Insect pollination and self-planting seed dispersal strategy in the true viviparous mangrove tree species *Ceriops tagal* (Perr.) C.B. Robinson (Rhizophoraceae)

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Abstract: *Ceriops tagal* is a seaward and high salt-tolerant specialist mangrove species. It flowers during the winter season. The flowers have an explosive pollen release mechanism and are adapted for tripping by flies and honey bees. The tripped flowers achieve self or cross-pollination. High winds can also trip flowers, but this only contributes to autogamy. The plant is viviparous; most propagules fall off and settle near the mother plant. We have observed that such propagules do not show healthy growth, hence the establishment of successive offspring in the same habitat is doubtful. These results suggest that *C. tagal* requires introduction of propagules from other mangrove forests to promote gene flow and maintain sufficient genetic diversity for the successful establishment and expansion of populations.

Keywords: *Ceriops tagal*, explosive pollination mechanism, insect pollination, vivipary, self-planting strategy

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Introduction

The genus *Ceriops* is represented by two species, *C. decandra* and *C. tagal*, distributed from East Africa and Madagascar throughout tropical Asia and Queensland to Melanesia and through Micronesia north to Hong Kong (Tomlinson 1986). Both species have been reported to be useful in different ways, providing edible fruit, wood for boat making, house building and fuel, and bark for tannin extraction (used in treating fishing nets, as a binder for particle board and as an ingredient in alcoholic beverages, lotions for malignant ulcers and treatments for diabetes, malaria, leprosy; Burkill 1966; Perry 1980; Little 1983; Bechteler et al. 2006). The occurrence of the two species side by side is rare (Aksornkoae et al. 1992). Both are typical inner mangrove species, *C. decandra* often grows within the tidal zone mixed with other Rhizophoraceae (Tomlinson 1986) while *C. tagal* occurs in harder and higher muddy soil of polyhaline zone, forming pure stands on better-drained soils and showing stunted growth in exposed and highly saline sites (Tomlinson 1986; Aksornkoae et al. 1992; Selvam & Karunagaran 2004).

In India, *C. decandra* is a common species in the interior tidal swamps and sporadic towards outer mangrove areas, while *C. tagal* is either rare or quite uncommon both on the east and west coasts. However, *C. tagal* has considerable population size in the mangrove forests of the Sundarbans, and on the Andaman and Nicobar Islands (Naskar & Mandal 1999).

In Andhra Pradesh, mangrove forests occur in the Krishna and Godavari deltas, and *C. decandra* is a common constituent of these forests. There are conflicting reports regarding the occurrence of *C. tagal* in these forests. According to Untawale (1986), Banerjee et al. (1989), and Singh & Odaki (2004), *C. tagal* occurs in the Krishna and Godavari deltas, but the Mangrove Status Report of the Ministry of Environment and Forests (1987) does not show its occurrence there. Naskar and Mandal (1999) also mentioned that it does not occur in Andhra Pradesh, citing the reports of different workers. Ramasubramanian et al. (2003) based on their field studies in the Krishna-Godavari mangrove forests and published a book which does not document the presence of *C. tagal* in these forests. However, our field studies showed the presence of *C. tagal* in Krishna mangrove forests. In this paper, we report on the pollination biology and seed dispersal ecology of *C. tagal* in Krishna mangrove forests, as existing information on these aspects is limited (Tomlinson 1986), especially under Indian conditions.

Materials and Methods

Krishna Mangrove Forests occur between 15°42'-15°55'N & 80°42'-81°01'E spread across Krishna and Guntur districts in Andhra Pradesh. Around 60 trees of *C. tagal* occur seaward on a well-drained muddy soil in Nachugunta reserve forest in Krishna district (Fig. 1). The area is well-drained during low tide periods and flooded with seawater during high tide periods. Ten accessible trees of *C. tagal* were used for the present work. Fortnightly field trips were conducted to visit these trees until the onset of flowering,
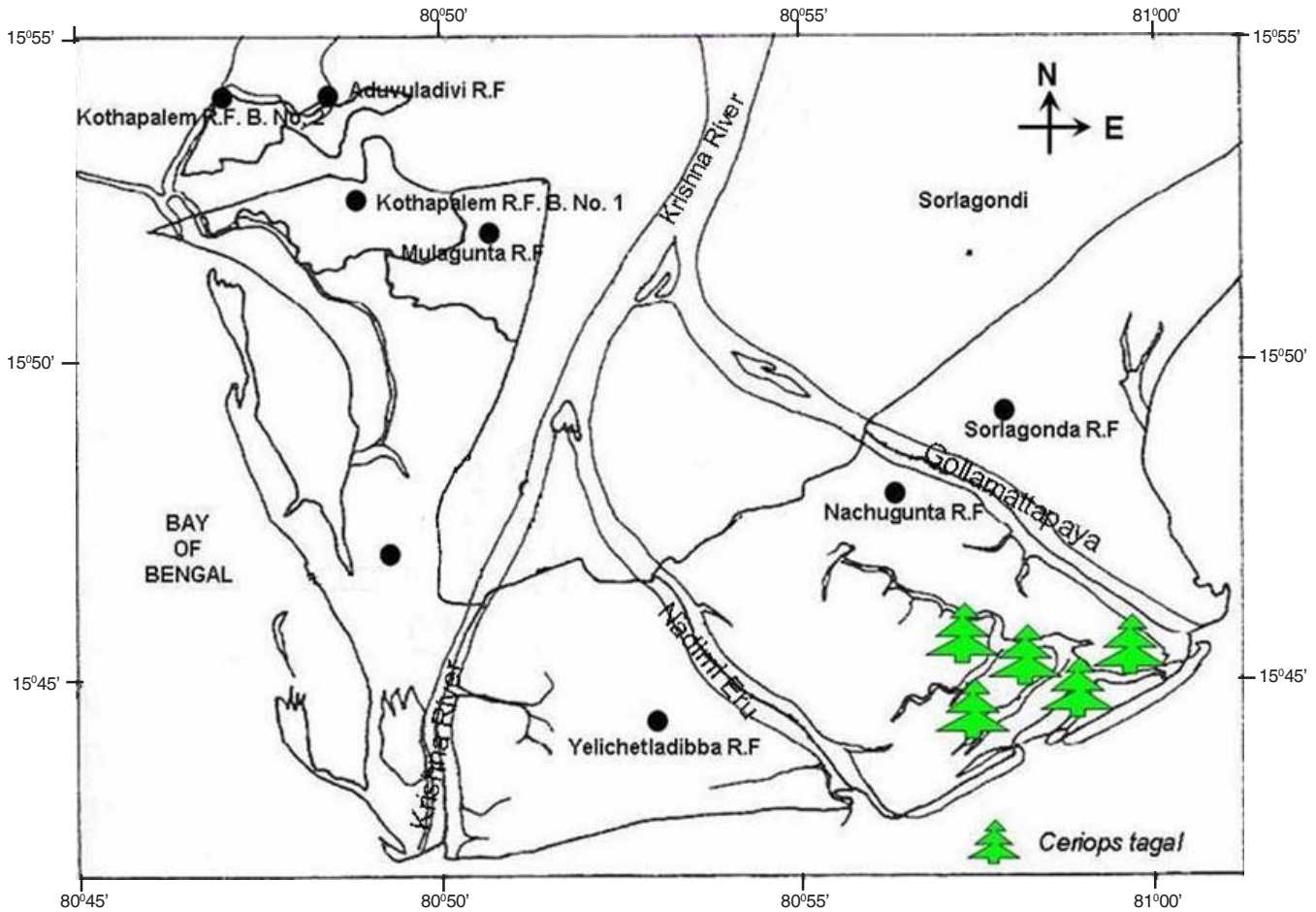
Figure 1. Location of *Ceriops tagal* in Krishna Mangrove Forest

and regular field studies were conducted during the entire period of flowering and until seedlings fell down during 2005-2006. Floral, structural and functional details were examined according to the protocols given by Dafni et al. (2005). Nectar characteristics including volume, sugar concentration, sugar types and amino acids were examined according to the methodologies provided by Roubik (1995) and Baker & Baker (1973). Flower visitors were observed for their role in effecting pollination. Five individuals each of bees and ten individuals of a fly species were captured, washed in aniline blue on a glass slide and the number of pollen grains counted under a microscope to determine their role in pollen transfer. As the flowers have an explosive pollen release mechanism, the role of wind in petal explosion and subsequent pollination was also observed during day time. For this, five easily-accessible inflorescences with newly open flowers exposed to direct sunlight towards creek side in the windward direction were tagged and bagged carefully in the evening of the previous day; bags were removed carefully in the morning of the next day and the tagged inflorescences observed at close quarters until late evening to note whether petal explosion occurred. Care was taken to prevent foragers from visiting these inflorescences throughout the observation period. Twenty inflorescence with 262 mature buds from ten trees were bagged and followed for fruit/seedling production to judge whether breeding system is vector dependent. One inflorescence each from 10 trees with a total of 123 flowers were tagged and

