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Original article

Leaf Architecture of Selected Philippine *Diplazium* Swartz Species (Athyriaceae)

Jennifer M. Conda[1*], Inocencio E. Buot, Jr.[2] and Ramiro P. Escobin[1]

[1]Department of Science and Technology - Forest Products Research and Development Institute, College, Los Baños, Laguna, Philippines
[2]Institute of Biological Sciences, University of the Philippines Los Baños, College, Los Baños, Laguna, Philippines

ABSTRACT: Taxonomic position of *Diplazium* species remained unresolved. It was timely to explore other plant features such as leaf architectural characters, particularly venation pattern, to describe and differentiate morphologically similar *Diplazium* species. Twenty seven *Diplazium* species were described based on applicable leaf architecture characters of angiosperms. General characteristics of the genus were generated while species were individually described. A dichotomous key, differentiating *Diplazium* species, was constructed. The results proved that leaf architecture could be a good taxonomic tool in describing and differentiating *Diplazium* species and very useful in field identification.

KEY WORDS: Leaf architecture, taxonomic tools, venation pattern, *Diplazium*

INTRODUCTION

The absence of sori in some season of the year, continuous morphological variations regarded as putative high breed (Takamiya *et. al.*, 1999) and young plants may be fertile but still difficult to assign to a species (Kramer *et. al.* 1990) were identified as limitations on the successful delineation of genus *Diplazium*. Leaf architecture was an option in differentiating taxonomically and morphologically similar species. It is defined as the placement and form of those elements constituting the outward expression of leaf structure, including venation pattern, marginal configuration, leaf shape, and gland position (Hickey, 1973). This tool aims to emphasize the usefulness of leaves and venation pattern as taxonomic features since they persist longer during a plant's life span (Laraño and Buot, 2010), are genetically fixed (Roth-Nebelsick *et al.*, 2001) and exhibit high degree of interspecific variation (Hickey, 1973). In fact, some taxonomic problems such as lack of flower, fruits and seeds and plant fossils lacking reproductive organs have been addressed using leaf architecture (Hickey, 1973; Dilcher, 1974). Although the use of a microscope is required when working on leaf surface characters, the value of leaf characters should not be diminished when making taxonomic decisions and evolutionary investigations (Stace, 1984).

Actually, some leaf architecture studies successfully differentiated, identified, described and constructed phylogenetic relationships among angiosperm taxa such as in species

*Corresponding author.
E-mail: jhen_0421@yahoo.com

of Solanaceae (Inamdar and Murthy, 1978), Bignoniaceae (Jain, 1978), Berberidaceae (Singh *et al.*, 1978), Labiatae (Tyagi and Kumar, 1978), Convolvulaceae and Merremia (Inamdar and Shenoy, 1981, 1982), Asteraceae (Ravindranath and Inamdar, 1982), Brassicacee (Rao and Inamdar, 1983), Chloranthaceae species (Todzia and Keating, 1991), *Ficus* species (Loutfy *et al.*, 2005), Coffea arabica cultivars (Mishra *et al.*, 2010), *Psychotria* (Banaticla and Buot, 2004), Gunneraceae (Fuller and Hickey, 2005), Malvaceae (Laraño and Buot, 2010), *Rosa* (Nawas *et al.*, 2011), *Camellia* (Lu *et al.*, 2012), Philippine Cinnamomum (Celadiña *et al.*, 2012), *Physalis* (Thepsithar and Thongpukdee, 2013), *Hoya* (Salvaña and Buot, 2014), *Shorea* (Pulan and Buot, 2014), Philippine *Terminalia* (Baroga and Buot, 2014), Euphorbiaceae (Tadavi and Bhadane, 2014) and *Mussaenda* (Kpadehyea and Buot, 2014).

Recently, leaf architecture was used to classify fern taxa, *Lygodium* (Shinta *et al.*, 2012), *Ophioglossum* (Magrini and Scoppola, 2010) and some terrestrial and epiphytic ferns from an Araucaria forest, namely: *Blechnum binervatum*, *Ctenitis falciculata*, *Magalastrum connexum*, *Microgramma squamulosa* and *Serpocaulon catharinae* (Larcher *et al.*, 2013). Being vascular plants, ferns are expected to have the same stability in terms of venation pattern. In fact, fern stipes are reinforced by a very stiff sclerenchyma consisting of dead cellswith non-extensible rigid cell walls (Leroux, 2012) that provide support and preserve leaf architecture (Larcher *et al.*, 2013). In addition, ferns have persisted throughout their evolutionary history and represent highly successful forms in both past and present (Taylor *et al.*, 2009; Pittermann, 2010).

Thus, it is hypothesized that *Diplazium* species could also be described and differentiated using solely leaf characters. This study aim to described and differentiate the leaf architectural characters of genus Diplazium and some of its representative species.

MATERIALS AND METHODS

Herbarium Voucher Selection

Twenty-seven (27) well-preserved herbarium specimens of *Diplazium* species at the Philippine National Herbarium were studied. Two to four good specimens per species were evaluated for this activity. Around 8 to 15 leaflets depending on the number of pinnae and pinnules per lamina were examined. Exsiccata of species were noted.

