wealth of information regarding leaf cuticle, identification of gymnosperm seed cuticles could rarely be done, as enough study of extant taxa has not been made. The present study on the seed coat of *Ephedra* may help in the formation of a database that can be utilized in the identification of fragmentary seed coat cuticles from fossilized deposits, compare with the extant ones and also help in tracing their affinity.

Based on ultrastructural features of the seed coat, an artificial key to the four studied species of *Ephedra* is suggested as follows:

wax present as minute platelets, epidermal cells elongated, fibrillar, coiled thread-like, anticlinal wall grooved, wall level not conspicuous, periclinal wall level flat, wall texture undulated, vasculature well developed

Ephedra foliata

wax uniformly present, amorphous in nature, epidermal cells rectangular, cuticle longitudinally striated, ridges and furrows closely placed, shallow, appearing wavy in nature, epidermal cells with oblique transverse wall, verrucose line indistinct, anticlinal wall flat, wall level not conspicuous, periclinal wall level slightly convex, wall texture almost smooth, vasculature well developed

Ephedra intermedia

wax present as minute platelets, cuticle with well-developed ridges and furrows, closely placed, densely reticulate, grooved, epidermal cells rhomboidal to polyhedral, depressed, transverse wall of the epidermal cell distinct, anticlinal wall grooved, anticlinal and periclinal wall level concave, wall texture serrated or dentate, vasculature not found, profuse solitary and aggregated starch grains present

Ephedra gerardiana

wax present, as minute platelets, cuticle ridged, usually exerted, epidermal cells elongated rectangular, transverse wall indistinct, anticlinal wall grooved, anticlinal wall and periclinal wall level convex, wavy, vasculature not found, profuse wax and starch grains (solitary and aggregated) present

Ephedra saxatilis

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ACKNOWLEDGEMENTS. We thank the Geological Survey of India, Kolkata for the SEM photographs and the Botanical Survey of India, Howrah for allowing library. We also thank Prof. D. K. Chauhan (Department of Botany, University of Allahabad); Prof. (Ex) B. D. Sharma (J.N. Vyas University, Jodhpur), for providing the necessary materials and Prof. (Ex) G. G. Maity (Department of Botany, University of Kalyani) for help in constructing the artificial key to the species.

Received 1 August 2014; revised accepted 6 February 2015

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Khejri, the king of Indian Thar desert is under phenophase change

Vegetation of Indian Thar region is ecologically important, though fragile. Any change in its composition and trait will ultimately impact the productivity and sustainability of the system and the region. This region has 682 species belonging to 352 genera and 87 families of flowering plants. Among them, *Prosopis cineraria*, locally called as Khejri or Jandi is an indigenous tree, which effectively stabilizes sand dunes and can withstand periodic burial[1]. It is believed to be the best suitable agroforestry species, due to its deep taproot system, positive allelopathy effect, soil fertility improvement and yield augmentation of understorey crops. Khejri offers nutritious supplementary food (pod flour, fruits, seed, etc.), top-feed (leaves and pods) and protection-cum-shelter for the benefit of humans and livestock during all the seasons, effectively during harsh periods. It offers lifeline to human beings during famine, as its powdered bark can be mixed with flour and made into cakes for consumption[2].

The population density of Indian Thar region is quite high compared with the global arid zone average of 6–8 persons/sq. km. It is projected that the population will increase from the present 22.5 million to 33.6 million and its density to 161 by 2025 (ref. 3). In agriculture, improved varieties, cultivation practice, plantation activities, protection measures and value addition have been adopted by farmers to meet the increasing population requirements. In fragile ecosystems like Thar Desert, pure cropping alone cannot

be a dependable enterprise; hence desert dwellers with their traditional wisdom are integrating trees into farming since ages, in order to confer stability and generate assured income[4]. Most of the trees are drought-resistant, and are used for fuel, fodder and other products, when arable crops fail due to drought, a common feature of the hot arid regions. Historically, Indian arid zone has been an agrarian–pasturalist system, which was 'ecologically self-contained', 'economically safe producing' and 'socially complete'[5]. It is now widely believed that the underlying heterogeneity that sustained it ecologically and economically has been systematically changed. The popular/socio-religious movements like Chipko or those of 'Bishnois' in Rajasthan have been meeting the conservation efforts[6] which call for the integration of trees in farm lands as an assured livelihood source.

