

**A study on the vegetative and flowering phenology including insect visitors of *Rhododendron arboreum* Sm. (Ericaceae Juss.) in Darjeeling Himalaya (India)-Phase-I**

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**Abstract**

During field studies at different places of Darjeeling Himalaya including Singalila National Park since May 2019 till February 2021 under State Government-funded Major Research Project, an attempt was made to assess the diversity of vegetative phenology and insect visitors reflecting flowering phenology of *Rhododendron arboreum* Sm.

**D**uring field studies at different places of Darjeeling Himalaya including Singalila National Park since May 2019 till February 2021 under DST & BT-funded major Research Project, an attempt was made to assess the diversity of vegetative phenology and insect visitors reflecting flowering phenology of *Rhododendron arboreum* Sm. in and around Singalila National Park as well as in other localities of Darjeeling hills. Flowering phenological data include inflorescence nature, number of flowers per rachis, colour change observation in all flowers, bracts/bracteoles-nature & number, indumentums/scales, presence

of any mucilage like substances/not, flowering time, flower-buds to flower formation duration, flower colour and colour change, odour if any, floral parts in detail, calyx-nature, colour, union, indumentums etc., corolla-nature, indumentums, colour, inside colour markings for pollinator path etc., stamens-nature, number, size, colour, anther lobes nature etc., bracts/bracteoles—nature, number, colour; fruiting (duration, colour, maturity etc, persistent/not), seeds, insect flower visitors and pollination time.

Besides flowering phenology, variation in different vegetative phenological features

for a particular locality are also studied along with leaf and bark associates and their specificity to this species. Vegetative phenological data include nature of habit, indumentums/scales if any, nature of axillary and terminal buds, leaf phyllotaxy, leaf-colour (both surface), leaf-nature, indumentums/scales types, size-range, petiole ranges, leaf galls/protuberances, number of individual plants per locality.

For insect visitor study, a range of different sampling methods have been employed with special reference to net sweeping, aspiration sampling and pan trap sampling. Each of sampling has its own effectiveness based on time, location and accessibility to resource of flowering plants. In net sampling, the number and type of visiting insects were recorded from 08:00 to 16:00 h on sunny days during the flowering season at altitudes ranging from 2500 m – 3636 m at different places of Darjeeling hills. Vegetation of *R. arboreum* flowering plants was selected for pan trap sampling at BK Bhanjang, 2 km down Sandakphu. A combination of red, yellow and blue pans was set from 10.00 to 10.00 h. The vast array of insects belonging to orders Hymenoptera, Thysanoptera, Coleoptera and Diptera is the indicative of flowering phenology of *Rhododendron arboreum* Sm. in Singalila National Park of Darjeeling Himalaya. Out of these orders, Diptera and Coleoptera were considered as the most diversified groups. The order Diptera is represented by two sub-orders Nematocera and Brachycera. Out of these two groups, Nematocera was observed to be more diversified in number and forms. Among the Coleopteran families notable flower visitors are Coccinellidae, Elateridae, Scarabeidae, Nitidulidae, Dermestidae, Phalacridae and Tipulidae. Adaptive modifi-

cations of these minute sized beetles have also been noted to find their suitability in the extraction of nectar from flowers of *R. arboretum* so far studied. Very interestingly, a few Collembolan hexapods have been found from the pan trap sample of *Collembola* having unknown association with *Rhododendron arboreum*.

Probably J. D. Hooker<sup>11</sup> was first to explore the present area extensively in April-August, 1848 during his voyage to the Himalayas and he published “*The Rhododendron of Sikkim Himalayas*” in 1849, in which Darjeeling-Kalimpong areas was included under Sikkim. Since Hooker, several other workers like C. B. Clarke<sup>5</sup>, Hara<sup>10</sup>, Biswas<sup>2</sup>, Mukherjee<sup>14</sup>, Pradhan & Lachungpa<sup>16</sup>, Long<sup>13</sup>, Das<sup>6,7</sup>, Chhetri *et al.*<sup>4</sup>, Bhattacharyya & Sanjappa<sup>1</sup>, Rai *et al.*<sup>18</sup>, Ghosh & Mallick<sup>9</sup>, Panda & Kirtinia<sup>15</sup> surveyed the area and documented floristic elements in various ways, but very little or no investigations regarding vegetative and floral phenology and flower visitors were made.