Description Using Leaf Architecture Characters

To understand the morphology of fern and Leaf Architecture description of *Diplazium* species, an illustration of a typical fern species was provided (Fig. 1).

Eight to fifteen mature and fully expanded leaves out of 2-4 vouchers were measured under a 20x magnification hand lens. The length and width of pinna and pinnule, width of the primary (1°) vein, and vein spacing were measured using a ruler, while a protractor was used for angle of divergence determination. Some of the characters measured were as follows:

A. BLADE

1. Organization (simple, pinnate, tripinnate, pinnatifid, bipinnatifid, tripinnatifid)

2. Length (mm) – the distance from the proximal most extension to distal most extension of the leaf tissue

3. Width (mm) – the widest width of the lamina/pinna/pinnule

4. Area (mm2) – A = 2/3 LxW

5. L:W ratio – Length/Width

6. Blade class – determined by measuring the area of the leaf (Table 1)

7. Form - after the basic class (oblong, elliptic, ovate) was categorized, the computed length-width ratios (L/W) were used to determine the subclasses. The table below shows the leaf form character states and the subclasses with their length-width (L/W) ratios. The L:W ratios for the subclasses were lower limits except for the last (Table 2).

8. Apex (acute, obtuse, acuminate)

9. Base (lobate, rounded, truncate, cuneate, cordate); angle (acute, obtuse, wide obtuse); symmetry (symmetrical, asymmetrical)

10. Margin (entire, erose, crenate, serrate)

11. Lobation: unlobed or lobed (shallow, moderate, deep)

B. Primary (1°) vein

1. Venation type : Pinnate

2. Size – the ratio of vein width (vw) to leaf width (LW) (Table 3)

Size = vw/LW x 100%

C. Secondary (2°) vein

1. Venation pattern
   a. Cladodromous (secondaries freely branching toward the margin)
   b. Craspedodromous (secondaries terminating at the margin)
   c. Reticulodromous (secondaries branching into reticulum toward the margin)

2. Angle of divergence- ranges of values for the angle of divergence category were showed in Table 4.

3. Variation in angle of divergence.
   a. Divergence angle nearly uniform.
   b. Upper secondary veins more acute tha lower.
   c. Divergence angle varies regularly.
   d. Spacing (uniform, increasing towards the vein, irregular)

D. Tertiary (3°) vein

1. Venation pattern
   a. Forming commissural veins to sinuses
   b. Free, ending in sinuses
   c. Free and forked, touching margins

2. Angle of divergence- ranges of values for the angle of divergence category were showed in Table 5.

3. Variation in angle of divergence.
   a. Divergence angle nearly uniform.
   b. Upper 2°. veins more acute tha lower.
   c. Divergence angle varies regularly.
   d. Spacing (uniform, increasing towards the base, irregular)

E. Areoles : a. Present
b. Absent

RESULTS AND DISCUSSION

General Characteristics of Genus *Diplazium* Swartz

Table 6 outlines the general leaf architectural characters of *Diplazium*. The studied species were grouped into two according to leaf morphological characters and venation pattern. The former included leaf organization, shape, apex shape, base shape, angle and symmetry, margin type, stalk type and blade class. This classification coincided with how Copeland (1958) and Price (1975) described the genus *Diplazium*.

The venation pattern of *Diplazium* ended up to third order. Suprisingly, all of the 27 species exhibited pinnate 1o vein with sizes ranging from stout to massive. Variations in the venation pattern was observed in the 2° and 3° vein categories, angle of divergence, variation in angle of divergence and vein spacing.

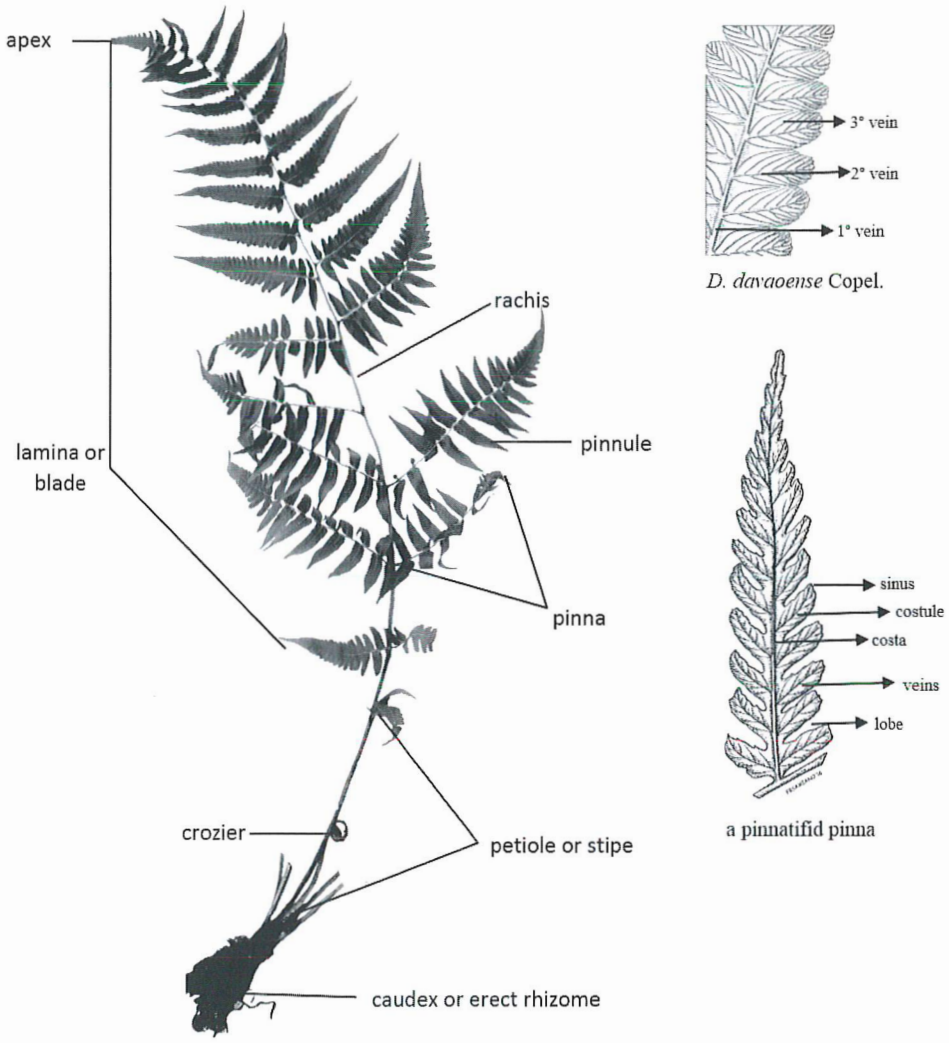


Figure 1. Illustrations of *Diplazium* species plant parts.

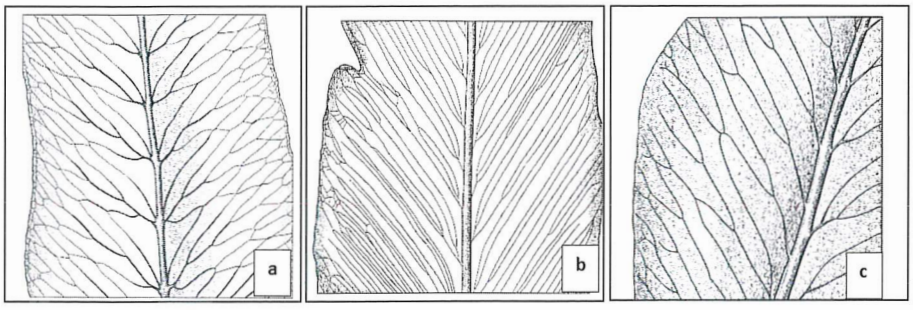


Figure 2. *Diplazium* species with reticulodromous venation pattern: (a) *D. cordifolium* Blume; (b) *D. cumingii* C. Chr.; and (c) *D. forbesii* C. Chr.

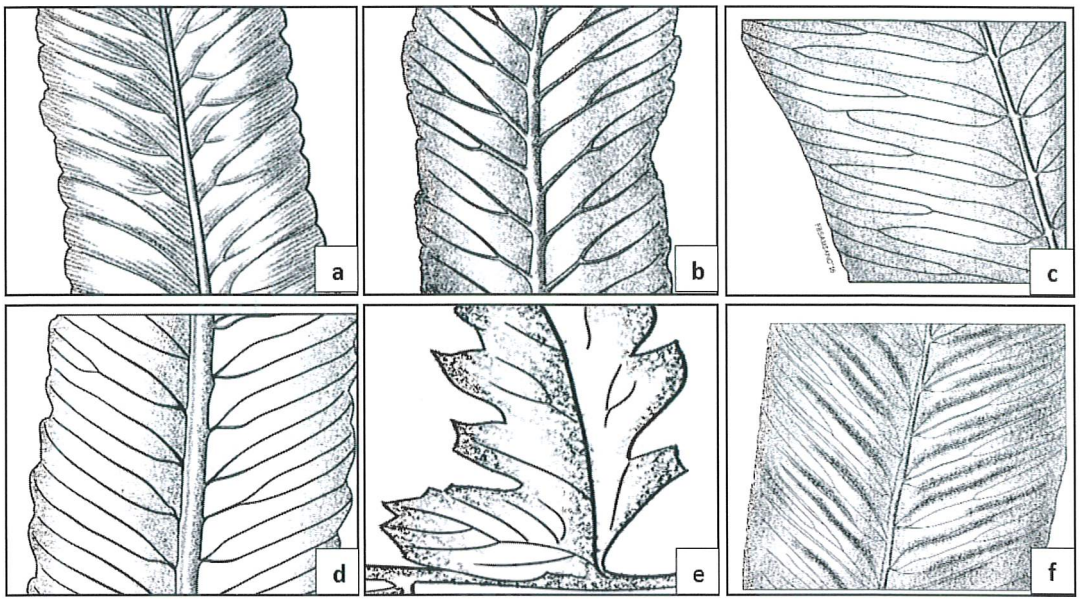


Figure 3. *Diplazium* species with cladodromous venation pattern: (a) *D. crenato-serratum* T. Moore.; (b) *D. cultratum* C. Presl.; (c) *D. fraxinifolium* C. Presl.; (d) *D. pallidum* T. Moore; (e) *D. williamsii* Copel; and (f) *D. xiphophyllum* C. Chr.

