



The leaf: A glimpse to identify some species of Ericaceae from Darjeeling Himalaya.

¹Sulaxana Baraily^{*} ²Projjwal Chandra Lama

¹SACT, ²Assistant Professor

P.G. Department of Botany, Darjeeling Government College, Darjeeling, 734101, West Bengal, India

ABSTRACT

The morphological study of the leaf of fifteen species of Ericaceae from Darjeeling Hill, a part of Eastern Himalayas [*Agapetes hookeri* (C.B.Clarke), *Agapetes saligna* (Hook. F.), *Agapetes serpens* (Wight), *Enkianthus deflexus* (Griff.), *Gaultheria fragrantissima* Wall., *Gaultheria semi-infera* (Clarke), *Gaultheria nummularioides* D. Don., *Gaultheria trichophylla* Royle, *Lyonia ovalifolia* (Wall), *Lyonia villosa* (Clarke), *Pieris formosa* (Wall.) D. Don, *Vaccinium dunalianum* Wight, *Vaccinium nummularia* Clarke, *Vaccinium retusum* (Griff.) Hook. f., *Vaccinium vacciniaceum* (Roxb.)] were studied to quickly identify different species belonging to the same family, Ericaceae, in the field. The diverse range of different shapes, sizes and margins of the leaf were studied for what we do not need: a microscope or a lab to identify the plants during collection/identification.

Keywords: Leaf morphology, the field, Ericaceae, Darjeeling Himalaya

INTRODUCTION

The eighth largest angiosperm family is the health family Ericaceae, with approximately 125 genera and 4100 species found (Kron & Luteyn, 2005). This family is widely distributed in temperate and subarctic regions and at high elevations in tropical areas. It also has a high rate of speciation and species richness in the Eastern Himalayas and southwestern China (Wang et al., 2018). *Rhododendron* is the largest genera, with about 1000 species; *Erica*, about 860; *Vaccinium*, about 140; and *Gaultheria*, about 134 (Mabberley, 2008). Eleven genera and 280 species have been noted in India, with 46 endemic species distributed in the Himalayas, Southwestern Ghats' hilltops and Northeast India (Sanjapa & Sastry, 2014). In West Bengal, about 33 species are found (Panda & Chowdhury, 2008). In Darjeeling Himalaya, there are approximately seven genera (*Agapetes spp*, *Enkianthus spp*, *Gaultheria spp*, *Lyonia spp*, *Pieris spp*, *Rhododendron spp* and *Vaccinium spp*), and 37 species have been noted at present.

Leaves of Ericaceous species often possess an imposing cuticle along with other specialized epidermal characteristics such as papillae and glandular trichomes, which exert protective functions against environmental stresses. The palisade parenchyma is usually well-developed, comprising several layers that increase photosynthetic efficiency (Tamas, 2005). The traits of leaves in Ericaceous species are determined by geographical and climatic factors, so they have phenotypic plasticity (Alcantara-Ayala et al., 2020).

In the field's taxonomic studies, the leaf's morphology is essential in identifying plants (Hickey & Taylor, 1991). The study of leaf structure, including shape, margin, apex, base and petiol, allows more rigorously to be compared among different species of the same genus (Metcalf & Chalk, 1950). In 1973, Hickey first used the leaf characters for outward expression of the leaf structure, venation pattern, leaf shape and position of glands. From cretaceous and tertiary, Hickey and Green studied the angiosperm leaves, which shows the uses of morphological groups instead of phylogenetic categories in rich ecologically informative measurements of plant evolutionary patterns (Lande, 2009). In this study, fifteen species of Ericaceae were analyzed to identify the plants primarily by their leaf morphological characteristics, allowing for differentiation of the various species in the field.

