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Note

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On the floral biology and pollination of a rare Twining Liana *Sarcolobus carinatus* Wall. (Asclepiadoideae: Apocynaceae) in Coringa Mangrove Forest, Andhra Pradesh, India

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Sarcolobus is a genus of sub-family Asclepiadoideae, family Apocynaceae according to APG IV System Classification (2016). Rintz (1980) documented that this genus formerly consisted of 17 described and eight undescribed species distributed in India, Malesia, Melanesia, and Australia. He revised the genus and listed only four species, *S. carinatus, S. retusus, S. globosus*, and *S. oblongus* as occurring in Australia. All four species are restricted to coasts and areas of brackish water, on mud in mangrove and swamp forests, and on sand and coral beaches scrambling over strand vegetation. Later, Forster (1991) documented that *Sarcolobus* is a genus of 13 species in India, Malesia including Papuasia, Melanesia, and Australia. Three species occur in Australia and eight species in Papuasia. ENVIS Centre on Floral Diversity hosted by Botanical Survey of India published a status document on Indian mangrove plant species in 2016. In this document, *S. globosus* and *S. carinatus* are the only species listed under the genus *Sarcolobus*; the former occurs in the Sunderbans, Mahanadi, and the Nicobar Islands while the latter occurs along the east coast in the mangrove areas of the Sunderbans, Mahanadi, Coringa tidal forests, and the Andaman Islands. Rintz (1980) reported that *S. carinatus* is distributed from India, Burma and the Andaman Islands with flowering during February to August and fruiting in June. He mentioned that the characters such as the shape of gynostegium, the presence or absence of double corona, the shape of twin-pollinia, the shape of fruit and the presence or absence of a coma on the seeds are important to distinguish *Sarcolobus* from other genera of the sub-family Asclepiadoideae. Forster (1991) also provided the characters important to distinguish *Sarcolobus* from other genera within the sub-family. These include the presence of slight to strongly papillate style-head, the narrowly oblong corpuscles that stand upright away from the anthers the length of the pollinia, and the geniculate caudicles of the pollinaria. The available information on *Sarcolobus* indicates that the taxonomic details of its species need revision to define total species accurately and provide distinguishing characters for each identified species. Further, none of the species of this genus have been studied thus far for their floral biology and pollination in any part of the world. Therefore, the present study is the first to document floral biology and pollination notes on *S. carinatus* based on field study conducted during January–December 2014 and January–December 2018 at Coringa Mangrove Forest (16^{0}43’47.413”N & 82^{0}12’54.864”E), Andhra Pradesh, India.

In the genus *Sarcolobus, S. carinatus* is the only species that occurs at Coringa Mangrove Forest. Here,

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it grows as a semi-evergreen twining liana along the brackish water creeks that end up after a short distance with the land (Image 1a-c). It uses *Clerodendrum inerme*, a common mangrove associate distributed towards landward side of mangrove forest, for vertical support. In areas where there is no supporting tree species, it grows erect for some time, then the stems twist and hang downwards almost touching the ground. It is rare in occurrence. The stem is light yellow initially and brown eventually. Leaf is petiolate, blade thick, coriaceous, elliptical and bright to dull green (Image 1d). Pheno-events, leaf fall, leaf flushing, flowering and fruiting occur sequentially. Leaf fall occurs during May and leaf flushing commences immediately from the old stems, but it is complete by July. Floral bud initiation occurs simultaneously (Image 1e–g) with leaf flushing and flowering commences in the last week of July, reaches to peak phase during second week of August and ceases by the end of August. Inflorescence is a pedunculate spirally elongating raceme with 6–7 hermaphroditic flowers borne at leaf axils (Image 2a). Calyx is represented by five inconspicuous green sepals with ciliate margins. Corolla is represented by five glabrous 6–10 cm long petals each with rows of brown to purple dots on the upper surface. Corolline corona composed of five distinct yellow pad-like segments, positioned on the petals in one whorl, aligned with the petals and located between the corolla and androecium; the coronal segments are separated from the staminal corona by a narrow cleft (Image 2d). Anthers are attached with the pistil forming papillate and capitate gynostegium (Image 2b, c); the style-head with five grooves support the anthers. The anther wings are narrow but extend back beneath the stigma to end up abruptly at the stamen tube without curving downward. Anthers are represented by twin sub-globose pollinia (Image 2e), each is attached to the caudicle by its basal end and hence held semi-erect and is away from the style-head. Both pollinia are attached by caudicles to the corpusculum which is a black horny structure and quite prominent against yellow corolline and staminal coronas. The ovary is bicarpellary syncarpous, whitish-green and many-ovuled on axile placentation (Image 2f); the style is one with stigma deeply 5-angled, the center with a papillose spherical knob, and five narrow ridges radiating from it to the apex of angles.

