LEAF PHENOLOGY OF PLANTS OF A DRY DECIDUOUS FOREST IN THE ARAVALLI HILLS OF RAJASTHAN, INDIA

ANIL K. CHHANGANI*

Introduction

Studies on general aspects of phenology of plants as well as phenology in relation to climate and availability of plants to herbivores and other fauna in different seasons have been carried out earlier by Blasco and Legris (1973), Oates *et al.* (1980), Boojh and Ramakrishnan (1982), Ralhan *et al.* (1985), Ansari and Bhadola (1989), Newton (1988), Koenig *et al.* (1998), Khan (1999). This study at Kumbhalgarh Wildlife Sanctuary (KWS) matches with most of the known information from different areas and also suggest that the biotic factors responsible for the evolution and sustenance of plant phenology as observed by Hladic and Hladic (1967), Snow (1971), Bawa (1974), Howe (1977), Heithaus (1979), Howe and Smallwood (1982) and Lieberman (1982). The forest phenology in KWS suggest that this forest produces enough leaves, flowers, fruits, flowers and seeds even in the difficult conditions to support herbivores and avian fauna which helps to maintain the faunal diversity of the KWS study area.

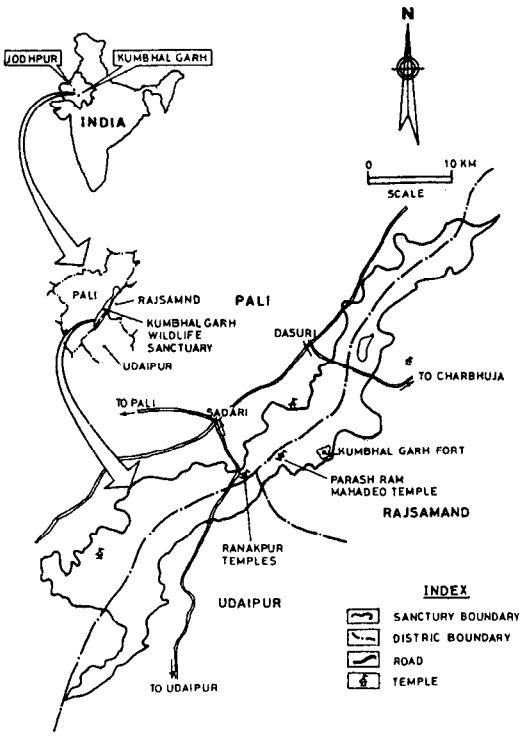
Material and Methods

Study Site : The Kumbhalgarh Wildlife Sanctuary (KWS) lies between 20°5' and 23°3' N latitude and 73°15' and 73°45'E longitude. It is situated 200 km South of Jodhpur in the West Aravalli hills of Rajasthan, India (Fig.1). The total area of Kumbhalgarh Wildlife Sanctuary is 585 km^2. Its altitude varies from 275 to 1,150 m. The climate of this area is characterised by distinct winter, summer and monsoon. During summer, temperature is more than 30°C and may rise upto 46°C during May and June. The mean temperature in winter is 5°C, which goes down to 2°C in December - January. The average rainfall is 725 mm, maximum touching 950 mm and minimum 403 mm. Monthly rainfall received by the KWS in the year 1997 are given in Fig. 2. In this paper data on leaf phenology is presented for a dry deciduous forest of Kumbhalgarh Wildlife Sanctuary (KWS) in the Aravalli hills of Southern Rajasthan, India, along with a detailed study of phytophases, seasonal patterns and their availability to herbivores.

The forest is broadly dry deciduous or woodland type dominated by 'Gorya dhawa' (*Anogeissus latifolia*), Salar (*Boswellia serrata*), Godal (*Lannea coromandelica*), Kherni (*Wrightia tinctoria*), Dhawa (*Anogissus pendula*), Kumbat (*Acacia senegal*), Khair (*Acacia catechu*), Ber (*Ziziphus mauritiana*), Dhonk (*Butea monosperma*), etc. The undergrowth mainly consists of Jharber (*Ziziphus nummerlaria*), Ardnsa (*Adhatoda vasica*), Gangan (*Grewia tenex*), Franger (*Grewia flavescens*), Kanter (*Capparis separaia*), Lantana (*Lantana indicus*), etc. Some climbers and grasses are also found.

