

Diversity of the tribe Vaccinieae Reichenbach (Ericaceae: Vaccinioideae) in Darjeeling Himalaya, India

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Summary

The tribe Vaccinieae Reichenbach with two dominant genera *Agapetes* D. Don ex G. Don and *Vaccinium* L. is well-known to plant systematists due to their recent evolutionary significance, diversity in flowering-phenology, habitat-range and recently increasing ethnomedicinal potentialities for herbal drug discovery. As a result of extensive field visits and herbarium consultations in Indian Herbaria (CAL, ASSAM, BSHC, DD) and abroad (K, BM: cibachrome images!), a total of ten species of these two genera are reported to occur in Darjeeling Himalaya: *Agapetes* D. Don ex G. Don (6 spp.: *A. serpens* (Wight) Sleumer, *A. hookeri* (C. B. Clarke) Sleumer, *A. sikkimensis* Airy Shaw, *A. saligna* (Hook. f.) Hook. f., *A. bhutanica* N. P. Balakr. & Sud. Chowdhury and *A. smithiana* Sleumer) and *Vaccinium* L. (4 spp.: *V. dunalianum* Wight, *V. nummularia* C. B. Clarke, *V. retusum* (Griff.) Hook. f. ex C. B. Clarke and *V. vacciniaceum* (Roxb.) Sleumer) of the tribe Vaccinieae Reichenbach. Members of these two genera are mostly epiphytic on trees, occasionally drooping from rock crevices and very rarely grow in loose rocky soil. The present work embodies detailed field and herbarium specimen-based exomorphological diversity, ethnobotanical-ITKs including societal impacts, global distribution and current status including conservation measures. This work also includes diversity in leaf-anatomy and pollen morphology among the four species of *Vaccinium* L.

Zusammenfassung

Die Tribus Vaccinieae Reichenbach mit den zwei dominierenden Gattungen *Agapetes* D. Don ex G. Don und *Vaccinium* L. ist in der Pflanzensystematik in ihrer Evolution, Diversität der Blütenphäologie, Habitatausdehnung und des ethnomedizinischen Potentials als Heilkräuter gut erforscht. Infolge intensive Felduntersuchungen und rechenen in indischen (CAL, ASSAM, BSHC, DD) und ausländischen Herbarien (K, BM: cibachrome images!) wurden für das Untersuchungsgebiet des Darjeeling Himalayas in der Tribus Vaccinieae Rchb insgesamt 10 Arten gefunden: in der Gattung *Agapetes* D. Don ex G. Don sechs Arten (*A. serpens* (Wight) Sleumer, *A. hookeri* (C. B. Clarke) Sleumer, *A. sikkimensis* Airy Shaw, *A. saligna* (Hook. f.) Hook. f., *A. bhutanica* N. P. Balakr. & Sud. Chowdhury und *A. smithiana* Sleumer) und in der Gattung *Vaccinium* L. vier Arten (*V. dunalianum* Wight, *V. nummularia* C. B. Clarke, *V. retusum* (Griff.) Hook. f. ex C. B. Clarke und *V. vacciniaceum* (Roxb.) Sleumer). Die Arten dieser Gattungen leben meist epiphytisch auf Bäumen, gelegentlich siedeln sie in Felsspalten und sehr selten im lockeren felsigen Untergrund. Die vorliegende Arbeit enthält detaillierte Feld- und Herbarstudien zu den Arten, die auf exomorphologischer Vielfalt, ethnobotanischen Erfahrungen basieren. Ebenso werden Angaben zur anthropogen bedingten Gefährdung, der globalen verbreitung und dem aktuellen Schutzstatus gemacht. Die Arbeit zeigt zudem die Ergebnisse der Blatt- und Pollenanstomiestudien innerhalb der vier Arten der Gattung *Vaccinium* L.

Keywords: Vaccinieae, Ericaceae, Darjeeling, India, diversity.

1. Introduction

The tribe Vaccinieae Reichenbach is represented by 33 genera (PANDA & SANJAPPA 2014) and distributed in four continents viz., Asia, Africa, America and Europe. The tribe is placed in the subfamily Vaccinioideae of the family Ericaceae and was first described by H. G. L. REICHENBACH (1831) in "Flora Germanica Excursoria". Members of this tribe possess dwarf shrubs to small tree habit, often drooping, terrestrial as well as epiphytic, alternate to pseudovercillate leaves convolute in bud, axillary to pseudoterminal racemes either fasciculate or pseudocorymbose, 4-7-merous epigynous flowers, tubulourceolate, urceolate to campanulate corolla and berry fruits.

The tribe is represented by only two dominant genera viz., *Agapetes* D. Don ex G. Don and *Vaccinium* L. in Darjeeling Himalaya as well as in the Eastern Himalayan flora of India. They are well-known to plant systematists due to their recent evolutionary significance, diversity in flowering-phenology, habitat-range and recently increasing ethnomedicinal potentialities for herbal drug discovery.

As a result of extensive field visits to different localities in and around erstwhile Darjeeling Himalaya (incl. Kalimpong district) from December 2011 to May 2019, and herbarium consultations in Indian Herbaria (CAL, ASSAM, BSHC, DD, Lloyd Botanical Garden Herbarium and Darjeeling Govt College herbarium, Darjeeling and Maulana Azad College herbarium, Kolkata) and abroad (K, BM: cibachrome images!), a total of ten species are reported to occur in these two genera:

Agapetes D. Don ex G. Don (6 spp.: *A. serpens* (Wight) Sleumer, *A. hookeri* (C. B. Clarke) Sleumer, *A. sikkimensis* Airy Shaw, *A. saligna* (Hook. f.) Hook. f., *A. bhutanica* N. P. Balakr. & Sud. Chowdhury and *A. smithiana* Sleumer) and *Vaccinium* L. (4 spp.: *V. dunalianum* Wight, *V. nummularia* C. B. Clarke, *V. retusum* (Griff.) Hook. f. ex C. B. Clarke and *V. vacciniaceum* (Roxb.) Sleumer) of the tribe Vaccinieae Reichenbach. Members of these two genera are mostly epiphytic on trees, occasionally drooping down from rock crevices and very rarely grown in loose rocky soil.

The present work embodies detailed field and herbarium specimen-based exomorphological diversity, ethnobotanical-ITKs including societal impacts, global distribution and current status including conservation measures. This work also includes diversity in leaf-anatomy and pollen morphology not reported earlier between the four species of *Vaccinium* L. Although Nair & KOTHARI (1985) reported pollen morphological data on Indian Ericaceae, still they lack detailed investigation on the tribe Vaccinieae.

Probably J. D. HOOKER (1849, 1850) was the first to explore Darjeeling Himalaya extensively during his expedition to the Himalayas. Since J. D. Hooker, several other workers like C. B. CLARKE (1882), GAMBLE (1896), BISWAS & CHOPRA (1956), HARA (1966), BISWAS (1966), MUKHERJEE (1988), DAS (1995, 2004), BHUJEL (1996), SAINI (2000), GURUNG & PALIT (2007), PANDA (2012, 2013, 2016), PANDA & REVEAL (2012),

PANDA & SANJAPPA (2014), PANDA et al. (2014) and GHOSH & MALLICK (2014) surveyed the area and documented members of Vaccinieae Reichenbach.

2. Materials and Methods

The present work is the result of a critical study of literature in the library of Central National Herbarium, Howrah (India), relevant references available in websites, consultations of herbarium specimens in Indian herbaria (CAL, DD, ASSAM, BSHC, Lloyd Botanical Garden Herbarium), consultation of Cibachrome images of type and other authentic specimens (K, BM) and extensive field survey (2011-2019) in and around natural habitats of erstwhile Darjeeling Himalaya including ethnobotanical investigations. This work also includes leaf-anatomy and pollen morphological investigations among the four mentioned species of *Vaccinium* L.

Morpho-taxonomical descriptions were made based on mainly data from live plants as well as herbarium data. For ethno-medicinal investigation, the first hand Indigenous Traditional Knowledge (ITK) were recorded during field visits at different localities in Darjeeling Himalaya through an oral interviews of experienced and elderly tribal people, local medicine men and field guides. Detailed information regarding local names(s), part(s) used, mode of administration or preparation and dosimetry are recorded in the field note book. Botanical identity is confirmed with herbarium consultations in Central National Herbarium (CAL). Important voucher specimens are deposited in the laboratory of Angiosperm Taxonomy & Ecology, Botany Deptt., Darjeeling Govt. College, Darjeeling (DGC) and Maulana Azad College Herbarium (MAC), Kolkata. The work was carried out in the laboratory of Angiosperm Taxonomy & Ecology, Post-Graduate Department of Botany, Darjeeling Govt. College and partly at Central National Herbarium, Botanical Survey of India, Howrah and Maulana Azad College Botany Department. For detailed study, floral parts of these plants were dissected and examined. The terminology for different external morphological characters mainly followed LAWRENCE (1951), FEATHERLY (1954), STEARN (1983), RADFORD (1986) and VELDKAMP (1987). All measurements are metric. Botanical identity was confirmed by herbarium consultations in Central National Herbarium (CAL). Authors of scientific names are abbreviated according to BRUMMIT & POWELL (1992), Authors of Plant Names. Herbarium acronyms are followed according to HOLMGREN et al. (1990), Index Herbariorum, part 1 (ed.8).

Anatomical and polliniferous materials used in this investigation were taken from the live materials collected from Darjeeling Himalaya which are deposited at DGC and MAC Herbaria. These pollen measurements are based on at least 10 grains from each specimen. Pollen and anatomical slides are deposited in the laboratory of the said two colleges.

Stomatal slide preparation: Small cubical pieces (c. 1 sq.cm) were excised from the base, middle and apical regions of the leaf blade. Several existing methods viz., 10% HNO₃-boiling for 10 minutes, 5% KOH overnight (12 - 24 hours) treatment with and without boiling were done. Pieces were ringed in ste-

rilized water until clear. After clearing, pieces were dehydrated in an ethanol series followed by staining with 10% safranin and mounted onto microscope slide in DPX (pieces of basal, middle and apical regions in one slide). The slide was examined using an Olympus (Tokyo, Japan) light microscope using 10X, 45X and 100X objectives and Camera Lucida drawings were made using a drawing prism. The descriptive terminology followed METCALFE & CHALK (1950), DILCHER (1974), STACE (1965, 1989), FAHN (1997) and CARPENTER (2005).

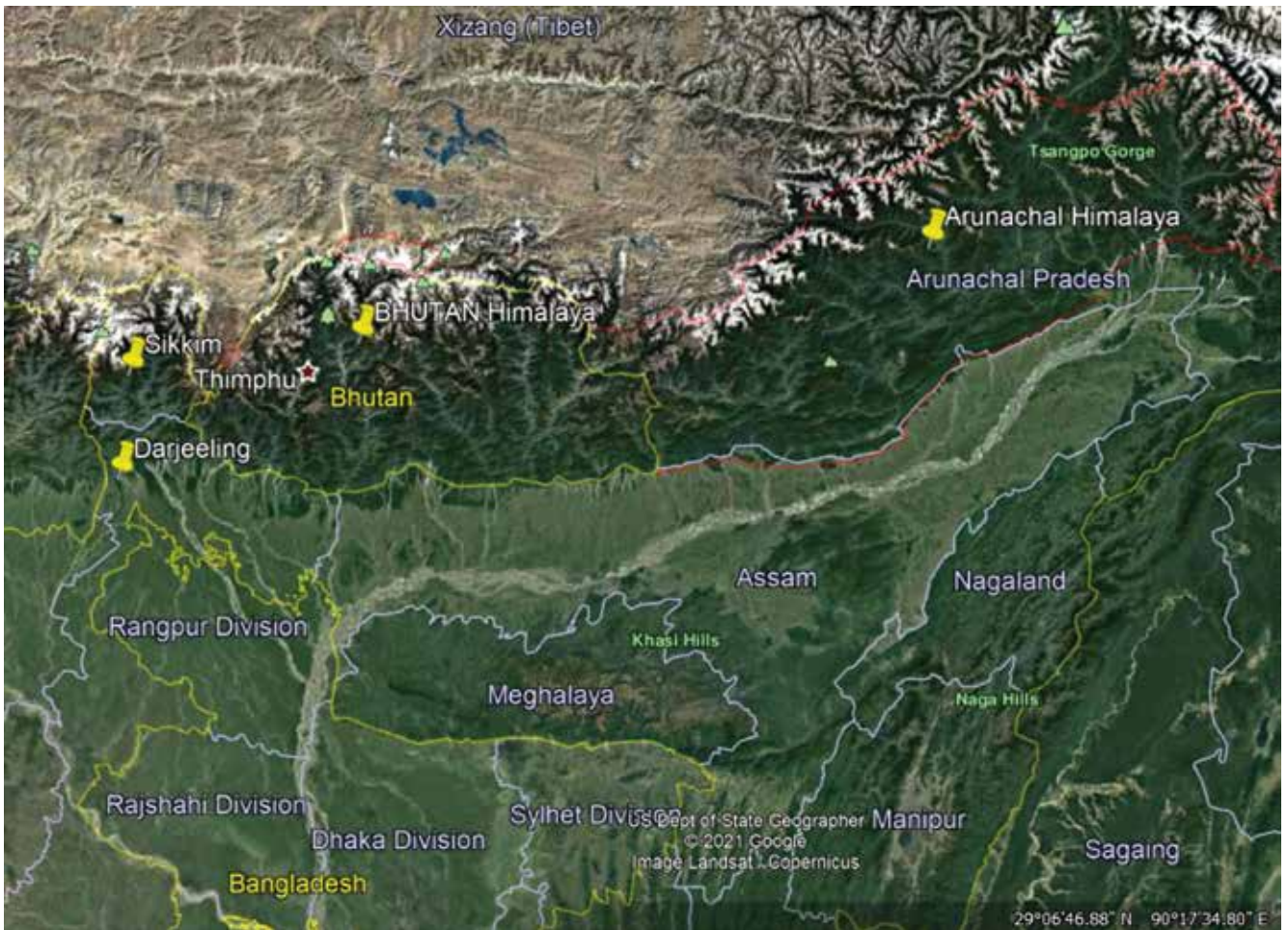
Methodology of leaf clearing for venation study: Entire mature leaves were immersed in 2.5% NaOH solution until clear (closed condition). In the present study, most of the leaves were cleared after 6 days of NaOH treatment. Leaf samples were then washed in distilled water. After clearing, pieces were dehydrated in an ethanol series followed by staining with 1% safranin and mounted onto microscope slide in DPX. The descriptive terminology follows HICKEY (1973) and DILCHER (1974).

Preparation of Pollen slides: The method used in this study was by ERDTMAN (1952, 1969, 1986). Dry polliniferous materials (mature flower buds) were taken from duplicate herbarium specimens deposited at Darjeeling Govt. College Herbarium. The descriptive terminology follows ERDTMAN (1952, 1969, 1986) and SARWAR et al. (2006).

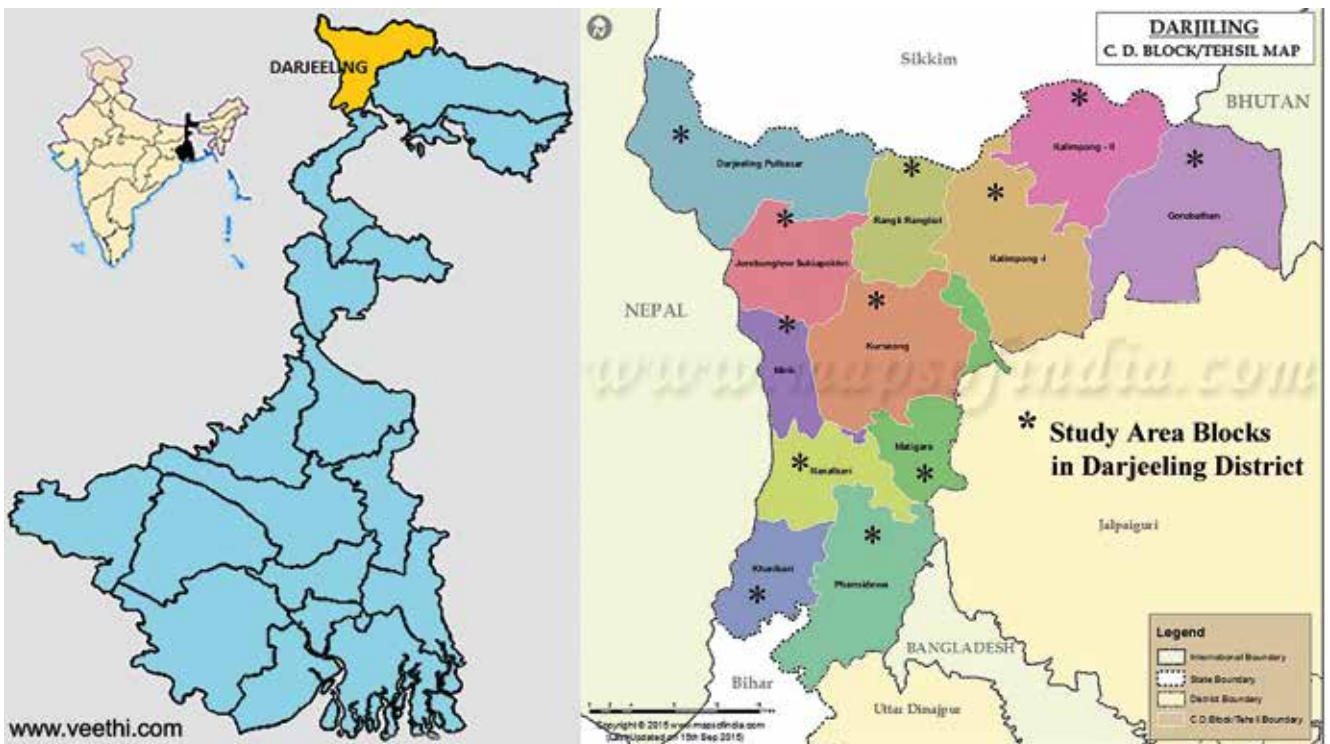
Sequence of presentation of data:

- Correct or accepted name of the species.
- Original citation and other references.
- Synonyms, if any.
- A reference to illustration or photo.
- Vernacular names along with languages in parenthesis where available.
- field-based description.
- Natural Distribution (globally including Darjeeling).
- Flowering & Fruiting.
- Habitat
- Specimens examined.
- Ethnic use (s).
- IUCN Status.
- Leaf anatomy (for *Vaccinium* spp.)
- Pollen morphology (for *Vaccinium* spp.).

Study Area: With an area of about 3149 sq. km, erstwhile Darjeeling district is located 27°13'N to 26°27'N Latitude and 88°53'E to 87°59'E Longitude. The district is characterized by its varying altitudes ranging from 90 m (Khoribari area) to 3780 m (Sandakphu), harbouring diverse elements of tropical, subtropical, temperate and alpine vegetation. 12 community Blocks (8 hilly Blocks viz., Darjeeling-Pulbazar, Jorebunglow-Sukhia Pokhri, Rongli-Rangliot, Kurseong, Mirik Kalimpong-I, Kalimpong-II, Gorubathan and 4 foothill Blocks viz., Khoribari, Naxalbari, Phansidewa and Matigara) were surveyed during December 2011 to May 2019.



Map 1. Indian Eastern Himalayan distribution of the tribe Vaccinieae Reichenbach (satellite imagery)



Map 2. Showing Darjeeling district (orange colour) in West Bengal & India with magnified Darjeeling district incl.12-Blocks (right)-source: www.veethi.com

3. Results

Taxonomic Treatment

1. *Agapetes* D. Don ex G. Don, Gen. Syst. 3: 862. 1834. Lectotype: *A. setigera* (Wall.) D. Don ex G. Don (Pfeiff., Nomencl. Bot. 1: 74. 1871). *Distribution*: 100 species in subtropical to temperate regions in Asia from Nepal to Malay Peninsula in the world (Nepal, Bhutan, China, Myanmar, Malaysia, Thailand, Vietnam and Cambodia); 58 species and 15 varieties including 17 endemics in India (Eastern Himalayas & North Eastern India (BANIK & SANJAPPA 2014).

Morphologically, the genus *Agapetes* differs from the genus *Vaccinium* in having flowers either in solitary or corymbs or fasciculate, mostly tubular corolla to rarely campanulate (but never urceolate as in *Vaccinium* L.), shorter filaments (often obscure: 1:14 or 1:17 in length to anther lobes).

Research mainly based on molecular data (*rbcL*, *matK*, ITS: KRON et al. 2002a) reveals that the majority of species of *Agapetes* belong to the same lineage as many South east Asian-Malaysian species of *Vaccinium* L. Species of *Agapetes* from New Guinea and the South west Pacific are now placed in *Paphia* Seemann (STEVENS 2004). The phylogenetic study also found that members of the genus *Agapetes* were not monophyletic and Asian Continental *Agapetes* were more closely allied to the SE Asian *Vaccinium* (KRON et al. 2002b).

Key to the Species (Darjeeling *Agapetes*)

1. Leaves compactly spiral 2
1. Leaves loosely spiral 3
2. Lamina ovate to ovate-elliptic; corolla deep red to pink 1. *A. serpens*
2. Lamina obovate to oblanceolate; corolla always yellow 2. *A. smithiana*
3. Lamina auriculate at base 4
3. Lamina attenuate at base 5
4. Lamina serrate at margin; corolla yellow 3. *A. hookeri*
4. Lamina crenate at margin; corolla red..... 4. *A. sikkimensis*
5. Leaf apex caudate; leaf margin entire; corolla red-maroon 5. *A. saligna*
5. Leaf apex acuminate; leaf margin obscurely crenate; corolla light pink 6. *A. bhutanica*

1. *Agapetes serpens* (Wight) Sleumer, Bot. Jahrb. 70: 105. 1939; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 382. 2014. *Vaccinium serpens* Wight, Calcutta J. Nat. Hist. 8: 171. 1847. *Pentapterygium serpens* (Wight) Klotzsch, Linnaea 24: 47. 1851. *Thibaudia myrtifolia* Griff., Itin. Notes pl. 2: 125. no. 434. 1848. *A. serpens* (Wight) Sleumer var. *stenophylla* Airy Shaw, Kew Bull. 13: 500. 1959.

This widely distributed species is highly variable in leaf shape, size and in floral characters especially the calyx (presence of glandular hairs on wings of calyx or in between wings of calyx), number of bracteoles and length of pedicel. Two varieties reported.

Key to the varieties

- 1a. Bracteoles more than 9; pedicel more than 13 mm long (15-25 mm long) 1a. var. *serpens*
- 1b. Bracteoles less than 9; pedicel less than 13 mm long (5-12 mm long) 1b. var. *alba*

1a. var. *serpens*; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 384. 2014. **Type**: Bhutan ('Bootan'), Phullong woods, Griffith s.n. (K, Cibachrome image!). (Plate 1)

Vernacular names: Aijaru, Chari amilo, Chara ko Khorsane (Nepalese of Darjeeling). Commonly called 'Himalayan Lantern'.

Generally epiphytic to rarely lithophytic drooping shrub, 0.5-1.5 m long. Stems robust, profusely branched, twigs red or brown, hispidulous, more dense at apex. Leaves compactly spiral; lamina reddish to dark brown when young, ovate-elliptic, 8-24×4-9 mm, rounded at base, slightly revolute at margin, entire towards base and serrate towards apex, acuminate-mucronate at apex, coriaceous, glaucous; petioles 1-3 mm long, glabrous, glandular. Flowers bright red, solitary or very rarely 2-together; bracts 2, linear, 2-3 mm long; bracteoles 12-15 in 3-6 whorls, acropetal, scaly, distinctly veined, puberulous and glandular hairy outside and at margin; pedicels 15-25 mm long, glandular-pubescent, a ring of 1 mm long hairs basal to calyx tube. Calyx 6-10 mm long, slightly winged, glandular-pubescent on wings, glandular hairs with reddish-green heads; lobes narrowly triangular to elliptic, entire to glandular hairy at margin. Corolla bright red to pink, tubulo-urceolate, 12-24 mm long, 6-8 mm in diameter, angular, reticulate in red or dark red, glandular hairy on midveins. Stamens 10, 2-whorled, 14-24 mm long; filaments 1-3 mm long, light green, puberulous outside; anthers 14-22 mm long including 5-6 mm long thecae, brown, depressed at middle and slightly ridged at 2 sides, verrucate, shortly appendiculate at base, yellow to brownish, tubules 8-16 mm long, glabrous, transparent-yellow. Ovary 4-5 mm long, globose to oblong-ovoid, glabrous. Style 14-25 mm long, slender, glabrous; stigma truncate. Berries white to light mauve, rounded, 11-14×6-8 mm, glandular hairy, becoming glabrescent when mature; fruiting pedicel with apical ring of dense glandular hairs, persistent. Seeds obovoid, minute, pointed at base.

