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Presage Biology: Lessons from nature in weather forecasting

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The method used by local and indigenous peoples for predicting rainfall and other weather conditions solely on the basis of bio-indicators – the phenology of plants and behavior of animals – is coined as a new term: *Presage Biology*. Some of these activities of floral and faunal diversity are described in their application to predict oncoming rain, based a literature review as well as personal observations of present author as well as other reference sources pertaining to India and different parts of the world.

Keywords: Plant phenology, Animal behaviour, Weather prediction, Forecasting rain

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Ethnic tribes and other local people, especially farmers, fishers and hunters are very astute weather watchers and are quick to recognize weather conditions and whether or not they are favorable to their production systems[1,2]. Local forecasting often combines empirical observations and weather predictions through the phenological patterns of plants and the behaviour of birds and other animals[2]. The production and application of local forecasts are deeply localized, derived from an intimate interaction with a micro environment whose rhythms are intertwined with the cycles of seasonal changes. The vulnerability caused by vagaries of the weather creates a knowledge base among farmers in the form of Indigenous Technical Knowledge (ITK) that helps people to overcome uncertainty and prepare for possible adverse or favorable events[2]. Local indicators and local knowledge systems cannot be replaced with scientific knowledge, because they are holistic and specific to local situations, providing farmers and others with the ability to make decisions and prepare for the coming agricultural year[2,3]. Mechanisms for integrating both traditional and scientific weather forecast systems would reduce uncertainties and improve farm management, as well as provide a basis for integrating scientific forecasts into existing decision processes of farmers[4].

For the traditional weather forecasters, the phenology of certain plants and behaviors of certain animals is a reliable indicator of a wet or dry year, or for the onset of the rainy season or adverse weather conditions[5]. Farmers often use such indicator plants and animals in planning for their cropping activities, especially when other indicators are not evident, for example due to a dry spell[5]. There is a tendency for western-educated individuals to dismiss such traditional weather lore as simply a set of beliefs designed to explain the steries of nature that people could not explain in any other way. Despite the presence of modern technology to predict weather conditions over the next day or month in a specific location, folk weather lore has remained an important form of local weather forecasting, and can serve to supplement public meteorological information and weather prediction[5]. People have been attempting to predict the weather for a very long time and have used a number of different methods, some of which have proven very effective and successful. There is an urgent need to authenticate the various traditional methods of weather prediction, especially rainfall forecasting, and ways to predict other natural weather phenomena such as floods, cyclones, etc.[6]

As very few scientific studies have ever been conducted in ancient Astro-science and almost all that have been undertaken have reported encouraging and positive outputs, there seems to have enormous scope for studying ancient sciences in greater depth. Unfortunately, with the advent of scientific technologies over the past century or so, ancient knowledge which is holistic and multidimensional in nature, has often been sidelined. The most important

aspect regarding our ancient scriptures is that the weather of the upcoming year(s) can be predicted with relatively high accuracy[6]. More accurate and reliable weather forecasts would be obtain through a synthesis of different approaches, both ancient and modern[6]. The modern meteorologist should take advantage of the astrological lore available in ancient books and from traditional knowledge systems and combine it with their studies, so that more reliable forecasts could be offered for the benefit of the people[6].

Plant indicators

Plants and certain fungi can accurately forecast the certainty of wet and dry weather. In western countries, some fascinating facts were recorded for dandelions (*Taraxacum officinale*), wild indigo (*Baptisia australis* (L.) R. Br.), clovers (*Trifolium repens*) and tulips (*Tulipa gesneriana*), all of which fold their petals prior to the rain[7,8]. *Pleorotus ostreatus*, a type of edible mushroom (fungus) growing on stumps and tree trunks, expands prior to a rain and closes in dry weather[7,8]. Mushrooms abound when the weather is moist as do mosses and seaweeds[7,8]. In fact, seaweeds exposed on the rocks at low tide seem to swell and rejuvenate in the high humidity preceding wet weather[8].Traditional indicators of an upcoming rain include: ripening and early rotting of fruits, unusual flowering of plants, increased length of inflorescence, etc. (Table 1). Among of the most reliable of all natural weather indicators are pine cones (*Pinus* sp)[9]. In dry weather, pine cones open out as the scales shrivel up and stand out stiffly. When it is damp, they absorb moisture and as the scales become flexible again, the cone returns to its normal shape[9]. The petals of the morning glory (*Ipomoea purpurea*) act in a similar way – with wide open blooms indicating fine weather and closed petals predicting rain and bad weather[9]. This opening and closing also occurs with the flat-leaved vanilla (*Naravelia zeylanica*)[9]. In coastal areas, seaweed is often used as a natural weather forecaster[9]. Brown sea algal weed, *Kelp*, for example, when exposed during low tide, shrivels and feels dry in fine weather, but swells and becomes damp if rain is in the air[9]. The flowers of scarlet pimpernel (*Anagallis arvensis*) "behave" according to weather conditions[9].

Animal indicators

In traditional weather forecasting, the onset of the rainy season and upcoming rain is also indicated by the unusual behavior of certain animals as outlined below (Tables 2-4). Traditional indicators of an upcoming rain include: unusual chirping and bathing with sand of birds, native frogs croaking near swampy areas and hiding their egg masses, dragon-flies flying low, female native crabs migrating from rivers to brackish water, spider spinning shorter and producing thicker webs, wasps hiding their honeycomb, etc. (Tables 2-4)[5,6,18,20]. In English literature, there is a well-known proverb related to the licking nature of the cat. This is explained as during fair weather, when the relative humidity is low, electrostatic charges (static electricity) can build up on a cat as it touches other objects[11-14]. Cat hair loses electrons easily, so cats become positively charged[15]. When a cat licks itself, the moisture makes its fur more conductive so the charge can "leak" off the cat. In fair weather during high pressure, dry air sinks from above. Relative humidity is low and cat hair becomes a better insulator. Many cats don't like to be petted during the cold winter season when the humidity is low because sufficient charge builds up to cause small sparks, which irritate them[15]. In contrast to this, during the onset of heavy rain, crickets produce shrill infrasonic sounds. These kinds of sounds produced before onset of heavy rain is a type of alarm because storms and thunder generates sound waves at those frequencies as well as it is also the matter of changes in barometric and hydrostatic pressure[16]**.** Normally, these pressures fluctuate slightly. Animals are highly tuned in to any changes beyond those natural fluctuations, which can signal big changes in the weather[16]. These variations can trigger an animal's survival mechanism. The animals' instinctive reaction is to seek shelter in the face of potentially violent weather[16]. For example, abnormal conditions like storms such as *Kal-Boishakhi* (local storm in Bay of Bengal during summer) and hurricanes cause large decreases in air pressure and water pressure[16]. Animals exposed and accustomed to certain patterns can quickly sense these changes. Researchers observed this type of behavior among a group of sharks as they tracked the sharks' movements during tropical storm *Gabrielle* and *Hurricane Charlie*[16]. After the barometric pressure dropped just a few millibars - an occurrence that causes a similar change in hydrostatic pressure - several sharks swam to deeper waters, where there was more protection from the storm[16]. Birds and bees also appear to sense this drop in barometric pressure

Table 1—Phenology of plants for prediction of weather conditions

Natural indicator	Plant	Predicted by tribe	Region/source	Types of forecast
Ripening and early rotting of fruits	*Abroma angusta* (L.)L. (Fam. Sterculiaceae)	Halam	Dry field and basin	B
Early unusual flowering of plants	*Abutilon indicum* (L.) Sweet (Fam. Malvaceae)	Jamatia	Basin area	B
Increased length of inflorescence	*Acrocephalus verbenaefolius* Watt ex Mukerjee (Fam. Lamiaceae)	Reang	Edge of paddy field	B
Drooping down of petals	*Cassia tora* L. (Fam. Caesulpinaceae)	Tripuri	Marshy area	C
Increased length of internodes	*Cassia fistula* L. (Fam. Caesulpinaceae)	Lusai	Marshy area	B
Increased length of corolla tube	*Costus speciosus* (Koenig) Smith (Fam. Costaceae)	Kuki	Upper dry land and Tilla (Table land like platue)	C
Increased length of leaves	*Ceratopteris thalictroides* (L.) Brongn. (Fam. Parkeriaceae)	Noatia	Marshy area	B
Profuse yellowing of leaves	*Croton oblongifolius* Roxb. (Fam. Euphorbiaceae)	Chakma	Marshy area	B
Short length of pedicel	*Curculigo orchioides* Gaertn. (Fam. Amaryllidaceae)	Reang	Upper dry land and Tilla (Table land like platue)	C
Change in colour of corolla	*Cuscuta reflexa* Roxb. (Fam. Cuscutaceae)	Lushai	Marshy area	B
Increase in volatile oil in roots	*Curcuma zedoaria* Rosc. (Fam. Zingiberaceae)	Uchai, Khasia, Bhil, Cheimal, Bhutia and Lepcha	Upper dry land and Tilla (Table land like platue)	B
Unusual secretion of glandular cells in leaves	*Drocera burmanni* Vahl. (Fam. Droseraceae)	Halam	Marshy area	C
Abundant anthocyanin in stem	*Eupatorium triplinerve* Vahl. (Fam. Asteraceae)	Mog	Marshy area	B
More scabrous character of stem and leaves	*Gnaphalium polycaulon* Pers. (Fam. Asteraceae)	Tripuri	Marshy area	B
Small size of lower leaves with dark color	*Gomphrena globosa* L. (Fam. Amaranthaceae)	Chakma	Marshy area	C
Dense inflorescence with smaller flower	*Holarrhena antidysenterica* Roxb. (Fam. Apocynaceae)	Noatia	Dry region	B
Early unusual flowering of plants	*Hydrocotyle javanica* Thunb. (Fam. Apiaceae)	Jamatia	Marshy area	B
scabrous character of stem and leaves	*Hyptis suaveolens* Piot. (Fam. Lamiaceae)	Reang	Dry as well as Marshy area	B
Yellow color of inflorescence	*Lantana camara* L. (Fam. Verbenaceae)	Uchai and Khasia	Marshy area	C
Color change in flowers	*Leonurus sibiricus* L. (Fam. Lamiaceae)	Darlong	Marshy area	B
Increased length of leaves	*Lippia alba* (Mill.) N.E. (Fam. Verbenaceae)	Manipuri	Marshy area	B
Small size of fruit and flower	*Marsdenia tinctoria* R.Br. (Fam. Apocynaceae)	Munda	Dense moist forest	B
Early unusual flowering of plants and wide open blooms indicating fine weather	*Naravelia zeylanica* DC. (Fam. Ranunculaceae)	Manipuri	Dense moist forest	C
Smaller size of leaves	*Houttuynia cordata* Thunb. (Fam. Saururaceae)	Bengali	Marshy area and dense moist forest	B
Early unusual leaf fall of plants	*Mangifera sylvatica* Roxb. (Fam. Anacardiaceae)	Chakma	Upper dry land and Tilla (Table land like platue)	B
Larger size of leaves	*Premna esculenta* Roxb. (Fam. Verbenaceae)	Jamatia	Marshy area and dense moist forest	B