followed to note flower abortion rate. In these inflorescence, flowers fell off two days after anthesis against the actual flower life, and this early flower drop was recorded as flower abortion. Sixty-four open inflorescence with 704 flowers from the same set of trees were tagged and followed for natural fruit set at the site. Fruit and seedling development and characteristics were also investigated in detail by following fruited flowers until propagules fell down. Visual observations on the dispersal and establishment of propagules at the study site were made to understand the planting strategy.

RESULTS

C. tagal is an evergreen shrub/tree (Image 1a) and flowers during November-February. Its associate plant species, *Aegiceras corniculatum* (December-March), *Bruguiera gymnorrhiza*, *Rhizophora apiculata* and *Ceriops decandra* (year-long) also show flowering simultaneously. In *C. tagal*, the flowers are born in condensed short-stalked cymes formed from dichotomizing panicles, which arise from the axils of leaves on the terminal nodes of new shoots (Image 1b,c). A cyme produces 11 ± 2.5 flowers which anthese over a period of 6-8 days (Image 1d,e). Flowers are short-stalked, small, white, cup-shaped, strongly fragrant, bisexual and zygomorphic. Sepals are five, small, yellowish-green, valvate enclosing the inner parts until anthesis and not reflexed after anthesis. Petals are five, free, white, pubescent, two lobed, and alternating with the sepals. The lower
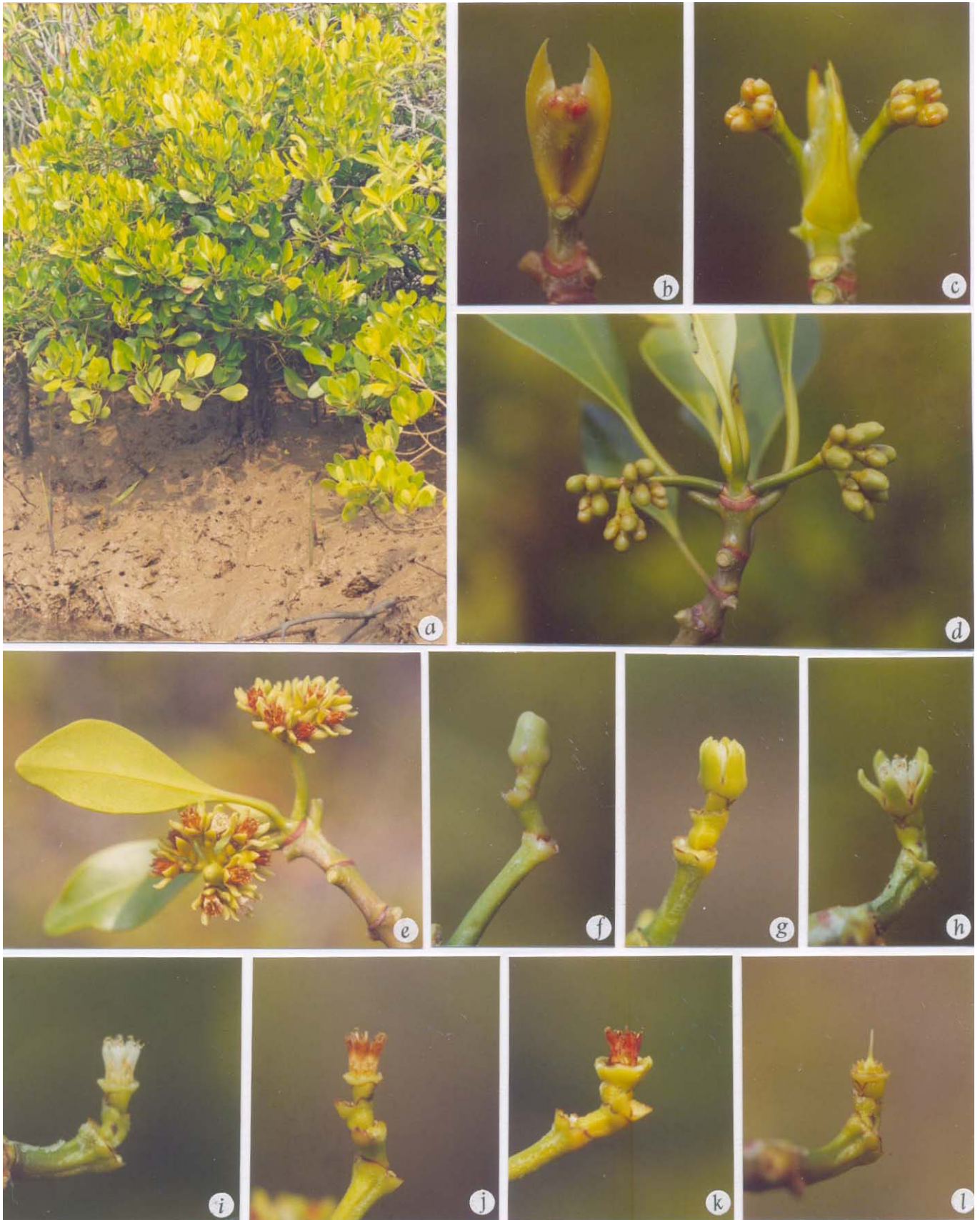
Image 1. *Ceriops tagal.* a - Habit; b & c - Short-stalked cymes emerging from the axils of leaves; d - Fully developed cymes; e - Flowering cymes; f - Mature bud; g - Partly open mature bud; h - Fully open flower; i - Petals with stamens inside and overtopped by filamentous appendages; j & k - Gradual petal colour change from the top to base; l - Flower showing style and stigma

