

Leaf Architecture of Selected Philippine *Cinnamomum* Schaeff. (Lauraceae) Species

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ABSTRACT: The characteristic leaf architecture of selected Philippine *Cinnamomum* species was studied. A description of each selected taxon is presented, and a dichotomous key is provided for quick reference. Marginal ultimate venation separates the selected taxa into two major groups: (1) the fimbrial marginal ultimate vein group comprised of *Cinnamomum perglabrum*, *C. mindanaense*, *C. subcuneatum*, *C. myrianthum*, and *C. zeylanicum*, and (2) the looped marginal ultimate vein group comprised of *C. oblongum*, *C. iners*, *C. mercadoi* and *C. celebicum*. The marginal ultimate venation, 2⁰ vein angle, 4⁰ and 5⁰ vein categories, areolation and FEVs are the most useful diagnostic characteristics of the selected Philippine *Cinnamomum* species while apex-base shape and angle, and laminar shape are also helpful in separating species from each other. Cluster and Principal Component analyses supported the major groupings. The latter ascertained that leaf venation patterns are very good diagnostic characteristics. The unifying and distinguishing morphometrics of the species were established, and it is shown that venation character states are good taxonomic markers in describing and identifying Philippine *Cinnamomum* species.

KEY WORDS: leaf architecture, Philippine *Cinnamomum*, venation characteristics, PCA, Cluster Analysis.

INTRODUCTION

Leaf architecture is a traditional morpho-anatomical method in characterizing plant species. The use of leaf architecture and leaf morphology in general has been demonstrated in paleobotanical and recent systematic studies (Dilcher, 1974; Fuller and Hickey, 2005). This method has been used in part as a

tool to resolve taxonomic controversies (Theibaut, 2000; Loutfy *et al.* 2005).

In the Philippines, the writers of three scholarly works have used leaf architecture Banaticla and Buot 2004; Obico *et al.* 2007; Laraño and Buot 2009. Banaticla and Buot, Jr. (2004) worked on *Psychotria* (Rubiaceae) species and delineated the genus

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using the marginal ultimate venation and the angle of loop-forming branches joining superadjacent secondary veins and areolation. Obico *et al.* (2007) worked on *Epipremnum* and *Rhaphidophora* (Araceae) species. The genera were categorized based on the presence or absence of lobation. *Epipremnum* species have pinnately lobed margins while *Rhaphidophora* species generally have entire margins except for *Rhaphidophora korthasii*, *R. merrilli* and *R. pinnata*. Laraño and Buot (2009), on the other hand, demonstrated that the four families in the order Malvales (sensu APG) namely; Sterculiaceae, Malvaceae, Tiliaceae and Bombacaceae could be lumped into one family Malvaceae based on the similarity of leaf architectural characteristics, conforming to the circumscription of APG (APG, 1998; APG, 2003; APG, 2009).

One of the goals of systematics is to explore important and relevant evidence useful in describing, classifying and identifying taxa. Leaf architecture particularly, seemed to be a useful approach to *Cinnamomum* because this genus has prominent, discernible venation patterns, and encompasses a wide range of leaf size and form. This will help taxonomists and systematicists to identify Philippine *Cinnamomum* even without the presence of reproductive organs.

The purpose of this paper is to present the leaf architectural characteristics of selected Philippine

Cinnamomum, provide descriptions, and create a key for identification purposes. This paper demonstrates that leaf architecture is one of the important tools in delineating species of Philippine *Cinnamomum*.

MATERIALS AND METHODS

Herbarium specimens deposited at the Philippine National Herbarium (PNH), Manila, Philippines were used in this study. Depending on the availability of well-preserved specimens, at least two representative herbarium samples were selected for each *Cinnamomum* species. All mature, fully expanded leaves of each species were examined using a hand lens with 20x magnification. The leaf architecture characteristics and terminologies of Hickey (1973) and the Leaf Architecture Working Group (LAWG, 1999) were used to describe the samples (Figure 1). Leaf blade, and petiole length and width were measured using a ruler and caliper and apex, base and venation angles were measured using a protractor.

The data were analyzed using cluster and principal component analyses of SAS v.9.1 and BioDiversity Professional Beta 1 Statistical Programs, respectively. Twenty-six (26) characteristics were used in the analyses. These characteristics were those that have variations among the Philippine *Cinnamomum* species. Suitable ranges and categories were computed and determined for each quantitative character. Each character state, both qualitative and quantitative, was then assigned a

characteristics of the selected Philippine *Cinnamomum* species.

A dichotomous key was then constructed and the species were described using leaf architecture characteristics.

RESULTS AND DISCUSSION

1. Leaf Architectural Characteristics of the Selected Philippine *Cinnamomum*

a. General Characteristics

The *Cinnamomum* species examined in this study exhibit unifying features as follows: simple, oppositely arranged leaves, the petiole base is swollen and marginally attached, entire and with unlobed leaf margin, pinnate type of primary vein and suprabasal acrodomous secondary veins, and highest vein order of 5⁰. The pattern of marginal ultimate venation, 2⁰ vein angle, 4⁰ and 5⁰ vein categories, and areoles and veinlets are the most useful diagnostic characteristics while apex-base shape and angle, and laminar shape also helped in separating species from each other.

b. Description of Leaf

Architecture of the Selected *Cinnamomum* Species

Cinnamomum celebicum Miq.

Leaves elliptic or ovate with convex to acuminate acute apex and acute to obtuse decurrent base, symmetrical, 6 – 10.4 cm long, 1.6 – 5.9 cm wide, 1.8 – 4.8 ratio, microphyllous to notophyllous class. Petiole 5 – 10 mm long, 0.7 – 1.3 mm in diameter. Primary vein pinnate. Secondary

veins suprabasal acrodomous; angle of divergence one pair acute basal secondaries and uniform; Inter-2⁰ vein absent. 3⁰ dichotomizing, opposite percurrent, or mixed opposite and alternate percurrent; vein course sinuous, convex or exmidially ramified; 3⁰ angle to 1⁰ acute to perpendicular, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate, 5⁰ regular polygonal rarely dichotomizing. Marginal ultimate venation looped. Areolation poorly developed. Veinlets usually absent, rarely unbranched.

Distribution: Sulawesi and the Philippines. Palawan (Mt Pulgar), Mindanao: Lanao, Davao (Mt Apo).

Exsiccatae: Dela Cruz & Fernando 56 (PNH); Ridsdale 1527 (PNH); Vendivil & Fernando 23 (PNH).

