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RESEARCH ARTICLE

ON THE MORPHOLOGY AND TAXONOMY OF TWO MULTIPURPOSE CONGENERIC TAXA- *CALOTROPIS GIGANTEA* AND *C. PROCERA* (APOCYNACEAE)

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ABSTRACT

Two multipurpose congeneric taxa *Calotropis gigantea* and *C. procera* have been described in detail from morpho-taxonomic view point along with seedling morphology. The reported taxa can be distinguished by comparing corolla, corona, pollinial sac and fruit shape. At seedling stage they can be differentiated and identified on the basis of colour, collet, and shape of the first and second leaf blades.

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INTRODUCTION

In Ayurveda, *Calotropis gigantea* (L.) R. Br. and *C. procera* (Ait. f.) Dry. are known as “Sweta Arka” and “Raktha Arka” respectively. In number of classical texts of Ayurveda like Astang Hridayas, Bhavprakash Nigantu, Dhanvantri Nigantu, Raj Nigantu, Shaligram Nigantu and Sushruta Samhita both the taxa are attributed medicinal. They are reported to have *katu vipaka, laghu guna, tikta rasa* and *ushna virya*. The roots are utilized in preparation of *Abhaya lavana, Arka lavana, Bhrihat Kasturibhairva rasa, Chitrkali taila, Dhanvantri Ghrita, Ekangveera rasa, Mahanarayana taila, Prabhanjana Vimardana taila, Saindhavadi taila, Vajraka kshara* and *Vatavidhavamsana rasa*. In recent years the medicinal applications of both the taxa have been mentioned by many workers as abortifacient, analgesic, anthelmintic, anti-angiogenic, anti-cancer, anti-coagulant, anti-convulsant, anti-diabetic, anti-diarrheal, anti-dysentric, anti-dyspepsia, anti-fertility, anti-fungal, anti-inflammatory, anti-microbial, anti-odontalgic, anti-oxidant, anti-purgative, anti-pyretic, anti-rheumatic, anti-sialagogue, anti-syphilitic, anti-tumor, anti-viral, appetizer, carminative, diaphoretic, emetic, expectorant, fibrinolytic, gastroprotective, hepatic protective, hypolipidemic, larvicidal, mosquitoicidal, molluscicidal, nematicidal, proteolytic, purgative, renal protective and

spasmogenic, and also used in the treatment of many diseases, mostly by local people, like anaemia, anasarca, ascites, baldness, body pain, burn injuries, constipation, deafness, elephantiasis, flatulence, headache, indigestion, iridocyclites, jaundice, leprosy, leucoderma, migraine, mumps, nausea, paralysis, piles, otitis, sinus fistula, snake bite, tooth aches, vomiting, wound healing, and rheumatoid/joint pains (T.S. Blair, 1907; A.K. Nadkarni *et al*, 1960; K.C. Chunekar, 1972; Anonymous, 1978; D.M.A. Jayaweera, 1980-1982; J.F. Caius, 1986; A. Basu *et al*, 1991; J.S. Mossa *et al*, 1991; J.A. Duke, 1992; M.K. Misra *et al*, 1993; A. Ghahraman, 1994; K.R. Kirtikar *et al*, 1994; B.B. Das, 1996; Himalaya, 2002; R. Vohra, 2004; M. Ahamed *et al*, 2005; Z. Iqbal *et al*, 2005; R. Rajesh *et al*, 2005; A.K. Pathak *et al*, 2007; C.R. Tenpe *et al*, 2007; G. Kumar *et al*, 2011; M.M. Mainasara *et al*, 2011; D. Moronkola *et al*, 2011; A.K. Sharma *et al*, 2011; F. Sheth, 2011; K.S. Shanty Sree *et al*, 2011; S. Gajalakshmi *et al*, 2012; A.K. Khairnar *et al*, 2012; A.K. Singh, 2012; G. Uddin, *et al*, 2012; J. Baby *et al*, 2013; N. Begum *et al*, 2013; P. Suresh Kumar *et al*, 2013; S. Quazi *et al*, 2013; C. Aarti, 2014; A.M. Farooq *et al*, 2014; H. Oloumi, 2014; A.E. Al-Snafi, 2015; M. Rahimi, 2015; M. Singh *et al*, 2015; P. Chandrawat *et al*, 2016 and N. Sharma *et al*, 2016). *Calotropis* is also a reputed Homoeopathic drug (N.C. Ghosh, 1988; E.A. Ferrington, 1990). *C. procera* has been identified as a potential petrocrop. The plant yields valuable hydrocarbons which could be converted into diesel substitutes. The derived bio-diesel is free from NOx gases, SO₂ and Suspended Particulate Matter and

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has high cetane value. This taxa has been suggested as potential plant for bio-diesel production under semi-arid and arid conditions (M.D. Erdman *et al*, 1981; B.K. Behra *et al*, 2000; A. Kumar *et al*, 2002; K. Shilpkar *et al*, 2007; S. Quazi *et al*, 2013). Fermented mixture of *Calotropis* and salt is used to remove the hair from goat and sheep skins to make leather, which is much used for inexpensive book-binding (J.A. Duke, 1992). Seed floss used for stuffing pillows in different parts of India and other Asian countries.

Shoushtari Diba (a garment) has been woven in the Achaemenid period from *Calotropis*. In the past, the fabric, especially Curtain of the Kaaba was made using fibers of *C. procera* seeds (A. Ghahraman, 1994). Fibres from stem bark is used for making fishing nets and twines by the local people in India. In addition to this the reported taxa are also highlighted as resource in paper manufacture and vet-medicines. Eugenol and Guaiacol, (major constituents of *Calotropis* essential oil), are recently reported as a substitute of fossil based chemicals for making biobased materials and green chemicals. The wood is used as cheap fuel. Latex obtained from plant is used to a limited extent in the tanning industry. The leaves and twigs are used as a green manure in paddy fields. The woody roots yield good charcoal and coal powder which are used in making fireworks (D. Airey *et al*, 1981). Milky juice is used for curdling milk, cheese preparation and in fermentation of maize beer in Africa. The dried root bark is a substitute for ipecacuanha. In addition to medicinal and other economic importance, both the reported taxa have the sacred and social values. The ancient name of the taxa, which occurs in Vedic literature, was *Arka* (wedge), alluding to the form of leaves, which were used in sacrificial rites. The flowers are used in the worship of Lord Shiva, and Lord Hanuman by Hindus. In Bengal (India), the sections of the corona of flowers are carefully picked from the corolla and strung into garlands, which are worn at certain religious ceremonies. In *Chaturmasa Mahatama*, in the narration of *Gallava Rishi*, taken from *Skand Puran*, the reported taxa are mentioned to be transformation of *Surya* (Sun). The leaves are used as *patri* (plate) in the worship of *Ganapati*, *Haritalika*, *Pitchri* etc. The twigs are mentioned as substitute for tooth-brushes in the *Smiritisar Granth*. The twigs are also employed as *Samidhas* for the feeding of sacred fires (Hawan) (B.P. Pandey, 2000).

Painted Grasshopper [*Poeciloceris pictus* (F.) (Orthoptera: Pyrgomorphidae)] and plain tiger butterfly [*Danaus chrysippus* (L.) (Lepidoptera: Nymphalidae)] are mainly dependent on *Calotropis* for their development and their population might be severely affected in the region where reported taxa does not exist. (M.G. Venkatesha, 2006). The *Calotropis* has the hazardous effects also. The milky exudates from the plant is a corrosive. It is said to have mercury like effects on the human body and is some times referred to as vegetable mercury. Calotropin a compound in the latex is more toxic than strychnine. The plant latex can lead to blindness if it comes in eye contact. All the part of the plant contains a cardio active steroid and calcium oxalate crystals, and cardio steroid resembling digitalis (V. Singh, 2012). From the medico-legal point of view, the latex and plant juice is used for procuring criminal abortion, for the purpose of suicide, infanticide, and homicide, and as a cattle and arrow poison. The generic name *Calotropis* is taken from kalos (~beautiful) and tropis (~a keel), alluding to the good look of the keel of flower. The

genus *Calotropis* R. Br. (Order Gentianales, subfamily Asclepiadoideae, tribe Asclepiadeae, sub-tribe Asclepiadinae) comprises three species of herbs and shrubs found in tropical and subtropical Africa, Asia and India-*C. acia.*, *C. procera*, and *C. gigantea*. The genus *Calotropis* was first described by Robert Brown (1810) in a preprint of Brown (1811). Brown did not list any species in these accounts (M.A. Rahman *et al*, 1990; P.I. Forster, 1998). Both *Asclepias gigantea* L. and *A. procera* Ait. included within *Calotropis*, and the latter is considered to be the type of the genus (W.T. Aiton, 1811). The genus consists of about four species; however, apart from *C. procera* and *C. gigantea* which are widely cultivated or naturalised in the tropics, the other species are poorly known (S.I. Ali, 1980). Present study comprises the morpho-taxonomic details of the mature plants as well as seedlings of *C. gigantea* and *C. procera* alongwith their taxonomic keys for their easy differentiation and identification.

MATERIALS AND METHODS

The voucher specimens of reported taxa viz. *C. gigantea* and *C. procera* have been collected from different parts of Varanasi district (25° 10'-25° 37' N & , 82° 11'-83° 01' E, 80.19 m a.s.l.), Uttar Pradesh, India. The identification and world distribution of the collected specimens were ensured after going through related publications (J.D. Hooker, 1872-1897; J.F. Duthie, 1903-1929; B.K. Mishra *et al*, 1992). Morpho-taxonomic details have been described after examining ten fresh collections from ten different localities and photographed with the help of digital Camera-Sony, α -200. Interesting microscopic structures have been observed and photographed using Stereo Microscope [Olympus microscope-SZ2-ILST]. Seedlings of two *Calotropis* species, viz. *C. gigantea* and *C. procera* were collected from different parts of Varanasi district, Uttar Pradesh, India during the months of July to September 2015. Seeds of these two species were also collected in June and July 2015, and grown in the greenhouse of the Experimental Botanic Garden of Department of Botany, Udai Pratap College (Autonomous), Varanasi, India to ensure correct identification of seedling species. The different stages of development of each species were considered for preparing a complete description out of ten individuals. All the specimens at different leaf stages were documented in the form of herbarium sheets. The gross morphological features of seedlings were described following the terminology proposed by (E.F.de Vogel, 1980). For the description of seedlings (J. Ahammed *et al*, 1996 and A.K. Singh, 2012) were followed. Key to the reported taxa and their seedlings have been prepared for differentiation and identification. Voucher specimens of plants and seedlings have been preserved in our herbarium (Voucher numbers 12691, 12737, 12781 and 12783) for future reference.