Image 2. *Ceriops tagal*. a - *Chrysomya megacephala* feeding on nectar; b-d - Fruited cycmes (b - one-fruited; c - two-fruited; d - three-fruited); e - Growing propagules; f - Cotyledonary yellow collar distinguishing the fruit from the hypocotyl.

margins of adjacent petals are held together by patches of tightly intertwining, helically coiled hairs. Each petal has three distinct clavate appendages on its distal margins. Stamens are 10, five of them antisepalous, five others antipetalous and all 10 inserted on the rim of the calyx cup. Each petal encloses the antipetalous stamen and an adjacent antisepalous stamen; the two stamens remain in the petal under tension enclosed above by the clavate appendages even after anthesis. The style is slender and terminated into minute separate stigmatic lobes. The stigma stands at the height of the stamens (Image 1l). Disc within the stamen ring is well developed and anther lobes enclose the base of the thick filaments. Ovary is semi-inferior, 3-carpelled and 3-locular with a total of six ovules.

The mature buds open during 1630-1800hr. The calyx lobes separate at anthesis and diverge to expose the petals (Image 1f-h). The petals with the stamens inside, two per petal do not unfold naturally throughout the flower life but remain in a state of tension with the spring-loaded stamens hooded above by clavate appendages (Image 1i). Anther dehiscence occurs in bud. Pollen grains are triangular, light yellow, exine smooth and 15μ in diameter. A flower produces $14,681 \pm 25.62$

pollen grains. The pollen-ovule ratio is 2,446:1. The stigma attains receptivity on the second day and remains receptive up to six days. But, peak receptivity occurs from third to fifth day. During this period, the white petals turn red gradually from the top to the base (Image 1j,k). A flower produces 5.65 ± 1.0 μl of nectar. The nectar sugar concentration is 35-50% and the common sugars include fructose, sucrose and dextrose with the first relatively more dominant. The nectar contains 12 amino acids which include tyrosine, glycine, methionine, proline, lysine, aspartic acid, glutamic acid, serine, cysteine, alanine, threonine and arginine. Of these, glycine, serine, cysteine, alanine and threonine are relatively dominant. The amino acids such as phenylalanine, valine, leucine, iso-leucine, tryptophan and histidine were not found in the nectar. The unpollinated flowers fall off on seventh day. In pollinated flowers, the petals, stamens, the style and stigma drop off in this order in 3-4 weeks while the fruit is in growing stage. The sepals are persistent, become warty and spiny gradually and remain on the plant even after the shedding of propagules.

