Indian Journal of Traditional Knowledge
Vol.10 (1), January 2011, pp 96-101

Prediction of rainfall variation through flowering phenology of night-flowering jasmine (*Nyctanthes arbor-tristis* L.; Verbenaceae) in Tripura

Sandeep Acharya
Department of Botany, Tripura (Central) University, Suryamaninagar, West Tripura 799 130
E-mail: phytosandeep@yahoo.com

Received 30 09 2010; revised 27 12 2010

Folk people of Tripura, a small state of Northeast India, rely on their own traditional knowledge of phenological indicators for predicting the weather, to help plan their agroforestry activities and for disaster prevention. One such prediction relates to the phenology of *Nyctanthes arbor-tristis* L., night-flowering jasmine, which helps them to forecast the onset of heavy rainfall. During 2007-2009, a comprehensive study was initiated to document the predictive accuracy of this indicator, through conversations and interviews with village members, observation and reviewing the older literature. The researchers found that the flowering of *Nyctanthes arbor-tristis* is a good indicator of weather lore for the prediction of both short- and long-range precipitation. The information about the prediction of rainfall by observing the flowering phenology was recorded through the interview with village elders. The researchers use interview schedule while interacting with elders. Several small groups of knowledge holders including elder men and women (as focus group) were selected randomly from a wider population of study areas and sampled. A questionnaire was also prepared for knowledge gathering through open conversation and discussion. Prior Informed Consent (PIC) was taken from the knowledge providers time to time.

Keywords: Traditional knowledge, Folk people, Tripura, Phenology, *Nyctanthes arbor-tristis* L., Weather lore, Short & long range rainfall

IPC Int. Cl.[8]: A01 C 5/00

Tripura is a predominantly agricultural state in India, with three-fourths of its people depending on farming for their livelihood. The success of the agriculture activities is closely related to weather and climatic conditions. Knowledge of the imminent rainfall season is important, especially in areas that substantially depend on rain-fed farming[1]. Farmers in these areas are alerted by forthcoming rains, which prompt them to prepare their land, planting materials and farm equipment. This makes weather forecasting indispensable to farmers. Accurate predictions of adverse weather conditions can prevent losses in agroforestry resources in many regions of the earth[1]**.** Over time, traditional farmers have relied on close observations of nature to forecast changes in weather, from short- to long-term. Such weather lore has been preserved and sustained from one generation to the next by farmers, hunters, fisherfolk and sailors throughout the world[2]. Weather lore is incorporates beliefs designed to explain mysteries of nature that old folks could hardly explain in any way[2]. Despite the methods of modern technology for predicting weather conditions for the next day or over the season in a specific location, weather lore has remained an important form of local forecasting in many areas through centuries[2].

The theory of rain conception, used by the ancient people, was cited in the early Indian texts and scriptures including *Vedang Jyotish* of Maharshi Laugakshi, *Rishi Parashar Samhita, Rishi Garg Samhita, Rishi Kashyapiya Samhita, Deval Samhita, Jivanartha Samhita, Sanvatsar Phal,* Acharya Kautilya's *Arthasastra, Rishi Narad Samhita, Rishi Vashishtha Samhita, Gura Samhita, Meghmala Samhita, Varahamihira Samhita*[3]. Indigenous methods of weather forecasting, ascribed in detail in these ancient text and scriptures, can be broadly classified into two categories: (i) Theoretical methods; and (ii) Observational methods. The former include astronomical or planetary factors and pertain to computation of planetary positions and conjunction of planet and stars[4]. The observational methods deal with atmospheric changes, including cloud forms (sky features) and biological and phenological

indicators[4]. The bio-indicators or biological indicators for rain prediction have also been well documented and are extensively used by local experts[5]. Plant or animal bio-indicators are those living species which change their behavior according to changes in the surrounding environment or weather conditions. For example, the tree *Cassia fistula* L., (Fam. Fabaceae; Eng. Name -golden shower, Indian laburnum) has proved to be a unique indicator of rain. It bears bunches of golden yellow flowers in abundance about 45 days before the onset of monsoon[6]. Kanani *et al*.[7] documented phenological changes in various tree species that have been used as indicators of rain by local communities. From the dawn of civilization, techniques for accurate weather prediction have often been developed through trial and error. Bhatvadekar[8] reported various techniques of rainfall prediction including observations of plants with particular reference to Vidarbha region, where he observed that the flowering of mango (*Mangifera indica* L.; Fam. Anacardiaceae) in January and emergence of new shoots in Ebony tree (*Diospyros melanoxylum* Roxb.; Fam. Ebenaceae), as well as profuse flowering in bamboo (*Bambusa balcooa* Roxb.; Fam. Poaceae) could be used as indicators of rain.

