CHAPTER: 6

6. PHENOLOGY

Phenology is defined as a branch of science dealing with the relations between climate and periodic biological phenomena. Phenology is the study of the times of recurring natural phenomena. The word Phenology, derived from the Greek word "*phaino*" which mean to show or appear, of periodic plant life cycle events that are influenced by environmental changes, especially seasonal variations in Rainfall, temperature and precipitation driven by weather and climate. Phenology means the study of life cycle of annual and perennial plants throughout the year. Phenology can be defined as relationship between climate and biological phenomena (Lieth, 1974). Phenology is the study of response of living organisms to seasonal and climatic changes to the environment in which they live. Seasonal changes include variations in the duration of sunlight, precipitation, temperature and other life-controlling factors.

In simpler way phenology means, study of complete life cycle of plants including its germination, fertile form and death phase relating to month of particular season. Belgian biologist Charles Morren (1855) first coined the term Phenology. The periodical climate change of a particular area is directly affects the plants' life cycle. Phenological study helps us to understand the rhythm of changes in life cycle of plants that indicates the proper time of showing, flowering, fruiting and death especially for the agricultural crops.

Such periodical records also bears scientific value for understanding the interactions between organisms and their environment and for assessing the impacts of climate change.

The phenogical study of floristic of any vegetation is very much useful tool for understanding of nature of vegetation in an area in better way. There are several authors who studied the details phenology for different species like Ihne (1884), Harper (1906), Koelmer (1959), Frankie *et al.* (1974), Schnelle (1955), Wang (1967) Leith (1970), Caprio (1966), Croat (1975) and Putz (1979).

In the field of phenological study of different weeds and other plants some works are also reported from India. Such phenological studies performed on several species by Bhoj & Ramkrishnan (1981), Sundriyal (1990), Sivaraj & Krishnamurthy (1981) on Eastern Ghats and Himalayan plants. Hooker (1872) Hara *et al.* (1966, 1971), Ohashi (1975), Grierson & Long (1983-1987, 1991, 1999), Nolties (1994-2000), Pearce & Cribb (2002), explored the flora of Eastern Himalaya. The Phenology of weeds of Darjeeling Hills and plains were also studied by Das & Chanda (1987), Kadir & Das (1999) and Ghosh & Das (2007).

On the other hand, there is no such work on the weed phenology of Maldah district as well for the central part of the West Bengal. However, Prain (1903), Guha Bakshi (1984) and Guha Bakshi *et al.* (1974) explored the flora of different parts of Central Bengal, but, phenological studies were always left aside.

Several works on the flora of aquatic and wetland plants are also available (Kachroo 1955; Haq, 1955 & Ghosh 1967). Duthie (1903-1929) worked on the flora of upper Gangetic plain and adjoining Siwalik and sub-Himalayan region. Naskar (1990) explored the aquatic and semi aquatic flora of lower Gangetic plains. After considering all these important works, it is noted that knowledge on the phenology of plants of Maldah district is not clear. Acharyya (1998) reported the phenology of 129 species of crop field weeds of this region. This is the only available work and appeared quite insufficient.

6.1. The Present works

The phenology of wetlands plants growing in Maldah district of West Bengal has been attempted. As much as 220 species of wetland angiosperms have chosen for such study. The observation have been made during 2003– 2007. During the study several data have been collected regarding plant growths and different successive stages of their life cycle *in vivo*. The following phenological parameters were studied during survey:

1. Period of seedling appearance or sprouting
2. Period of vegetative growth
3. Period of Flowering
4. Pollination method
5. Period of Fruiting and seed dispersal
6. Period of death or resting

All the above mentioned phenophases are observed month wise. The pollination patterns of wetland plants are very interesting. Three major pollination modes have been found to be recognized among the wetland plants. Expect these three major types so many species use more than one mode. The recognized modes of pollination are i. Anemophilous ii. Entomophilous iii. Hydrophilous iv. Anemo-Entomophilous v. Entomo-Hydrophilous and vi. Anemo-Hydrophilous.

The nature and time of seedling appearance is some how different from terrestrial plants. During phenological study of wetland plants it was noted that maximum number of the aquatic and wetland loving plants seedling appear during April to December. Those species, which appear from bulb, rhizome, rootstalk etc., the phenomenon of new flash or new shoot appearance is treated as the start of new life cycle. Similarly, drying up or passing into the dormant phase has been treated as the completion of life cycle.

6.2. Result and Discussion

6.2.1. Life forms

Life forms study of wetland plants of Maldah district have been recorded for 5 years (2003 - 2008). The observation shows the Therophytes are the most dominating group with 111 species (50.68%). They are followed by Cryptophytes with 64 species (29.23%), 27 species of Chamaephytes, 13 species of Hemicrytophytes and 5 species of Phanerophytes. As the study is restricted to the wetland so the Cryptophytes were studied in details and result shows that these are 34 Hydrophytes and 30 Helophytes. The vegetation in Maldah wetlands are mainly dominating with Therophytes and Cryptophytes.

Table: 6.1. Life forms distribution among the wetland plants

Sl. No.	Life Forms	Sub-Classes	No. of Species	Percentage (%)		Raunkiaer's Normal value (%)
01.	Phanerophytes	-	05	2.28	2.28	46.00
02.	Chamaephytes	-	27	12.33	12.33	9.00
03.	Hemicryptophytes	-	13	5.94	5.94	26.00
04.	Cryptophytes	Helophytes	30	14.61	29.22	6.00
		Hydrophytes	34	14.61		
05.	Therophytes	-	111	50.68	50.68	13.00
		Total	**220**			

The present life forms of wetland plants also can be compared with Raunkiars value of Biological spectrum. Among the wetland vegetation Therophytes contributes maximum value with 50.23 % that is three times more that of Raunkiars normal value whereas Cryptophytes with 29.22% is five times more than normal spectrum value. Third largest group is Chamaephytes with 12.33% which is quite nearer to the normal value. Last two groups show reverse value, where Hemicryptophytes and Phanerophytes shows value 5.94 and 2.28 against the normal spectrum values of 26.00% and 46.00% respectively.

6.2.2. Habit groups

As much as 220 species of angiosperms recorded from the wetland vegetation in the district of Maldah. Of these 125 species (57.07%) are annuals. They complete their life cycle within the year to avoid drought and flood. They are followed by 57 species (26.03%) Emerged or marshy species, 9 species of rooted with floating leaf hydrophytes, 8 species of submerged hydrophytes, 7 species of perennial herbs, 5 species of undershrubs, 4 species of suspended hydrophytes, 2 species of free floating hydrophytes. In addition, there are 2 species of aquatic trailer hydrophytes.