The buds produced proceed to open without abortion. In open flowers, flower abortion rate is 42%. Of the 20
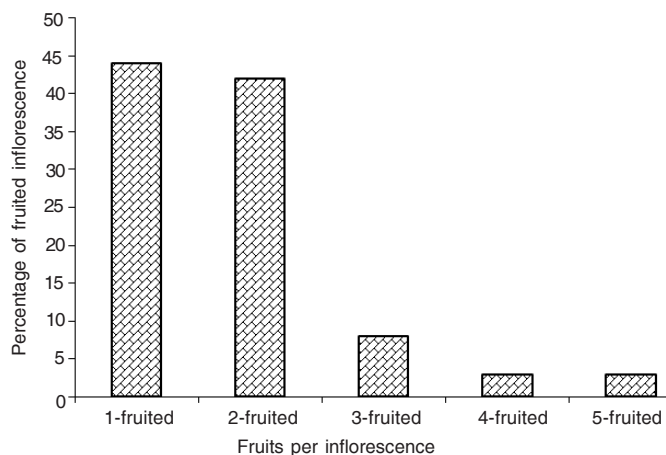
Figure 2. Fruit set rate at inflorescence level in *C. tagal*

inflorescence bagged, only eight flowers set fruits and thus the fruit set in bagged flowers is 3%. Of the 64 open inflorescence tagged, only 115 flowers set fruit, constituting 16.3% natural fruit set. Fruit set per inflorescence varied from 1 to 5 but 1- and 2-fruited inflorescence were more common (Image 2b-d; Fig. 2). The pollinated flowers take four weeks to produce mature fruits, which are single seeded. Fruits are conical by the extrusion of the upper part of the ovary, surface brown and roughened. The seed has no dormancy and produces hypocotyls while on the mother tree in a span of about two months. The cotyledonary yellow cylindrical collar (1cm long; Image 2f) appears from the fruit about 10 days prior to detachment of the hypocotyls. The hypocotyl is 26cm long, distinctly ridged and hangs downwards. It is initially green (Image 2e), after the development of collar it shows a gradual colour change to brownish-purple from hypocotyls end to plumule. The mature hypocotyls separate from fruit, leaving the latter attached to the mother plant. The detached hypocotyls were found to settle in the vicinity of the mother plant.

The flowers do not expose stamens naturally, but the latter attain a tensed condition in the delicate petals for release by a delicate external touch. The foragers included honeybees, *Apis cerana indica*, *A. florea* and a fly species, *Chrysomya megacephala* (Image 3a). Of these, honeybees foraged for pollen and nectar occasionally while the fly foraged for the nectar consistently until the floral source exhausted. All three species approached the flower from above and probed for nectar, causing sudden release of stamens from the petals. In effect, the pollen from the already dehiscent anthers was ejected forcibly and deposited on the underside of the foraging bee or fly. Body washings for pollen revealed the presence of pollen grains which varied from 231 to 413 per bee and from 79 to 147 per fly suggesting that both bees and the fly have an important role in petal explosion and pollination. In case of bees, they also carried pollen loads in pollen baskets present on their legs. As each petal independently encloses two stamens, a single foraging visit of the bee or fly did not result in the explosion of all five petals. Both the bees and the fly tended to visit more than one flower on the same inflorescence or different inflorescences on the same plant before flying away to visit the neighboring trees, and may return back again to visit the same flowers later. As they tended to move back and forth between trees, their foraging activity may result in substantial self- and cross-

pollination. The honey bees were found to concentrate principally on *B. gymnorrhiza* and *A. corniculatum* while the fly species was exclusively observed on *C. tagal*.

We observed that the explosion of petals in open flowers was also triggered by the action of wind. The plant grows in the seaward zone and high winds are characteristic of the site. Of the 24 flowers observed, four had shown petal explosion triggered by wind action, indicating that 16.6% of flowers may achieve pollination by wind action. In such flowers also, the explosion of all five petals did not take place at one time. It had not been possible to study whether wind could trigger petal explosion in the flowers located on the branches facing the landward direction and mixed with the canopy where wind action becomes relatively ineffective. Wind-triggered petal explosion may result in autogamy.