RESULTS

Key to species: 1a. Corolla lobes reflexed, uniformly coloured, purple to white, obovate and 3.5 cm long. Corona 1.0 to 2.0 cm long, shorter than the staminal column with pubescent back, and entire apex. Pollinial sac 0.17 cm long. Gynoecium 0.8 cm long. Fruit oblong
.....*C. gigantea* 1b. Corolla lobes inflexed, white with pink or purple spots on the lobes, ovate and 1.3 cm long. Corona 0.5 to 1.0 cm long, equal to or longer than the staminal column with glabrous back and bifid apex. Pollinial

sac 0.14 cm long. Gynoecium 0.52 cm long. Fruit ovoid.....
.....*C. procera*

Key to the Seedlings

1a. Seedling ash-green. Collet swollen. Paracotyledons adaxially ash-green. First leaf blade obovate with obtuse apex. Second and subsequent leaf blades oblanceolate.....*C. gigantea*

1b. Seedling green. Collet not swollen. Paracotyledons adaxially green. First leaf blade elliptic with acute apex. Second and subsequent leaf blades obovate.....*C. procera*

Morpho-taxonomic study

Calotropis R. Br., On Asclepiad. 28 (1810); Mem. Wern. Nat. Hist. Soc. 1: 39 (1811); Wight, Contrib. Bot. India 53 (1834); J.D. Hook., Fl. Brit. India 4: 17 (1883); Gamble, Fl. Madras 2: 834 (1923); Huber in Abeyw., Rev. Handb. Fl. Ceylon 1(1): 35 (1973).

Type: Asclepias procera Ait. (= *Calotropis procera* (Ait.) R. Br.)

Perennial herbs/shrubs to small trees with white latex. Young leaves and stems with dense white indumentum. Leaves opposite and decussate, slightly fleshy. Calyx and Corolla 5-lobed, inflexed/reflexed. Staminal corona single, fleshy, laterally compressed, adnate to staminal column; basally with a recurved vesicle; apically with a pair of auricles. Stamens connate into staminal column. Pollinaria with 2 pollinia; pollinia pendulous, ellipsoid; corpusculum ovate. Style head conical. Carpels glabrous. Follicles oblong-ovoid. Seeds flattened, ovate; comose at micropylar end.

Calotropis gigantea (L.) R. Br. in Ait. f., Hort. Kew. 2: 78. 1811; Hook. f. in Fl. Brit. India 4: 17. 1883; FUGP. 2: 48. 1903-1929; Sant. & Irani, Univ. Bombay Bot. Mem. 4: 74. 1962; Huber in Dassan. & Fosb., Rev. Handb. Fl. Ceylon 4: 1983.-*Asclepias gigantea* L., Sp. Pl. 214. 1753. (Fig. 1; Fig. 3A₁).

Common name: Bowstring-hemp, crown plant, Giant milkweed, Lechoso, Mercury vegetal, Madar, Mudar, Mudarpflanza.

Shrub with milky latex, 2-3 m tall. Bark cream-gray, shallow fissured, rough and loose. Blaze light green, 0.2-0.3 cm thick, flake size 0.2 × 0.1 cm, surface configuration irregular. Stem light green, tomentose; hairs multicellular, base broad, apex acute, transparent, 0.1-0.2 cm long (Fig. 1A₁₁); terete and solid. Internodes 3.0-4.0 cm long. Leaves simple, opposite and decussate, exstipulate and petiolate (Fig. 1A₁). Petiole light green, hairy; hairs as on stem; base pulvinate, terete and channel, 0.5-0.8 cm long. Leaf blade elliptical-obovate, 12.0-18.0 × 4.0-6.0 cm, mean length : width ratio (l/w) 3.0, base cordate-auriculate, apex acute/rounded, margins entire, hairy, hairs as on stem; adaxial surface green and glaucous with 20-25 extrafloral nectaries at base, abaxial surface light green, hairy and glaucous. Venation brochidodromous, unicostate, reticulate; single primary vein distinct, reaching to blade apex,

with 5/6 secondary veins on each side; alternate, secondary vein divergence moderately acute, upper secondary veins obtuse, lower most slightly acute, curved at margins; tertiary veins obtuse angled from secondary veins, randomly reticulated, higher order venation not clear. Inflorescence cymose upto 10 cm long, terminal, some times axillary; peduncles up to 2.4-2.8 cm long, waxy, glaucous or with scattered indumentum. Flowers campanulate, 2.0-2.2 cm long, pentamerous, actinomorphic, bracteate; bracts light green, lanceolate, 0.5 × 0.1 cm long, mean l/w 5; hermaphrodite, hypogynous, pedicellate (Fig. 1A₄). Pedicels green-white, hairy; hairs as on stem; terete, 2.0-2.5 cm long. Calyx polysepalous, deciduous (Fig. 1A₃). Sepals 5, obovate, 0.6-0.8 × 0.2-0.3 cm, mean l/w 2.7, base truncate, apex acute, margins entire, green-white and hairy; hairs as on stem; quincuncial/imbricate. Venation not distinct. Corolla gamopetalous. Petals 5, reflexed, obovate, 1.8-2.6 × 0.6-0.7 cm, mean l/w 3.5, base truncate, apex acute, margins entire and hairy; hairs as on stem; green-white when young, white/purple at maturity, glaucous, twisted, venation fissured (Fig. 1A₅). Corona 5, 1.0-2.0 cm long; shorter than the staminal column with pubescent back, apex entire, white (Fig. 1A₆). Androecium pentandrous, inserted, stamens 5, fused with stigma and form gynostegium; pentangular, peltate disc; each stamen represents two pollinia, 0.25 cm. long. Pollinial sac oblong, 0.17 cm long (Fig. 1A₈).

Gynoecium apocarpous, 0.8 cm long; ovary superior, green, 0.3-0.4 cm long, placentation marginal; styles terete; light green, terminal, 0.5-0.6 cm long; stigma pentangular; light green and glaucous. (Fig. 1A₇). Follicles oblong, fleshy and inflated, 7-10 cm long, 5-6 cm in diameter, light green-white (Fig. 1A₉). Seeds ovate, 0.8 cm long, bearing silky coma; coma 0.25 cm long, white (Fig. 1A₁₂). Seedling *Macaranga* type (as per Vogel, 1980), epigeal, phanerocotylar (Fig. 1A₁₃; Fig. 1A₁₄). Primary root non-fibrous, tap root, white, glabrous and terete, 9.0 cm long at 5th leaf stage. Collet distinct, white, glabrous, slightly swollen. Hypocotyl grey, looped when young, tomentose, 0.2 cm long; terete, 1.6 cm long at 5th leaf stage. Paracotyledons two, opposite, simple, leafy, isocotylar, exstipulate, petiolate. Paracotyledon petioles grey, tomentose, terete and channelled, 0.5 cm long. Paracotyledon blade oblong, 1.5 x 1.0 cm, mean l/w 1.5, base attenuate, apex obtuse, margins entire, adaxial surface grey, abaxial surface light grey; both sides tomentose. Venation eucamptodromous; unicostate reticulate, green, 7 veins distinct, 3 secondary veins on each side of primary vein, 2 lower most pairs of secondary veins opposite, others alternate. Epicotyl grey, tomentose, terete, 6.5 cm long at 5th leaf stage. Internodes (at 5th leaf stage): 1st 2.5 cm, 2nd 1.0 cm, 3rd 1.2 cm, 4th 1.5 cm, and 5th 1.0 cm long.

First leaves simple, opposite, exstipulate, petiolate. Petiole light green, tomentose, terete and channelled, 0.3 cm long. Leaf blade ovate, 1.7 x 0.8 cm, mean l/w 2.1, base attenuate, apex obtuse, margins entire, adaxial surface grey, abaxial surface light grey, both sides tomentose. Venation eucamptodromous; unicostate reticulate, green, 9 veins distinct, 4 secondary veins on each side of primary vein, lower most and upper most pairs opposite, other veins alternate. Subsequent leaves same as that of first leaves but leaf blades oblanceolate with acute apex. Seed coat persists in early stage of germination.

Flowering period: Throughout the year, commonly during the summer season.

Fruiting period: Two to three months after flowering.

GPS 25° 19.691' N; 082° 59.828' E, Elevation 71 m.

Common name: Aak, Algodao-de-seda, Akada, Akund, Apple-of-sodom, Arbre a sere, Auricula tree, Calotropis, Madar, Rubber bush, Small crown flower, Sodom apple, Sodom's milkweed, Swallow wort. A shrub with milky fluid, 1-2m tall. Bark cream-gray, shallow fissured, rough and loose.