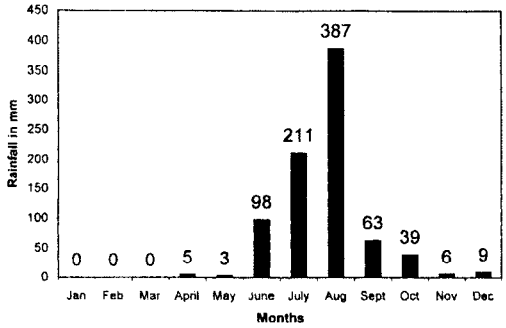
*Indo-US Primate Project, Department of Zoology, JNV University, Jodhpur (Rajasthan).
e-mail:chhanganiak@yahoo.com

Fig. 1



Location of Kumbhalgarh Wildlife Sanctuary in the Aravalli hills

Fig. 2



Monthly rainfall received by Kumbhalgarh Wildlife Sanctuary in the year 1997

The main herbivores and omnivores fauna of KWS is as follows : Hanuman langur (*Semnopithecus entellus*), Four horn antelope (*Tetracerus quadricornis*), Chinkara (*Gazella g. bennetti*), Porcupine (*Hystrix indica indica*), Samber (*Cervas unicolor*), Blue bull (*Boselaphus tragocamelus*), Sloth bear (*Melursus ursinus* and Toddy cat (*Paradoxorus hermaphordiatus*).

Methods of studying phenology : Methods were designed to provide an estimate of the availability of different 'phytophases' in the forest ecosystem on which langurs subsist. The crown density method of Koelmeyer (1959), Struhsaker (1975), Marsh (1981) and Newton (1988) was used. Five plants (where posible) of each 45 species were selected for this study. In the last week of each month two days were spent examining the canopy of every sampled tree by naked eyes and using binocular to estimate the density, size, colour and texture of the individual plant parts. The abundance of each phytophase was estimated relative to the maximum abundance expected for that species.

The following definitions have been adopted after Opler *et al.* (1980) with slight modification by Balasubramaniam and Bole (1993) wherein a tree is defined as "any woody perennial which rises from the ground with a trunk" attaining a minimum of 3 m. A shrub is defined as a woody non-climbing multiple stemmed or single stemmed perennial plant less than 3 m high.

Phenological observations were noted on a linear 0 – 4 scale. A score of 4 is referred to the maximum density of a particular phytophase for a given species. Value of 3, 2, 1 and 0 indicated densities of 75%, 50%, 25% and 0% of the maximum respectively. The phytophase categories recognised after Struhsaker (1975), Marsh

(1981) and Newton (1988) with slight modification was adopted in this study which is as follows :

Leaf buds : Lamina curled within closed bud with immature texture and colour often soapy pink or light green

Young leaves : Full size with immature texture, often thin, light coloured with bright surface

Mature leaves : Full size with mature texture often leathery. Colour bright and dark green.

As there is no clear cut distinction between evergreen, semi-evergreen, deciduous and dry-deciduous phenology, categories were distinguished in the manner of Koelmeyer (1959) and Newton (1988) with some modification on the basis of the intensity of leaf depletion.

Dry deciduous : Mean leaf (young and mature) phenological score falling to 0 or 1 during two or more months

Deciduous : Mean leaf phenological score is not falling below 0 or 1 more then one month

Semi-evergreen : Mean leaf phenological score is not falling below 2 in any month

