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Reproductive Phenology and Morphological Analysis of Indian *Dendrobium* Sw. (*Orchidaceae*) from the Northeast Region

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Abstract- The present paper deals with sixteen species of Indian *Dendrobium* Sw. from the Northeastern regions which are economically important from aesthetic value related industry. The detailed morphological characterization and the reproductive phenology are discussed. Vegetative characters reveal sizeable variations among the species which can be differentiated from one another. The height of the psuedobulb stem with nodes and internodes ranges from 15 cm to 130 cm, the maximum height was recorded in *D. moschatum*. The sessile lanceolate leaves with a maximum length were recorded in *D. moschatum*. The longest inflorescence was found in *D. clavatum*, interestingly in Dendrobium the longer the inflorescence the more the numbers of flower bearing. The flowers were exquisite and showy which exhibit different shapes and colours, the largest flower was recorded in *D. formosum*. Most of the species began to sprout new shoots during spring season. The low temperature, rainfall and humidity promote the flower bud initiation except in *D. nobile*, and *D. heterocarpum* favoured by moderate temperature and high humidity. The longevity of the flower ranges from 5 to 23 days with a maximum recorded in *D. formosum*. Post fertilization phenophase is the longest period exhibited by all the species under study, for instance seedpod initiation to maturity ranges from 56 to 120 days.

Index Terms- Dendrobium, Morphology, Phenology, Phenophase. Reproductive.

I. INTRODUCTION

The study of periodically occurring phenomena in plants in relation to the climate and changes of seasons is known as phenology. Leith (1970), Leith and Radford (1971) first discussed the concepts of phenological studies and its significance. The phenology study deals not only the vegetative and reproductive phase corresponding to the climate and seasonal changes of a particular area, but also determines the degree of reproductive synchrony with other plant species (Rathcke, 1988 a, b). Synchrony among species might be advantageous in which the presence of one species facilitates increase in pollinator visitation and enhanced in fruit/seed set in another species (Thomson, 1980, 1982; Rathcke and Lacey, 1985). Phenological study is important in plant management and combating afforestation, honey analysis, floral biology, estimation of reproductivity and regeneration (Mulik and Bhosale, 1989). The flowering phenology differs from species to species in accordance with the ecosystems they associates and this suggest that specific patterns of flowering phenology may be a characteristic of specific ecosystem types (Pojar, 1974; Heinrich, 1976). The floral initiation in orchids is determined by the genotypes and its interactions with the environmental conditions such as temperature, humidity, light, and photoperiod (Bose and Yadav, 1992).

Phenological studies reflect the daily occurrence of plants and animals in total response to environment. For plants, this includes both vegetative and reproductive such as bud formation, flowering, fruiting, and seed germination, along with vegetative phase like leaf flushing and shedding. Most phenological studies are based on observation of periodic phenomena occurring at a given location over a period of several years. The microclimatic study with reference to phenological research gains a tremendous attention because it represents the actual conditions that influence plant response. The factors governing phenology are both internal and external. The internal or the inherited traits are the outcome of the development of the species through the ages and determined the broad patterns of its phenological behaviour even when it grows in places with dissimilar climatic conditions. The external factors modify the internal factors. Among these factors may be listed rainfall, temperature, humidity, soil moisture at different depth, light intensity, and its duration, reserve food materials etc.

Generally three environmental factors which triggers the phenological progress of the plant have been identified – viz., photoperiod, temperature and moisture (Rathcke and Lacey, 1985). These three factors can be considered as responsible that breaks bud dormancy and initiates the developmental activity. Once set in motion this process advances as a function of temperature and day length, or a combination of the two. Since the phenological patterns varies for species to species with respect to different ecosystems, using the climatic and flowering data, determination of the flowering triggers and the developmental requirements for different species can be evaluated. The duration of different phenophases constitutes specific supply of available resources such as pollen, nectar, fruit and seeds. In plants, allocation of resources to reproduction may occur at the expenses of future vegetative growth (Allinson *et al*., 1989; Evenson, 1983; Sohn and Policansky, 1977; Law, 1979). The size of the plant body and not the age is an important determinant or an essential for the reproductive success rate (Werner, 1975; Gross, 1981).

The phenological study helps to understand the adaptative strategies of the plant species in a particular kind of ecosystems

and its management. Therefore, it is important to study the phenological patterns of different taxa for critical analysis of reproductive biology and its implications on scientific study.

The mode of reproduction and development of fruits in orchids was studied by few investigators (Reekie and Bazzaz, 1987a, b; Primack *et al*., 1994). The cost of flower and fruit production in *Tipularia discolor* (Orchidaceae) was studied by Allinson and Dennis (1989). Maheswari (1950), Wirth and Withner (1959), and Veyret (1974), carried out the works on structural aspects of reproduction in some orchids species, and reported that the development of orchid fruit is generally associated with long period so as to form a mature embryo sac after pollination. Taylor *et al*., (1992) studied on hormonal and structural aspects of fruit development in orchids. The deferential variation of fruit set depending upon the position of flowers on the inflorescence has been reported on several Orchids species. The flower positioned towards the bottom of the inflorescence record higher fruit set and decreases towards the top of the inflorescence (Cole and Firmage, 1984; Berry and Calvo, 1991).
The phenological study on Indian orchids are reported and found in strayed papers. Hegde (1980) attempted one hundred horticulturally important species from Arunachal Pradesh. A flowering calendar of several orchid species from the Northeast was presented by Kakati *et al*., (1992). A phenological study on Indian Paphiopedilum was conducted by Joy (1996) (*Vanda* by Limasenla et al., 2002; *Bulbophyllum* by John et al., 2001). However, there are no comprehensive phenological studies on Indian *Dendrobium*. Therefore, in the present study detailed phenological studies including vegetative characters of selected 16 species from Northeast India have been undertaken with emphasis on reproductive phenophases in a chronological manner.

II. Materials and Methods

Sixteen *Dendrobium* species were collected from the Northeast region for the detailed phenological observation viz. (i) *D. chrysanthum* (ii) *D. chrysotoxum* (iii) *D. crepidatum* (iv) *D. densiflorum* (v) *D. devonianum* (vi) *D. fimbriatum* (vii) *D. formosum* (viii) *D. heterocarpum* (ix) *D. moschatum* (x) *D. nobile* (xi) *D. ochreatum* (xii) *D. primulinum* (xiii) *D. transparens* (xiv) *D. wardianum and* (xv) *D. williamsonii.*

The plants were collected from their natural habitats and maintained in the experimental net house, Botany department N.E.H.U., Shillong. The plants were identified and marked by giving their field number and respective accession number for all the species selected for the phenology study. For the experimental studies, 10 healthy plants of each species were maintained in the net house. To ascertain the chronological events of each species the phenological observations were made for three years consecutively.