MATERIALS AND METHOD

Mature leaves of the fourteen species of Ericaceae [*Agapetes hookeri* (C.B. Clarke), *A. saligna* (Hook. f.), *A. serpens* (Wight), *Enkianthus deflexus* (Griff.), *Gaultheria fragrantissima* Wall., *G. nummularioides* D. Don., *G. semi-infera* (Clarke), *G. trichophylla* Royle, *Lyonia ovalifolia* (Wall), *L. villosa* (Clarke), *Pieris formosa* (Wall.) D. Don, *Vaccinium dunalianum* Wight, *V. nummularia* Clarke, *V. retusum* (Griff.) Hook. f., *V. vacciniaceum* (Roxb.)] from Darjeeling Himalaya were collected from different parts of Singalila National Park, Tiger Hill, Chatakpur, Jorbangla, Ghome, Singamari and for descriptive terminology, Hickey et al.'s manual of leaf architecture, 1973; Hickey & Wolfe, 1975; and Ellis, 2009 have been followed. The characters described were leaf phyllotaxy, blade class, petiole feature, laminar size, shape and area, symmetry, laminar ratio, apex and base angle and shape and margin type.

RESULT AND DISCUSSION

The analysis of the leaf morphology of the fifteen species from the family Ericaceae is helpful regarding the taxonomic identification of different species.

Agapetes hookeri (C.B. Clarke) Sleumer: Epiphytic shrub with tuberous base/stem. Leaves are simple rugose above with impressed veins; dark green on the abaxial surface and light green on the adaxial surface; reticulate venation; alternate/aggregated into pseudo whorls; rigidly coriaceous, ovate to lanceolate, 5.2 - 9.5 X 3.4 - 4.2cm; symmetrical; apex acuminate, base subcordate, margin crenate to serrate; petiolate subsessile 1 mm, marginal.

Agapetes saligna (Hook. f.) Bentham & Hook. f.: Epiphytic shrub. Leaves are simple, alternate, coriaceous; glabrous; slightly rugose on the abaxial surface, light green on the adaxial surface; reticulate venation; lanceolate, 4.5 - 6 X 1.3 - 1.8cm; symmetrical, apex acuminate, base cuneate, margin slightly toothed; petiolate, 2.1 - 3 mm, marginal.

Agapetes serpens (Wight): Epiphytic shrub, leaves are simple, densely leafy; alternate; coriaceous; glabrous, dark green on the abaxial surface, light green on the adaxial surface; reticulate venation; ovate-lanceolate, 1.5 - 1.8 X 0.4 - 0.5cm; symmetrical, apex subacute; base rounded; margin serrulate; petiolate subsessile 1 mm, marginal.

Enkianthus deflexus (Griff): Deciduous shrub or small tree. Leaves simple papery, terminal clusters; alternate; reticulate venation; distinct pink line mid-vein at ventral side; ovate-elliptic, 1.8 - 3.5 X 1.5 - 2cm; asymmetrical base; pubescent beneath; apex acute/acuminate; base acute; margin serrulate; petiolate 4-8 - 8mm, marginal.

Gaultheria fragrantissima Wall.: Bushy, erect and stout shrub, leaves simple, alternate; coriaceous, glabrous dark green on the dorsal side and light green on the ventral side; reticulate venation; ovate-elliptic; ovate-lanceolate to rarely ovate/obovate, 4.5 - 11 X 1.8 - 5.5cm; symmetrical, mucronate at apex acute/crenate; base cuneate; margin serrate to serrulate; petiolate 2-7 - 7mm and marginal.

Gaultheria nummularioides D. Don: A prostrate shrublet. Leaves simple papery to sub-coriaceous, alternate; glabrous dark green on the dorsal side; ventral side light green with coarsely dense hispid setose beneath; reticulate venation; broadly ovate to rarely ovate-elliptic, 0.4-2.5 X 0.3-1.6 cm, symmetrical, mucronate at apex, ciliate (entire); base sub-cordate to rounded; margin ciliated serrulate; petiolate 0.8-1mm, marginal.

Gaultheria semi-infera (C.B. Clarke): Stout, bushy, erect shrub, leaves simple, alternate, sub-coriaceous; glabrous or slightly hispid dark green on dorsal side, rarely punctate and light green on ventral side; reticulate venation; oblong-lanceolate-elliptic, 3-8.3 X 1-4cm, symmetrical, mucronate at apex, base cuneate; margin crenate-serrate; petiolate 1-3mm, marginal.

Gaultheria trichophylla Royle: Dwarf shrub with much branch, leaves simple, alternate, glabrous dark green on the dorsal side; pinkish green with few setose hairs along midvein beneath; reticulate venation; elliptic - oblanceolate; 1 - 1.2 X 0.4 - 0.5cm, symmetrical, mucronate at apex, base narrowly cuneate; margin serrulate ciliate 0.5 - 2mm; petiolate 0.3 - 1mm, marginal.

Lyonia ovalifolia (Wall): Semi-evergreen or deciduous tree, leaves simple, alternate, somewhat leathery, and generally smooth; reticulate venation; the abaxial surface is leathery; the adaxial surface is light green; ovate; 5 - 12.6 X 3 - 6cm, symmetrical; acuminate apex, base rounded; margin entire; petiolate 5.2 - 12mm, marginal.

Lyonia villosa (Clarke): Deciduous or evergreen shrub or small tree, leaves simple, alternate, somewhat papery, reticulate venation; light green on the adaxial surface, yellowish green on the abaxial surface; elliptic to obovate, 4 - 7.6 X 3 - 4.8cm, symmetrical, apex is acute, base slightly cordate to broadly cuneate; margin entire; petiolate 4 - 9.2mm, marginal.

Pieris formosa (Wall) D. Don: Small tree or shrub, leaves simple, pseudo verticillate, coriaceous & leathery, reticulate venation, dark green on the abaxial surface, light green on the adaxial surface; elliptic or lanceolate or rarely oblanceolate, 5 - 9 X 1.4 - 3cm, symmetrical, apex acuminate or acute, base cuneate to obtuse; margin serrated; petiolate 3 - 12mm, marginal.

Vaccinium dunalianum Wight: Epiphytic shrub, leaves simple, scattered alternate, glabrous & leathery, dorsal surface waxy or glossy, reticulate venation; oblong to lanceolate, or ovate, 4.5 – 10.5 X 2 – 3cm, symmetrical, apex caudate/acuminate, base cuneate to obtuse; margin entire; petiolate 4.5 – 5mm, marginal.

Vaccinium nummularia Clarke: Forest epiphyte, leaves simple, dense, alternate, glabrous, and leathery; reticulate venation, adaxially dark green and present very fine hairs on midvein, adaxially light green; elliptic or obovate, 1 – 1.8 X 0.8 – 1.3cm, symmetrical, apex rounded, base rounded; margin revolute; petiolate hairy 0.8 – 1mm, marginal.

Vaccinium retusum (Griff.) Hook. f.: Epiphytic shrub leaves simple, alternate, smooth, leathery, reticulate venation; adaxial surface is green, and venation is distinct; abaxial surface is light green; obovate, 1.5 – 2.8 X 0.5 – 1.2cm, symmetrical, apex rounded, base cuneate/decurrent; margin entire, slightly revolute; petiolate 1.8 – 2.5mm, marginal.

Vaccinium vacciniaceum (Roxb.) Sleumer: Epiphytic sometimes shrub Leaves simple, pseudo verticillate, papery, glabrous, reticulate venation; adaxially dark green compared to the abaxial surface; oblong to lanceolate, 4 – 9 X 0.6 – 2.5cm, symmetrical, apex acute/acuminate, base cuneate or complex; margin serrate – crenate; petiolate 5 – 8 mm, marginal.

Table 1: Macro - Morphological characters of leaves of the studied sample of Ericaceae

NAME OF THE SPECIES	PHYLLOTAXY	BLADE CLASS	LAMINA LENGTH MEAN (L mm)	MEAN LAMINA WIDTH (W mm)	LAMINA AREA (mm ²)	LAMINA SHAPE	LAMINA SYMMETRY	LAMINA (L/W ratio)
<i>Agapetes hookeri</i>	Alternate /pseudo verticillate	Notophyll	73.5	38	2793	ovate – lanceolate	symmetrical	73:38
<i>Agapetes saligna</i>	Alternate	Microphyll	52.5	15.6	819	Lanceolate	symmetrical	52:15
<i>Agapetes serpens</i>	Alternate	Nanophyll	16.5	4.5	74.25	ovate – lanceolate	symmetrical	16:04
<i>Enkianthus deflexus</i>	Alternate	Microphyll	29	20	580	ovate-elliptic	base asymmetrical	29:20
<i>Gaultheria fragrantissima</i>	Alternate	Notophyll	77.5	36.5	2828.75	ovate-lanceolate	symmetrical	77:36
<i>Gaultheria nummularioides</i>	Alternate	Nanophyll	14.5	09.5	137.75	ovate/elliptic	symmetrical	14:19
<i>Gaultheria semi-infera</i>	Alternate	Microphyll	56.4	20	1128	oblong/ Lanceolate	symmetrical	56:20
<i>Gaultheria trichophylla</i>	Alternate	Nanophyll	07	04.5	31.5	elliptic - lanceolate	symmetrical	07:04
<i>Lyonia ovalifolia</i>	Alternate	Mesophyll	105	50.8	5334	ovate	symmetrical	100:51
<i>Lyonia villosa</i>	Alternate	Notophyll	62.5	41	2562.5	elliptic/ obovate	symmetrical	62:41
<i>Pieris Formosa</i>	Alternate/ pseudo verticillate	Microphyll	70	22	1540	elliptic – lanceolate	symmetrical	70:22
<i>Vaccinium dunalianum</i>	Alternate	Microphyll	75	25	1875	oblong - lanceolate/ ovate	symmetrical	75:25
<i>Vaccinium nummularia</i>	Alternate	Nanophyll	14	05.5	77	elliptic/ obovate	symmetrical	14:05
<i>Vaccinium retusum</i>	Alternate	Nanophyll	21.5	08.5	182.75	obovate	symmetrical	21:08
<i>Vaccinium vacciniaceum</i>	Alternate/ pseudo verticillate	Microphyll	68	18	1224	oblong – lanceolate	symmetrical	68:18

Most of the attachment of leaves are clear findings of alternate, but few show pseudo verticillate like *A.hookeri*, *P.formosa* and *V.vacciniaceum*. Blade type ranges from nanotypes like *G. trichophylla* to mesophylls like *L.ovalifolia*. Lamina shape varies from ovate-lanceolate, ovate, ovate-elliptic and obovate. L/W ratio ranges from 7: 4 (*G.trichophylla*) to 100: 51 (*L.ovalifolia*). Leaf margin varies from entire, ciliated serrulate, slightly toothed, and revolute to serrate. Apex angle ranges from 35° (*A.serpens*) to 70° (*G.fragrantissima* & *L.ovalifolia*). The base angle ranges from 30° (*V.retusum*) to 120° (*L.ovalifolia*). Apex shapes are rounded, acuminate, mucronate/ caudate. Base shapes are rounded, cuneate, and acute—Subcordate and narrowly cuneate.

Table 2: Macro–morphological characters of leaves from the studied sample of Ericaceae