Description of the Leaf Architecture Characters of Selected *Diplazium* Species

Leaf architecture characters of 27 *Diplazium* species in Philippine National Herbarium (PNH) had been described. Some terminologies were adopted from the works of Hickey (1973), Leaf Architecture Working Group (1999) and Palmer (2003). The morphological characters such as leaf form, blade shape and size, apex shape and base shape conformed to previously published monographs on *Diplazium* (Copeland, 1958; Price, 1975; Amoroso, 1987, 1990).

This study supported Dilcher's (1974) observation that "Gross leaf form alone cannot produce reliable information and must be coupled with the finer venation to be useful in recognizing taxa". Hence, though more tedious compared with angiosperms, smaller details of upper venation patterns in *Diplazium* were meticulously studied and drawn. The small and close spacing of 2° and 3° veins pose difficulties in the measurement of angle of divergence even under a hand lens and a dissecting microscope. In addition, the presence of sori and thickness of leaves caused the delay in the measurement. Despite experiencing uncertainties in measurements, the venation pattern served as a differentiating tool for *Diplazium* species.

Table 7 enumerated the detailed leaf architecture characters of the 27 selected *Diplazium* species. Surprisingly, all species exhibit pinnate 1° vein but the 2° and 3° venation varied among species. The species that reached 2° vein category were *D. cordifolium*, *D. crenato-serratum*, *D. cultratum*, *D. cumingii*, *D. forbesii*, *D. fraxinifolium*, *D. pallidum*, *D. williamsii* and *D. xiphophyllum* while the rest have 3° level. Majority of the species (67%) exhibit cladodoromous 2° vein while 11% (3 species) are reticulodromous. The 3° vein of genus *Diplazium* usually end in sinuses, however, two species, *D. esculentum* and

