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RESEARCH REVIEW

Overview of an introduced species, *Tara cacalaco* (Bonpl.) Molinari & Sánchez Och. (Leguminosae) in India: With a brief review on its utility and phytochemistry

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Abstract

Tara cacalaco (Bonpl.) Molinari & Sánchez Och., native to Mexico, was introduced as an ornamental plant in India in the AJCB Indian Botanic Garden, Howrah, West Bengal, in 1845. The present work highlights the distribution of the species in the botanical garden of the CSIR-National Botanical Research Institute, Lucknow, as an ornamental plant. Given that this species is poorly known in India, a detailed description is provided, along with other taxonomic information, line drawings, and colored photographs to facilitate its easy identification. In its native Mexico, the wood and pods of this species are highly utilized for dyeing or carpentry. Additionally, a brief overview of the ethnopharmacology, phytochemistry, and pharmacology of the species is discussed.

Keywords

Caesalpinia; distribution; ethanobotany; pharmacology; *Tara cacalaco*; taxonomy

Introduction

Tara Molina, a genus within the Fabaceae family comprising three species, is naturally distributed in the tropical and subtropical regions of America. This genus has also been introduced in various other countries, including California, the Canary Islands, the Cape Provinces, