# Monoecy and entomophily in *Cardiospermum canescens* Wall. (Sapindaceae), a medicinally valuable herbaceous vine

*Cardiospermum* is a genus of approximately 15 species of herbaceous tendrillar climbers in the soapberry family Sapindaceae. It is chiefly distributed in the tropical and subtropical regions of America, India and Africa. The genus name has been derived from the Greek words '*kardia*' and '*sperma*', meaning heart-shaped seed[1,2]. It is characterized by unisexual, obliquely monosymmetric flowers with a tetramerous corolla. Other important characters are the petals with a scale adnate to their adaxial basal surface, a unilateral nectary with two or four protruding lobes, and eight stamens of unequal lengths. The fruits are schizocarps or capsules[3].

In India, the floristic accounts suggest that *Cardiospermum halicacabum* and *C. canescens* occur throughout the country; the former is common and occurs in all habitats, whereas the latter is somewhat restricted to stream-side areas in open scrubs[4]. Both the species have been reported to be medicinal plants. The leaf extract of the two species is used to reduce body pain and rheumatism[5–7]. Mikolajcak[8] reported that *C. canescens* stores carbon or nitrogen to serve as potent insecticides to protect the plant, and aid specific insects in locating a particular plant, either to feed, lay eggs, or assist in the reproductive cycle of the plant. Keeping the medicinal importance of these plants in view and in the absence of any information on the pollination biology and even taxonomic details in case of *C. canescens*, the present study has been contemplated to address certain aspects of pollination biology of *C. canescens* to understand its sexual system, pollinators and fruiting aspects.

*C. canescens* is a climbing herb and commonly found during rainy season at Kadiri (GPS coordinates 14°06′N and 78°09′E), a rocky hill area at 1183 ft elevation in Anantapur District, Andhra Pradesh. Its presence is characterized by patchy occurrence with numerous plants. Field studies and experiments were conducted during 2008 and 2009. Twenty tagged, mature buds were followed for recording the time of anthesis and anther dehiscence; the mode of anther dehiscence was also noted using a 10× hand lens. The details of flower morphology such as flower sex, shape, size, colour, odour, sepals, petals, stamens and ovary have been described. The protocols of Dafni *et al*.[9] were followed for determination of pollen output, pollen–ovule ratio and stigma receptivity. Twenty-five pistillate flowers were hand-pollinated with the pollen of staminate flowers of the same plant and bagged to test geitonogamy. Another set of 25 pistillate flowers was hand-pollinated with the pollen of staminate flowers of different plants and bagged to test xenogamy. These bagged flowers were kept under regular observation until fruit set. Then, the percentage of fruit set was calculated. The pistillate flowers were tagged on different plant species and followed for fruit set rate in open-pollinations. Regular observations were made on the insect species visiting the flowers for forage. Their foraging activity was confined to daytime only. The insects were observed on a number of occasions for their foraging behaviour such as mode of approach, landing, probing behaviour, the type of forage they collect, contact with essential organs to result in pollination, inter-plant foraging activity in terms of cross-pollination, etc. Fruits and seed characteristics were also recorded.

The seeds of *C. canescens* germinate following the southwest monsoon showers in June and produce plants at a rapid pace. At the same time, the perennial root stock below the ground produces aerial vegetative growth. Within three weeks, the plants show full vegetative growth; the inflorescences begin to appear and produce flowers until late October. Individual inflorescences flower for about 5–6 days. The plants produce white flowers in axillary dichasial cymes with a pair of bracts modified into tendrils subtending them. A dichasial cyme consists of six flowers which are functionally either staminate or pistillate, although they are morphologically identical, except for the sex organs. Each dichasial cyme produces both flower sexes. In a three-flowered cyme, if the first one is pistillate, the other two are staminate; if the first one is staminate, the other two represent one staminate and one pistillate flower.

In both sexes, the flowers are small, pedicellate, white, odourless and obliquely zygomorphic. The calyx is light green and consists of two shorter and sub-orbicular external sepals, and two internal obovate and petaloid sepals. The corolla is white and contains two posterior and two anterior ovate free petals with scales, which are symmetric in the posterior petals and asymmetric in the anterior petals. Additionally, there are four scales originating inside the petals and covering the vertically held staminal complex or ovary from the base to the top. The two anterior scales are villous to glabrous, white except for the apex which is yellow and quite prominent, whereas the two posterior scales are completely white and sparsely villous to almost glabrous giving the appearance of a hood sheltering the sex organs. The stamens are eight and free in both flower sexes. In staminate flowers, the stamens are fertile, aggregated and hooded by the posterior scales; they are of unequal length – three higher anterior, two median lateral and three shorter posterior. In pistillate flowers, the stamens are short with indehiscent anthers. The ovary is reduced to rudimentary pistillode in staminate flowers, while it is eccentric, three-carpellate syncarpous with a single campylotropous ovule per carpel in pistillate flowers. Further, the pistillate flowers show a trigonous–obovoid, villous ovary extended into a short columnar style and three-lobed stigma.