Cinnamomum iners Reinw. ex Blume
Blade elliptic or ovate, symmetrical, 10.4 – 18.7 cm long, 3.6 – 6.3 cm wide, 2.4 – 3.2 ratio, notophyllous to mesophyllous class, acute convex apex, narrow-cuneate base. Primary vein pinnate. Secondary veins suprabasal acrodomous; angle of divergence one pair acute basal secondaries and uniform; Inter-2⁰ vein weak. Basal veins 3. 3⁰ mixed opposite and alternate percurrent, vein course sinuous, vein course exmidially ramified, 3⁰ angle to 1⁰ acute, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate, 5⁰ dichotomizing rarely regular polygonal. Marginal ultimate

venation looped. Areolation moderately developed without veinlets.

Distribution: India, Myanmar, Thailand, Indochina, Sumatra, Peninsular Malaysia, Java, Borneo, Sulawesi, Philippines. Palawan, Tawi-Tawi, Mindanao: Lanao. Forests, up to 700 m.

Exsiccatae: Tadena 5259-2 (PNH); Sulit 3554 (PNH).

Cinnamomum mindanaense Elmer

Blade elliptic with acuminate acute apex and acute decurrent base, symmetrical, 6.8 – 10.5 cm long, 2.3 – 3.1 cm wide, 2.9 – 4.2 ratio, notophyllous class. Petiole 3 – 11 mm long, 0.7 – 1.1 mm diameter. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence one pair acute basal secondaries and uniform; Inter-2⁰ veins weak. Basal veins 3. 3⁰ mixed opposite and alternate percurrent, vein course exmidially ramified, 3⁰ angle to 1⁰ acute to perpendicular, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate, 5⁰ dichotomizing. Marginal ultimate venation fimbrial vein. Areolation moderate to well developed usually 4-sided with or without unbranched veinlets.

Distribution: Mindanao: Zamboanga, Davao (Mt Apo), Jolo (Mt Dajo), and Surigao. In low and medium altitude thickets and forests. Endemic.

Exsiccatae: Heideman 173 (PNH); Elmer 16266 (PNH).

Cinnamomum mercadoi S. Vidal

Blade elliptic or ovate with acuminate-convex acute apex and acute decurrent base, symmetrical, 9.7 – 16.0 cm long, 3.7 – 6.9 cm wide, 2.0 – 2.9 ratio, notophyllous to mesophyllous class. Petiole 9 – 18 mm long, 1.4 – 2.0 mm diameter. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence one pair acute basal secondaries and uniform; Inter-2⁰ veins weak. 3⁰ mixed opposite and alternate percurrent, vein course exmidially ramified, 3⁰ angle to 1⁰ acute to perpendicular, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate; 5⁰ regular polygonal reticulate. Marginal ultimate venation incomplete loops or looped. Areoles well developed, randomly arranged, small to large, triangular, square, rectangle, rounded and irregular. Veinlets absent or unbranched.

Distribution: Babuyan Islands and Northern Luzon to Mindanao. Common in lowland and medium altitude forests, with some forms ascending to 2000m. Endemic.

Exsiccatae: Mendoza 61-475 (PNH); Tadena 9 (PNH); Lagrimas 317 (PNH).

Cinnamomum myrianthum Merr.

Blade ovate or elliptic, symmetrical, 5.9 – 11.9 cm long, 2.4 – 5.4 cm wide, 1.7 – 2.7 ratio, notophyllous to mesophyllous class, retuse apex, acute concave base. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence one or two pair acute basal

secondaries and uniform; Inter-2⁰ vein weak. Basal veins 3 or 5. 3⁰ mixed opposite and alternate percurrent, vein course exmidially ramified, 3⁰ angle to 1⁰ acute to perpendicular, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate, 5⁰ regular polygonal. Marginal ultimate venation fimbrial vein. Areolation moderately developed usually 4 sided but sometimes irregular in shaped. Veinlet absent.

Distribution: Luzon: Ilocos Norte. Low altitude forests. Endemic.

Exsiccatae: Conklin 1112 (PNH); *Sulit 1475* (PNH).

Cinnamomum oblongum Kosterm.

Leaves oblong or elliptic with acute convex apex and base, symmetrical, 12.7-18.0 cm long, 5.5- 7.2 cm wide, 2.0-2.6 ratio, mesophyllous class. Petiole 7 mm long, 1.2-1.9 mm in diameter. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence two pair acute basal secondaries and uniform; Inter-2⁰ vein weak. Basal veins 5. 3⁰ mixed opposite and alternate percurrent, vein course exmidially ramified, 3⁰ angle to 1⁰ acute, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate, 5⁰ dichotomizing. Marginal ultimate venation looped. Areoles poorly developed, randomly arranged, small to large, triangular, square, rectangle, rounded and irregular. Veinlets absent.

Distribution: Samar (Catubig River). Endemic.

Exsiccatae: Eballo 1063a & b (PNH)

Cinnamomum perglabrum Kosterm.

Leaves ovate, apex acute, obtuse but rarely acute decurrent base, symmetrical, 4.4-6.2 cm long, 2.1-3.1 cm wide, 1.7-2.6 ratio, microphyllous class. Petiole 6-10 mm, 1.3-1.7 diameter. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence one pair acute basal secondaries and uniform; Inter-2⁰ vein absent or weak. Basal veins 3. 3⁰ mixed opposite and alternate percurrent, vein course exmidially ramified, 3⁰ angle to 1⁰ acute, 3⁰ vein angle variability very inconsistent. Higher venation order distinct, 4⁰ regular polygonal reticulate, 5⁰ dichotomizing. Marginal ultimate venation fimbrial vein. Areolation moderately developed with 1-branched veinlet.

Distribution: Luzon: Ifugao (Bana-we); Panay Island, in forest, altitude c. 1820 m.

Exsiccatae: Busemeyer, Ippolito & Barcelona 259 & 302 (PNH)

Cinnamomum subcuneatum Miq.

Leaves usually elliptic, seldom ovate, apex acute, cuneate at base, symmetrical, 16.8 – 20.5 cm long, 5.2 – 7.5 cm wide, 2.2 – 3.5 ratio, mesophyllous class. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence one pair acute basal secondaries and uniform; Inter-2⁰ vein weak. 3⁰

mixed opposite and alternate percurrent, vein course sinuous and/or exmidially ramified, 3^0 angle to 1^0 perpendicular, 3^0 vein angle variability very inconsistent. Higher venation order distinct, 4^0 and 5^0 regular polygonal reticulate. Marginal ultimate venation fimbrial vein. Areolation moderately developed without veinlets.

Distribution: India, Myanmar, Thailand, Indochina, Sumatra, Peninsular Malaysia, Java, Borneo, Sulawesi, Philippines. Palawan, Tawi-tawi, Mindanao: Lanao. Forests, up to 700m.

Exsiccatae: Edaño 808 & 2099-2 (PNH); Podzorski SMHI 503 (PNH); Sulit 3984 (PNH)

Cinnamomum zeylanicum Blume

Syn: *Cinnamomum verum* J. Presl

Leaves ovate to oblong with convex acute apex and acute to obtuse decurrent base, symmetrical rarely

asymmetrical, 9.1 – 11.6 cm long, 5.2 – 7.1 cm wide, 1.6 – 2.1 ratio, notophyllous to mesophyllous class. Petiole 11 – 15 mm long, 1.1 – 1.8 mm diameter. Primary vein pinnate. Secondary veins suprabasal acrodromous; angle of divergence two pair acute basal secondaries and uniform; Inter- 2^0 vein weak. Basal veins 5. 3^0 mixed opposite and alternate percurrent; vein course exmidially ramified; 3^0 angle to 1^0 perpendicular, 3^0 vein angle variability very inconsistent. Higher venation order distinct, 4^0 regular polygonal reticulate, 5^0 regular polygonal. Marginal ultimate venation fimbrial vein. Areoles well developed, usually 4-sided. Without veinlets.

Distribution: Native of Sri Lanka or India. Occasionally planted in the Philippines.

Exsiccatae: Canicosa 96 (PNH); Steiner 1235 (PNH); Salvosa 39 (PNH); Sulit 4517 (PNH).

2. Key to the Selected Philippine Species of *Cinnamomum* Based on Leaf Architecture

1. Incomplete loops or looped marginal ultimate veins..... 2
1. Fimbrial marginal ultimate veins 5
 2. Leaves elliptic to oblong, mesophyllous class size; convex base shape; 2^0 vein angle of divergence two pair acute basal secondaries *Cinnamomum oblongum*
 2. Leaves elliptic to ovate, microphyllous to mesophyllous class size; decurrent or cuneate base shape; 2^0 vein angle of divergence one pair acute basal secondaries 3
 3. base angle obtuse; absent intersecondaries; 3^0 vein category variable, dichotomizing, mixed opposite & alternate, and opposite percurrent.....
.....*Cinnamomum celebicum*
 3. base angle acute; weak intersecondaries; 3^0 vein category mixed opposite and alternate percurrent 4

4. base shape decurrent; indumentum absent *Cinnamomum mercadoi*
4. base shape cuneate; indumentum present underneath *Cinnamomum iners*
5. Laminar size mesophyllous; decurrent or concave base shape; silky very short indumentum present and scattered all-over underneath *Cinnamomum subcuneatum*
5. Laminar size microphyllous to mesophyllous; cuneate base shape; indumentums absent 6
6. Leaves microphyllous; areolation moderately developed with irregular sizes and sides and 1-branched veinlets *Cinnamomum perglabrum*
6. Leaves notophyllous to mesophyllous; areolation moderate to well-developed usually 4-sided; veinlets absent or unbranched 7
7. quaternary veins regular polygonal reticulate; 5⁰ veins dichotomizing; areolation moderate to well-developed usually with 4 sides *Cinnamomum mindanaense*
7. quaternary and 5⁰ veins regular polygonal reticulate; areolation moderate to well-developed without veinlet 8
8. Laminar shape oblong to ovate; convex, acute apex; decurrent base shape; 2⁰ vein angle two pair acute basal secondaries; basal veins 5... *Cinnamomum zeylanicum*
8. Laminar shape elliptic to ovate; retuse, acute apex; concave base shape; 2⁰ vein angle one pair acute basal secondaries or two pair acute basal secondaries; basal veins 3 or 5... *Cinnamomum myrianthum*

The selected Philippine *Cinnamomum* species illustrated good diagnostic leaf venation characteristics as shown in the descriptions as well as in the key. Thus, it is evident that leaf architecture is useful in delineating species from one another. Banaticla and Buot Jr (2004) also proved that this method is an effective species marker for the genera of *Psychotria* (Rubiaceae). Obico *et al.* (2007)

demonstrated the usefulness of leaf architecture in delineating *Epipremnum* and *Rhaphidophora* (Araceae) species. Other studies have used this method in delineating species in Salicaceae (Theibaut, 2000), Gunneraceae (Fuller and Hickey, 2005), *Ficus* (Loutfy *et al.* 2005) and the woody dicotyledons in tropical and subtropical China (Cheng-Hong and Za-lian, 1991).