Table 1—Phenology of plants for prediction of weather conditions—*Contd.*

Natural indicator	Plant	Predicted by tribe	Region/source	Types of forecast
Dark color of leaves and stem	*Psidium guineense* Swartz. (Fam. Myrtaceae)	Tripuri	Upper dry land and Tilla (Table land like platue)	C
Larger size of internodes	*Rotala indica* (Willd.) Koehne. (Fam. Lythraceae)	Tripuri	Marshy area	B
Scabrous character of stem and leaves	*Piper khasianum* C.DC. (Fam. Piperaceae)	Tripuri	Dense moist forest	B

Type of forecast: A – Onset of rainy season; B – Upcoming rain; C – Adverse weather condition (typhoon or flood)

Table 2—Behaviour of birds for prediction of weather conditions

Scientific name & common English name	Presage biological activity	Types of forecast
Aethopyga saturate (Black-throated Sunbird)	Unusual chirping	A
Alophoixus flaveolus (White-throated Bulbul)	Unusual chirping and bathing with sand	B
Arborophila atrogularis (White-cheeked Partridge)	Unusual chirping and flying up in the sky	C
Chloropsis hardwickii (Orange-bellied Leafbird)	Unusual chirping and flying low to chase insects	A
Copsychus malabaricus (White-rumped Shama)	Unusual chirping	A
Culicicapa ceylonensis (Grey-headed Canary Flycatcher)	Unusual chirping and flying in the low catchment's area	A
Cyornis concretus (White-tailed Flycatcher)	Unusual chirping and flying in the low catchment's area	C
Ducula badia (Mountain Imperial Pigeon)	Unusual movement to take shelter in shadow of leaves	C
Gallus gallus (Red junglefowl)	Unusually clucks and sand bathing	C
Glaucidium brodiei (Collared Owlet)	Unusual chirping with very low tune and spreading of the wings in soil	C
Glaucidium radiatum (Jungle Owlet)	Unusual chirping and spreading of the wings in soil	C
Gracula religiosa (Hill Myna)	Unusual chirping and aggressive behaviour	C
Lonchura striata (White-rumped Munia)	Unusual chirping with shrill sound	C
Loriculus vernalis (Vernal Hanging Parrot)	Unusual chirping and flying in fleet	B
Megalaima asiatica (Blue-throated Barbet)	Unusual chirping	B
Megalaima australis (Blue-eared Barbet)	Unusual chirping and flying low	B
Melanochlora sultanea (Sultan Tit)	Unusual chirping	B
Myiomela leucura (White-tailed Robin)	Unusual chirping with very low tune	B
Myophonus caeruleus (Blue Whistling Thrush)	Unusual chirping with very low tune	B
Orthotomus atrogularis (Dark-necked Tailorbird)	Unusual chirping and very fast movement	B
Orthotomus sutorius (Common Tailorbird)	Unusual chirping and very fast movement	B
Picus canus (Grey-headed Woodpecker)	Unusual activity with rotation around the tree	B
Pycnonotus jocosus (Red-whiskered Bulbul)	Unusual chirping	B
Streptopelia chinensis (Spotted Dove)	Unusual chirping and moves in pair and take shelter in shadow of leaves	B
Treron curvirostra (Thick-billed Green Pigeon)	Unusual chirping and unusual movement to take shelter in shadow of leaves	B

Type of forecast: A – Onset of rainy season; B – Upcoming rain; C – Adverse weather condition (typhoon or flood)

and will instinctively seek the cover of their nests or hives. Birds also use their ability to sense air pressure to determine when it is safe to migrate[16].

Methodology

Phenology of different plants and behaviors of animals were observed from 2005-2009 for conduction of the study in Tripura, North Eastern regional part of India. Identification, analysis and documentation of the traditional indicators used for seasonal rainfall forecast were conducted[24,25]. North, West, South and Dhalai districts from Tripura were identified for data collection. A total of 20 villages were sampled. The selection of village was not systematic; it was mainly based on the accessibility to the respective villages and availability of transportation[25]. A total of 110 respondents were randomly selected based on age factor, where all

people older than 35 yrs were eligible to participate in the interviews[25]. They were both tribes and non-tribes. These studied people were cultural and socially rich but poor in economic background. The communities that were selected in this study included village elders, folk-tellers, ethnic priests, ethnic bards (folk singers), pastoralists, crop producers, hunters, fishers and agro-pastoralists[25] (Tables 1-3). The study was conducted by interaction with people through key informant interviews and focus group discussion[25]. The participants' observations were also used in data collection. Questionnaires were administered to different group of elders, where a checklist that included issues on conventional climate forecasts knowledge, seasonal rainfall predictions, knowledge on traditional indicators and past climatic events guided the interviews[25]. The collected data was analyzed and synthesized using Statistical Package for Social Science (SPSS) and Excel computer programmes[25]. Focus group discussions were important in weighing and balancing the information collected through interviews with a view to produce generalizations that represent the traditional knowledge existing in the community[25]. Focus group discussion of up to 20 people was organized and the various techniques used within the community in weather forecasting were explored[25]. Prior information and data were collected from different sources through literature searches to compile data on the phenology of different plants and behaviors of animals used in weather forecasting[25].