The staminate and pistillate flowers open at the same time during 0600–0800 h (Figure 1 *a–c*). The mature buds unfold petals gradually exposing the vertical column comprising scales covering the stamens and ovary. The scales remain in vertical position during the entire period of flower life. The staminate flowers dehisce anthers an hour after anthesis by longitudinal slits from side walls. A glandular disc present at the base of staminate and pistillate flowers secretes nectar in trace amounts and it is protected by the vertically held scales. The ratio of staminate and pistillate flowers is 2 : 1. A staminate flower produces $3040 \pm 25.8$ fertile pollen grains. The pollen–ovule ratio is 2026 : 1 at the plant level. The pollen grains are smooth on exine, heteropolar, triangular, peroblatoid and $15 \times 48$ μm in size. The stigma

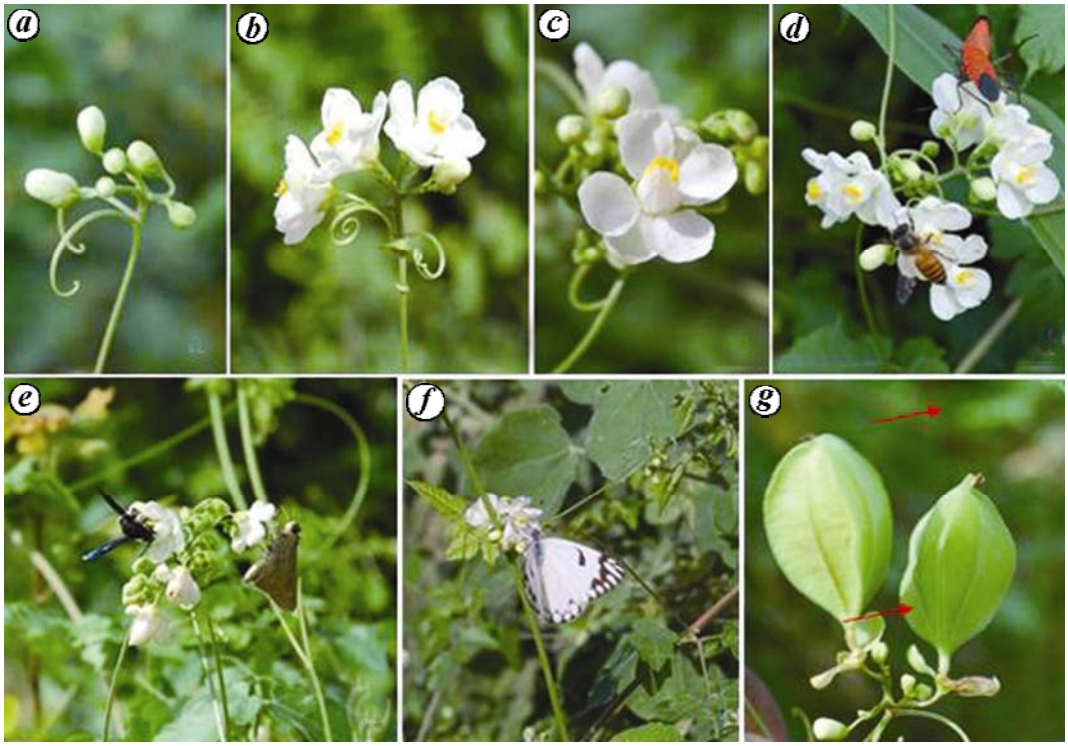


**Figure 1.** *Cardiospermum canescens*. ***a***, Buds; ***b***, ***c***, Flowers; ***d***, *Apis cerana* – down, *Lygaeus* sp. – top; ***e***, *Rhynchium* sp. – left, *Borbo cinnara* – right; ***f***, *Cepora nerissa* and ***g***, Fruits.

of pistillate flowers attains receptivity 1 h after anther dehiscence in staminate flowers. It is viscid and shiny during the receptive phase, which ceases by the end of the day. The pistillate flowers set fruit through geitonogamy and xenogamy; the fruit set in the former mode stands at 66%, and in the latter mode at 100%. The fruit set in open-pollinations ranged from 45% to 74%.