In Tripura, *Nyctanthes* is also used year 'round for weather forecasting. The present study was undertaken with two main objectives: (i) Forecasting, analyses and documentation of indigenous traditional knowledge (ITK) of tribal farmers regarding rain forecasting in Tripura; and (ii) documenting weather forecasting in terms of reliability and conformity with actual rainfall data recorded by the Meteorological Department. Generally, we know that the timing, duration, and frequency of flowering of any plant/tree define flowering patterns. Plants display a wide variety of patterns, particularly in the tropics, where favorable conditions for flowering throughout the year result in a broad range of variation in timing, frequency, and duration of flowering[9,10] which is considered as the basis of the present study.

Nyctanthes arbor-tristis L. (Fam. Verbenaceae), night-flowering jasmine, is a small tree with drooping quadrangular branchlets. Its local vernacular names include – *Singhara*, *Sheoli* and *Shiuli phool*. It is a sacred tree in different tribal pockets of Tripura[11]. Its flowers are sweetly scented, sessile in bracteate heads, disposed in terminal trichotomous cymes. The peduncles are quadrangular; bracts are somewhat elliptic and pubescent. Calices are funnel shaped but pubescent. Corolla is generally salver shaped and corolla tube is orange-red with twisted white lobes. Flowers are used for yielding a yellow dye which is used for coloring silk and cotton[11]. Fruit is cordate to almost orbicular flat capsule, about 2 cm across, brown, 2 celled, opening transversely from the apex and seed single per cell; compressed in nature.

Study area

The study was conducted in tribal areas all around the state particularly in northern tropical moist deciduous forests of Tripura (20°51′-24°32′ N latitude and 90°10′-92°21′ E longitude), with a total geographical area of about 10,500 sq km. It is a tract of hilly terrain with gentle slopes and broad valleys at altitudes ranging from 380 - 900m. The top-most hill area is characterized by grey-brown podsolic soil and lateritic soil whereas the bottom of the valley is distinguished by red loamy and reddish yellow sandy loamy soil with clay loamy- alluvial soil. The soil is slightly acidic in nature with *p*H ranging from 4.8 - 6.9 and average monthly soil moisture content varies from 20 - 45%. The climate of the area is monsoonal and divisible into three seasons: summer (March-June), rainy (July-October) and winter (November-February). The average annual rainfall varies from 800 - 2100 mm and is largely restricted to the period from July to October. Pre-monsoon showers occur during May and June. Post monsoon showers occur during November and December. The mean maximum temperature varies from 16°C (December) to 37°C (June) and mean minimum temperature from 6°C (January) to 20°C (June).

Methodology

Flowering phenology of *Nyctanthes arbor-tristis* was observed at surrounding area of Agartala as well as seven other places (viz. Unokoti, Jampui hill, Kumarghat, Deotamura, Udaipur, Pilak and Dambur) (Fig. 1) for approximately 3 yrs (2007–2009). Flowering time, frequency and duration of flowering were noted at weekly intervals on the basis of rainfall pattern of the selected/sampled areas for present study Approximately 270 plants were marked, and flowering in the canopy was observed with binoculars. The actual period of flowering of *Nyctanthes arbor-tristis* is more or less all the year round. For the

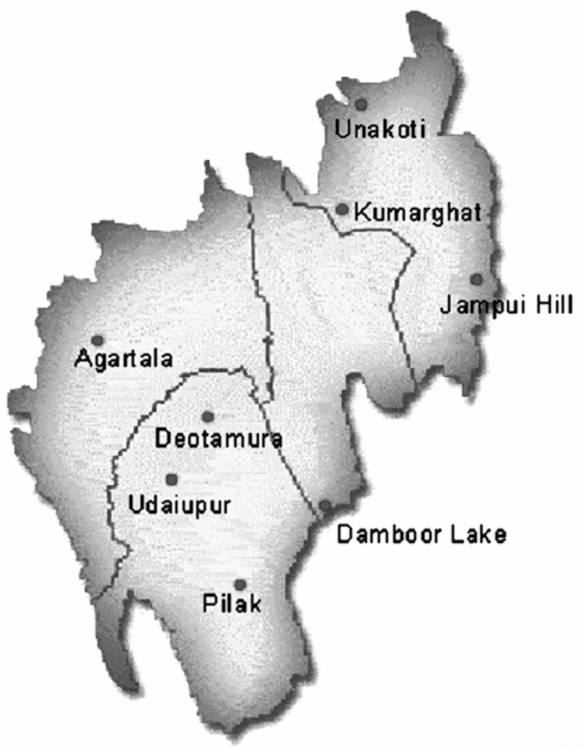

Fig. 1—Map of Tripura depicting observational area

present study, the outskirt areas of Agartala as well as seven other places mentioned above were randomly selected where this tree is easily available.

