

## Pollination by bats and passerine birds in a dry season blooming tree species, *Careya arborea* in the Eastern Ghats

*Careya arborea* Roxb. (Lecythidaceae) is a medium-sized deciduous tree found throughout India. It is valued for its leaves, bark, flowers, fruits, seeds and wood. Leaves and flowers are used in the form of paste to cure several skin diseases. Bark yields tannins. Syrups and wines made from ripe fruits are used as sedatives. Seeds are edible and quench thirst. Wood is useful for paper making<sup>1,2</sup>. Except for a small note on flower-visitors by Ali<sup>3</sup>, there is no information on the floral biology, breeding systems and pollinators of *C. arborea*. In this context, these aspects have been studied during 2002 and 2003 for *C. arborea* occurring in the eastern ghats forests of Visakhapatnam District (Lotugedda, Lambasingi, Chintapalli and Paderu), Andhra Pradesh, India. Flower visitors, including bats and birds, were observed for three weeks in each year of study. Observations were made for bat activity at flowers from 1800 h to 0100 h and for bird activity from 0600 h to 1800 h. Thirty trees, some (12) greater than 20 m and some (18) below 20 m in height were used for making field observations on all aspects described.

*C. arborea* is leafless during flowering period (Figure 1a). It flowers during March–April. The flowers are borne in small cymes and crowded together (Figure 1b). They occur at the axillary and terminal part of the branches. The flowers are sessile, large, bisexual and actinomorphic. The calyx is with four valvately arranged sepals. The corolla is also with the same number of petals which are arranged alternate to sepals. The petals are inserted on the top of the deep cup-like receptacle situated at the base of the flower. They form a cap in the bud condition. Stamens are numerous, as many as 560, free and arranged on the rim of the receptacle in several rows. About 1/3 of the stamens are non-antheriferous and arranged in the inner and outer rows. The remaining stamens are antheriferous. The ovary is 4-carpellary and syncarpous. Each carpel is unilocular with numerous ovules on axile placentation. Style is terminal and stigma is capitate; both style and stigma projecting beyond the level of the anthers.