Evergreen : Mean leaf phenological score is not falling below 3 in any month

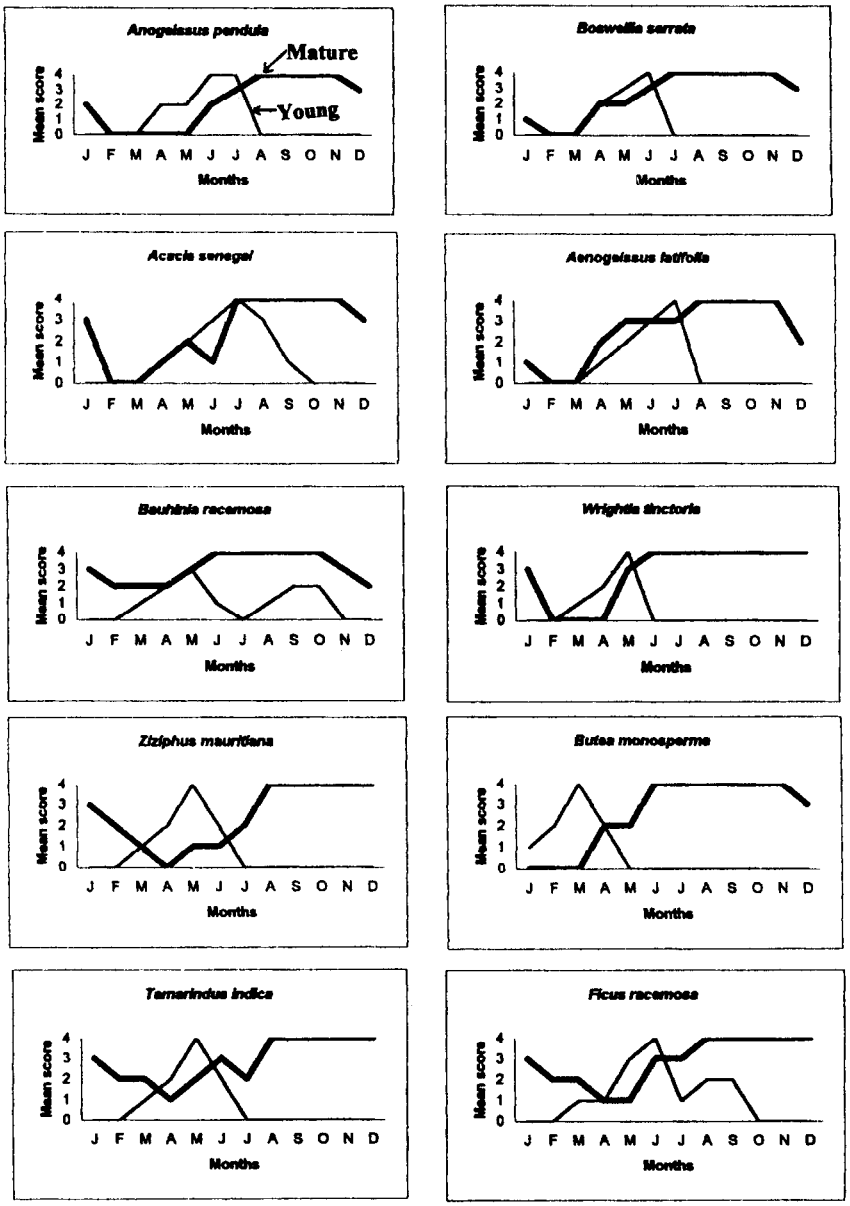
Results

Out of 214 plant species in the Kumbhalgarh Wildlife Sanctuary (KWS) 45 plant species covering 198 plants belonging to over 30 families were selected for the phenological studies. These families mostly represent native species of Aravalli hills (except *Lantana camara*). The monitoring of phenology yielded indices of each phytophase for 12 contiguous months (Jan. 1997 to Dec. 1997). The mean phenological score for each species was calculated for each phytophase in every month. Most of the species had one major period of leaf renewal during the annual cycle, which is between January and August (Fig. 3). Many species lost their leaves between January and April and young leaves flushed between March and July. The peak of young leaves occurred with the following monthly percentage : March (10.87%), April (22.54%), May (25.99%), June (12.32%) and in July (8.75%).

By the method of scoring and definitions of dry-deciduous, deciduous, semi-evergreen, etc. no species showed an evergreen pattern. Eleven tree-species, *Acacia nilotica, Albizia lebbek, A. procera, Annona squamosa, Bauhinia racemosa, Ficus benghalensis, F. racemosa, F. religiosa, Prosopis juliflora, Syzygium cumini* and *Tamrindus indica* showed semi-evergreen pattern. These semi-evergreen species also tended to produce leaf buds throughout the year with a peak production after the leaf fall in May, June, July and August. Out of eleven species, *F. benghalansis, F. racemosa, F. religiosa, S. cumini, T. indica* were found near or in the water streams in the forest, where as *A. nilotica* and *P. juliflora* were found near the water streams or near cultivated areas on the border of forest or in the buffer area of the sanctuary.

The remaining 34 tree and shrub species sampled were dry-deciduous or deciduous. On the basis of monthly mean phenological score, if a species maintain its mean phenological score 0 or 1 for one

Fig. 3



Monthly variation in mean phenological score of young and mature leaves of 10 plant species of Langur study area

month it is considered deciduous and if its mean phenological score fall to 0 or 1 in two or more months then it is considered dry-deciduous. Therefore, out of 34 remaining species of trees and shrubs, 11 species (7 trees, 4 shrubs) showed

Sambhar (*Cervus unicolour*) in the Kumbhalgarh Wildlife Sanctuary

Sloth Bear (*Melursus ursinus*) in the Kumbhalgarh Wildlife Sanctuary

Mother & Infant Hanuman langur in
Kumbhalgarh Wildlife Sanctuary (KWS)