Distribution: INDIA (Eastern Himalaya: West Bengal and Sikkim); Nepal, Bhutan, China and Thailand. DARJEELING: Sonada (1908 m: 26°57'31.68"N & 88°16'07.50"E), Rangbul (2272 m: 26°59'22.64"N & 88°16'22.49"E), Kurseong (1865 m: 26°53'08.37"N & 88°17'23.67"E), Senchal Forest (2308 m: 27°00'09.78"N & 88°15'46.52"E), Chhatakpur (2342 m: 26°57'57.48"N & 88°18'39.88"E), Tinmile (2153 m: 27°00'38.59"N & 88°17'32.30"E), Alubari Jungle Busty (2147 m: 27°00'54.12"N & 88°15'42.46"E), Darjeeling Hooker Road (2138 m: 27°02'56.34"N & 88°16'00.35"E), Lebond (1810 m: 27°03'34.95"N & 88°16'44.38"E), Manebhanjang-Chitrey (2120 m: 26°59'19.11"N & 88°07'00.36"E), Chitrey-Lamedura (2380 m: 26°59'30.91"N, 88°06'40.66"E), Meghma (2864 m: 27°01'31.42"N & 88°04'59.54"E), Sukhia-Manebhanjang (2182 m: 26°59'24.61"N & 88°08'54.76"E), Sukhia Simana

(2226 m: 26°58'52.19"N & 88°08'00.24"E), Lava (2102 m: 27°05'14.82"N & 88°39'32.52"E), Neora Valley National Park (2114 m: 27°04'50.95"N & 88°40'08.87"E).

Flowering: April-May, October-November; **Fruiting:** June-July.

Habitat: Subtropical to temperate forests from 1600-2700 m altitude.

Specimens examined in Darjeeling district: CAL: Rangbul, 2272 m, March 1877, G. King s.n., Acc.No. 264367; North side of Senchal Forest, 2308 m, 28.6.1862, S. Kurz s.n.; Alubari, 2093 m, 13.11.1948, K. Biswas 8725, fl.; Gairibas, 13 October 2003, M. Debta 1326. DGC (Darjeeling Govt. College Herbarium): Lebung, 07.05.2014, 1810 m, S. Panda & P. Roy 55; Alubari Jungle Busty, 2147 m, 14.04.2015, S. Panda & J. K. Thami 912. MAC (Maulana Azad College Herbarium): Alubari Jungle Busty, 2147 m, 27.04.2016, S. Panda & D. S. Mahanty 333.

Ethnic Uses: Corolla tastes sour and used to prepare chatney as well as cooked with dal by the Nepalese of Darjeeling. They also use fruits are used to prepare tarts and jams. The plants are grown for their beautiful foliage and also yield tannin, are used as fodder for cattle, cultivated as pot plants in front of Nepalese houses in Darjeeling. As a variety of birds eat both flowers and fruits of this plant, so it is often called as 'Chara-Ko-Khorsane' by the Nepalese (Chara means 'birds', khorsane means 'capsicum', as the red flower resembles 'capsicum').

IUCN Status: NE as the variety is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it will not qualify as 'Threatened' category, but it may be threatened in near future due to rapid urbanization, and habitat degradation as a result of anthropogenic causes.

1b. var. *alba* Airy Shaw in Kew Bull. 1948: 102. 1948; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 386. 2014. **Type:** India, West Bengal, Darjeeling district, Kalimpong subdivision, Between Kalimpong and Algarah, 1830-2000 m, 1946, *W.T. Stearn s.n.* (K, cibachrome image!). (Plate 2)

Vernacular name: Chara-ko-Khorsane (Nepalese of Jungle Busty).

This variety differs from var. *serpens* in having dense glandular hairy calyx, relatively shorter pedicels, 5.5-12.0 mm long and lesser number of bracteoles 3-6 (-9).

Distribution: INDIA (Eastern Himalaya: West Bengal, Sikkim and Arunachal Pradesh); Bhutan. DARJEELING: Lamey Dhura (2609 m: 27°00'15.81"N & 88°05'37.07"E), Algharah-Lava road (2114 m: 27°04'50.95"N & 88°40'08.87"E) and Lava (2102 m: 27°05'14.82"N & 88°39'32.52"E).

Flowering: March-June, October-February; **Fruiting:** July-September, October-December.

Habitat: Subtropical to temperate evergreen forests from 1800-2900 m.

Specimens examined in Darjeeling district: CAL: Algarah to Lava, 19.4.2001, D. Banik 27852. BSHC: Kalimpong, Labha highest point, 9th mile, 2414 m, 25.4.1981, B. Krishna 1443. DGC: Lamey dhura, 2609 m, 24.04.2012, S. Panda 151.

Ethnic use: Same use as var. *serpens*.

IUCN Status: NE as the variety is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

2. *Agapetes smithiana* Sleumer, Bot. Jahrb. 70: 106. 1939; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 388. 2014. (Plate 3)

Two varieties are recognized under this species viz., var. *smithiana* and var. *major*. var. *major* occurs from Arunachal Pradesh of India and Bhutan. So, in this work only var. *smithiana* is described.

var. *smithiana*: Panda & Reveal, Phytoneuron 8: 1-7. 2012; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 388. 2014. *Pentaptergyium sikkimense* W.W. Sm. in Rec. Bot. Surv. India 4: 268. 1911. **Type:** Sikkim, Lachung valley, 7500 ft., 14.9.1892, Gammie 1216. (Lecto. K, Cibachrome image!; Isolecto. CAL!).

Vernacular name: Hario phulo (Nepalese of Chitrey).

Epiphytic dwarf shrub on tree trunks, up to 1 m long. Stem rigid, sparsely strigose-hispid; branches similar to stems but beset with dense brown strigose-hispidulous to hirtellous hairs (more towards twigs). **Leaves compactly 2-3-stichous**, 2-10 mm apart, coriaceous, subsessile;; **lamina elliptic obovate to obovate**, 12-32×6-16 mm, glaucous and green adaxially, glabrous and light green abaxially, serrate with minute teeth to 0.5 mm long, these becoming obscure near basal half, incurved marginally, mucronate to mucronulate apically, cuneate to obtuse basally with one basal pair of glands; petioles 1-3 mm long, puberulous. **Inflorescence cauline, 1-4-fascicled in a corymb**; peduncle 3-5 mm long, sparsely hirtellous with several basal bracts. **Flowers 12-16 mm long** including pedicels with bract and bracteoles; pedicels greenish-pink, sparsely hirtellous, 4-5 mm long; bract 1, basal, 1×0.5 mm, ovate-triangular, glabrous, caducous; bracteoles 2-4, basal to subbasal, persistent in fruit, otherwise like bract. **Calyx cup-like, winged, light green with pinkish wings**, 6-8×4 mm, glabrous, accrescent in fruits; lobes 5, basally united, ovate-triangular, 4-5×3 mm, glabrous, shortly acuminate apically, entire marginally. **Corolla greenish-yellow, tubular, 10-13×4 mm**, 3.5-4.5 mm diam., glabrous; lobes 5, 1×0.5 mm, ovate-linear. Stamens 10, encircling the pistil, distinct, 8-8.5 mm long; filaments slightly adnate to ovary disc, ca. 1 mm long, greenish-white, glabrous, spatulate, basally dilated; anthers 2-lobed, 7-7.5 mm long incl. tubules 4-5 mm long, granular with a minute tail. Ovary c. 4×3.5 mm, glabrous; style slender, 8 mm long with 3-4 longitudinal ridges, glabrous; stigma truncate. **Fruit a berry, ovoid, 12-16×10-12 mm, light green (immature) to white (mature)**, glabrous, with an accrescent, winged calyx. Seeds numerous, c. 1 mm long, obconical, scarious.

Distribution: INDIA (Eastern Himalaya: West Bengal and Sikkim); Nepal and Bhutan. DARJEELING: Chitrey-Lamedura Road side hilly slope (only locality noticed to date) (2380 m: 26°59'30.91"N & 88°06'40.66"E).

Flowering: February-March; September-December; **Fruiting:** December-March.

Habitat: Subtropical to temperate forests from 2330-2760 m.

Specimens examined in Darjeeling district: CAL: Below Tonglu at Dilpa, 8300 ft., 2.4.1975, D. Chamberlain 49, fl. (DD). DGC: Chitrey-Lamedura Hill side road, 2380 m, 14.11.2011, S. Panda 81. MAC: Chitrey-Lamedura Hill side road, 2380 m, 17.05.2019, S. Panda 309.

Ethnic use: Mature fruits are eaten raw to cure indigestion and acidity problems by the Nepalese of Chitrey.

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Critically Endangered (CR)** based on Criteria A2(c), B1(a) & (b), C2(b) and D. Only a single populations consisting of two individuals seen in Darjeeling Himalaya, even very scant populations reported from its other natural habitats.

3. *Agapetes hookeri* (C. B. Clarke) Sleumer, Bot. Jahrb. 70: 106. 1939; Airy Shaw in Kew Bull. 1948: 98. 1948; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 371. 2014. *Pentapterygium hookeri* C. B. Clarke in Hook. f., Fl. Brit. India 3: 450. 1882. *Agapetes incurvata* (Griff.) Sleumer var. *hookeri* (C.B. Clarke) Airy Shaw. Kew Bull. 13: 486. 1959. **Syntypes:** India, West Bengal ('Sikkim'), Darjeeling, 7300 ft., 17.8.1875, C. B. Clarke 27025 & C. B. Clarke 12043 (K, Cibachrome image!). (Plate 4)

Vernacular name: Pito Phulo (Nepalese of Alubari, Darjeeling).

Epiphytic dwarf shrub, often drooping. Stems robust, striate, when young hirtellous. Leaves pseudowhorled, pseudowhorls 2-3 cm apart, 3-5-leaved; lamina sessile, elliptic to ovate-elliptic, 4-14×1.5-4 cm, obtuse to slightly auriculate or cordate at base with a pair of glands, serrate, slightly revolute at margin, acutely acuminate at apex, coriaceous, glabrous to puberulous on midvein above, puberulous to glabrous below on reticulation; veins depressed above. Inflorescences corymbose, 3-6-flowered, sparsely puberulous; bracts 4-5, alternate, narrow-elliptic to linear, 3-8 mm long. Flowers greenish-yellow; pedicels 1-2 cm long, striate, puberulous, hairs dendroid. Calyx winged, campanulate pandurate, 10-12 mm long, 10-12 mm in diam., membranous, glabrous. Corolla greenish-yellow, tubular, 14-16 mm long, 5-6.5 mm in diameter, puberulous outside. Stamens 10; 15-20 mm long; filaments 1.5-2 mm long, ellipsoid, pilose outside; anthers 14-15 mm long including 3-3.5 mm long verrucate, theca shortly appendiculate at base, slightly recurved, tubules 11-12 mm long, calcarate, spurs basal to tubules, 0.5-2 mm long, descending and deflexed in adjacent anthers. Ovary 4-6 mm long, oblong-ovoid, glabrous. Style 15-16 mm long; stigma clavate. Berries obovoid-truncate, 5.5-7 × 3-4 mm, white. Seeds curved obovoid, 0.5-1×0.5-1 mm, pointed at base.

Distribution: INDIA (E Himalaya: West Bengal and Sikkim); Bhutan and Nepal. DARJEELING: Rangbul (2272 m: 26°59'22.64"N & 88°16'22.49"E), Senchal Forest (2308 m: 27°00'09.78"N & 88°15'46.52"E), Tinnile-Jorebungalow road side hills (2106 m: 27°00'25.94"N & 88°16'09.14"E), Manebhanjang-Chitrey road side hills (2120 m: 26°59'19.11"N & 88°07'00.36"E), Lamey Dhura (2609 m: 27°00'15.81"N & 88°05'37.07"E), Alubari Jungle busty (2147 m: 27°00'54.12"N & 88°15'36.48"E), 6th Mile-Takhdah road side hills (2040 m: 27°02'12.64"N & 88°20'15.25"E).

Flowering: April - September; **Fruiting:** August - November.

Habitat: Subtropical to temperate forests from 1850 - 2750 m.

Specimens examined in Darjeeling district: CAL: Darjeeling, 7500 ft, S. Kurz s.n. Acc.No. 264399; Senchal Forest, 2308 m, 2. 5. 1862, T. Anderson 770. DD: Rangbul, 2272 m, 1.7.1902, J.H. Lace 2303. BSHC: Manebhanjyan to Dhotrey, 3.9.1985, B. Krishna 4671; Lava to Algarah, 10.9.1989, S. Kumar 11524. DGC: Senchal Forest, 2308 m, 13.09.2012, S. Panda & A. Pradhan 17; Manebhanjang-Chitrey Trek, 2120 m, 16.09.2015, S. Panda & S.S.Nepal 94; Tinnile, 2153 m, 27.08.2014, S. Panda 145.