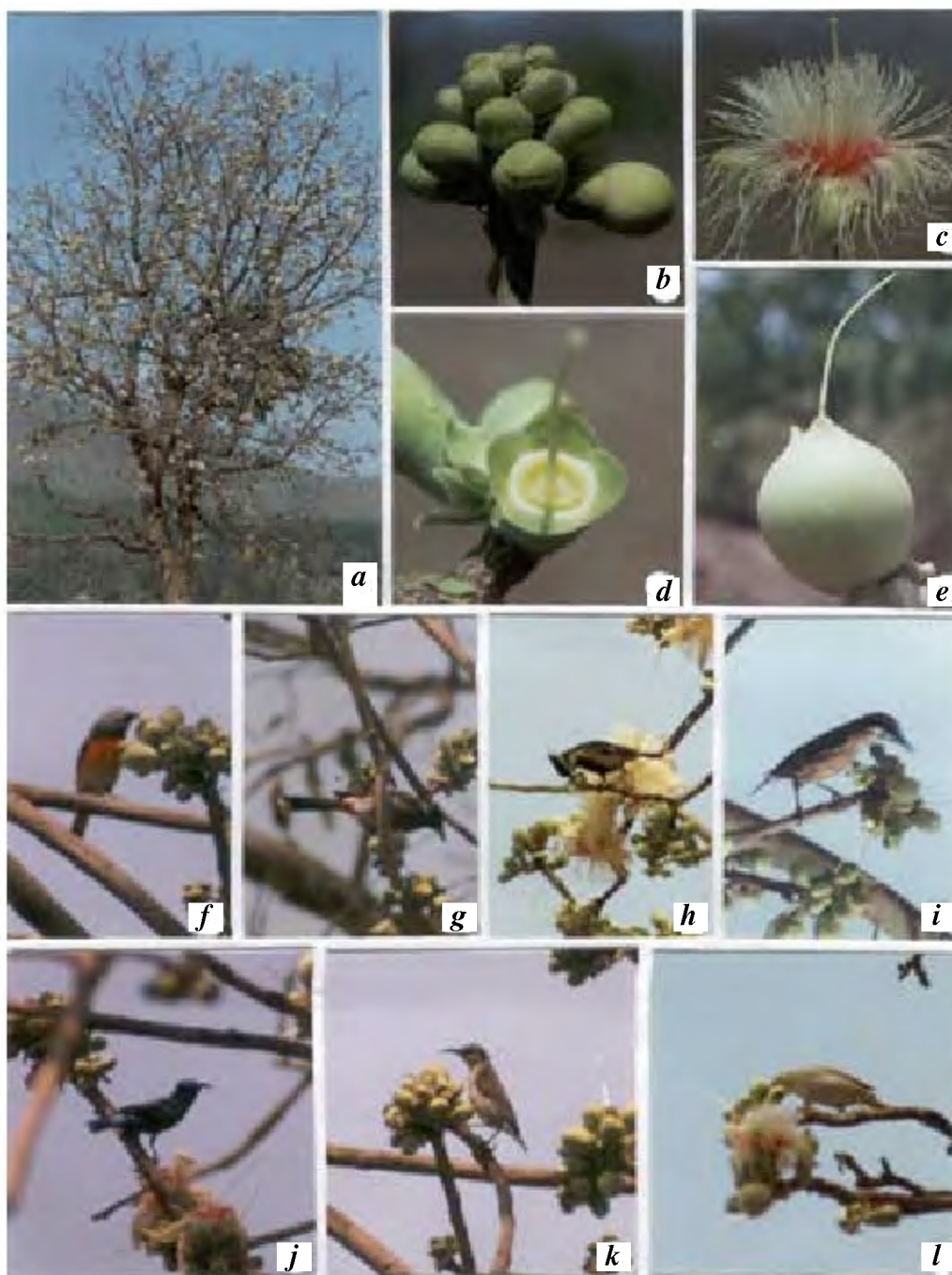
The flowers open at night around 2100 h. The opening of the flowers is confined to the hours of darkness. In open flowers, the style and stigma stand erect and are surrounded by stamens in several rows (Figure 1c). The anthers dehisce by longitudinal slits. Nectar is produced in copious amount and is well seated in the annular disc at the flower base (Figure 1d). Strong unpleasant odour is emitted by the flowers.

Soon after flower opening, bats were found flying around the trees. They were large and small bats and represent the large fruit bat, *Pteropus giganteus* and the small bats, *Cynopterus sphinx* and *Taphozous longimanus* as they are reported to occur in this region<sup>4</sup>. They were found to collect nectar from the flowers. Brownish scars appeared on the corolla and staminal filaments by the following morning. As *C. arborea* is said to be a source of tannins<sup>2</sup>, the flowers may produce tannins and the marks left by the visiting bats on corolla and stamens oxidize and appear conspicuous as brownish scars by the next morning. Jaeger<sup>5</sup> reported that *Adansonia* flowers are tannin-rich and visited by bats. These flowers show marks of claws left by the bats and the marks oxidize and become conspicuous as brownish scars by the following morning. He suggested that bats also eat pollen because their digestive tract has been found with a considerable amount of pollen. Similarly, bats visiting the flowers of *C. arborea* may seek pollen as the protein in the pollen would make an excellent balance in their diet with the water and sugars provided by the nectar.

Bats quench their thirst by visiting the flowers of *C. arborea*. They provide a vital reciprocal service to *C. arborea* flowers in terms of pollination. They make long distance flights and in their visits to conspecific trees effect cross-pollination<sup>6,7</sup>. The floral characteristics of *C. arborea* such as nocturnal anthesis, whitish corolla, white and pinkish stamens, strong unpleasant odour, strong single flowers with wide mouth, copious amount of nectar and numerous stamens conform to the syndrome of bat-pollinated flower<sup>6</sup>. Even after bat activity, nectar is still available in small or large quan-

tity in most of the flowers. The flowers in this state attracted different passerine bird species during daytime. The floral characteristics such as white and pinkish, silky staminal filaments and nectar present in the disc appear to play a key role in attracting the birds.