**For Phenological Studies:** Relevant Taxonomic references and herbarium specimens consultation were done in CAL (Central National Herbarium), BSIS (Industrial Section Indian Museum, Kolkata), Lloyd Botanical Garden Herbarium, Darjeeling for preliminary information and species identification purpose. Field visits are carried out at the end of every month for the same taxon at different areas of Darjeeling Himalayas. Phenological data include nature of **Stem**-bark, stem-bark-associated plants like mosses, leafy liverworts etc., branch-stem nature, indumentums/scales if any, **leaves**-colour (both surface), indumen-

tums/scales types, size-range, then their leaf nature, leaf-associated bryophytes *etc.*, **inflorescence** nature, number of flowers per rachis, colour change observation in all flowers, bracts/bracteoles-nature & number, indumentums/scales, presence of any mucilage like substances/not, **flowering** (time of beginning, peak & end—duration), flower-buds to flower formation duration, flower colour and colour change, odour if any, flowering time change if any (early or late) if unusually flower in other season, unusual flower nature in detail, floral parts in detail, **calyx**-nature, colour, union, indumentums *etc.*, **corolla**-nature, indumentums, colour, inside colour markings for pollinator path *etc.*, **stamens**-nature, number, size, colour, anther lobes nature, colour, indumentums *etc.*, **flower-nectar in detail**; **Bracts/bracteoles**—nature, number, colour; fruiting (duration, colour, maturity *etc.*, persistent/not), maturity of seeds after how many days of fruit formation, fruit is formed/not, nature of seeds, time of inflorescence emergence (from main or branch shoot), flower visitors (only type viz., insect/birds/butterfly/moth *etc.*) and pollination time. Field data are written on specially prepared Field Note Book along with GPS data for each taxon available at different localities/single locality. Live photography were done for different populations using CANON 1500D DSLR Camera along with its Micro lens. Each and every parts were also studied under Dissecting Binocular Microscope for detailed study purpose in the Laboratory of Maulana Azad College, Kolkata.

Descriptive terminology for Phenological-morphology followed Lawrence<sup>12</sup>, Featherly<sup>8</sup>, Stearn<sup>19</sup>, Radford<sup>17</sup> and Veldkamp in Vogel<sup>20</sup> and Chamberlain *et al.*<sup>3</sup>. Botanical

identity will be confirmed with consulting herbarium specimens in Central National Herbarium (CAL), Online Type images (Kew Herbarium) and relevant Taxonomic References. Important voucher specimens are deposited in the laboratory of Angiosperm Taxonomy, Botany Deptt., Maulana Azad College, Kolkata, also one sample specimen will be deposited in CAL.

***Flower visitors:*** As variations in the flowering phenology of *Rhododendron* spp. are greatly reflected by the diversity of insect pollinators, and major Insects (usually belong to orders Hymenoptera, Diptera and Lepidoptera) visiting the flowers also showing temporal variation in the flowering season, two commonly used sampling methods are employed for collecting such pollinators---**pan traps** and **net sweeping** which are considered to be effective at capturing the most species and highest abundance of pollinators.

***Net sweeping:*** Flower-visiting invertebrates were to be sampled along each 100 m 65 m belt transect. Four collectors were deployed among the eight transects at each site: two at each location. Collectors were sampled flower-visitors using nets from all plant species along transects for two hours and fulfilled these conditions: concurrent sampling of crest and swale between collectors. Each transect would be sampled for 30 minutes by each collector. These measures would help to negate any effect of collector's bias. Flower-visitors were then be caught using nets and plastic containers, and were transferred into 5 ml vials for transportation. Net sampling at each site were conducted for three consecutive days in morning and afternoon sessions, the timing of which might be varied to best match

the activity patterns of invertebrates. To increase the representation at the transect and above levels, and to minimise any potential effects of weather on captures, sampling were performed during fine weather, and pooled over the three day period. Sites were sampled in random order for each survey.