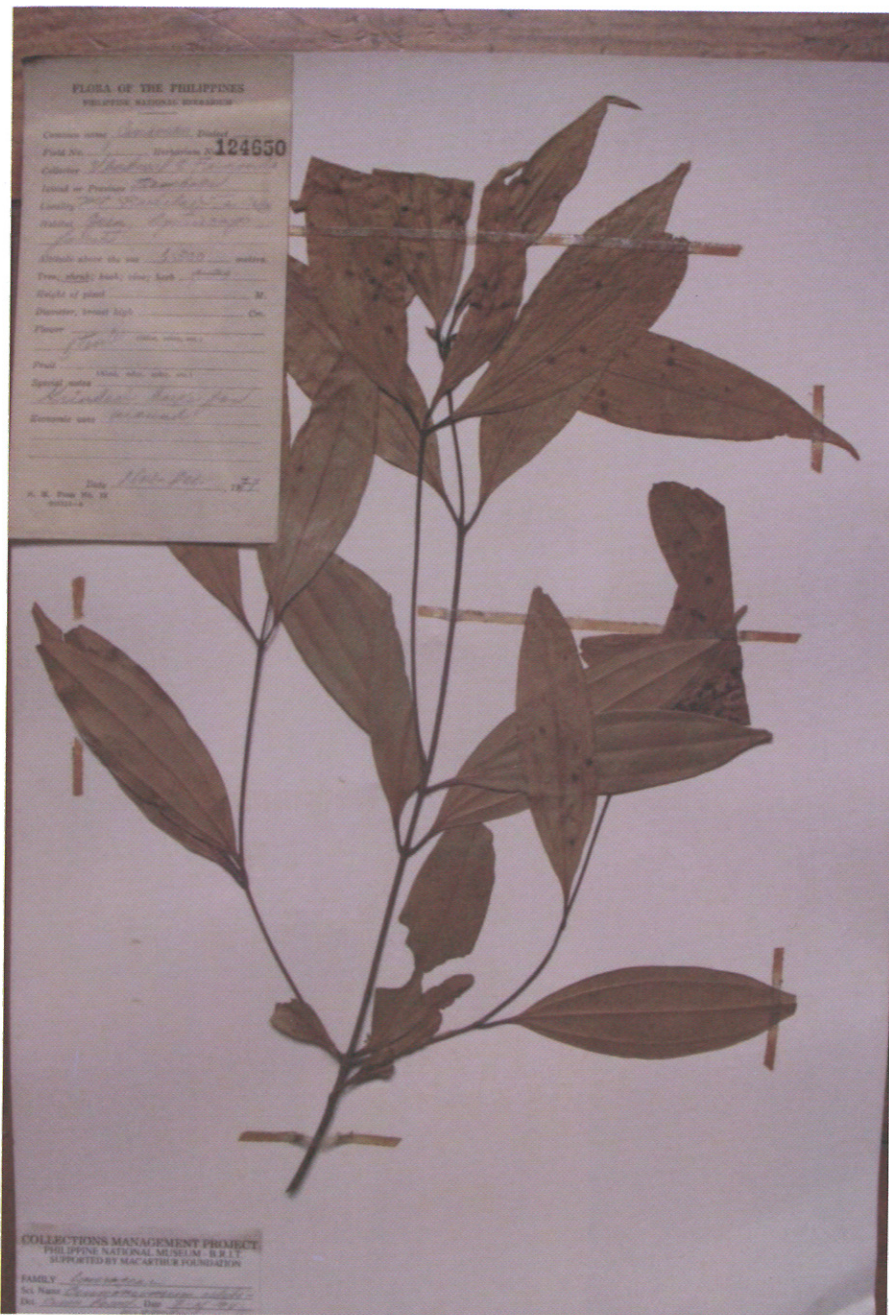


Figure 2. Voucher specimen of *Cinnamomum celebicum* deposited in PNH.

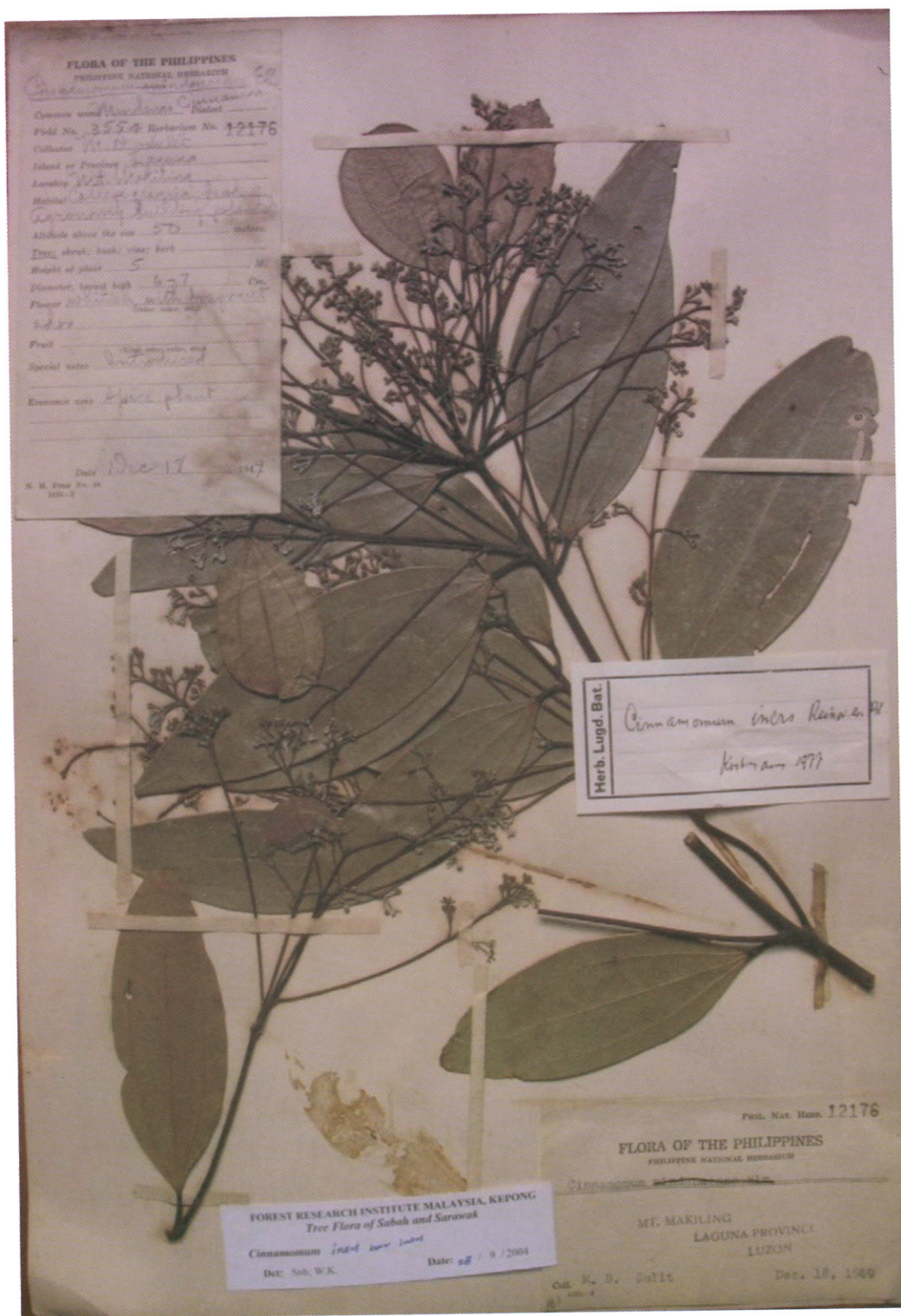


Figure 3. Voucher specimen of *Cinnamomum iners* deposited in PNH.



Figure 4. Voucher specimen of *Cinnamomum mindanaense* deposited in PNH.