Name of the species	Apex angle (degree)	Apex shape	Base angle (degree)	Base shape	Margin	Mean petiole length (mm)
<i>Agapetes hookeri</i>	55	acuminate	70	subcordate	crenate - serrate	0.8
<i>Agapetes saligna</i>	45	acuminate/slightly caudate	55	cuneate	slightly toothed	2.5
<i>Agapeter serpens</i>	35	subcunate	40	rounded	serrulate	1
<i>Enkianthus deflexus</i>	50	acuminate	45-50	acute	serrulate	6
<i>Gaultheria fragrantissima</i>	70	acuminate/caudate	60	cuneate	serrate - serrulate	4.5
<i>Gaultheria nummularioides</i>	55	acute/mucronate	65	subcordate - rounded	ciliated serrulate	1
<i>Gaultheria semi–infera</i>	50	acute/mucronate	45	cuneate	crenate - serrate	2
<i>Gaultheria trichophylla</i>	60	acute/mucronate	55	narrowly cuneate	ciliated serrulate	0.6
<i>Lyonia ovalifolia</i>	70	caudate/slightly acuminate	120	rounded	entire	7
<i>Lyonia villosa</i>	60	acuminate	65	slightly cordate	entire	5.5
<i>Pieris Formosa</i>	55	acuminate	50	cuneate	serrated	6.6
<i>Vaccinium dunalianum</i>	30	caudate/ acuminate	60	cuneate	entire	4.5
<i>Vaccinium nummularia</i>	50	rounded	40	rounded	revolute	0.8
<i>Vaccinium retusum</i>	50	rounded/slightly acute	30	cuneate/ decurrent	entire/slightly revolute	1.8
<i>Vaccinium vacciniaceum</i>	55	acute/ acuminate	60	cuneate	serrate/crenate	1