Table 3—Behaviour of animals except birds for prediction of weather conditions

Natural indicator	Types of forecast
Biting nature of mosquitoes (mainly *Culex* females)	A,B
Exodus of ants from their caves	A
Native frogs croaking near swampy areas and hide their egg mass	B
Insects migrating to mountain	C
Abundance of Insects	B
Incessant chirping of insects	C
Dragonfly flying low	B
Loose dogs excreting waste in the middle of road or at higher elevation	B
Native shrimps transferring to creeks	B
Apex of the mound is moist	B
Female native crabs migrating from rivers to brackish water	B
Chicken staying under shade at noontime and seem like taking a bath with dust	B
Calves becoming uneasy	B
Spider spinning shorter and producing thicker webs	C
Native pigs gathering their litter	B
Earthworm coming out of ground	C
Wasps hiding their honeycomb	B
Deer becoming restless	C

Type of forecast: A – Onset of rainy season; B – Upcoming rain; C – Adverse weather condition (typhoon or flood).

Results and Discussion

Ethnic weather forecasters of 19 tribal communities (viz. *Halam, Tripuri, Kuki, Chakma, Mog, Jamatia, Noatia, Lushai, Reang, Garo, Munda, Orang, Santhal, Uchai, Khasia, Bhil, Cheimal, Bhutia* and *Lepcha*) of Tripura mostly relied on similar bio-indicators to predict rainfall and other weather conditions. All of them predicted for three related phenomena: the onset of the rainy season (A); upcoming rain (B) and adverse weather conditions, i.e. typhoons or floods (C). The weather lore grouped by them depended on three kinds of bio-indicators: phenology of plants and fungi, the behaviors of birds; and activity and behaviour of animals other than birds. These indicators can be further classified based on the type of weather forecast that each pertains to[5]: short-range forecast (forecast for an upcoming rain or the next few days or daily rainfall); medium-range forecast (forecast for the next few months or onset of rainy season); long-range forecast (seasonal outlook for the year); and occurrence of adverse weather conditions (i.e., storm or flood) (Table 4).

Traditional indicators for weather forecasts were validated by several means in Tripura. For the traditional weather forecasters, phenology of plants is a reliable predictor of rainfall[5]. Onset of the rainy season, for example, is easily predicted by the larger sized leaves of *Premna esculenta* Roxb. It is also equally predicted by the increased length of internodes of *Cassia fistula* L. and increased length of the corolla tube in *Costus speciosus* (Koenig) Smith. Prediction of upcoming rain can be explored from various plant bio-indicators such as ripening and early rotting of fruits of *Abroma angusta* (L.) L., early unusual flowering and increased length of inflorescence of *Abutilon indicum* (L.) Sweet and *Acrocephalus verbenaefolius* Watt ex Mukerjee, respectively (Table 1). Likewise, the occurrence of adverse weather conditions (i.e., storm or flood) can be predicted by sudden drooping down of petals of flowers of *Cassia tora* L. and unusual secretion of glandular cells from the leaves of sundew (*Drocera*

Table 4—List of some references for phenological and behavioral activities of bio-indicators for rain forecasting

Bio-indicator(s)	Type of rain forecasting	Explanation for phenological and behavioral activities of bio-indicators
Movement of dragon flies (*Odonata* sp.)	Short range	When humidity reaches saturation, a couple of hours before dragon flies move in swarms indicating rain[18].
Flapping of ears by goats (*Capra hircus*)	Short range	Increasing moisture causing uneasiness and sweating to goats, thereby flapping of ears[19].
Foxes howling in the morning and evening	Short range	Steady increase in relative humidity with peaks at 8 A.M. and 5 P.M. If saturation at these timings is sensed by foxes, they reflect the same through howling indicating impending rain[2].
Jumping cattle (*Bos taurus*)	Short range	Cattle anticipate rain few hours early by sensing cool breezes developed before rain for a short period. Therefore, they jump joyfully[2].
Poultry (*Gallus gallus*) inserting feathers in the soil	Short range	Poultry birds respond to the increased moisture content in the soil, by relishing some hotness while pushing their wings into the soil[2].
Flocking of sheep (*Ovis aries*) and goats	Short range	When low clouds are formed, enough energy is released from water vapor resulting in formation of excess heat, which cannot be tolerated by sheep and goats. Hence they form flocks[20].
Biting nature of housefly (*Musca domestica* L.)	Short range	Houseflies become active when atmospheric humidity reaches saturation, which brings rain[2].
Movement of termites in rows	Short range	If both atmospheric and soil surface humidity are high, termites move in large numbers in rows. Since rain is expected when humidity is more, these termites are believed to indicate rain in a few hours[2].
Dogs (*Canis familiaris*) barking continuously and sharply	Short range	Due to release of heat from water vapour into the atmosphere, cloud formation takes place resulting in restlessness among dogs indicating ensuing rain[2].
Chirping of birds (detail in Table-2)	Short range	When these birds move at heights above 0.5 kms, they sense the upper air winds and chirp. Usually rain bearing clouds occur at heights between 0.5 and 2.5 kms. Because of the sensible response of these birds to the winds, farmers predict rain. It is also believed that if these birds fly in rows after the occurrence of rain, the possibility of further increase in rain is very high[2].(discussed in detail in Table-2).
Parabolic flight of open stork bill birds (*Ciconia nigra*)	Short range	Response to change in winds at higher altitudes (around 0.6 km) brings about a change in behavioural pattern of these birds in the form of a parabola shaped flight. This indicates rain[2].
Movement of birds	Short range	Response to change in winds at higher altitudes (around 0.6 km) brings about sudden movement of these birds in the atmosphere, indicating rains[2].
Appearance of (insect) in large numbers at onset of monsoon	Short range	Abrupt increase in the moisture causing saturation, thereby rain[2].
Peacock (*Pavo cristatus*) making sound early in the morning, late in the evening	Short range	Sometimes cool breeze along with nearly saturated atmospheric humidity co-exist. Hence, peacocks play and exhibit rhythmic movements, which indicates possible occurrence of rain[2].
Movement of Red hairy caterpillar (*Amsacta albistriga*)	Short range	The adults of red hairy caterpillar become restless as the humidity increases beyond 90%. Their quick movement is considered as an indicator of rain[2].
Frogs (*Rana tigrina*) croaking underneath stones, leaping of small frogs	Short range	Frogs under stones become restless because of deficient oxygen and come out of holes for want of air. Hence they croak [2,21].
Squeaking of owls (*Tyto alba pratincola*)	Short range	Owls are sensitive to humid conditions. The fear of increasing humidity and heat released by clouds instigates restlessness among owls. The peculiar squeaking sound of owls has been attributed to be an indicator of rain[2].
Migration of parakeets (*Psittacula krameri manillensis*) in N-S direction	Short range	Presence of moisture and possible occurrence of rain[2].

Contd

Table 4—List of some references for phenological and behavioral activities of bio-indicators for rain forecasting—*Contd.*

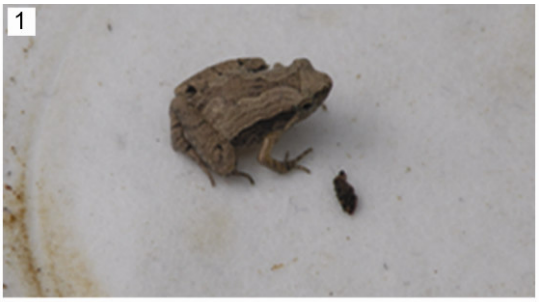
Bio-indicator(s)	Type of rain forecasting	Explanation for phenological and behavioral activities of bio-indicators
Singing of black cuckoo (Cuculus clamosus)	Short range	Change in wave motion of air due to change in water vapour content on a large area is sensed by cuckoo and is induced to sing. These melodious sounds are often taken as indicators of rain on any given day during that season22.
Movement of black ant (Componotus herculeanus) in a row	Short range	Hair and antenna of ants lengthens due to increase in the humidity triggering the process of carrying the eggs to a safer place. This process is observed with thousands of ants moving in a stream, thereby indicating rain23.
Number of seeds in the fruits of Butea monosperma	Short range	Petiole of Palash (Butea monosperma) sensitive to changes in the humidity. So length of the fruit it bears also changes. Usually each fruit bears three seeds. Farmers believed if seed base of the fruit develops into full size, rains occur early in the season. If middle seed develops, rains occur heavily in the middle of the season. When seed is at the top of the fruit, rains occur at the end of the season. If all the three seeds develop fully, then good rainfall is predicted with uniform distribution throughout the season. So, when the monsoon winds start blowing, the seed near the petiole (first seed) develops fully in a short time. If the winds are further strong, middle seed develops. Similar is the case with third seed development. It can be concluded that seed development in fruits of this tree is directly related to the monsoon winds blowing18.
Termites developing living hills at corner bunds (Globitermes sulphureus)	Medium range	Because of soil moisture differences above soil surface to that inside the soil, termites come to the hills indicating ensuing rain2.
Positioning of nests by weaver bird (Ploceus philippinus)	Long range	If the nest is built near the bottom of the well, it acts as an indicator of poor recharge in the well due to poor monsoon. Contrast to this, if the nest is built at the top of the well, it indicates good monsoon. Also the possibility that this bird observes the clouds, sky condition and weaves its nest slightly above the water level in the well anticipating possible good rain2.
Full bloom of Neem (Azadirachta indica A. Juss.) tree in Summer	Long range	When temperatures exceed 40°C for a week, low pressure is created. Clouds move into the low pressure after onset of monsoon triggering heavy rains19.

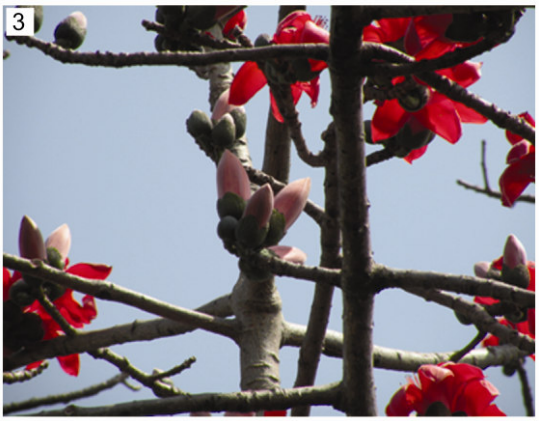
burmanni Vahl. (Table 1). Bad weather is traditionally predicted to be approaching when ferns and mosses grow abundantly near the ditches, rivers and other wetlands[5].

In traditional weather forecasting, the onset of the rainy season and upcoming rain is also indicated by the unusual behavior of certain birds and animals' aggressive and abnormal activities. The beginning of the rainy season in Tripura is signaled by the unusual chirping of the Black-throated Sunbird (*Aethopyga saturata*), Orange-bellied Leaf Bird (*Chloropsis hardwickii*), White-rumped Shama (*Copsychus malabaricus*) and Grey-headed Canary flycatcher (*Culicicapa ceylonensis*) (Table 2) and equally signaled by the biting nature of *Culex fatigans* females mosquitoes, exodus of ants usually evacuating stored foods, and migration of groups of birds and bees[5] (Tables 2 & 3). Traditional indicators of an upcoming rain event are: unusual chirping and flying in fleet by the Vernal Hanging Parrot (*Loriculus vernalis*), flying low by the Blue-Eared Barbet Bird (*Megalaima australis*), chirping with very low tune by the Blue-Whistling Thrush (*Myophonus caeruleus*), and very fast movement of the Common Tailor Bird (*Orthotomus sutorius*), as well as when native frogs (*Rana tigrina*) croaking near swampy areas and hide their egg mass, dragonflies flying low, chickens staying under shade at noontime and seeming to like taking a bath with dust, native pigs gathering their litters, wasps hiding

their honeycombs, etc. (Tables 2 & 3). In traditional weather forecasting, a typhoon or flood is imminent when insects start incessant chirping, spiders spin shorter and thicker webs, and deer become restless and also when earthworms come out of the ground and scatter in the streets[5]. It was believed that when wasps build their nests on high trees, a flood is coming, and if they build them near the ground, there is going to be a strong wind[5]. Some birds fly low because they chase insects and these are at a level near the ground surface at such times. When rain clouds are approaching, the downward current of air blows insects down from high altitudes. Birds that ordinarily catch insects high in the air now have to follow them close to the ground[5]. Some birds are noisy or make mournful sounds when rain is imminent and dogs are observed to excrete their wastes in the middle of the road or on higher ground before upcoming rain[5]. One of the world's smallest frogs, *Noblella pygmaea*, found near the marshy areas of Suryamaninagar, Tripura, showed peculiar activity at the time of an upcoming rain and tended to colonize within small groups, whereas after the rain finished, they again segregated from each other (Fig. 1). The medicinal plant *Morinda angustifolia* exudes nectar heavily before a rain, which attracts ants for pollination (Fig. 2). In contrast, the cotton plant *Bombax ceiba* shows abnormal movement of leaf and floral parts during the onset of rain (Fig. 3), and the sacred white orchid, *Vanda roxburghii*, produces thicker flowers, fruit and seeds during the rainy season as compared to the dry winter season (Fig. 4).

There have been interesting proposals about the validity of some animal folklore and it is pointed out that science is based on observation and folklore is based on centuries of observations - although the observations were not conducted in controlled circumstances[16]. Also, differences exist across species and between individuals of the same species in their sensitivity to weather fluctuations. While some animals may be great weather predictors, others within that same species might not show the same sensitivity[16]. It is said that when cows (in average) are lying down in a field, rain is on its way[9]. This is explained by the fact that the cows sense the moisture in the air and are making sure they have somewhere dry to lie down[9]. If they stand up in their fields or pastures (in average), weather will be fine. If, on the other hand, they lie down (in average), they sense the





Figs.1-4—World's one of the smallest frog - *Noblella pygmaea,* Catenazzi. was found in Suryamaninagar, Tripura., 2 *Morinda angustifolia* Roxb exudates heavily during upcoming rain which attracts the ants., 3 *Bombax ceiba* L. - movement of leaf and floral parts are well being documented for weather lore, 4 *Vanda roxburghii* flower, fruit and seed characters are documented for weather lore

moisture of approaching rain and make sure they have a dry patch to lie on. In a similar way, squirrels are often used in forecasting the weather over the coming winter. If their tail is very bushy or they are collecting big stores of nuts in autumn, then a severe winter is expected[9]. As is true with human hair, wool is also very responsive to the amount of moisture in the air. When the air is dry, hair shrinks and curls up, whereas if the air is moist (indicating rain), it swells and straightens out[9]. As a weather forecaster in Germany, the green frog called *Laubfrosch* (in German language) is very popular for accurate prediction of weather condition[10]. For experimentation, if it is kept under a big glass jar with a tiny ladder in it and covered with a cloth, it will survive for a few days and move inside. If the frog remained at the bottom of the glass, rain would be predicted[10]. The higher up on the ladder the frog climbed, the better the weather would be. It has been observed in nature that this particular kind of frog (*Hyla regilla*) tends to climb up on branches the warmer the weather gets[10].

There are also reports of unusual animal behavior prior to tornadoes and even other natural calamities[10,17]. It is now speculated that animals may be responding to the subtle variations to the earth's electromagnetic field that happen prior to tornadoes[10,17]. Other studies suggest that animals may be reacting to ultrasound or micro temblors not significant enough to be picked up by humans[17]. Animals also seem to be quite accurate predicting more average weather. Birds tend to fly lower to the ground when a storm is approaching, as the falling air pressure can make flying more arduous and may even cause discomfort in their ears[17]. Seagulls stop flying before a storm, choosing to roost on the coast until the rain passes. Animal who hibernate are good predictors of how harsh the coming winter will be. For example, bears keep eating until very late in the fall and squirrels gather an unusually large amount of food in preparation for a particularly snowy winter[17]. With all of these above examples, it is said that traditional functional documentation procedures of living beings (biological agents) by the ethnic, indigenous and local peoples for forecasting weather in which rapid interaction of a group of organisms towards abiotic factors of the ecosystem are to be recorded in accordance with the dynamicity of behaviors within a specific period of time may be termed as Presage Biology. In other words, the prediction of weather condition according to the phenology of plants and behaviour of animals may be coined as 'Presage Biology'.