The following parameters are categorized into two parts: Vegetative and Phenological. Detailed studies of both vegetative and phenological observations were made from 10 healthy plants for each selected species.

A). Vegetative Morphological Characters:

1. Shoot height: The height of the shoot were measured from the basal to the tip of the stem and recorded in a standard unit.

2. Leaf**:** (a) Shape (b) Apex and (c) Size
The length and breadth of the leaves were measured from 10 healthy leaves for each species in cm. Length measurement were taken from the base to the longest point and the breadth measurement from the widest part of the leaves.

3. Inflorescence**:** (a) Type (b) Position and (c) Length
Length measurements of inflorescence were taken in cm. from the point of emergence from the nodes to the end point of the axis.

4. Floral Parts: (a) Flower number (b) Flower across (c) Size of petals (d) Size of the sepals (e) Size of the lip (f) Column length (g) Pollinia size (h) Pedicel length (i) Ovary length and (j) Bracts. The numbers of flowers were counted from 10 plants and average values are provided. Flower across were made between the two lateral sepals. The length of sepals, petals and the lip are measured from the basal margin straight to the tip. Breadth of sepals, petals and the lip were measured from the widest part in each case. Pollinia length measured from the longest axis from one end to the other end and the breadth from the widest portion. The lengths of bracts were taken from the basal to the tip and the breadth from the widest portion.

5. Seed-pod: Length measurements were taken from the point of attachment to the stalk to the tip of the capsule.

B). Phenological characters:

The phenological observations were made in two distinct phenophases viz., Pre-pollination and Post-pollination. The Pre-pollination observations were made from ten fully open flowers and ten full-grown plants for each species and data were recorded from the following parameters:

1. Pre-pollination: (a) Emergence of new shoot (Months) (b) Flowering seasons (Months) (c) Initiation of flower buds (Months) (d) Anthesis of flower (Days) (e) Longevity of Individual Flower (Days)

The emergence of new shoot, flowering seasons and initiation of flower buds are recorded in months. Anthesis and longevity of flowers are recorded on daily basis. Anthesis is the period recorded from the day of bud initiation to the opening of an individual flower. Longevity of an individual flower is the duration from the day of its opening till wilting of the flower.

2. Post-pollination: (a) Fruit initiation (days) (b) Maturation of seed-pod (days) (c) Browning of seedpod (Month) (d) Bursting of seed-pod (Month) (e) Seed-pod dehiscence (Months)

Fruit initiation is counted in days from the day of pollination till swollen of the ovary and observed on daily basis. The period from fruit initiation up to the fully-grown is taken as maturation and observed daily basis. The duration from maturation to changes in colour of the seedpod is taken as browning and observed on weekly basis. Browning, bursting and dehiscence of seedpod are recorded in months, in the successive year or within the same year.

Climate of the study sites:

The phenological observations was carried out in Meghalaya, Shillong plateau, the state capital situated in the Northeastern region of India with an altitude of about 1500m lies

between 26.5 N latitude and 91.90 E longitude. The climatic data for the study period were collected from the Siesmological department, Shillong. On the basis of the daily recordings the monthly average readings for the last three years were calculated. The data obtained from these three years, the mean for each corresponding month was calculated. The climatic data for temperature, humidity and rainfall for the past three consecutive years are presented in the tables (Tables 1, 2 and 3).

III. METEROLOGICAL DATA

Table: 1. Meteorological data of the first year

Sl. No	Month	Temperature in ^{0}C (Monthly average)		Humidity (Monthly average)		Rainfall (average)
		Minimum	Maximum	Morning	Evening	Mm
1	January	05.3	14.3	62	89	12.0
2	February	07.8	17.3	64	82	4.1
3	March	09.5	19.3	68	83	112.0
4	April	13.8	22.7	67	79	220.6
5	May	16.3	23.9	77	84	109.6
6	June	18.6	25.6	83	82	93.2
7	July	18.4	24.0	87	87	439.1
8	August	18.1	24.1	85	88	500.3
9	September	17.2	24.0	79	89	270.2
10	October	15.9	22.6	71	91	169.3
11	November	12.6	20.6	62	90	85.6
12	December	8.3	18.0	90	86	00.00

Table: 2. Meteorological data of the second year

Sl. No	Month	Temperature in ^{0}C		Humidity		Rainfall
		Minimum	Maximum	Morning	Evening	mm
1	January	06.6	21.7	49	85	07.8
2	February	10.6	16.4	43	71	0.0
3	March	12.3	21.2	40	55	04.4
4	April	15.9	22.9	61	67	13.8
5	May	15.9	25.2	83	82	522.1
6	June	17.9	22.9	83	85	225.8
7	July	18.0	24.2	88	88	717.5
8	August	17.6	23.5	89	88	353.2
9	September	16.9	23.7	84	92	130.3
10	October	15.2	23.3	79	90	318.0
11	November	109	21.7	66	91	9.7
12	December	07.9	19.0	56	87	2.1

Table: 3.Meterological data of the third year

Sl. No	Month	Temperature in ^{0}C		Humidity		Rainfall (average)
		Minimum	Maximum	Morning	Evening	mm
1	January	06.1	15.5	52	86	07.2
2	February	5.9	15.9	51	71	07.8
3	March	10.4	20.6	51	61	46.0
4	April	13.9	22.9	68	75	171.8
5	May	15.9	22.8	80	88	388.2
6	June	17.6	23.8	87	86	708.3
7	July	17.95	24.5	83	85	114.2
8	August	17.7	23.7	88	90	402.6
9	September	16.6	23.0	82	90	211.1
10	October	14.5	21.6	73	91	220.9
11	November	10.6	18.9	63	89	0.5
12	December	06.55	16.3	59	90	0.0

IV. RESULTS AND DISCUSSION

Table: 4. Important vegetative and floral characters:

Sl. No.	Name of the species	*Shoot*	*Leaf*		Inflorescence			Floral bract	Mentum
		Nature	Shape	Apex	Type	Position	Nature	Shape	Nature
1	**D. chrysantham**	Psuedo-bulbs	Lanceolate	Acute	Raceme	Nodal	Sub-erect	Oblong acute	Obtuse
2	***D. chrysotoxum***	Psuedo-bulbs	Obovate	Unequal-bilobed	Raceme	Base of leaf	Pendu-lous	Ovate acute	Rounded
3	***D. clavatum***	Psuedo-bulbs	Lanceolate	Acute	Raceme	Base of leaf	Pendu-lous	Ovate acute	Obtuse
4	***D. crepidatum***	Psuedo-bulbs	Linear lanceolate	Acute	Raceme	Nodal	Sub-erect	Ovate acute	Obtuse
5	***D. densiflorum***	Psuedo-bulbs	Broadly lanceolate	Acute	Raceme	Base of leaf	Pendu-lous	Oblan-ceolate deltoid	Subglo-bose
6	***D. devonianum***	Psuedo-bulbs	Linear lanceolate	Acumi-nate	Raceme	Nodal	Sub-erect	Ovate acute	Saccate
7	***D falconerii***	Psuedo-bulbs	Linear lanceolate	Obliqu-ely acute	Raceme	Nodal	Sub-erect	Ovate acute	Incurved
8	***D. fimbriatum***	Psuedo-bulbs	Lanceolate	Acumi-nate	Raceme	Base of leaf	Pend-ulous	Ovate acute	Obtuse
9	***D. formosum***	Psuedo-bulbs	Oblong lanceolate	Obliqu-ely lobes	Raceme	Termi-nal axillary	Sub-erect	Lance-olate	Conical
10	***D.heterocarpum***	Psuedo-bulbs	Oblong lanceolate	Obliqu-ely lobes	Raceme	Nodal	Sub-erect	Ovate acute	Obtuse
11	***D. moschatum***	Psuedo-	Lanceolate	Notch	Raceme	Nodal	Sub-erect	Ovate	Obtuse

		bulbs						acute	
12	***D. nobile***	Psuedo-bulbs	Oblong	Obliqu-ely notch	Raceme	Nodal	Sub-erect	Ovate acute	Short obtuse
13	***D. ochreatum***	Psuedo-bulbs	Lanceolate	Acute	Raceme	Oppo-site leaf	Sub-erect	Ovate acute	Obtuse
14	***D. primulinum***	Psuedo-bulbs	Oblong	Unequ-ally acute	Raceme	Nodal	Sub-erect	Ovate acute	Conical obtuse
15	***D. transparens***	Psuedo-bulbs	Lanceolate	Obliqu-ely acute	Raceme	Nodal	Sub-erect	Oblong lance-olate	Conical
16	***D. wardianum***	Psuedo-bulbs	Oblong lanceolate	Acute	Raceme	Nodal	Sub-erect	Ovate acute	Rounded

Table: 5. Measurement of Vegetative and Floral characters: (Sht., Lf., Infl., Fl. Brt., Fl./Infl.).

Sl. No.	**Name of the species**	**Shoot height cm.**	*Leaf Measurement* **cm.**			**Inflore-scence cm.**	*Floral bract* **cm.**			**Number of flower per inflorescence**
			L	*B*	*L/B*	*L*	*L*	*B*	*L/B*	
1	**D. chrysantham**	12-55	13.00	3.0	4.33	0.50	0.45	0.38	1.18	2-3
2	***D. chrysotoxum***	12-30	12.50	4.6	2.71	16.10	0.60	0.30	2.00	12-20
3	***D. clavatum***	20-80	14.97	3.37	4.44	18.30	2.00	1.00	2.00	7-10
4	***D. crepidatum***	10-18	14.00	2.2	6.36	0.40	0.20	0.20	1.00	3-5
5	***D. densiflorum***	15-40	13.00	4.5	2.88	13.6	1.10	0.80	1.37	25-30
6	***D. devonianum***	15-70	7.56	1.37	5.51	1.00	0.40	0.20	2.00	2-3
7	***D. falconerii***	15-60	4.74	0.5	9.48	0.80	0.30	0.30	1.00	3-4
8	***D. fimbriatum***	30-110	14.50	3.7	3.71	14.50	0.40	0.20	2.00	15-25
9	***D. formosum***	10-30	7.90	2.8	2.82	3.00	0.80	0.40	2.00	2-3
10	***D. heterocarpum***	10-20	10.20	1.52	6.71	0.50	0.30	0.20	1.30	2-3
11	***D. moschatum***	25-130	15.00	4.00	3.76	17.50	1.00	0.80	1.26	10-15
12	***D. nobile***	15-50	10.50	3.0	3.50	1.30	1.00	0.50	2.00	2-3
13	***D. ochreatum***	10-15	9.60	3.46	5.51	2.50	0.20	0.20	1.00	2-3
14	***D. primulinum***	10-20	7.73	2.48	3.11	0.80	1.20	0.60	2.00	1-2
15	***D. transparens***	20-60	6.50	1.5	4.33	0.50	1.00	0.80	3.30	2-3
16	***D. wardianum***	10-20	11.94	1.61	7.42	1.00	2.00	1.40	1.66	2-3

Abbreviations:

Sht. = Shoot
Lf. = Leaf
Infl. = Inflorescene
Fl. Brt. = Floral bract
Fl./Infl. = Number of flower per inflorescene
L = Length.

B = Breadth.
L/B= Length/Breadth Ratio.

Table: 6. Measurements of Floral Parts, Pollinia and Fruit:

Sl. No.	*Name of the species*	Pedicel cm.	Ovary cm.	Flower Across cm.	Dorsal Sepal cm.			Lateral Sepal cm.			Petal cm.			Labellum cm.			Col-umn cm.	Pollinia mm.		Seed pod cm.
		L	L		L	B	L/B	L	B	L/B	L	B	L/B	L	B	L./B	L	L	B	L
1	**D. chrysantham**	4.55	0.97	4.32	2.1	1.3	1.61	2	1	2	2.3	1.8	1.27	2	2	1	0.6	1.71	1.67	5.53
2	***D. chrysotoxum***	3.71	0.46	4.20	1.8	0.9	2	2	0.8	2.5	2	1.5	1.33	2	2.2	0.90	0.5	1.71	1.53	5.0
3	***D. clavatum***	3.57	0.45	5.0	2.8	1.5	1.86	3.3	1.3	2.53	2.7	1.7	1.58	3.1	2.8	1.10	0.5	1.93	1.65	4.58
4	***D. crepidatum***	3.3	0.59	3.81	2.2	1.0	2.2	2.3	1.7	1.35	2	1.2	1.66	2.2	2	1.10	0.4	1.45	1.30	2.5
5	***D. densiflorum***	3.2	0.46	3.35	1.7	1.0	1.7	2.3	1.1	2.09	1.8	1.4	1.28	2.1	2.3	0.91	0.4	1.76	1.12	4.78
6	***D. devonianum***	2.58	0.38	4.87	2.5	0.9	2.77	3	0.9	3.33	2.7	1.5	1.8	2.8	3.2	0.87	0.4	1.53	1.38	3.73
7	***D. falconerii***	3.0	0.5	6.50	3.3	1.0	3.0	3.2	0.9	3.55	3.2	1.5	2.13	3.6	2.9	1.21	0.4	1.50	0.99	2.75
8	***D. fimbriatum***	3.17	0.38	4.97	3.0	1.4	2.14	3	1.2	2.5	3.4	2.2	1.45	3.4	3.3	1.03	0.5	1.85	1.68	4.97
9	***D. formosum***	2.78	0.97	9.50	6.0	1.5	4.3	6.2	2	3.1	6.5	4.5	1.4	6.5	4.8	1.35	0.8	3.0	2.6	4.03

							3						4					9	5	
10	***D.heterocarpum***	2.5	0.50	3.50	3.9	1.0	3.9	3	1	3	3.3	1.3	2.53	3.3	2.3	1.43	0.8	1.77	1.55	3.8
11	***D. moschatum***	3.5	1.0	6.80	3.7	2	1.85	3.5	1.2	3.16	4.5	3.8	1.18	3.5	1.3	2.69	0.4	2.57	2.16	5.2
12	***D. nobile***	3.71	0.49	6.8	3.9	1.2	3.25	4.1	1.1	3.72	4	2.2	1.81	3.6	2.8	1.28	0.5	1.74	1.38	4.52
13	***D. ochreatum***	3.22	0.73	4.90	3.0	1.2	2.5	3.2	1.1	2.90	2.8	1.2	2.33	2.7	2.6	1.03	0.3	1.49	1.40	6.73
14	***D. primulinum***	1.79	0.71	5.97	2.8	1	2.8	2.8	1.0	2.8	2.8	1	2.8	3.5	3.8	0.92	0.4	2.05	1.73	4.89
15	***D. transparens***	1.5	0.50	3.20	2.1	0.5	4.2	2.5	0.4	6.25	2.3	0.9	2.55	2.5	1.5	1.66	0.5	1.65	1.35	3.70
16	***D. wardianum***	3.8	0.6	5.80	3.8	1.5	2.53	4.2	1.3	3.23	4	2.2	1.81	3.2	2.8	1.14	0.5	2.10	1.58	4.57

Table: 7. Phenological observations of Reproductive & Vegetative phenophases:

SL. No.	Name of the Species	*A Mth.	*B Mth.	*C Days	*D Days	*E Mth.	*F Days	*G Days	*H Mth.	*I Mth.	*J Mth.
1	**D. chrysantham**	Sept-Nov	Jun-Jul	60	10	Jun-Oct	5	95	Nov	Feb-May	May-Jun
2	***D. chrysotoxum***	Jun-Aug	Feb-Apl	62	10	Mar-Apl	4	67	Dec	Mar-Apl	May-Jun
3	***D. clavatum***	Jun-Aug	Apl-May	102	11	May-Jul	5	75	Jan	Mar	Mar-Apl
4	***D. crepidatum***	May-Jul	Feb-Mar	65	8	Apl-May	7	65	Jan-Feb	May	Jun-Jul
5	***D. densiflorum***	Jun-Aug	Mar-May	100	9	Apl-Jun	8	92	Aug	Sept-Oct	Sept-Oct
6	***D. devonianum***	Jan-Feb	Feb-Mar	57	8	May-Jul	6	78	Dec	Mar-May	Jun
7	***D. falconerii***	Apl-Jun	Mar-Apl	55	7	Apl-May	5	63	Dec	Feb	Mar-Apl
8	***D. fimbriatum***	May-Jun	Jan-Mar	95	8	Mar-May	8	102	Dec	Jan-Feb	Apl
9	***D. formosum***	May-Jun	Mar-Apl	68	23	May-Jun	9	107	Mar-Apl	May	Jul
10	***D. heterocarpum***	Feb-Mar	Oct-Nov	75	20	Dec-Jan	10	68	Oct	Oct-Jan	Jun-Jul
11	***D. moschatum***	May-Jun	May-Jun	65	8	May-Jul	6	83	Mar	May	May-Jun
12	***D. nobile***	Jan-Apl	Dec-Feb	95	21	Mar-Apl	7	73	Nov	Apl-May	Apl-May
13	***D. ochreatum***	Apl-May	Feb-Mar	60	8	Mar-May	7	120	Jan-Feb	Apl-May	May-Jun
14	***D. primulinum***	May-Jul	Mar-Apl	45	7	Apl-May	5	60	Jan-Feb	Apl-May	May
15	***D. transparens***	May-Jun	Mar-Apl	58	6	Apl-Jun	6	65	Apl-May	May	May
16	***D. wardianum***	Mar-Apl	Jan-Feb	70	12	Mar-Apl	5	60	Feb	Mar-Apl	Apl-May

*A= Initiation of shoot *B = Initiation of flower buds

*C = Initiation of flower buds to Anthesis *D = Longevity of individual flower

*E = Flowering seasons *F = Initiation of seed pod after pollination

*G = Maturation of seed pod *H = Browning of seed pod:

*I = Bursting of seed pod *J = Dehiscence of seed pod

*Mth. = Month

Fig.1. Mean Value of Temperature Rainfall

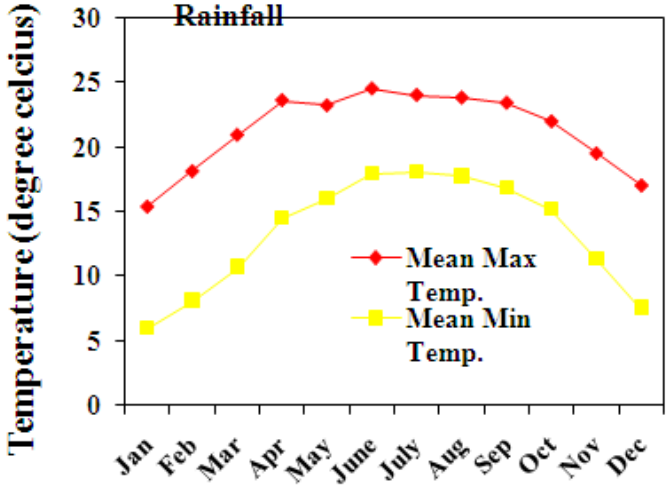


Fig.2. Mean Value of

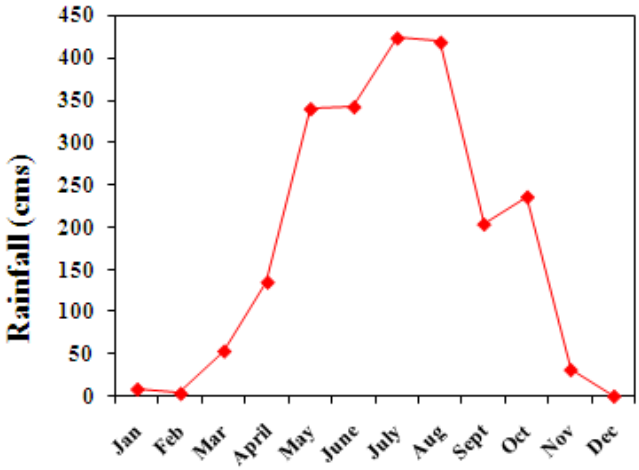
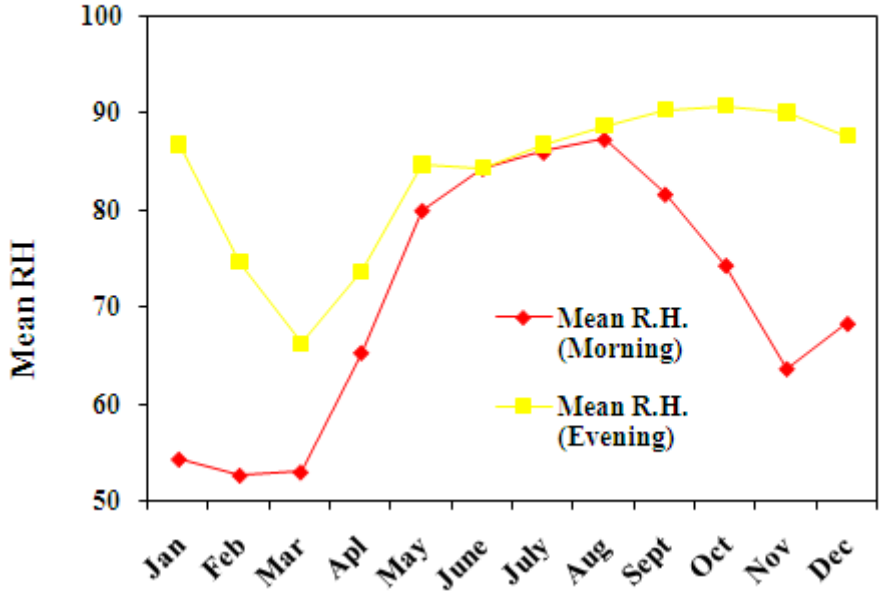


Fig.3. Mean Value of Humidity



(I).Vegetative Morphological Characters Analysis:

The stems are pseudo-bulbs in general and exhibit variations in shape and size ranging from slender and pendulous to thick and fleshy, erect or sub-erect pseudo-bulbs cover with leaf sheaths. The height of the stems varies from species to species (Table 5). The maximum height was recorded in *D. moschatum* (130 cm) and a minimum in two species, *D. williamsonii* and *D. ochreatum* (15cm). The leaves are sessile, varying in shape and size (Table 4). Lanceolate leaves are more common than oblong shapes among the species. However, other forms are also encountered such as broadly lanceolate in *D. densiflorum* and oblong lanceolate in *D. wardianum*. The length of the leaf varies from one species (Table 6) to another and recorded with a maximum length in *D. moschatum* (15cm) and a minimum in *D. falconerii* (4.47cm). The length and breadth ratio depicted a maximum value in D. *falconerii* and a minimum in D. *formosum*. It is apparent that the greater the length and breadth ratio the more the elongation, slender and narrower the leaves and lesser the ratio the broader and wider the leaves.

The inflorescence is racemes in all the species although it differs in form and sizes (Table 4). For instance, *D. nobile*, *D. chrysanthum*, *D. devonianum*, *D. primulinum*, *D. transparens*, *D. crepidatum*, *D. wardianum* and *D. falconerii* has a short inflorescence, arising from the nodes of the pseudo-bulbs stems. *D. moschatum*, *D. fimbriatum* and *D. clavatum* has a pendant inflorescence arising from the upper part of the slender stems. Interestingly, *D. densiflorum* and *D. chrysotoxum* has a pendulous inflorescence arising from the base of the leaf from the internodes of the stems. *D. formosum* and *D. williamsonii* has

a terminal axillary short inflorescence. A maximum length of inflorescence is found in *D. clavatum* (18.3cm) and minimum in *D. ochreatum* (0.4cm) (Table 5)

The number of flower per inflorescence varies from one species to another and is related with the length of the inflorescence (Table 5). It is observed that, the longer the length of inflorescence the more the number of flowers. The species comprising of *D. crepidatum, D. chrysanthum, D. transparens, D. heterocarpum, D. williamsonii, D. falconerii, D. wardianum, D. devonianum, D. nobile, D. ochreatum* and *D. formosum* bear one to five flowers with the length ranging from 4mm to 3cm long. On the contrary, *D. densiflorum, D. fimbriatum, D. chrysotoxum, D. moschatum* and *D. clavatum* bear five to thirty flowers with the length ranging from 13 to 20 cm long. Although the pedicel is short and small the variations among the different species are prominent (Table 6). The maximum length was recorded in *D. chrysanthum* (4.55cm) and minimum in *D. transparens* (1.5 cm) long. Similarly, the length of the ovary also shows variations among the species and a maximum was recorded in *D. moschatum* (1cm) and minimum in *D. devonianum* (0.38cm) (Table 6).

The flowers of the *Dendrobium* exhibit a variety of shapes, size and colour, which makes them one of the important groups in the field of floriculture. The flower across length was measure and recorded the maximum in *D. formosum* (9.5cm) and minimum in *D. transparens* and *D. williamsonii* (3.20 cm) each (Table 6). The different parts such as the sepals, petals and the labellum largely contribute the beauty of a flower. The shapes and colour of these parts reflects/spells the beauty of an orchid flower. The three sepals are similar in appearance and shows variations from species to species with respect to shape, size (Table 6) and colour. The maximum length was recorded in *D. formosum* (6cm) and minimum in *D. densiflorum* (1.7cm). Similarly, the maximum breadth recorded in *D. formosum* (2cm) and minimum in *D. transparens* (0.5cm). From the present study it is reveal that the greater the length and breadth ratio the more the length in elongation as found in *D. formosum* with a maximum value and the lesser the ratio the globular and shorter as found in *D. chrysanthum*.

The petals are more pronounce in colour than the sepals and differ in size (Table 6) with an exception in *D. primulinum* where the sepals and petals are equal in size. The petals shows varying shade in colour and different from species to species. The maximum length was recorded in *D. formosum* (6.5cm) and minimum in *D. densiflorum* (1.8cm). And the breadth ranges from 9 mm to 4.5cm and recorded maximum in *D. formosum* and minimum in *D. transparens*. The length and breadth ratio was found maximum in *D. primulinum* and minimum in *D. moschatum*. This suggested, that the greater the ratio the more the elongation and the lesser the ratio the broader in breadth and shorter the length. The length and breadth ratios of sepals were found maximum in *D. formosum* and minimum in *D. falconerii*. Pedicel length ranges from a maximum 4.55 cm in *D. chrysanthum* to a minimum length of 1.5 cm in *D. transparens* (Table 6). The ovary length varies from one species to another ranging from a maximum of 1cm in *D. moschatum* and a minimum 0.38cm in *D. devonianum* (Table 6).