Rintz (1980) reported that *Sarcolobus* genus includes both coronal and non-coronal species. He noted that *S. retusus* and *S. oblongus* are non-coronal species lacking both corolline and staminal coronas while *S. carinatus* is a coronal species consisting of both corolline and staminal coronas. He noted that corolline and staminal coronas are either present or absent in *S. globosus*. Forster (1991) reported that *S. globosus* and *S. kaniensis* are coronal species consisting of both corolline and staminal coronas. In *S. vittatus*, corolline corna is present

Image 1. *Sarcolobus carinatus*: a–c—habit | d—close-up view of leaves | e–g—floral bud development stages. © A.J. Solomon Raju.

but staminal corona is absent. In *S. brachystephanus, S. hullsii, S. porcatus, S. ritae, S. secamonoides* and *S. spathulatus*, corolline corona is absent but staminal corona is present. The present study substantiates the report by Rintz (1980) that *S. carinatus* is a coronal species with well-developed corolline and staminal coronas. In *S. carinatus*, the stigmatic chamber in gynostegium has nectariferous tissues which secrete nectar in minute volume and the nectar can accumulate in the staminal corona or at the area where the corolline corona is connected to the gynostegium. Such a secretary pattern is related to the specialized pollination mechanism and it is characteristic of Asclepiadoideae (Kunze 1991, 1997; Demarco 2008). The pollinia in the flowers of *S. carinatus* represent coherent masses of pollen grains and are transferred as single units by flower-visiting insects when the latter collect nectar. Field observations indicated that only juvenile carpenter bees (*Xylocopa latipes* and *X. pubescens*) visit the flowers soon after anthesis and until evening for nectar collection during which their legs or tongue are trapped between the pollinia and in effect, their struggle to withdraw these parts from the flowers result in them capturing the pollinia. Then, they leave carrying the pollinia and in their subsequent visit to another flower get rid of the pollinia and deposit them on that flower effecting pollination. It is not clear if there is any chance of the carpenter bees losing the pollinia during flight. Field observations also indicated that carpenter bees make few visits and very often occasionally to the flowers of *S. carinatus*; such a situation could be attributed to the landward side location of the plants from tidal creeks, scattered occurrence of plants, production of a few flowers per day, which are mixed with the foliage and flowers of host plants, occurrence of high winds during flowering season, which influence the foraging activity of carpenter bees.

In *S. carinatus*, the fertilized flowers take 3–4 months to produce mature fruits (Image 2g-o). The fruits are of follicle type, 5–6 cm long, ellipsoid in shape with 3 flattened ribs, keeled along the dorsal side and terminated into a short beak. They are initially green and brown when mature. Each fruit produces many seeds attached to the vertical receptacle (Image 2p). Mature seeds are dark brown, lacking coma, papery, 10–12 mm long, broadly ovate and flattened. Fields observations indicated that individual plants produce 2–4 fruits in a flowering season suggesting that *S. carinatus* is an

