 | 0 | 1 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 3 |
| *F. koordersiana*  | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 1 | 1 | 2 | 1 | ? | 1 | 0 | 1 | 2 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 3 |
| *F. kostermansii*  | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 1 | 0 | 1 | 2 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 4 |
| *F. minahassae*    | 0 | 1 | 0 | 2 | 5 | 1 | 1 | 0 | 0 | 3 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 1 | 3 |
| *F. oblanceolata* | 0 | 0 | 1 | 2 | 6 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | ? | 1 | 0 | 1 | 1 | 2 | ? | 0 | ? | 0 | 2 | 0 | 1 | 5 |
| *F. polystachya*   | 0 | 1 | 0 | 1 | 4 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 1 | ? | 1 | 0 | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 3 |
| *F. rigidifolia*   | 0 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 3 | 3 | 1 | 0 | 3 | 2 | 2 | ? | 1 | ? | 0 | ? | 0 | ? | ? |
| *F. sarasinorum*   | 0 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 2 | 1 | 2 | 1 | 0 | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 4 |

Figure 2. A strict consensus of 16 most parsimonious trees with bootstrap support value.

*Freyceinetia funicularis* Merr and *F. kostermansii* B.C Stone are in the same clade within clade I and supported by the high bootstrap value of 79% suggests very close relationship. The result of this current study suggests that the two species united by at least 17 morphological characters (numbers 1, 2, 4, 5, 6, 10, 12, 16, 18, 19, 20, 22, 26, 27, 28, 29, and 30). Among these seventeen characters, the two species are apparently united only by one very informative (i.e. strong) morphological character, character number 19 (the position of the
infructescence). Both *F. funicularis* Merr and *F. kostermansii* B.C Stone have lateral infructescences. Furthermore, the result of this current study is in accordance with Stone (1968) in placing the two species into the same section, *Lateriflorae*.

*Freycinetia devriesei* Solms is suggested to be the closest sister species to the clade that unites *F. funicularis* Merr and *F. kostermansii*. B.C Stone. The clade is supported by the bootstrap value of 52%. Although nine characters (numbers 2, 10, 16, 18, 19, 20, 26, 27, and 28) are involved in forming the clade that unites the three species, only two characters that are actually informative, characters number 19 and 27. *Freycinetia devriesei* Solms shares the possession of lateral infructescences and rostrate berries. This result raises a question that the section *Lateriflorae* is suggested to have a close relationship with the section *Devriesella*. However, this result is still preliminary; thus, further study with more taxa involved is needed.

Although without bootstrap supporting value, *F. beccarii* Hemsl is regarded as the sister species to the clade that unites *F. funicularis* Merr, *F. kostermansii* B.C Stone, and *F. devriesei* Solms. This can also be interpreted that Stone’s section of *Oligostigma* (see Stone 1968) is regarded to have a close relationship with both sections *Lateriflorae* and *Devriesella*. This is also a preliminary result, further study is essential.

The other species within clade I (*F. amboinensis* Martelli from section *Auriculifoliae*, *F. polystachya* Martelli from section *Polystachyae*, and *F. rigidifolia* Hemsl from section *Hemsleyella*) are without supporting bootstrap values. Thus, the relationships with the other species are not as supported as the previous.

*Freycinetia inermis* Ridl and *F. koordersiana* Martelli are suggested to have a closer relationship as shown in the clade (clade II) and supported by the high bootstrap value of 82%. Nineteen supporting morphological characters are character numbers 1, 2, 4, 6, 8, 9, 10, 12, 13, 17, 18, 19, 20, 25, 26, 27, 28, 29, and 30. However, despite the high bootstrap supporting value, none of these
characters can be regarded as a decisive informative character that constructs the clade.

*Freycinetia minahassae* Koord, *F. ob lanceolata* Martelli, and *F. sarasinorum* Warb are unresolved in the tree, there is not enough supporting value to place any of them in either clade I or II. Thus, they occupy clades on their own. One interesting discovery is that despite the fact that *F. ob lanceolata* Martelli is placed in the same section as *F. beccari* Hemsl in Stone’s infrageneric classification (see Stone 1968), which is Oligostigma but the tree does not suggest a close relationship.