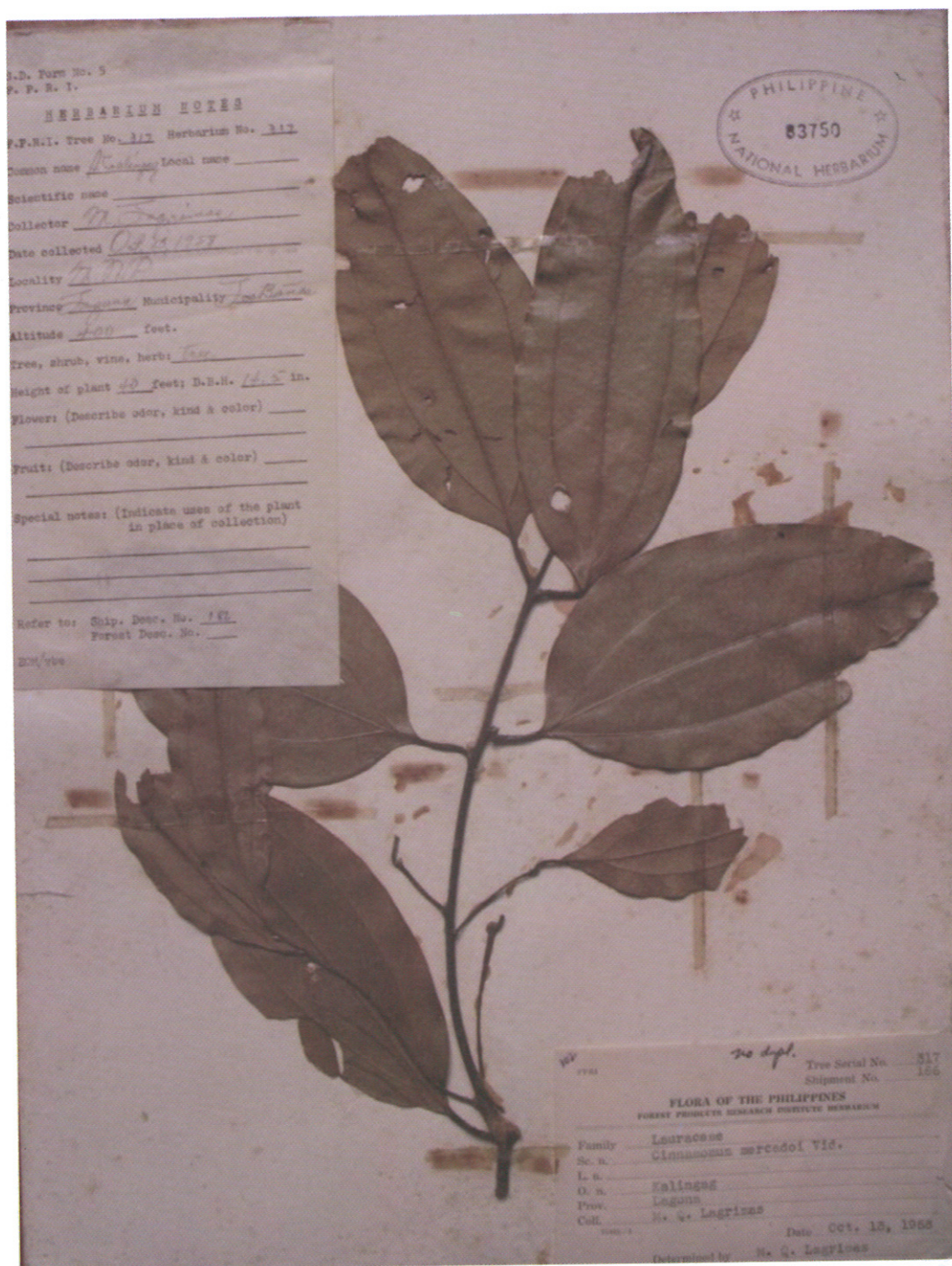


Figure 5. Voucher specimen of *Cinnamomum mercadoi* deposited in PNH.



Figure 6. Voucher specimen of *Cinnamomum myrianthum* deposited in PNH.



Figure 7. Voucher specimen of *Cinnamomum oblongum* deposited in PNH.



Figure 8. Voucher specimen of *Cinnamomum perglabrum* deposited in PNH.

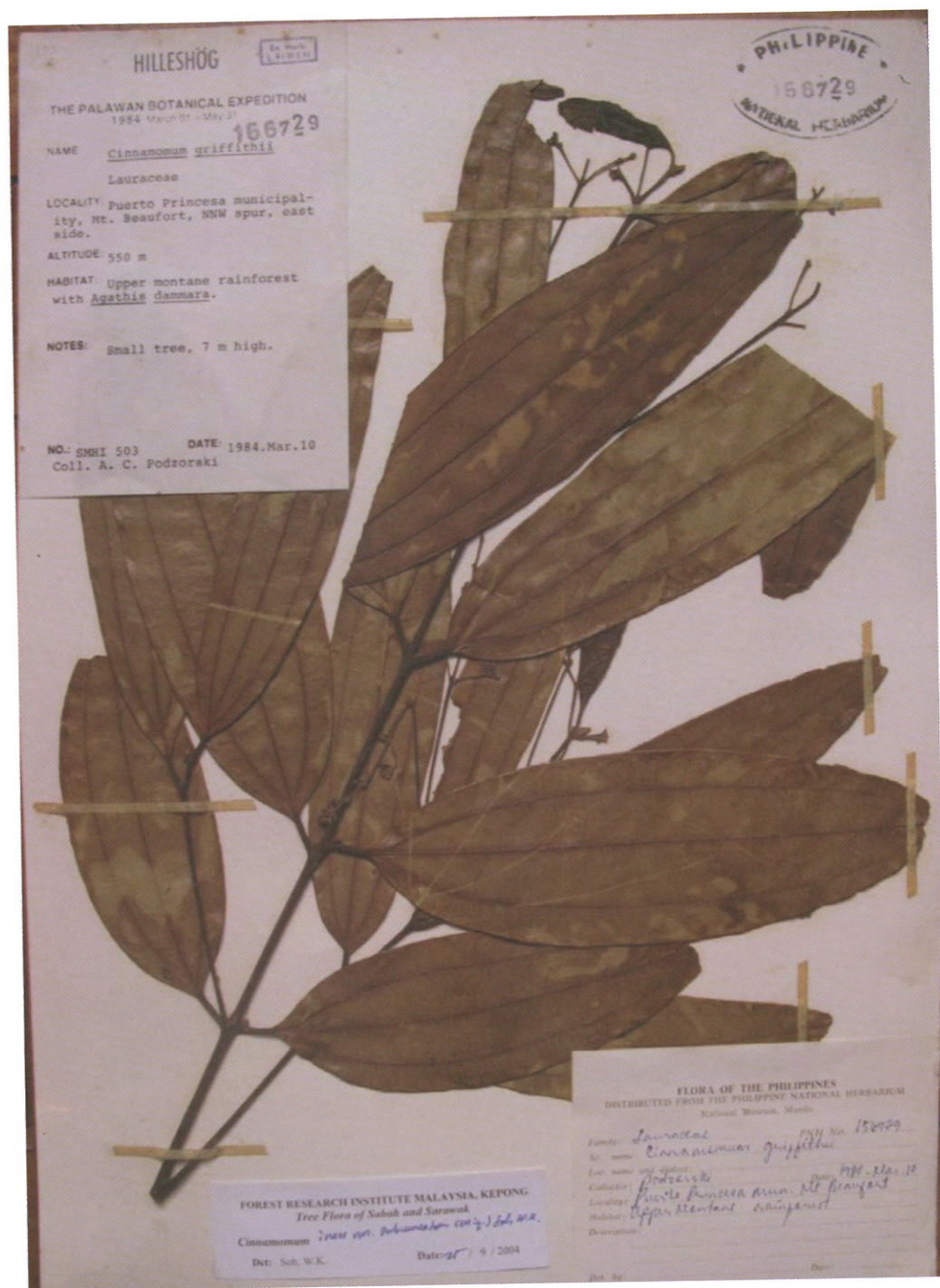


Figure 9. Voucher specimen of *Cinnamomum subcuneatum* deposited in PNH.