Ethnic Uses: Mature fruits are eaten raw by the Nepalese of Manebhanjang to relieve stomach pain and indigestion problems.

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

4. *Agapetes sikkimensis* Airy Shaw, Kew Bull. 1935: 29. 1935; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 302. 2014. *Agapetes auriculata* C. B. Clarke in Hook. f., Fl. Brit. India 3: 444. 1881. **Type:** India, Sikkim, Teesta (now under Kalimpong district of West Bengal), 1200 m, 12.11.1870. C. B. Clarke 13865B, fl. (K, Cibachrome image!). (Plate 5)

Vernacular name: Dhungri Phul (Nepalese of Teesta valley).

Epiphytic drooping shrub up to 1 m tall. Stems robust, drooping, striate. Leaves pseudowhorled, pseudowhorls 2.5-6.5 cm apart, 3-5-leaved; lamina sessile, lanceolate, 15-20×3-5 cm, auriculate at base, crenate at margin, obtusely acuminate at apex, coriaceous, glabrous, glaucous above. Flowers bright red, axillary or cauline, 3-6 in fascicles or in short corymbs, puberulous; bracts and bracteoles minute, deltoid; pedicels obconical, 5-9 mm long, cupulate at apex 4.5-5 mm broad, puberulous. Calyx 9-10 mm long, puberulous, 5-angled; lobes lanceolate to elliptic, 6.5-8 mm long, acuminate at apex. Corolla bright red, tubulo-urceolate, 14-21 mm long, c. 6 mm in diameter, puberulous outside. Stamens 10 in pseudowhorl, c. 2 cm long; filaments spatulate to elliptic, 2-3 mm long, incurved, obscurely puberulous outside; anthers 1.6-1.8 cm long including 4-7 mm long thecae, verrucate, minutely appendiculate at base, tubules 10-11 mm long. Ovary 4-5 mm long, oblong to globose-ovoid, glabrous. Styles filiform, 14-21 mm long, glabrous, glandular; stigma glandular-capitate, 5-lobed. Berries red, ovoid, 6-7× 6-7 mm, puberulous. Seeds obovoid, pointed at base, 1-2×c. 1.5 mm, seed coat obscurely reticulate.

Distribution: India (Eastern Himalaya: Sikkim and West Bengal); Nepal and Bhutan. DARJEELING: Teesta valley (980 m: 27°00'48.07"N & 88°24'17.02"E).

Flowering: November; **Fruiting:** April-May.

Habitat: Subtropical forests from 1600-2000 m.

Specimens examined in Darjeeling district: CAL: Teesta valley, Kalimpong district, 980 m, 19.9.1892, G. A. Gammie 1266.

Ethnic Use: Corolla sour in taste and used to prepare chatney by the Nepalese of Teesta.

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

5. *Agapetes saligna* (Hook. f.) Hook. f. in Benth. & Hook. f., Gen. Pl. 2: 571. 1876; C. B. Clarke in Hook.f., Fl. Brit. India 3: 444. 1881; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 292. 2014. *Vaccinium salignum* Hook. f., Illus. himal. pl.: t. 15. 1855. **Type:** India, West Bengal ('Sikkim'), Pankabari, 5000-7000 ft., April 1850 J. D. Hooker s.n. (K, Cibachrome image! CAL!). (Plate 6)

Vernacular names: Amile, Ongary (Nepalese of Pankabari & Kurseong).

Epiphytic drooping dwarf shrub, up to 70 cm long. Stems stout, glabrous, wrinkled, lenticellate when mature, puberulous when young. Leaves spiral, 1-2 cm apart; lamina lanceolate, 5-10×1-3 cm, attenuate at base, entire, slightly revolute at margin, caudate at apex, coriaceous, glabrous; petioles 2-6 mm long, puberulous to glabrous. Inflorescences cauline, corymbose, 7-14-flowered. Flowers red, pedicels reddish-maroon, stout, 1.6-2.5 cm long, glabrous; pedicel bracts 3-4. Calyx reddish-maroon, 5-6 mm long, glabrous, glandular outside. Corolla reddish-maroon, tubular, obscurely infundibuliform, 5-angular, 1-3 cm long, c. 5 mm in diameter, glabrous, reticulate with 8-10 pairs of secondary veins. Stamens 10 in 2-whorls, 2.5-2.8 cm long; filaments spatulate, incurved, 2-3 mm long; anther lobes ca 25 mm long including 7-8 mm long thecae, verrucate, appendiculate at base, recurved; tubules 18-20 mm long, glabrous. Ovary 3-4 mm long, globose-ovoid, glabrous. Style red, slender, 15-30 mm long; stigma truncate. Berries red, globose, 6-8×5-6 mm, glabrous, glandular; fruiting stalk maroon red. Seeds obovoid, minute.

Distribution: INDIA (Eastern Himalaya: West Bengal and Sikkim); Nepal, Bhutan and Myanmar. DARJEELING: Sevoke hills (800 m: 26°53'45.38"N & 88°27'02.41"E), Badamtam (1357 m: 27°04'58.56"N & 88°17'56.55"E), Rambhi (524 m: 26°59'32.33"N & 88°24'55.57"E), Mongpoo (1161 m: 26°58'25.66"N & 88°21'51.97"E).

Flowering: March-June; **Fruiting:** June-August.

Habitat: Subtropical forests from 1200-2300 m.

Specimens examined in Darjeeling district: CAL: Sivoke hills (Suike hills), 2000 ft., March 1874, C. B. Clarke 3667A;

Mongpoo, March 1878, J.L. Lister s.n. Acc. No. 264123, fl.; Rambhi, 23.6.1908, Ribu 975; Badamtam, 1357 m, 30.5.1913, G.H. Cave s.n.

Ethnic Uses: Leaves are used as substitute of tea by the local Nepalese of Mongpoo, Badamtam and Rambhi (may be due to their tannin content).

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

6. *Agapetes bhutanica* N.P. Balakr. & S. Chowdhury, Reinwardtia 7: 287. 1966; Banik & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India 25: 262. 2014. **Type:** Eastern Bhutan, near Deothang, on the road to Tashiglang, alt. 800 m, 29. 03. 1965, N.P.Balakrishnan 41943A (holo. CAL!). (Plate 7)

Epiphytic drooping shrub up to 70 cm long. Stems robust, glabrous, wrinkled. Leaves pseudowhorled, pseudowhorls 3-8 cm apart, 4-6-leaved; lamina narrowly elliptic to narrowly oblanceolate, 7-18×1-3 cm, attenuate to cuneate at base, obscurely crenate, acuminate at apex, coriaceous, glaucous above; petiole 2-5 mm long, glabrous; Flowers deep to light pink, cauline, 9-17 in fascicles; bracts 2-3, alternate to opposite, c. 1 mm long, caducous, glandular hairy; pedicels light pink, 15-18 mm long, densely glandular hairy at base. Calyx light pink, 5-6 mm long, 5-6 mm in diameter, accrescent in fruit, glandular hairy. Corolla deep to light pink, tubular-urceolate, 23-28 mm long, 8-10 mm in diameter, membranous, 12-14 pairs of pink or red secondary veins forming horizontal reticulation, midveins sparsely glandular hairy. Stamens 10 in 2-whorls, inner 5, c. 23 mm long, outer 5, c. 25 mm long; filaments spatulate to ellipsoid, 2-3 mm long, slightly incurved, puberulous outside; anthers c. 21-25 mm long including, 4-6 mm long thecae, verrucate, obscurely appendiculate at base; tubules c. 15 mm long, calcarate, spurs basal to tubule, linear, 1-1.5 mm long. Ovary 3-4 mm long, oblong, glabrous. Style 22-24 mm long, slender, glabrous; stigma truncate. Berries globose, 5-6×6-7 mm, glandular hairy. Seeds obovoid.

Distribution: INDIA (E Himalaya: West Bengal); Bhutan. DARJEELING: near Sevoke Bridge (800 m: 26°53'45.38"N & 88°27'02.41"E).

Flowering: March-May. **Fruiting:** July-August.

Habitat: Subtropical forests from 770-800 m.

Specimens examined in Darjeeling district: CAL: near Sevoke Bridge, 800 m, 12.05.2001, D. Banik 27886, CAL. MAC: 1 km from Sevoke bridge toward Gangtok, 770 m, 7.5.2018, S. Panda 172.

Ethnic uses: Ripe fruits are the source of tart by local Nepalese of Sevoke Kali bari area.

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

2. *Vaccinium* L., Sp. Pl. 1: 349. 1753; Juss., Gen. Pl.: 162. 1789. Lectotype: *V. uliginosum* L. (Vander Kloet, Taxon, 30: 647. 1981; Linn. no. 497.3, LINN). **Distribution:** 140 species (under 33 sections) distributed in America (North & South), Europe, tropical Africa and SE Asia; 27 species (6 endemic) in 7 sections occurs in India (PANDA & SANJAPPA 2014).

Key to the Species of *Vaccinium* L. (Darjeeling)

- 1a. Leaf apex caudate to caudate-acuminate 1. *V. dunalianum*
 1b. Leaf apex acuminate to retuse 2
 2a. Leaf-apex acuminate; corolla greenish-yellow 2. *V. vacciniaceum*
 2b. Leaf-apex retuse; corolla pinkish 3
 3a. Lamina obovate to obovate elliptic; entire at margin 3. *V. retusum*
 3b. Lamina oblong-elliptic; serrulate-ciliate at margin 4. *V. nummularia*

1. *Vaccinium dunalianum* Wight, Calcutta J. Nat. Hist. 8: 175. 1847 (“*Dunallianum*”) & Ic. Pl. 4 (1): t. 1194. 1850; Panda & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 395. 2014.

Among three varieties, var. *dunalianum* occurs in Darjeeling.

var. *dunalianum* (Plates 8-9)

Epigynium dunalianum (Wight) Klotzsch, Linnaea 24: 51. 1851. *Thibaudia revoluta* Griff., Icon. pl. 4: t. 513. 1854. **Type:** Bhutan, Tongsa, Griffith 2258 (K, Cibachrome image!).

Vernacular name: Sweto-Hario phulo (Nepalese of Manebhanjang).

Stout, drooping shrub to treelet, 1-5 m high, often epiphytic. Stems greyish-white, terete to angular, profusely branched, glabrous; branches silvery white, usually glabrous to rarely hispid-setulose. Leaves coriaceous, lamina elliptic, oblong-elliptic, ovate, ovate-oblong to oblong lanceolate, 5-14×2-5 cm, entire with slightly revolute at margin, broadly cuneate to rounded or rarely narrowly cuneate at base, caudate to caudate-acuminate at apex, glabrous to hispid-setulose along lower half of midvein above, light green, hispid-setulose to rarely punctate beneath; petioles stout, 3-12 mm long, hispid-setulose. Racemes axillary or rarely pseudoterminal, rachis light green, 1-4 cm long, 5-12-flowered, puberulous or rarely glabrous. Flowers 10-14 mm long; pedicels light green, 3-7 mm long, puberulous; bracts and bracteoles not seen. Calyx lobes equal, light green, ovate-triangular, c. 1.5×1 mm, glabrous. Corolla broadly to rarely narrowly campanulate, light green, 5-7 mm long, c. 3 (at base)-5 (at apex) mm diam., glabrous. Stamens 10, 4-5 mm long, free or loosely epipetalous; filaments light green, c. 1 mm long, slender, papillose, glabrous or rarely puberulous adaxially, slightly dilated at base; anthers orange brown, oblong, c. 1.5 mm long, each lobe with c. 2 mm long single tubule and with 2 equal spurs of c. 1 mm long at anther lobe-tubule junction. Ovary globose, light green, c. 2×2 mm, puberulous. Style light green, c. 5 mm long, slender, glabrous. Stigma truncate. Berries globose, dark green (immature) to pinkish (mature), 4-7 mm long, 4-6 mm diameter with 5-7 mm long pedicel, glabrous or puberulous. Seeds brown, minute, 20-30, obconical, scarious.

Distribution: India (Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim and West Bengal), Bhutan, China, Myanmar, Nepal, Taiwan and Vietnam. **DARJEELING:** Sukhia-Manebhanjang road side hills (2182 m: 26°59'24.61"N & 88°08'54.76"E), Tinnile (2153 m: 27°00'38.59"N & 88°17'32.30"E), Senchal Forest (2308 m: 27°00'09.78"N & 88°15'46.52"E).