**Taxonomy**

**Generic Description**

*Freycinetia* Gaudich


Woody dioecious climbers with clasping adventitious roots. Leaves simple, spirally arranged in 3 ranks (tristichous); leaf linear, oblong, ellipse, lanceolate or ob lanceolate; margin integer or serrate-dentate; leaf base clasping the stem to form leafsheath; auricles present, membraneous, usually caducous. Male inflorescence terminal or lateral; bracts marcescent; peduncle short; pedicel glabrous or scabrous; inflorescence consists of numerous crowdedly arranged stamens; pistillodes absent; anther sub globose; anthesis short, 1 to 3 days only. Pistillate inflorescences consists of numerous multiovulate gynoecia. Infructescences terminal or lateral, consists of 1 to 4 (rarely more than 4) cephalia; cephalia arranged in umbel or racemose; peduncle short, almost absent; pedicel much longer than peduncle, glabrous or scabrous. Berry prismatic to needle-like, multiloculate, baccate when ripe, usually with rigid or coriaceous pileus; stigma 1
to 12 (rarely more), microscopically papillate, often within a low rim. Seeds numerous on vertical placentae corresponding to each stigma, usually elliptic or hemi-elliptic to falcate, with a noticeable translucent raphe with some silvery raphidophorous cells, and sometimes a similar andopposite strophiole. Embryo minute, within endosperm.

**Key to the Species of *Freycinetia* in Sulawesi**

1. Infructescence lateral ................................................................. 2
   Infructescence terminal ............................................................ 4

10. Cephalium narrowly ellipsoidal (40 – 42 × 5 – 10 mm)........... F. koordersiana
   Cephalium never narrow ................................................................. 11
11. Leaf narrowed ellipsoidal, acute apex ........................................... F. inermis
   Leaf spathoideous or oblanceolate, acuminate apex ............ F. oblanceolata
12. Berry filiformis (needle-like,5 – 10 × 0.6 – 2 mm) ............... F.minahassae
   Berry prismatic (1.5 – 2 × 0.5 – 0.8 mm), never filiformis (needlelike).........
   .......................................................................................... F. sarasinorum

Enumeration of Species
1. Freycinetia amboinensis Martelli, Webbia. iii. 170. (1910). Type : Indonesia,
   Maluku, 6-4-1980, B.C Stone 158b (Holotype BO!) (Fig. 3).

Moderate scandens/climber, climbing up to 35-40 m high. Stem
cylindrical 0.7-1.3 cm in diameter; internode 1.2-2 cm, surface glabrous,
yellowish brown, covered by densely spirally arranged leaves, Leaf linear, each
leaf 50-75 cm long, 1.5-2 cm wide, apex acuminate, adaxial surface glabrous,
abaxial surface with sparse brown tomentose, spines on 1/4 - 1/3 part of leaf
basally and acuminate apex, in between hardly seen or absent; leafsheath 5 cm
long, amplexicaulis; Auricle present, observed clearly, lobed, 4-5 cm long, 1-1.3
cm wide, spines, brownish with longitudinal line and brown spot; main nerve
thick with spines on part of middle and apex main nerve, vein nerve
paralellinervis, amount of vein nerve 20-24 pairs, distance between two nerves
0.4-0.5 mm, closed. Infructescence terminal, ternate, cephalia elongate, green,
4.2 cm long, 1 cm wide; pedicel half terete, scabrid, 3 cm long, 0.6 cm wide;
peduncle 2 cm long; bracts bright yellow. Berry very short, 3 mm long, 1 mm
wide, green. Seeds ellipsoid 0.4 mm long, 0.2 mm wide, black. Stigmatic remains
2.

Specimen examined :
Indonesia, Sangir and Talaud Island, Talaud, Karakelang, SW Slope of G. Duata,
7-5-1926, H.J. Lam 2891 (BO!); Laloemboelan, Pakoe Oere, 8-4-1895, SH.
**Koorders** 18459 β (BO!); Celebes, G. Kawatak, 6-7-1954, *AHG Alston* 16246 (BO!)

**Distribution**: Sangir and Talaud Island, Talaud; Celebes

**Habitat**: Lowland tropical rainforest at about 150 to 400 m altitude.

**Uses**: Not recorded

**Vernacular name**: Aretes (Loloemboelan by Pakoe Oere)

**Notes**: *Freycinetia amboinensis* Martelliis easily recognised in the field through the possession of lobed auricle with short spines on its margin. In fact this is the only species known in Sulawesi to possess the lobed auricle. The other field characters are number of stigma 2 and the bright eye-catching yellow bracts (see Martelli 1940; Warburg 1900).
Figure 3: *Freycinetia amboinensis* Martelli. A. habit. B. infructescence ternate. C. fruit.

Climbing pandan. **Stem** cylindrical, 0.4-0.45 cm in diameter, distance between two leaves 10-12 mm long, glabrous, reddish brown coloured. **Leaf** narrowly ellipsoidal, 8.3-9 cm long, 1.3-1.7 cm wide, glabrous, apex acuminate, integer margin except on apical and basal part with minutes spines; leafshead not clearly seen. **Auricle** not clearly seen, presumable tapered; vein nerve sharp; spines on apical/terminal part; vein nerve paralellinervis; distance between two vein nerve 1mm, amount of vein nerve 12-14 pairs. **Infructescence** terminal, cephalia quaternate, each cephalia 1.7 cm long, 0.55 cm wide, cephalia oblongus/elongate globose; pedicel half terete, glabrous, 1.7 cm long, 0.15 cm wide; peduncle 1.1 cm. **Berry** small obviously not filiform or rostrade, 0.15 cm long, 0.5 mm wide. **Seeds** ellipsoid in shape, 0.3 mm long, 0.2 mm wide, brown coloured. **Stimatic** remains 2.

