

The Identity and Morphology of the Three Species of *Drynaria* (Polypodiaceae) in Bukidnon, Philippines

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Abstract - The objective of the study was to compare the morpho-anatomical characters of the species of *Drynaria* found in Bukidnon, Philippines. The species identified were *Drynaria quercifolia* (Linn) Sm., *D. sparsisora* (Desv.) and Moore, *D. rigidula* (Sw.) Bedd. Morpho-anatomical comparisons of the three species of *Drynaria* showed some similarities such as long creeping and branched rhizome, mature fertile fronds green and sterile fronds brown, leathery and with shiny upper surface and exindusiate sori. On the other hand, differences were observed in the plant height, type of lamina, presence or absence of groove in the stipe, costa and rachis, length and width, margin, fertile and sterile fronds attachment to the rhizome, base, apex, paleae, hair shape and sori arrangement. Anatomically, the five species also differed in the attachment of paleae to the rhizomes, length, width, number and shape of vascular bundles in the stipe, costa and rachis, presence and absence of hypodermis, type of stomata, length, width, number

of subsidiary cells, walls of epidermal cells, the cortical arrangement of the tissues in the costa and midvein of the pinna. Based on their morpho-anatomical differences, a taxonomic key was constructed to identify the three species of *Drynaria*.

Keywords - morphology, anatomy, systematic, *Drynaria*, Bukidnon

INTRODUCTION

In the Philippines, there are at least 31 families of ferns in 151 genera and 958 species (Salgado 1990). One of these families is Polypodiaceae. This is a large family of ferns consisting of about 51 genera and 1,500 species throughout the tropical and subtropical regions of the world (Copeland 1947, 1960; Holttum 1968; Price 1972) of which 28 genera and 109 species have been found in the Philippines (Zamora 1988).

One of the 28 genera found in the Philippines is the Genus *Drynaria* (Bory) J. Sm. known commonly as "Oak leaf fern". This genus consists of about 21 species distributed from Africa to the Pacific, northwards to China and Southwards to Australia. In the Philippines, 4 species were reported by Zamora (1975), viz., *Drynaria quercifolia* (Linnaeus) J. Smith, *D. sparsisora* (Disvaux) Moore, *D. rigidula* (Swartz) Beddome and *D. descensa* Copeland. Two of these species have been reported by Amoroso (1987) to be medicinal. They are *D. quercifolia* (L.) J. Smith which is used as astringent, antibacterial and for cough and *D. rigidula* (Swartz) Beddome is used for gonorrhoea and dysentery (Quisumbing, 1978).

Although the morphology of *D. quercifolia*, *D. sparsisora* and *D. rigidula* have already been described by Copeland (1958), Zamora and Co (1986), Chin (1984) and Amoroso (1987), these gross morphological descriptions were incomplete and have not been studied anatomically.

Thus, this study attempted to compare the morphology of the species of *Drynaria* found in Bukidnon, Philippines. Specifically it aimed to identify and describe the gross morpho-anatomy of *Drynaria* species and to construct a taxonomic key leading to the identity of the different species.

MATERIALS AND METHODS

Collection, Preparation of Herbarium Specimens and Identification

Field collection of the different species of *Drynaria* (Bory) J. Sm. was done throughout Bukidnon, Philippines. At least four plants of the same species from the same habitat were collected. The collected samples were placed in plastic bags. In each collection, the date, place of collection, collection number, altitude and habitat were noted.

Suitable plants were selected from the field collection for propagation. The remaining specimens were used for morphological studies as well as for herbarium preparations.

Copeland's Fern Flora of the Philippines (1958-1960) and Flora Malesiana Series (II) were used to identify the specimens.

Morphological and Anatomical Studies

- a. The description of the gross morphological features of *Drynaria* include the following: length and width of rhizome, stipe, costa, rachis and entire fronds; b. color, abundance and distribution of paleae. c. branching pattern of the rhizome; d. presence and absence of grooves and color stipe; e. shape, base, apex and margin of lamina; f. venation pattern and laminar hairs; and, g. distribution and arrangement of sori.

All the representative specimens were fixed in 70% ethyl alcohol, stored in covered containers and were later sectioned for anatomical studies. Free-hand techniques of Johansen (1980) were used in preparing temporary and permanent slides of the rhizome, stipe, rachis, midrib and lamina. Sections were stained 1% safranin and counterstained with 0.5% fast green in 95% ethyl alcohol.

RESULTS AND DISCUSSION

Three species of *Drynaria* were found in Bukidnon, Philippines, viz., *Drynaria quercifolia* (L.) Sm. (Plate 1 A), *D. sparsisora* (Desv.) Moore (Plate 1 B) and *D. rigidula* (Sw.) Bedd. (Plate 1 C), The morpho-

anatomical descriptions (Table 1) and occurrence, altitudinal range and status of the three species of *Drynaria* (Table 2) are shown:

Table 1. Comparative morpho-anatomical features of the three species of *Drynaria*

Morpho Anatomical Features	<i>D. quercifolia</i>	<i>D. sparsisora</i>	<i>D. rigidula</i>
Habit & Habitat	some terrestrial but mostly epiphytic ferns on tree trunks and wet rocks	some terrestrial but mostly epiphytic ferns on tree trunks & wet rocks	some terrestrial but mostly epiphytic ferns on tree trunks
	grows in cool, moist & shady areas at an altitude of 305-840 meters above sea level	grows in cool, moist & shady areas at an altitude of 320-847 meters above sea level	grows in cool, moist & shady areas at an altitude of 330-750 meters above sea level
	plant height ranges from 60-100 cm long	plant height ranges from 45-60 cm long	plant height ranges from 54-90 cm long
Roots Type/color	adventitious & fibrous/dark brown	adventitious & fibrous/dark brown	adventitious & fibrous/dark brown
Rhizome	long creeping thick & fleshy covered with imbricate pale brown paleae branched & woody	long creeping thick & fleshy covered with imbricate pale brown paleae branched & woody	long creeping thick & fleshy covered with appressed pale brown paleae branched & woody
Fronde Stipe Color	Green	Green	Green
Grooved	Adaxial	Adaxial	Adaxial
Length	10-20 cm long	5-15 cm long	6-12 cm long
Structure Present	Hairs & paleae but less abundant	Hairs & paleae but less abundant	Hairs & paleae but less abundant
Costa/Rachis Color	Dark brown to green	Light brown to light green	Dark brown to light green
Grooved	Adaxial	Adaxial	adaxial
Length	40-80 cm long	20-45 cm long	17- 27 cm long
Width	0.5-0.6 cm wide	0.1-0.3 cm wide	0.2-1.5 cm wide
Structure present	Hairs but less abundant	Hairs but less abundant	Hairs but less abundant

Continuation of Table 1

Lamina Apex	Caudate	Caudate	caudate
Base	Attenuate	attenuate	attenuate
Type	Pinnatifid	Pinnatifid	alternate pinnate
Margin	Deeply lobed	deeply lobed	linear lanceolate
Texture	Leathery	leathery and shiny	leathery
Length	50-60 cm long	18-40 cm long	8-36 cm long
Width	5-6 cm wide	3-4 cm wide	1-1.5 cm wide
Structure Present	Hairs	Hairs	Hairs
Color	Green	Green	Green
Sterile Length	20-40 cm long	10-15 cm long	11-36 cm long
Width	15-25 cm wide	5-12 cm wide	5-8 cm wide
Color	Green when young brown & shiny when mature	Green when young brown & shiny when mature	Green when young brown & shiny when mature
Shape of Blade	Broadly-ovate	less broadly ovate	ovate
Sterile Texture	Leathery/stiff/ rough	leathery/stiff/ rough	leathery/stiff
Shape of Apex	obtuse	obtuse	acute
Shape of Base Leaf	oblique	oblique	oblique
Attachment	Normal frond stalked	Normal frond stalked	stalked
Venation	netted	netted	netted
Paleae Apex	filiform	filiform	filiform
Base	bordered-clathrate	clathrate	Peltate
Length	18-23 cm long	8-11 cm long	3-8 cm long
Point of Attachment	Imbricate	imbricate	Appressed
a. Shape	Thickened circu-lar- shaped in the middle of the base	Thickened circu-lar- shaped in the middle of the base	Thickened circu- lar-shaped in the middle of the base
b. Color	Black	black	black