Table: 6.2. Habit group of wetland plants

Sl. No.	Habit Groups	No. of Species	Percentage (%)
01.	Free floating Hydrophytes(HFF)	2	0.01
02.	Rooted with floating leaf Hydrophytes (HRF)	9	4.11
03.	submerged Hydrophytes (HS)	8	3.65
04.	Suspended Hydrophytes (HSP)	4	1.83
05.	Emerged or marshy Hydrophytes (HE)	57	26.03
06.	Annual wetland herbs (HA)	125	57.07
07.	Perennial wetland herbs (HP)	7	3.20
08.	Trailer Hydrophytes (HT)	2	0.91
09.	Tree (T)	1	0.46
10.	Under shrub (SU)	5	2.18
	Total	**220**	

The wetland plants complete their life cycle easily during rainy season. All the wetlands become flooded. Dry season vegetation eliminated submerged vegetation survive at some places; agricultural activity stops and a completely different picture prevails in all parts of the wetland dominating district. But, after the monsoon, when the water level recedes, the agricultural activities regains. Removal of weeds manually or within application of herbicides starts in large scale and disturb life cycle of all these plants.

6.2.3. Phenology of Wetland plants

6.2.3.1. Seedling appearance

In field observation, it has been recorded that in wetland system of Maldah district most of the plants are breaking dormancy during July to December. As the wetlands always maintain few watery areas, that is why most of the species extend their period of seed germination. This starts with the receiving of first shown of rain in monsoon that comes at Maldah during 2nd or 3rd week of July. During this 124 species

out of 220 species break their seed dormancy. The seedlings or new shoots of annual and few perennial plants appear from the ground during this month, when 98 species were recorded in their seedling stage. The maximum seed germination was recorded in the month August when 120 species found in their seedling stage followed by September (94 species), October (74 Species), December (73 species) and November (61 species). The wetland plants prolong their period of seed germination or new shoot appearance upto 9 months. Seeds of *Eclipta prostrata, Cynodon dectylon* and *Cyperus difformis* were recorded to germinate throughout the year. *Parthenium hysterophorus* shows two distinct germination periods, June - July and November – December.

On the other hand with the withdrawal of water from the wetlands, some normal terrestrial plants start breaking of their dormancy. It has been observed that January is the peak month for such plants when 59 species starts their seed germination followed by February (37 species), June (36 Species), March (35 Species), April (33 Species) and May (32 species). All these species maintain their germination period for 2-7 months.

Life form, habit group and phenological calendar of different wetland species are presented in table-6.3.

Table: 6.3. Phenology, Life forms, Habit groups and modes of Pollination for wetland flora of Maldah.

Name of Plants	Life forms	Habit groups	Germi-nation	Vegeta-tive growth	Flowe-ring	Fruiting	Death/ Rest	Pollin-ation
Aeschynomene aspera	HH	HE	Jun-Aug	Jun-Apr	Jul-Jan	Aug-Feb	Jan-Apr	E
Aeschynomene indica	HH	HE	Jul-Sept	Jul-Feb	Sept-Dec	Oct-Mar	Feb-May	E
Ageratum conyzoides	T	HA	Dec-Jan	Dec-Mar	Jan-Mar	Feb-Apr	Mar-May	E
Alternanthera paronychioides	Ch	HA	Nov-Feb	Dec-Sep	Feb-Aug	Jul-Sep	Aug-Sep	E
Alternanthera philoxeroides	T	HA	Aug-Oct	Jan-Dec	Jan-May	Apr-Jun	Jun-Sep	E
Alternanthera pungens	T	HA	Nov-Jan	Nov-Aug	Jan-May	Apr-Aug	Jul-Sep	E
Alternanthera sessilis	Ch	HA	Jul-Aug	Jan-Dec	Oct-May	Mar-Jul	Jul-Sep	A
Alysicarpus bupleurifolius	Ch	HA	Jul-Aug	Jul-Feb	Aug-Dec	Sep-Jan	Jan-Feb	A
Amaranthus spinosus	T	HA	Oct-Dec	Oct-Jun	Dec-Apr	Jan-Jun	May-Jul	A
Amaranthus viridis	T	HA	Jul-Sept	Aug-Mar	Sept-Jan	Dec-Mar	Feb-Apr	A
Ammannia baccifera	T	HA	Nov-Jan	Nov-May	Dec-Mar	Feb-May	Mar-Jun	E
Ammannia multiflora	T	HA	Dec-Jan	Jan-Mar	Dec-Feb	Jan-Mar	Mar-Apr	E
Ammannia salicifolia	T	HA	Dec-Jan	Jan-Mar	Dec-Feb	Jan-Mar	Mar-Apr	A
Anagallis arvensis	T	HA	Nov-Dec	Nov-Jan	Jan-Feb	Feb-Apr	Mar-May	E/A
Aponogeton crispum	HD	HRF	Aug-Oct	Aug-Mar	Sept-Feb	Oct-Mar	Feb-Apr	E/H
Aponogeton natans	HD	HRF	Jul-Sept	Jan-Dec	Aug-Jan	Sept-Feb	Feb-Apr	H