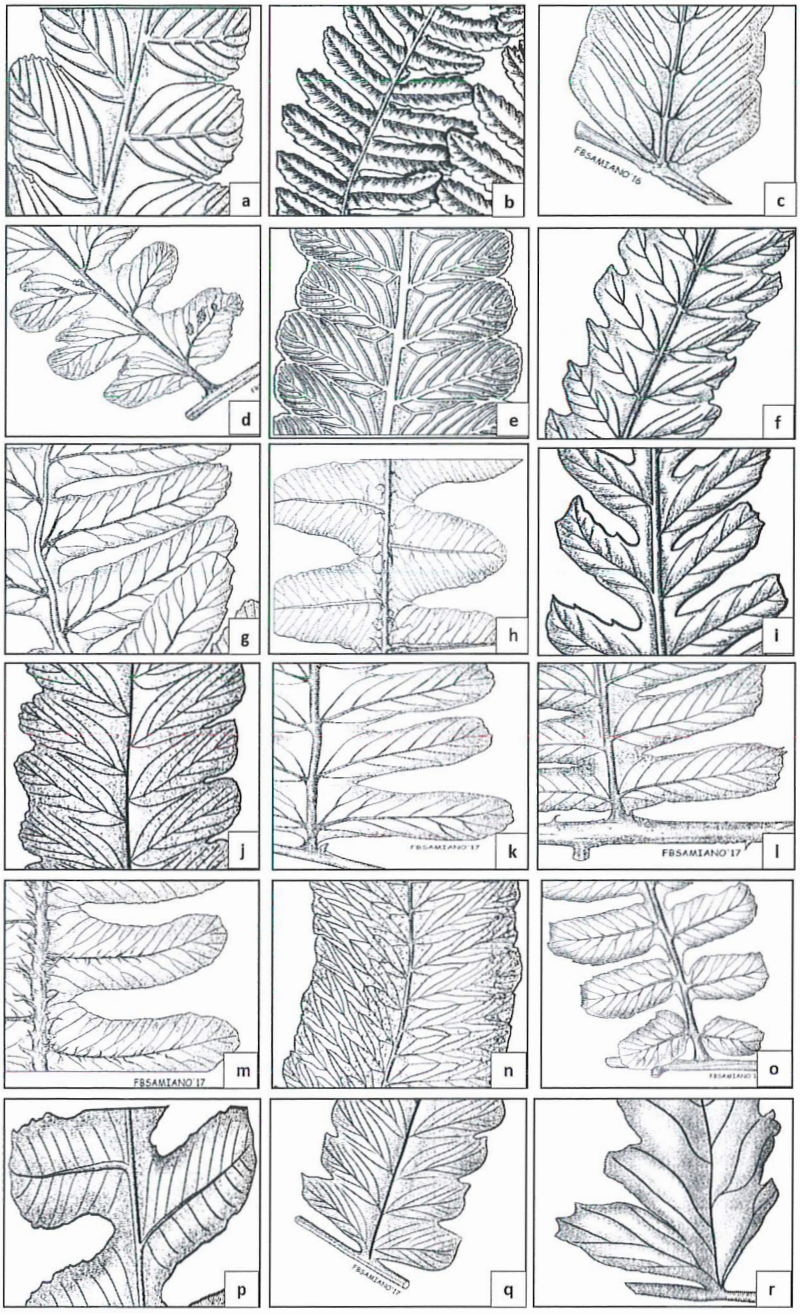


Figure 4. *Diplazium* species with craspedodromous venation pattern: (a) *D. davaoense* Copel.; (b) *D. deltoideum* C. Presl.; (c) *D. dolichosorum* Copel.; (d) *D. doederleinii* (Luerss.) Makino.; (e) *D. esculentum* (Retz.) Sw.; (f) *D. fructuosum* Copel.; (g) *D. griffithii* T. Moore.; (h) *D. lomariaceum* (C. Chr.) M.G. Price; (i) *D. magnificum* (Copel.) M.G. Price; (j) *D. maximum* (D. Don) C. Chr.; (k) *D. oligosorum* Copel; (l) *D. polypodioides* Blume.; (m) *D. porphyrorachis* Diers.; (n) *D. proliferum* (Lam.) Thours.; (o) *D. pseudocyatheifoleum* Rosent.; (p) *D. sorsogonense* (C. Presl.) C. Presl.; (q) *D. vestitum* C. Presl.; (r) *D. whitfordii* Copel

D. proliferum, possessed a 3° vein forming commissural pattern. Areolation was notably observed only in 3 species namely: *D. cordifolium, D. cumingii* and *D. forbesii.*

The success of describing and differentiating species through higher venation pattern confirmed that leaf architecture is indeed an important tool in delineating *Diplazium* species. Thus, a dichotomous key was constructed.

Key to the Selected Diplazium Species Based on Leaf Architecture

1. Vein anastomosing 2
    2. Variation in angle of divergence varies irregularly ..... *D. forbesii*
    2. Variation in angle of divergence nearly uniform 3
        3. 2° vein spacing irregular ..... *D. cordifolium*
        3. 2° vein spacing uniform ..... *D. cumingii*
1. Vein free 4
    4. Long stalked 5
        5. 2° and 3° veins spacing uniform ..... *D. porphyrorachis*
        5. 2° and 3° veins sapacing irregular ..... *D. lomariaceum*
    4. Short-stalked 6
        6. 2° vein cladodromous.....7
            7. Leaves elliptic ..... *D. fraxinifolium*
            7. Leaves lanceolate 8
                8. Base rounded, variation in angle of divergence nearly uniform 9
                    9. Mesophyllous class ..... *D. xiphophyllum*
                    9. Microphyllous class ..... *D. pallidum*
                8. Base truncate, upper secondary vein more acute than lower 10
                    10. Margin entire ..... *D. cultratum*
                    10. Margin serrate 11
                        11. Nanophyllous class, 2° vein spacing irregular..... *D. williamsii*
                        11. Microphyllous class, 2° vein spacing uniform ... *D. crenato-serratum*
        6. 2° vein craspedodromous.....12
            12. Leaves oblong 13
                13. Microphyllous class, 2° vein spacing increasing toward the base .... *D. grifitthii*
                13. Notophyllous class, 2° vein spacing irreg ..... *D. deltoideum*
            12. Leaves lanceolate 14
                14. 3° vein spacing irregular ..... *D. maximum*
                14. 3° vein spacing uniform or increasing toward the vein 15
                    15. 3° vein forming commisural veins 16
                        16. 2° vein angle of divergence moderate ..... *D. proliferum*
                        16. 2° vein angle of divergence wide ..... *D. esculentum*
                    15. 3° vein not forming commissural veins 17
                        17. Base angle wide obtuse ..... *D. oligosorum*
                        17. Base angle obtuse 18
                            18. 2° vein angle of divergence wide angle to right 19

19. Margin serrate 20
20. 3° vein spacing uniform ..... *D. sorzogonense*
20. 3° vein spacing increasing toward the base ..... *D. magnificum*
19. Margin entire 21
21. Base rounded, 3° vein angle of divergence moderate ..... *D. pseudocyathefolium*
21. Base truncate, 3° vein angle of divergence narrow ..... *D. doederlenii*
18. 2° vein angle of divergence moderate to wide 22
22. Margin crenate ..... *D. davaoense*