Continuation of Table 1

Hairs	With glandular hairs	With glandular hairs	With glandular hairs
Shape	Stellate with small yellow club-shaped & glandular tips	Stellate with small yellow club-shaped & glandular tips	Stellate hair-like structure, 6-8 ribbon-like arms
Color	Light to dark brown	Light to dark brown	Light to dark brown
Cellular Type	Multicellular	Multicellular	Multicellular
Abundance	Abundant on the lower portion of the lamina	Abundant on the lower portion of the lamina	Abundant on the lower portion of the lamina
	Found also in the stipe & costa but less	Found also in the stipe & costa but less	Found also in the stipe & costa but less
Rhizome Outline	Oblong	oblong	oblong
Shape of the vascular bundle	Fan-shaped	Fan-shaped	Fan-shaped
Kind of Stele	Dictyostelic	dictyostelic	dictyostelic
Kind of Xylem	non-hippocampus	non-hippocampus	non-hippocampus
Paleae's Attachment to the Rhizome	attached within the epidermal line (imbricate)	attached within the epidermal line (imbricate)	attached within the epidermal line (appressed)
Length	19 cm long	18 cm long	8 cm long
Width	26 cm wide	24 cm wide	6 cm wide
Stipe Outline	Circular-ovate-winged on the opposite side	Circular-ovate-winged on the opposite side	Circular-ovate-winged on the opposite side
Shape of the vascular bundle	bean to circular ovate	bean to circular ovate	bean to circular ovate
Kind of Stele	dictyostelic	dictyostelic	dictyostelic
Kind of Xylem	non-hippocampus	non-hippocampus	non-hippocampus
Component Present	thick phlobaphene containing cells	thick phlobaphene containing cells	thick phlobaphene containing cells
Number of vascular bundles	15-17	10-11	8-9

Continuation of Table 1

Costa/Rachis Outline	Raised adaxial and abaxial outline	Raised adaxial and abaxial outline	Obconic outline winged on the opposite sides
Kind of Stele	dictyostelic	dictyostelic	dictyostelic
Kind of Xylem	non-hippocampus	non-hippocampus	non-hippocampus
Component Present	thick phloba-phene containing cells	thick phloba-phene containing cells	thick phloba-phene containing cells
Number of vascular bundles	4	3	5
Pinna Type of Mesophyll	Undifferentiated	undifferentiated	undifferentiated
Presence/Absence of Hypodermis	Present (adaxial)	Present (adaxial)	Absent
Midvein of Middle Pinna	Reniform(kidney-shaped)	Retusely rounded	Circular ovate
Shape of Bundle	thick phloba-phene containing cells	thick phloba-phene containing cells	thick phloba-phene containing cells
Component Present	non-hippocampus	non-hippocampus	non-hippocampus
Kind of Xylem	polocytic	polocytic	polocytic
Type of Stomata	parietocytic	parietocytic	parietocytic
Subtype	epidermal cells are large, walls broadly & deeply sinuous	epidermal cells are less or slightly sinuou	walls are broadly and deeply sinuous
Shape of Walls	netted	netted	netted
Venation Type	3 (2-3)	3 (2-3)	3 (2-3)
Number of Subsidiary Cells	35 microns 50 microns	29 microns 38 microns	32 microns 41 microns
Size (HPO) width length Number of Stomata per sq. mm (LPO)	209	228	174

Table 2. Occurrence, altitudinal range and status of the three species of *Drynaria*

Species	Altitudinal Range (M)	Status
<i>Drynaria quercifolia</i>	305-840	A, NRL, EIS
<i>Drynaria sparsisora</i>	320-847	A, NRL, EIS
<i>Drynaria rigidula</i>	330-750	M, NRL, EIS

Legend:

- A - Abundant (75% - 100%)
- M - Moderate (51% - 75%)
- R - Rare (50% - below)
- NRL - New record in terms of locality
- EIS - Economically important species

Drynaria quercifolia (L.) Sm.

Gross morphology. Roots fibrous, adventitious and dark brown. Rhizome fleshy, blackish, long-creeping, very thick, woody, covered with imbricate pale brown palea, measures 13 cm. long and 26 cm. wide (Plate 2 and Table 1). Fronds pinnately lobed, green and dimorphic. Sterile fronds green when young (Plate 2) and shiny brown when mature (Fig. 3) , about 20-30 cm long and 15-25 cm wide, broadly-ovate, apex obtuse, base oblique, leathery, rough and stiff . Fertile fronds green, 60-100 cm. long, lamina about 50-60 cm long and 5-6 cm wide, deeply lobed, pinnatifid, leathery, apex caudate and base attenuate, (Plate 2). Hairs abundantly distributed at the lower surface of the lamina. Stipes green grooved adaxially and 10-20 cm long (Fig. 1 and Table 1). Costa dark brown to green, grooved adaxially, about 40-80 cm long and 0.5-0.6 cm wide (Plate 2 and Table 1). Palea bordered-clathrate base, apex filiform, pale brown, with a thickened black circular cells at the, 18-23 cm. long with glandular hairs (Figs. 5 and 6 and Table 1). Hairs stellate with small yellow club-shaped and

glandular tips, multicellular and light to dark. Abundant in lower surface and less in stipe and costa (Table 1). Sori mostly round in 2 rows between main veins. Sporangia composed of thin annular cells and sporangial stalk. Spores bilateral, monoletic, elliptic-oblong and plano to nearly concavo-convex (Fig.19 and Table 1).

Anatomy. Transsections of the rhizome revealed an oblong outline and the different tissues like epidermis, cortex and vascular bundles (Fig. 1 and Plate 7). The outer layer of the cells of the rhizome is the epidermis with outer walls thicker than the inner walls (Fig. 1). Next to the epidermis is the cortex and thick-walled endodermis which surrounds the vascular bundles (Fig. 1). Each vascular bundle is circular to oblong and is composed of compact phloem surrounded by the non-hippocampus xylem tissue (Fig. 1). The rhizome has a dictyostelic stele and the arrangement of vascular bundles is fan-shaped. The attachment of the paleae to the rhizome is imbricate (Fig. 1 and Table 1).

Transsections of the basal, middle and upper stipes clearly showed a circular-ovate outline and winged to the base. The epidermis is single-layered and followed by the cortex which is differentiated into outer cortical sclerenchyma and inner cortical parenchyma (Fig. 4 and Plate 8). The stele is dictyostelic with 17 vascular bundles at the base, 16 at the middle and 15 at the upper stipe. The bundles assumed a U-shaped outline, opening towards the adaxial surface of the stipe with non-hippocampus xylem strand and surrounded by compactly-arranged cells. Two of these bundles are longer and kidney-shaped and circular. The endodermis is single-layered which is surrounded by thick phlobaphene containing cells (Fig.4, Plate 8 and Table 1).

Transsections of the middle costa showed raised adaxial and abaxial outline. The cortex of the costa is also differentiated into outer cortical sclerenchyma and inner cortical parenchyma. The former is composed of compactly arranged cells while the latter has loosely arranged cells (Fig.7 and Plate 8). There are four vascular bundles and stele is dictyostelic. The endodermis is single-layered and surrounded by thick phlobaphene containing cells. The xylem is non-hippocampus and surrounded by the compactly arranged phloem tissue (Fig.7 and Plate 8). Transsections of the middle pinna showed single-layered

upper and lower epidermis (Figs.10 and 13). Below the epidermis is the hypodermis layer on the adaxial portion (Figs.10 and 13). In between the upper and lower epidermis is the mesophyll region which is undifferentiated. The midvein portion of the middle pinna shows the reniform vascular bundle (Figs.10 and 13). The vascular bundle is enclosed by a single-layer of endodermis surrounded by a thick phlobaphene containing cells. The xylem tissue is non-hippocampus surrounded by compactly-arranged phloem tissue (Figs. 10 ,13 and Table 1).

Cleared pinna showed the netted type of venation. The stomata have 3 subsidiary cells, polocytic type and of parietocytic subtype (Fig.16). Abundant on the lower surface, the epidermal cells have broad walls and deeply sinuous (Table 1).

Distribution and location. This species is commonly found as epiphytes on tree trunks and wet rocks, though sometimes they can be observed terrestrially on exposed or unexposed places at an altitude of 305 – 840 m above sea level (Fig. 21 and Table 2).

Status. Abundant, new record in terms of locality and an economically important species (Table 2).