**Specimen examined**
Indonesia, Celebes, Nokilalaki mountain, SouthEast Lindu Lake to Sidaunta, 4-5-1975, *W. Meijer* 10026 (BO!)

**Distribution**: Celebes

**Habitat**: Lower montane forests at 1000-1500 m altitude.

**Uses**: Not recorded

**Vernacular name**: Not recorded

**Notes**: *Freycinetia beccarii* Hemsl is identified in the field by the small bracts, small female spadix, ternate infructescence, and numbers of stigma 2 to 3.
3. *Freycinetia celebica* Solms. Linnaea. xLII (1878). 103. Type: Indonesia, Sulawesi, first possibility 1970, *Forsten sn* (Holotype B†); Type; Ceram, *G.H de Vriese*, 1857-1861 (Holotype L) (Fig. 5).


Apparently moderate scandens/climber, climbing up to 60 feet high. **Stem** cylindrical, 0.3-0.6 cm in diameter, glabrous, distance between two leaves 0.5-1 cm, pale yellow to gold yellow. **Leaf** very narrowly ellipsoidal, 14-33 cm long, 0.7-1.8 cm wide, apparently darkgreen coloured, both surface glabrous, leaves thin almost like paper (chartaceus), apex acuminate, very minute spines observed on basal and apex part; main nerves thick toward apex sharp, spine observed on basal and apex part of main nerve, vein nerve paralellinervis; almost vein nerve 8-16 pairs, distance between two vein nerve 0.3-0.8 mm, closed; **Auricle** tapered, transparent with longline and brown spot, 0.5-2.3 cm long, 0.5-2.5 mm wide, spines. **Infructescence** apparently terminal, spadix/single with one cephalium or binate with two cephalium, cylindrical/oblong, 5-9.5 cm long, 1-2 cm wide, unequal; pedicel very short or absent; peduncle cylindrical, glabrous, 3-3.5 long, 0.5-1 cm wide. **Berry** polystigmatic, each berry 2.5-5 mm long, 1.2-3 mm wide. **Seed** ellipsoidal, white, 0.8-1.5 mm, 0.2-0.5 mm wide. **Stigma** remains apparently 6-8.

**Specimen examined**
Distribution: North Sulawesi

Habitat: Hill slope on secondary forests at 1100 to 1350 m altitude.

Uses: Stem used for rope of a bird and other animal trap.

Vernacular name: Aretes (Tontemboan, Tombulu), Sinsing (Mongondow).

Notes: Prior to this current study, *F. celebica* Solms has been considered as the most illusive species in Sulawesi (see Keim & Rustiami 2007). *Freycinetia celebica* Solms is straightforwardly recognised in the field through 2 distinctive morphological characters; the possession of 1 to 2 cephalia in an infructescence and numbers of stigma 6 to 8. Stone (1969b) placed *F. candeliformis* into synonymy. The result of this current study is in accordance with him.
Figure 5: Freycinetia celebica Solms. A. habit. B. Cephalia. C. Fruit.
D. Stigmatic remains. A. from Girmansyah 2009.

Moderate scandens/climber, up to 10 m high. **Stem** angular/triangle shape, 4-6 mm in diameter, distance between two leaves 10-17 mm, apparently glabrous, rather reddish brown dry on dry material observed. **Leaf** narrowly ellipsoid-very narrowly ellipsoid, green, 13.5-17 cm long, 0.9-3.5 cm wide, both surface glabrous, apex acuminate, leafsheath short 2.5 cm long; spines present, very small/minute, sparsely on the long leaf margin; main nerve thick, spines present on long main nerve, vein nerve paralellinervis, distance between two vein nerve 0.5-1 mm, unclosed, amount vein nerve 10-19 pairs. **Auricle** present, 1.5-2.1 cm long, 7 mm wide, apparently lobed, spines present, transparent, with curved lines. **Infructescence** terminal and lateral,cephalia quaternate, each cephalia 2.5-4.5 cm long, 0.8-2 cm wide; peduncle 1 cm long; pedicell cylindrical, glabrous, 1.5-2.5 cm long, 1.5-2 mm wide. **Berry** rostrate, green, 3-8 mm long, 1-3 mm wide, young fruits green coloured, after mature fruits red coloured. **Seed** linear, creamy, 1.5-2.5 mm long, 0.2-0.5 mm wide. **Stigmatic** remains 4,5,6, mostly 4.