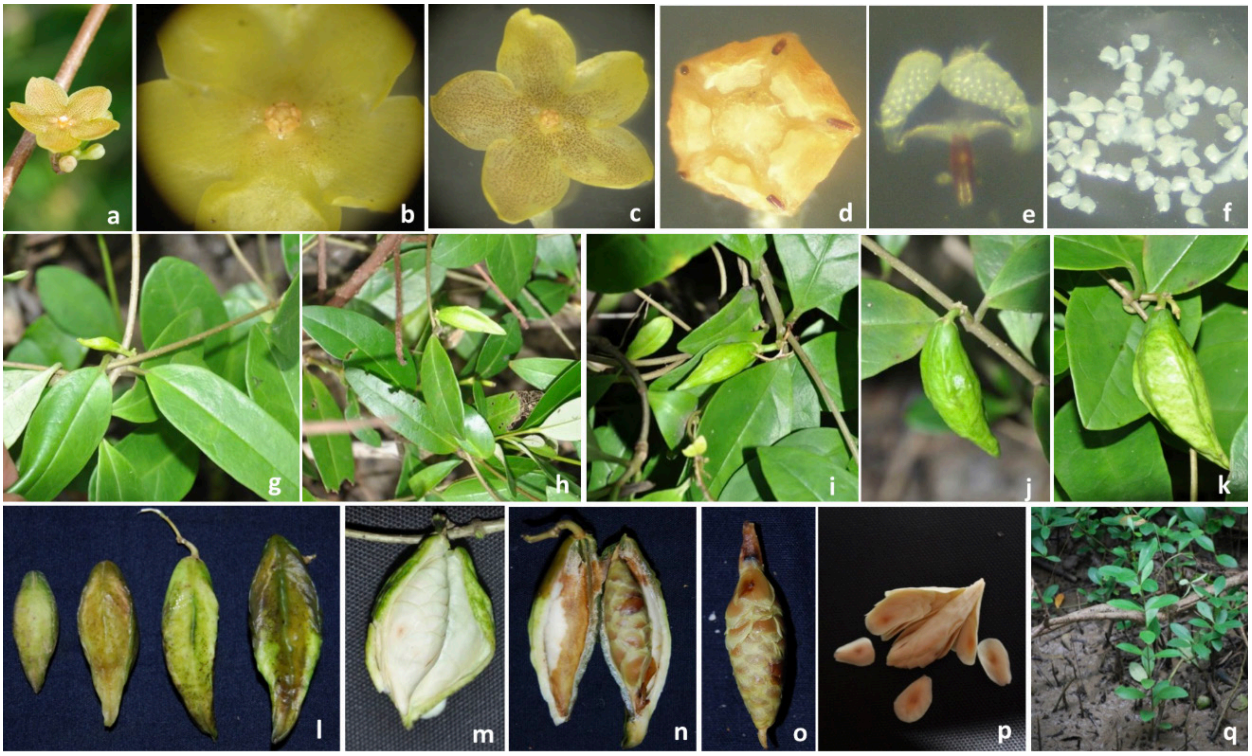

Image 2. *Sarcolobus carinatus*: a—inflorescence with buds and flowers | b–c—gynostegium in the central portion of the flower | d—corollaine corona and staminal corona | e—pollinia | f—ovules | g–l—fruit development stages | m–o—inside view of fruit and seed development stages | p—developing seeds without coma | q—seedling. © A.J. Solomon Raju.

obligate out-crosser and essentially dependent on insect pollinators, particularly carpenter bees which act as efficient pollinators. Further, the fruit set rate is probably pollinator-limited but individual flowers upon receipt of a pair of pollinia each consisting of several pollen grains are able to produce several seeds per fruit as compensation against low fruit set. Therefore, the rare occurrence of *S. carinatus* is attributable mainly to specialized pollination system that prevents insect pollinators other than carpenter bees and pollinator limitation, resources available to the plant in areas where it occurs and edible nature of tender fruits which are often eaten by locals.

Forster (1991) reported that *Sarcolobus* seeds with a layer of seed coat and well-developed lateral margins appear to be adapted to water dispersal but suggested field observations to confirm the same. In this study, *S. carinatus* disperses seeds from mature and dry fruits upon dehiscence into the air during November–December. The flat, papery nature of seeds without coma appear to be a perfect adaptation for wind dispersal. The wind-driven seeds that fall into the tidal water subsequently disperse by floating and settle in muddy areas where they germinate and produce new plants from seedlings if the soil environment is favourable (Image 2q). Therefore, *S. carinatus* is both anemochorous and hydrochorous. Despite efficient seed dispersal modes this plant species is not able to recruit new plants due to its restricted habitat requirement; the sites along the tidal creeks which interface with landward zone.

In Coringa Mangrove Forest, ecotourism, fishing activity and fuel wood collection are regular activities and if these activities are not regulated, the mangrove plant species that grow along brackish water creeks interfacing with landward side are at risk. *S. carinatus* is one such species that is most likely to disappear in the near future because of its rare occurrence if proper conservation and management measures are not implemented by the forest department.

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