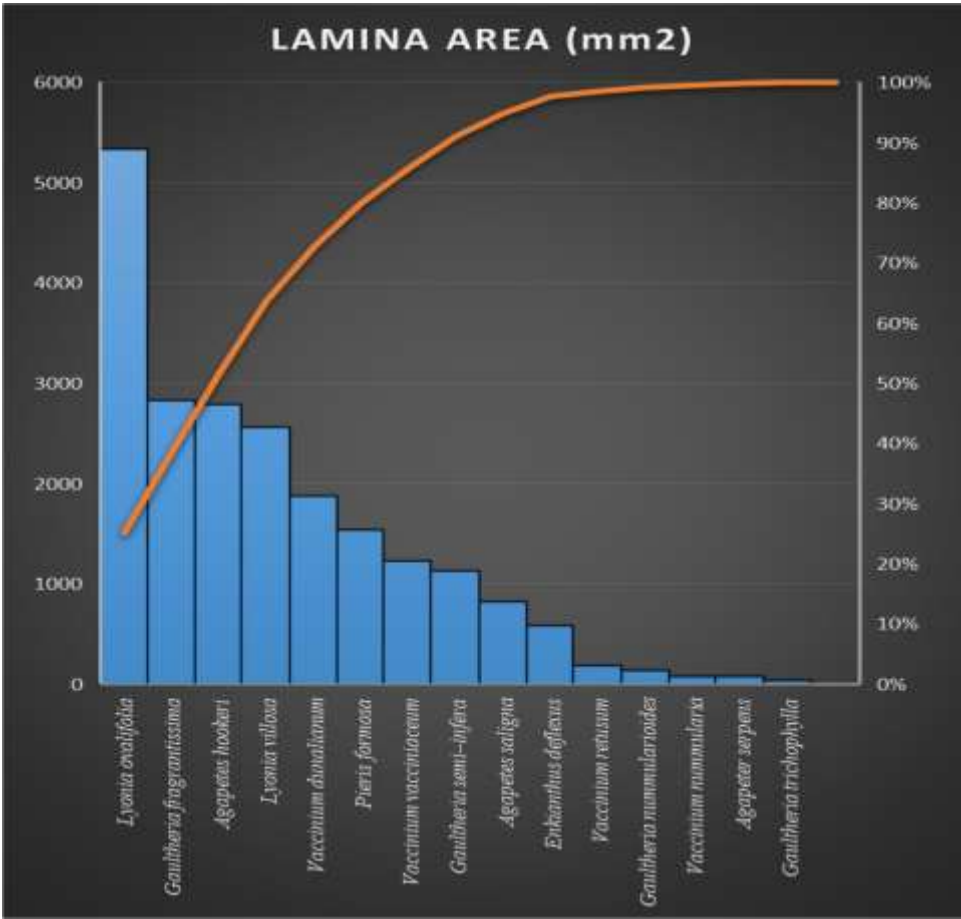


Table 1: Showing the range of area of lamina

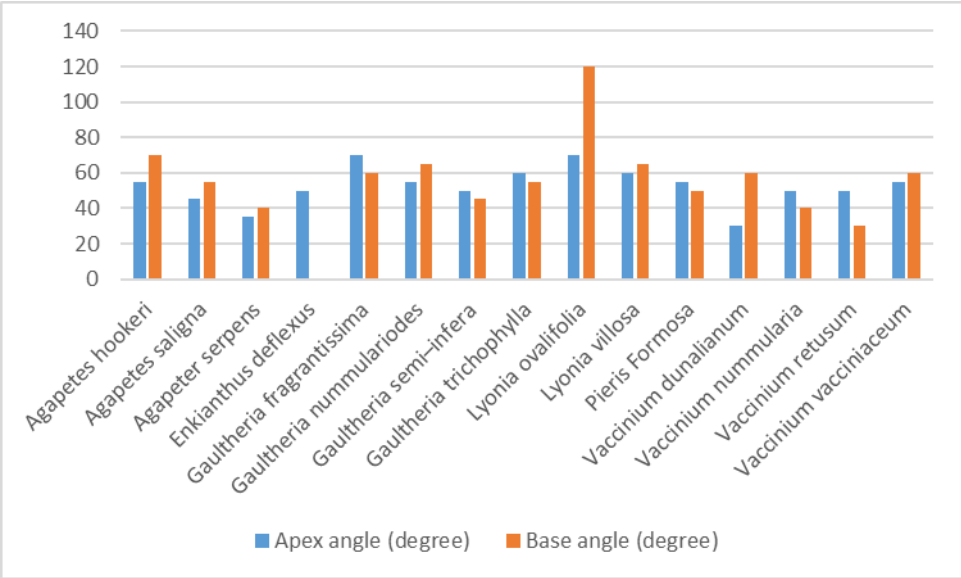


Table 2: showing the apex & base angles in degrees



PLATES: 1. *Agapetes hookeri* (C.B. Clarke), 2. *Agapetes saligna* (Hook. F.), 3. *Agapetes serpens* (Wight), 4. *Enkianthus deflexus* (Griff.), 5. *Gaultheria fragrantissima* Wall., 6. *Gaultheria nummularioides* D. Don., 7. *Gaultheria semi-infera* (Clarke), 8. *Gaultheria trichophylla* Royle

9.



10.

11



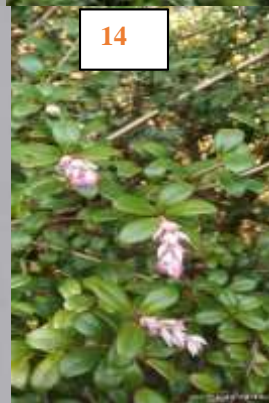
12



13



14



15



9. *Lyonia ovalifolia* (Wall), 10. *Lyonia villosa* (Clarke), 11. *Pieris formosa* (Wall.) D. Don, 12. *Vaccinium dunalianum* Wight, 13. *Vaccinium nummularia* Clarke, 14. *Vaccinium retusum* (Griff.) Hook.f. 15. *Vaccinium vacciniaceum* (Roxb.)

CONCLUSION

The 15 leaf samples analysed are similar in the case of one character or more than one, but not 100%. This brings to the limelight the importance of leaf morphology in the taxonomic classification of various species of the Ericaceae family. Surface texture, shape, size, blade type, and margin type are important for species differentiation without undergoing laboratory techniques. The present research has highlighted the significant diversity within the Ericaceae family in the Darjeeling region, which encompasses seven genera and about 37 species. This diversity is relevant for ecological studies and conservation activities in the study area for which we are working on the leaves' anatomy, especially the trichomes' presence. This knowledge of morphological characters will help conserve these species because this knowledge will help better assess the diversity of plants and the sensitivity of plants to changes in the environment. Such high biodiversity within the Ericaceae family in the Himalayas suggests a vast scope for discovering new species. Future botanists can also work under the correlation between the indumentum and the habitat of the leaf, emphasising *Rhododendron* species. This is particularly useful for botanists and ecologists working in remote areas without laboratory facilities.

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