**Specimen examined**


**Distribution** : North Celebes; SouthEast Celebes

**Habitat** : Usually sparsely dispersed at the edge of lowland tropical rainforests at altitude of 700 m.

**Uses** : Not recorded

**Vernacular name** : Aretes (Tontemboan), Wuwuk

**Notes** : *Freycinetia devriesei* Solms is the only species known in Sulawesi to have rostrate berries; thus the unique morphological character for the species. Other
important field characters are the trigonal shape of the stem and the possession of both terminal and lateral infructescences.

Figure 6: Freycinetia devriesei Solms. A & B. habit with infructescence. C. fruit. A. from Girmansyah 2009.
5. *Freycinetia funicularis* Merr. Interpr. Rumph. Herb. Ambon. 83 (1917). Type: Ind, SW Celebes, Lombosang, 7-5-1921, *Bunnenmeyer* 11421 (Holotype BO!) (Fig. 7).

Rather robust climber/scandens. **Stem** cylindrical, 0.8-1 cm in diameter, distance between two leaves 1.5-3 cm, apparently glabrous, reddish brown coloured. **Leaf** narrowly ellipsoid, amplexicaulis, 12-12.5 cm long, 2.5-2.8 cm wide, both surface glabrous, apex acuminateg, main nerve sharp, vein nerve parallellinervis, distance between two vein nerve 1 mm, unclosed, amount vein nerve 7 pairs; spines hardly seen on apex more apparent. **Auricle** tapered with spines, 1.7-2.2 cm long, 0.3 cm wide, brownish coloured with curved line; leafsheath short, 2.25 cm long. **Infructescence** lateral, quaternate, each cephalia 0.7-1.2 cm long, 0.5-0.7 cm wide, ellipsoid shape; pedicel 1.5-1.8 cm long, 0.18-0.2 cm wide, apparently glabrous, cylindrical; peduncle short. **Male inflorescence** present 7,5-8 cm long, 0,3 cm wide, light creamybrown coloured; pedicel 4 cm long. Bracts 6 obvious, white coloured, greater bracts 10-14 cm long, 2.5-3 cm wide, other bracts smaller 4.5-5 cm long, 2.5 cm wide, spirally arranged. **Berry** short, prismatic shape, 0.2-0.5 cm long, 0.08-0.15 cm wide, apparently orange when mature and still fresh. **Seed** ellipsoid shape, 0.3-0.9 mm, 0.2-0.4 mm wide, black coloured. **Stigmatic** remains 3

**Specimen examined**
Indonesia, South Celebes, Lake Matano, 29-06-1979, *van Balgooy*, 3790 (BO!); Celebes, Todjamboe, 21-6-1929, *G Kjellberg* 1713 (BO!)

**Distribution** : South Celebes.
**Habitat** : Commonly found in ultrabasic soil at low altitude (400 m) or lowland tropical rainforests at about 1000 m altitude
**Uses** : Not recorded
**Vernacular name** : Ind, Maluku : Kakuri bunga merah, Pandan merah, Pandan tali.
**Notes** : *Freycinetia funicularis* Merr is straightforwardly identified in the field by
the lateral infructescences, small-short prismatic berries, and the number of stigma 4 to 6.

Figure 7: Freycinetia funicularis Merr.  A. habit.  B. infructescence.  C. male inflorescence. D. fruit
6. *Freycinetia inermis* Ridl. Trans. Linn. Soc. II. Bot. 9: 236. 1916. Type: C. Sulawesi, Mt. Roroka, Timbu. W Slope, 8-5-1979, *V. Balgooy* 3216 (Isotype BO; Holotype=L) (Fig. 8).

Apparently cylindrical climber up to 8 m high. **Stem** 0.4-0.7 cm in diameter, distance between two leaves 0.8-1.7 cm, glabrous, yellowish brown to reddish brown coloured. **Leaf** very narrowly ellipsoid, 8-13 cm long, 1.3-1.8 cm wide, rather like chartaceus, leaf both surface apparently glabrous, apex acuminate, spines found throughout length of leaf margin, main nerve thick, spines found throughout length of main nerve, vein nerve paralline nervis; amount vein nerve 8-10 pairs, distance between two vein nerve 0.4-1 mm, unclosed. **Auricle** tapered, integer, 0.7-1.5 cm long; 0.1-0.12 cm wide, brownish coloured without long lines and spots. **Infructescence** terminal, quaternate, yellowish green to reddish coloured, each cephalia 2 cm long, 1 cm wide, ellipsoidal shape, peduncle very short, 1-1.5 cm long; pedicel half terete, glabrous, 2-2.5 cm long. **Berry** yellowish green or reddish green, 1.1-1.5 mm long, 0.7-1 mm wide. **Seed** small ellipsoid shape, 0.2-0.3 mm long, 0.1-0.2 mm wide. **Stigmatic** remains 2

**Specimen examined**

**Distribution**: Central Celebes

**Habitat**: Gentle slopes on depleted forests or on very wet flat alluvial soil in lowland tropical rainforest at altitude 970 to 1000 m.