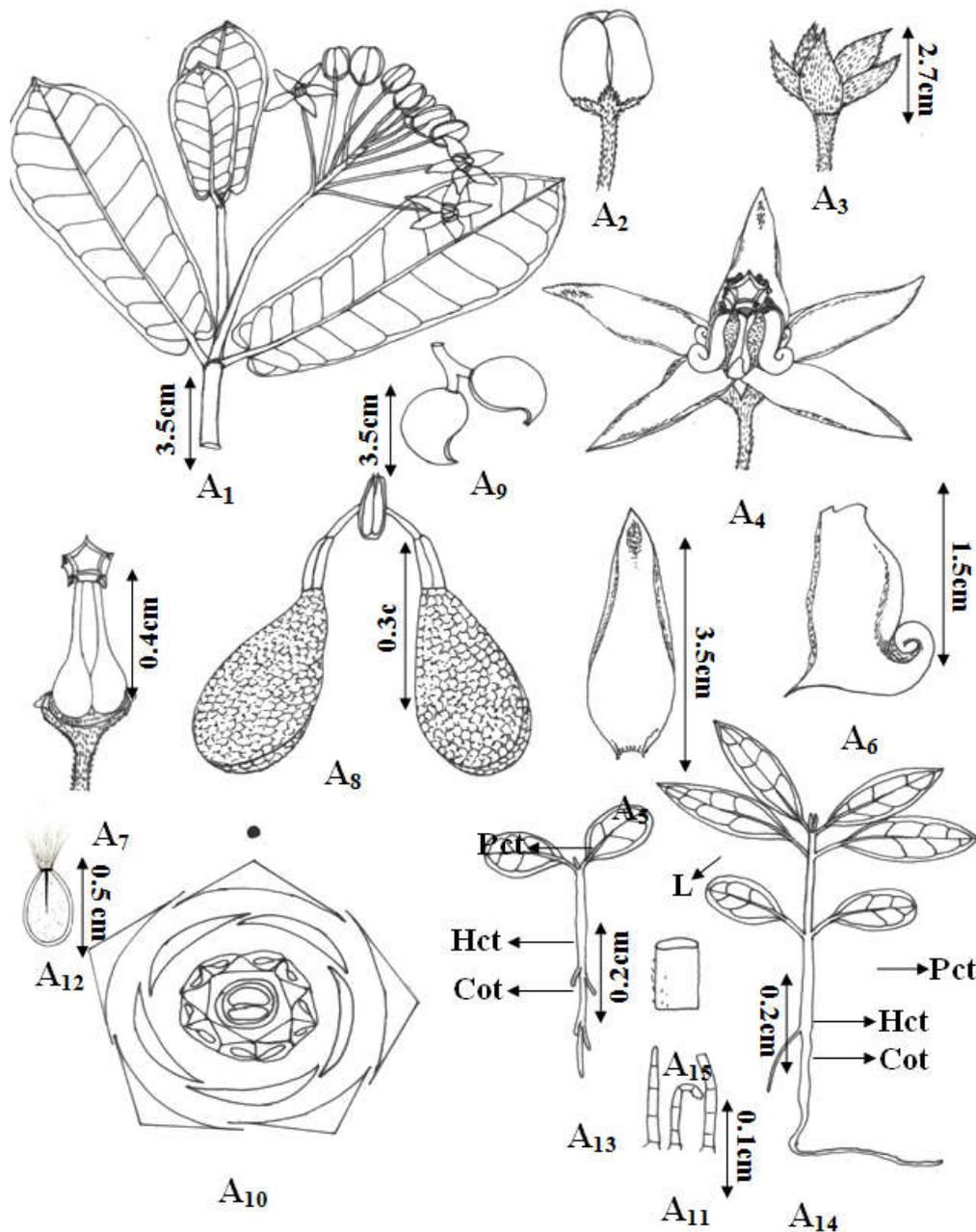


Fig. 1. *Calotropis gigantea*; A₁. A twig; A₂. Flower bud; A₃. Calyx; A₄. A single flower; A₅. A petal; A₆. A single corona; A₇. Gynoecium with gynostegium; A₈. Pollinium; A₉. Fruits; A₁₀. Floral Diagram; A₁₁. Hairs; A₁₂. Seed; A₁₃. Seedling at paracotyledon stage; A₁₄. Seedling at second leaf stage; A₁₅. Part of hypocotyl (L-Leaf; Pct. Paracotyledon; Hct. Hypocotyl; Cot. Collet)

Distribution: Cambodia, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, India and China. It is growing widely throughout the tropical and subtropical regions of Asia and Africa. Mostly found under cultivated conditions near temples in India.

C. procera (Ait. f.) Dry. in Ait. f., Hort. Kew. ed. 2, 2: 78. 1811; Hook. F. in Fl. Brit. India 4: 18. 1883; FUGP. 2: 48. 1903-1929; Sant & Irani, Univ. Bombay Bot. Mem. 4: 19. 1962.-*Asclepias prosera* Ait., Hortus Kew. Ed. 1. 1: 305. 1789. (Fig. 2; Fig. 3B₁).

Blaze light green, 0.1-0.2 cm thick, flake size 0.2 × 0.1 cm, surface configuration irregular. Stem light green, tomentose; hairs multicellular, base broad, apex acute, transparent, 0.1-0.2 cm long (Fig. 2A₁₁); terete and solid. Internodes 3.0-4.0 cm long. Leaf simple, opposite and decussate, exstipulate and petiolate (Fig. 2A₁). Petioles light green, hairy; hairs as on stem; base pulvinate, terete and channel, 0.5-0.8 cm long. Blade elliptical, 7.0-11.0 × 3.0-5.0 cm., mean l/w 2.2, base cordate-auriculate, apex acute to rounded, margins entire and hairy; hairs as on stems; adaxial surface green, glaucous with 25-30 extrafloral nectaries at base, abaxial surface light green,