D. sparsisora (Desv.) Moore

Gross morphology. Roots, fibrous, adventitious and dark brown. Rhizome fleshy, long-creeping, woody, covered with imbricate pale brown palea (Plate 2 and Table 1), about 18 cm long and 24 cm wide (Plate 2- and Table 1). Fertile fronds green, 45-60 cm long, lamina about 18-40 cm long and 3.40 cm wide, deeply lobed, pinnatifid, leathery, shiny, apex caudate, and base attenuate (Plate 2). Hairs abundantly distributed at the lower surface. Sterile fronds green when young and shiny brown when mature, 5-12 cm wide and 10-15 cm long, less broadly ovate, leathery, stiff, rough, apex obtuse, and base oblique (Plate 3 and Table 1). Stipes green, grooved adaxially, and about 5-15 cm long (Plate 2 and Table 1). Costa light brown to light green, grooved adaxially, about 0.1 – 0.3 cm wide and 20-45 cm long (Plate 2 and Table 1). Palea clathrate base and filiform apex (Plates 4 and 5), pale brown thickened black circular shape at the base. 8-11 cm long with glandular hairs (Table 1). Hairs stellate with small yellow club-shape

and glandular tips, multicellular, light to dark brown and abundantly distributed at the lower surface of the lamina, and sparsely on the stipe and costa (Plate 6 and Table 1).

Anatomy. Transections of the rhizome revealed an oblong outline. The outer layer of the cells of the rhizomes is the epidermis with outer walls thicker than inner walls (Plate 7 and Fig. 2). Next to the epidermis is the cortex and thick-walled endodermis which surrounds the vascular bundles (Fig. 2). Each vascular bundle is circular to oblong and is composed of compact phloem surrounded by the non-hippocampus xylem-tissue (Fig. 2). The type of stipe is dictyostelic and arrangement of bundles is fan-shaped. The attachment of the palea to the rhizomes is imbricate (Fig. 2 and Table 1).

Transections of the basal, middle, and upper stipes clearly showed the circular-ovate outline and winged to the base. The outer layer is the single-layered epidermis which is thick-walled cells mainly for support and protection from loss of water and from injury. The cortex which lies next to the epidermis consists of two kinds of cell types. The outer cortical tissue is mainly composed of sclerenchyma cells while the inner cortex had the parenchyma cells (Plate 8). The stele is dictyostelic with 11 vascular bundles at the base, 10 at the middle and upper stipes. The bundles assume a U-shaped and mostly circular bundles and two of which are larger, in kidney-shaped in adaxial portion, surrounded by thick phlobaphene containing cells with a non-hippocampus xylem strands (Plate 8, Fig. 5 and Table 1).

Transections of the middle portion of the costa exhibited the raised adaxial and abaxial outline. The middle portion of the costa is composed of cutinized single-layered epidermal cells. The costa is also differentiated into outer cortical sclerenchyma and inner cortical parenchyma. The former is composed of smaller compactly arranged cells while the latter has loosely arranged cells (Plate 8 and Fig. 8). There are 3 vascular bundles, the adaxial portion assumed a butterfly-shape and the abaxial circular-oblong bundles. The stele is dictyostelic and endodermis is surrounded by phlobaphene containing cells. The xylem is non-hippocampus surrounded by compactly-arranged phloem tissue (Fig. 11 and Table 1).

Transections of the middle pinna showed a single-layered upper and lower epidermis (Fig. 11). Below the epidermis is the hypodermis layer on adaxial portion (Fig. 14). Situated between the upper and lower epidermis is the undifferentiated mesophyll tissue. The midvein portion of the middle pinna shows the vascular bundle surrounded by a single-layer of endodermis and a thick band of phlobaphene containing cells and non-hippocampus xylem tissue which is surrounded by phloem tissue (Fig. 14 and Table 1).

Cleared pinna showed the netted type of venation, stomata with 3 subsidiary cells, polocytic type and axillocytic subtype (Fig. 17). Stomata are abundant on lower surface and epidermal cells smaller and with slightly sinuous walls (Table 1).

Distribution and location. This species is commonly found attached on the tree trunk, old walls which are either shaded or exposed, though sometimes it becomes terrestrial in habit because of the creeping branched. This can be located at an altitude of 320 m – 847 m above sea level (Fig. 21 and Table 2).

Status. Abundant, new record in terms of locality and an economically important species (Table 2).

***D. rigidula* (Sw.) Bedd.**

Gross morphology. Roots fibrous, adventitious and dark brown. Rhizomes are thick, fleshy, long-creeping, covered with appressed pale brown palea, about 8 cm long and 6 cm wide (Plate 2 and Table 1). Fertile fronds green, 50-90 cm long, lamina about 8-36 cm long and 1–1.5 cm wide, linear lanceolate, alternate pinnate, apex acuminate, base attenuate and leathery (Plate 2). Sterile fronds greenish when young and shiny brown when mature, 5-8 cm wide and 11-36 cm long, ovate, apex, acute, base oblique (Plate 3 and Table 1). Stipes dark purple, grooved adaxially and 6-12 cm long (Plate 3 and Table 1). Palea peltate base (Plates 4 and 5), apex filiform (Plate 4 and 5), pale brown, thickened black circular shape in the middle of the base, about 3-8 cm long with glandular hairs (Table 1). Hairs stellate with 6-8 ribbon-like arms (Plate 6), abundant at the lower surface of the lamina, and sparse found in stipe and costa , unicellular, transparent (Table 1). Sori

mostly in one row on each side of the costa. Sporangia composed of annular cells and sporangial stalk. Spores bilateral , monolete, oblong and plano-convex (Fig. 20 and Table 1).

Anatomy. Transection of rhizome revealed an oblong outline (Plate 7 and Fig. 3) and different tissues like, epidermis, cortex and vascular bundles (Fig. 3). The outer layer of cells of the rhizome is the epidermis with outer walls thicker than inner walls (Fig. 3). Next to the epidermis is the cortex. The next layer is the thick-walled endodermis which surrounds the vascular bundle (Fig. 3). Each vascular bundle is circular to oblong and composed of compactly arranged phloem surrounded by the non-hippocampus xylem tissue (Plates 7 and Fig.3). The rhizome has a dictyostelic stele and it has a fan-shape outline of vascular bundles. The attachment of the palea to the rhizome is appressed (Plate 7, Fig. 3 and Table 1).

Transections of the basal , middle and upper stipes clearly showed the circular-ovate outline and winged to the base. The outer layer is the thick-walled epidermis followed by the cortex which is differentiated into outer cortical sclerenchyma and inner cortical parenchyma (Plate 8 and Fig. 17). The stele is dictyostelic with a vascular bundle at the base and middle, 8 at the upper stipes. Two of the bundles are larger kidney-shaped, situated adaxially and the others are circular-oblong and located abaxially. The vascular bundles are surrounded by phlobaphene containing cells with a non-hippocampus xylem strand and surrounded by compactly arranged phloem tissues (Plate 8 , Fig. 6 and Table 1).

Transections of the middle rachis exhibited the raised adaxial and abaxial outline. The cortex is differentiated into outer cortical sclerenchyma and inner cortical parenchyma. The former is composed of compactly arranged cells while the latter has loosely arranged cells (Fig. 9). There are 4 vascular bundles, two of which are kidney-shape situated on adaxial portion and the other two are circular-ovate in abaxial ends. The xylem strands is non-hippocampus which is compactly surrounded by phloem tissue. The stele is dictyostelic and single-layered, endodermis surrounded by thick phlobaphene containing cells (Fig. 9 and Table 1).

Transections of the middle pinna showed a single-layer upper and lower epidermis (Figs. 12 and 15). Situated between the upper and lower epidermis is the undifferentiated mesophyll. The midvein portion showed the circular-ovate vascular bundles (Fig. 12). The vascular bundles are enclosed by a single-layer of endodermis surrounded by a thick phlobaphene containing cells. The xylem strand is non-hippocampus and compactly surrounded by a phloem tissue (Fig. 12 and Table 1).

Cleared pinna indicated a netted type of venation, 2 subsidiary cells, polocytic type and parietocytic subtype (Fig. 18). Stomata are abundant on the lower surface and epidermal cells large, walls broadly and deeply sinuous (Table 1).

Distribution and location. This species is commonly attached on trunks of trees, on shaded or exposed areas. Sometimes they can be found terrestrially on exposed places and under canopy of trees at an altitude of 330 m – 750 m above sea level (Fig. 21 and Table 2).

Status. New record in terms of locality and economically important species (Table 2).

Morpho-Anatomical Comparison of the Three Species of *Drynaria*

Comparisons of the gross-morphology and anatomy of the three species, viz, *Drynaria quercifolia* (L.) J. Sm., *D. sparsisora* (Desv.) Moore, *D. rigidula* (Sw.) Bedd. revealed some similarities and differences as shown in Table. 1.

Morpho-anatomical similarities were observed in the following: habit and habitat, roots, rhizome, stipe, costa, rachis, lamina, fertile fronds, sterile fronds, paleae and hairs.

Gross Morphological Similarities

Habit and Habitat. All five species of *Drynaria* are mostly epiphytic on tree trunks and wet rocks, although occasionally some are terrestrial. They grow on cool, moist, and shady areas.

Roots and Rhizome. All have fibrous, adventitious and dark brown roots. The rhizomes are long creeping, thick, fleshy, branched, woody, and grow to several meters.

Fertile Fronds. The fertile fronds are all green, leathery, shiny, apex caudate, base attenuate and bear hairs abundantly distributed at the lower surface. This was also reported by Chandra (1979).

Sterile Fronds. All are green when young and shiny brown when mature, broadly-ovate blade, leathery, and with oblique shape of base.

Paleae. The paleae have filiform apex and with thickened black circular shape at the center of the base. Thus, sometimes old stems are black due to its persistent bases of the paleae (Copeland 1958; Zamora and Co. 1986), with light to dark brown glandular hairs.

Anatomical Similarities

Rhizome. The rhizome of the *Drynaria* studied have oblong outline in transection, having a fan-shaped vascular bundles, dictyostelic type of stele, and non-hippocampus xylem strand.

Stipe. The basal, middle and upper stipes are circular, ovate in transaction and winged to the base, vascular bundles are bean to circular-ovate in shape, irregularly placed and surrounded with a band of phlobaphene containing cells, xylem strand configuration of the larger adaxial bundles is non-hippocampus and dictyostelic stele. These characters also conform with the description of Amoroso (1983).

Costa. The costae have non-hippocampus xylem strand, dictyostelic stele, and vascular bundles surrounded by thick-phlobaphene containing cells.

Pinna. They have undifferentiated mesophyll. The midvein of the pinna has non-hippocampus xylem strand and vascular bundles surrounded with thick-phlobaphene containing cells.

Clearing technique of the lamina of the three species of *Drynaria* exhibited have netted type of venation and the stomatal type is polocytic.

Spores. The spores are bilateral, monolete, elliptic-oblong, and plano-convex as also reported by Joaquin (1985).

Although the three species of *Drynaria* resembled each other in the aforementioned characteristics, they also showed differences in their morpho-anatomy. Differences were observed in its distribution, plant height, length and groove in the stipe, costa and rachis color, length and width, type of lamina, margin, length and width, sterile leaf attachment, base, apex, length and width, paleae base, length and attachment, and hairs shape and cellular type.

Gross Morphological Differences

Habit and Habitat. In their habitat and altitudinal range. *D. quercifolia* can be found in both shaded and exposed places at an altitude of 305 to 840 masl and *D. sparsisora* can be found epiphytically on tree trunks and shaded, moist old concrete walls at an altitude of 320 to 847 masl, *D. rigidula* can be found epiphytically on trunks of trees and terrestrially on floors of shaded or exposed places at an altitude of 330 to 750 masl.

Plant height. In plant height, *Drynaria quercifolia* is the longest (60-100cm long), followed by *D. rigidula* (54-90cm long), and *D. sparsisora* (45-60cm long) is the shortest.

Rhizome. The species differed also in their rhizomes. The rhizomes of *Drynaria quercifolia* and *D. sparsisora* are covered with imbricate pale brown paleae while the rhizome of *D. rigidula* is covered with appressed pale brown paleae.

Stipe. The stipes of *Drynaria quercifolia* and *D. sparsisora* are green while *D. rigidula* has dark purple stipe. On the other hand, *D. quercifolia* has the longest stipes among the three species (10-23 cm long), followed by *D. sparsisora* (5-15 cm long) and the shortest *D. rigidula* (6-12 cm long).

Costa and Rachis. The costa of *Drynaria quercifolia* and rachis of *D. rigidula* are dark brown to green and in *D. sparsisora* light brown to

light green. The length and width of the costa also differed. The costa in *Drynaria quercifolia* is 40-80cm long and 0.5-0.6 cm wide and in *D. rigidula* 17-27 cm long and 0.2 cm-0.4 cm wide.

Pinna. The lamina of the three species of *Drynaria* is also different from one another. The pinna of *Drynaria quercifolia* and *D. sparsisora* are simple pinnatifid and lobed while *D. rigidula* has simple-pinnate compound lamina. The longest and largest pinnae have been observed in *D. quercifolia*, (50-60 cm long and 5-6 cm wide).

Sterile fronds. The sterile fronds of *Drynaria* also differed. *Drynaria quercifolia*, and *D. sparsisora* have obtuse apices and *D. rigidula* has an acute apex.

They also vary in length and width. *D. quercifolia* has the longest fronds measuring 20-30 cm long, in *D. rigidula* measures 11 to 36 cm long and *D. sparsisora* measures 10 to 15 cm long. Among the species, *Drynaria quercifolia* has the widest frond (15-25.5 cm wide).

Paleae. The paleae of the three species also differed. The paleae of *Drynaria quercifolia* have a bordered-clathrate base, *D. sparsisora* has clathrate base while *D. rigidula* has peltate base. The positions of paleae are also different. *Drynaria quercifolia* and *D. sparsisora* have imbricate paleae while *D. rigidula* has appressed paleae.

Hairs. Hairs of *Drynaria quercifolia* and *D. sparsisora* are stellate with a small yellow club-shaped and glandular tips while *D. rigidula* are stellate with 6-8 ribbon like arms. The former is multicellular and light to dark brown while the latter is unicellular.

Sori. The locations of the sori also differed. The sori of *Drynaria quercifolia* are in more or less two regular rows on each side of each main vein, of a junction of 3-4 or more veins, usually round, nearly 2mm wide, sometimes slightly oblong and slightly impressed while the sori of *D. rigidula* are in one row on each side of the costa, usually nearer, the midrib than the edge. This was also reported by Zamora and Co (1986).

Anatomical Differences

Rhizome. The attachment of the paleae to the rhizome in *Drynaria quercifolia* and *D. sparsisora* is imbricate while in *D. rigidula* appressed. The length and width also differed. In *Drynaria quercifolia* the rhizome is 19 cm long and 26 cm wide, *D. sparsisora* 18 cm long and 24 cm wide while *D. rigidula* 8cm long and 6 cm wide.

Stipe. The basal , middle and upper stipes of the three species differed in the number of vascular bundles. *Drynaria quercifolia* has 15-17 vascular bundles, *D. sparsisora* has 10-11 vascular bundles while *D. rigidula* has 8-9 vascular bundles.

Costa and Rachis. The outline and number of vascular bundles in costa also vary in transections. In *Drynaria quercifolia* and *D. sparsisora*, the costa are raised in adaxial and abaxial surfaces while the rachis in *D. rigidula* is obconic and winged to the base. There are 4 vascular bundles in *Drynaria quercifolia*, *D. sparsisora* has 3 vascular bundles and *D. rigidula* has 5 vascular bundles.

Pinna. Hypodermis tissue is present in *Drynaria quercifolia* and *D. sparsisora* and absent in *D. rigidula*., It is a mechanical strengthening of leaves through abundant development sclerenchyma and it reduces the injurious effect of wilting. The hypodermal tissue is observed just below the epidermis of the pinna.

Hypodermal attributes are of potential value in the assessment of relative specialization and relationship. The occurrence of hypodermis is itself a specialization in any evolutionary line.

The presence of hypodermis in *Drynaria quercifolia* was also observed by Chandra (1979) in *D. sparsisora*.

The midvein of the middle pinna of the five species of *Drynaria* differed in shape of bundle. In *Drynaria quercifolia* the vascular bundles are reniform, retusely rounded in *D. sparsisora*, and circular-ovate in *D. rigidula*.. They also differed in the arrangement of tissues. *D. rigidula* has outer cortical sclerenchyma at the adaxial portion only while absent in *Drynaria quercifolia* and *D. sparsisora*.

The types of stomata in the three species of *Drynaria* studied are all polocytic. The subtype parietocytic occurs in *Drynaria quercifolia* and *D. rigidula* with 3 cells whereas *D. rigidula* has 2 subsidiary cells although 4 subsidiary cells were observed by Chandra (1979). The subtype axillocytic is observed in *D. sparsisora* with 2 subsidiary cells.

Key to the Species of *Drynaria*

1. Fertile fronds pinnatifid, stellate hairs broad with small yellow club-shaped and glandular tips; stipe transections with more than 10 vascular bundles; lamina hypodermis present 2
2. Sterile leaves long, 20-30 cm long, stipe in transection with 15-17 vascular bundles. *D. quercifolia*
2. Sterile leaves short, 2-18 cm long, stipe in transaction with 10-11 vascular bundles. *D.sparsisora*
1. Fertile fronds pinnate, stellate hairs slender with the absence of small yellow club-shaped and glandular tips; stipe transaction with less than 10 vascular bundles; lamina hypodermis absent. *D. rigidula*

CONCLUSIONS

Examination of the gross morphology and anatomy of the three species of *Drynaria* revealed some similarities and differences.