**Uses**: Not recorded

**Vernacular name**: Not recorded
Notes: Merrill & Perry (1939) described the species as easily identified by the white chromatic bracts and red berries. The result of this present study is in accordance with them and added narrowed leaves on the list.

Figure 8: Freycinetia inermis Ridl. A. habit. B. infructescence

Apparently medium to robust climber, up to 4-5 m high. **Stem** cylindrical, 0.6-1.2 cm, distance between two leaves 1.5-2.5 cm, glabrous, pale yellow coloured. **Leaf** narrowly ellipsoid, 17.5-29 cm long, 2-4 cm wide, glabrous, apex acuminate, spines on leaf margin apparently obvious more on basal and terminal part. **Auricle** tapered, rather rotundate, integer with curve lines, 2-3.7 cm long, 2 mm wide, transparent; main nerve sharp, part of terminal or apical with spines; vein nerve paralelivenervis, distance between two vein nerve 0.7-1 mm, closed, amount of vein nerve 15-20 pairs; bracts 9 bright yellow. **Infructescence** lateral, ternate, each cephalia ellipsoid in shape, 1.5-4 cm long, 1.3-2.3 cm wide; pedicel cylindrical, scabrid, 1.3-2.5 cm long, 1.3-2.3 cm wide. **Berry** rostrate, 2-6.5 mm long, 1mm wide. **Seed** ellipsoid, black, 0.2-0.4 mm long, 0.1-0.2 mm wide. **Stigmatic** remains 3,4,6,8, mostly 4.

**Specimen examined**: Indonesia, outh West. Celebes, Lombosang, 7-5-1921, *H.A.B Bunnemeijer* 11421 (BO!); Celebes, Malino boven Morasbi, *A. Rant* 444 (BO!); Celebes, Timampoe, 6-9-1920, *Kjellberg* 2301 (BO!)

**Distribution**: SouthWest Celebes.

**Habitat**: Lowland tropical rainforest at 700 m altitude.

**Uses**: Not recorded

**Vernacular name**: Not recorded

**Notes**: The oblanceolate or spathoideous leaves are possessed by both *F. kostermansii* B.C Stone and *F. ob lanceolata* Martelli; however, *F. kostermansii* B.C Stone has number of stigmas 5 to 9 (see Stone 1962), while *F. ob lanceolata* Martelli1 to 2 (see Martelli 1910c). The result of this current study shows that the number of stigma most commonly found in observed specimens of *F. kostermansii* B.C Stone (including the isotype kept in BO, *A. Kostermans* 1193) is 8.
Figure 9: *Freycinetia kostermansii* B.C Stone. A. habit. B. infructescence. C. bract. D. fruit
8. *Freycinetia koordersiana* Martelli. Webbia. iii. 171 (1910). Type: Indonesia, NorthEast Celebes, Manado, Pinamorongan, 26-2-1895, *Koorders* 18461β (Holotype BO!) (Fig. 10).

Apparently cylindrical climber pandan up to 20 m high. **Stem** cylindrical, 4-8 mm in diameter, distance between two leaves 1-1.5 cm long, glabrous, yellow coloured. **Leaf** ellipsoid shape, apparently dark green when still fresh, 18-19 cm long, 0.8-1.5 cm wide, both surface apparently glabrous, apex acuminate, spine rather obvious found throughout length of leaf margin; main nerve thick but toward on terminal part sharp; spines on main nerve at abaxial surface at middle and terminal part; vein nerves parallelinervis, distance between two vein nerve 0.3-0.4 mm, closed; amount vein nerves 12-20 pairs. **Auricle** tapered, integer, 1-4.5 cm long, 2.5-11 mm wide, brownish coloured with the vague long line. **Infructescence** terminal, ternate/quaternate, each cephalia elongate, 4-4.2 cm long, 0.5-1 cm wide; pedicel half terete, scabrid, 1.7-3 cm long; bracts 9. **Berry** green if mature red coloured, not filiform in shape, berry very small-short, 1-3 mm long; 1 mm wide. **Seed** small, crescent moon shape black coloured, 0.3-0.4 mm long, 0.2 mm wide. **Stigmatic** remains 2.