**Pan traps:** Pan Traps were deployed along each 100 m transect at B.K. Bhanjang from 10.00 am to 10.00 am (24 hours). Pans are made from polyethylene plastic bowls (400 ml, 110 mm diameter, 70 mm high) painted in

either UV fluorescent yellow, blue or white paint. These colours are equally effective for capturing of a broad range of invertebrates. Six pans (two of each colour) were to be placed along each transect, 15 m apart, in alternating colours. In each pan we placed 100 ml of detergent mixture (5 ml of non-odorous detergent in 1.5 litre water). Pans were checked and cleared of captures after 24 hours at 10.00 am of the next day. Specimens were stored in 70% ethanol for microscopic study.

Table-1. Collection no, locality, time, altitude, habit-habitat of *R. arboreum* Sm.  
in Darjeeling Himalaya

Coll No.	Place of Collection	Month of Collection	Altitude (m)	Habit	Habitat
49	T.N. Road, Alubari	July	2257	Tree	Loose Rocky soil
50	T.N. Road, Alubari	July	2257	Tree	Loose Rocky soil
52	Jungle Busty	July	2045	Tree	Rocky soil
54	Jungle Busty	July	2063	Tree	Near Jhora
55	Jungle Busty	July	2063	Tree	Loose Rocky soil
60	Tumling	July	2937	Tree	Rocky soil
65	Tumling	July	2993	Tree	Loose Rocky soil
70	Bhutta Kheti, Sonada	July	1814	Tree	Loose Rocky soil
71	Darjeeling Mall Road	July	1898	Tree	Rocky soil
77	Rambhi Busty	August	2205	Tree	Near Jhora
89	Betw Kayakatta & Kalpokhari	September	2897	Tree	Rocky soil
95	1km above BKB	September	3190	Tree	Hill slopes
96	1.1 km above Gairibas to Sandakphu	September	2968	Tree	Hill slopes
100	Sandakphu-Gurudum road	September	3361	Tree	Rocky soil
84	1km above Gairibas to Sandakphu	September	2608	Tree	Loose Rocky soil
93	Between Kalpokhari and BKB	September	3065	Tree	Loose Rocky soil

**Field Images Of Vegetative, Flowering & Fruiting Phenology Of *Rhododendron Arboreum* In Darjeeling Himalaya:-**



Fig. 1. (Sukhia Simana)



Fig. 2. (Kalipokhri road)



Fig. 3. (Darjeeling Town)



Fig. 4. (Lebong)



Fig. 5. (Gairibas)



Fig. 6. (Gurdung: immature fruiting)



Fig. 7. (Meghma)



Fig. 8. (Tonglu)

Figs.1-8. Flowering phenology observation in *R. arboreum* subsp. *arboreum* in Darjeeling in May, 2019.



Fig. 9 (near Sandakphu)



Fig. 10 (near Sandakphu)



Fig. 11 (Sandakphu-Phalut Road)

Figs.9-11: Flowering phenology observation in May, 2019





Fig.12      Fig. 13      Fig. 14      Fig. 15  
Figs.12-15: Fruiting phenology & Lichen-association with stem observed along BK Bhanjyang-Sandakphu Road in Sept. 2019.



Fig. 16      Figs.17-18      Figs.19-20  
Fig.16: Lichen-association observation at Kalipokhri-BK Bhanjyang Road in Sept. 2019. Figs.17-18: Leaf abaxial surface showing golden yellowish scales observed at BK Bhanjyang in Sept. 2019. Figs.19-20: Leaf abaxial surface showing brownish scales observed at Sandakphu-Gurdung Road in Sept. 2019.

Figs.9-20. *R. arboreum* subsp. *cinnamomeum* var. *cinnamomeum* in Darjeeling Himalaya in May-September, 2019 (Kalipokhri-BK Bhanjang-Sandakphu-Gurdung).

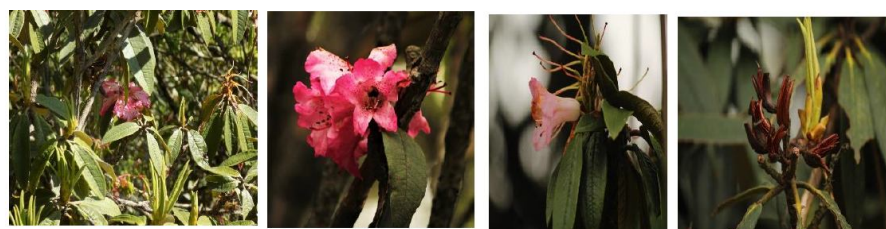


Fig. 21      Fig. 22      Fig. 23      Fig. 24  
Figs.21-23: Flowering phenology observation at Tonglu in May, 2019; Fig. 24. Fruiting phenology observation at Tonglu in Sept. 2019.