Flowering: April-June. **Fruiting:** May-December.

Habitat: Moist rocky slopes, often epiphytic in association with *Gaultheria fragrantissima*, *Lyonia ovalifolia*, *Rhododendron arboreum* and *R. inaequale* at altitudes ranging from 1600-2800 m.

Specimens examined in Darjeeling district: CAL: Darjeeling, 7500 ft, 06.07.1875, C. B. Clarke 26784A. DGC: 1 km from Manebhanjang toward Sukhia, 2182 m, 12.06.2014, S. Panda & A. Roy 73.

Ethnic Use: Mature fruits are used to prepare tarts and chatney by the Nepalese of Manebhanjang.

IUCN Status: **NE** as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

Leaf stomata (Plate 9A-B): The study of Light Microscopic stomatal architecture (10X, 40X) includes number, form and arrangement of specialized epidermal cells associated with the stomatal guard cells. Stomata are distributed more or less evenly over the entire abaxial leaf surface in between the veins, but generally not over the finer veins and main veins. The stomata are uniformly distributed in abaxial surface only, they are widely separated from each other by epidermal cells.

Stomata type: The investigated species shows only one type, paracytic. Average dimension of stomata is 27.4×27.4 µm. Average dimension of guard cells: 18.3×3.4 µm. Epidermal cells are mostly polygonal and isodiametric, some are elongated to deltoid. The epidermal walls in surface view are slightly arched to rarely straight. The epidermal walls in the adaxial surface are mostly straight. The maximum length of epidermal cell is 51.2 µm and breadth is 19.8 µm, while minimum length is 19.2 µm and breadth is 11.4 µm.

Leaf areoles (vein islets) (Plate 9C-D): Pentagonal, hexagonal to rarely triangular in shape. Larger areole: 859×628 µm. Smaller areole: 409×305 µm. Areoles: 4 (average) per 1 mm². Vein endings: 48 (average) per 1 mm²; veinlets simple unbranched to branched (once). Branched and unbranched veinlets occur in the same areole. Vein ends: bulbous.

Pollen morphology (Plate 9E-F): Pollen grains occur in tetrahedral tetrads, 3-zonocolporate. Tetrad size (D): 40.5-42 µm diameter. Individual grain size (d) variable, 16-24 µm diameter. Individual grain possesses distinct slender transverse furrows. Exine tectate, ca. 2.6 µm thick, surface faintly rugulate-psilate. D/d = 2.05. Colpi distinct, 4.4- 8.2 µm long, 0.9-1.3 µm wide. Colpus margin distinct, acute to tapering towards ends. Septum thickness 1.7-3.4 µm.

2. *Vaccinium vacciniaceum* (Roxb.) Sleumer, Bot. Jahrb. 71: 479. 1941; Panda & Sanjappa in Sanjappa & Sashtri, Fasc. Fl. India Ericaceae 25: 433. 2014. *Ceratostem(m)a vacciniacea* Roxb., Fl. Indica 2: 412. 1832. *Agapetes vacciniacea* (Roxb.) Dunal in DC., Prodr. 7 (2): 554. 1839. **Type:** India, Meghalaya, Garrow Hills, 1813, *Roxburgh s.n.* (BM, photo!). *Agapetes serrata* G. Don, Gen. Syst. 3: 862. 1834. *Gaylussacia serrata* (G. Don) Lindl. in Royle, Illus. Bot. 2: t. 79, fig. 2, 1835. *Vaccinium serratum* (G. Don) Wight, Calcutta J. Nat. Hist. 8: 171. 1847. *Epigynium serratum* (G. Don) Klotzsch, Linnaea 24: 50. 1851. *V. vacciniaceum* (Roxb.) subsp. *glabritubum* P. F. Stevens, J. Arnold Arbor. 66 (4): 487. 1985. (Plates 10-11) **Vernacular names:** Bandri Phul, Godra dana (Nepalese of Manebhanjang);

Stout, drooping shrub, 0.3-1.5 m high, often epiphytic on old tree trunks, rarely on rock crevices. Stems profusely branched, glabrous, lenticillate; branches and twigs often covered with lanceolate scales up to 1 cm long. Leaves pseudo-verticillate to rarely subopposite, 4-7 (-10) leaves in each pseudo-verticel, chartaceo-coriaceous, lamina elliptic-lanceolate, oblong-lanceolate to lanceolate, 5-8×1-2 cm, serrate to rarely crenate-serrate at margin, narrowly to broadly cuneate at base, acute to acuminate at apex, glabrous, dark green above, light green beneath; petioles subsessile to 3 mm long, glabrous. Racemes axillary or pseudo-terminal from upper foliar axils, 3-7 racemes per pseudoverticel; each rachis 12-35-flowered, glabrous. Flowers 12-24 mm long; pedicels light green to purple, 7-15 mm long, glabrous; bract 1, basal, caducous; bracteoles 2, opposite, basal to subbasal, caducous. Calyx lobes light green to purple, ovate-triangular to broadly ovate-deltoid, c. 1×1 mm, glabrous. Corolla ovoid-urceolate to tubulo-urceolate, light green, 6-9 mm long, 3-4 mm diameter, glabrous or pilose inside. Stamens 10, 4-6 mm long; filaments light green to greyish-white, 1-2 mm long, slender, papillose, glabrous or pilose, dilated at base; anthers oblong, orange brown, 1-2 mm long, smooth, each lobe with c. 2 mm long single tubule. Ovary globose, light green, 1-2 mm long, 1.5-2.5 mm diam., glabrous. Style light green, 5-7 mm long, slender, glabrous, pilose or dotted. Stigma truncate. Berry globose, light green, c. 3×3 mm with 8-10 mm long pedicels, glabrous. Seeds 30-40, yellowish-brown, obconical, c. 1×0.5 mm, scarious.

Distribution: INDIA (E Himalaya: Arunachal Pradesh, Sikkim and West Bengal and NE India: Manipur, Meghalaya, Mizoram and Nagaland), Nepal, Bhutan, China and Myanmar. **DARJEELING:** Darjeeling Hooker Road (2138 m: 27°02'56.34"N & 88°16'00.35"E), Lebung (1810 m: 27°03'34.95"N & 88°16'44.38"E), Tinmile (2153 m: 27°00'38.59"N & 88°17'32.30"E), Sonada (1908 m: 26°57'31.68"N & 88°16'07.50"E), Kurseong (1865 m: 26°53'08.37"N & 88°17'23.67"E), Neora valley National Park (2114 m: 27°04'50.95"N & 88°40'08.87"E), Lava (2102 m: 27°05'14.82"N & 88°39'32.52"E), Algarah (2114 m: 27°04'50.95"N & 88°40'08.87"E), Mirik (1640 m: 26°53'14.81"N & 88°11'13.53"E), Manebhanjang-Chitrey road side hills (2120 m: 26°59'19.11"N & 88°07'00.36"E), Srikhola (1931 m: 27°07'50.38"N & 88°04'26.68"E), Rimbick (1941 m: 27°07'09.15"N & 88°06'30.14"E).

Flowering: March-May; December. **Fruiting:** May-August. **Habitat:** Epiphytic on old tree trunks, sometimes on moist rocky slopes or rock crevices in association with *Agapetes serpens*, *Lyonia ovalifolia*, *Rhododendron arboreum* and *Vaccinium obovatum* and at altitudes ranging from 1500-2400 m.

Specimens examined in Darjeeling district: CAL: Darjeeling, 6000 ft, 22.09.2003, S. Panda 30765. DGC: Manebhanjang-Chitrey trek, 2120 m, 12.05. 2013, S. Panda 714; Alubari, 7000 ft, 19.06.2013, S. Panda & J. K. Thami 732. MAC: Senchal Forest, 2308 m, 27.04.2016, S. Panda & D. S. Mahanty 179.

Ethnic uses: Tender leaves, flowers and floral buds are used as vegetables, for preparation of curries, and fruits are used to prepare tarts by the Nepalese of Darjeeling, Alubari, Manebhanjang and Jungle Busty.

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it will not qualify as 'Threatened' category, but it may be threatened in near future due to rapid urbanization and habitat degradation as a result of anthropogenic causes.

Leaf stomata (Plate 11D-E): The study of Light Microscopic stomatal architecture (10X, 40X) includes number, form and arrangement of specialized epidermal cells associated with the stomatal guard cells. **Stomata type:** The investigated species shows only one type, amphiparacytic. Average dimension of stomata is 38.4×36.4 µm. Average dimension of guard cells: 26.3×4.4 µm. Epidermal cells are mostly polygonal and isodiametric, some are elongated to deltoid. The epidermal walls in surface view are sinuous. The epidermal walls in the adaxial surface are arched. The maximum length of epidermal cell is 43.2 µm and breadth is 18.8 µm, while minimum length is 19.2 µm and breadth is 11.4 µm.

Leaf areoles (vein islets) (Plate 11A-C): Pentagonal, hexagonal to rarely triangular in shape. Larger areole: 919×428 µm. Smaller areole: 309×205 µm. Areoles: 6 (average) per 1 mm². Vein endings: 58 (average) per 1 mm²; veinlets simple unbranched to branched (once). Branched and unbranched veinlets occur in the same areole. Vein ends: bulbous.

Pollen tetrads (11F-G): Pollen grains occur in tetrahedral tetrads, 3-zonocolporate. Tetrad size (D): 48 (46-51) µm diameter. Individual grain size (d) variable, 35(32-37) µm diameter. Individual grain possesses distinct slender transverse furrows. Exine tectate, ca.2.4 µm thick, surface faintly psilate. D/d=1.37. Colpi distinct, 3.9-6.2 µm long, 0.7-1.2 µm wide. Colpus margin distinct, acute to tapering towards ends. Septum thickness 1.7-3.4 µm.

3. *Vaccinium retusum* (Griff.) Hook. f. ex C. B. Clarke in Hook. f., Fl. Brit. India 3: 451. 1882; Panda & Sanjappa in Sanjappa & Sashtri, Fasc. Fl. India Ericaceae 25: 410. 2014. *Thibaudia retusa* Griff., Not. pl. asiat. 4: 300. 1854 and Icon. pl. asiat. 4: t. 509. 1854. **Type:** Bhutan, Griffith s.n. (Kew distrb. no. 3457, K, Cibachrome image!).

Vernacular names: Tomarke Dada (Nepalese of Tumling). (Plates 12-13)

Stout, drooping epiphytic as well as lithophytic shrub, 0.5-2 m high, often grown in moist rock crevices, rarely on rocky slopes. Stem rhizomatous, profusely branched, glabrous; branches greyish-white to blackish-brown, hispid-setulose; twigs blackish-brown to pinkish-red, hispid-setulose. Leaves chartaceo-coriaceous, lamina obovate, obovate-elliptic to elliptic, 15-30×6-14 mm, entire with slightly revolute at margin, narrowly cuneate at base, retuse at apex, glabrous or setulose along midvein, dark green above, light green beneath; petioles 1-3 mm long, setulose. Racemes pseudoterminal, perulate or eperulate, 10-20-flowered, puberulous. Flowers 10-12 mm long; pedicels light green, 3-5 mm long, glabrous; bract 1, basal, caducous, pinkish-white, ovate to ovate-elliptic, 7-11 mm long, glabrous; bracteoles 2, opposite, subbasal to middle on pedicel, light pink to white, elliptic to ovate-elliptic, c. 5×3 mm, glabrous. Calyx lobes light pink, broadly ovate, minute, glabrous. Corolla ovoid-urceolate, pink, c. 5×3 mm long, glabrous outside, pilose inside. Stamens 10, c. 4 mm long; filaments pinkish, c. 1.5 mm long, slender, pilose, slightly dilated at base; anthers light yellow, oblong, c. 1 mm long, glabrous, each lobe with c. 1.5 mm long single tubule and 2 equal, minute spurs at anther lobe-tubule junction. Ovary globose, light green, c. 2×3 mm, glabrous. Style pinkish, c. 4 mm long, slender, slightly dilated at middle, densely dotted. Stigma capitate or truncate. Berry globose, blackish-purple, c. 4×4 mm with c. 3 mm long pedicel, glabrous. Seeds 20-30, blackish-brown, obconical, c. 1 mm long, scariosa.