**Specimen examined**
Indonesia, SouthEast Celebes, Rumbia, 20-9-1909, *J. Elbert* 3103 (BO!); Celebes, Paloe 10 km East of Lindu Lake to the top of Mountain Nokilalaki, 9-7-1939, *S. Bloembergen* 3974 (BO!); Gorontalo, Suwawa, Tulabolo, Matombo, 23-12-1994, *Afriastini & Rohajawati JJA* 2877 (BO!); North Celebes, Bolang Mongondow, Dumoga Bone Nat. Park, Mountain Mogogonipa, 5-4-1985, *De Vogel & Vermenten* 6997 (BO!)

**Distribution** North Celebes; Gorontalo; SouthEast Celebes.

**Habitat**: From lowland tropical rainforest at 350 m altitude to montane forest at 2200 m altitude.

**Uses**: Leaves are boiled than given to the mother after labour (childbirth) to clear the womb.

**Vernacular name**: Aretes

**Notes**: *Freycinetia koordersiana* Martelli is recognised by the small elongated ellipsoidal cephalium (4.2 cm × 1 cm) with diameter 0.5 to 1 cm. In appearance the cephalium looks like a potato french-fries. Other character is the pyramidal shaped berry with 2 stigmas.
Figure 10: Freycinetia koordersiana Martelli. A. habit. B. infructescence. C. fruit
9. *Freycinetia minahassae* Koord. Mede deel Van’s Lands Plantentuin xix (1898). 267 & 638. Type: Indonesia, North East Celebes, Manado, Minahasa, 12-3-1895, *Koorders* 18465β (Holotype BO!) (Fig.11).


Robust climber up to 3 m high. **Stem** cylindrical, 0.6-2.2 cm in diameter, distance between two leaves 0.5-7.5 cm long, glabrous, yellow coloured. **Leaf** great linear, amplexicaulis, 47-121 cm long, 2.5-6.5 cm wide, both surface apparently glabrous, apex acuminate; margin with spines throughout the length but more prominent at terminal and basal part; leafsheath 5.5 cm long. **Auricle** tapered, integer, 5 cm long, 0.3-2 cm wide, brownish coloured with long lines without spots; main nerve thick toward to apex sharp with spines on apex part, vein nerve paralellinervis, distance between two vein nerve 0.5-1 mm, amount vein nerve 22-36 pairs. **Infrcustescence** is very robust and filiform carpel, terminal, ternate; each cephalia 8-18.5 cm long, 2-4.5 cm wide, oblongus shape; pedicel half terete, scabrid, 2.5-5.5 cm long.; 0.5-1.2 cm wide. **Berry** filiformis, 0.5-1 cm long, 0.6-2 mm wide. **Seed** ellipsoid shape, 0.3-0.8 mm long, 0.2-0.3 mm wide, blackish brown coloured. **Stigmatic** remains 2.

**Specimen examined**
South Celebes, SouthWest Soroako, Wawonseru mountain, 29-6-1979, E. Hennipman 6078 (BO!); North Celebes, Bolaang Mongondow, Modayag, Mooat Lake, 24-3-2006, Y. Purwanto et al, PSU 38; PSU 39 (BO!)

**Distribution**: North Celebes; Central Celebes, South Celebes.

**Habitat**: This species is found in various habitats from ultrabasic to volcanic-derived alluvial soils and from hill slopes in depleted forests to swampy forest on highland at altitude 1070 m.

**Vernacular name**: Natang (Kotamobago Lang); Lolon (Tombulu; Tontemboan); Aretes (Totemboan)

**Notes**: *Freycinetia minahassae* Koord is the most wide spread species in Sulawesi (see Keim 2005; Keim *et al* 2005; Purwanto *et al* 2006a; Keim & Rugayah 2007 *in prep.*). The result of this study is in accordance with those previous studies. This species is easily recognised in the field by the robust habit, leaves with spines throughout margins, white bracts, and especially on the needle-like (filiform) berries, in which each with 2 stigmas. Stone (1969a) placed the Philippine *F. maxima* into synonymy. This current study is in accordance with him as there is no significant difference between the two species, thus the submission of *F. maxima* is supported. *Freycinetia latispina* was also placed into synonymy by Stone (1969b). Actually Warburg (1900) himself rather unconvinced on *F. latispina* being a species of its own as he described that his *F. latispina* very much resembles that of Koorders' *F. minahassae*. The result of this present study supports Stone in placing *F. latispina* into synonymy as there has been no noteworthy morphological characters separating the two species. *Freycinetia latispina* is observed as also a Celebes species, having robust habit, possessing leaf with sharp obvious spines throughout margin, needle-like (filiform) berries, and number of stigmas 2. In other words, characters also possessed by *F. minahassae* Koord; thus, *F. latispina* is submerged.
10. *Freycinetia oblanceolata* Martelli. Webbia iii. 176. (1910). Type: Indonesia, Papua, Doel, Teysmann 6762 (Syntype BO!) (Fig. 12).

