INTERNATIONAL JOURNAL OF ENVIRONMENT

Volume-2, Issue-1, Sep-Nov 2013 **ISSN 2091-2854**

Received:12 September ***Revised:5 October*** ***Accepted:10 October***

HUMAN THREAT ON PHENOLOGICAL CYCLE OF SELECTED DRY DECIDUOUS TREE SPECIES IN NORTH GUJARAT REGION (NGR), GUJARAT, INDIA

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Abstract

Phenological observations were taken for 13 woody species for two years (Jan 2006 - Dec 2007) in dry deciduous forest of North Gujarat. The phenological behavior of most of the woody species was almost similar in two different years. Leaf initiation started in the month of March with peak April – May before pre-monsoon showers and leaf - fall began in October with a peak in November and December. Flowering in most of the woody species was observed in the month of February continued till May, fruit appearance for these species from March, with a peak of August. In July and August 69% of woody species appeared in fruit ripening stage. While monsoon begins same duration, that allow to the optimal germination of tree species. An observing human impact on selected species facing seasonal threats, more number of species faced cutting during leaf fall period or before on setting of flowers.

Key words: Dry deciduous, Human impact, Cutting, Woody species, Leaf fall

Introduction

Phenology is the relationship between climatic factors and periodic phenomena in organisms. Plant phenologies are the result of interactions of biotic and climatic factors with plant species that through natural selection, determine the most efficient timing for growth and reproduction (Van Schaik et al., 1993). Biotic factors include morphological and physiological adaptations of plants (Borchert, 1983) and climatic factors include photoperiod (Wright and Van Schaik, 1994), temperature (Arroyo et al., 1981) and rainfall (Opler et al., 1976).

The plant species within communities may share phenological patterns at varying degrees for a variety of reasons, for example, being subject to the same climatic regimes. The plant species may also share phenologial patterns independently of their morphological and physiological adaptations. On the other hand different species may show similar patterns in phenology because of close phylogeny (Wright and Calderon, 1995). Hence, the study on phenology provide knowledge about the pattern of plant growth, relationship with

environment and selective pressure on flowering and fruiting behaviors of a particular region or vegetation type (Zhang et al., 2006).