Arundo donax	H	HE	Aug-Oct	Jan-Dec	Nov-Feb	Jan-Mar	May-Jul	A
Athroisma laciniatum	T	HA	Dec-Jan	Jan-Jun	Mar-Jul	Apr-Jun	May-Jul	E
Bacopa monnieri	Ch	HA	Aug-Nov	Jan-Dec	Sept-Feb	Jan-Apr	Apr-Jun	E
Barringtonia acutangula	P	T	Dec-Feb	Jan-Dec	Aug-Dec	Sept-Jan	**	A/E
Bergia ammannioides	T	HA	Jul-Aug	Jul-Feb	Sept-Jan	Dec-Feb	Feb-Apr	A
Blumea hieracifolia	T	HA	Jan-Feb	Jan-Apr	Feb-May	Apr-Jun	May-Jul	E
Blumea lacera	T	HA	Dec-Feb	Dec-Mar	Feb-May	Apr-Jun	May-Jul	E
Blyxa octandra	HD	HS	Jul-Aug	Jul-Jan	Nov-Feb	Jan-Mar	Feb-Mar	H
Bulbostylis densa	T	HA	Jul-Aug	Jul-Jan	Sept-Feb	Oct-Mar	Jan-Mar	E
Caesulia axillaris	T	HE	Aug-Sept	Aug-Mar	Oct-Feb	Nov-Mar	Feb-Apr	A/E
Celosia argentea	T	HA	Dec-Jan	Dec-Mar	Dec-Feb	Jan-Mar	Feb-Apr	E
Centaurium centaurioides	T	HA	Dec-Jan	Dec-Mar	Jan-Mar	Feb-Apr	Feb-May	A/E
Centella asiatica	Ch	HA	Dec-Jan	Jan-Dec	Sept-Dec	Oct-Jan	**	E
Ceratophyllum demersum	HD	HSP	Aug-Oct	Jan-Dec	Oct-Dec	Nov-Jan	Apr-Jun	H
Chloris inflata	T	HA	Mar-May	Mar-Sept	May-Sept	Jun-Oct	Sept-Nov	A
Chrozophora rottleri	P	SU	Jan-Apr	Jan-Jun	Jan-Jul	Jan-May	May-Jul	E
Cirsium arvense	T	HA	Dec-Jan	Dec-Mar	Jan-Mar	Mar-May	Feb-Jun	E
Clerodendrum indicum	H	SU	Mar-Jun	Mar-Jul	Jun-Jan	Jul-Feb	Dec-Jan	E
Coix aquatica	H	HE	Sept-Oct	Sept-Dec	Oct-Dec	Oct-Jan	Dec-Feb	A
Coldenia procumbens	Ch	HA	Dec-Feb	Dec-Apr	Jan-Jun	Feb-Aug	Jul-Aug	A
Commelina benghalensis	Ch	HA	Nov-Feb	Nov-Jul	Jan-Aug	Feb-Sept	Oct-Jan	E
Commelina diffusa	Ch	HA	Nov-Feb	Nov-Jul	Jan-Aug	Feb-Sept	Oct-Jan	E
Commelina longifolia	Ch	HA	Jun-Sept	Jun-Dec	Jul-Dec	Aug-Jan	Jan-Feb	E
Commelina suffruticosa	H	HA	Nov-Jan	Nov-Feb	Jan-Feb	Feb-Mar	Mar-Apr	E
Cotula anthemoides	T	HA	Nov-Dec	Nov-Jan	Dec-Feb	Jan-Mar	Feb-May	A
Cotula hemisphaerica.	T	HA	Dec-Jan	Dec-Feb	Jan-Feb	Jan-Mar	Feb-May	A
Cryptocoryne ciliata	C	HE	Jan-May	Dec-Jun	May-Aug	Jun-Sept	Sept-Nov	E
Crytococcum accrescens	C	HA	Mar-May	Mar-Nov	Jun-Sept	Jul-Oct	Oct-Nov	A
Cyanoglossum lanceolatum	T	HA	Jun-Aug	Jun-Oct	Jul-Nov	Oct-Dec	Dec-Jan	E
Cynodon dactylon	Ch	HP	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	**	A
Cyperus compactus	HH	HE	Sept-Oct	Sept-Dec	Oct-Feb	Oct-Mar	Jan-Apr	A
Cyperus compressus	T	HE	Jul-Sept	Jul-Jan	Jul-Dec	Aug-Jan	Jan-Mar	A
Cyperus difformis	HH	HE	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Mar-Jul	A
Cyperus digitatus	HH	HE	Jul-Sept	Jul-Jan	Aug-dec	Sept-Jan	Dec-Feb	A
Cyperus distans	HH	HE	Jul-Sept	Jul-Dec	Aug-dec	Sept-Jan	Dec-Feb	A
Cyperus flavidus	HH	HE	Jun-Aug	Jun-Sept	Jul-Sept	Jul-Oct	Oct-Dec	A
Cyperus haspan	HH	HE	Apr-Sept	Apr-Oct	May-Dec	Jun-Jan	Dec-Mar	A
Cyperus imbricatus	HH	HE	Apr-Sept	Apr-Oct	May-Sept	May-Oct	Oct-Dec	A
Cyperus iria	T	HA	Jul-Nov	Jul-Jan	Aug-Jan	Sept-Feb	Feb-Mar	A
Cyperus niveus	HH	HE	Apr-Sept	Apr-Oct	May-Sept	Jun-Oct	Nov-Dec	A
Cyperus pilosus	HH	HE	Jul-Sept	Jul-Oct	Aug-Dec	Sept-Feb	Dec-Mar	A
Cyperus rotundus	T	HE	Jul-Dec	Jul-Jan	Jul-Dec	Aug-Jan	Jan-Mar	A