22. Margin serrate 23
23. Bi-tripinnatifid 24
24. 1° vein massive ..... *D. whitfodii*
24. 1° vein stout ..... *D. polypodioides*
23. Tripinnate 25
25. Variation in 2° vein angle of divergence nearly uniform ..... *D. vestitum*
25. Upper 2° vein more acute than lower 26
26. Moderately lobed ..... *D. fructuosum*
26. Shallowly lobed ..... *D. dolichosorum*

CONCLUSION

Using leaf architectural characters, the description of the genus *Diplazium* has been established, while individual species have been briefy described. Similarities and differences were mostly observed in the morphological characters (leaf form, blade shape and size, apex shape, base shape, angle and symmetry, and margin) and venation pattern (vein category, angle of divergence, variation in angle of divergence and vein spacing), respectively, of *Diplazium* species. Thus, problems on taxonomic identification of young plants and absence of sori in some season of the year have been addressed through leaf architecture. Therefore, leaf architecture, particularly, venation pattern is an important tool not only in describing and differentiating morphologically controversal*Diplazium* species but possibly other fern taxa as well.

More studies for other pteridophytes using leaf architecture is highly recommended to strengthen the effectivity and usefulness of leaf architecture in describing fern taxa. Studying leaf architecture with leaf clearing techniques may be a good option instead of relying solely on dried leaf samples.

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Table 1 The ranges of areas for the different leaf classes (Webb, 1955)

Blade Class	Leaf Area (mm2)
Leptophyll	< 25
Nanophylll	25 - 225
Microphyll	225 - 2,025
Notophyll	2,025 - 4,500
Mesophyll	4,500 - 18,255
Macrophyll	18,255 - 164,025
Megaphyll	> 164,025

Table 2 The leaf form categories and the subclasses with their L:W ratios (Hickey, 1973)

Form	L:W Ratio
Oblong	
Linear	10:1
Lorate	6:1
Narrow elliptic	3:1
Oblong	2:1
Wide oblong	1.5:1
Very wide oblong	1.2:1 or less
Elliptic	
Very narrow elliptic	6:1
Narrow elliptic	3:1
Elliptic	2:1
Wide elliptic	1.5:1
Suborbiculate	1.2:1
Orbiculate	1:1
Oblate	0.75 or less
Ovate	
Lanceolate	3:1
Narrow ovate	2:1
Ovate	1.5:1
Wide ovate	1.2:1
Very wide ovate	1:1

Table 3 Primary vein size category

Category	Size in %
Massive	> 4
Stout	2-4
Moderate	1.25-2
Weak	< 1.25

Table 4 The ranges of values for the angle of divergence category (Hickey, 1973)

Category	Angle in degrees
Acute angle	Less than 80°
Narrow	<45°
Moderate	45-65°
Wide	65-80°
Right angle	80-100°
Obtuse angle	>100°

Table 5 The ranges of values for the angle of divergence category (Hickey, 1973)

Category	Angle in Degrees
Acute angle	< 80°
Narrow	< 45°
Moderate	45-65°
Wide	65-80°
Right angle	80-100°
Obtuse angle	> 100°

Table 6 General leaf architecture charactertistics of genus *Diplazium*

Leaf Morphology	
Leaf organization	pinnately and pinnatifid dissected
Shape (pinna/pinnule)	mostly lanceolate, few elliptic and oblong
Apex shape (pinna/pinnule)	acuminate and acute
Base (pinna/pinnule)	
Shape	usually truncate, few cuneate and rounded, rare cordate
Angle	obtuse to wide obtuse
Symmetry	asymmetrical
Margin type	entire to serrate
Stalk type	usually short stalked
Blade Class (pinna/pinnule)	nanophyll to mesophyll
Lobation	shallow to deep
Venation Pattern	
1° vein	
Category	pinnate
Size	stout to massive
2° vein	
Category	Mostly craspedodromous, rarely anastomosing
Angle of divergence	moderate to right angle
Variation in angle of divergence	usually upper 2° vein more acute than lower
Spacing	usually increasing toward the base, some are uniform
3° vein	
Category	free and forked, sometimes end in sinuses, few forming commissural veins
Angle of divergence	usually narrow
Variation in angle of divergence	upper 3° vein more acute than lower
Spacing	usually increasing toward the base
Areole	generally absent

Table 7 Leaf architecture characters of 27 selected *Diplazium* species (Athyriaceae): General Leaf Morphology