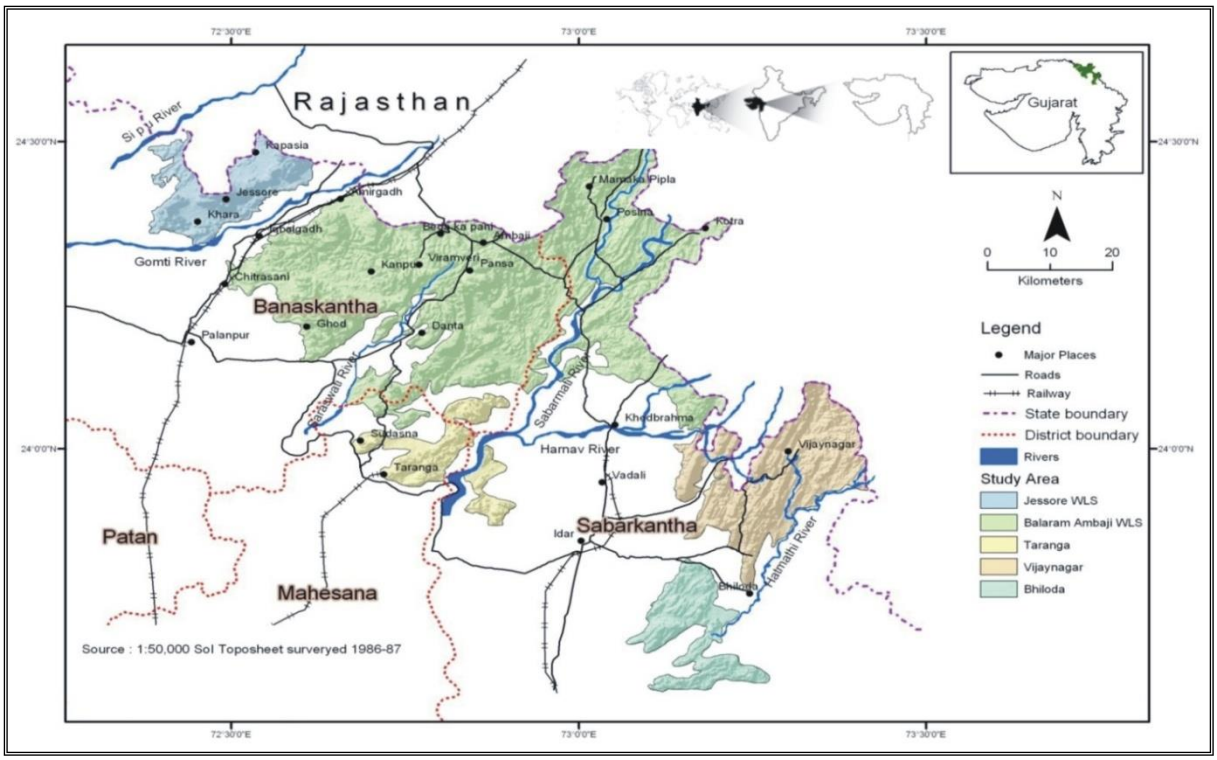
The NGR is dominated by dry deciduous forest, falls under agro-climatic zones and hot semi-arid type. The study area in NGR experiences three prominent seasons: summer, winter and monsoon. The summer season covers the months between March and June, while the monsoon starts in the month of July and lasts till the end of October. Winter season stars in November and ends in February. The average rainfall was of 913mm during the period of 2001 – 2007, with the minimum of 373 mm in 2002 and maximum of 1483mm in 2006. The temperature ranged from 5^0 (winter) – 46^0 (summer). Above said climatic conditions provides an ideal environment for the occurrence and abundance of diverse flora and the richness of this forest. In additions, the presence of biotic, abiotic and threat factors of diverse habitats also give selective pressure on plants, which might change the pattern of plant growth and reproduction (Joshua et al., 2007).

Further, tree species in this habitat are used by local people for constructing house, furniture, fuel wood and fodder for cattle has added to the degradation. As a result, significant numbers of woody species have lost their regeneration capacity. The present study on phenology of selected dry deciduous tree species was comprises, vegetative and reproductive status of plants, mainly flowering and fruiting patterns and human pressure on phenological cycles of tree species. An outcome of this study provides information on factors which exactly affects the reproduction potential of tree species. Also, the study results reflect the changes in phenological patterns of tree species by on-going human threats in long-term.

Materials and Methods:

Study area

The NGR lies between 23^o 35' 13.0" to 24^o 30' 57.0" N and 72^o 10' 28.0" to 73^o 24' 47.0" E and falls under three administrative districts viz. Banaskantha, Sabarkantha and Meshsana. It extends to about 8.7% (1638 km^2) of the total forest cover of Gujarat state (18,868.28 km^2) and includes protected areas viz. Jessore Sloth Bear Wildlife Sanctuary (JSBWS), Balaram Ambaji Wildlife Sanctuary (BAWS), Taranga hill and Vijaynagar forest (Map 1). Forest was the most predominant land use type of the study area covering 1638 km^2, followed by agriculture land use largely in the valleys. Third major land use is rocky barren surface, while mining areas cover over 15 km^2. Only 8 km^2 areas are in the form of water bodies or wetlands (Joshua et al., 2007). Although major forest types are found in the study area, they have been classified into two major sub-groups viz. 5A - Southern Tropical Dry Deciduous Forest and 6B - Northern Tropical Thorn Forest (Champion and Seth, 1968). The dominant soil of this region is classified as alluvial sandy soil mixture of sandy and coarse particles. Further, sandy loam and black soil are distributed in Banaskantha and Sabarkantha districts. In Meshana, 90% of the area is covered by light sandy soil and at some patches where sandy soil is mixed with black soil, the cultivation is possible. The pure sandy soil usually distributed in the forest region of Meshana districts, mainly Taranga hill and Abarkantha forest, have good natural thorn forest (Chavan and Lal, 1984).