Distribution: INDIA (E Himalaya: Sikkim, West Bengal and Arunachal Pradesh and NE India: Nagaland, Manipur); Nepal; Bhutan; China and Myanmar. DARJEELING: Senchal Forest (2308 m: 27°00'09.78"N & 88°15'46.52"E), Tinmile (2153 m: 27°00'38.59"N & 88°17'32.30"E), Tinmile-Mongpu road side hills (1861 m: 27°00'08.30"N & 88°18'36.43"E), Sonada (1908 m: 26°57'31.68"N & 88°16'07.50"E), Dow Hill (1913 m: 26°53'11.72"N & 88°17'29.34"E), Neora valley National Park (2114 m: 27°04'50.95"N & 88°40'08.87"E), Lava (2102 m: 27°05'14.82"N & 88°39'32.52"E), Chitrey-Lamedura road side hills (2380 m: 26°59'30.91"N & 88°06'40.66"E), Meghma (2864 m: 27°01'31.42"N & 88°04'59.54"E), Tonglu (3058 m: 27°02'06.20"N & 88°04'38.81"E), Singalila National Park (Gairibas: 2570 m: 27°02'54.24"N & 88°01'48.85"E), Kaia-kata (3003 m: 27°04'15.31"N & 88°01'04.97"E).

Flowering: March - May, January; **Fruiting:** June - October. **Habitat:** On old tree trunks, mostly on *Quercus incana* and *Rhododendron* spp., sometimes in moist humus-covered rocky slopes, rarely in rock crevices at altitudes ranging from 1900-3500 m.

Specimens examined in Darjeeling district: CAL: Tonglu, 2960 m, S. Kurz s.n., acc. no. 264512. DGC: Chitrey-Lamedura hill side road, 2380 m, 30.05.2014, S. Panda & P. Roy 39; Meghma, 2864 m, 12.06.2015, S. Panda 822; Tonglu, 3058 m, 27.05.2012, S. Panda 391; MAC: Kaia-kata, 3003 m, 18.05.2019, S. Panda & D. K. Som 145.

Ethnic uses: flowers and ripe fruits are used in preparation of delicious curries and jams by Nepalese Sikkim (S. PANDA 29930, 30005, 30023, CAL); fruits are eaten raw by Nepalese of Darjeeling (GAMBLE 1896); leaves are used as a substitute for tea and giving tea colour after boiling by the Nepalese of Pankabari (A. T. Guha 2, DD).

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

Leaf Stomata (Plate 13A-B): The study of Light Microscopic stomatal architecture (10X, 40X) includes number, form and arrangement of specialized epidermal cells associated with the stomatal guard cells. **Stomata type:** The investigated species shows only one type, amphiparacytic. Average dimension of stomata is 32.2×32.2 µm. Average dimension of guard cells: 21.3×3.4 µm. Epidermal cells are mostly polygonal and isodiametric, some are elongated to deltoid. The epidermal walls in surface view are straight. The epidermal walls in the adaxial surface are slightly arched. The maximum length of epidermal cell is 32.2 µm and breadth is 22.8 µm, while minimum length is 12.2 µm and breadth is 8.4 µm.

Leaf areoles (vein islets) (Plate 13C-D): Triangular, pentagonal to hexagonal in shape. Larger areole: 619×212 µm. Smaller areole: 115×75 µm. Areoles: 12 (average) per 1 mm². Vein endings: 62 (average) per 1 mm²; veinlets simple unbranched to branched (once). Branched and unbranched veinlets occur in the same areole. Vein ends: tapered to bulbous.

Pollen tetrads (11F-G): Pollen grains occur in tetrahedral tetrads, 3-zonocolporate. Tetrad size (D): 48 (43-54) µm diameter. Individual grain size (d) variable, 43 (41-45) µm diameter. Individual grain possesses distinct slender transverse furrows. Endocolpium la-longate, I-shaped. Exine tectate, ca. 2.2 µm thick, surface granulate (LM). D/d=1.11. Colpi distinct, 3.2-6.4 µm long, 0.7-1.2 µm wide. Colpus margin distinct, acute to tapering towards ends. Septum thickness 1.4-3.2 µm.

4. *Vaccinium nummularia* Hook. f. & Thomson ex C. B. Clarke in Hook. f., Fl. Brit. India 3: 451. 1882; Panda & Sanjappa in Sanjappa & Sastry, Fasc. Fl. India Ericaceae 25: 404. 2014. **Type:** Bhutan, Griffith s.n. (Kew distrb. no. 3460, CAL; K, Cibachrome image!). (Plates 14-15)

Vernacular names: Tomarke Didi (Nepalese of Tumling).

Stout, drooping dwarf shrub, 0.1-1 m high, often epiphytic, sometimes drooping from rock crevices (Tonglu population, S. Panda 179, MAC). Stems rhizomatous, profusely branched, glabrous; branches and twigs densely blackish-brown hirsute. Leaves coriaceous, lamina oblong-elliptic, oblong to ovate, 10-24×5-13 mm, serrate, serrulate to serrulate-ciliate with slightly revolute at margin, rounded to broadly cuneate at base, retuse at apex, dark green, glabrous above, light green, glabrous beneath; petioles 1-2 mm long, puberulous beneath. **Racemes short, axillary or pseudoterminal; 4-10-flowered**, puberulous. Flowers 10-12 mm long; pedicels light green, 4-5 mm long, glabrous; bract 1, basal, light green to greyish-white with pinkish stripes, elliptic-orbicular to broadly elliptic, 4-6×2-4 mm, glabrous outside, puberulous inside; bracteoles 2, opposite, basal to middle on pedicel, greyish-white with pinkish stripes, ovate to elliptic, minute to 2×1 mm, glabrous. Calyx lobes light green with pinkish stripes, ovate to broadly ovate, 1×1.5 mm, glabrous. Corolla ovoid-urceolate to somewhat tubulo-urceolate, light pink, 5-6 mm long, 3-4 mm diameter, glabrous outside, pilose inside. Stamens 10, 3.5-4.5 mm

long; filaments pinkish-white, c. 1.5 mm long, slender, pilose, slightly dilated at base; anther lobes yellowish, oblong, c. 1 mm long, glabrous, each lobe with 1-1.5 mm long single tubule with 2 equal, minute spurs at anther lobe-tubule junction. Ovary globose, light green, c. 1.5 mm long, 2-3 mm diam., glabrous. Style light green, c. 5 mm long, slender, glabrous or pilose. Stigma capitate or truncate. Berries globose, light green (immature) to blackish-brown (mature), 4-6 mm long, 3-8 mm diameter with c. 6 mm long pedicels, glabrous. Seeds 20-30, blackish-brown, ovoid to obconical, minute, scariosse.

Distribution: INDIA (E Himalaya: Sikkim, West Bengal and Arunachal Pradesh and NE India: Meghalaya, Nagaland and Manipur and Mizoram); Nepal; Bhutan; China and Myanmar. DARJEELING: Senchal Forest (2308 m: 27°00'09.78"N & 88°15'46.52"E), Meghma (2864 m: 27°01'31.42"N & 88°04'59.54"E), Tonglu (3058 m: 27°02'06.20"N & 88°04'38.81"E), Singalila National Park (Kaiakata: 3003 m: 27°04'15.31"N & 88°01'04.97"E; Kalipokhri: 3007 m: 27°04'44.49"N & 88°01'01.09"E; Sandakphu: 3462 m: 27°06'09.64"N & 88°00'14.93"E Gorkhey: 2273 m: 27°11'14.70"N & 88°04'20.87"E)

Flowering: April-May. **Fruiting:** July-September.

Habitat: Epiphyte on moss-covered old tree trunks, mostly on *Quercus* and *Rhododendron* spp., often drooping from moist humus-covered rocky slopes in association with *Gaultheria trichophylla*, *Pieris formosa* and *Vaccinium retusum* at altitudes ranging from 2200-3500 m.

Specimens examined in Darjeeling district: CAL: Tonglu, July, 1881, 3058 m, *J. S. Gamble* 9448. DGC: Tonglu, 3058 m, 27.05.2012, *S. Panda* 393; Kaiakata-Kalipokhri Road side hill, 3003 m, 18.05.2012, *S. Panda* 412; Gorkhey, 2273 m, 17.05.2013, *S. Panda* 09; MAC: Sandakphu, 3462 m, 17.05.2019, *S. Panda & D. K. Som* 167.

Ethnic uses: the wood is used for making cooking spoons by the Nepalese of Tumling. They use the ripe fruits to prepare good quality tarts and jams.

IUCN Status: NE as the species is not assessed yet as per the IUCN Red List of Threatened Species, but if IUCN criteria (version 14, 2019) applied to Darjeeling populations, it would qualify as **Vulnerable (VU)** based on Criteria A1(c), B2(c), C2(b) and D1.

Leaf-stomata (Plate 15A-B): The study of Light Microscopic stomatal architecture (10X, 40X) includes number, form and arrangement of specialized epidermal cells associated with the stomatal guard cells. **Stomata type:** The investigated species shows only one type, amphiparacytic. Average dimension of stomata is 39.8×39.2 µm. Average dimension of guard cells: 29.3×5.4 µm. Epidermal cells are mostly polygonal and isodiametric, some are deltoid. The epidermal walls in surface view are slightly straight. The epidermal walls in the adaxial surface are slightly arched. The maximum length of epidermal cell is 30.2 µm and breadth is 21.3 µm, while minimum length is 18.2 µm and breadth is 11.4 µm.

Leaf areoles (vein islets) (Plate 15C-D): Pentagonal, hexagonal, triangular to polygonal in shape. Larger areole: 419×215 µm. Smaller areole: 213×178 µm. Areoles: 16 (average) per 1 mm². Vein endings: 68 (average) per 1 mm²; veinlets simple unbranched to branched (once). Branched and unbranched veinlets occur in the same areole. Vein ends: mostly tapered to rarely bulbous.

Pollen tetrads (Plate 15E-F): Pollen grains occur in tetrahedral tetrads, 3-zonocolporate. Tetrad size (D): 53.5 (48-58) µm diameter. Individual grain size (d) variable, 49 (44-54) µm diameter. Individual grain possesses distinct slender transverse furrows. Endocolpium obscure. Exine tectate, ca. 2.8 µm thick, surface faintly granulate (LM). D/d=1.09. Colpi distinct, 3.4-7.2 µm long, 0.9-1.2 µm wide. Colpus margin distinct, acute to tapering towards ends. Septum thickness 1.8-2.8 µm.

4. Discussion

The diversity of the genus *Agapetes* G. Don ex D. Don and *Vaccinium* L. in Darjeeling Himalaya based on extensive field survey, herbarium consultations, detailed local distribution, flowering phenology, IUCN status, ethnic uses as well as leaf anatomical and pollen morphological investigations especially for the genus *Vaccinium* L., have not been previously studied, not only in Darjeeling, but also in an Indian context. This work also highlights different populations including the localities for each taxon in Darjeeling Himalaya with a note on very scanty population like *Agapetes smithiana* Sleumer which survives in a single population near Chitrey-Lamedura Road side under Lower Tonglu area. The author has informed the Forest Department, for better conservation *in situ* and put a Name Board (Plate 3B) to raise awareness of its conservation. This work also reported several first hand new and noteworthy ITKs based on oral interviews with elderly Nepalese people, mostly dealing with ethnomedicinal uses of plants, which may be subjects of herbal medicine in the global market if proper laboratory based research can be carried out. This work also provides brief field-based identification key (both vegetative and floral as bold-italic in the description part) including a species key for the purpose of easy identification in the field.

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I am thankful to Herbarium-In-Charges of CAL, DD, BSHC & Lloyd Botanical Garden Herbaria for their permission to consult herbarium specimens, to Dr. P. Lama, Officer-In-Charge of Darjeeling Govt College for his all types of cooperation and permission to carry out the work. I am also grateful to Dr. Partha Roy, Head Department of Botany and Dr. Subhasis Dutta, Principal of Maulana Azad College, Kolkata for their kind permission and providing necessary facilities during the course of the work.

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Plate 1. *Agapetes serpens* (Wight) Sleumer in Darjeeling Himalaya: A. Lamedura; B. Dhotrey; C. Jungle Basty; D. Tinnile-Mongpoo Road; E. Rangeroong valley; F. Chitrey.



Plate 2. *Agapetes serpens* var. *alba* Airy Shaw: A. Habit (Lamedura, S. Panda 82, DGC); B. Dissected floral parts with leafy twig.



Plate 3. *Agapetes smithiana* Sleumer (S. Panda 81, DGC): A. Habit with single plant; B. Leafy twig; C. Close up of flowering and fruiting twigs; D. Name board for conservation awareness in front of the plant.