Intensive efforts were made to translate qualitative descriptions of timing into approximate quantitative terms through discussions with elders, observations and documentation from the ancient holy literatures such as *Puthis* and *Granthas* where most of the information from the ancient *Bengali Granthas* regarding weather lore was given in qualitative terms. These data were then compared with prediction of quantities of rainfall through satellite imageries by the Indian Meteorological Department (IMD) at Narsingarh, Bimangarh and weekly data from the Department of Physics, Tripura University. On the basis of both qualitative and quantitative data documentation, five levels of rain intensity were recorded for comparison with the actual rainfall data from these institutions: heavy rain (A), moderate rain (B), light rain (C), very light or no rain (D) and drought (E), and Correct Prediction (CP); Over Prediction (OP); Under Prediction (UP). If rainfall was predicted to occur on a particular day, but no rain occurred, this was termed Inefficient Prediction (IP). If rainfall was predicted to occur in a particular season, but no rain actually occurred within a one- or two-month period, it was termed a False Prediction (FP). These data were documented and calculated to test the predictive accuracy of *Nyctanthes arbor-tristis* phenology in Tripura.

The information about the prediction of rainfall by observing the flowering phenology was recorded through the interview with village elders. Prior Informed Consent (PIC) was taken from the knowledge providers time to time. The researchers use interview schedule while interacting with elders. Several small groups of knowledge holders including elder men and women (as focus group) were selected randomly from a wider population of above mentioned study areas and sampled, as by open conversation and discussion. The following types of questions were incorporated for interviewing as a part of questionnaire programme. (1) What can be predicted from large size of buds (about rainfall)? (2) What does the early development of bud indicate- heavy, moderate or no rainfall? (3) What is the indication of full blooming of plant in the month of June – is it heavy, moderate or no rainfall? (4) What type of forecast can be deduced from early flowering time of *Nyctanthus arbor-tristis*? (5) What type of forecast can be deduced from late flowering time of *Nyctanthus arbor-tristis*? (6) What is the indication of glabrous leaf surface of *Nyctanthus arbor-tristis*? (7) What is the indication of acute scabrous leaf surface of *Nyctanthus arbor-tristis*? (8) What is the indication of short length of flower of *Nyctanthus arbor-tristis*? (9) What is the indication of dark color of flower of *Nyctanthus arbor-tristis*? (10) What is the indication of ripening and early rotting of fruits of *Nyctanthus arbor-tristis*?(11) What is the indication of short duration of flowering of *Nyctanthus arbor-tristis*? (12) What is the indication of longer duration of flowering of *Nyctanthus arbor-tristis*? (13) What is the indication of more frequency of flowering of *Nyctanthus arbor-tristis*? (14) What is the indication of less frequency of flowering of *Nyctanthus arbor-tristis*? (15) What is the indication of dense inflorescence in floral parts of *Nyctanthus* ? (16) What is the indication of segregated inflorescence in floral parts of *Nyctanthus* ?

Results and discussion

The most important findings related to analysis of rainfall prediction are presented (Tables 1 & 2). *Nyctanthes arbor-tristis* flowers throughout the year in Tripura. However, the number of total flowers

varied widely across the months of the year (Fig. 2) and was the highest in September to November (≤100%) and lowest in January (≤50%). When the months were grouped into four periods (February–April, May–July, August–October, November–January), the mean number of flowers was not equal across the four periods during 2007-2009 (Fig. 2). But the peculiarity is that during 2007-2009, maximum flowering was noticed in the month of June and July but not in the usual periods which predict the onset of heavy rainfall (Fig. 3). The Village Headmen (*Gram Pradhanas*) and elders (men and women) predicted a heavy rain during 2007-2009. Surprisingly, the prediction of upcoming rain and its timing proved to be accurate and thus validated the traditional phenological knowledge and its predictive capacity compared with the modern weather forecasts by Indian Meteorological Department (IMD) at Narsingarh, Bimangarh.

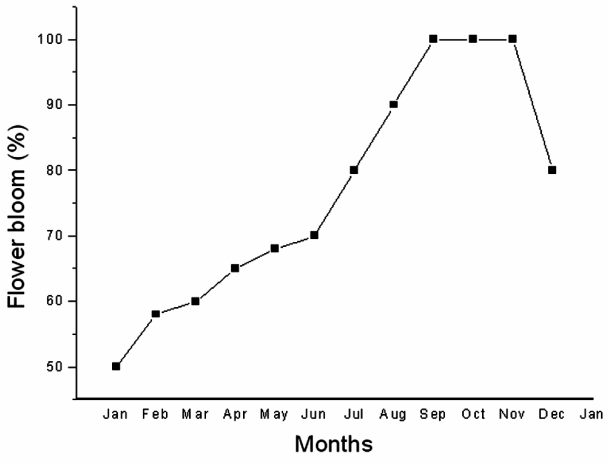

Fig. 2—Frequency of natural blooming of *Nyctanthes arbor-tristis* L. in Tripura

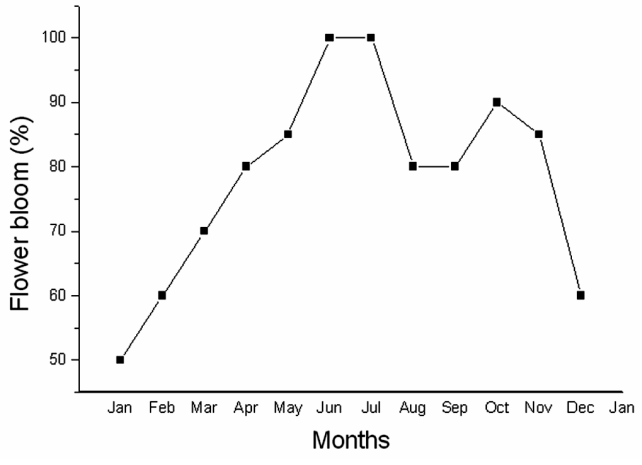

Fig. 3—Frequency of exceptional blooming of *Nyctanthes arbor-tristis* L. in Tripura during 2007-2009 study period

Table 1—Phenology of *Nyctanthes arbor-tristis* L. used as weather indicator by traditional weather forecasters and their perceived degree of reliability

Natural indicator from *Nyctanthus arbor-tristis*	Plant parts from *Nyctanthus arbor-tristis*	Types of forecast	No. of Responses	Perceived degree of reliability	
				High	Low
Large size of buds	Flower	A	34	30 (88.2)*	4 (11.8)*
Early development of buds	Flower	B	23	18 (78.3)	5 (21.7)
Full blooming of plant in the month of June	Whole Plant	C	20	15 (75.0)	5 (25.0)
Early flowering time	Flower	A	42	33 (78.6)	9 (21.4)
Late flowering time	Flower	B	40	28 (70.0)	12 (30.0)
Glabrous	Leaf	C	14	10 (71.4)	4 (28.6)
Acute Scabrous	Leaf	A	8	5 (62.5)	3 (37.5)
Short length	Flower	B	15	11 (73.3)	4 (26.7)
Dark color	Flower	C	11	9 (81.8)	2 (18.2)
Ripening and early rotting of fruits	Fruit	A	14	11 (78.6)	3 (21.4)
Short duration of flowering	Flower	A	15	12 (80.0)	3 (20.0)
Longer duration of flowering	Flower	C	10	6 (60.0)	4 (40.0)
More frequency of flowering	Flower	A	14	10 (71.4)	4 (28.6)
Less frequency of flowering	Flower	C	12	9 (75.0)	3 (25.0)
Dense inflorescence	Floral parts	A	16	10 (62.5)	6 (37.5)
Segregated inflorescence	Floral parts	C	12	10 (83.3)	2 (16.7)

*(Figures in the parenthesis indicate percentage) (N=90+90+90 = 270)
Type of forecast: heavy rain (A), moderate rain (B), light rain (C), very light or no rain (D) and drought (E)

Table 2—Presentation of monthly correctness of rainfall prediction compared with weekly reports from Indian Meteorological Department (IMD) at Narsingarh, Bimangarh and Department of Physics, Tripura University