Map 1: Location of Study Area

Field study

To study the phenology, 13 dominant dry deciduous species were selected and 10 individuals of each were marked and studied during the period of Jan 2006 to Dec 2007. These species were checked once in every 15 days (twice in a month, n=48) (Marques et al., 2004). Phenological study included various stages of vegetative phases (Sprouting leaves (SPL), Young leaves (YL), Matured leaves (ML), Dead leaves or Yellow leaves (DL/YEL) and No leaves (NIL) and reproductive phases (flowering and fruiting stage). Flowering stage was further divided into Flower Bud (FLB), Young Flower (YFL), and Matured Flower (MFL), while the fruiting stage was divided into Young fruit (YFR), Matured Fruit (MFR), and Dry fruit (DFR). Availability of different stages was given in percentage with both vegetative and reproductive phases accounting for 100% each. Human interference on phenology was recorded by cutting and lopping signs on selected trees species.

Data analysis

The variation of phenology were examined and classified into (1) Flushing (2) Leaf Fall (3) Flowering and (4) Fruiting. Flushing is defined to be the interval between the beginnings of leaf bud opening to the appearance new leaves to at least 75% of their final size. This was calculated from the proposition of SPL, YL, and ML. Leaf fall is defined as when <50% of the leaves on the plant showed DL, YEL and NL or fallen leaves were on the ground. Flowering was the presence of the one or more open flowers in the phase of FLB, YFL and MFL. Similarly fruiting was the presence of one or more fruit in the phases of YFR, MFR and DFR. Intervals between phases were also examined. Further, month wise cutting activities were concurrent with phenology of plant species.

Results

Leaf flushing: Leaf initiation started in the month March. The flushing was continued till the month of July - August, with a peak in May – June before the onset of monsoon (Figure 1). Out of the 13 species studied, *Butea monosperma* and *Diospyros melanoxylon* showed leaf initiation in March 2006 followed by *Aegle marmelos*, *Anogeissus latifolia*, *Feronia limonia*, *Holarrhena pubscens*, *Lannea coromandelica*, *Miliusa tomentosa*, *Mitragyna parvifolia*, *Terminalia bellirica* in April and *Boswellia serrata*, *Cassia fistula*, *Wrightia tinctoria* in May. But in 2007, 11 species, (about 85%) showed leaf initiation in April followed by May (Table 1).

Table 1: Flushing, leaf fall, flowering and fruiting pattern of woody species in three different forest types of North Gujarat Region

Sl. No	Scientific Name	Flushing		Leaf Fall		Flowering		Fruiting	
		2006	2007	2006	2007	2006	2007	2006	2007
1	*Aegle marmelos* (L.) Corr.	Apr	Apr	Nov	Nov	Mar	Mar	Apr	Apr
2	*Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill. & Perr.	Apr	Apr	Dec	Nov	Oct	Sep	Nov	Nov
3	*Boswellia serrata* Roxb. ex Cocls.	May	May	Nov	Nov	Feb	Feb	Apr	Apr
4	*Butea monosperma* (Lam.) Taub.	Mar	Apr	Nov	Nov	Feb	Jan	Apr	Apr
5	*Cassia fistula* L.	May	Apr	Nov	Nov	Apr	Apr	May	May
6	*Diospyros melanoxylon* Roxb.	Mar	Apr	Nov	Nov	Apr	Apr	Jun	Jun
7	*Feronia limonia* (L.) Swingle	Apr	Apr	Nov	Nov	May	Apr	Jun	May
8	*Holarrhena pubscens* (Buch. - Ham.) Wall. ex G. Don	Apr	Apr	Nov	Nov	Mar	Mar	May	May
9	*Lannea coromandelica* (Houtt.) Merrill	Apr	Apr	Nov	Oct	Feb	Feb	Apr	Apr
10	*Miliusa tomentosa* (Roxb.) J. Sinclair	Apr	Apr	Nov	Oct	Mar	Mar	May	May
11	*Mitragyna parvifolia* (Roxb.) Korth.	Apr	Apr	Nov	Nov	Apr	Mar	May	May
12	*Terminalia bellirica* (Gaertn.) Roxb.	Apr	Apr	Nov	Nov	Mar	Mar	May	May
13	*Wrightia tinctoria* (Roxb.) R. Br.	May	May	Nov	Nov	Mar	Mar	May	Apr

Leaf fall: Leaf shedding began in the month of October with peaks in November and December (Figure 1). The earliest leaf shedding was also observed in *Lannea coromandelica* and *Miliusa tomentosa*.