Climbing pandan. **Stem** cylindrical, 2.5-5 mm in diameter, distance between two leaves 0.5-4.4 cm, glabrous, yellowish brown. Leaf narrowly ob lanceolate/spathoideus, apparently bright green when still fresh, spines on leaf margin obvious, throughout the length; leafsheath not none. **Auricle** very obvious, tapered (rather obtuse), 1.5-8.8 cm long, 0.3-1 cm wide, transparent with longitudinal lines and white spots, rather like chartaceus/papery, amplexicaulis, 20-45.5 cm long, 1.8-3.5 cm wide, apex caudate; main nerve thick, spines on terminal part of main nerve; vein nerve paralellinervis, distance between two vein nerve 0.3-1 mm, unclosed/rarely. **Infructescence** absent (specimen steril)/no infructescence available.

**Specimen examined**: Indonesia, North Celebes, Tomohon, Mahawu Mountain, 18-3-2006, Y. Purwanto et al, PSU 13; PSU 14; PSU 15; PSU 16; PSU 17; PSU 18 (BO!)  
**Distribution**: North Celebes.  
**Habitat**: Hill slope in a secondary forest at about 1000 m altitude.  
**Uses**: Not recorded  
**Vernacular name**: Not recorded  
**Notes**: Prior to this current study *F. oblanceolata* Martelli is only known from New Guinea, thus it is a new record. The possession of spathoideous leaf and few number of stigmas (1 to 2) characterised this species. The presence of a New Guinean *F. oblanceolata* Martelli in Sulawesi supports the hypothetical floristic link between Sulawesi, the Philippines and Eastern Malesia (i.e. Moluccas and New Guinea; see Lam 1945a; 1945b).

![Figure 12: Freycinetia oblanceolata Martelli.](image-url)

Robust climber, up to 4-12 m high. **Stem** cylindrical, yellowish, 1 cm in diameter, distance between two leaves 1.5-1.7 cm, glabrous. **Leaf** linear, 58 cm long, 2 cm wide, glabrous, apex acuminate, spines on leaf margin apparently obvious on basal and terminal part. **Auricle** tapered with spines, brownish coloured with the vague long lines without brown spots, 3 cm long, 2 mm wide.; main nerve sharp with spines on terminal part, vein nerve paralellinervis, distance between two vein nerve 0.5 mm, closed; amount of vein nerve 15 pairs. **Infrafructescence** terminal, quaternate, there are 4 cephalia 3 of them are big the other smaller; each cephalia elongate, 5-9 cm long, 1-2.8 cm wide, green to yellowish green and brownish orange when mature; pedicel half terete, scabrid, 2.5-2.8 cm long, 4 mm wide; peduncle 1.5 cm long. **Berry** rostrate to elongate, 6 mm long, 1.5 mm wide. **Seed** ellipsoid, 0.3 mm long, 0.2 mm wide, blackish brown coloured. Stigmatic remains 3, some there are 2.

**Specimen examined**

**Distribution**: North Celebes; Central Celebes

**Habitat**: Hill slope on light-brown coloured and limestone soils in secondary forests at about 1300 m altitude. This species is also found on lowland tropical rainforest with dark brown coloured soils at 1400 to 1500 m altitude.

**Uses**: Not recorded

**Vernacular name**: Aretes (Tontemboan); Sinsing (Mongondow)

**Notes**: The result of this current study is in accordance with Keim & Rustiami (2007) in recognising the presence of *F. polystachya* Martelli in Sulawesi. *Freycinetia polystachya* Martelli previously is known only in the Philippines (*see* Martelli 1910b; Merril 1925) and the presence of Philippine species in Sulawesi and vice versa has been postulated by Stone (1969a). In appearance *F. polystachya* Martelli resembles *F. minahassae* Koord especially regarding their robust habits; however, the possession of needle-like berries by *F. minahassae* Koord straightforwardly distinct this species from *F. polystachya* Martelli. *Freycinetia polystachya* Martelli does not possess the filiform (needle-like) berry.
Figure 13: *Freycinetia polystachya* Martelli. A. habit. B. infructescence C. fruit. D. stigmatic remains
12. *Freycinetia rigidifolia* Hemsl. Kew Bull. 1896.165. Type: Malaysia, Sarawak, *Haviland*.436 (Holotype K). (Fig. 14)


Apparently rather longer climbing pandan. **Stem** cylindrical, 0.5-1.5 cm in diameter, distance between two leaves 3-4 cm, glabrous, pale yellow. **Leaf** narrowly ellipsoid to very narrowly ellipsoid, amplexicaulis, 11-14 cm long, 1.8-2.5 cm wide, glabrous, apex acuminate. **Auricle** tapered 1.3-2.4 cm long, 2-3 mm wide, brownish coloured with horizontal strips without spots, with spines on margin very obvious, 1mm long; spines of leaves margin on basal and terminal, basal part is more obvious; main nerve thin, spines found throughout length of main nerve; vein nerve paralellinervis, distance between two vein nerve 0.6-1 mm, unclosed/rarely, amount of vein nerve 6-17 pairs. Neither infructescence is observed, steril material.