S No	Months	Year	CP	OP	UP	IP	FP	Total correct prediction	Total incorrect prediction
1.	January	2007	15	2	0	3	0	17 (85.0)*	3 (15.0)*
		2008	14	2	0	4	0	16 (80.0)	4 (20.0)
		2009	16	2	0	2	0	18 (90.0)	2 (10.0)
2.	February	2007	14	2	0	6	0	16 (72.7)	6 (27.3)
		2008	13	1	0	6	0	14 (70.0)	6 (30.0)
		2009	15	0	0	3	0	15 (83.3)	3 (16.7)
3.	March	2007	16	3	0	2	0	19 (90.4)	2 (9.3)
		2008	14	1	0	2	0	15 (88.2)	2 (11.8)
		2009	18	2	0	2	0	20 (90.9)	2 (9.1)
4.	April	2007	14	1	2	2	0	17 (89.4)	2 (10.3)
		2008	15	1	1	5	0	17 (77.3)	5 (22.7)
		2009	16	1	0	2	0	17 (89.5)	2 (10.5)
5.	May	2007	13	0	0	6	0	13 (68.4)	6 (31.6)
		2008	14	1	0	4	0	15 (78.9)	4 (21.1)
		2009	15	2	0	5	0	17 (77.3)	5 (22.7)
6.	June	2007	11	0	0	5	2	11 (61.1) ^{L}	7 (38.9) ^{H}
		2008	12	0	0	2	1	12 (80.0)	3 (20.0)
		2009	13	0	0	3	0	13 (81.3)	3 (18.8)
7.	July	2007	12	0	0	6	0	12 (66.7)	6 (33.3)
		2008	11	0	0	4	0	11 (73.3)	4 (26.7)
		2009	13	0	0	3	0	13 (81.3)	3 (18.6)
8.	August	2007	15	1	0	5	0	16 (76.2)	5 (23.8)
		2008	14	0	0	4	0	14 (77.8)	4 (22.2)
		2009	13	2	0	4	0	15 (78.9)	4 (21.1)
9.	September	2007	15	2	0	3	0	17 (85.0)	3 (15.0)
		2008	16	1	0	3	0	17 (85.0)	3 (15.0)
		2009	17	3	0	4	0	20 (83.3)	4 (16.7)
10.	October	2007	17	1	0	2	0	18 (90.0)	2 (10.0)
		2008	18	2	0	4	0	20 (83.3)	4 (16.7)
		2009	19	3	0	3	0	22 (88.0)	3 (12.0)
11.	November	2007	19	4	2	6	0	25 (80.6)	6 (19.4)
		2008	20	4	3	6	0	27 (81.8)	6 (18.2)
		2009	21	1	1	2	0	23 (92.0)	2 (8.0)
12.	December	2007	16	3	0	3	0	19 (86.4)	3 (13.6)
		2008	15	3	0	5	0	18 (78.3)	5 (21.7)
		2009	14	0	0	1	0	14 (93.3)^{H}	1 (6.67)^{L}
		Overall prediction						603 (81.7)	135 (18.3)

*(Figures in the parenthesis indicate percentage) (N=90+90+90 = 270)
(L: lowest prediction; H: highest prediction; CP: Correct Prediction; OP: Over Prediction; UP: Under Prediction; IP: Inefficient Prediction; FP: False Prediction)

These results identify *Nyctanthes arbor-tristis* phenological observation as a valid and effective method for future forecasting of rainfall timing and duration. It was noted by author that before onset of heavy rainfall, there was usually a tendency for early flowering, along with large-sized buds and a noted scabrous character of the leaves. Thus greater frequency of flowering with short duration and dense inflorescence predicts the heavy rainfall which was proved by the higher perceived degree of reliability (60-80%) during the 3 yrs-course-of-time of the present study (Table 1). But early development of bud with slow (late) flowering time along with short length of flower advocates about the moderate rain which was supported by the moderate to high (70-78.3%) perceived degree of reliability. In contrast to that full blooming of plant in the month of June as well as more glabrous leaves along with dark orange-red colour of corolla tube responded about the light

rain prediction with higher range (18.1 - 81.8%) of perceived degree of reliability (Table 1). The range of monthly overall total correct prediction of rainfall, however, varied from 61.1% (June, 2007) to 93.3% (December, 2009) with a monthly over all total incorrect prediction of rainfall varied only 6.6% (December, 2009) to 38.8% (June, 2007) respectively (Table 2). Thus, it may be presumed to be a relatively accurate prediction with higher perceived degree of reliability by the folk people which have ornamented the life-style of rural people from ancient times.

Conclusion

In Tripura, the prediction of onset of rainfall helps farmers to plan their crop planting and other farming activities. Proper scheduling of such activities can maximize resource utilization and increase cropping intensity, thus providing more products for the farmer and his family's continuous sustenance and a greater chance for additional income[1]. Thus, accurate forecasting of upcoming rains helps farmers to mobilize their day to day farming activities, especially post harvesting[2]. Traditional knowledge on weather forecasting is thus widely used in local farming activities[1].Weather predictions have improved greatly in accuracy over the past years with the advancement of science and technology. This enables better weather forecasts from the modern meteorological stations. Despite the availability of macro-weather forecasts, however, farmers, fishermen and residents are likely to continue using specific local weather forecasting for their farming and fishing activities[1]. Such localized weather forecasting is normally not made available in the official weather forecasts. Hence, the rural communities are likely to continue relying on their traditional methods of forecasting the weather, which they claim to be important and reliable[1]. Our results for the most part supported the predictions based on phenology of one tree species at least, and revealed some new trends not reported before.

Acknowledgement

Author wishes to convey deep gratitude to village Headmen (*Gram Pradhanas*) and all the elders (men and women) of the study sites for decoding the qualitative terms into approximated quantitative terms through several discussions. Prior Informed Consent (PIC) was taken from the knowledge providers time to time. Author conveys sincere thanks to Indian Meteorological Department (IMD) at Narsingarh, Bimangarh and Department of Physics, Tripura University for data collection, support and encouragement. Author appreciates the support and encouragement from Forest Department of Tripura and Medicinal Plant Board of Tripura. Author conveys sincere thanks to Dr TK Mukherjee and Dr KP Singh, Editors, IJTK for their valuable comments. Finally, author conveys heartfelt gratitude for insertion of comments and corrections and also for combing review processing of Honorable Guest Editors of IJTK Special Issue, Prof Nancy Turner and Dr Ranjay K Singh, for the present manuscript and acknowledge thereby.

References

1 Galacgac ES & Balisacan CM , Traditional weather forecasting for sustainable agroforestry practices in Ilocos Norte Province, Philippines, *Forest Ecol Management*, 257 (2009), 2044-2053.

2 Burghart R, Weather lore – Weather by Nature, In: *http://www.suite101.com article.cfm/nature_sketches/33934*, (2000).

3 Kale K, Venugopal T, Vaidya VB & Vinod M, Rain induction through *Vedic* technology, In*: Proc 1st World Cong Vedic Sciences*, edited by Krishnamurthy BL & Vasu KI, (*Vijnana Bharati*, Bangalore), 2005, 56-59.

4 Mishra SK, Dubey VK & Pandey RC, Rain forecasting in Indian almanacs (*panchangs*): A case for making *Krishi-Panchang*, *Asian Agri-Hist*, 6 (1) (2002) 29-42.

5 Varshneya MC, Kale N, Vaidya VB, Kane PV & Pandey V, Forecasting and validation of rainfall for Barshi in Maharashtra based on Astro-meteorological principle of rainfall conception, *Asian Agri-Hist*, 13 (3) (2009) 189-196.

6 Pisharoty PR, Plant that predicts monsoon, *Honey Bee*, 4 (4) (1993) 12.

7 Kanani PR, Munshi MA, Makwana DK & Sawalia VJ, *Bhadli nu bhantar ketlu sacchu* (in Gujarati), *Krishi Jivan*, Special Issue, *Varshad Agahi*, 1 (1995) 26.

8 Bhatvadekar VG, *Viderbha vibhagakarita monsooncha andaj va peek yojana* (in Marathi), In*: Proc Seminar on Prediction of Rainfall based on Astrological Methods and Local Practices*, edited by Varshneya MC & Vaidya VB, (MPKV Research Publication, No 39, MPKV, Maharashtra), 2002, 100-104.

9 Newstrom LE, Frankie GW & Baker HG, A new classification for plant phenology based on flowering patterns in lowland tropical rain forest trees at La Selva, Costa Rica, *Biotropica*, 26 (1994 a) 141-159.

10 Newstrom LE, Frankie GW, Baker HG & Colwell RK, Diversity of long-term flowering patterns, In*: La Selva: Ecology and Natural History of a Neotropical Rain Forest*, edited by McDade LA, Bawa KS, Hespenheide HA & Hartshorn GS, (University of Chicago Press, Chicago, Illinois, USA), 1994b, 142–160.

11 Deb DB, Verbenaceae, In: *The Flora of Tripura State,* Vol II, edited by DB Deb, (Today and Tomorrow's Printers and Publishers, New Delhi), 1983, 133.