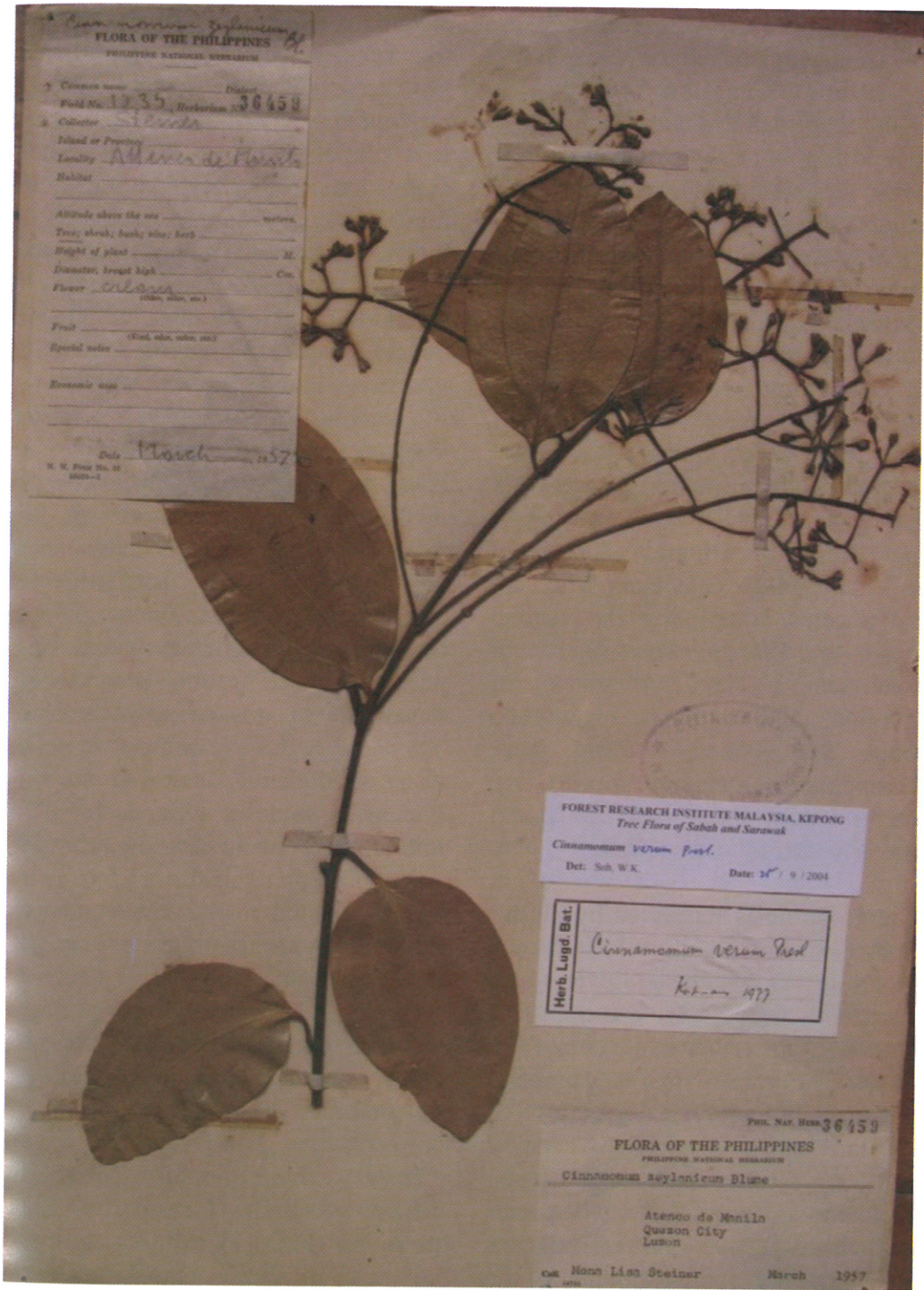


Figure 10. Voucher specimen of *Cinnamomum zeylanicum* deposited in PNH.

3. Philippine *Cinnamomum* Groupings based on Marginal Ultimate Venation

Using marginal ultimate venation, the nine Philippine *Cinnamomum* species were initially separated into two groups (Fig. 11 & 13): (1) the *Cinnamomum* species with fimbrial vein-type and (2) the *Cinnamomum* species with looped vein-type. *Cinnamomum perglabrum* Kosterm., *C. mindanaense* Elmer, *C. subcuneatum* Miq., *C. myrianthum* Merr., and *C. zeylanicum* Blume are the species that comprises the first group, and *C. oblongum* Kosterm., *C. iners* Reinw. ex Blume, *C. mercadoi* s. Vidal and *C. celebicum* Miq. are the species comprising the second group. *Cinnamomum mercadoi* possesses 2 character states for marginal ultimate vein, incomplete loops and looped. From these Philippine *Cinnamomum* species, five are endemic, three indigenous and one is an introduced species.

The grouping is supported by cluster analysis using SAS v.9.1 Statistical Program. Two clusters were also generated based on the morphological characteristics of taxa (Fig. 11). The same species comprise Clusters 1 and 2 except that *C. subcuneatum* is placed in Cluster 2 and *C. celebicum* is placed in Cluster 1. The inclusion of these two species in their respective clusters indicates that they are more similar to the general characteristics of the entire cluster.

Cluster 1 (Fimbrial Marginal Ultimate Vein Group). This group

has no distinct feature common to the five species (Fig. 11). This cluster has decurrent base except for *C. myrianthum* having a concave base. It is similar to *C. zeylanicum*. They both have notophyllous to mesophyllous laminar size, weak intersecondaries, mixed opposite and/or alternate percurrent 3^0 venation, exmidially ramified 3^0 vein course, 4^0 and 5^0 regular reticulate venations, areoles without veinlet and 5^0 highest vein order. The other distinct feature of the 2 species is based on their apex. *Cinnamomum myrianthum* is easily recognizable due to its retuse apex and *C. zeylanicum* has a convex apex. *Cinnamomum zeylanicum* has 5 basal veins making the 2^0 vein angle of divergence to 2 pair acute basal secondaries. *Cinnamomum mindanaense* and *C. celebicum* both have one pair of acute basal secondaries, acute to perpendicular 3^0 angle to 1^0 , and absent to unbranched freely ending ultimate veins (FEVs). The former has acute base angle and weak intersecondaries while the latter has obtuse base angle, and the intersecondary vein is lacking. *Cinnamomum perglabrum* is easily recognized based on its relatively small-ovate leaf blade and obtuse base.