Discussion

C. tagal is strictly a winter bloomer, whereas its closely related species *C. decandra* is a year-long bloomer with alternate flowering and fruiting phases (Raju et al. 2006). Aksornkoae et al. (1992) reported that the occurrence of the two species at the same site is rare; we also found a similar situation at the Krishna mangrove forests. The distribution of *C. tagal* in this forest indicates that it has a distinct seaward zonation and prefers well-drained high saline soils, suggesting that the species is a salt-tolerant mangrove with the competitive ability to grow in highly saline and partly inundated locations (Aziz & Khan 2001). The site is flooded with water only during high tides and is well drained during low tides indicating that *C. tagal* is a higher inter-tidal mangrove specialist; the plants occurring in such sites are inundated about 20 times a month (Duke et al. 1998). Further, in such sites rains make no difference, and hence the salt content of the soil remains high and approximately uniform throughout the year (Joshi 1933). Duke et al. (1998) reported that *Excoecaria agallocha* becomes more common in the absence of *C. tagal* in such sites. At the study site, a few trees of *C. tagal* occur with some naked habitat and *E. agallocha* grows here and there in its association. On the contrary, *C. decandra* is not a strict seaward mangrove plant and it occurs commonly even in areas of tidal zone far away from sea shore (Tomlinson 1986). Our field studies in mangrove forests in Andhra Pradesh showed that *C. tagal* is absent in the Godavari mangrove forest, while a few trees still survive in Krishna mangrove forests. Therefore, *C. tagal* being a seaward mangrove has not been successful in establishing a good population size, while its sister species, *C. decandra* with flexibility to survive in tidal zones even far away from the seashore, has built up its populations to the extent of becoming a common constituent of mangrove forests.

In *C. tagal*, the floral characteristics such as white flowers, strong fragrance, complex petal-stamen configuration and production of moderate amount of nectar suggest an elaborate and specialized floral mechanism. The petals require an external delicate touch for the explosive release of stamens. The helically-coiled hairs at the lower margins of the petals help to propagate explosive pollen release effectively (Juncosa & Tomlinson 1987). The petal clavate appendages of petals in *C. tagal* lack hydathodes and abundant xylem which are characteristically present and have a role in flower function under extreme water pressure deficits during the day in *C. decandra* (Juncosa & Tomlinson 1987). Such a state may make

appendages light and provide necessary trigger for petal explosion by the delicate touch of the forager in *C. tagal*. An explosive pollination mechanism has also been reported in *Bruguiera* species for which the flower-tripping agents are birds and butterflies (Tomlinson et al. 1979; Ge et al. 2003).

Tomlinson (1986) reported night-flying insects, especially moths as probable pollinators. Meeuse & Morris (1984) described the characteristics of moth flowers, which include: flower opening in the evening, display of overwhelming fragrance at that time, light flower colour, absence of a landing platform, fringed petals for guidance, visual and olfactory nectar-guides, long and narrow corolla tube, abundance of nectar and short-tongued visitors. Baker & Baker (1983) reported that hawk moth flowers produce sucrose-rich or dominant nectar with low sugar concentration. Cruden et al. (1983) reported that small moth flowers produce relatively small volumes of nectar with small amount of sugar. They also stated that moth flowers initiate nectar secretion 1-3 hours or even 10 or more hours prior to the activity period of moths. In *C. tagal*, nectar guides and tubular corolla are lacking, the nectar secretion begins an hour after anthesis; it is in moderate volume, hexose-rich with high sugar concentration. These characters together with the shallow nature of flowers are suitable for foraging by short-tongued bees and flies (Baker & Baker 1983; Cruden et al. 1983). In our study we have not found the foraging activity of hawk moths or settling moths at the flowers after anthesis until late evening (up to 2200hr), and the absence of moths could be due to non-availability of nectar at anthesis and reduced opportunities for food and breeding opportunities in harsh mangrove habitats. *C. tagal* with a few trees and a few numbers of flowers per unit of time per tree does not constitute a potential nectar station for moths. Further, adult moths do not survive for longer period and in particular, hawk moths may survive for a period exceeding a month (Opler 1983). Within that life span, the availability of nectar in the habitat is crucial and since *C. tagal* is unable to attract and supply its nectar requirement, the moths might have disappeared or migrated to other reliable food-rich habitats. *Apis* bees and *Chrysomya* flies make up day-time foragers for *C. tagal*. With a small number of trees and again each tree with a small number of flowers per day, *C. tagal* is not a potential pollen and nectar source for honey bees. Yao et al. (2006) also reported that this plant species is a minor pollen and nectar source for honey bees. In the study site, *Aegiceras* and *Bruguiera* flowers attract honey bees and the latter were found concentrating on these species. *Chrysomya* flies frequent the flowers of *C. tagal* daily effecting pollination but they have limited pollen transport capacity; this however, is compensated by their numbers and could bring about substantial geitonogamy and xenogamy (Faegri & van der Pijl 1979). The petal colour change may act as a nectar guide for the flies to visit the flowers for several days. The close proximity between trees of *C. tagal* at the study site also facilitates xenogamy. The fly is present throughout the year unlike periodic bees and moths; but its presence depends on local opportunities for breeding sites (Faegri & van der Pijl 1979). Our observations suggest that *Chrysomya* is the primary and consistent pollinator while honey bees are secondary and occasional pollinators. Petal explosion also occurs sporadically in nature due to wind action and this is evident in bagging experiment in which there is a negligible fruit set and also in natural conditions to some extent. The role