The flowers of *C. canescens* were visited by hymenopterans, hemipterans and lepidopterans during daytime with intense activity during forenoon period, when standing nectar crop at plant level is fresh and adequate for collection. The hymenopterans included *Apis cerana* (Figure 1 *d*), *A. florea*, *Trigona iridipennis* (bees) and *Rhynchium* sp. (wasp, Figure 1 *e*). The hemipteran was *Lygaeus* sp. (Figure 1 *d*), whereas the lepidopterans were the pierid butterfly, *Borbo cinnara* (Figure 1 *e*) and hesperiid butterfly *Cepora nerissa* (Figure 1 *f*). The bees foraged for pollen and nectar, whereas all others foraged for nectar only. Several other insect species were found in the surroundings of the plant, but they never foraged on *C. canescens*. The yellow part of the anterior scales appeared to serve as nectar guides for the foragers. Accordingly, the visiting insects approached the flower frontally by landing on the vertically held posterior scales. These insects inserted their tongue or proboscis into the floral base from above on the side of anterior scales for nectar and/or pollen collection. During flower probing by *Apis* bees, the flower oscillated and the vertically held scales got separated to some extent, facilitating them to collect the forage with ease. The separated scales remained so following the departure of the bees. Two to three visits by these bees were found to result in the complete removal of pollen in staminate flowers. During pollen collection in staminate flowers, the ventral side and lower part of the head of the bees gets dusted with pollen. The pollen and nectar collecting bees and other nectar collecting insects visited the staminate and pistillate flowers indiscriminately and such a forage-searching behaviour was considered to be contributing to successful pollination. The simultaneous presence of staminate and pistillate flowers on the same plant favours geitonogamy, whereas synchronous flowering and patchy occurrence of the plant species promotes xenogamy.

The fruits of *C. canescens* mature within a month. The fruit is a globular, inflated, tri-lobed, paper-thin capsule containing three small black spherical seeds (Figure 1 *g*), each with a white, 'heart'-shaped centre. The brown and dry fruits fall to the ground or are driven-off by wind. They expose seeds following rupture or decomposition of the fruit pericarp. Seeds germinate within two weeks if the soil is sufficiently wet, or they remain dormant for germination following monsoon showers.

*C. canescens* is a rainy-season plant. Its allied species, *C. halicacabum* also exhibits similar behaviour[10]. Inflorescence is a dichasial cyme with six flowers in *C. canescens*, whereas it is a trichasial cyme with nine flowers in *C. halicacabum*[10]. Inflorescence flowering pattern is similar to that in *C. halicacabum*[10]. This pattern conforms to the 'steady state' flowering of Gentry[11]. In *C. canescens*, the flowers are morphologically bisexual, but functionally unisexual. The ovary is non-functional in staminate flowers, whereas the anthers are indehiscent in pistillate flowers. Since both flower sexes occur in the same inflorescence and are functional at the same time, this sexual system conforms to monoecy. *C. halicacabum*, *Sapindus emarginatus* and *Allophylus serratus* also exhibit monoecious sexual system with similar floral characteristics[10,12,13]. But

*S. emarginatus* and *A. serratus* display characteristic flowering phenology with alternation of staminate and pistillate functions within individual plants contributing to temporal dioecism.

*C. canescens* and *C. halicacabum* do not exhibit such flowering phenology. The simultaneous presence of staminate and pistillate flowers in *C. canescens* at the plant level facilitates selfing through geitonogamy and the synchronous flowering of plants in an area allows fruit set through xenogamy. Selfing may be a special adaptive value for this herbaceous vine, and compatibility to cross-pollen provides scope for maintaining genetic heterogeneity. The production of more staminate flowers against pistillate flowers is a mechanism for adjusting reproductive effort to male or female functions[14] for increasing male fitness, since the resources saved by producing fewer pistils could be directed to male function[15] and also for meeting the requirement of pollen-collecting bee pollinators. The conspicuous floral display serves as an attractant to pollinators[16].

Despite being white and prominent, the flowers could attract only a few pollinator species. This could be due to the production of nectar in traces. *C. halicacabum* also produces nectar in traces and is pollinated by a few insect pollinators[10]. Likewise, *C. integerrimum* has been reported to be exclusively pollinated by three species of bees, *Xylocopa* sp., *Apis mellifera* and *Trigona spinipes*[17]. Therefore, the production of traces of nectar appears to be an inherent trait in *Cardiospermum* species and adaptive to attract only a few insect pollinators. *C. canescens* is thus entomophilous. The fruit characteristics in *C. canescens* conform to the genus name. The fruit is a tri-lobed capsule with each lobe containing a single seed[3]. *C. cardiospermum* and *C. microcarpum* also produce fruits with the same characteristics[10,18]. Seeds of *C. canescens* germinate depending on the soil moisture status. The study suggests that the plant with monoecy, geitonogamy and xenogamy, and with a few insect pollinator species reproduces successfully and builds up sufficient populations in favourable areas, especially in open scrubs.