The three species are similar in habitat being epiphytes on tree trunks although some are terrestrial which grow in cool, moist, shaded or exposed places. The roots are fibrous and adventitious arising from the rhizome. The rhizomes of the three species are branching, long creeping, thick, fleshy and woody. The fronds of *Drynaria* are of two forms: the fertile and sterile frond or nest-leaves. The paleae of the five species of *Drynaria* have all filiform apex. The hairs are abundantly distributed in the lower surface of the lamina while less abundant in stipe, costa and rachis.

Transections of the rhizome, stipe, costa and rachis are nearly similar except for a few differences. The kind of stele throughout the plant is dictyostelic and non-hippocampus. Phlobaphene deposits can

also be observed throughout the different organs of the plant especially around the vascular bundles. All species have undifferentiated mesophyll and cutinized epidermis.

The paleae of *D. quercifolia* are bordered-clathrate, *D. sparsisora* are clathrate and *D. rigidula* are peltate. The sori in *Drynaria quercifolia* are distributed in regular rows on either side of a main secondary vein and in *D. rigidula* sori borne on single rows on either side of the midrib.

The midvein of the middle pinna of the three species of *Drynaria* differed in the shape of vascular bundle. In *D. quercifolia* the bundles are reniform or kidney shaped, in *D. sparsisora* retusely rounded, in *D. rigidula* circular ovate. They also differed in tissue arrangement. *D. rigidula* has outer cortical sclerenchyma present only in the adaxial portion while none was observed in *D. quercifolia* and *D. sparsisora*. Hypodermis is present in the lamina of *D. quercifolia* and *D. sparsisora* while none in *D. rigidula*.

The aforementioned similarities on their morphology and anatomy support the contention that they should be placed in one genus *Drynaria*. On the other hand, the marked differences clearly support that the three species are distinct from one another and should be identified as three different species.

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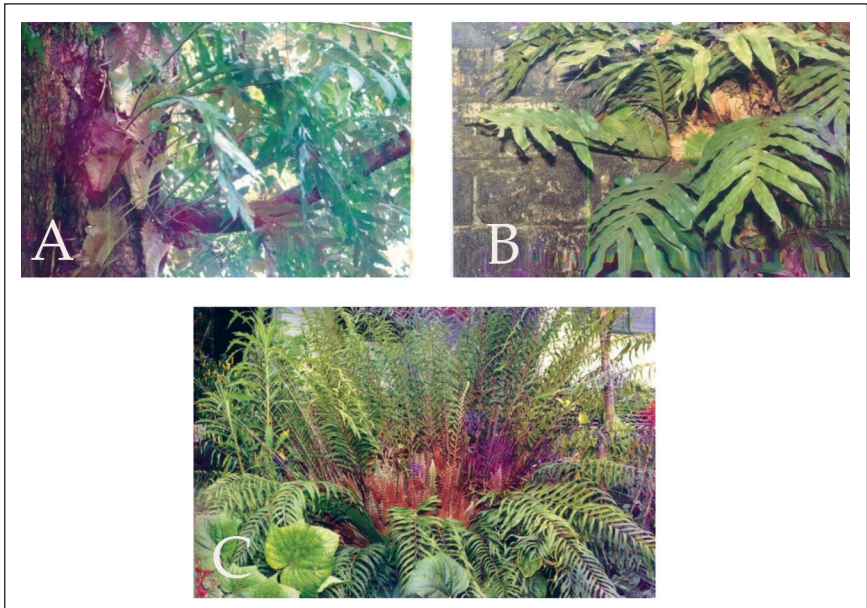


Plate 1. Natural habitats of the three species of *Drynaria*

A. *Drynaria quercifolia* (Linn) j.sm.

B. *D. sparsisora* (Desv.) Moore

C. *D. rigidula* (Sw.) Bedd.



Plate 2. Fertile fronds of the three species of *Drynaria*

A. *Drynaria quercifolia* (Linn) j.sm.

B. *D. sparsisora* (Desv.) Moore

C. *D. rigidula* (Sw.) Bedd.

[rh-rhizome, st-stipe, c-costa, r-rachis]

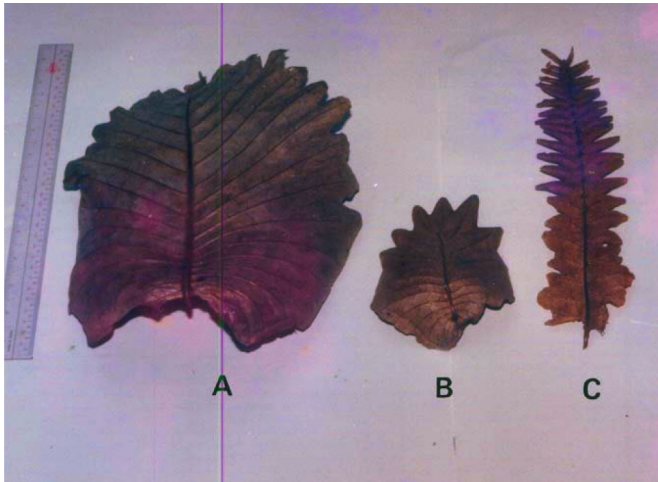


Plate 2. Sterile fronds of the three species of *Drynaria*

- A. *Drynaria quercifolia* (Linn) j.sm.
- B. *D. sparsisora* (Desv.) Moore
- C. *D. rigidula* (Sw.) Bedd.

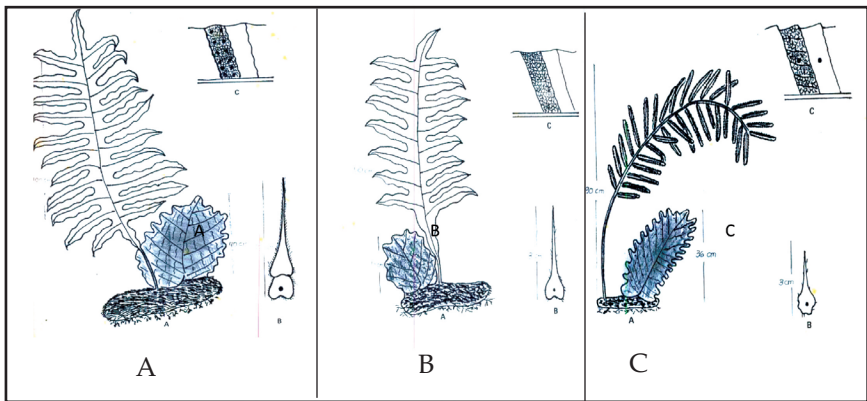


Plate 4. Habit (A), palea (B) and venation (C) of the three species of *Drynaria*

- A. *Drynaria quercifolia* (Linn) j.sm.
- B. *D. sparsisora* (Desv.) Moore
- C. *D. rigidula* (Sw.) Bedd.

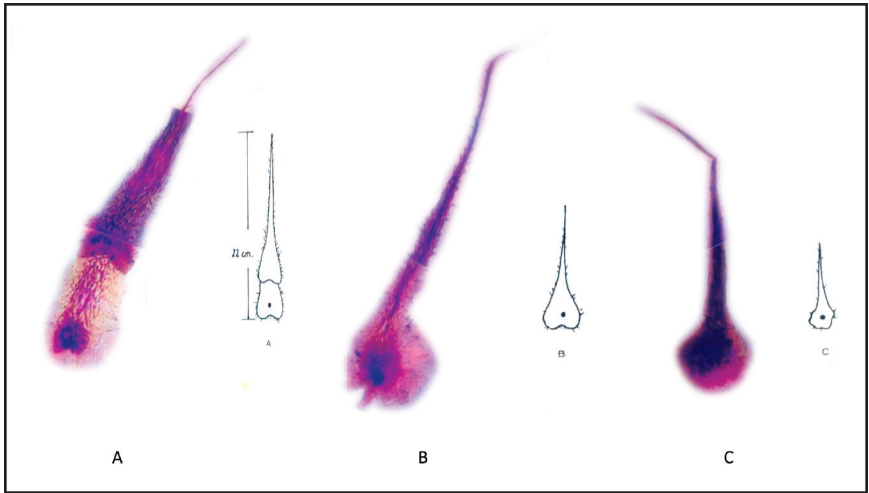


Plate 5. Paleae of the three species of *Drynaria* showing glandular hair (gh) (x40)

- A. *Drynaria quercifolia* (Linn) j.sm.
- B. *D. sparsisora* (Desv.) Moore
- C. *D. rigidula* (Sw.) Bedd.