Sun basking by Hanuman langur groups in
Kumbhalgarh Wildlife Sanctuary (KWS)

Male Hanuman langur sitting on top branch of a tree monitoring around in Kumbhalgarh Wildlife Sanctuary (KWS)

deciduous pattern and remaining 23 species (14 trees and 9 shrubs) showed dry-deciduous pattern. Tree species like *Ziziphus mauritiana, Terminalia arjuna, Mangifera indica, Cordia dichotoma, Aegle marmelosa, Acacia leucopholea, Acacia catechu* and shrub species like *Calotropis procera, Commiphora wightii, Grewia flavescens* and *Lantana camara* showed deciduous pattern. Shrub species close to water streams and river banks showed deciduous pattern.

The predominant forest type of the study area is dry-deciduous. Eleven deciduous species and eleven semi-evergreen species renewed their leaves during the same season. No species showed prominent leaf fall during the monsoon season. Tables 1 and 2 shows leaf pattern and leaf phenology in the KWS.

The mean value for the index (the mean phenological score) for each species was calculated for young and mature leaves for each month and plotted in Fig. 3 for the ten most useful and common plant species of KWS.

Discussion

This study carry information on the phenology of leaves, a most relevant aspect in the study of food and feeding of harbivores living in the dry deciduous forest habitat like the Kumbhalgarh Wildlife Sanctuary (KWS). It is also important for evolving management programme for any forest as it refers to quality of forest ecosystem and its capacity to support animals.

Table 1

Leaf pattern observed in langur study area in Kumbhalgarh Wildlife Sanctuary.

Leaf pattern	Tree	Shrub	Total
Dry-deciduous	14	9	23
Deciduous	7	4	11
Semi-evergreen	11	0	11
Evergreen	0	0	0
Total	32	13	45

Although some research has been done in India on the general aspects of phenology of plants as well phenology in relation to climate and plants available to langurs in different seasons as food (Blasco and Legris, 1973; Oates *et al.* 1980; Boojh and Ramakrishnan, 1982; Ralhan *et al.* 1985; Ansari and Bhadola, 1989 and Newton, 1988, and Koenig *et al.* 1998). This study at KWS matches with most of the known information from different areas and also suggest that the biotic factors are important in the evolution and sustenance of plant phenology as observed by Hladic and Hladic (1967), Snow (1971), Bawa (1974), Howe (1977), Heithaus (1979), Howe and Smallwood (1982), Lieberman (1982) and Khan (1999).

This study of phenology suggests that changes in the forest largely takes place in the summer season as evidenced by phytophases of plants. Some of the trees and shrubs change their phytophase in winter or monsoon seasons, whereas few species change their phytophase in all seasons. These observations suggest that there was no month in which phytophase of plants below 5% of total mean phenological score occur. This shows that KWS is a good habitat supporting wildlife and livestock.

The forest phenology in KWS suggests that this forest produces enough leaves

Table 2

Leaf phenology observed in langur study area in Kumbhalgarh Wildlife Sanctuary. (study period Jan. 1997 to Dec. 1997)

Plant Name, Habits & No. of individuals					Leaf period		
Sr. No.	Local name	Botanical Name	Habit	No. of plants	Young leaves	Mature leaves	Leaf fall
1		2	3	4	5	6	7
1.	Kher	*Acacia catechu*	Tree	5	Feb. - April	April - Jan.	Jan. - March
2.	Aranjia	*Acacia leucophloea*	Tree	3	March - May	May - Jan.	Jan. - April
3.	Babool	*Acacia nilotica*	Tree	5	Feb. - Oct.	Jan. - Dec.	Semi-Evergreen
4.	Kumbat	*Acacia senegal*	Tree	5	May - July	July - Jan.	Feb. - March
5.	Beel	*Aegle marmelos*	Tree	3	March - April	April - Jan.	Jan. - March
6.	Sarais	*Albizia lebbek*	Tree	3	May - Aug.	Aug. - July	Semi-Evergreen
7.	Safad saras	*Albizia procera*	Tree	3	May - June	Aug. - July	Semi-Evergreen
8.	Sitaphal	*Annona squamosa*	Shrub	5	May - June	Aug. - July	Semi-Evergreen
9.	Safed Dhaw	*Anogeissus latifolia*	Tree	5	April - Aug.	Aug. - Jan.	Jan. - March
10.	Dhawra	*Anogeissus pendula*	Tree	5	April - Aug. -	Aug. - Jan. -	Jan. - April -
11.	Neem	*Azadirachta indica*	Tree	5	April - May	May- Jan.	Feb. - March
12.	Jhinjha	*Bauhinia racemosa*	Tree	5	March - April	July - Feb.	Semi-Evergreen
13.	Samel	*Bombex ceiba*	Tree	5	April - May	June - Jan.	Jan. - April
14.	Salar	*Boswellia serrata*	Tree	5	April - June	June - Jan.	Jan. - March
15.	Palas	*Butea monosperma*	Tree	5	Jan. - March	March - Nov.	Nov. - Jan.
16.	Aak	*Calotropis procera*	Shrub	5	June - Aug.	Aug. - July	Jan.- March
17.	Ker	*Capparis decidua*	Shrub	3	Feb. - April	Jan. - Aug.	Sept. - Dec.
18.	Anwal	*Cassia auriculata*	Shrub	2	April - May	May - Jan.	Feb. - March

Contd...

1	2	3	4	5	6	7
19. Amaltash	*Cassia fistula*	Tree	5	March - April	May - Jan.	Feb. - March
20. Gugal	*Commiphora wightii*	Shrub	3	March - April	April - Dec.	Jan.- Feb.
21. Gunda	*Cordia dichotoma*	Tree	5	April - May	June - Jan.	Feb. - March
22. Gundi	*Cordia gharaf*	Tree	2	June - Aug.	Aug. - July	Feb. - March
23. Kolai	*Dichrostachys cinerea*	Shrub	5	April - July	July - Jan.	Feb. - March
24. Timru	*Diospyros melanoxylon*	Tree	5	April - May	June - Feb.	Feb. - March
25. Thor	*Ephorbia caducifolia*	Shrub	5	July - Aug.	July - Sept.	Oct. - June
26. Bargad	*Ficus benghalensis*	Tree	5	July - Aug.	June - May	Semi-Evergreen
27. Gular	*Ficus racemosa*	Tree	5	May - June	June– May	Semi-Evergreen
28. Pepal	*Ficus religiosa*	Tree	5	April - July	June– May	Semi-Evergreen
29. Gangan	*Grewia damine*	Shrub	5	March - April	May– Jan.	Jan. - March
30. Farangnee	*Grewia flavescens*	Shrub	5	March - April	May– Jan.	Jan. - April
31. Marorphali	*Helicteres isora*	Shrub	5	April - May	June– Jan.	Jan. - April
32. Godal	*Lannea coromandelica*	Tree	5	April - May	June– Dec.	Jan. - March
33. Latina	*Lantana camara*	Shrub	5	July - Sept.	Sept. - Aug.	March - April
34. Aam	*Mangifera indica*	Tree	5	April - May	July - Feb.	Feb. - March
35. Kadam	*Mitragyna parvifolia*	Tree	2	April - May	July - Feb.	Feb. - April
36. Harsingar	*Nyctanthes arbortristis*	Shrub	2	April - May	June - Feb.	Feb. - March
37. Karanj	*Pongamia pinnata*	Tree	5	April– July	July - June	March - April
38. Vilayti Babul	*Prosopis juliflora*	Tree	5	June - Aug.	Aug. - July	Semi-Evergreen
39. Kadaya	*Sterculia urens*	Tree	4	May - June	June - Jan.	Feb. - April
40. Jamun	*Syzygium cumini*	Tree	5	March - April	June - May	Semi-Evergreen
41. Imli	*Tamarindus indica*	Tree	5	March - June	July - June	Semi-Evergreen

Contd...

1	2	3	4	5	6	7
42. Arjun	*Terminalia arjuna*	Tree	3	April - May	June - May	Feb.- March
43. Khirni	*Wrightia tinctoria*	Tree	5	April - May	June - Dec.	Jan.- March
44. Ber	*Ziziphus mauritiana*	Tree	5	April - June	July - June	March - April
45. Jhar Ber	*Ziziphus nummularia*	Shrub	5	April- June	July - June	March - April

even in the difficult conditions to support animal taxa which help maintain the faunal diversity of the KWS. In summer months (March to June), 18.0% young leaves were available with a peak of 25.99% in May. Mature leaves were available throughout the monsoon and winter (except February) with an average of 11.05% reaching peak with 12.51% in the month of September of total mean phenological score.