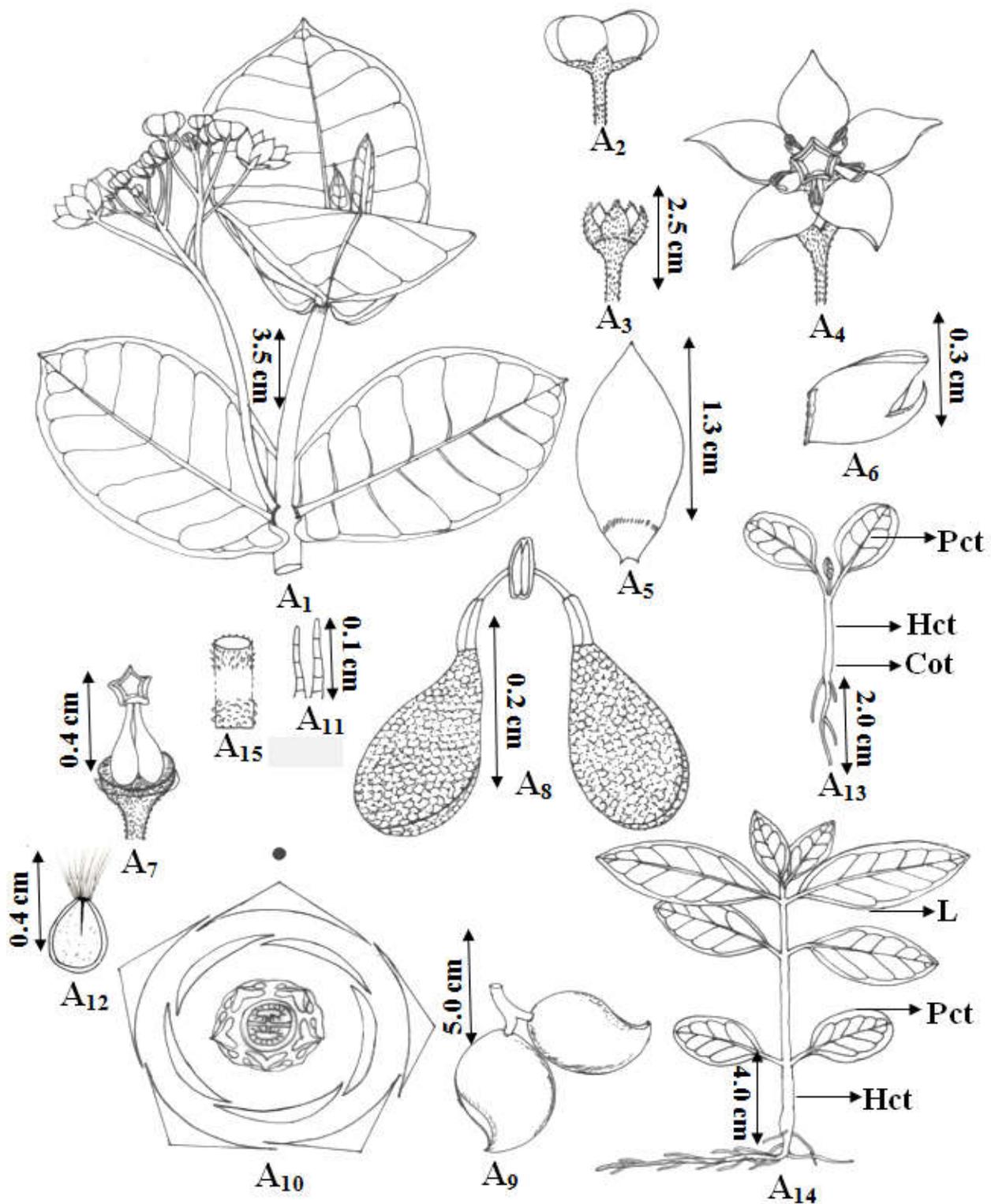


Fig. 2. *Calotropis procera*; A₁. A twig; A₂. Flower bud; A₃. Calyx; A₄. A single flower; A₅. A petal; A₆. A corona; A₇. Gynoecium with gynostegium; A₈. Fruits; A₉. Floral Diagram; A₁₀. Part of hypocotyl; A₁₁. Hairs; A₁₂. Seed; A₁₃. Seedling at paracotyledon stage; A₁₄. Seedling at third leaf stage; A₁₅. Part of hypocotyl (L-Leaf; Pct-Paracotyledon; Hct-Hypocotyl; Cot-Collet)

hairy and glaucous. Venation brochidodromous; unicostate, reticulate, single primary vein distinct, reaching to blade apex, secondary veins 5-6 on each side of primary vein; alternate, secondary veins divergence moderately acute, upper secondary veins obtuse, lower most slightly acute, curved at margins, tertiary veins obtuse angled from secondary veins, randomly reticulate, higher order venation not clear. Inflorescence cymose, up to 10 cm long, terminal, sometimes axillary.

Peduncles 3.5 cm long, glabrous or with sparse indumentum. Flowers campanulate (Fig. 2A₄), 13-20 cm long with sweet smell, pentamerous, actinomorphic, bracteate; bracts light green, lanceolate, 0.5 × 0.1 cm, mean l/w 5, glabrous or with sparse indumentum, apex acuminate; hermaphrodite, hypogynous, pedicellate; pedicels green-white, hairy; hairs as on stem; terete, 1.6-1.8 long. Calyx polysepalous, deciduous, quincuncial (Fig. 2A₃). Sepals 5; obovate, 0.5-0.6 × 0.2-0.3 cm., mean l/w 2.5, base truncate, apex acute, margins entire,

