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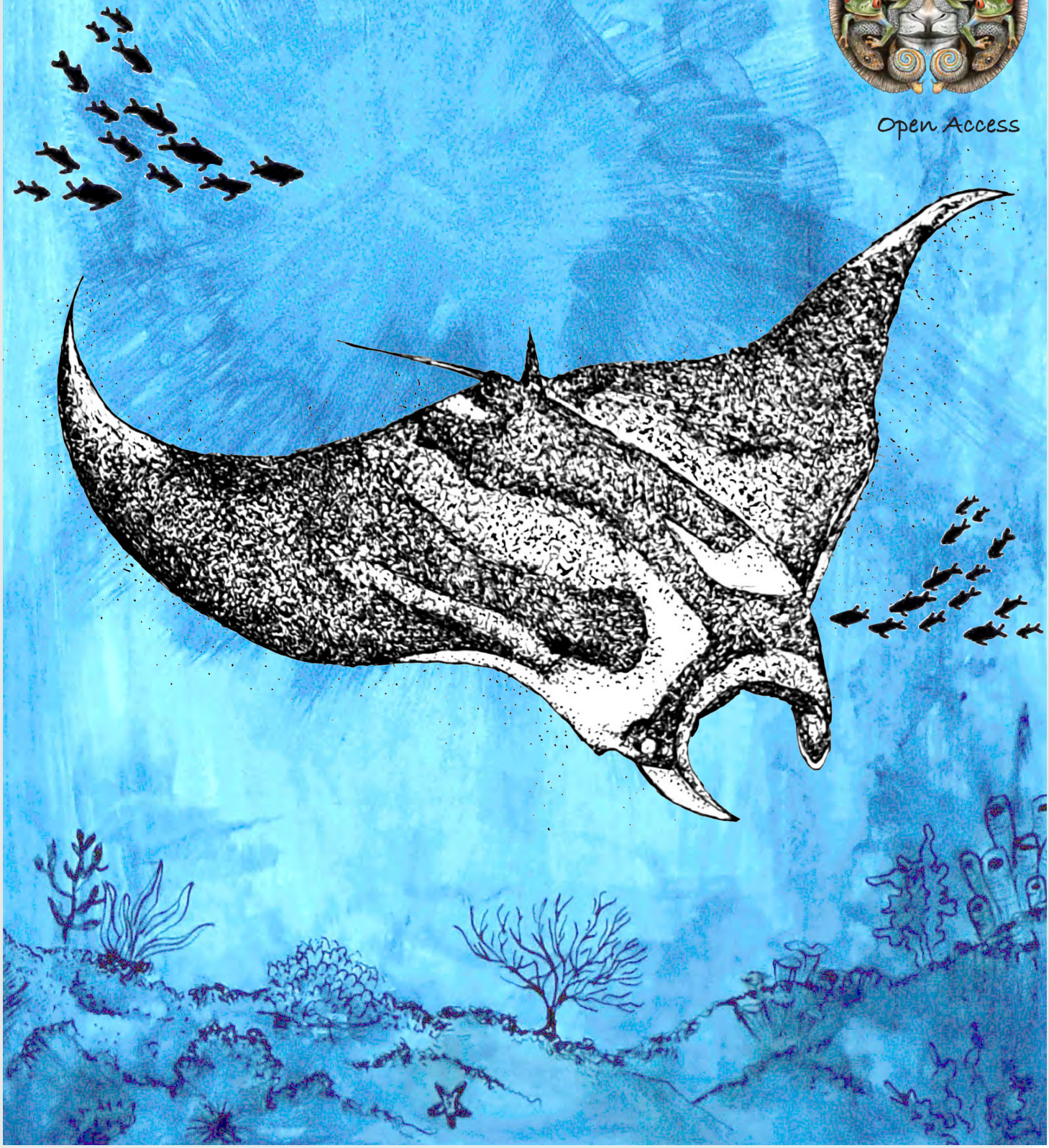

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Cover: Giant Oceanic Manta Ray *Mobula birostris* in ink on acrylic wash by Elakshi Mahika Molur adapted from scientific illustration by Roger Hall.

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NOTE

Polychorous Puncture Vine *Tribulus terrestris* L. (Zygophyllaceae), a potential forage source for a guild of insect pollinators during the wet season

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In the Zygophyllaceae family, *Tribulus* is a genus of 25 species distributed in the Old World. Several of these species are weedy occupants of dry disturbed habitats. Among weedy species, *T. cistoides* is native to tropical and sub-tropical Africa, and *T. terrestris* to the Mediterranean region. But, these two species are reported to be largely anthropochorous. The spiny mericarp trait is noted to be a perfect mechanism for easy dissemination of these weeds worldwide (Porter 1971). *T. cistoides* is protandrous (Robertson & Gooding 1963) and effectively pollinated by the honey bee, *Apis mellifera,* and solitary bees, *Agapostemon, Halictus* and *Lasioglossum* in Florida, USA (Austin 1972). *T. terrestris* is protogynous with the stigma attaining receptivity on the first day and pollen shedding on the second day (Goldsmith & Hafenrichter 1932). Both the species are out-crossing and pollinated mainly by *Xylocopa darwini* in Galapagos Islands (Porter 1971). Other works have reported that *T. terrestris* is cross-pollinated by insects with a backup self-pollination system in Bulgaria (Semerdjieva et al. 2011). These reports indicate that *T. terrestris* is insect-pollinated while keeping the option open for autonomous autogamy. Further, these studies indicate that few insect species have a role in the pollination of this weed. With this backdrop, the present study is contemplated to report on *T. terrestris* as a potential floral source for a guild of insect pollinators during the wet season in different habitats, especially in open habitats.

T. terrestris a ruderal plant species growing in the open habitat of the Andhra University campus (17°41’25.7064’’N and 83°13’51.7764’’E) during the wet season from June to October 2022 was used to observe its floral details and the importance of its flowers as a potential food source for visiting insect species. The study indicated that the plant grows well as a common villous herbaceous weed (Image 1a) and produces numerous individuals in open habitats and occurs intermingled with other simultaneously growing low-ground herbaceous taxa. Seed is the only mode of propagation. The plants appear as soon as the first monsoon showers or rainfall occurs. It produces a silky or appressed-hairy stem with even-pinnate compound leaves each with 6–12 elliptic leaflets. The plant produces flowers within three weeks’ time and continues the flowering phase until late October but flowering extends and remains so throughout the year in wet habitats. The flowers are pedicellate, solitary, yellow, dish-shaped, bisexual,

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Image 1. ***Tribulus terrestris*****: a—Habit | b—Flower | c—Pollen grain | d—Pistil with capitate stigma | e— Ovules | f—Thrips | g—** ***Apis dorsata*** **collecting nectar | h—** ***Apis dorsata*** **collecting pollen | i—** ***Apis cerana*** **collecting nectar | j—** ***Apis cerana*** **collecting pollen | k—** ***Apis florea*** **collecting pollen | l—** ***Trigona iridipennis*** **collecting pollen | m—** ***Ceratina simillima*** **collecting pollen | n—** ***Anthophora bicincta*** **collecting nectar | o—** ***Camponotus*** **sp. collecting nectar | p—** ***Nomia*** **sp. collecting nectar. © A.J. Solomon Raju.**