The phenology of plants, behaviour of animals and the appearance and movement of birds and insects are frequently used by elders to predict weather and climate in their communities[25]. Local indicators were used by local communities in seasonal rainfall prediction. It has been found that plants phenology is mostly used as potential predictors for seasonal rainfall prediction. The appearance and behavior of animals (black butterflies - *Charaxes pollux*, army worms- *Spodoptera exempta*, Grass-green grasshopper- *Hesperotettix* sp. etc.) are among the best predictors used in rainfall prediction[25]. Briefly, the appearance of large swarms of red ants (*Treiberameisen*-local name) in September to November, occurrence of large swarms of black butterflies (*Charaxes pollux*) is an indicative of imminent rainfall onset and it also indicates that the upcoming rainfall season will be good[25]. Likewise, the presence of higher than normal flowering intensity of the *Mihemi* (*Erythrina abyssinica*), *Mikwe* (*Brachystegia speciformis*) and *Mpinigesi* (*Prunus persca*) trees during the months of July to November are the indicative of good amount of well distributed rainfall in the upcoming season[25]. However, a good fruits harvest from *Mikusu* (*Uapaca kirkiana*) trees is a signal of impending drought in the upcoming season. significant flowering of *Mikuyu* (*Ficus* sp) trees is a signal of imminent rainfall onset and breeding of *Mipegele* (*Syzygium cordatum*) trees is a signal of abundant rainfall in the upcoming season[25]. Now, here is a little bit confusion about the bench mark (normal)[25]. It therefore imperative that more research will be needed to quantify the norms. Since indigenous knowledge is mainly based on relative experience and local experience, lack of benchmark makes it difficult to be harmonized and integrated into conventional forecasting system. Systematic documentation, quantification and subsequent integration of indigenous knowledge into conventional weather forecasting system is therefore recommended as one of the strategy that could help to improve the accuracy and reliability of seasonal forecasting information under a changing climate[25].

Traditional Phenological Knowledge[38-42]

Traditional Phenological Knowledge (TPK) is one type of Traditional Ecological Knowledge, paralleling the formalized study of species life cycle events and

biological change known as ‘‘phenology[26]. TPK relates to traditional knowledge of seasonal timing of growth, development, reproduction and migration of organisms, which generally occurs in a predictable sequence based on temperature thresholds, length of daylight, moisture or other environmental determinants[27]. Environmental factors influencing species development may be recognized directly, or through concurrent effects on other species. People everywhere have learned to use physical environmental indicators – onset of seasonal rains, forest snowfall or melting patterns of particular snow banks – as well as biological indicators – spring leaf falling out of certain trees or shrubs and blooming of certain flowers, such as salmonberry[28], or appearance of certain migrating animals or birds – to predict optimal times for harvesting particular kinds of fish (e.g. spawning time for salmonids), for hunting certain animals or for picking berries or other activities taking place at more distant locations[29]. They can also predict abundance of a given species or productivity of certain plant resources through such indicators[30-42]. Thus the new term, *presage* is being accurately nominated for all kinds of traditional phenological knowledge.

Conclusion and policy implication

Presage biology deals with the activity of species at those very moments when plants and animals prepare to take necessary precautions against upcoming natural dangers. Thus it can be applied to short, medium and long range rain forecasting. Due to formation of low pressure in the oceans, humidity in their air reaches its highest saturation; as a result - rain, thundershowers and even hail storms occur suddenly or over the subsequent few days. During these conformational changes in the atmospheric weather, a couple of hours before a rainfall, plants undergo regeneration of a number of defensive chemicals and stress hormones and enzymes in different organs, along with production of anti-nutrients or simultaneous exudation. In contrast, the nervous systems of animals (in higher group of vertebrates and invertebrates) become more active than in normal conditions. This is further proven by substantial evidence from bio-indicators (Table 4) from India, with a possible explanation for abrupt changes in phenological and behavioral activities of plants and animals respectively. A number of literature sources also support this evidence[2,18-23,33-42]. Now is the time to integrate the data from modern techniques of weather forecasting with presage biological evidence from traditional knowledge, to support the extra demands for local weather prediction at specific times and in particular regions at this era of rapid climate change. If it is not done, countries like India, which are totally dependent on the seasonal rainfall for sustainable agricultural and allied activities, will suffer greatly in near future from deficiencies in short, medium and long range rain forecasting[39-42].

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References

1 Mcfarland JM & Strand JF, Weather-wise planning in farm management, In: *Handbook of Agricultural Meteorology*, edited by Griffiths JF, (Oxford University Press, London), 1994, 264-272.

2 Ravi Shankar K, Pochaiah Maraty, Murthy VRK & Ramakrishna YS, In: *Indigenous Rain Forecasting in Andhra Pradesh*, edited by Prasad YG, (Central Research Institute for Dryland Agriculture, CRIDA, Santoshnagar, Hyderabad), 2008, 67.

3 Bharara LP & Seeland K, Indigenous knowledge and drought in the arid zone of Rajasthan: weather prediction as a means to cope with a hazardous climate, *Int Asienforum*, 25 (1994) 53-71.

4 Ngugi RK, Climate forecast information: The status, needs and expectations among smallholder agro-pastoralists in Machakos district, Kenya, In: *IRI Technical Report*, published by IRI, Lamont–Doherty Earth Observatory of Columbia University, Palisades, New York, 2002.

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

6 Angchok D & Dubey VK, Traditional method of rainfall prediction through Almanacs in Ladakh, *Indian J Traditional Knowledge*, 5(1) (2006) 145-150.