Flowering: Flowering activity of selected woody species is in the month of February continued till May. When *Aegle marmelos*, *Boswellia serrata*, *Butea monosperma*, *Cassia fistula*, *Diospyros melanoxylon*, *Feronia limonia*, *Holarrhena pubscens*, *Lannea coromandelica*, *Miliusa tomentosa*, *Mitragyna parvifolia*, *Terminalia bellirica*, *Wrightia tinctoria* flowering pattern were observed (Figure 1 and Table 1).

Fruiting: The initial fruiting activity was observed in the month of March. All the selected species had attained the fruiting stage in April and May continued till November, with a peak in August (Figure 1). During this period 69% of the woody species (*Aegle marmelos*,

Boswellia serrata, *Butea monosperma*, *Cassia fistula*, *Holarrhena pubscens*, *Miliusa tomentosa*, *Mitragyna parvifolia*, *Terminalia bellirica*, *Wrightia tinctoria*) appered to be in fruiting stage. Rest of the species attained fruiting stage in June (Table 1).

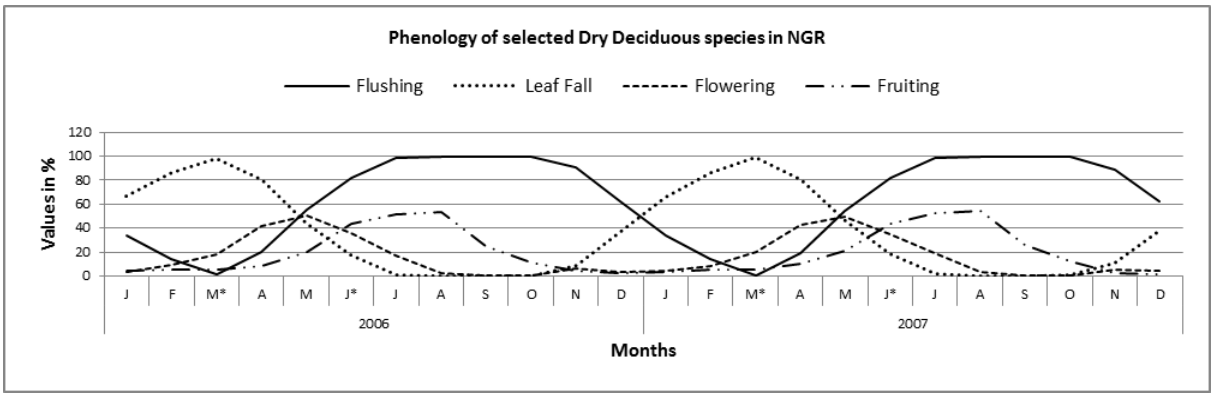


Figure 1: Phenological pattern of selected dry deciduous species in North Gujarat Region

Human interface on phenological cycle: Two years of phenological observation showed all studied species faced threat in the form of cutting. Month wise cutting activities of 13 species are given figure 2. It revealed that, more numbers of species faced cutting during winter (Dec - Feb) or before the winter seasons starts (Sep - Nov) and, 80% species faced threats during the summer (May – Jun). Rest of the months the plant faced minimal threats

Further, the cutting activities were correlated with phenological cycle. Out of 13 species 11 species (except *Holarrhena pubscens* and *Lannea coromandelica*) faced cutting, in the month of May – Jun during the leaf initiation stage. Whereas Sep – Nov, Dec – Feb all the tree species faced high incidence cutting, that falls leaf fall stage. But *Anogeissus latifolia* and *Lannea coromandelica* were in reproductive stage.