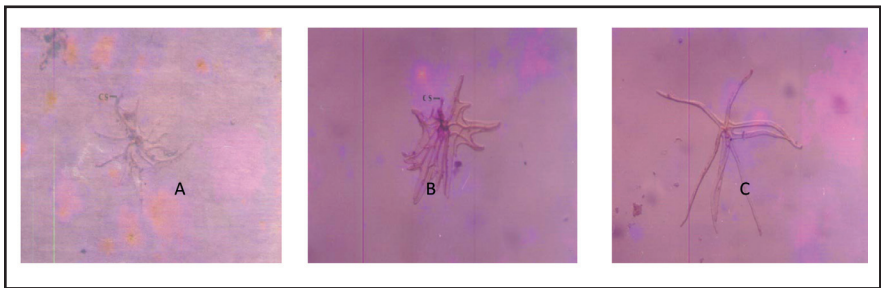


Plate 6. Foliar palea of the three species of *Drynaria* (100x) [cs-club-shaped]

- A. *Drynaria quercifolia* (Linn) j.sm.
- B. *D. sparsisora* (Desv.) Moore
- C. *D. rigidula* (Sw.) Bedd.

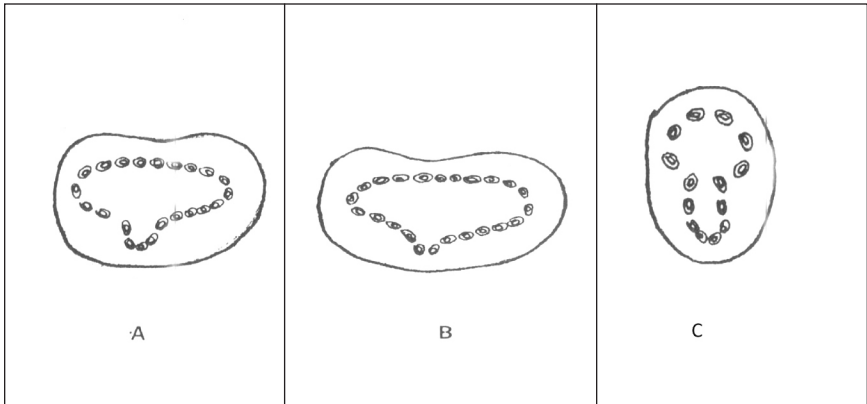


Plate 7. Transection diagram of the rhizome of the three species of *Drynaria* showing the number and arrangement of vascular bundle

e-epidermis

vb-vascular bundle

A. *Drynaria quercifolia* (Linn) j.sm.

B. *D. sparsisora* (Desv.) Moore

C. *D. rigidula* (Sw.) Bedd.

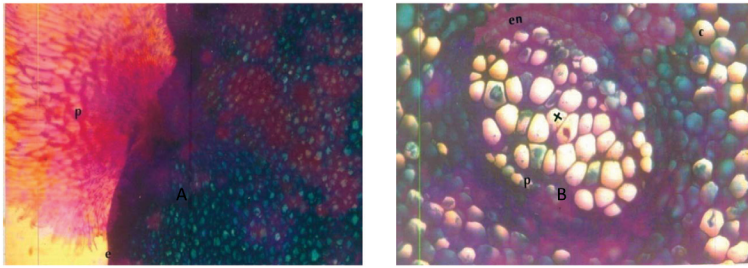


Fig. 1. Portion of the transverse section of the rhizome of *D. quercifolia* showing the attachment of the basal portion of palea (A) and enlarged view of the vascular bundle (B) (x100) [p-palea, e-epidermis; c-cortex; en-endodermis; p-phloem; x-xylem.

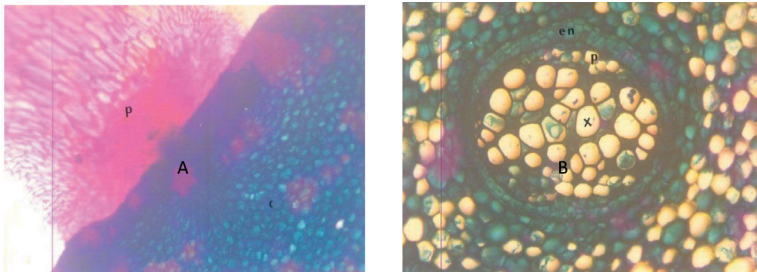


Fig. 2. Portion of the transverse section of the rhizome of *D. sparsisora* showing the attachment of the basal portion of palea (A) and enlarged view of the vascular bundle (B) (x100) [p-palea; e-epidermis; c-cortex; en-endodermis; p-phloem; x-xylem]

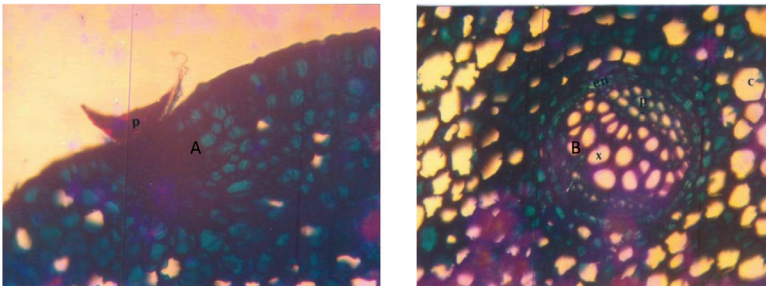


Fig. 3. Portion of the transverse section of the rhizome of *D. rigidula* showing the attachment of the basal portion of palea (A) and enlarged view of the vascular bundle (B) (x100) [p-palea; e-epidermis; c-cortex; en-endodermis; p-phloem; x-xylem].

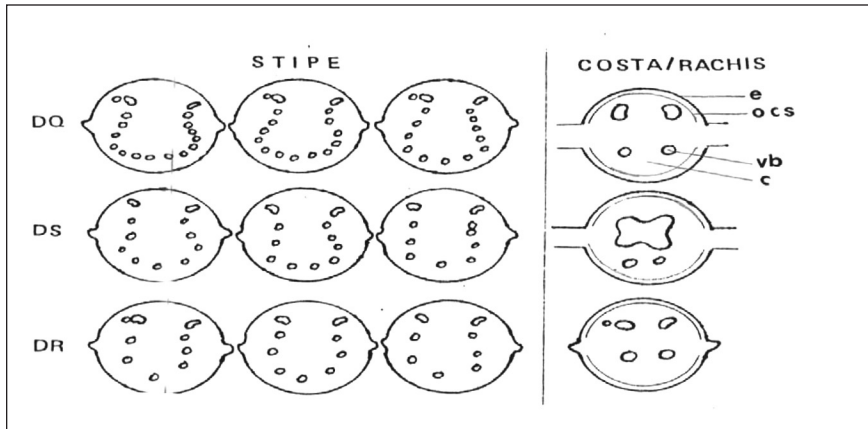


Plate 8. Transsection diagram through the stipes and costa/rachis of the three species of *Drynaria*

DQ. - *Drynaria quercifolia* (Linn) J.Sm.

DS. - *D. sparsisora* (Desv.) Moore

DR. - *D. rigidula* (Sw.) Bedd.

B-Basal

M - Middle

U - Upper

E - Epidermis

C - Cortex

OCS - Outer cortical sclerenchyma

ICP - Inner Cortical parenchyma

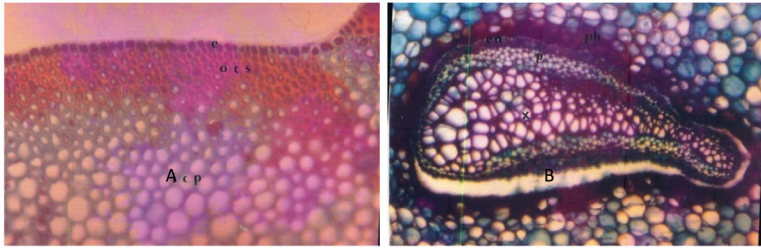


Fig. 4. Portion of the transverse section of the stipe of *D. quercifolia* showing the differentiated cortex (A) and vascular bundle (B) (x100). [e-epidermis; ocs-outer cortical sclerenchyma; icp-inner cortical parenchyma; en-endodermis; ph-phlobaphene deposits; p-phloem; x - xylem]