Ali<sup>3</sup> indexed birds *Acridotheres tristis* (Indian myna), *A. fuscus* (Jungle myna), *Sturnus roseus* (Rosy pastor), *Nectarinia asiatica* (Purple sunbird), and *N. zeylonica* (Purplerumped sunbird) as regular visitors to *Careya arborea*. He has not mentioned about their role in pollination. In the present study, the birds observed were all passerines and they included *Corvus macrorhynchos* (Jungle crow), *C. splendens* (House crow), *Pericrocotus cinnamomeus* (Small minivet; Figure 1f), *Pycnonotus cafer* (Redvented bulbul; Figure 1g), *P. jocosus* (Redwhiskered bulbul), *Parus xanthogenys* (Yellow-cheeked tit; Figure 1h), *Sitta castanea* (Chestnutbellied nuthatch; Figure 1i), *Dicaeum erythrorhynchos* (Tickell's flowerpecker), *D. agile* (Thickbilled flowerpecker), *Nectarinia zeylonica* (Purplerumped sunbird), *N. asiatica* (Purple sunbird; Figure 1j,k) and *Zosterops palpebrosa* (White-eye; Figure 1l). Of these, sunbirds, white-eyes and bulbuls were more in number and visited the flowers of *C. arborea* for nectar until the cessation of flowering. Other birds were few in number and visited the flowers occasionally for nectar and/or for eating larvae and insects. While collecting nectar, all these birds contacted the stamens and stigma with their bill and forehead both ventrally and dorsally. The petals and stamens fall off as a unit from open flowers. This event begins from the late morning onwards following anthesis and bat-visitation during the previous night, and by the evening of the same day, all flowers are devoid of petals and stamens. The calyx and the style and stigma remain intact until late evening of the 2nd day in unpollinated flowers and are persistent in pollinated and fruited flowers (Figure 1e). The flowers devoid of petals and stamens but with some amount of nectar present in the disc were also found to be visited by birds. The stigma receptivity was tested by hydrogen peroxidase



**Figure 1.** *Careya arborea*. *a*, a tree in flowering; *b*, buds; *c*, flower; *d*, cup-like receptacle with nectar; *e*, fruit; *f-l*, Bird visitors—*f*, Small minivet; *g*, Redvented bulbul; *h*, Yellowcheeked tit; *i*, Chestnutbellied nuthatch; *j*, Purple sunbird (male); *k*, Purple sunbird (female); *l*, White-eye.

test<sup>8</sup> at different times of the flower life and the test showed that the stigma is receptive to pollen from anthesis onwards and until the evening of the 2nd day. The visits of birds to 2-day old flowers may result in pollination. As the flowers are crowded and occur conspicuous, the birds sip nectar from several flowers in

quick succession in the same visit. The birds also make frequent visits to the flowers of different trees of *C. arborea* for want of nectar and/or solid insect diet. Such a foraging behaviour of birds may effect both self- and cross-pollination.

The present study shows that *C. arborea* is adapted for bat-pollination. *C. ar-*

*borea* flowers with large mouth facilitate foraging by birds with great ease. Different passerine birds make use of this floral source as a feeding station during dry season and provide pollination service reciprocally during daytime. Dry season flowering appears to be advantageous for *C. arborea* to get pollination service from

passerine birds because the latter utilize this floral source to quench their thirst or hunger. Hence, *C. arborea* occupies a key position in sustaining bats and birds during dry season.