Cluster 2 (Looped Marginal Ultimate Vein Group). This grouping (Fig. 11) exhibits common characteristics such as a symmetrical leaf blade with acute base angle. In terms of venation pattern, the group has weak intersecondaries, mixed opposite/alternate percurrent and exmidially ramified tertiary veins,

regular polygonal reticulate quaternary veins, and highest vein order is up to 5⁰.

Two subclusters can be seen in Looped Marginal Ultimate Vein Group. *Cinnamomum mercadoi* and *C. iners*, and *C. oblongum* and *C. subcuneatum* subclusters (Fig. 11). Aside from the common characteristics of this cluster, the first subgroup is similar in 2 character states. Both have notophyllous to mesophyllous and elliptic to ovate leaves. *Cinnamomum mercadoi* has a cuneate base with 5 basal veins, thus, two – pair of acute basal secondaries and without pubescence. *Cinnamomum iners* has a decurrent base, three basal veins, one – pair of acute basal secondaries, with sparsely scattered silky short hairs underneath. *Cinnamomum subcuneatum* also possessed pubescence underneath the leaf surface, however, its pubescence is more prominent and more dense compared to *C. iners*. *Cinnamomum subcuneatum* and *C. oblongum* is very similar. They both have mesophyllous leaf blades. The former has the longest average laminar length while the latter has the widest average laminar width. However, in terms of leaf length – width (L:W) ratio, *C. subcuneatum* has the greatest with approximately 3:1 ratio. The distinguishable features of the two species are in terms of base shape, 3⁰ angle to 1⁰, and 5⁰ vein category. *Cinnamomum subcuneatum* has cuneate base, 3⁰ is perpendicular to 1⁰, and with regular polygonal reticulate 5⁰ veins while *C. oblongum* has convex base, acute 3⁰

angle to 1⁰ and dichotomizing 5⁰ vein.

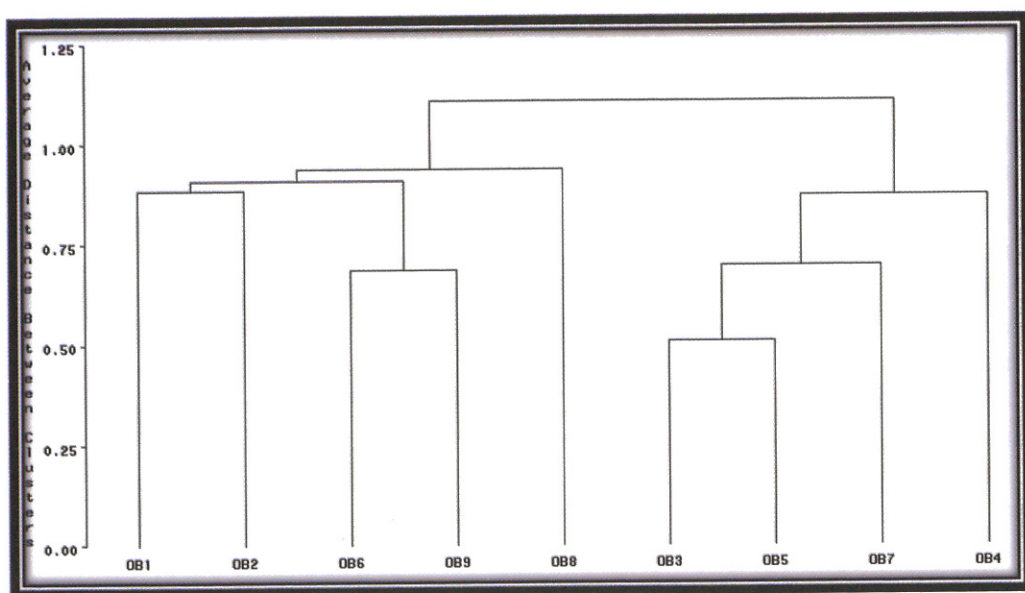
Interestingly, in terms of distribution in the Philippines, the Looped Marginal Ultimate Vein Group shows a distinct distributional pattern (Fig. 12). This group is composed of endemic and indigenous species thriving in forests of low to medium altitude. The Fimbrial Marginal Ultimate Vein Group, composed of indigenous, endemic and exotic species, exhibits a wide elevation range of distributional pattern congruent with its morphological characteristics.

Cluster analysis shows that there is no clear separation between the 2 major clusters of *Cinnamomum* species. There is no single character that divides the groupings. The presence of overlaps of some characters defining each cluster has been noted. Similar observations were discussed by Obico et al. (2007). In his study, the clusters could not be represented exclusively by a single characteristic or by a number of similar characteristics but a combination of certain numbers of similar characteristics is needed to allow a given group to be linked together in a cluster. The number of similar characteristics tend to increase as the distance among the species decreases, and vice versa.

Figure 13 shows the results of the Principal Component analysis using the 26 leaf architectural characteristics. It also supports the cluster analysis showing the two major

groupings of the Philippine *Cinnamomum* species. Principal Component analysis suggests that leaf size, petiole length and width are not good taxonomic markers due to their plasticity. These characteristics vary in individual samples of each species. However, the analysis demonstrated the usefulness of leaf architecture in

identifying Philippine *Cinnamomum* species on account of the unique venation characteristics of each group. Aside from the venation patterns, leaf shape, base, and apex angle and shape are important parameters to distinguish one species from another.



OB1-*Cinnamomum mindanaense*; OB2-*C. celebicum*; OB3-*C. iners*; OB4-*C. subcuneatum*; OB5-*C. mercadoi*; OB6-*C. myrianthum*; OB7-*C. oblongum*; OB8-*C. perglabrum*; OB9-*C. zeylanicum*

Figure 11. Phenogram of the selected Philippine *Cinnamomum* species showing the two major groupings, namely: Fimbrial Marginal Ultimate Vein Group (left cluster) and Looped Marginal Ultimate Vein Group (right cluster) using SAS v9.1 Statistical Program.

Elevation (masl)	Species
1500 – 2000	<i>Cinnamomum mercadoi</i> , <i>C. myrianthum</i> , <i>C. perglabrum</i>
1000 -1500	<i>Cinnamomum perglabrum</i>
500 – 1000	<i>Cinnamomum iners</i> , <i>C. mercadoi</i> , <i>C. mindanaense</i> , <i>C. subcuneatum</i>
0 – 500	<i>Cinnamomum iners</i> , <i>C. mercadoi</i> , <i>C. mindanaense</i> , <i>C. myrianthum</i> , <i>C. subcuneatum</i>

Figure 12. Orographic distribution of the selected *Cinnamomum* species in the Philippines.

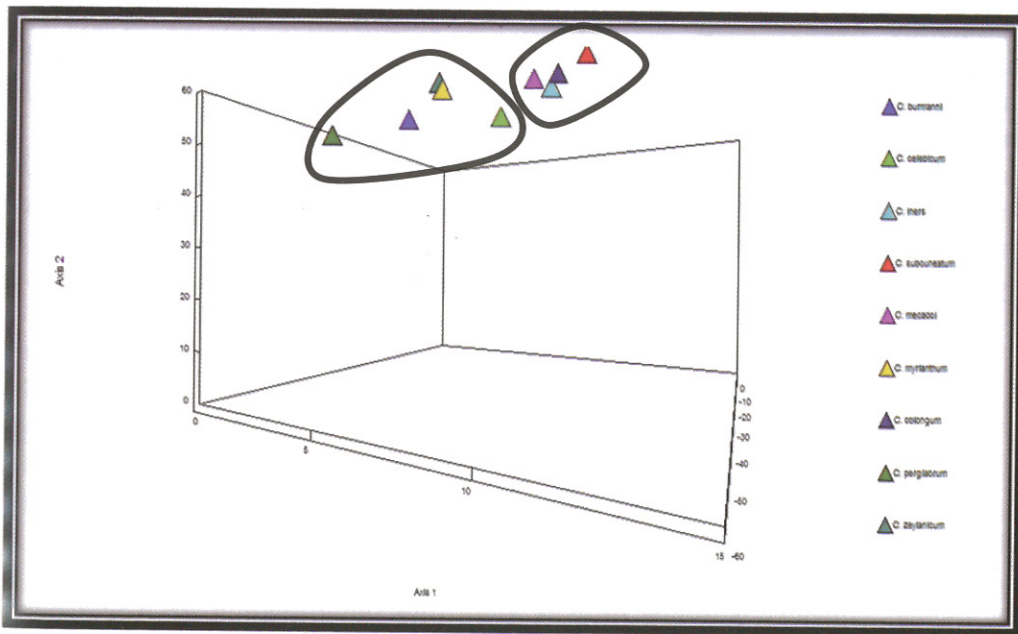


Figure 13. Principal Component Analysis showing the two major groups of Philippine *Cinnamomum* species using BioDiversity Professional Beta 1 Program.

SUMMARY AND CONCLUSION

The preceding observations proved the usefulness of leaf architecture in determining the unifying and distinguishing features of Philippine *Cinnamomum* species. The selected Philippine *Cinnamomum* species could be classified into two groups based on the marginal ultimate venation, the Fimbrial Marginal Ultimate Vein Group and the Looped Marginal Ultimate Vein Group. Tertiary, quaternary, 5⁰ veins, areolation and FEVs are the characteristics that show great variation among the taxa. Venation characteristics of Philippine *Cinnamomum* species are good taxonomic markers. It should be further noted that venation patterns are stable just like the reproductive structures of plants. Indeed, leaf architecture, particularly, venation patterns, provides additional useful evidence in taxonomy and systematics.

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value corresponding to a legend as follows: PW1-9 for petiole width, PL1-9 for petiole length, LL1-9 for laminar length, LW1-9 for laminar width, LWR1-9 for laminar length-width ratio, LSz1-3 for laminar size, LSh1-3 for laminar shape, LSy1-2 for laminar symmetry, BA1-2 for base angle, BS1-4 for base shape, AS1-3 for apex shape, NBV1-2 for the number of basal veins, SVA1-2 for secondary vein angle, ISV1-2 for intersecondary veins, TVC1-3 for

tertiary vein category, TVCo1-3 for tertiary vein course, TAP1-2 for tertiary angle to the primary vein, QVC1-2 for quaternary vein category, FVC1-3 for 5^0 vein course, Are1-3 for areolation, FEV1-3 for freely ending ultimate veins, HO1-2 for highest venation order, HE1-3 for highest venation excurrent, MU1-3 for marginal ultimate venation, LR1-4 for leaf rank, and Pub1-2 for the presence or absence of indumentum underneath the leaf surface.

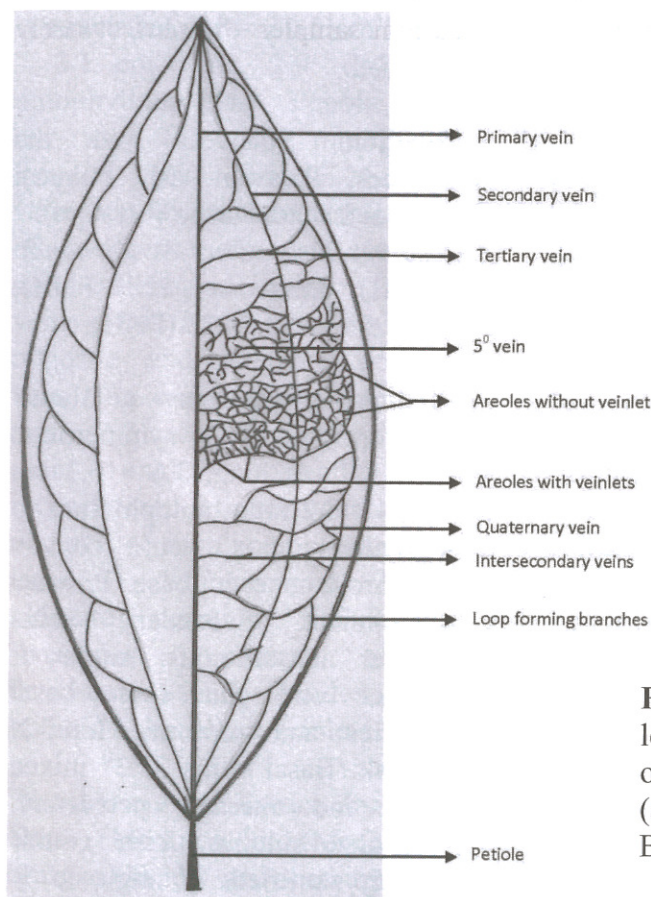


Figure 1. The typical leaf architecture features of *Cinnamomum* species (after Banaticla and Buot, 2004).

A dendrogram was constructed using the Unweighted Pair-group method with Arithmetic Averages (UPGMA)

of SAS v9.1. Principal Component Analysis (PCA) was also applied to determine the groupings of the