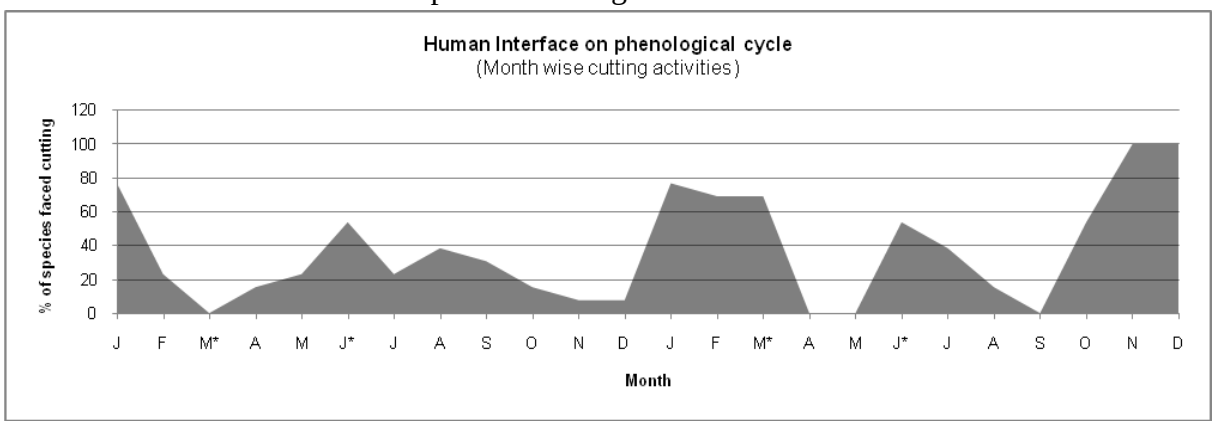


Figure 2: Month wise human interface on phonological cycle of selected dry deciduous species in North Gujarat Region

Discussion

Leaf flushing: Leaf initiation peak in May may be attributed to the triggering effect of the rising temperature and increase in the length of photoperiods as suggested by Njoku (1964), Lawton and Akpan (1968) and Walter (1968). Leaf production during the dry seasons and before rains has already been observed by several researchers (Frankie et al., 1974; Shukla

and Ramakrishnan, 1982; Sundriyal, 1990; Singh and Singh, 1992; Kikim and Yadava, 2001; Singh and Kushwaha, 2005a and b; Yadav and Yadav, 2008). Borchert and Rivera (2001) also suggested that in dry summer season, the vegetative buds of spring flushing stem succulent species are in a state of endo-induced dormancy and terminated by declining and increasing photoperiod, respectively. The role of photoperiod has been confirmed by Rivera et al (2002) who reported that spring flushing in tropical semi-deciduous trees is induced by an increase in photoperiod of 30 minutes or less. They further supported that production of new foliage shortly before the rainy season is likely to optimize synthetic gain in tropical forests with relatively short growing season. This is also approved by Elliot et al (2006) and Kushwaha and Singh (2005).

Leaf fall: The leaf fall was concentrated in cool winter months of the year i.e. from October to December. Prasad and Hegde (1986) observed similar pattern of leaf fall in tropical deciduous forests in the Bandipur Tiger Reserve, South India. The results are also in conformity with Singh and Singh (1992) who reported that initiation of leaf fall coincides with the onset of the post-monsoon, low temperature, dry period and can be a mechanism maintaining turgidity of shoots. However, Borchert and Rivera (2001) and Borchert et al (2002) suggested that in Argentina forest, leaf shedding of several species before time is probably caused by a combination of increasing leaf age and declining photoperiod rather than increasing drought. Further, Morellato et al (1989) suggested that, flushing and leaf fall are often correlated in intensity and timing in which flushing follows leaf fall.