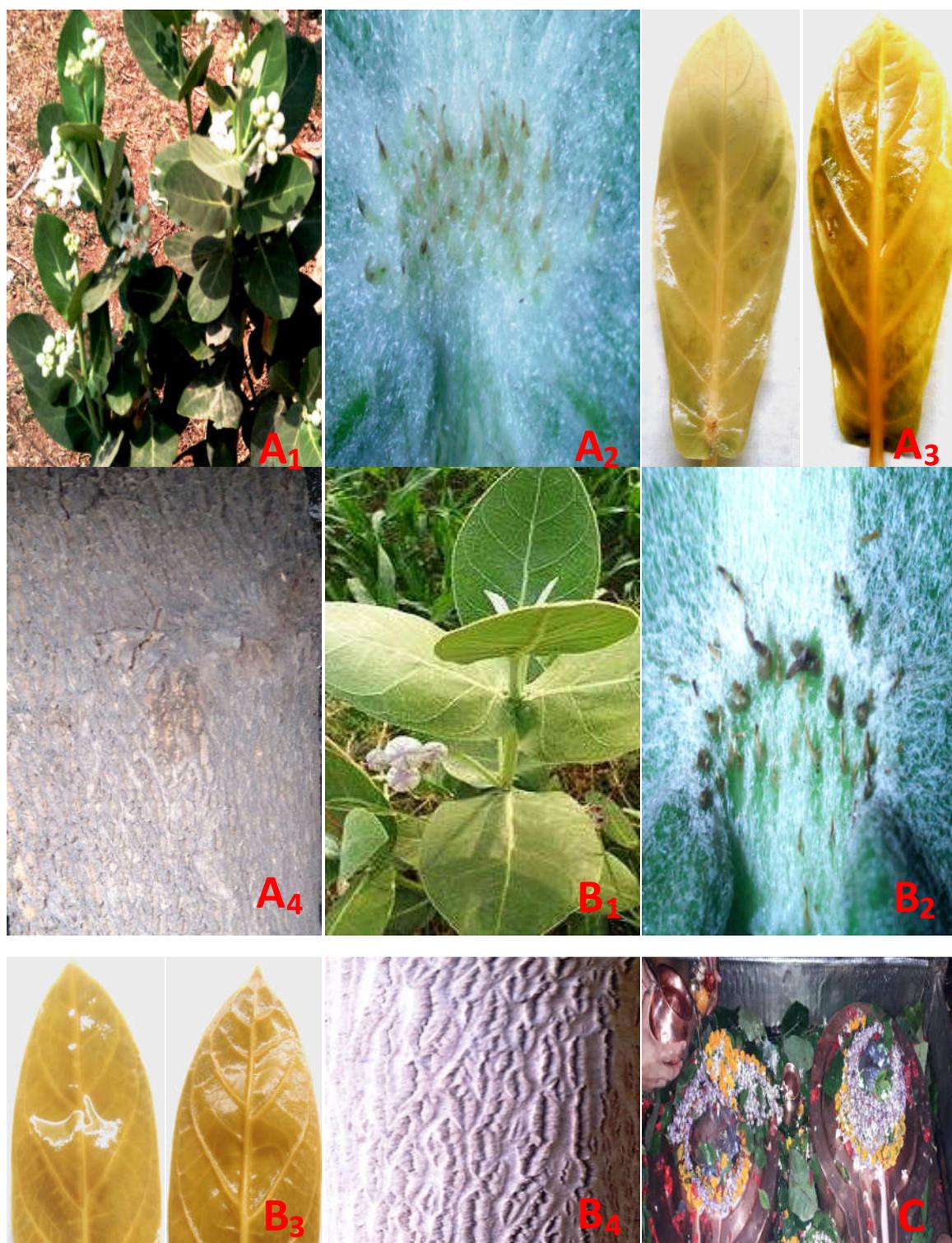


Fig. 3. A. *Calotropis gigantea*; A₁. Mother plant; A₂. Leaf nectaries; A₃. Adaxial and abaxial view of leaf blade showing venation; A₄. Bark surface; B. *C. procera*; B₁. Mother plant; B₂. Leaf nectaries; B₃. Adaxial and abaxial view of leaf blade showing venation; B₄. Bark surface; C. *Calotropis* flowers offered in Lord Shiva temple

green-white and hairy; hairs as on stem. Venation not distinct. Corolla gamopetalous, twisted. Corona 5, purple, 0.4–0.5 cm long, equal to or longer than the staminal column with glabrous back, apex bifid (Fig. 2A₆). Petals 5, inflexed, cream with purple tips, oval, 1.5–1.4 × 0.7–0.6 cm, mean l/w 3.0, base truncate, apex acute, margins entire and hairy; hairs as on stem; glaucous (Fig. 2A₅). Venation fissured. Androecium pentandrous, inserted, stamens 5, fused with stigma and form gynostegium; pentangular peltate disc; each stamen represents two pollinia, 0.2cm long.

Pollinial sac oblong, 0.14 cm long (Fig. 2A₈). Gynoecium apocarpous, 0.52 cm long, bicarpellary; ovary superior, green, 0.1–0.2cm long, placentation axile; style terete; light green, terminal 0.2–0.3cm. long; stigma pentangular; light green and glaucous (Fig. 2A₇). Follicles ovoid, fleshy and inflattened, 10–12 cm long, 8–10 cm in diameter, green-grey-white (Fig. 2A₉). Seeds ovate, brown, 0.85 cm long, bearing silky coma; 0.27 cm long, white (Fig. 2A₁₂). Seedling *Macaranga* type, epigeal, phanerocotylar (Fig. 2A₁₃; Fig. A₁₄).