Cyperus squarrosus	HH	HE	Apr-Sept	Apr-Dec	Jun-Feb	Jun-Mar	Feb-May	A
Dactyloctenium aegyptium	Ch	HA	Jun-Sept	Jun-Nov	Jul-Nov	Aug-Jan	Dec-Feb	E
Dentella repens	Ch	HA	May-Aug	Mar-Dec	Aug-Dec	Oct-Feb	Dec-Mar	E
Desmodium gangeticum	T	HA	Oct-Dec	Oct-Nov	Apr-Oct	May-Nov	Oct-Jan	E
Desmostachya bipinnata	H	HP	Feb-May	Feb-Sept	Apr-Dec	May-Jan	Jan-Mar	A
Digera arvensis	T	HA	May-Aug	May-Oct	Jul-Dec	Aug-Feb	Jan-Mar	E
Dopatrium junceum	T	HA	Jul-Aug	Jul-Oct	Aug-Oct	Sept-Nov	Nov-Dec	E
Echinochloa colona	T	HE	Jul-Oct	Jul-Oct	Jul-Nov	Aug-Dec	Dec-Mar	A
Echinochloa crus-galli	HH	HE	Jul-Oct	Jul-Oct	Aug-Nov	Sept-Dec	Dec-Mar	A
Echinochloa stagnina	HH	HE	Aug-Sept	Aug-Nov	Sept-Dec	Oct-Dec	Dec-Jan	A
Eclipta prostrata	T	HA	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Mar-Jul	A/E
Eichhornia crassipes	HD	HFF	Jul-Dec	Jan-Dec	Sept-Jan	Sept-Feb	Apr-Jun	E
Eleocharis congesta	HH	HE	Jul-Dec	Sept-Jan	Jul-Nov	Aug-Dec	Nov-Jan	A
Eleocharis palustris	HH	HE	Sept-Dec	Sept-Jan	Nov-Feb	Dec-Mar	Feb-May	A
Eleocharis retroflexa	HH	HA	Jul-Dec	Sept-Jan	Jul-Nov	Aug-Dec	Dec-Jan	A
Eleocharis tetraquetra	HH	HE	Sept-Dec	Sept-Jan	Oct-Nov	Nov-Dec	Dec-Jan	A/E
Eleusine indica	T	HA	Jun-Aug	Jun-Nov	Jul-Nov	Jul-Dec	Dec-Jan	E
Enydra fluctuans	Ch	HA	Nov-Dec	Jan-Dec	Jan-Mar	Feb-Apr	Apr-Jul	A/E
Eragrostis gangetica	T	HA	Jul-Aug	Jul-Dec	Aug-Dec	Sept-Feb	Dec-Feb	A
Eragrostis tenella	T	HA	Jul-Aug	Jul-Dec	Aug-Feb	Sept-Mar	Jan-Mar	A
Eragrostis unioloides	T	HA	Mar-Jun	Mar-Dec	Jun-Feb	Jul-Mar	Feb-Apr	E
Eriocaulon cinereum	HH	HE	Aug-Oct	Aug-Dec	Oct-Jan	Nov-Mar	Dec-Apr	A/E
Euphorbia indica	T	HA	Dec-Mar	Dec-Apr	Jan-Apr	Jan-May	Mar-May	E
Euryale ferox	HD	HRF	Dec-Feb	Dec-May	Apr-Jun	May-Jul	Jul-Aug	E
Ficus heterophylla	H	HP	Nov-Feb	Nov-Mar	Jan-May	Feb-Jun	Jun-Sept	E
Fimbristylis aestivalis	T	HA	Mar-Oct	Mar-Dec	Aug-Jan	Sept-Feb	Jan-Mar	A
Fimbristylis dichotoma	T	HA	Mar-Sept	Mar-Dec	May-Oct	Jun-Nov	Oct-Jan	A
Fimbristylis littoralis	HH	HE	Feb-Jun	Feb-Jul	Feb-Jun	Mar-Jul	Jun-Aug	A
Fimbristylis squarrosa	T	HE	Feb-Jun	Feb-Jul	Feb-Jun	Mar-Jul	Jun-Aug	E
Fimbristylis tetragona	T	HA	Jul-Oct	Jul-Dec	Oct-Dec	Oct-Jan	Dec-Feb	E
Fuirena ciliaris	T	HA	Sept-Nov	Sept-Nov	Oct-Nov	Nov-Dec	Dec-Jan	E
Fumaria indica	T	HA	Oct-Dec	Oct-Dec	Nov-Feb	Dec-Mar	Fed-Apr	A/E
Glinus lotoides	Ch	HA	*Feb-Jun*	Feb-Jul	Apr-Jul	May-Aug	Jul-Aug	E
Glinus oppositifolius	Ch	HA	Jan-Apr	Jan-Dec	Feb-Jun	Mar-Jul	Jul-Aug	E
Gnaphalium purpureum	T	HA	Jan-Mar	Jan-Dec	Feb-Oct	Mar-Non	Nov-Jan	A
Gnephalium luteo-album ssp *affine*	T	HA	Nov-Dec	Nov-Apr	Dec-Apr	Jan-May	Apr-Jul	A
Gnephalium luteo-album ssp *luteo- album*	T	HA	Nov-Jan	Nov-Apr	Jan-Mar	Feb-Jun	May-Jul	A
Gnephalium polycaulon	T	HA	Jan-Mar	Jan-Apr	Feb-Jun	Mar-Jul	May-Aug	E
Grangea maderaspatana	Ch	HA	Jan-Feb	Jan-Mar	Feb-Apr	Mar-	Apr-Jun	E

						May		
Hedyotis corymbosa	T	HA	Nov-Feb	Jan-Dec	Jan-Dec	Feb-Dec	Nov-Dec	A
Heliotropium indicum	T	HA	Aug-Nov	Aug-Mar	Sept-Jun	Oct-Jul	Jul-Aug	E
Heliotropium ovalifolium	T	HA	Jan-Mar	Jan-Jun	Jan-Jul	Jun-Aug	Aug-Sept	E
Hemarthria compressa	T	HE	Dec-Jan	Dec-Mar	Jan-Mar	Feb-Apr	Mar-May	E
Hemarthria longiflora	T	HE	Dec-Jan	Dec-Mar	Jan-Mar	Feb-Apr	Mar-May	E
Hydrilla verticillata	HD	HS	Jul-Aug	Jul- Mar	Nov-Jan	Dec-Feb	Feb-Apr	H
Hedyotis corymbosa	T	HA	Jul-Sept	Jul-Jan	Sept-Jan	Oct-Feb	Feb-Mar	A
Hydrolea zeylanica	HH	HE	Aug-Dec	Aug-Jan	Nov-Feb	Dec-Mar	Feb-Apr	A/E
Hygrophila auriculata	T	HA	Nov-Dec	Nov-May	Jan-Apr	Feb-Jul	Aug-Sept	E
Hygrophila difformis	Ch	HA	Sept-Nov	Oct-Mar	Jan-May	Feb-Jul	Jul-Aug	E
Hygrophila polysperma	T	HE	Oct-Dec	Oct-Aug	Mar-Jul	Apr-Jul	Jul-Aug	A/E
Hygroryza aristata	Ch	HE	Aug-Oct	Aug-Nov	Oct-Nov	Oct-Dec	Dec-Jan	E
Imperata cylindrical	H	HP	Jan-Apr	Jan-Dec	Feb-Apr	Mar-May	Aug-Dec	A
Ipomoea aquatica	Ch	HE	Jul-Dec	Jan-Dec	Aug-Feb	Sept-Feb	Feb-Apr	E
Ipomoea carnea var. *fistulosa*	H	SUA	Jul-Sept	Jul-Dec	Aug-Feb	Sept-Mar	Feb-May	E
Ixeris polycephala	T	HA	Nov-Jan	Nov-Feb	Nov-Apr	Dec-May	May-Jul	E
Justicia diffusa	T	HA	Aug-Oct	Aug-Apr	Oct-Feb	Jan-Apr	Mar-May	A
Justicia simplex	T	HA	Jul-Aug	Jul-Dec	Aug-Oct	Sept-Dec	Oct-Jan	A
Kyllinga brevifolia	T	HA	Dec-Jan	Dec-Mar	Jan-Mar	Feb-Apr	Mar-May	A
Lasia spinosa	C	HA	Jun-Aug	Jan-Dec	Nov-Jan	Dec-Feb	Feb-Jun	E
Launaea aspleniifolia	T	HA	Dec-Feb	Dec-May	Jan-Apr	Feb-May	Apr-Jul	E
Leersia hexandra	T	HA	Aug-Oct	Aug-Oct	Oct-Nov	Nov-Dec	Nov-Dec	A
Leptochloa panicea	T	HA	Mar-May	Mar-Nov	May-Sept	Jun-Oct	Oct-Jan	A
Limnophila heterophylla	HD	HE	Aug-Oct	Aug-Jan	Oct-Jan	Nov-Feb	Jan-Mar	E
Limnophila indica	HD	HE	Jul-Aug	Jul-Jan	Aug-Feb	Sept-Mar	Jan-Apr	E
Limnophila repens	HD	HE	Sept-Nov	Sept-Dec	Nov-jan	Dec-Feb	Jan-Mar	E/H
Limnophila sessiliflora	HD	HE	Jul-Sept	Jul-Dec	Sept-Jan	Nov-Feb	Jan-Mar	E/H
Lindernia anagallis	T	HA	Nov-Dec	Nov-Mar	Jan-Feb	Jan-Mar	Feb-Apr	E
Lindernia cordifolia	T	HA	Mar-Jun	Mar-Dec	Jul-Dec	Aug-Dec	Nov-Mar	A
Lindernia crustacea	Ch	HA	Jul-Aug	Jul-Dec	Aug-Dec	Oct-Dec	Nov-Mar	A
Lindernia hirsuta	T	HA	Jun-Jul	Jun-Dec	Jun-Nov	Oct-Dec	Nov-Jan	E
Lindernia oppositifolia	T	HA	Jul-Aug	Jul-Dec	Aug-Dec	Oct-Dec	Nov-Mar	E
Lindernia pusilla	T	HA	Jul-Aug	Jul-Nov	Aug-Nov	Oct-Jan	Dec-Feb	A/E
Lindernia pyxidaria	T	HA	May-Aug	Jul-Dec	June-Jan	Aug-Dec	Nov-Feb	E
Lippia javanica	P	HA	Jan-Apr	Jan-Sept	Jan-Jul	Feb-Aug	Sept-Nov	E
Lobelia alsinoides	T	HE	Sept-Nov	Sept-Nov	Sept-Nov	Oct-Dec	Nov-Dec	E
Ludwigia adscendens	HD	HT	Jul-Aug	Jan-Dec	Sept-May	Oct-Jun	Jun-Jul	E
Ludwigia octavalvis ssp	T	HE	Jul-Aug	Jul-Dec	Aug-Jan	Sept-Feb	Dec-Feb	E