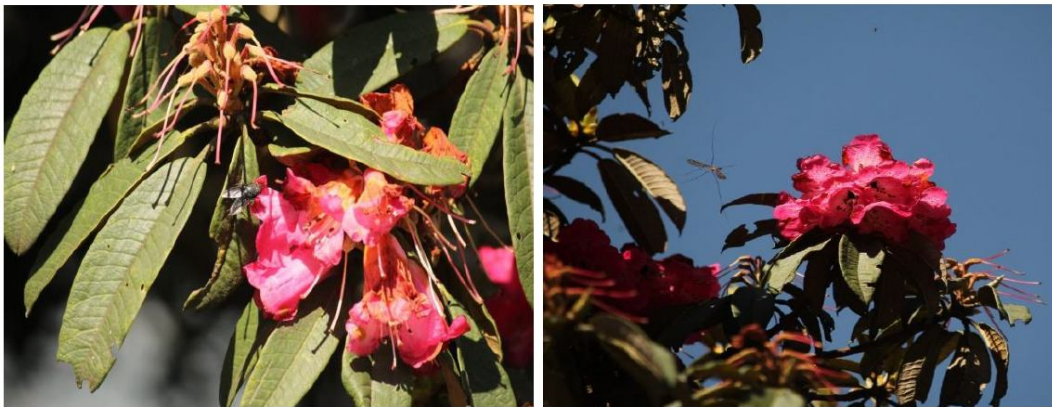


Fig. 25 (Tumling)      Fig.26 (BK Bhanjyang)      Fig.27 (BKB)      Fig.28 (BKB)  
Figs.25-28: Flowering phenology observation in May, 2019



**Fig.29**  
**Figs.29-33: Lichen-Bryophyte-Pteridophytic association with stem observed at Tumling in Sept.19**

Figs.21-33. *R. arboreum* subsp. *cinnamomeum* var. *roseum* in Darjeeling Himalaya in May-September, 2019 (Tonglu-Kalipokhri-BK Bhanjang).



**Figs. 34-35. Insect visitors observed at Kalipokhri in May 2019**



**Fig. 36.** Family: Tipulidae (Crane fly); **Fig. 37.** Family: Tipulidae; **Fig. 38.** Family: Coccinellidae

Figs. 34-38. Insect visitors observed in *R. arboreum* subsp. *cinnamomeum* var. *roseum* in and around Kalipokhri-B.K. Bhanjyang Road based on NET SWEEPING





Fig. 39. Insect visitors observed in *R. arboreum* subsp. *cinnamomeum* var. *cinnamomeum* in and around Kalipokhri-B.K. Bhanjyang Road based on PAN TRAP & NET SWEEPING



Fig. 40. Insect visitors observed in *R. arboreum* subsp. *arboreum* in and around Kalipokhri-B.K. Bhanjyang Road based on NET SWEEPING



Table 2. Height, girth & colour of stem, bark association & phyllotaxy of  
*R. arboreum* in Darjeeling Himalaya:-

Coll No.	Height (m)	Girth of Stem	Color of Stem	Bark association	Phyllotaxy
49	3m	42cm	Redish Brown	BR., PT., LI.	Sub-alternate
50	4.5m	36cm	Redish Brown	BR., LI.	Sub-alternate
52	6m	68cm	Redish Brown	BR., PT., LI.	Sub-alternate
54	3m	60cm	Brown	BR., PT., LI.	Sub-alternate
55	7.5m	140cm	Brown	BR., PT., LI.	Sub-alternate
60	3m	77cm	Redish Brown	BR., LI.	Sub-alternate
65	6m	103cm	Redish Brown	BR., PT., LI.	Sub-alternate
70	7m	120cm	Redish Brown	BR., PT., OR.	Sub-alternate
71	3.5m	64cm	Brown	BR., PT., OR.	Sub-alternate
77	2m	72cm	Redish Brown	LI.	Sub-alternate
89	2.5m	52cm	Redish Brown	LI.	Sub-alternate
95	4.5m	125cm	Redish Brown	BR., LI.	Sub-alternate
96	2.5m	32cm	Redish Brown	BR.	Sub-alternate
100	5.25m	97.5cm	Brown	LI.	Sub-alternate
84	4m	97cm	Light Brown	BR.	Sub-alternate
93	4.5m	115cm	Light Brown	BR., LI.	Sub-alternate

BR=Bryophyte; PT=Pteridophyte; LI=Lichen; OR=Orchid

Table 2. Localities like Table 1

In the first phase, present work embodies 19 populations of *R. arboreum* including its two subspecies viz., subsp. *arboreum* and subsp. *cinnamomeum* studied and documented from 19 different localities in Darjeeling Himalaya (vegetative phenological data were documented from 16 populations and flowering phenological data were documented from 3 other populations). 10 vegetative and 12 floral characters including

character-states were observed and documented from the said localities (Table 1 – 14). Following 14 tables show comparative vegetative, floral, fruiting and insect visitors diversity in 19 populations of *R. arboreum* Sm. Data were collected in respect to stem and leaf indumentum, leaf-size, shape, colour, venation, scales, petiole nature, stem-colour, bark, bud-scales and branches, axillary and terminal branching, leaf & bark-association etc.

Table 3. leaf apex, margin, surfaces, length & breadth of *R. arboreum* in Darjeeling

Lf apex	Lf margin	Lf surface ad	Lf surface ab	Lf length	Lf breadth
Mucronate	Entire	Glabrous	Dense brown scales	79-128mm	20-38mm
Mucronate	Entire	Glabrous	Silver scales	84-170mm	24-45mm
Acuminate	Entire	Glabrous	Silver brown scales	58-106mm	20-32mm
Acuminate	Entire	Glabrous	Silvery white hairs	85-140mm	20-41mm
Mucronate	Entire	Glabrous	Silvery white hairs	62-155mm	16-58mm
Mucronate	Entire-wavy	Glabrous	greenish-white scales	46-75mm	16-40mm
Acuminate	Entire-wavy)	Glabrous	Silver brown scales	64-136mm	17-47mm
Mucronate	Entire	Glabrous	Silvery White scales	118-154mm	28-39mm
Mucronate	Entire	Glabrous	Silvery White scales	34-110mm	11-27mm
Mucronate	Entire	Glabrous	Silvery white scales	72-100mm	15-30mm
Mucronate	Entire	Glabrous	orange-brown scales	58-128mm	17-38mm
Mucronate	Entire	Glabrous	Orange-brown scales	82-100mm	26-55mm
Acute	Entire	Glabrous	light brown scalers	86-111mm	18-28mm
Mucronate	Entire	Glabrous	Brownish scales	67-104mm	22-34mm
Acute	Entire	Glabrous	Light brown scales	42-104mm	14-31mm
Mucronate	Entire	Glabrous	Light brown scales	42-83mm	16-27mm

Lf=Leaf; ad=adaxial surface; ab=abaxial surface

Table 3. Coll no. &amp; Localities like Table 1

Table 4. Petiole length and indumentum of *R. arboreum* in Darjeeling

Coll No.	Adaxial petiole	Abaxial Petiole	Petiole length
49	Red, brown scales		10-20mm
50	Light green, glabrous	Light green to Yellow scales	10-18mm
52	Brown scales	Light green to Sparsely silver scales	7-19mm
54	Light green-whitish scales	Light green to sparsely brown scales	4-13mm
55	Light green-whitish scales	Green to slightly white scales	7-25mm
60	Greenish-brown, glabrous	brown-green to green-white scales	10-11mm
65	Yellowish green, glabrous	Light green to silver brown scales	10-18mm
70	Light green, glabrous	Green, Silver scales	5-7mm
71	Greenish-white scales	Green, Brown scalers	15-20mm
77	Green, glabrous	Silver-white dense scales	10-15mm
89	Light green to brown scales	Light green to brown scales	15-20mm
95	Green, glabrous	Light Green to brown scales	15-17mm
96	Green, brown scales	Green-Brown scales	18-20mm
100	Green, Brownish scales	orange-brown scales	16-23mm
84	Green, Reddish Brown scales	Greenish scales	16-20mm
93	Reddish brown scales	Light green to brown scales	17-23mm

Table 4. Localities like Table 1

Table 5. Altitudinal height-girth variation of stems of *Rhododendron arboreum* subsp. *arboreum* in Darjeeling Himalaya

Coll No.	Month	Altitude (m)	Habit	Habitat	Girth of St	Height of St	Height/Girth
49	July	1814	Tree	hilly slope	120cm	700cm	5.83
50	July	1898	Tree	moist open rocky soil	64cm	350cm	5.46
52	July	2045	Tree	shaded rocky soil	68cm	600cm	8.82
54	July	2063	Tree	near Jhora	60cm	300cm	5
55	July	2063	Tree	loose open rocky soil	140cm	750cm	5.35
60	August	2205	Tree	near Jhora	72cm	200cm	2.77
65	July	2257	Tree	loose open rocky soil	42cm	300cm	7.14
70	July	2257	Tree	loose wet rocky soil	36cm	450cm	12.5
71	Sept.	2608	Tree	loose wet rocky soil	97cm	400cm	4.12
77	Sept.	2897	Tree	open moist rocky soil	52cm	250cm	4.8
89	July	2937	Tree	open moist rocky soil	77cm	300cm	3.89
95	Sept.	2968	Tree	hilly slopes	32cm	250cm	7.81
96	July	2993	Tree	loose rocky soil	103cm	600cm	5.82
100	Sept.	3065	Tree	loose rocky soil	115cm	450cm	3.91
84	Sept.	3190	Tree	hilly slopes	125cm	450cm	3.6
93	Sept.	3361	Tree	loose wet rocky soil	97.5cm	525cm	5.38

Localities like Table 1.

#### FLOWERING PHENOLOGY

Table 6. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: Part A

Name of the species	Coll no.	Locality	Fl bract	No of fl/ infl
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	14	Kalapokhari	2-3: 16-18mm long	8-flowered
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	41	Sandakphu-BKB	1: 16-20mm long	12-14-flowered
<i>R. arboreum</i> subsp. <i>arboreum</i>	3	Sukhia Simana	6-7: 14-18mm long	12-flowered

Fl=flowers; infl=inflorescence

Table 7. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: B

Name of the species	corolla colour	corolla scent	corolla shape	corolla size
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	rose-purple red	Not-scented	tubulo-campanulate	38-46x35-38mm
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	Rose-red	Not-scented	tubulo-campanulate	32-40x28-34mm
<i>R. arboreum</i> subsp. <i>arboreum</i>	Blood red	Not-scented	tubulo-campanulate	45x50mm

Table 7. locality and coll no similar to Table 6

Table 8. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: Part C

Name of the species	corolla indumentum	calyx length	calyx indumentum	calyx color
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	Glabrous	1mm	glabrous	purple red
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	Smooth	1mm	glabrous	rose-red
<i>R. arboreum</i> subsp. <i>arboreum</i>	Smooth	1.5mm	apical hairy	pinkish-green

Table 8. Coll no. &amp; locality similar to Table 6

Table 9. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: Part D

Name of the species	No of Stamens	Length of Stamens	Length of Filaments	Filament Indumentum
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	10 (-8)	18-34mm	16-32mm long	Glabrous
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	10	10-32mm	7.5-29mm long	Glabrous
<i>R. arboreum</i> subsp. <i>arboreum</i>	8	26-37mm	25-36mm long	Glabrous

Table 9. Coll no. &amp; locality similar to Table 6

Table 10. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: Part E

Name of the species	colour of filament	anther length	anther colour	Anther indumentum
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	light purple	2mm long	Brown	Glabrous
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	white to light pink	2.5mm long	Dark brown	Glabrous
<i>R. arboreum</i> subsp. <i>arboreum</i>	white with basal pink	1mm long	Dark brown	Smooth