The labellum is the most prominent of all perianth parts, endowed with different shade in colour, shape and size (Table 6). This is the most attractive parts of the flower of an orchid and well displayed by the genus *Dendrobium* that varies from species to species. The lips are flat in all the species except in *D. moschatum* where the lip forms a small round pouch. The margins of the lip are entire with small foldings except in *D. fimbriatum*, where the lip is deeply fimbricate on its margin. The flowers of *D. falconerii* and *D. devonianum* are similar in appearance and confusing but can be differentiate from their blotch on their lip. The two blotches in *D. devonianum* are yellow but in case of *D. falconerii* the blotch are purplish in colour. Similarly, *D. clavatum* and *D. fimbriatum* can be identify basing on the shape of their blotch as well, the blotch in *D. clavatum* in "w" shaped and two distinct blotch with purple on the lip of *D. fimbriatum*. The length of labellum varies from one species to another and recorded maximum in *D. formosum* (6.5cm) and minimum in *D. chrysanthum* and *D. chrysotoxum* of equal length (2cm). The breadth was found maximum in *D. formosum* (4.8cm) and minimum value in *D. moschatum* (1.3cm). The length and breadth ratio of the lip shows that the greater the ratio the greater is the elongation/broader and lowers the ratio the shorter the length of the lip. The length of the column was found maximum in *D. formosum* (1.2cm) and minimum in *D. ochreatum* (0.3cm) long. Pollinia, four in lobes, maximum length was observed in *D. formosum* (3.09mm) and minimum in *D. crepidatum* (1.45mm) also maximum breadth in *D. formosum* (2.65mm) and minimum in *D. crepidatum* (0.99mm).

The floral bracts are very small in size and shows varying shapes. The maximum value of bract length and breadth ratio was recorded in *D. transparens* and a minimum value in *D. falconerii* (Table 5). It is obvious from the present findings that, the greater the value of length and breadth ratio the more linear and elongate and lesser the ratio the broader and short are the bracts. Majority of the species shows ovate acute shape bracts. Besides this other forms are also found such as oblong acute in *D. chrysanthum* and *D. moschatum*, oblong lanceolate in *D. transparens* and oblong deltoid shape in *D. densiflorum*, acute lanceolate in *D. formosum* and an obtuse bracts in *D. fimbriatum*.

(II) Reproductive Phenology Observation:

The emergence of new shoots in respect to time varies among the species (Table 7). Depending on their timing of formation of new shoots the species are group together into four season viz., autumn, spring, summer and winter respectively. It is observed that maximum numbers of species sprout out new shoots from early spring to late summer, starting from the month of March to August (Table 7). However, two species viz., *D. devonianum* and *D. heterocarpum* sprout their shoots in winter (Jan-Feb) and emergence of new shoots occurred in *D. chrysanthum* during autumn season (Sept-Oct) (Table 7). During the present studies, it is found that a warm to high temperature accompany with sufficient rainfall/moistures favours the sprouting of new shoots in *Dendrobium* species (Figs. 1, 2, & 3). Flowering season/time varies from species to species and majority blooms during warmer season depicting similar conditions as in the case of sprouting of new shoots. Maximum number of species flowered from March to July and one species each in both autumn (*D. chrysanthum*) and winter (*D. heterocarpum*) (Table 7).

The emergence of the flower bud occurred maximum during the month from January to April. *D. wardianum, D. falconerii, D.chrysotoxum, D. densiflorum, D. crepidatum, D. transparens, D. formosum, D. ochreatum, D. primulinum, D. devonianum, D. fimbriatum* and *D. williamsonii* followed by *D. moschatum, D. clavatum* and *D. chrysanthum* in the successive three months (May-July) (Table 7). After a gap of two months *D. nobile and D. heterocarpum* flower bud emerges during the month of October to December. Therefore, it is apparent that low temperature with less rainfall and low relative humidity promotes the bud initiation in most of the species considered for the present study (Figs. 1, 2 & 3). On the other hand, *D. moschatum, D. clavatum* and *D. chrysanthum* initiate flower bud during long days of mid-summer with high temperature, moderate humidity and maximum rainfall. However, *D. nobile* and *D. heterocarpum* are favoured by moderate temperature with high humidity and dry seasons for the initiation of their flower bud (Figs. 1, 2 & 3). It is a general opinion that many orchid species are induced by, or triggered to flower by low temperature (Kosugi, 1952; Leffring, 1972; Kronenberg, 1976). The initiation of flower bud differs from species to species in orchids and determined by its genotype and interactions with the environmental conditions for further development (Bose and Yadav, 1986). From the above pattern of flower bud initiation, it reflects the phenological requirements are species specific among the Northeast *Dendrobiums* (Table 7)

The inter-phenophase from flower bud initiation to opening of the flower varies from species to species, which ranges from 45 to 102 days (Table 7). Though, *D. clavatum* and *D. primulinum* flowered during the same seasons the inter-phenophases gap varies considerably between the two species that may be due to its genotype. Kochmer and Handel (1986) and Wright and Calderon (1995) suggested that the phylogenetic factors strongly affect the flowering phenologies to a large extent. The flowering peak was recorded during the spring and early summers, which falls during the month from March to July. *D. heterocarpum* flowered during winter seasons and *D. chrysanthum* flowered during the later part of summer to autumn seasons. It is obvious from the mentioned pattern of flowering that the environmental factors play an important role for inducing or triggered for flowering. The temperature during the peak duration ranges from 20.93^{o}C to 24.53^{o}C suggesting the *Dendrobiums* from this region thrives well during the warm and wet seasons with low to moderate humidity (Fig.1). Conversely, *D. heterocarpum* flowered during cold and dry seasons. The longevity of an individual flower varies from species to species and ranges from 5 to 23 days among the genus *Dendrobiums* (Table 7). *D. formosum* flower recorded with maximum of 23 days and minimum in *D. transparens* flower lasted only for 5 days. It was observed that the longevity does not depend on the size of the plant rather related with the thickness of the perianth parts. The thicker the perianth, the longer is the longevity of the flower in *Dendrobium* species. The seasonal periodicity and sequential patterning of the phenological activity differs from one species to another. Several factors, which governed the phenology of the flowering plants, determine the reproductive success of the plant species. Among these factors, the time, frequency, and duration of the flowering period is obviously of great importance (Rathcke and Lacey, 1988a, b). Generally, the orchid flowers remain alive for longer periods of time in the absence of pollination but shorten the longevity of a flower after being pollinated (Decker, 1941; Poddubnaya-Arnoldi and Sclezneva 1957; Van der Pijl and Dodson, 1966; Arditti 1979). The pollination effect on longevity of the flower depends on the species or the genus, causing a variety of developmental, physiological, and biological events, including wilting, senescence, greening, fading, or anthocyanin formation in some or all parts of the perianth (Arditti, 1976, 1979). In majority of the species considered for the present study shows changing of colours in their perianth segment especially the lip after pollination on the third or fourth day. The phenology of a species not only encompasses the seasonality and duration of reproduction but also determined the degree of reproductive synchrony with other plant species (Rathcke, 1988 a, b). Despite seasonality, a substantial overlap in the timing and duration of flowering among plant species (Gross, et al., 2000). The process of seedpod formation/development, maturation and retention was found to be the longest phenophase in all the species. The swelling of an ovary was presumed to be an indication for seedpod setting after the pollination. Increase in diameter of the ovary after pollination varies from one species to another, ranging from 4 to 10 days. The longest period was observed in *D. heterocarpum* and the shortest in *D. chrysotoxum.* Seedpod initiation till maturation ranges from 56 to 120 days (Table 7). The longest period was recorded in *D. ochreatum* and the shortest period in *D. wardianum*. Browning of seedpod falls into two categories depending upon their occurrence in seasons or year. *D. densiflorum, D. heterocarpum, D. nobile, D. chrysanthum, D. falconerii, D. fimbriatum* and D. *devonianum* shows browning of their seed-pod during the month from September to December in the same year of its seed setting. However, *D. primulinum, D. ochreatum, D. formosum, D. trasparens, D. crepidatum, D. clavatum, D. moschatum, D. wardianum* and *D. chrysotoxum* exhibit browning of their seed-pod from the month January to April in the following year from its development.

Despite of the differences in the phenological events among the species, majority of the species shows bursting of the seedpod during the month from March to May (Table 7) in the following year of the seed formations. Bursting of the seedpod of *D. heterocarpum* and *D. densiflorum* occurs during the month of September to November. Dehiscence of seed- pod occurs during the same or subsequent month of bursting in all the species, which provides a better chance of dispersal of seeds by a strong wind, which prevails in the region. All the seedpod breaks in a single longitudinal slit at first and gradually two to three additional slits develop, facilitating for wind dispersal.

The vegetative characters exhibits variations among the *Dendrobium* species studied. The nature of the stems are psuedobulbs in all the species and the height of the stems ranges from 130 cm to 15 cm consisting nodes and internodes which is one of the characteristic features of this taxa (Tables 4 & 6). Leaves are variously shaped and comprise of lanceolate to oblong-lanceolate type. The length and breadth ratio of the leaves depicts a maximum value in *D. falconerii* and minimum in *D. formosum* suggesting, the greater the values the slender and linear is the leaves in shapes. The length of inflorescence varies from one species to another and the maximum length is found in

D. clavatum and minimum in *D. heterocarpum*. Based on the number of flowers on the axis of the inflorescence they can be broadly categorized into two groups: Firstly, species bearing two to five flowers comprising of *D. crepidatum, D. chrysanthum, D. transparens, D. heterocarpum, D. williamsonii, D. falconerii, D. wardianum, D. devonianum, D. nobile, D. ochreatum* and *D. formosum*. Secondly, species bearing more than five flowers and consists of *D. densiflorum, D. fimbriatum, D. chrysotoxum, D. moschatum* and *D. clavatum*. The size of flowers varies among the species and the biggest flower was found in *D. formusum* and the smallest in *D. tranparens* in the present studies. The flower displayed a variety of colours viz., White, yellow, purplish white and pinkish white among the species studied. The phenological studies depict chronological patterns with respect to the environment and seasons. These can broadly categorize into three phases viz., emergence of new shoots, flowering and fruiting phases respectively (Table 7). Emergence of the vegetative shoots in *Dendrobium* species occurred from the early part of spring and continues till late summer (March- August) in most of the species indicating a warm to high temperature and high moistures enhanced vegetative sprouting. On the other hand, *D. devonianum* and *D. heterocarpum* shoots emerged during winter (Jan-Feb) favouring cold and dry seasons and *D. chrysanthum* in autumn (Sept-Oct) (Figs. 1 & 3). Majority of the species initiates flower buds during the month stretching from January to April revealing low temperature with less rainfall and low relative humidity promotes the bud initiation in *Dendrobium*. The three species, *D. moschatum, D. clavatum* and *D. chrysanthum* initiate their flower buds during long day, high temperature, moderate humidity and maximum rainfall. However, *D. nobile* and *D. heterocarpum* are favoured by moderate temperature with high humidity and dry seasons for the initiation of their flower bud. The inter-phenophase from flower bud initiation to opening of the flower varies from species to species, which ranges from 45 to 102 days. The flowering peak was recorded during the spring and early summers which falls during the month from March to July (20.93^{o}C to 24.53^{o}C) suggesting the Dendrobiums from this region thrives well during the warm and wet seasons with low to moderate humidity (Figs. 1, 2 & 3). The longevity of an individual flower of *D. formosum* flower was recorded with a maximum of 23 days and minimum of 5 days in *D. transparens* (Table 4.7). The longest period of seedpod initiation to maturation was recorded in *D. ochreatum* (56 days) and the shortest period in *D. wardianum* (120 days). *D. densiflorum, D. heterocarpum, D. nobile, D. chrysanthum, D. falconerii, D. fimbriatum* and D. *devonianum* shows browning of their seed-pod during the month from September to December in the same year of its seed setting. However, *D. primulinum, D. ochreatum, D. formosum, D. trasparens, D. crepidatum, D. clavatum, D. moschatum, D. wardianum* and *D. chrysotoxum* exhibit browning of their seed-pod from the month January to April in the following year from its development.

V. CONCLUSION

It is important to study the vegetative nature and habits of a plant so as to give a complete understanding about their morphology, structures and forms for various developments and its management in scientific study. The phenological studies are important for a better understanding of their biology, adaptations to environment, proper utilization of the available resources in management and floriculture industry. The environmental and genetically factors play a major role in the phenology of *Dendrobium* species from Northeast region. The phenological data obtained in the present studies are not only useful for scientific study in resource management and conservation of the individual species but also to the hybridizers and amateur orchid grower for orchid culture. Plant phenology is per-requisite to scientific study for multiplication, propagation, and also for the conservation of germaplasm and improvement.

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REFERENCES

[1] **Allinson, A. S. and F.W. Dennis.** 1989. Costs of flower and fruit production in *Tipularis discolor* (Orchidaceae), Ecology. **70**(5): 1286-1293.

[2] **Arditti, J.** 1976. Post-pollination phenomena in Orchid flowers; A pictorial view. Orchid Rev. **84**: 261-262.

[3] **Arditti, J.** 1979. Aspects of Orchid Physiology. In: H. Woolhouse (eds.), Advances in Botanic research. **7**: 421-665. Academic Press, London.

[4] **Bose, T.K. and L.P. Yadav** 1992. Physiology of flowering of orchids. *In*: S.P.Vij (eds.). Biology, conservation and culture of Orchids. East West Press. Delhi. 79-82.