sessiliflora								
Ludwigia perennis	T	HE	Jul-Aug	Jul-Feb	Aug-Mar	Sept-Apr	Jan-Mar	E
Mariscus compactus	HH	HE	Jul-Aug	Jul-Oct	Aug-Nov	Aug-Dec	Nov-Dec	A
Mariscus sumatrensis	HH	HE	Jul-Aug	Jul-Oct	Aug-Nov	Aug-Dec	Nov-Dec	A
Mazus pumilus	T	HA	Oct-Dec	Jan-Dec	Nov-Mar	Dec-Apr	Mar-May	E
Mecardonia procumbens	Ch	HA	Jul-Aug	Jul-Jan	Sept-Mar	Oct-Mar	Feb-Jun	E
Medicago lupulina	T	HA	Jan-Mar	Jan-Apr	Jan-Jun	Feb-Jul	Jun-Aug	E
Melochia corchorifolia	T	HA	Jul-Aug	Jul-Oct	Jun-Nov	Jul-Dec	Nov-Jan	A/E
Microcarpaea minima	Ch	HA	Oct-Dec	Oct-Dec	Nov-Dec	Dec-Jan	Dec-Feb	E/H
Mollugo pentaphylla	Ch	HA	Dec-Mar	Dec-Sept	Jan-Sept	Feb-Oct	Oct-Nov	E
Monochoria hastata	HD	HE	Jul-Dec	Jul-Jan	Aug-Sept	Aug-Oct	Nov-Feb	A/E
Monochoria vaginalis	HD	HE	Jul-Jan	Jul-Jan	Sept-Apr	Oct-May	Apr-Jun	A
Murdannia nudiflora	T	HA	Aug-Oct	Aug-Nov	Sept-Nov	Oct-Dec	Nov-Jan	E
Murdannia spirata	T	HA	Jul-Aug	Jul-Nov	Aug-Nov	Oct-Dec	Dec-Jan	E
Myriophyllum indicum	HD	HE	Aug-Nov	Aug-Dec	Jul-Dec	Aug-Jan	Dec-Mar	A/H
Myriophyllum tuberculatum	HD	HE	Jul-Nov	Aug-Dec	Jul-Dec	Aug-Jan	Dec-Mar	A/E
Najas graminea	HD	HS	Aug-Oct	Aug-Dec	Oct-Mar	Nov-Apr	Apr-Jun	H
Najas indica	HD	HS	Aug-Oct	Aug-Dec	Nov-Jan	Nov-Feb	Apr-Jun	H
Nechamandra alternifolia	HD	HS	Aug-Oct	Aug-Apr	Nov-Feb	Jan-Apr	Mar-May	H
Nelsonia canescens	Ch	HA	Dec-Jan	Dec-Apr	Feb-Mar	Mar-May	May-Jun	E
Nesaea brevipes	T	HA	Oct-Dec	Oct-Jan	Nov-Feb	Dec-Mar	Mar-Apr	E
Nicotiana plumbaginifolia	T	HA	Oct-Dec	Oct-Jan	Nov-Feb	Dec-Mar	Mar-May	E
Nymphaea nouchali	HD	HRF	Jul-Aug	Jul-Dec	Aug-Dec	Sept-Jan	Dec-Feb	E
Nymphaea pubescens	HD	HRF	Jul-Aug	Jul-Dec	Aug-Dec	Sept-Jan	Dec-Feb	E
Nymphoides hydrophylla	HD	HRF	Jul-Oct	Jan-Dec	Jan-Dec	Jan-Dec	Feb-Jun	E
Nymphoides indica	HD	HRF	Jul-Oct	Jan-Dec	Jan-Dec	Jan-Dec	Feb-Jun	E
Oenanthe javanica	T	HA	Dec-Feb	Jan-Mar	Jan-Mar	Feb-Apr	Mar-May	A/E
Oldenlandia biflora	T	HA	Jul-Sept	Jul-Jan	Sept-Jan	Oct-Feb	Feb-Mar	A
Oldenlandia corymbosa	T	HA	Jan-Apr	Jan-Dec	Feb-Jun	Mar-Jul	Jul-Aug	E
Oryza rufipogon	T	HA	Oct-Dec	Oct-Nov	Nov-Dec	Dec-Jan	Jan-Mar	A
Ottelia alismoides	HD	HS	Jul-Aug	Aug-Mar	Oct-Feb	Dec-Mar	Feb-Mar	E
Panicum repens	T	HA	Jul-Oct	Jul-Nov	Sept-Nov	Sept-Dec	Dec-Feb	A
Parthenium hysterophorus	T	HA	Jun-Jul & Nov-Dec	Jan-Dec	Jan-Dec	Jan-Nov	Sept-Nov	A
Paspalidium flavidum	T	HA	Jul-Oct	Jul-Oct	Aug-Nov	Sept-Dec	Nov-Jan	E
Paspalidium punctatum	T	HA	Jul-Sept	Jul-Nov	Aug-Nov	Sept-Dec	Nov-Dec	A
Paspalum distichum	T	HA	Mar-May	Mar-Nov	Jun-Nov	Jul-Dec	Nov-Feb	A
Paspalum scrobiculatum	T	HE	Jun-Aug	Jun-Nov	Aug-Sept	Sept-Nov	Nov-Dec	A
Pentapetes phoenicea	T	HSU	Jun-Sept	Jun-Oct	Aug-Oct	Sept-Dec	Nov-Jan	E
Persicaria barbata	T	HA	Jul-Jan	Jul-Feb	Jul-Nov	Aug-Dec	Jan-Mar	A/E
Persicaria hydropiper	T	HE	Mar-May	Mar-Nov	May-Nov	Jun-Dec	Dec-Mar	E
Persicaria lapathifolia	T	HE	Apr-Sept	Apr-Dec	May-Oct	Jun-Nov	Nov-Jan	E

Physalis orientalis	T	HA	.Mar-May	Mar-Nov	Apr-Jan	May-Feb	Nov-Mar	A/E
Persicaria salicifolia	T	HA	Apr-Sept	Apr-Dec	Jun-Dec	Jul-Jan	Jan-Mar	E
Pistea stratiotes	HD	HFF	Apr-Sept	Apr-Dec	May-Sept	Jun-Oct	Nov-Feb	E
Polygonum plebeium	T	HA	Feb-Jun	Feb-Sept	Mar-Aug	Apr-Sept	Aug-Sept	A/E
Potamogeton crispus	HD	HS	Jul-Oct	Jan-Dec	Aug-Nov	Aug-Dec	Dec-Mar	A/H
Potamogeton nodosus	HD	HRF	Jul-Aug	Jul-Dec	Sept-Feb	Oct-Mar	Feb-Apr	H
Pouzolzia zeylanica	HH	HE	Jul-Aug	Jul-Oct	Sept-Nov	Oct-Dec	Nov-Dec	E
Ranunculus sceleratus	T	HA	Oct-Jan	Oct-Feb	Dec-Mar	Jan-Apr	Mar-Apr	E
Rosa involucrata	P	SUA	Dec-Jan	Dec-Jun	Feb-Aug	Mar-Aug	Aug-Sept	E
Rotala rosea	T	HA	Jul-Oct	Jul-Dec	Aug-Nov	Sept-Dec	Dec-Jan	E
Rotala rotundifolia	T	HA	Oct-Jan	Oct-Mar	Nov-Mar	Dec-Apr	Apr-May	E
Rottboellia cochinchinensis	T	HA	Jul-Oct	Jul-Dec	Aug-Nov	Sept-Dec	Dec-Feb	A
Rumex dentatus	T	HA	Feb-May	Feb-Jul	Mar-Sept	Apr-Oct	Nov-Dec	E
Rumex maritimus	T	HA	Nov-Feb	Nov-Apr	Dec-Mar	Jan-Apr	Api-May	E
Rungia pectinata	T	HA	Aug-Oct	Aug-May	Nov-Mar	Jan-Apr	Mar-Jul	A
Saccharum spontaneum	H	HP	Jun-Sept	Jun-Oct	Sept-Nov	Oct-Dec	Dec-Jan	A
Sacciolepis indica	T	HA	Jul-Oct	Jan-Dec	Aug-Dec	Sept-Jan	Jan-Apr	A
Sacciolepis interrupta	H	HP	Jul-Nov	Jul-Dec	Aug-Jan	Sept-Feb	Dec-Apr	E
Sagittaria guayanensis	HD	HRF	Jul-Aug	Jul-Oct	Aug-Nov	Aug-Dec	Nov-Jan	E
Sagittaria sagittifolia	C	HE	Jan-Mar	Jan-Apr	Feb-Aug	Mar-Aug	Jul-Sept	E
Schoenoplectus articulatus	H	HE	Aug-Dec	Aug-Jan	Oct-Dec	Nov-Jan	Dec-Mar	A
Schoenoplectus grossus	H	HE	Aug-Dec	Aug-Jan	Sept-Dec	Oct-Jan	Dec-Feb	A
Schoenoplectus lateriflorus	HH	HE	Jul-Aug	Aug-Jan	Aug-Dec	Sept-Jan	Dec-Jan	A
Schoenoplectus juncoides	HH	HE	Jun-Jul	Jun-Nov	Jul-Jan	Aug-Feb	Jan-Apr	A
Schoenoplectus mucronatus	T	HA	Jun-Oct	Jun-Nov	Aug-Dec	Sept-Jan	Dec-Feb	A
Schoenoplectus supinus	HH	HE	Jul-Aug	Aug-Jan	Aug-Dec	Sept-Jan	Dec-Feb	A
Scirpus michelianum	T	HA	Aug-Dec	Aug-Jan	Jul-Dec	Aug-Feb	Jan-Apr	A/E
Seseli diffusum	T	HA	Dec-Feb	Jan-Mar	Jan-Mar	Feb-Apr	Mar-May	E
Setaria glauca	T	HA	Jan-Mar	Jan-Jun	Feb-Jul	Mar-Aug	Jul-Aug	A
Solanum nigrum	T	HA	Sept-Nov	Sept-Jan	Nov-Mar	Nov-Apr	Mar-May	E
Solanum torvum	T	HA	Sept-Nov	Sept-Dec	Nov-Mar	Nov-Apr	Mar-Apr	E
Sphaeranthus indicus	Ch	HA	Dec-Jan	Dec-Mar	Jan-Mar	Feb-May	Apr-Jun	E
Sphenoclea zeylanica	T	HA	Dec-Aug	Dec-Sept	Jan-Sept	Jan-Oct	Oct-Nov	E
Spilanthes calva	Ch	HA	Jul-Sept	Jul-Mar	Sept-Feb	Nov-Mar	Feb-May	E
Thespis divaricata	T	HA	Feb-Mar	Feb-May	Apr-Jul	May-Jul	Jul-Aug	E
Tonningia axillaris	Ch	HA	Jul-Sept	Jul-Nov	Jul-Dec	Aug-Jan	Dec-Feb	E
Typhonium flagelliforme	C	HE	Jul-Sept	Jul-Dec	Aug-Oct	Sept-Nov	Oct-Dec	E
Utricularia aurea	HD	HSP	Jul-Sept	Jul-Oct	Sept-Jan	Oct-Feb	Jan-Mar	A
Utricularia gibbosa ssp. *exoleta*	HD	HSP	Jul-Oct	Jul-Dec	Sept-Jan	Oct-Feb	Feb-Mar	A
Utricularia inflexa var. *stellaris*	HD	HSP	Jul-Nov	Jul-Oct	Sept-Jan	Oct-Feb	Jan-Mar	A
Vallisneria spiralis var. *denseserrulata*	HD	HS	Dec-Jan	Dec-Sept	Jan-May	Feb-Jul	Jun-Sept	H