of wind in tripping explosive pollination has also been reported in *Hyptis suaveolens* (Lamiaceae) (Raju 1990) and *Shorea robusta* (Dipterocarpaceae) (Atluri et al. 2004). Therefore, petal explosion and subsequent pollination events are primarily vector-dependent and inadequate numbers or non-availability of pollinators are bound to result in reduced or no fruit set in *C. tagal*.

Honey bees respond to differences in amino acid concentration and detect amino acids. They prefer certain amino acids and their presence make nectar more attractive (Dress et al. 1997). Tyrosine is not an essential amino acid but may be important in the formation of sclerotin (Gardener & Gillman 2002). Phenylalanine is a precursor of specific honey aroma component, phenyl-ethanol (Thawley 1969), iso-leucine is required for rapid breeding (Slansky & Feeny 1977). Flies also prefer amino acids in nectar. In the flies, *Boettcherisca peregrine* and *Phormia regina*, proline stimulates salt receptor cells, methionine and valine stimulate sugar receptors, methionine also elicits a feeding response from flies and glycine and serine invoke an extension of the proboscis (Shiraishi & Kuwabara 1970; Goldrich 1973). *C. tagal* flowers with a mix of floral characteristics of moth, bee and fly flowers contain conventional protein building amino acids such as tyrosine, glycine, methionine, proline, lysine, aspartic acid, glutamic acid, serine, cysteine, alanine, threonine and arginine but are devoid of other protein-building amino acids such as phenylalanine, valine, leucine, iso-leucine, tryptophan and histidine. The nectar provides an instant supply of methionine, lysine and arginine for honey bees and flies; moths if occur in the habitat also make use of this nectar for protein building. The presence of several amino acids in this nectar source stimulates feeding and may also be an important source for flower foragers.

In viviparous mangrove plants, mixed mating system has been reported in *Bruguiera gymnorrhiza*, *Kandelia candel*, *Rhizophora mucronata* and *R. mangle*; the first three species are mainly out-crossing while the last is predominantly self-pollinating (Ge et al. 2003; Sun et al. 1998; Chen et al. 1996; Kondo et al. 1987). In such species, out-crossing rates vary between populations and affected by plant density, population structure, pollinators, adaptability and self-incompatibility. Environmental factors may disrupt and bring about distinct out-crossing rates (Ge et al. 2003). *C. decandra* as a common species in most of the regions in its distribution range may have achieved distinct out-crossing rates and accordingly, it has been reported to be an out-crosser (Raju et al. 2006). On the contrary, *C. tagal* with a small number of individuals at the study site can produce offspring with mixed mating system only if it fails to attract potential and adequate pollinators. In line with this, we found that it possesses such a system to produce fruit set even through autogamy. But, autogamy is negligible as realized in our bagging experiment. In *K. candel* and also in a crypto-viviparous species, *Avicennia marina*, negligible self-pollination has been reported in bagging experiments (Sun et al. 1998; Clarke & Myerscough 1991). The fruit set in *C. tagal* is through geitonogamy and xenogamy. The long flower life and stigma receptivity and high pollen-ovule ratio (Cruden 1977) indicate that the plant is primarily out-crossing. However, the close proximity of the existing trees at the study site in course of time could bring about genetic uniformity and if this happens, the survival of this species becomes doubtful.