actinomorphic, and borne in the axils of leaves (Image 1b). The calyx has five caducous, narrowly lanceolate green sepals. The corolla has five bright yellow petals. The stamens are 10 consisting of five shorter and five longer free yellow stamens arranged in two whorls. The shorter stamens with anthers are placed well below the level of the stigma and arranged opposite the sepals; each of these is subtended by a small gland. The longer stamens with anthers are placed at the level of the stigma and arranged opposite the petals. The pollen grains are oblate-spheroidal, pantoporate, and radially symmetrical; the exine has reticulate ornamentation with straight to slightly expressed wavy barriers with a simple columnar structure (Image 1c) (Semerdjieva et al. 2011). The ovary has five carpels, each one with a single ovule (Image 1e). The style is short, connate into a stout column, 5-ridged, and ends with a 5-lobed papillate capitate stigma (Image 1d). The floral biology and pollination aspects were investigated as per the protocols provided in Dafni et al. (2005). *T. terrestris* flowers open after sunrise from 0600 to 0800 h. The stigma attains receptivity soon after anthesis while the anthers dehisce synchronously by longitudinal slits an hour after the commencement of stigma receptivity indicating the function of protogyny. This finding is not in agreement with the report by Goldsmith & Hafenrichter (1932) that the stigma attains receptivity on the first day and pollen shedding on the second day in *T. terrestris*. The short staminal glands secrete nectar continuously during the open state of the flower and it is accumulated in the hollow calyx. The flowers close back in the late afternoon during which the petals and the longer stamens curl inwards facilitating the contact between these stamens and the stigma which ends up in autonomous autogamy. The flowers do not open again. Such a floral self-pollinating mechanism is a fail-safe strategy for the plant to achieve pollination if the flowers are not pollinated when the flowers are in an open state (Goldsmith & Hafenrichter 1932; Reddi et al. 1981; Semerdjieva et al. 2011).

Tribulus terrestris is reported to be pollinated by a few insect species such as carpenter bees in Galapagos Islands (Porter 1971), honey bees, ants, and butterflies in India (Reddi et al. 1981). In this study, *T. terrestris* is found to be utilized as an important forage source consistently during the wet season in open habitats by hymenopterans and lepidopterans. The hymenopterans represented Apidae, Halictidae and Formicidae families.

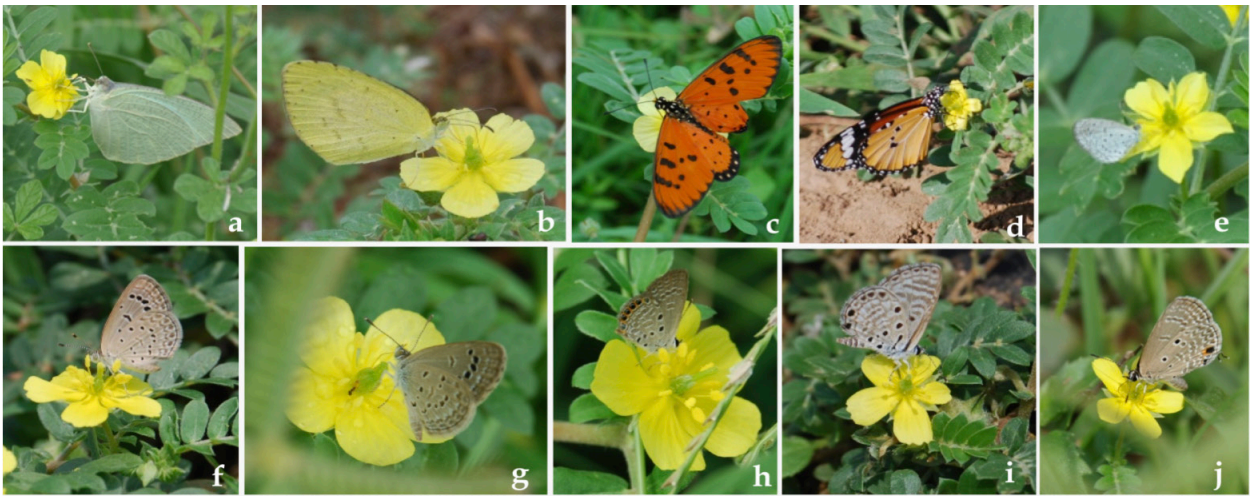

Image 2. ***Tribulus terrestris*****: a&b—Pierid butterflies: a—*****Catopsilia pyranthe*** **| b—*****Eurema hecabe*** **| c&d—Nymphalid butterflies: c—*****Acrae violae*** **| d—*****Danaus chrysippus*** **| e–j—Lycaenid butterflies: e—*****Zizula hylax*** **| f—*****Zizeeria karsandra*** **| g—*****Zizina otis*** **| h—*****Freyeria trochylus*** **| i—*****Azanus jesous*** **| j—*****Chilades pandava*****. © A.J. Solomon Raju.**

The Apidae members were *Apis dorsata* (Fabricius 1793) (Image 1g,h), *A. cerana* (Fabricius 1793) (Image 1i,j), *A. florea* (Fabricius 1787) (Image 1k), *Trigona iridipennis* (Smith 1854) (Image 1l), *Ceratina simillima* (Smith 1854) (Image 1m), *Anthophora bicincta* (Fabricius 1793) (Image 1n). The Halictidae is represented by a single species, *Nomia* sp. (Latreille 1804) (Image 1p). The Formicidae is also represented by a single species, *Camponotus* sp. (Mayr 1861) (Image 1o). All hymenopterans were regular and consistent foragers throughout the day. The lepidopterans observed represented pierid, nymphalid and lycaenid families. Pierids were *Catopsilia pyranthe* (Linnaeus 1758) (Image 2a) and *Eurema hecabe* (Linnaeus 1758) (Image 2b). Nymphalids were *Acraea violae* (Fabricius 1775) (Image 2c) and *Danaus chrysippus* (Linnaeus 1758) (Image 2d). Lycaenids were *Zizula hylax* (Fabricius 1775) (Image 2e), *Zizeeria karsandra* (Moore 1865) (Image 2f), *Zizina otis* (Fabricius 1787) (Image 2g), *Freyeria trochylus* (Freyer 1845) (Image 2h), *Azanus jesous* (Guerin 1847) (Image 2i), and *Chilades pandava* (Horsefield 1829) (Image 2j). Of these, lycaenids foraged on the flowers the most. All hymenopterans except *Camponotus* sp. foraged for both pollen and nectar. *Camponotus* sp. and lepidopterans collected exclusively nectar from the flowers. All these insect species probed the flowers legitimately for forage collection and effected both self- and cross-pollination by contacting the stamens and stigma because the flowers are of the open type with exposed sex organs. Apart from these insects, thrips (unidentified) also used the flowers of *T. terrestris* for breeding during the bud stage and feeding on pollen and nectar during the flower stage with the latter activity resulting in self-pollination (Image 1f). The study indicates that *T. terrestris* does not necessarily require pollinators even for self-pollination but seed production from this pollination mode is detrimental or even fatal in the long run. In this context, the insects using the flowers of *T. terrestris* as their important forage source play an important role in self-pollination between flowers of the same plant and cross-pollination between closely or distantly spaced individuals. The function of autonomous selfing, and selfing and cross-pollination functional through pollinating insects in *T. terrestris* enable it to grow as a successful plant and provide sufficient forage for the foragers visiting its flowers when in flowering. Therefore, *T. terrestris* serves as a potential forage source for a guild of pollinating insects during the wet season.

Fruit maturation takes place within two weeks. The fruit is a schizocarp, woody burr, flattened, hairy, grey to yellow-tan, and separated into five wedge-shaped indehiscent nutlets or cocci or burs each with two stout dorsal spreading spines and several prickles. Seeds vary 2–5 per coccus and remain enclosed inside; they are flattened, triangular-ovate with a sharp lengthened tip and a flat base (Semerdjieva et al. 2011). The bur spines resembling the horns of bulls or goats are sharp enough to puncture bicycle tires and other air-filled tires. For this reason, *T. terrestris* is called Puncture Vine (Adlakha 1961; Julien 1992). The weedy nature of this plant is attributed to its hard spiny fruits which are attached to and disseminated by farm machinery, grazing animals, vehicles, and human clothes and shoes. These modes of seed dispersal indicate that *T. terrestris* is polychorous

and this trait is quite advantageous for the plant to disperse its seeds effectively to different habitats and grow as a successful weed. Being a C4 plant, *T. terrestris* can efficiently use water and conserve soil moisture which enables it to grow for longer periods in arid or semi-arid habitats or conditions common to tropical and subtropical latitudes.

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