P. cineraria and *Ziziphus nummularia* (Bordi) are the two most important multipurpose woody components planted in traditional agro-forestry system of the region. *P. cineraria*, a wonder tree, also known as the 'king of the desert' is worshipped by a large number of people in Rajasthan, especially by Bishnoi community. In AD 1730, this tree came into limelight when a brave lady (Amrita Devi) from Bishnoi clan of local Marwar region sacrificed her life along with her 3 daughters and 363 people for the sake of *P. cineraria* trees. Soldiers of the then local ruler, Maharaja Abhay Singh, wanted to cut Khejri trees for construction of a palace. But the Bishnoi clan under the leadership of Amrita Devi hugged the trees and faced the axes of the soldiers. After the incident, the king realized his mistake and called back his soldiers. Even now, an annual fair in the memory of the 363 people killed, is held every year in the village Khejarli, where the massacre took place.

Khejri is a small to medium-sized tree, that can withstand extremes of temperature up to 48°C and less than 100 mm rainfall. Hence it became an integral part of the traditional agriculture and the lifeline of the desert inhabitants. Farmers of these regions have been consciously maintaining and promoting a few randomly growing trees, most commonly the *P. cineraria* (L.), in their fields with the aim of obtaining fodder from the foliage, vegetable from the pods and fuel from pruned branches, particularly during famine years[7]. Khejri wood is useful for house construction and for making cart and agricultural implements.

The phenophase (an observable stage or phase in the annual life cycle of a plant or animal that can be defined by a start and end point; phenophases generally have a duration of a few days or weeks) of the tree, especially fruiting during summer (April–June) and the protein-rich new leaf formation during end of summer (June–August) assures fodder availability to livestock in the harsh summer period. The common practice of 100% canopy pruning just before winter and its bearing ability ensure the availability of sunlight to the understorey crops, which makes this the best agro-forestry tree. The leaves also can be used for mulching and the pruned branches are used as fuel wood. This tree is also called 'Kalpataru' due to its phenophase suitability and popular utilization pattern.

Though Khejri is the best adapted tree in Indian Thar region, its mass mortality due to a combination of factors may threaten its sustainability[8]. Climate change has a profound impact on the vegetation, which may change the habitat location, and extinction of less-tolerant species[9]. Gopalakrishnan *et al.*[10] projected that nearly half of the forest grids (45%) undergo changes in India due to climate change and other associated factors. This changing climatic scenario has influenced agriculture, vegetation and livelihood of the local poor. Hence agriculture scientists have to be ready to face the challenges and offer solutions for sustenance of agriculture sector by means of adaptation to global climate change[11]. Climate change has an impact on survival, growth, flowering and fruiting season of Khejri trees. Unusual off-season flowering has been observed in Khejri during November 2011 by the present authors and it has been confirmed by subsequent observations in 2012. This off-season flowering during winter does not have significant influence on the normal flowering and fruiting of Khejri trees. If the crown is preferred for winter pruning, this off-season fruit/pod production might be an unwanted phenomenon. But it is an economical and socially important phenophase change from the already reported phenology of Khejri[12]. Since Khejri pods (locally called as 'sangar'