Table 10. Coll no. &amp; locality similar to Table 6

Table 11. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: Part F

Name of the species	pistil length	Ovary size	Ovary shape	Ovary colour	Ovary indumentum
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	42mm long	5-6x3mm	oblong	white	tomentose
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	36mm long	6x3mm	oblong	light green	tomentose
<i>R. arboreum</i> subsp. <i>arboreum</i>	42-43mm	7-8x3mm	oblong green	light	tomentose

Table 11. Coll no. &amp; locality similar to Table 6

Table 12. Flowering phenology of *Rhododendron arboreum* in Darjeeling Himalaya: Part G

Name of the species	Style length	Style colour	Stigma
<i>R. arboreum</i> subsp. <i>cinnamomeum</i>	32-34mm	purple red	dark purple
<i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i>	30mm	light green	dark red
<i>R. arboreum</i> subsp. <i>arboreum</i>	35mm	purple pink	purple

Table 12. Coll no. &amp; locality similar to Table 6



Table 13. Fruiting phenology of *R. arboreum* in Darjeeling Himalaya  
Fruiting phenology of *R. arboreum* subsp. *arboreum* in Darjeeling

Coll no.	Locality	Time	Fr colour (mature)	Fr colour (immature)	Fr indum	Fr length	Fr breadth
49	T.N. Road, Alubari	July	green	brown	yellow hairs	25mm	8mm
50	T.N. Road, Alubari	July	green	brown	white hairs	20mm	6mm
52	Jungle Busty	July	light green	brown	brown hairs	25mm	11mm
54	Jungle Busty	July	light green	brown	white hairs	28mm	5mm
55	Jungle Busty	July	light green	brown	white hairs	26mm	7mm
60	Tumling	July	not found	not found	not seen	N/F	N/F
65	Tumling	July	light green	brown	not seen	33mm	7mm
70	Bhutta Kheti, Sonada	July	green	brown	white hairs	10mm	3mm
71	Darjeeling Mall Road	July	green	dark brown	not seen	15mm	7mm
77	Rambhi Busty	Aug	N/F	N/F	not seen	N/F	N/F
Fruiting phenology of <i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>cinnamomeum</i> in Darjeeling							
89	Kayakatta to Kalpokhari	Sept.	green	brown	white hairs	7mm	7mm
95	BKB to Sandakphu	Sept.	red-green	brown	reddish hairs	7mm	7mm
96	Gairibas to Sandakphu	Sept.	green	brown	brown hairs	8mm	8mm
100	Sandakphu-Gurdum	Sept.	green	brown	white hairs	7mm	7mm
Fruiting phenology of <i>R. arboreum</i> subsp. <i>cinnamomeum</i> var. <i>roseum</i> in Darjeeling							
84	Gairibas to Sandakphu	Sept.	green	brown	red hairs	8mm	8mm
93	Kalapokhari to BKB	Sept.	not seen	not seen	not seen	not seen	not seen
Fr=fruit; indum=indumentum;							

Table 14. Insect Flower Visitors: Following Orders & Families observed in *R. arboreum* subsp. *arboreum*, subsp. *cinnamomeum* var. *cinnamomeum* and var. *roseum* in Kalipokhari-BK Bhanjyang Road based on PAN TRAP & NET SWEEPING.

Sl no.	Order	Family
1.	Hymenoptera	Apidae
2.	Coleoptera	Phalacridae
3.	Coleoptera	Coccinellidae
4.	Thysanoptera	Phlebotripidae
5.	Coleoptera	Scarabaeidae
6.	Coleoptera	Scarabaeidae
7.	Coleoptera	Scarabaeidae
8.	Diptera	Calliphoridae
9.	Hymenoptera	Apidae
10.	Coleoptera	Nitidulidae
11.	Diptera	Tipulidae
12.	Hymenoptera	Apidae
13.	Coleoptera	Elataridae
14.	Coleoptera	Nitidulidae
15.	Coleoptera	Elataridae
16.	Coleoptera	Dermestidae
17.	Coleoptera	Phalacridae

#Genus and Species level identification is under process in ZSI

Detailed vegetative and floral phenological data of *R. arboreum* Sm. based on 19 different local natural populations in Darjeeling Himalaya may help to understand range of variation as well as the raw materials for climate change study when these will compare with past data (if and when available). Documentation of insect flower visitors including specific pollinators of *R. arboreum* Sm. are urgently required for biodiversity as well as *Rhododendron* conservation, not only in Darjeeling but also throughout Indian Himalayas. This work will be a raw material cum model for future climate change study not only in *Rhododendron* but also for other plants in respect to biodiversity conservation.

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#### References :

1. Bhattacharyya, D. and M. Sanjappa, (2014). *Rhododendron arboreum* Sm. In: Sanjappa, M. and A.R.K. Sastry (Eds.), Fascicles of Flora of India: Fascicle 25 Ericaceae. pp. 87. *Botanical Survey of India, Kolkata*.
2. Biswas, K.P. (1966). Plants of Darjeeling and Sikkim Himalayas. pp. 540. Calcutta.
3. Chamberlain, D.F., R. Hyam, G. Argent, G. Fairweather, and K.S. Walter, (1996). The genus *Rhododendron*: Its classification and synonymy: 1-184. Royal Botanic Garden, Edinburgh.
4. Chhetri, D.R., D. Basnet, P.F. Chiu, S. Kalikotay, G. Chhetri, and S. Parajuli, (2005). *Current Sci.* 89(2): 264-268.
5. Clarke, C.B. (1882). Ericaceae. In Hooker, J.D., Flora of British India, vol. 3. pp. 465, Reeve & Co., London.
6. Das, A.P. (2004). Floristic Studies in Darjeeling Hills. *Bull. Bot. Surv. India* 43 (1-4): 1-18.
7. Das, A.P. (1995). Diversity of angiospermic flora of Darjeeling hills. In *Taxonomy and Biodiversity* (ed. A.K. Pandey), pp. 118-127. CBS Publishers and Distributors, New Delhi.
8. Featherly, H. I. (1954). *Taxonomic Terminology of the Higher Plants*. pp. 1-166. Ames, Iowa, USA.
9. Ghosh, D. K. and J. K. Mallick, (2014) *Rhododendron cinnabarinum* Hook. f. Flora of Darjeeling Himalaya and Foothills (Angiosperms). Bishen Singh Mahendra Pal Singh, Dehra Dun. pp. 199.
10. Hara, H., (1966). The Flora of Eastern Himalaya – Results of the Botanical Expedition to Eastern Himalaya organized by the University of Tokyo, 1960 – 1963. 1<sup>st</sup> Report. pp. 1-744. University of Tokyo Press, Japan.
11. Hooker, J.D. (1849). *J. Asiat. Soc. Bengal* 18: 419-449.
12. Lawrence, G.H.M. (1951). *Taxonomy of Vascular Plants*. pp. 1-823. Macmillan

- Co., New York, USA.
13. Long, D.G (1991). Ericaceae. In: Grierson, A.J.C., Long, D.G. (eds.), *Flora of Bhutan* 2(1): 372. Royal Botanic Garden, Edinburgh.
  14. Mukherjee, A. (1988). *Flowering Plants of Darjeeling*. Pp. 1-287. Atma Ram & Sons, Delhi.
  15. Panda, S. and I. Kirtania, (2016). Variation in *Rhododendron arboreum* Sm. complex (Ericaceae): Insights from exomorphology, leaf anatomy and pollen morphology. *Modern Phytomorphology* 9: 27-49.
  16. Pradhan, U.C. and S.T. Lachungpa (1990) *Sikkim Himalayan Rhododendrons*. Primulaceae Books, Kalimpong, Darjeeling, India. pp. 75.
  17. Radford, A.E. (1986). Ericaceae. *Fundamentals of Plant Systematics*. pp. 365-367. Harpers & Row, New York, USA.
  18. Rai, U., D. Lama, N. Thapa, and S. Rai, (2013) *Pleione* 7 (2): 434. 2013.
  19. Stearn, W.T. (1983). *Botanical Latin*. pp. 1-541. 3<sup>rd</sup> revised ed. David & Charles Inc., USA.
  20. Veldkamp, J.F. (1987). *Manual for the description of Flowering Plants*. In: Vogel, E. F., *Manual of Herbarium Taxonomy: Theory and Practice*: UNESCO Regional Office, Jakarta (Indonesia). pp. 20 – 64.