Veronica anagallis-aquatica	T	HA	Sept-Oct	Sept-Dec	Nov-Jan	Dec-Jan	Jan-Mar	E
Vetiveria zizanioides	H	HP	Jul-Sept	Jul-Oct	Aug-Oct	Sept-Dec	Nov-Jan	A
Wahlenbergia marginata	T	HA	Oct-Nov	Oct-Jan	Nov-Feb	Jan-Apr	Mar-May	A/E
Xanthium indicum	P	HA	Dec-Jan	Jan-Dec	Aug-Mar	Aug-Apr	Jul-Oct	E
Xyris pauciflora	T	HE	Oct-Nov	Oct-Dec	Oct-Jan	Dec-Jan	Dec-Feb	E
Zeuxine strateumatica	T	HE	Dec-Jan	Feb-Mar	Mar-Apr	Mar-May	Apr-Jun	E

6.2.3.2. Vegetative growth

Most of the angiospermic plants show their maximum vegetative growth during July to August. The peak period for vegetative growth is September to October. During October ±162 species remain in vegetative stage followed by September (157 species), November (152 species), December (153 species), August (146) and January (127 Species). There are 22 species, those show their vegetative growth round the year and also produce flower for some period. The vegetative growth declines during dry period and the peak month is May when only 75 species show their vegetative growth.

6.2.3.3. Flowering

The vegetative phase is interrupted with reproductive state i.e. flowering. It has been observed that most interesting period is September-January when maximum number of wetland plants (Aquatic and amphibian plants) found in blooming stage. The peak month is November when 123 plants were recorded in flowering condition followed by September to December (118 species) and January (112 species).

During dry period, February (100 species) and March (70 Species) show highest number of species in flowering stage. During April to June when the flowering phase declines and most of the aquatic and amphibian plants disappear. On the other hand, during dry period, wetlands become the house for few terrestrial plants and most of them in flower during March to June. So, the monsoon and winter are main flowering periods for most of the wetland plants.

There are 5 species *Cyperus difformis, Nymphoides hydrophylla, Nymphoides indica, Hedyotis corymbosa* and *Eclipta prostrata* those extend their flowering phase round the year.

6.2.3.4. Pollination

Pollination is the very important step towards the reproduction of plants. Pollination helps the fertilization to produce proper seeds. The pollination of wetland plants is somehow interesting. All three major pollination type i.e. Anemophilly, Zoophily (mostly Entomophilous) and Hydrophily are common for wetland plants. The field observation of 220 angiosperms, it has been recorded that around 109 (49.77 %) species are Entomophilous followed by Anemophilous (75 species) and Hydrophilous (9

species). Some species utilized two or more ways for effective pollination. So, there are 21 anemo – entomophilous, 4 entomo– epihydrophilous and only 2 anemo – epihydrophilous. Among the 9 hydrophilous plants, 4 species (*Najas indica, N. graminea, Nechamandra alternifolia* and *Ceratophyllum demersum*) are hypohydrophilous (fertilization takes place under water) and rests 5 species (*Hydrilla verticillata, Blyxa octandra, Nechamandra alternifolia, Vallisneria spiralis* var. *denseserrulata* and *Potamogeton crispus*) are epihydrophilous (fertilization takes place on the water surface). Table 6.4 shows the numerical distribution of different categories of pollination in these plants.

Table: 6.4. Pattern of Pollination types found in wetland plants of Maldah district

Sl. No.	Pollination type	No. of Species	Percentage (%)
01.	Anemophilous	75	34.25
02.	Entomophilous	109	49.77
03.	Hypohydrophilous	4	1.83
04.	Epihydrophilous	5	2.28
05.	Anemo-Entomophilous	21	9.59
06.	Entomo-Epihydrophilous	4	1.83
07.	Anemo-Epihydrophilous	2	0.91
	Total	**220**	

6.2.3.5. Fruit

After the effective pollination the ovaries transform into fruits. As for the other plants, wetland plants also bear fruits simultaneously with flower. Similarly, fruit dehiscence or seed dispersal also continue parallel with flowering and fruiting. The herbaceous flora of wetland bear fruits with flower for most part of their life span. It is observed that during October to February most of the plants remain in fruiting stage. The peak month is December when around 132 species bear fruits. The next peak month is November (121 species) and is followed by October (118 species), January (114 species) and February (108 species). June and July shows lowest number of plants in their fruiting stage. Six species, namely *Cynodon dactylon, Cyperus difformis, Eclipta prostrata. Nymphoides hydrophylla, N. indica* and *Parthenium hysterophorus* produce fruits round the year.

6.2.3.6. Seed Dispersal

Seed dispersal is another important stage in the life cycle of a plant. The fruit of aquatic plants are generally indehiscent so the dispersal occur due only degradation of fruit wall. But there are several semi-aquatic, marshy and wetland plant those bear dehiscent fruits. So, various mode of seed dispersal have been recognized among the recorded species. Accordingly, different recorded modes of dispersal are:

(i). ***Zoochorous*** (by animals): The seeds of aquatic or marshy plants of families like Asteraceae, Poaceae, Cyperaceae etc. are mainly dispersed by the aquatic birds, snails, cattle etc.