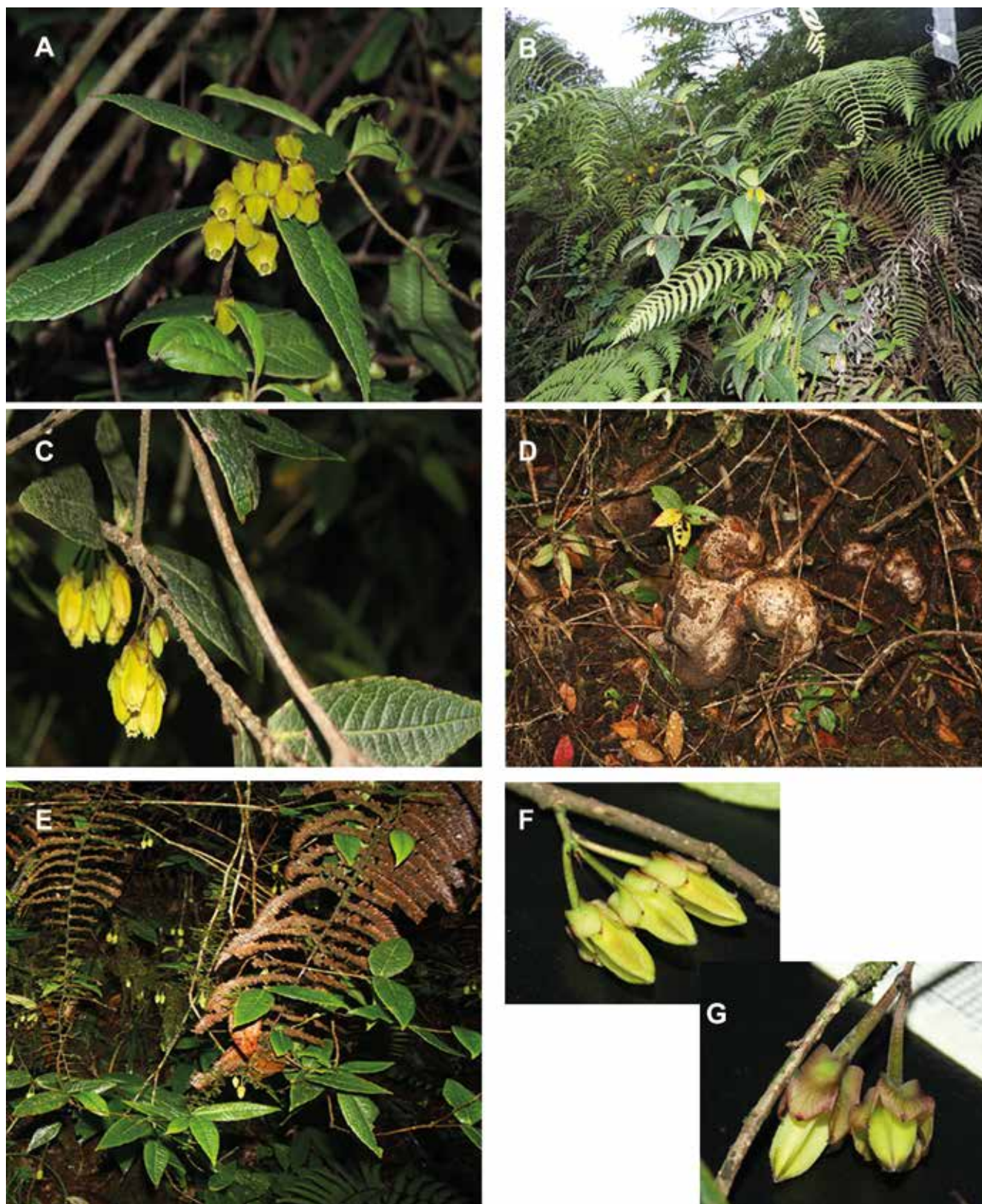


Plate 4. *Agapetes hookeri* (C. B. Clarke) Sleumer in Darjeeling Himalaya: A. Rambhi Forest; B. Tinnmile; C. Senchal Forest; D. Lignotuber at Rambhi Forest; E. Sukhia-Manebhanjang Road; F. Flowers close up at Chitrey; G. Flowers close up at Sonada.



Plate 5. *Agapetes sikkimensis* Airy Shaw (Image procured from K, K000729411).



Plate 6. *Agapetes saligna* Hook. f. & Thomson (Image procured from K, K000729391).



Plate 7. *Agapetes bhutanica* (S. Panda 172, MAC, Sevoke Rd): A. Flowering twig; B. Close up of corollas and abaxial leaf; C. Dissected floral parts; D. Habit.

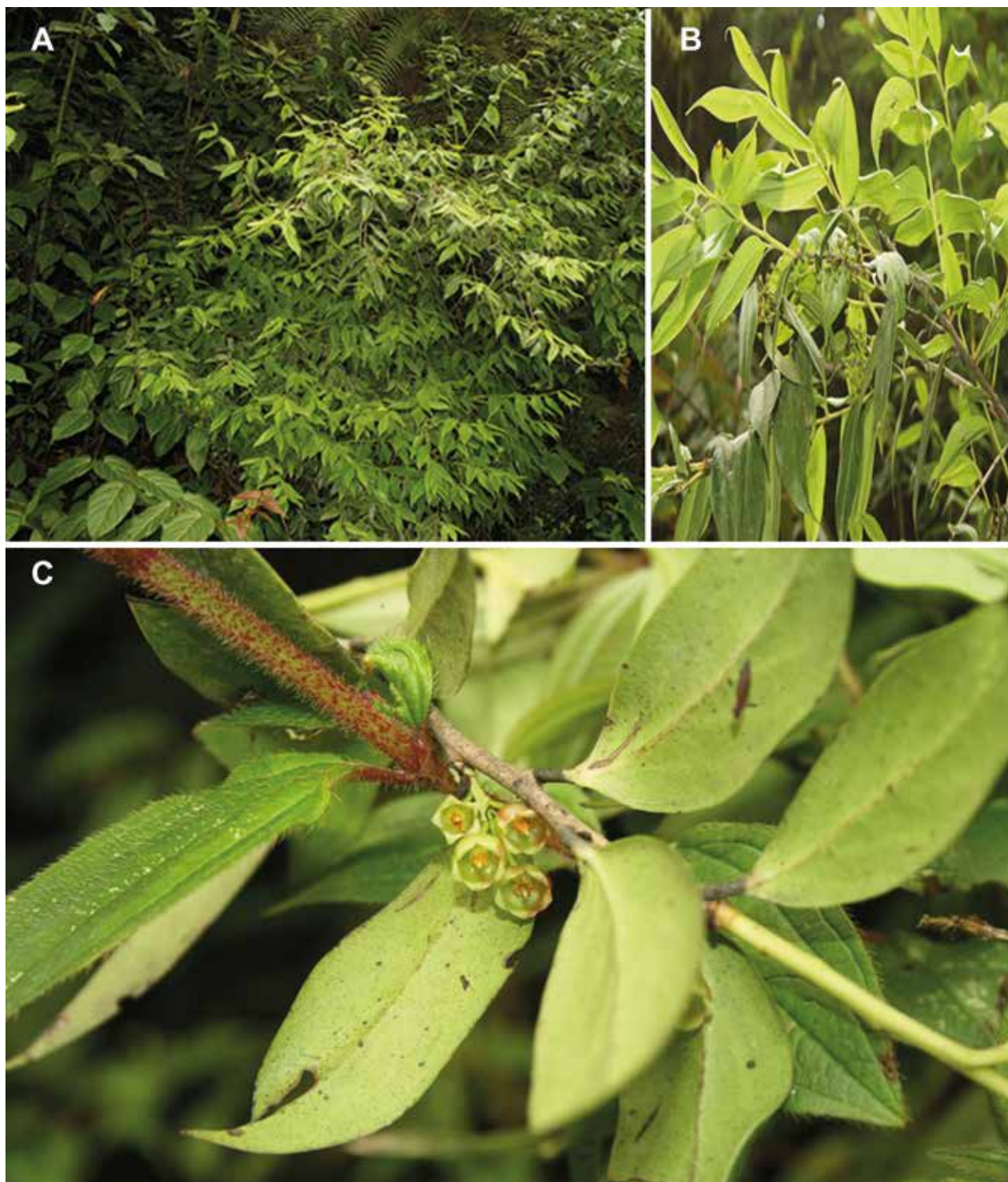


Plate 8. *Vaccinium dunalianum* Wight (Sukhia-Mane Bhanjang Population, June 2014): A. Habit; B. Close up of branches; C. Flowering twig close up.

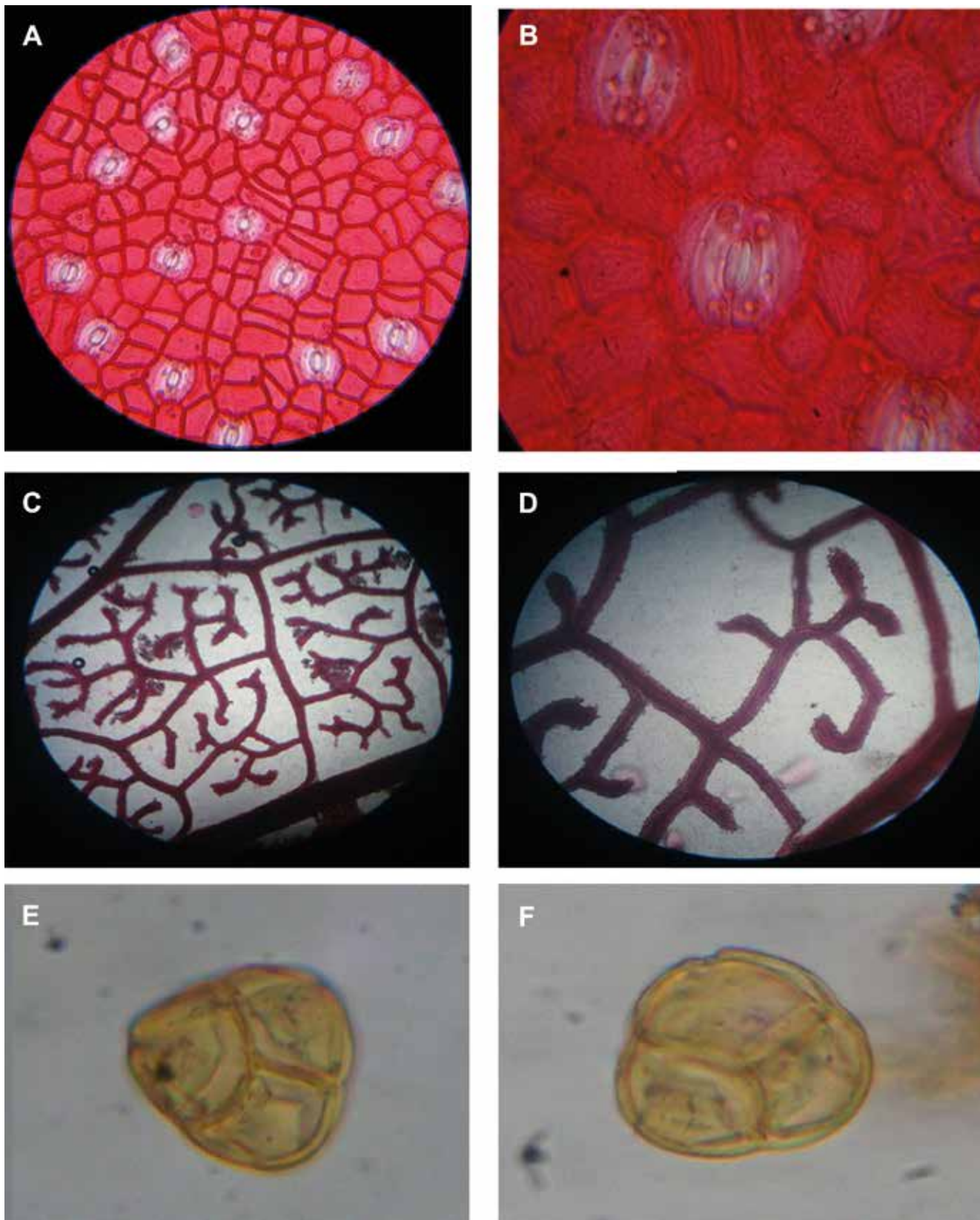


Plate 9. *Vaccinium dunalianum* Wight (S. Panda 321, DGC): A-B. Leaf stomata (10X, 40X); C-D. Leaf vein islets (5x, 10X); E-F. Pollen tetrads (40X).



Plate 10. *Vaccinium vacciniaceum* (Roxb.) Sleumer in Darjeeling Himalaya: A. Manebhanjang; B. Senchal Forest; C. Tinmile.