[5] **Cole, F.R. and D.H. Firmage.** 1984. The Floral Ecology of *Platanthera blephariglottis*. Amer. J. Bot.**71**: 700-710.

[6] **Berry, P.E. and R.N. Calvo.** 1991. Pollinator limitation and position dependent fruit set in the high Andean Orchid *Myrosmodes cohleasre* (Orchidaceae). Plant Syst. and Evol. **174**: 93-101.

[7] **Decker, J.S.** 1941. Note. Orquidea (Brazil) **4**: 56.

[8] **Evenson, W.E.** 1983. Experimental studies of reproductive energy allocation in plants. *In*: E.E. Jones and R.J. Little (eds.). Handbook of Experimental Polllination Biology. 249-274. Van Nostrand Reinhold, New York.

[9] **Gross, K.L**. 1981. Predictions of fate from rosette size in four biennial plant species, *Verbascum thapsus, Oenothera bienis, Daucus carota* and *Tragopogon dupius.* Oecologia. **48**: 209-213.

[10] **Gross, C.L., D.A. Mac Kay and M.A. Whalen.** 2000. Aggregated flowering phenologies among three sympatric legumes: the degree of non-randomness and the effect of overlap on fruit set. *Plant Ecology.* **148**:13-13.

[11] **Hegde, S.N.** 1980. Preliminary observations and list of Orchids of Arunachal pradesh. *Arunachal Forest News.* **3** (3): 1-11.

[12] **Heinrich, B.** 1976. Flowering phenologies: bog, woodland, and disturbed habitats. Ecology. **57**: 890-899.

[13] **John, A. Kumar, Y. and Sharma, J.** 2001. Orchids of India: Biodiversity and Status of *Bulbophyllum* Thou. Daya books, Tri Nagar, Delhi-India. pp. 47-63.

[14] **Joy, K.A.** 1992. Studies on Paphiopedilum Pfitz. of North-Eastern Region of India. M. Phil. dissertation North-Eastern Hill University, Shillong.

[15] **Kataki, S.K. and S.L. Abbas.** 1992. Flowering calendar of the Northeast Indian orchids with a special reference to ornamental species. J. Orchid. Soc. India. **6** (1&2): 109-113.

[16] **Kochmer, J.P., and S.N. Handel.** 1986. Constraints and competition in the evolution of flowering phenology. Ecol. Monogr. **56**: 303-325.

[17] **Kosugi, K.** 1952. Effect of soil moisture and low temperature upon flower differentiation in *Dendrobium nobile*. J. Hort. Assam. **21**: 179-182.

[18] **Kronenberg, H.G.** 1976. Flowering *Dendrobium crumentum* Sw. Amer. Orchid. Soc. Bull. **45**: 513.

[19] **Law, R.** 1979. The cost of reproduction in annual meadow grass. Am. Nat. **113**: 3-16.

[20] **Leith, H.** 1970. Phenology in productivity studies. In: D. Reichle (eds.). Analysis of Temperate Forest Ecosystems. Heidelberg. Spriner- Verlag.

[21] **Leith, H. and J.S. Radford.** 1971. Phenology, resource management and synagraphis computer mapping. Bio. Sci. **21**: 62-70.

[22] **Leffring, L.** 1972. Influencing the flowering of *Cymbidium*. Vakil. Voor de Bloem. **27**: 13.

[23] **Limasengla. Kumar, Y. and Sharma, J.** 2002. Orchids of India III. Biodiversity and Status of *Vanda* Jones Ex. R. Br. Daya books, Tri Nagar, Delhi-India. pp.24-33.

[24] **Maheshwari, P.** 1950. An introduction to Embryology of the Angiosperms. Mc Graw-hill, New York.

[25] **Mulik, N.G. and L.J. Bhosale.** 1989. Flowering phenology of the mangroves from the West Coast of Maharashtra. J. Bom. Nat. Hist. Soc. **86** (3): 355-359.

[26] **Poddubnay-Arnoldi, V.A. and V.A Selezneva.** 1957. Orchideiiih Koultoura (Orchids and their Culture). Academy of Science, U.S.S.R., Moscow.

[27] **Pojar.** 1974. Reproductive dynamic of four plant communities of Southwestern British Columbia. Can. J. Bot. **52**: 1819-1834.

[28] **Primack, R.K., L. Miao and Katherine R. Becker.** 1994. Costs of reproduction in the Pink Lady's Slipper Orchid (*Cypripedium acule*) Defoliation, increased fruit production and fire. Amer. J. Bot. **81**(9): 1085-1090.

[29] **Rathcke, B. and E.P Lacey.** 1985. Phenological patterns of terrestrial plants. Annu. Rev. Ecol. Syst. **16**: 179-214.

[30] **Rathcke, B. and E.P Lacey.** 1988a. Interactions for pollination among co-flowering shrubs. Ecology. **69**: 446-446.

[31] **Rathcke, B. and E.P Lacey.** 1988b. Flowering phenologies in a shrub community: competition and constraints. J. Ecology. **76**: 975-975.

[32] **Reekie, E.G. and F.A. Bazzaz.** 1987a. Reproductive effort in plants. I. Carbon allocation to reproduction. Amer. J. Bot. **129**: 876- 896.

[33] **Sohn, J.J., and D. Policansky.** 1977. The cost of reproduction in the mayapple, *Podophyllum peltatum* (Berberidaceae). Ecology, **58**: 1366-1374.

[34] **Taylor, J.S., S.J. Blackman, and E. C. Yeung**. 1992. Hormonal and structural aspects of fruit development in the Orchid, *Epidendrum*. J. Exp. Bot. **32**: 494-505.

[35] **Thomson, J.D.** 1980. Skewed flowering distributions and pollinator attraction. Ecology. **61**:572-572.

[36] **Thomson, J.D.** 1982. Patterns of visitation by animal pollinators. Oikos. **39**: 241-241.

[37] **Van Der Pijl, I. and C.H. Dodson.** 1966. Orchid flowers, their pollination and evolution. Coral Gables: University of Miami Press.

[38] **Veyret, Y.** 1974. Development of the embryo and the young seedling stages of Orchids. In: C.L. Withner (eds.) The Orchids: Scientific studies. pp. 223-265. John Wiley and Sons, New York, NY.

[39] **Werner, P.A.** 1975. Predictions of fate from rosette size in teasel (*Dipsacuss fullonum* L.) Ecologia. **20**: 197-201.

[40] **Wirth, M. and C.L. Withner.** 1959. Embryology and development in the Orchidaceae. In: C. L. Withner (eds.). The Orchids: A scientific survey. The Ronald Press, New York. pp. 155-188.

[41] **Wright, S.J. and O. Calderon**. 1995. Phylogenetic patterns among tropical flowering phenologies. J. Ecology. **83**: 931-948.

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