(ii.) ***Anemochorous*** (by wind): The species Asteraceae, Solanaceae etc used this process for seed dispersal.

(iii.) ***Hydrochorous*** (by water flow): Fruit or seeds of family Nelumbonaceae, Nymphaeaceae, Menyanthaceae, Hydrocharitaceae, Cyperaceae, Poaceae etc. are dispersed by this process.

(iv.) ***Some special mechanical process***: Species family Acanthaceae used explosive mechanism for dispersal seed.

6.2.3.7. Death or Withdrawal

It is observed that most of the herbaceous species has no interphase between seed dispersal and germination. However, in wetland habitat it is mandatory for some species to have a minimum dormant period. Mainly the true aquatic species are unable to germinate or sprout in dry period because they need enough water for germination and seedling growth. Similarly some terrestrial weeds that grow during dry period cannot survive during monsoon. The death or resting phase of aquatic and amphibian plants are maximum during February and March (96 and 95 species respectively). On the other hand plants that grow during dry seasons become dead or dormant during July and August (28 and 22 species respectively).

The phenological study of wetland plants helps us to understand the life cycle pattern of those wetland plants. The plants are always struggling for their existent with local climate. Most of the aquatic or semi aquatic plants complete their life cycle before dry season and the seeds remain dormant during the entire dry period. These seed again germinate with the drop of first rain of monsoon season. On the other hand few terrestrial plants avoid the flood during rainy season. They complete their life cycle before monsoon starts and seed becomes dormant during monsoon under-water soil. The plant that grows in wetlands of Maldah shows such interesting phenophasic characters.

Table: 6.5. Distribution of different phenophasic parameters for wetland plants in Maldah

Month	Phenophases									
	Germinatio/ new flash		Vegetative growth		Flowering		Fruiting & seed dispersal		Death/Rest	
	No.	%	No.	%	No.	%	No.	%	No.	%
January	58	26.48	126	57.53	111	50.68	114	52.05	93	42.47
February	37	16.89	105	47.95	100	45.66	108	49.32	96	43.84
March	35	15.98	109	49.77	70	31.96	94	42.92	95	43.38
April	33	15.07	90	41.10	54	24.66	72	32.88	77	35.16
May	32	14.61	77	35.16	55	25.11	56	25.57	57	26.03
June	36	16.44	82	37.44	56	25.57	55	25.11	39	17.81

July	98	44.75	130	59.36	63	28.77	51	23.29	37	16.89
August	120	54.79	146	66.67	101	46.12	66	30.14	28	12.79
September	94	42.92	157	71.69	120	54.79	93	42.47	21	9.59
October	74	33.79	162	73.97	120	54.79	118	53.88	19	8.68
November	51	23.29	154	70.32	125	57.08	121	55.25	47	21.46
December	73	33.33	153	69.86	117	53.42	132	60.27	81	39.99

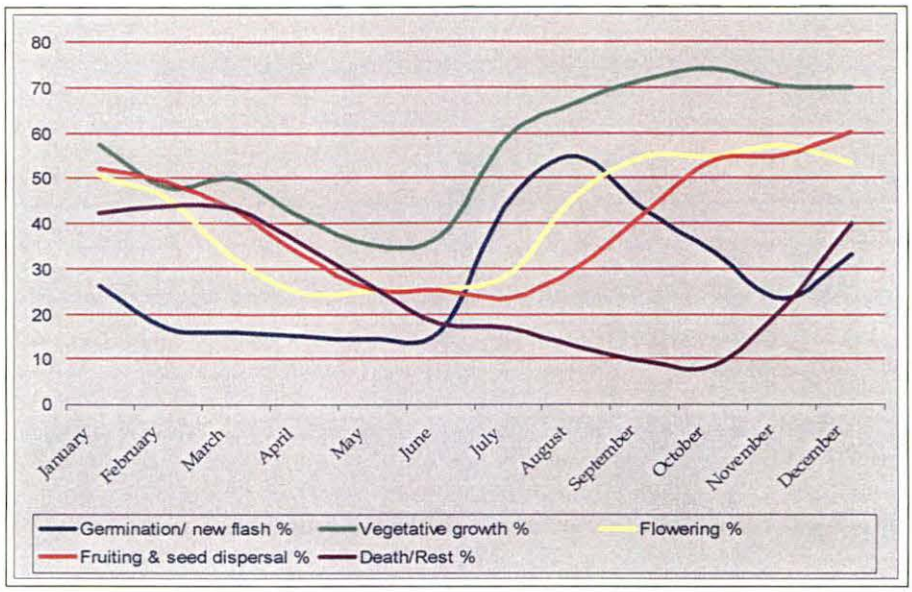

Fig: 6.1. **Graph representing different phenophasic parameters of wetland plants**

The graphical representation shows the comparative study of different phenophasic parameters of wetland plants. This graph shows it clearly that the period late July to February is good for all the parameters of wetland plants because during this period wetland areas remain filled with water. On the other hand, during April to June when most of the wetlands of this region dried up, majority of warm season species proceed to resting phase and that is reflected in the decline of different phenophases.

During the present investigation several interesting points have been noted. Some true aquatic plants belonging to the families Nymphaeaceae, Menyanthaceae, Araceae and Pontederiaceae are generally regenerate vegetatively from the last year's rhizome. But most of the marshland and submerged plants are regenerate through the germination of their seeds. Seedling appearance or dormancy of seed, in some aquatic species depends on rainfall and ambient temperature during August to December. However, several semi-aquatic or terrestrial plants start appearing with the withdrawal of water and the increase of ambient temperature during April-May. It is very interesting feature of wetland plant that aquatic and semi aquatic plants start life cycle with the first shown of rain during monsoon and complete before the onset of dry season. On the other hand several terrestrial plants grow in wetland during dry period. These plants also start life cycle during December- March and complete before the start of monsoon shows during July – August. So the wet loving plants remain dormant during summer

whereas dry soil lovers remain dormant during rainy season. There are so many perennial plants those grow in wetland throughout the year. Few plants like *Coix aquatica, Xyris pauciflora, Typhonium flagelliforme* shows very short life cycle only about 3 months. *Rosa involucrata,* a wetland wild rose shows interesting phenology. It starts producing new shoots after the withdrawal of water and with the onset of starts rain, rootstalk become dormant, withdraw the aerial branches and wait upto the next dry period.