Ceriops decandra displays a high per cent of bud and flower abortion. In *C. tagal*, there is no bud abortion but it shows a high per cent of flower abortion. This abortion could be due to defective nature of the flowers and adjustments of the available resources to growing healthy fruits and seedlings in order to prevent premature fruit abortion. The number of fruits per inflorescence varies from 1 to 5 but 1- and 2-fruited inflorescences are most common. The fruited flowers produce only one seed against the actual number of six ovules as in *C. decandra* and all other viviparous species of Rhizophoraceae. This characteristic may permit these plants to save resources and use them to produce one-seeded viable fruits. Despite this effort by *C. tagal*, a few propagules lack green pigment and becoming entirely yellowish or yellowish on one side and purplish on another side. Such hypocotyls have been referred to as "albino" forms which also occur in *C. decandra* and *Bruguiera gymnorrhiza* (Raju et al. 2006; Allen & Duke 2006). These propagules are non-viable, cannot photosynthesize and die after depleting reserves if settled in the habitat. The propagules that are green first and brownish-purple later are healthy and grow to their actual size. The length of hypocotyls in *C. tagal* is almost double the length of hypocotyls in *C. decandra*. Both the species of *Ceriops* show a short period of attachment to the maternal plant (Raju et al. 2006) and this characteristic is not in agreement with the report of Bhosale & Mulik (1991) that the hypocotyls of true viviparous mangrove species remain attached to the mother plant for a full year. The hypocotyl grows upward in *C. decandra* in which flowers are sessile (Raju et al. 2006) while in *C. tagal*, it grows downward which seems to be because of stalked flowers and more weight of the hypocotyls. This is an important field characteristic feature to distinguish *C. tagal* from *C. decandra*. The downwardly hanging hypocotyl is also a characteristic of *Bruguiera*, *Rhizophora* and *Kandelia* species. In *C. tagal*, the cotyledonary yellow cylindrical collar emerges from the fruit about 10 days prior to the detachment of the hypocotyl while this structure is entirely absent in *C. decandra* (Raju et al. 2006). The cotyledonary collar is a characteristic also in *Rhizophora* in which it is reddish brown and *Kandelia* in which it is yellow and the hypocotyl is about double the length of *C. tagal* (Aksornkoae et al. 1992).

Fruit in *C. tagal* grows continuously and the seed also has no dormancy like in other mangrove species of Rhizophoraceae (Farnsworth & Farrant 1998). This form of fruit growth and seed germination leading to the formation of hypocotyl while still attached to the mother plant represents "vivipary", the opposite of "ovipary" in which seed dormancy is the rule. The viviparous condition has been considered as an evolutionary loss of seed dormancy (Farnsworth & Farrant 1998), however, it is an adaptive feature for the plant to overcome the harsh tidal environment for seedling establishment in the parental sites but it is not considered adaptive for dispersal either in time or space (Sun et al. 1998). The other adaptive values of vivipary include facilitation of early rooting (MacNae 1968), buoyancy during sea dispersal (Rabinowitz 1978), transfer of maternal nutrients to the hypocotyls (Pannier & Pannier 1975), maintenance of embryonic osmotic equilibrium, establishment in coarse grained environments. On the other hand, vivipary incurs maternal costs to supply water and necessary nutrients. Numerous attached seedlings may constitute a substantial carbon sink to the maternal plant, a concentrated apparent resource for herbivores (Farnsworth & Farrant 1998). *C. tagal*

at the study site was found to produce 20 to 60 hypocotyls per tree and it is not known whether this small number could attract herbivores.

Kairo et al. (2001) reported that viviparous mangrove species use self-planting or stranding strategy for establishment depending on forest conditions tide and stability of the soils. The self-planting strategy dominates in undisturbed mangrove forests but stranding strategy is dominant in exploited and open or naked forests (Dahdouh-Guebas et al. 1998). *C tagal* with epigeal seed germination, elongated and pointed hypocotyls with straight curvature (Clarke et al. 2001) fall freely from the mother plant and plant themselves into the mud at the same site during low tide period. The hypocotyls if fallen during high tides float to another site for settlement. But, our field studies do not show settlement of hypocotyls away from the mother plants suggesting that *C. tagal* uses self-planting strategy only. This is further substantiated by McGuinness (1997) who also reported that hypocotyls of *C. tagal* in northern Australia dispersed very short distances; only 9% moved more than 3m from the parent tree. He also mentioned that within that short distances, a high percentage of them were either damaged or eaten by animals. *C. tagal* at the study site may also be experiencing the damage or consumption by animals, especially crabs as the latter have been reported to show high predation on hypocotyls in high inter-tidal areas (Duke et al. 1998). Some of the fallen hypocotyls settled at the mother plants showed signs of withering. Therefore, the study suggests that *C. tagal* though occurring in undisturbed and human-free site is almost unable to add new plants and the presence of only a few individuals at the site attests this contention. The work reported in this paper is important for initiating studies on the genetic structure of *C. tagal* population. The genetic marker analysis may help to understand the variability within and between different populations. Introduction of *C. tagal* from the mangrove forests of the Sundarbans and Andaman and Nicobar Islands to this site would help to enhance gene flow in order to maintain the gene diversity and expansion of population size of *C. tagal* in Krishna Mangrove Forests.

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