7 http://ezinearticles.com (An-Introduction-to-Weather-Forecasting)

8 http://www.atmosphere.mpg.de/enid/html
9 http://www.rcn27.dial.pipex.com/cloudsrus/lore.html
10 http://www.suite101.com/content/weather-prediction-lore.htm
11 http://www.windandweather.com/folklore/folklore8.html
12 http://www.pulseplanet.com/archive/Nov99/2007.html
13 http://vegetablemdonline.ppath.cornell.edu
14 http://www.stalkingthewild.com/weather.htm
15 http://www.atmosphere.mpg.de/enid/3sn.html
16 http://science.howstuffworks.com/nature/climate-weather/storms/animals-predict-weather2.htm
17 http://www.googobits.com/articles/p0-1856-how-to-predict-the-weather.html
18 Sivanarayana G, Indigenous Technical Knowledge and its Communication Pattern in East Godavari District of Andhra Pradesh, PhD Thesis, (Department of Extension Education, BHU, Varanasi), 1993.
19 Chhaganbhai CK, Forecasting Rain Ants, *Honey Bee*, 3 (3 & 4) (1992) 16.
20 Seetharaman RN, Indigenous Technical Knowledge and Seasonal Forecasting, In: *Short Course on Capturing the Benefits of Seasonal Climate Forecasts in Agricultural Management*, (Tamil Nadu Agricultural University, Coimbatore), 2001.
21 Lishk SS, General principles of Ancient Indian Meteorology, *Astrol Mag*, 72 (3) (1983) 262-263.
22 Shukla CJ, In: *A Scientific Understanding Behind Traditional Customs in Agriculture*, (Sourashtra Gandhiji Gramodhar Trust, Gohadha, Bhavnagar), 1989.
23 Selvanayagum M, Some of the traditional beliefs currently in vogue at Kovilpatti, *Honey Bee*, 2 (2) (1991).
24 Kihupi NI, Kingamkono R, Rwamugira W, Kingamkono M, Mhita M & Brien KO, Promotion and integration of indigenous knowledge in seasonal climate forecasts, (Consultancy report, Drought Monitoring Center, Harare, Zimbabwe), 2002.
25 Chang'a LB, Yanda PZ & Ngana J, Indigenous knowledge in seasonal rainfall prediction in Tanzania: A case of the South-western Highland of Tanzania, *J Geogr Reg Planning*, 3 (4) (2010) 66-72.
26 Rathcke B & Lacey EP, Phenological patterns of terrestrial plants, *Ann Rev Ecol Syst*, 16 (1985) 179-214.
27 Lantz TC & Turner NJ, Traditional phenological knowledge (TPK) of aboriginal peoples in British Columbia, *J Ethnobiol*, 23 (2) (2003) 263-286.
28 Davis A, Wilson B & Compton B, In: *Salmonberry Blossoms in the New Year, Some Culturally Significant Plants of the Haisla known to occur within the Greater Kitlope Ecosystem,* (The Kitimaat Village Council, Nanakila Press and Ecotrust Canada, Kitamaat, British Columbia), 1995.
29 Thornton TF, Tleikw aaný´, the ''berried'' landscape: the structure of Tlingit edible fruit resources at Glacier Bay, Alaska, *J Ethnobiol*, 19 (1999) 27-48.
30 Anandaraja N, Rathakrishnan T, Ramasubramanian M, Saravan P & Suganthi NS, Indigenous weather and forecast practices of Coimbatore district farmers of Tamil Nadu, *Indian J Traditional Knowledge,* 7 (2008) 630-633.
31 Gissila T, Black E, Grimes DIF & Slingo JM, Seasonal forecasting of the Ethiopian summer rains, *Int J Climatol*, 24 (2004) 1345-1358.
32 Johnston PA, Archer ER, Vogel CH, Bezuidenhout CN, Tennant WJ & Kuschke R, Review of seasonal forecasting in South Africa: producer to end user, *Clin Res,* 28 (2004) 67-82.
33 Matari ER, Chang'a LB, Chikojo GE & Hyera T, Climate Change scenario development for Second National Communication – Tanzania, *TMA Res J,* 1 (2008) 40-54.
34 Roncoli C, Ingram K & Kirshen P, Reading the Rains: Local Knowledge and rainfall forecasting in Burkina Faso, *Soc Nat Resour*, 15 (2002) 409-427.
35 Senos R, Lake F, Turner NJ & Martinez D, Traditional ecological knowledge and restoration practice in the Pacific Northwest, In: *Encyclopedia for Restoration of Pacific Northwest Ecosystems*, edited by Apostol D, (Island Press, Washington, DC), 2006, 393-426.
36 Sewid-Smith DM, Dick K, Chief A & Turner NJ, The Sacred Cedar Tree of the Kwakwaka'wakw People, In: *Stars Above, Earth Below: Native Americans and Nature*, edited by Bol M, (Background Book for Alocoa Foundation Hall of Native Americans (Exhibit) The Carnegie Museum of Natural History, Pittsburgh, Pennsylvania), 1998,189-209.
37 Shiva V, Tsunami lessons, *Resurgence*, 230 (2005) 6-8.
38 Turner NJ, In: *Plant Technology of British Columbia First Peoples*, (University of British Columbia Press, Royal British Columbia Museum, Vancouver, Victoria) 1998.
39 Turner NJ, The ethnobotany of 'edible seaweed' (*Porphyra abbottiae* Krishnamurthy and related species; Rhodophyta: Bangiales) and its use by first nations on the Pacific Coast of Canada, *Can J Bot,* 81 (2) (2003) 283-293.
40 Turner NJ, In: *The Earth's Blanket, Traditional Teachings for Sustainable Living*, (Douglas and McIntyre, University of Washington Press, Vancouver, British Columbia, Seattle), 2005.
41 Turner NJ & Berkes F, Coming to understanding: developing conservation through incremental learning, *Human Ecol Dev Res Manage Conserv* (Spl Issue), 34 (4) (2006) 495-513.
42 Turner NJ & Clifton H, ''It's so different today'': Climate change and indigenous life ways in British Columbia, Canada, *Global Environ Change*, 19 (2009) 180-190.