SPECIES	LEAF ORGANIZATION	SHAPE	APEX SHAPE	L:W RATIO	BLADE CLASS	BASE SHAPE	BASE ANGLE	BASE SYMMETRY	MARGIN	STALK	LOBATION
Diplazium cordifolium	simple-pinnate	lanceolate	acute	2.7-3.4:1	mesophyll	cordate	wide obtuse	asymmetrical	entire	short-stalked	unlobed
Diplazium crenato-serratum	pinnate	lanceolate	acute	3.4-4.6:1	microphyll	trruncate	wide obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium cultratum	pinnate	lanceolate	acute	1.4-5:1	microphyll	truncate	wide obtuse	asymmetrical	entire	short-stalked	unlobed
Diplazium cumingii	Pinnate	lanceolate	acute	3.6-9:1	Mesophyll	cuneate	acute	asymmetrical	entire	short-stalked	unlobed
Diplazium davaoense	tripinnate	lanceolate	acute	5.2-5.5:1	notophyll	truncate	obtuse	asymmetrical	crenate	short-stalked	shallow
Diplazium deltoideum	bipinnatifid	oblong	acute	3.3-5:1	notophyll	truncate	obtuse	asymmetrical	serrate	short-stalked	deep
Diplazium dolichosorum	tripinnate	lanceolate	acute	3.2-3.9:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium doederleinii	tripinnatifid	lanceolate	acute	3.7-3.9:1	microphyll	truncate	obtuse	asymmetrical	entire	short-stalked	moderate
Diplazium esculentum	bipinnate-tripinnate	lanceolate	acute	4.1-5:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium forbesii	pinnate	lanceolate	acute	3.4-7:1	mesophyll	rounded	obtuse	asymmetrical	entire	short-stalked	unlobed
Diplazium fraxinifolium	pinnate	elliptic	acute	4.6-6.1:1	mesophyll	cuneate	acute	asymmetrical	entire	short-stalked	unlobed
Diplazium fructuosum	tripinnate	lanceolate	acute	4.7-7.8:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-stalked	moderate
Diplazium griffithii	tripinnatifid	oblong	acute	3.1-4.1:1	microphyll	truncate	wide obtuse	asymmetrical	serrate	short-stalked	deep
Diplazium lomariaceum	pinnatifid	elliptic	acute	10.5-12.4:1	mesophyll	cuneate	acute	asymmetrical	entire	long-stalked	deep
Diplazium magnificum	tripinnatifid	lanceolate	acute	4-4.9:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-	deep
Diplazium maximum	tripinnate	lanceolate	acute	3.9-5:1	mesophyll	truncate	obtuse	asymmetrical	crenate	short-stalked	shallow
Diplazium oligosorum	tripinnatifid	lanceolate	acute	3.9-4.7:1	microphyll	truncate	wide obtuse	asymmetrical	entire	short-stalked	moderate
Diplazium pallidum	pinnate	lanceolate	acute	6.3-10.9:1	microphyll	rounded	obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium polypodioides	tripinnatifid	lanceolate	acute	3.9-5.1:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-stalked	deep

Table 7 (Continued)

SPECIES	LEAF ORGANIZATION	SHAPE	APEX SHAPE	L:W RATIO	BLADE CLASS	BASE SHAPE	BASE ANGLE	BASE SYMMETRY	MARGIN	STALK	LOBATION
Diplazium porphyrorachis	pinnatifid	elliptic	acute	5.3-6.9:1	mesophyll	cuneate	obtuse	asymmetrical	entire	long-stalked	deep
Diplazium proliferum	pinnate	lanceolate	acute	2.8-4.4:1	notophyll	truncate	obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium pseudocyatheifoleum	tripinnatifid	lanceolate	acute	3.6-4.9:1	microphyll	rounded	obtuse	asymmetrical	entire	short-stalked	deep
Diplazium sorsogonense	bipinnatifid	lanceolate	acute	4.6-7:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-stalked	deep
Diplazium vestitum	tripinnate	lanceolate	acute	3.3-6:1	microphyll	truncate	obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium whitfordii	bipinnatifid	lanceolate	acute	2.7-3:1	nanophyll	truncate	obtuse	asymmetrical	serrate	short-stalked	deep
Diplazium williamsii	pinnate	lanceolate	acute	2.8-3.3:1	nanophyll	truncate	obtuse	asymmetrical	serrate	short-stalked	shallow
Diplazium xiphophyllum	pinnate	lanceolate	acute	4.8-6.3:1	mesophyll	rounded	obtuse	asymmetrical	entire	short-stalked	unlobed

Table 8 Detailed leaf architecture character of 27 Selected *Diplazium* species (Athyriaceae): Venation Pattern

Species	Primary Vein		Secondary Vein				Tertiary Vein			
	Category	Size	Category	AD	VAD	Spacing	Category	AD	VAD	Spacing
Diplazium cordifolium (Fig. 2a)	Pinnate	moderate	Reticulodromous	moderate	regular	Irregular	-		-	-
Diplazium crenato-serratum (Fig. 3a)	pinnate	massive	Cladodromous	narrow	upper vein more acute than lower	uniform	-	-	-	-
Diplazium cultratum (Fig. 3b)	pinnate	massive	Cladodromous	wide	upper vein more acute than lower	increasing toward the base	-	-	-	-
Diplazium cumingii (Fig. 2b)	pinnate	stout	Reticulodromous	moderate	nearly uniform	uniform	-	-	-	-
Diplazium davaoense (Fig. 4a)	pinnate	massive	Craspedodromous	moderate	upper vein more acute than lower	increasing toward the base	Free end in sinuses	narrow	upper vein more acute than lower	increasing toward the base
Diplazium deltoideum (Fig. 4b)	pinnate	stout	Craspedodromous	right	nearly uniform	irregular	free and forked touching margin	wide	upper 3° vein more acute than lower	upper 3° vein more acute than lower
Diplazium dolichosorum (Fig. 4c)	pinnate	massive	Craspedodromous	moderate	upper 2° vein more acute than lower	increasing toward the base	free end in sinuses	narrow	upper 3° vein more acute than lower	increasing toward the base
Diplazium doederleinii (Fig. 4d)	pinnate	massive	Craspedodromous	wide	upper 2° vein more acute than lower	increasing toward the base	free end in sinuses	narrow	upper 3° vein more acute than lower	increasing toward the base
Diplazium esculentum (Fig. 4e)	pinnate	massive	Craspedodromous	wide	varies irregularly	increasing toward the base	forming commissural vein	narrow	upper 3° vein more acute than lower	increasing toward the base
Diplazium forbesii (Fig. 2c)	pinnate	moderate	Reticulodromous	moderate	varies irregularly	irregular	-	-	-	-
Diplazium fraxinifolium (Fig. 3c)	pinnate	stout	Cladodromous	moderate	upper 2° vein more obtuse than lower	uniform	-	-	-	-
Diplazium fructuosum (Fig. 4f)	pinnate	massive	Craspedodromous	wide	upper 2° vein more obtuse than lower	increasing toward the base	free end in sinuses	narrow	upper 3° vein more acute than lower	increasing toward the base

Table 8 (Continued)

Species	Primary Vein		Secondary Vein				Tertiary Vein			
	Category	Size	Category	AD	VAD	Spacing	Category	AD	VAD	Spacing
Diplazium griffithii (Fig. 4g)	pinnate	massive	Craspedodromous	wide	upper 2° vein more obtuse than lower	increasing toward the base	free and forked touching margin	narrow	upper 3° vein more acute than lower	increasing toward the base
Diplazium lomariaceum (Fig. 4h)	pinnate	massive	Craspedodromous	right	nearly uniform	irregular	free and forked touching margin	moderate	varies irregularly	irregular
Diplazium magnificum (Fig. 4i)	pinnate	massive	Craspedodromous	right	upper 2° vein more acute than lower	increasing toward the base	free end in sinuses	moderate	uniform	increasing toward the base
Diplazium maximum (Fig. 4j)	pinnate	stout	Craspedodromous	wide	upper 2° vein more acute than lower	irregular	free end in sinuses	moderate	uniform	increasing toward the base
Diplazium oligosorum (Fig. 4k)	pinnate	stout	Craspedodromous	moderate	upper 2° vein more acute than lower	increasing toward the base	free end in sinuses	moderate	upper 3° vein more acute than lower	increasing toward the base
Diplazium pallidum (Fig. 3d)	pinnate	massive	Cladodromous	wide	nearly uniform	uniform	-	-	-	-
Diplazium polypodioides (Fig. 4l)	pinnate	stout	Craspedodromous	wide	upper 2° vein more acute than lower	uniform	free end in sinuses	narrow	upper 3° vein more acute than lower	increasing toward the base
Diplazium porphyrorachis (Fig. 4m)	pinnate	stout	Craspedodromous	wide	upper 2° vein more obtuse than lower	uniform	free and forked touching margin	moderate	upper 3° vein more acute than lower	uniform
Diplazium proliferum (Fig. 4n)	pinnate	stout	Craspedodromous	moderate	upper 2° vein more obtuse than lower	increasing toward the base	forming commissural vein	narrow	upper 3° vein more acute than lower	uniform
Diplazium pseudocyatheifoleum (Fig. 4o)	pinnate	massive	Craspedodromous	right	upper 2° vein more acute than lower	increasing toward the base	free end in sinuses	moderate	uniform	increasing toward the base
Diplazium sorsogonense (Fig. 4p)	pinnate	massive	Craspedodromous	right	upper 2° vein more acute than lower	increasing toward the base	free end in sinuses	moderate	uniform	increasing toward the base
Diplazium vestitum (Fig. 4q)	pinnate	massive	Craspedodromous	wide	nearly uniform	uniform	free end in sinuses	narrow	upper 3° vein more acute than lower	increasing toward the base

Table 8 (Continued)

Species	Primary Vein		Secondary Vein				Tertiary Vein			
	Category	**Size**	**Category**	**AD**	**VAD**	**Spacing**	**Category**	**AD**	**VAD**	**Spacing**
Diplazium whitfordii (Fig. 4r)	pinnate	massive	Craspedodromous	moderate	upper 2° vein more acute than lower	uniform	free end in sinuses		upper 3° vein more acute than lower	increasing toward the base
Diplazium williamsii (Fig. 3e)	pinnate	massive	Cladodromous	moderate	upper 2° vein more acute than lower	irregular	-		-	-
Diplazium xiphophyllum (Fig. 3f)	pinnate	stout	Cladodromous	moderate	nearly uniform	uniform	-		-	-

Note: AD = angle of divergence; VAD = variation in angle of divergence