**Specimen examined**
Indonesia, North Celebes, Ambang Mountain, Modayag, Bolaang Mongondow, 23-3-2006, *Y. Purwanto et al*, PSU 31 (BO!)

**Distribution**: North Celebes.

**Habitat**: Mountain slope in secondary forests at altitude about 1250 m.

**Uses**: Not recorded

**Vernacular name**: Not recorded

**Notes**: Keim (2006) records the first presence of *F. rigifolia* Hemsl in Sulawesi and it is supported by the result of this current study. Furthermore, this present study regards *F. rigifolia* Hemsl as one of the most wide spread species of *Freycinetia* in Malesia, the other is *F. scandens*. 
Figure 14: *Freycinetia rigidifolia* Hemsl.
13. **Freycinetia sarasinorum** Warb. Engl. Pflanzenreich Pandan : 35 (Fig. 15).

Apparently climber pandan. **Stem** cylindrical 0.3-2 cm in diameter, distance between two leaves 0.9-1.5 cm long, glabrous, pale yellow colored. **Leaf** linear, 29-60 cm long, 0.7-2 cm wide, amplexicaulis; leafsheath 6.75 cm, apex acuminate; spines found throughout length of leaf margin, glabrous, green when still fresh. **Auricle** tapered, integer 2-5.5 cm long, 0.4-1 cm wide, brown coloured, the vague of long line without spots; main nerve sharp, vein nerve parallelinervis, distance between two vein nerve 0.3-0.5 mm long, closed, amount of vein nerve 16-23 pairs; spines found throughout length of main nerve; pedicel half terete, scabrid, 2-3.5 cm long, 0.3-0.4 cm wide; Bracts 3-4 white or bright yellow; **Berry** very small, 1.5-2 mm long, 0.5-0.8 mm wide, **Infructescence** terminal, quaternate, each cephalia 2.5-3.6 cm long, 0.8-1 cm filiform in shape. Seed ellipsoid in shape, 0.4-0.5 mm long, 0.2 mm wide, black coloured. **Stigmatic** remains 2.

**Specimen examined**
Indonesia, Celebes, central part, area of Mountain Nokilalaki, above Kp. Tomado by lake Lindu, 28-4-1975, W. Meijer 9701 (BO!); Celebes, Tjamba, 1909, Teysmann 12756 (BO!); South Celebes (between Soroako & Wawondula), 18-7-1979, V. Balgooy 4063 (BO!)

**Distribution**: Central Celebes; South Celebes.

**Habitat**: Mountain slope in secondary forest at 1000 to 1200 m altitudes. This species can also be found in lower altitude at about 400 m in lowland forests.

**Uses**: Not recorded

**Vernacular name**: Oeeh (Tinadoh, Archipel. Ind. Tjamba Celebes)
Figure 15: Freycinetia sarasinorum Warb. A. habit with infructescence. B. fruit
CONCLUSION

In this current study thirteen species of Freycinetia are recognised from Sulawesi. Freycinetia devriesei Solms, F. koordersiana Martelli, and F. minahassae Koord have wide spread distribution, in which F. minahassae Koord is the most wide spread species in Sulawesi. Freycinetia oblongolata Martelli, F. beccarii Hemsl, and F. rigidifolia Hemsl have limited distribution areas.

The result of phylogenetic analysis suggests that Freycinetia in Sulawesi are monophyletic and at least there are two clades. The first clade consists of F. amboinensis Martelli, F. beccarii Hemsl, F. devriesei Solms, F. funicularis Merr, F. kostermansii B.C Stone, F. celebica Solms, F. polystachya Martelli, and F. rigidifolia Hemsl. The second clade includes F. inermis Ridl and F. koordersiana Martelli. The other three species (F. minahassae Koord, F. oblongata Martelli, and F. sarasinorum Warb) are unresolved.

This current study also suggests that species of Freycinetia in Sulawesi has stronger affinity with the eastern part of Malesia rather than with the western part. In other words, the biogeographical pattern of Freycinetia in Malesia is confined to Huxley’s line rather than Wallace’s line. Thus, the biogeographic patterns in Freycinetia in Sulawesi are explained better with Huxley’s line.
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