In KWS 65% of 45 species renew their leaves during cold weather which flesh between March and July. A similar situation was found by Dinerstein (1979) in the Royal Karnali Bardia Wildlife Reserve, Nepal where deciduous tree species with 86% of the 43 species renewing leaves during cold weather giving a pattern similar to that described for Kanha National Park by Newton (1988). Studies of humid subtropical forest in Meghalaya, North-East India (Shukla 1997; Boojh and Ramakrishnan, 1981), Bhaber sal forest in Kumaun Himalays (Ralhan *et al.* 1985) and (Newton, 1988) in Kanha Tiger Reserve in Central India suggest that the phenological patterns are nearly same as found in this study.

Newton (1988) observed phenology of 215 trees belonging to 61 species in Kanha National Park in Central India. There were 9 species common to KWS. Newton found January to March as the main leaf renewal period. A similar situation was observed in KWS. Of the 9 common species of both study sites which were classified as deciduous or semi-evergreen, some of the dry-deciduous species of Kumbhalgarh were classified as deciduous in Kanha. The variation is probably due to climate like, rainfall, environmental conditions and geomorphological situation. Nevertheless, trees show some relationship between flushing of young leaves and reproductive phenology at both the study sites at Kanha and Kumbhalgarh.

The above study therefore suggests a similar pattern with dry season leaf fall and flush. Raemakers *et al.* (1980), Reich and Borchart (1984), Longman and Jenik (1974), Daubenmire (1972) and Khan (1999) have observed that many tropical deciduous and dry-deciduous trees and shrubs shed their leaves during dry season depending on the degree of drought and flush soon afterwards or in early monsoon.

Acknowledgements

This study is part of the Indo-US Primate Project, a collaborative project of the

Ministry of Environment and Forests, Government of India, and United States Fish & Wildlife Service (Grant Agreement No. INT/FWS-22). The author would like to thank Prof. S.M. Mohnot, Director, Indo-US Primate Project, staff and officials of Rajasthan State Forest Department especially Mr. Lalit Singh Ranawat, A.C.F. of Kumbhalgarh Wildlife Sanctuary and Manager Ranakpur Temple Board for their support during this field study.

SUMMARY

Plant phases and their phenological events in time and space were recorded in respect of leaf buds, young leaves and mature leaves. Out of 214 plant species found in Kumbhalgarh Wildlife Sanctuary (KWS). 45 species were subjected to examination of leaf phenology between January 1997 to December 1997. Most of them are native species of Aravalli hills. The phenological scores of each species and their phytophases were examined. The phenology in KWS suggest that this forest produced enough leaves even in the difficult and dry conditions to support animals. In summer months (March to June) 18.0% young leaves were available with a peak (25.99%) in May. Mature leaves were also available throughout monsoon and winter (except February) with a peak in September. In this area 65% of 45 species renew their leaves during cold weather, which flesh between March and July.

राजस्थान, भारत की अरावली पहाड़ियों के शुष्क पर्णपाती वन में पत्तियों की ऋतुजैविकी और मौसमीयता

अनिल कुमार छंगानी

सारांश

पर्ण कलिकाओं, नई पत्तियों और वयस्क पत्तियों में समय और स्थान की दृष्टि से देखी जाने वाली पादप अवस्थाएं और ऋतुजैविकीय घटनाएं आलेखित की गई कुंभलगढ वन्यप्राणी अभयारण्य में पाई जाने वाली 214 पादप जातियों में से 45 जातियों की पर्ण ऋतुजैविकी का जनवरी 1997 से दिसम्बर 1997 के दरम्यान परीक्षण किया गया । इनमें से अधिकांश जातियां अरावली पहाड़ियों की देशज जातियां हैं । प्रत्येक जाति ऋतुजैविक चिह्न और उनकी पादपावस्थाएं जांची गई । कुंभलगढ़ वन्यप्राणी अभयारण्य की ऋतुजैविकी देखने से पता लगता है कि इस वन से कठिन और शुष्क दशाओं में भी काफी पत्तियां उत्पन्न होती हैं जिनपर पशु पलते रह सकते हैं । गर्मियों के महीनों (मार्च से जून) में भी 18% नई पत्तियां विद्यमान रही जिनको शिखर (25.99%) मई में मिला । वयस्क पत्तियां पूरे मानसून काल और शीतकाल में (फरवरी को छोड़कर) उपलब्ध रही जिनका शिखरकाल सितम्बर में था । इस क्षेत्र में इन 45 जातियों का 65% भाग अपनी पत्तियां शीतकाल में नई करता है जो मार्च और जुलाई के मध्य निकलती हैं ।

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