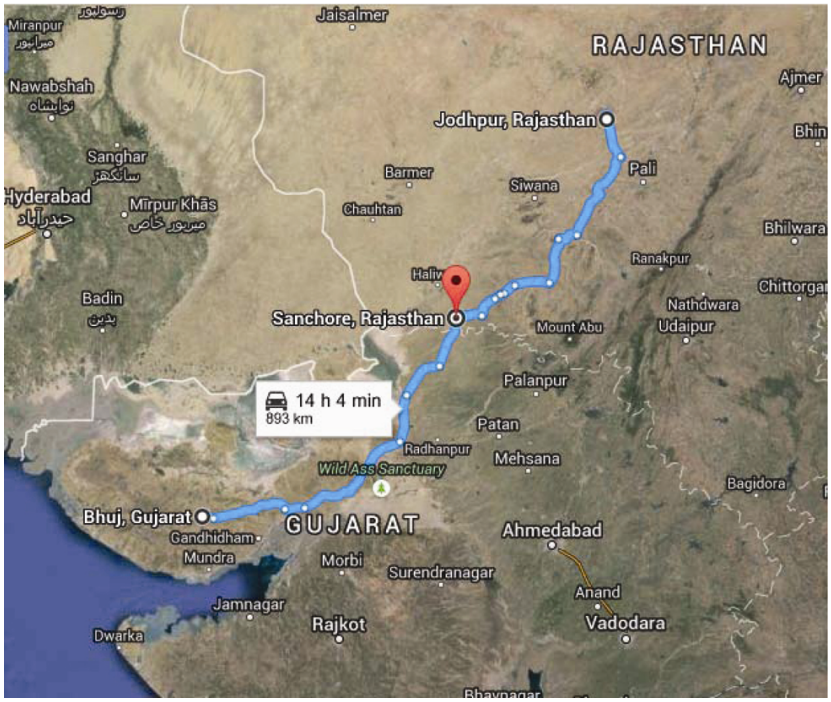

Figure 1. Survey route of the study.

Figure 2. A Khejri stand observed for off-season flowering and fruiting.

or 'sangri') have economic value due to the vegetable value (major ingredient in Panchcuta, a traditional diet), this off-season flowering and fruiting is considered as an important opportunity to increase/improve value of this species.

Khejri trees exist in the western part of India covering northeastern Gujarat, Rajasthan, Haryana and Punjab, with density gradient from low to high in the same order. Hence an exploration survey (survey route presented in Figure 1) was conducted immediately after the first observation (November 2011) of off-season flowering. The intensity of off-season flowering and fruiting in Khejri was observed in three geographic locations, viz. Bhuj in Gujarat, and Sanchore and Jodhpur in Rajasthan. Khejri flowering and fruiting were quantified by scoring and reported in numbers. Sample quadrats of 1 acre area have been made for observation of tree density, off-season flowering and fruiting between Bhuj and Jodhpur at regular intervals of 100 km.

Even though seven sample plots were observed and studied, only three locations (Bhuj, Sanchore and Jodhpur) are reported here due to their significant variability in off-season flowering and fruiting. Flowering and fruiting data were quantified by scoring them from 1 (very less) to 10 (plenty or full) and the data have been used to analyse the off-season flowering and fruiting variability over geographic locations. Meanwhile observations were also carried in the available Khejri stands (Figure 2) at the Central Arid Zone Research Institute (CAZRI), Jodhpur with three different age groups (15, 20 and 25 yrs), height (<8, 8–10 and >10 m) and diameter at breast height (DBH; <20, 20–30 and >30 cm) growth. Phenophase variability studies over stand nature (stand developed by seedling and air-layered material) have been carried out in twenty trees of twenty-five-year-old stand, raised each through seeds and through air-layering. They were evaluated for pod and seed trait variability during off-season (October–November) and normal season of flowering and fruiting (May–June) during 2011 and the results were rechecked during 2012.

The survey conducted during November 2011 over geographic location from Bhuj to Jodhpur revealed that early flowering varies from 5% in less dense stands of Bhuj, Kutch district, Gujarat; 8% in sparse dense stands of Sanchore Barmer district to 22% in moderate dense stands of Jodhpur district, Rajasthan (Table 1). This kind of gradient may be due to the edapho-climatic variability of the locations, which influences the micro zonal environmental factors such as site condition, light and temperature influence on Khejri tree canopy, etc. It can also be used as an indicator for environmental warming[13].

The observations carried at CAZRI revealed that this kind of off-season flowering has significant variability over age, height and diameter at breast height (DBH) (Table 2). Also, 62% off-season flowering and 40% off-season fruiting were recorded in 15-year-old trees, whereas only 18% off-season flowering and 15% off-season fruiting were recorded in 25-year-old trees. In contrast, the big-sized trees (height >10 m and DBH >30 cm) produced more flowers and fruits (60–70% flowering and 50–55% fruiting) during off-season. Meanwhile, there is no variability of flowering and fruiting due to age and size of trees during the

Table 1. Khejri tree density, off-season (November–December 2011) flowering and fruiting variability over various locations

Location	Khejri tree density (no./ha)	Off-season flowering		Off-season fruiting		Site condition
		%	Score (1–10)	%	Score (1–10)	
Bhuj, Gujarat	0–4	5	1	3	1	Saline soils, irrigated area; major crops: castor; agroforestry system: mixed MPTs (neem, Khejri, Babool, etc.) based
Sanchore, Rajasthan	8–12	8	1	6	2	Undulating sandy soil/terrain, irrigated area; major crops: castor, wheat, mustard; agroforestry system: neem based is prevailing
Jodhpur, Rajasthan	16–38	22	2	20	4	Sandy loam soil, rainfed area; major crops: bajra, wheat, guar; agroforestry system: Khejri, Salvadora based

Score represents the quantity gradients, viz. very less (1) to plenty/full (10) flowering and fruiting.