1. Ferrucci, M. S., *Novon*, 1998, **8**, 235–238.
2. Ellis, B. W., *Taylor's Guide to Annuals: How to Select and Grow more than 400 Annuals, Biennials, and Tender Perennials*, Houghton Mifflin Company, Boston, 1999.
3. Solis, S. M. and Ferrucci, M. S., *Ann. Bot. Fennici.*, 2009, **46**, 485–495.
4. Chetty, K. M., Sivaji, K. and Tulasi Rao, K., *Flowering Plants of Chittoor District Andhra Pradesh, India*, Students Offset Printers, Tirupati, 2008.
5. Vikneshwaran, D., Viji, M. and Raja Lakshmi, K., *Ethnobot. Leaflets*, 2008, **12**, 948–953.
6. Karuppusamy, S., *Nat. Prod. Radiance*, 2007, **6**, 436–442.
7. Ganesan, S., Ponnuchamy, M., Kesavan, L. and Selvaraj, A., *Indian J. Trad. Knowledge*, 2009, **8**, 154–162.
8. Mikolajcak, K. L., *Cyanolipids, Progress in the Chemistry of Fats and other Lipids*, Pergamon Press, Great Britain, 1977, vol. 15, pp. 97–130.
9. Dafni, A., Kevan, P. G. and Husband, B. C., *Practical Pollination Biology*, Enviroquest Ltd, Ontario, 2005.
10. Rama Das, K., Subba Reddi, C., Solomon Raju, A. J. and Atluri, J. B., *J. Bombay Nat. Hist. Soc*., 1997, **94**, 333–341.
11. Gentry, A. H., *Biotropica*, 1974, **6**, 64–68.
12. Subba Reddi, C., Reddi, E. U. B., Reddi, N. S. and Reddi, P. S., *Proc. Indian Natl. Sci. Acad*., 1983, **49**, 57–72.
13. Solomon Raju, A. J., Subba Reddi, C. and Rama Das, K., *Plant Species Biol*., 1998, **13**, 1–5.
14. May, P. G. and Spears Jr, E. E., *Am. J. Bot*., 1988, **75**, 1830–1841.
15. Emms, S. K., *Am. J. Bot.*, 1993, **80**, 914–923.
16. Primack, R. and Lloyd, D. G., *Am. J. Bot*., 1980, **67**, 361–368.
17. Viana, B. F. and Kleinert, A. M., *Rev. Brasil. Entomol*., 2006, **50**, 53–63.
18. Weaver, R. E. and Anderson, P. J., *Cardiospermum microcarpum* Kunth (heartseed). *Tri-ology*, 2009, **48**, 4.


Received 14 June 2010; revised accepted 27 July 2011

A. J. SOLOMON RAJU*
K. VENKATA RAMANA
N. GOVINDA RAO
P. VARALAKSHMI

*Department of Environmental Sciences,*
*Andhra University,*
*Visakhapatnam 530 003, India*
**For correspondence.*
*e-mail: ajsraju@yahoo.com*

# *Cynodon dactylon* (L.) Pers.: a self-treatment grass for dogs

Vomiting can be defined as a voluntary or forcible expulsion of the stomach contents through mouth and nostrils[1–3]. By this, over-loading of the stomach can be easily relieved during normal gastric trouble[4]. Many animals, especially dogs and cats instinctively treat themselves during illness or indigestion. Studies have revealed that vomiting in these animals is a safeguard (not always) against indigestion for food poisoning and other indigestible materials[2], viz. polythene bag, plastic, strong spices, etc. In Britain, dogs are known to induce vomiting by eating green shoots of *Elymus hispidus* (Opiz.) A. Melderis (*Triticum repens* Hegetschw), indigestion of which stimulates vomiting[2] in 4–5 min. *E. hispidus*, popularly called dog or cough grass, is a common weed in Europe and America. It is rich in vitamine C and is an anthelmintic, antibacterial, anti-inflammatory, antiseptic, demulcent, diuretic, herbicide, litholytic and sedative[5]. This grass is extensively used in human medical preparations to cure diseases like herbalist of gout, enlarged prostrate gland, incipient nephritis, purulent cystitis, jaundice, incontinence urination, restoration of poor eyesight, chest pain, syphilis, lumbago, irritation of bladder, as a female corrective agent, etc. in Europe, America and Russia[6]. It is interesting that unlike Europe, vomit-inducing grasses in dogs and cats have not been mentioned in the literature related with grasses[7–12] and medicinal plants[13–20] of India and the adjoining countries. However, it is a well-known fact that these animals prefer grasses to induce vomiting by regurgitation.

Since last two years one of us (M.K.K.) has been observing dogs for their grass-eating habit. About 25 dogs were observed during this period which included Dober-