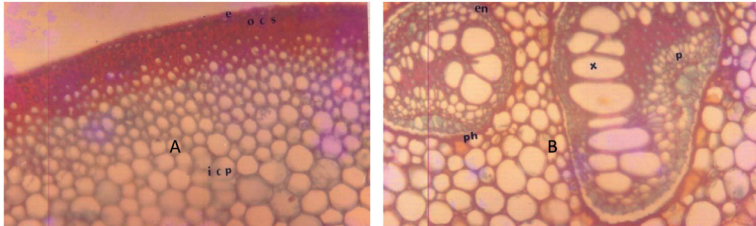


Fig. 5. Portion of the transverse section of the stipe of *D. quercifolia* showing the differentiated cortex (A) and vascular bundle (B) (x100). [e-epidermis; ocs-outer cortical sclerenchyma; icp-inner cortical parenchyma; en-endodermis; ph-phlobaphene deposits; p-phloem; x - xylem]

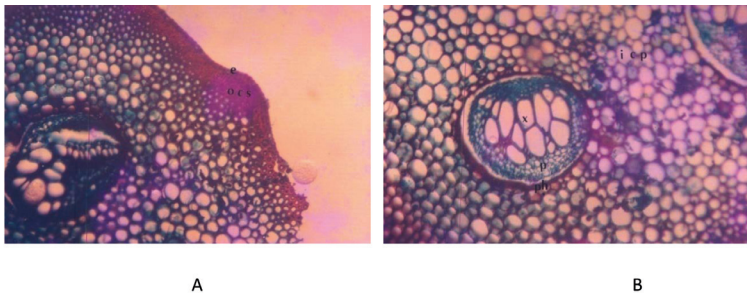


Fig. 6. Portion of the transverse section of the stipe of *D. rigidula* showing the differentiated cortex (A) and vascular bundle (B) (x100). [e-epidermis; ocs-outer cortical sclerenchyma; icp-inner cortical parenchyma; en-endodermis; ph-phlobaphene deposits; p-phloem; x - xylem]

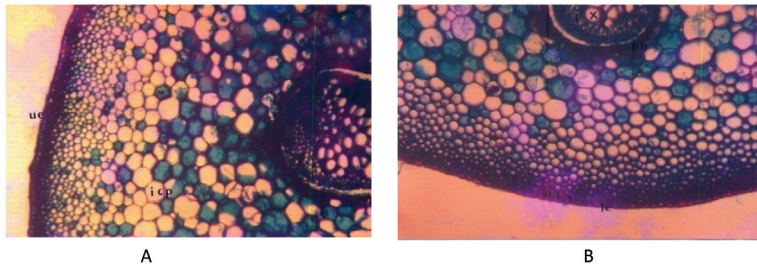


Fig. 7. Portion of the transverse section of the costa of *Drynaria Quercifolia* (Linn) J. Sm. showing the vascular bundle and epidermis (A) and differentiated cortex (B) (x100). [ue- upper epidermis; le-lower epidermis; ocs-outer cortical sclerenchyma; icp-inner cortical parenchyma; en-endodermis; ph-phlobaphene deposits; p-phloem; x - xylem]



Fig. 8. Portion of the transverse section of the costa of *D. sparsisora* showing the vascular bundle and epidermis (A) and differentiated cortex (A) (x100). [ue- upper epidermis; le-lower epidermis; ocs-outer cortical sclerenchyma; icp-inner cortical parenchyma; en-endodermis; ph-phlobaphene deposits; p-phloem; x - xylem]

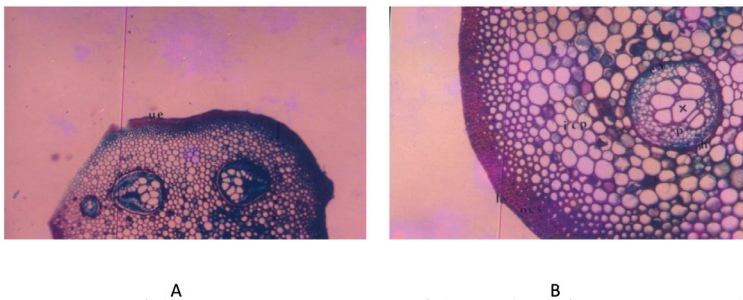


Fig. 9. Portion of the transverse section of the rachis of *D. sparsisora* showing the vascular bundle and epidermis (A) and differentiated cortex (B) (x100). [ue- upper epidermis; le-lower epidermis; ocs-outer cortical sclerenchyma; icp-inner cortical parenchyma; en-endodermis; ph-phlobaphene deposits; p-phloem; x - xylem]

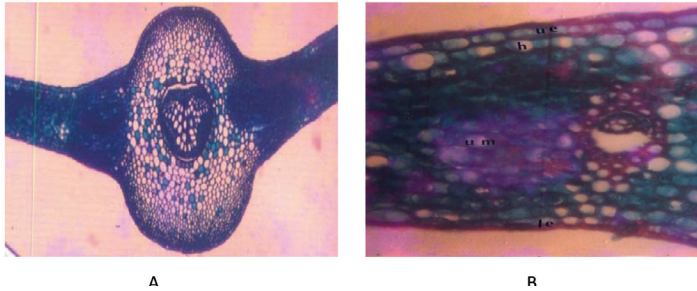


Fig. 10. Transection of the lamina of *D. quericifolia* showing the vascular bundle (A) (x40). Undifferentiated mesophyll and adaxial hypodermis (B) (x400)[ue- upper epidermis; le-lower epidermis; h-hypodermis; vb-vascular bundle; um-undifferentiated mesophyll]

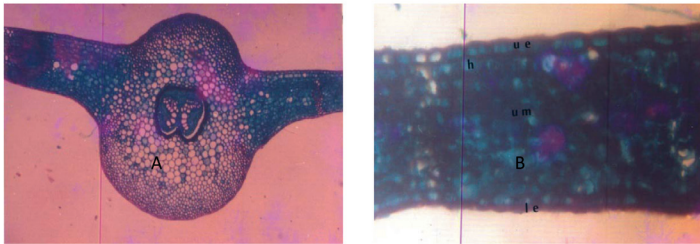


Fig. 11. Transection of the lamina of *D. sparsisora* showing the vascular bundle (A) (x40). Undifferentiated mesophyll and adaxial; le-lower epidermis (B) (x400); h-hypodermis; vb-vascular bundle; um-undifferentiated mesophyll]

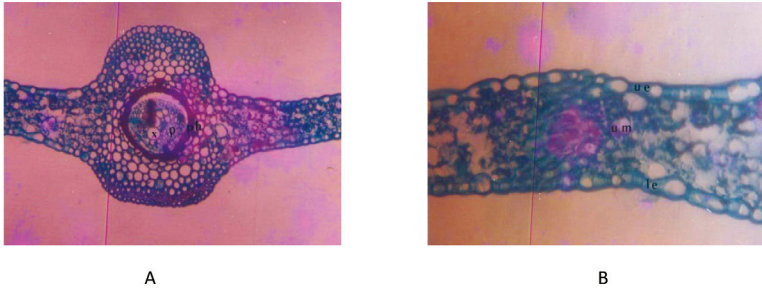


Fig. 12. Transection of the lamina of *D. rigidula* showing the vascular bundle (A) (x40). Undifferentiated mesophyll (B) [ue-upper epidermis; le-lower epidermis; vb-vascular bundle; um undifferentiated mesophyll]

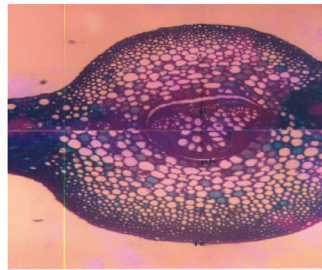


Fig. 13. Portion of the transverse section of the lamina of *D. quercifolia* showing upper epidermis. Lower epidermis and vascular bundle (x100). [ue-upper epidermis and vascular bundle (x100). [ue-upper epidermis; le-lower epidermis; en-endodermis; ph-phlobaphene deposits; p-phloem; x-xylem; c-cortex].

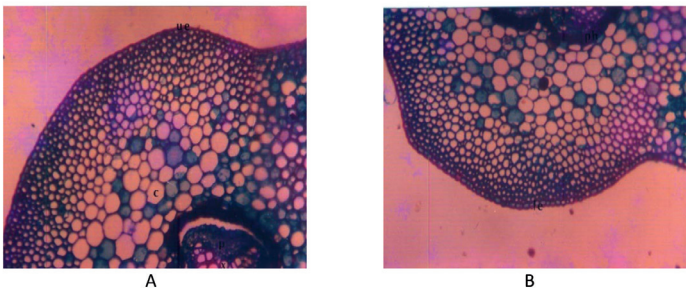


Fig. 14. Portion of the transverse section of the lamina of *D. sparsisora* showing upper epidermis. Lower epidermis and vascular bundle (A&B) (x100). [ue-upper epidermis le-lower epidermis; en-endodermis; ph-phlobaphene deposits; p-phloem; x-xylem; c-cortex].

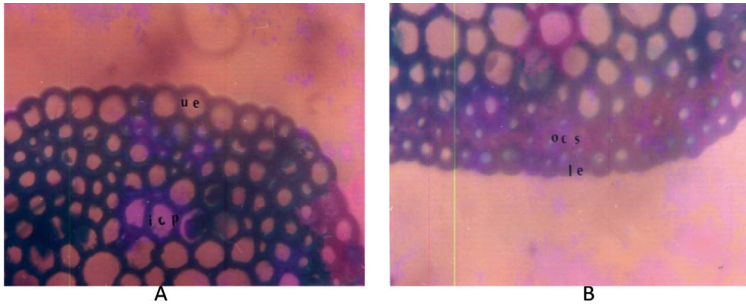


Fig. 15. Portion of the transverse section of the lamina of *D. rigidula* showing upper epidermis. Lower epidermis and vascular bundle (A&B) (x100). [ue-upper epidermis le-lower epidermis; en-endodermis; ph-phlobaphene deposits; p-phloem; x-xylem; c-cortex].

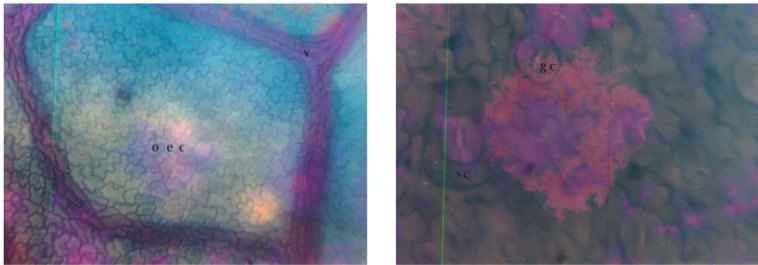


Fig. 16. Cleared pinna of *D. quercifolia* showing the ordinary epidermal cell (A) (x150) enlarged view of stomata (B) (x600) [oec-ordinary epidermis subsidiary cell].

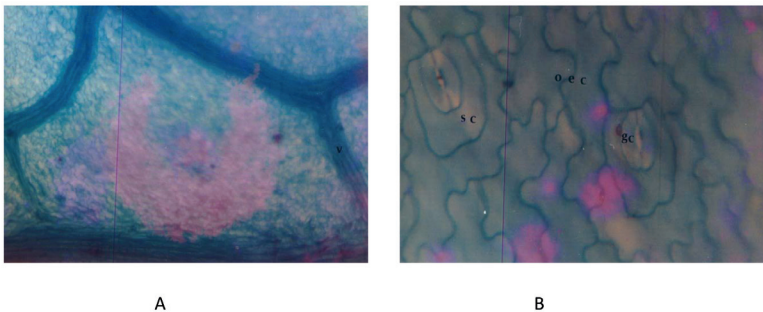


Fig. 17. Cleared pinna of *D. sparsisora* showing the ordinary epidermal cell (A) (x150) enlarged view of stomata (B) (x600) [oec-ordinary epidermis subsidiary cell; v-vein; gc-guard cell; sc-subsidiary cell].

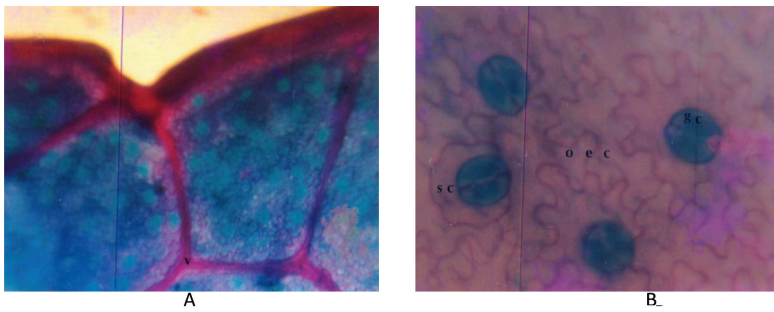


Fig. 18. Cleared pinna of *D. rigidula* showing the ordinary epidermal cell (A) (x150) enlarged view of stomata (B) (x600) [oec-ordinary epidermis subsidiary cell; v-vein; gc-guard cell; sc-subsiary cell].

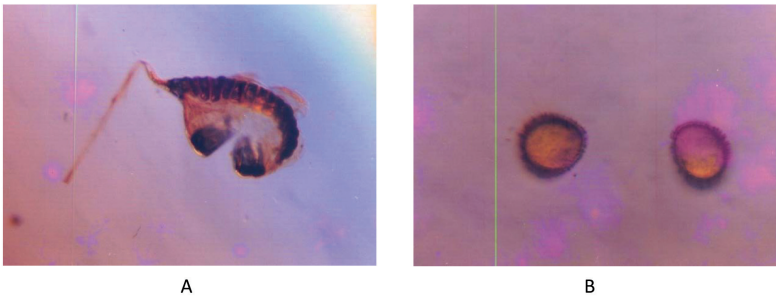


Fig. 19. Sporangia (A) and Spores (B) of *D. quercifolia* (A-x 150; B-x600)

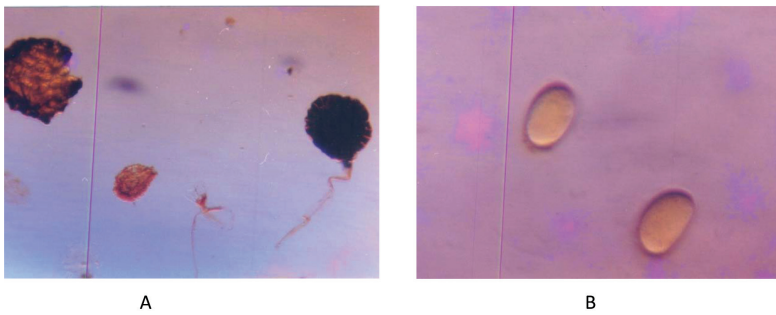


Fig. 20. Sporangia (A) and Spores (B) of *D. rigidula* (A-x 150; B-x600)

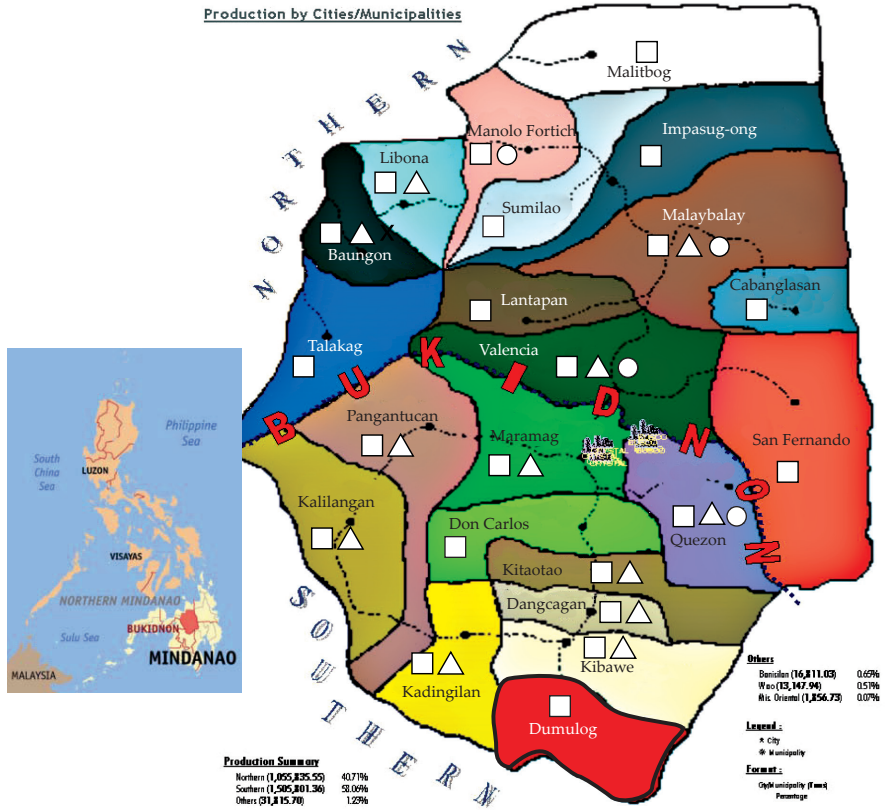


Fig. 21. Map of the Philippines (A) and Bukidnon (B) showing distribution of *Drynaria*.

- - *Drynaria quercifolia* (Linn) J.Sm.
- △ - *D. sparsisora* (Desv.) Moore
- - *D. rigidula* (Sw.) Bedd.