Table 2. Regular, off-season flowering and fruiting variability over age, height and diameter at breast height (DBH) of Khejri trees

Variability due to	Group/class	Regular season (April–June 2012)				Off-season (November–December 2011)			
		Flowering		Fruiting		Flowering		Fruiting	
		%	Score range	%	Score range	%	Score range	%	Score range
Age (years)	15	100	4–10	100	2–9	62	1–2	40	1
	20	100	4–10	100	4–10	33	1–4	24	1–3
	25	100	5–10	100	4–10	18	1–3	15	1–2
Height (m)	<8	95	4–10	95	2–8	15	1	15	1
	8–10	100	4–10	100	4–10	39	1–4	36	1–3
	>10	100	5–10	100	5–10	60	1–2	50	1
DBH (cm)	<20	98	4–10	98	2–9	10	1–3	10	1
	20–30	100	4–10	100	4–10	47	1–4	44	1–3
	>30	100	5–10	100	4–10	70	1–2	55	1–2

Score represents the quantity gradients, viz. very less (1) to plenty/full (10) flowering and fruiting.

Table 3. Observation on flowering and fruiting in air-layered and seed-origin *Prosopis cineraria* trees

Propagated by	Height range (m)	DBH range (cm)	Observation during	Flowering		Fruiting		Germination
				%	Score	%	Score	%
Air layering	3.2–7.6	7.0–29.1	Regular	100	5–8	100	5–8	45.50
			Off-season	50	1–2	45	1–2	6.67
Seed	7.5–11.7	19.0–43.4	Regular	100	4–10	100	2–9	70.50
			Off-season	62	1–2	48	1	7.50

Score represents the quantity gradients, viz. very less (1) to plenty/full (10) flowering and fruiting.

normal season of flowering and fruiting (April–June).

Difference in off-season flowering and fruiting over years was observed; and it was more in 2011 than in 2012. This kind of natural off-season flowering and fruiting in Khejri needs further understanding for its better usage like in the case of mango[14]. This kind of off-season flowering might be due to the new shoots arising, mostly as laterals from auxillary buds, around the stump of the twigs fruited in the previous season/year and such growth either remains unextended or makes further extension growth in subsequent months as in mango[15]. It may also be due to the initiation of shoot growth (the first event of vegetative growth) from buds of resting stems, which leads to the development of off-season flowers[16].

Observations were made on 25-year-old Khejri trees raised from seeds and air-layering for off-season flowering/fruiting in November–December 2011 and compared with the normal season of April–June 2012 for pod yield, seed germination, etc. Flowering, fruiting percentage in seed origin and air-layered trees did not significantly vary, whereas flowering and fruiting varied significantly between off-season and normal season (Table 3). Seed germination in June was 45.5% for seeds of normal season, whereas it was only 6.67% for off-season seeds. The winter availability of 'sangri' (local name of Khejri pod as vegetable), which contains more protein may fetch more market price due to its off-season availability, demand and presence of lesser seeds in the pod. If this off-season flowering and fruiting in Khejri continue over the years, there will be more demand for this vegetable pod in the market. On the contrary, this off-season fruit/pod production of Khejri might be an unnecessary phenomenon if the crown is preferred for pruning to meet the fodder demand. Further in-depth structured studies for a period of at least a decade on its cause and impact are necessary for sustainable utilization of off-season fruiting in Khejri.

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Received 18 October 2013; revised accepted 23 March 2015

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Acrobotrys disolenia Haeckel from the late Miocene of Andaman and Nicobar Islands

In the present-day oceans, radiolarians are one of the most significant components of the plankton community. They utilize opaline silica to build their skeleton[1]. They have considerable influence on the oceanic silica cycle. There is disputed report of this old group of protozoans in the Precambrian strata[2]; however, there is confirmed report of radiolarians from the early Cambrian black cherts of Yangtze Platform, China[3]. Molecular data indicate that radiolarians originated approximately 1 billion years ago[4,5], but there is no fossil evidence in support of these molecular data. Apart from their natural beauty, radiolarians are useful for biostratigraphy owing to their wide distribution, considerably high species diversity