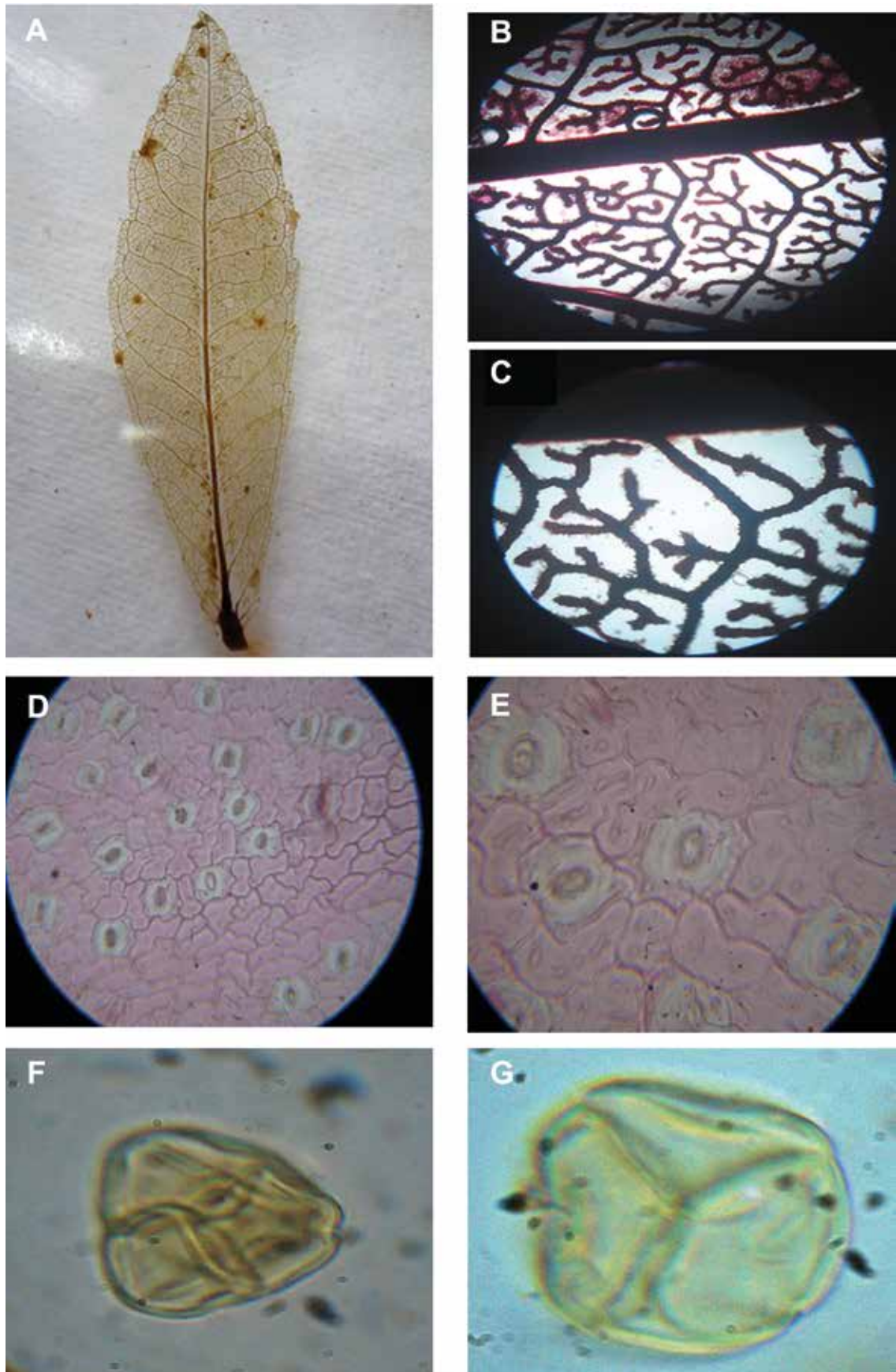


Plate 11. *Vaccinium vacciniaceum* (Roxb.) Sleumer (S. Panda 112, MAC): A-C. Leaf vein islets (5X, 5X, 10X); D-E. Leaf stomata (10X, 40X); F-G. Pollen tetrads (40X, 100X).



Plate 12. *Vaccinium retusum* (Griff.) C.B. Clarke in Darjeeling Himalaya: A. Lamedura; B. Meghma; C. Senchal Forest; D. Tonglu; E. Dhotrey.

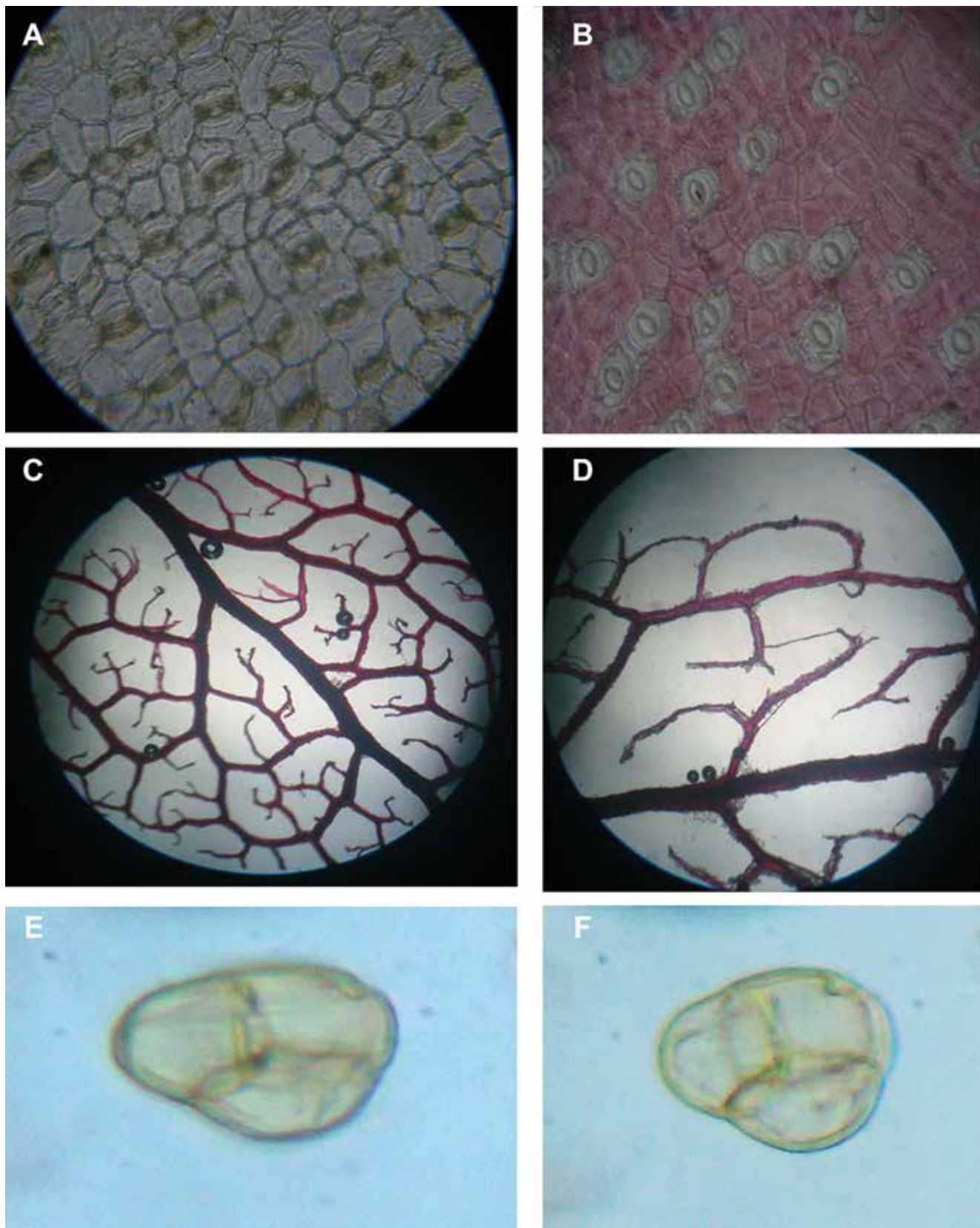


Plate 13. *Vaccinium retusum* (Griff.) C. B. Clarke (S. Panda 29930, CAL): A-B. Leaf stomata (10X, 40X); C-D. Leaf vein islets (5X, 10X); E-F. Pollen tetrads (40X).



Plate 14. *Vaccinium nummularia* C.B.Clarke in Darjeeling Himalaya: A-B. Tonglu; C. Kalapokhri; D. Senchal Forest; E. Tonglu-Dhotrey Road.

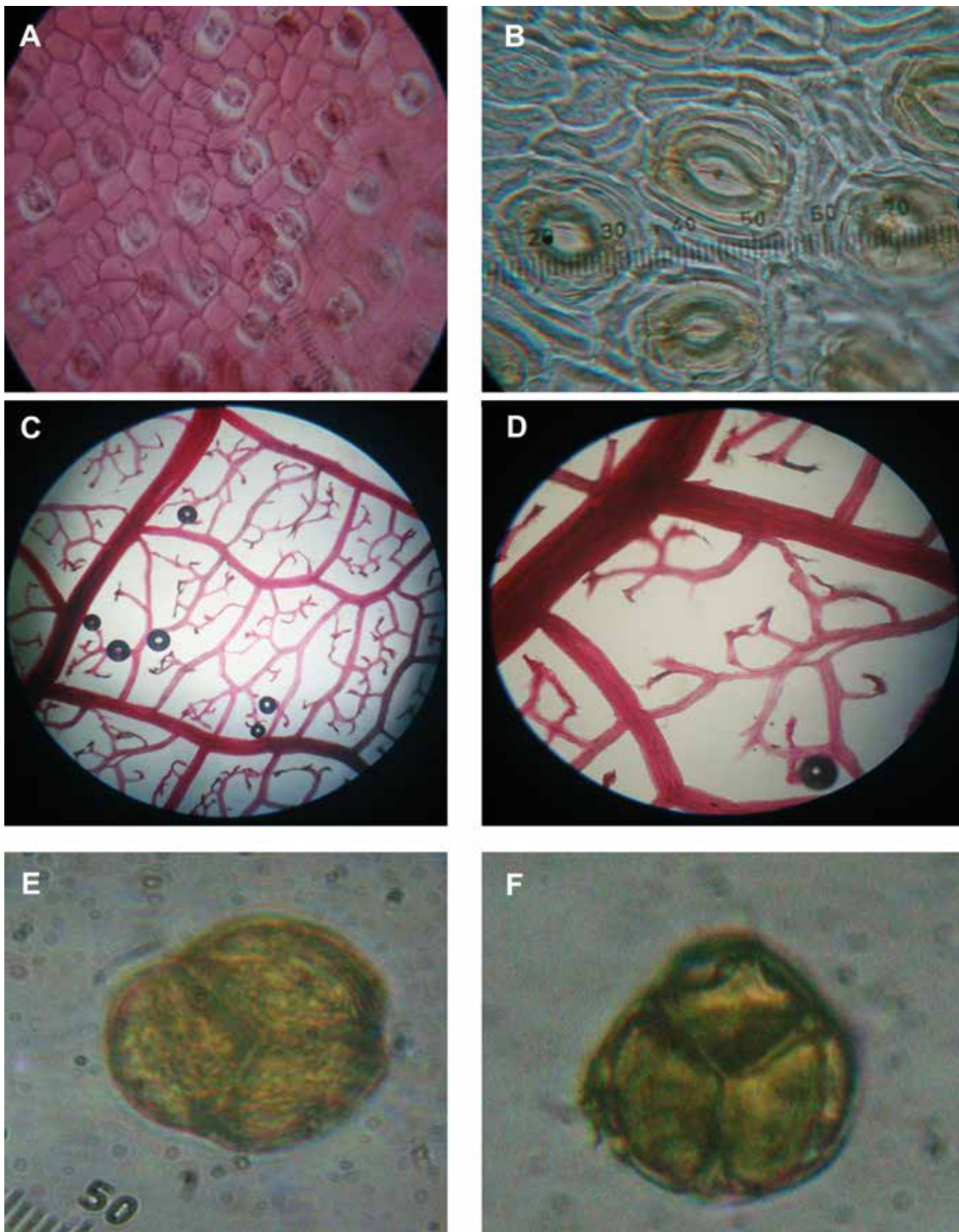


Plate 15. *Vaccinium nummularia* C.B.Clarke (S. Panda 344, DGC): A-B. Leaf stomata (10X, 40X); C-D. Leaf vein islets (5X, 10X); E-F. Pollen tetrads (100X).