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## Gender difference in phosphate transport by the mouse intestine

Gender differences in transport of endogenous and exogenous compounds have been recently reviewed<sup>1</sup>. However, in the intestine only calcium transport seems to show such sex-related variations<sup>2</sup>. In a bid to see if phosphate transport also exhibits similar variation, we studied the transport of this anion in everted intestinal sacs of mice.

Monitoring phosphate transport in everted gut sacs of mice was performed according to the methods described previously<sup>3,4</sup>. Briefly, male Swiss albino mice (25–30 g) of 3 months age were used for all the experiments. They were fed *ad libitum* with commercial feed (Ca = 1%, P = 0.6%) obtained from Gold Mohur Animal Feeds, Bangalore, for one week before the experiments. After overnight fasting, the mice were killed under ether anaesthesia. The abdominal cavity was opened and the entire small intestine was detached carefully from the mesentery and kept immersed in ice-cold physiological saline.

After flushing out the contents with ice-cold saline, the intestine was everted gently with a steel rod and sacs of 6 cm length were prepared according to the method of Wilson and Wiseman<sup>5</sup>. After filling with 0.5 ml of the incubation medium (serosal fluid) and weighing, each distended sac was placed in 5 ml of the incubation medium (mucosal fluid) contained in a 25 ml Erlenmeyer flask. The con-

tents of the flask were oxygenated for 1 min with 100% oxygen and tightly stoppered. The flask was then incubated at 37°C for 1 h in a metabolic shaker bath (Techno India Ltd, Pune, India) at a frequency of 100–110 shakes/min.

At the end of the incubation period, the sacs were removed from the flasks, blotted and weighed again. The serosal fluid was drained through a small incision into a test tube. The emptied sac was then shaken gently to remove the adhered fluid and the tissue was weighed again.

The incubation medium contained NaCl (135 mmol/l), KCl (11 mmol/l) and CaCl<sub>2</sub> (0.04 mmol/l) dissolved in 2 mmol/l phosphate buffer containing KH<sub>2</sub>PO<sub>4</sub> and Na<sub>2</sub>HPO<sub>4</sub> at pH 7.4.

The method of Chen *et al.*<sup>6</sup> was used to estimate inorganic phosphate. Volume changes caused by water transport were taken into consideration by weighing the

empty and full sacs before and after incubation.

The fall in the phosphate content of the mucosal medium was treated as uptake of phosphate by the sac, while the rise of phosphate content of the serosal medium was taken as the release of phosphate by the sac. All the values are expressed in  $\mu\text{mol/g}$  tissue wet wt/h. Statistical comparisons were carried out using Student's *t* test.

The present study indicates a clear sex difference in phosphate transport in mice (Table 1). However, this difference is noticeable only in the initial 6 cm segment of the intestine which corresponds to the duodenum. Since the plasma phosphate level did not show any difference, it is presumed that phosphate absorption in the other segments compensates for the shortfall in duodenal transport of phosphate observed in female mice. Age<sup>7</sup>,

**Table 1.** Phosphate uptake and release by various segments of mouse intestine

Segment	Phosphate uptake		Phosphate release	
	Male	Female	Male	Female
1	9.1 $\pm$ 0.25	4.5 $\pm$ 0.23*	5.2 $\pm$ 0.20	2.5 $\pm$ 0.1*
2	1.3 $\pm$ 0.40	1.8 $\pm$ 0.50	1.0 $\pm$ 0.33	1.2 $\pm$ 0.15
3	4.0 $\pm$ 0.10	4.2 $\pm$ 0.10	2.8 $\pm$ 0.40	2.4 $\pm$ 0.50
4	4.8 $\pm$ 0.20	5.2 $\pm$ 0.30	2.8 $\pm$ 0.20	3.2 $\pm$ 0.30
5	7.0 $\pm$ 0.70	6.0 $\pm$ 0.80	4.2 $\pm$ 0.12	3.8 $\pm$ 0.25

All values are expressed as mean  $\pm$  SEM of six observations in each group. Values marked \* in the female groups are significantly less ( $P < 0.005$ ) than those in males.