Flowering: As majority of the species produced flowers during flushing or leaf-fewer phases, flowering and flushing may overlap in some species. The same meristems that produce buds also produce the flowers (Borchert, 1983). Synchronization of flowering and leaf flushing seems to be related to moisture, temperature and day length, which is in conformity with observations made by others workers (Boojh and Ramakrishnan, 1981; Murali and Sukumar, 1994). Borchert (1994) also suggested that the stored water buffers the impact of seasonal drought and enables flowering and flushing during the dry season.

Further, the flowering activity was observed in drier (February to May) periods are due to synchronous flowering in a particular time may be due to seasonally active pollinators, or because several species share the same set of pollinators. The asynchronous flowering (delayed or earlier flowering activity) may reduce competition for pollinators (Rathcke and Lacey, 1985; Van Schaik et al., 1993), which also favors the wind pollinators (Singh and Singh, 1992).

Fruiting: The peak of fruiting follows that of flowering. In several species fruit ripening begins in monsoon period that may be due to the difference in fruit maturation activity (Kikim and Yadava, 2001). Thus fruit dehiscence of tree species coincides with the monsoon to allow optimal germination (Frankie et al., 1974; Primack, 1987; Singh and Kushwaha, 2006; Singh and Singh, 1992).

Human Interface on phenological cycle: The recorded phenological cycle of selected tree species showed Leaf initiation – Mar – May; Leaf fall – Oct – Dec; Flowering – Feb – May; Fruiting – Mar – Aug. Similarly threat on tree species are in two peaks 1. Leaf initiation period; 2. Before attaining flowering and fruiting (leaf fall period). The degradation caused by human being upon the trees, is called as “seasonal threats”.

This seasonal threat affects the flowering and fruiting pattern of tree species, mainly delaying or absence of flowering and fruiting at a particular time, leads to low manifestation of reproduction. Extensive wood cutting in the species or individual, result shifts in switch of vegetative and reproductive phase (Bernier, 1988), affects the phenological cycle (like, time of fruit ripening, fruit maturation and fruit dehiscence are shunt) and a process of maturation (Rajvansh and Goutam, 1990), changes in canopy structure (Longman and Jenik, 1974), and ecosystem functions (Picket et al., 1989). The cut tree does not maintain a maximum structure and therefore the rates or magnitude of the interaction between the physical components of that tree are impaired in companion to certain (uncut) trees (Rykicl, 1985). Naturally the system of reproduction is getting disturbed or restorative effective of tree species is less has resulted in the environmental maladies of most of the tree species (Khoshoo, 1988).

Conclusion

- ❖ Tree species exhibited inconsiderable variation in leaf initiation and leaf fall.
- ❖ As majority of tree species produced flowers during flushing or leaf-fewer phases, exception in *Anogeissus latifolia*
- ❖ Similarity in all species fruiting follows that of flowering
- ❖ Fruit ripening begins in monsoon period, to allow optimal germination of tree species
- ❖ All selected tree species facing "seasonal threats" in the form of cutting, results early losses of tree branches, affects the flowering and fruiting pattern of NGR.

Implications for Conservation

Genuine efforts to minimize the human pressure are essential for the survival of forest in NGR, Since the tribal, dependence on forest for fuel wood and timber, is almost inevitable, there is urgent need for strategic planned to save the forest

- Creating awareness on rotational cutting, educating people about the value of forest and species usage.
- Enhancing the fuel wood through afforestation program with species having high calorific values
- Encourage fuel wood plantation in degraded lands
- Long term study on impact of cutting on plant phenology
- Also, detailed research on human activities in forest with relation to the plant phenology
- Understanding the impact of cutting pressure on regeneration potential of crucial woody species through long term research

Acknowledgement

The authors wish to acknowledge the constant encouragement, supports and facilities provided by Gujarat Institute of Desert Ecology (GUIDE), Bhuj, Kachchh and Foundation for Ecological Security (FES), Anand, Gujarat for successful completion of this work. Many thanks are due to Dr. V. Gokula, M.Sc., M. Phil., Ph.D., Associate Professor, Department of

Zoology, National College, Tiruchirappalli for the valuable suggestions and the review of this paper.

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