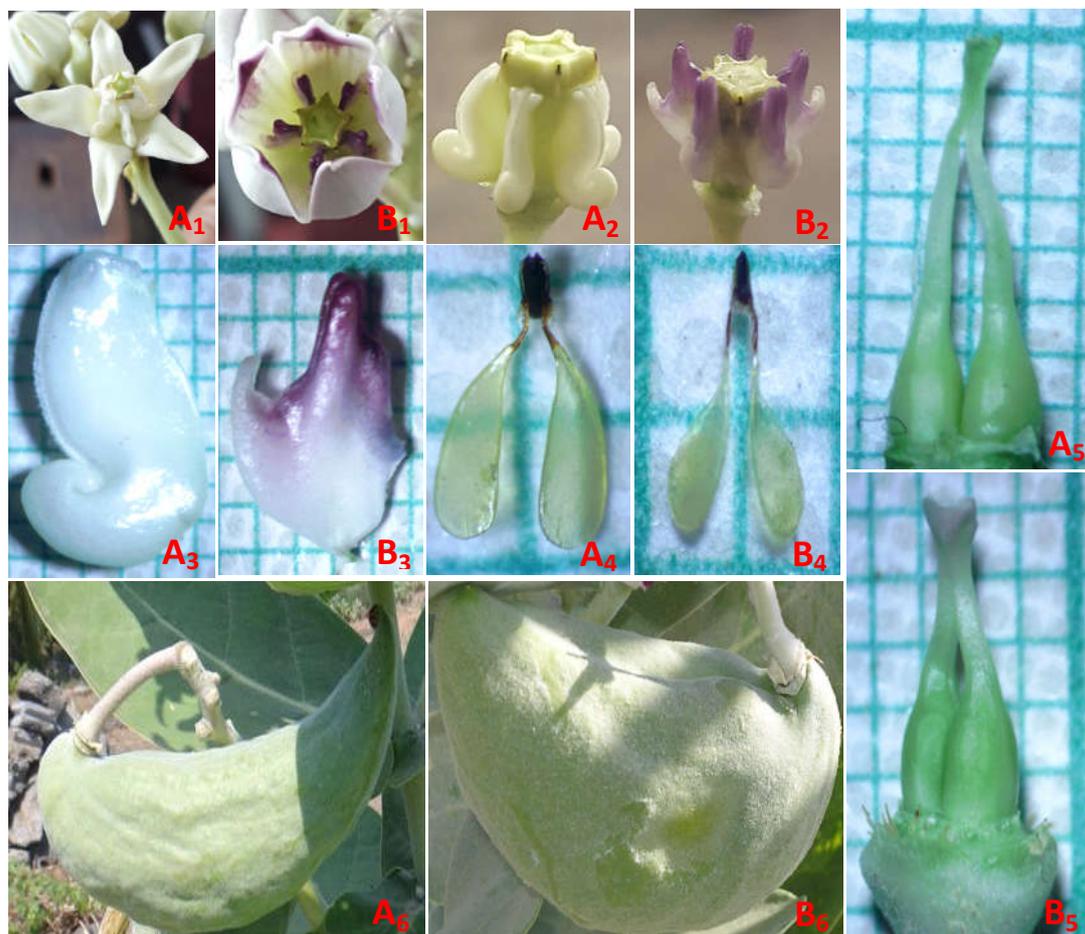


Fig. 4. A. *Calotropis gigantea*; A₁. A single flower-top view; A₂. Corona and staminal column; A₃. Single corona; A₄. Pollinium; A₅. Gynoecium; A₆. Fruit; B. *C. procera*; B₁. A single flower-top view; B₂. Corona and staminal column; B₃. Single corona; B₄. Pollinium; B₅. Gynoecium; B₆. Fruit

Primary root non-fibrous, tap root, branched, white, glabrous, terete, 6.2 cm long at 5th leaf stage. Collet distinct, white, glabrous, slightly swollen. Hypocotyl green, tomentose, terete, 3.4 cm long at 5th leaf stage. Paracotyledons two, opposite, simple, leafy, isocotylar, exstipulate, petiolate. Petioles green, tomentose, terete and channelled, 0.6 cm long. Paracotyledon blade oblong, 1.3 x 1.3 cm, mean l/w 1.0, base attenuate, apex obtuse, margins entire, adaxial surface dark green, abaxial surface light green, both sides tomentose. Venation eucamptodromous; unicastate reticulate, green, 7 veins distinct, 3 secondary veins on each side of primary vein, alternate. Epicotyl green, tomentose, terete, 6.1 cm long at 5th leaf stage. Internodes (at 5th leaf stage): 1st 2.0 cm, 2nd 1.0 cm, 3rd 0.6 cm, 4th 1.5 cm, and 5th 1.1 cm long. First leaves simple, opposite, exstipulate, petiolate. Petioles green, tomentose, terete and channelled, 0.5 cm long. Leaf blade elliptic, 2.1 x 0.8 cm, mean l/w 2.6, base attenuate, apex acute, margins entire, adaxial surface dark green, abaxial surface light green, both sides tomentose. Venation eucamptodromous; unicastate reticulate, 8 veins distinct, 3 secondary veins on one side and 4 veins on other side of primary vein, veins alternate. Subsequent leaves same as that of first leaves but leaf blade obovate in shape. Appearance of axillary buds as in *C. gigantea*. Seed coat persists in early stage of germination.

Flowering period: Throughout the year, common during summer.

Fruiting period: two to three months after flowering.

GPS 25° 21.167' N; 082° 58.751' E, Elevation 68 m.

Distribution: North and East Africa, South Angola, the Arabian Peninsula, SW Asia (India, Pakistan, Afghanistan, Iran, Arabia, Jordan), Madagascar, Indochina and Malaysia. The species is now naturalized in Australia, many Pacific islands, Mexico, Central and South America, and the Caribbean islands. It is distributed in tropical and sub-tropical regions of India including Gujarat, Jammu and Kashmir, Orissa, Rajasthan, Tamil Nadu, West Bengal, and Uttar Pradesh.

DISCUSSION

After going through published literature on various aspects of *Calotropis*, we have noticed that most of the research workers are not very much clear about the taxonomy of *C. gigantea* and *C. procera*. In many published manuscripts *Calotropis* taxa are wrongly identified. Keeping these facts in mind present study was conducted and keys for mature plants and seedlings were constructed, so that both the reported taxa can be identified and differentiated easily at seedling stage as well as at maturity. It is evident from key provided above that mature specimens of *C. gigantea* and *C. procera* can be differentiated very easily from each other on the basis of orientation, colour, shape and length of corolla lobes. Similarly on the basis of length of corona, particularly in relation to staminal column as well as its surface and apex. In addition to this length of pollinial sac and gynoecium are also found distinct between reported species, but not much significant.

The seedlings of both the reported taxa can also be distinguished and identified on the basis of colour and collet of the seedlings, shape and apex of leaf blades of paracotyledons and leaves. The seedling colour of *C. gigantea* was ash coloured, but in *C. procera* it was green. The collet was distinctly swollen in *C. gigantea* but in *C. procera* it was not much pronounced. The first leaf blade was obovate with obtuse apex in *C. gigantea* whereas in *C. procera* it was elliptic with acute apex. Similarly second and subsequent leaf blades are oblanceolate in shape in *C. gigantea* but in *C. procera* it was obovate. Finally, we conclude that the morpho-taxonomic parameters such as inflexed and reflexed corolla and length of corona (in relation to staminal column) of mature plants, and colour and shape of collet; shape and apex of first leaf blade and shape of second and subsequent leaves in seedlings have significance and can be exploited to delimit reported *Calotropis* species.

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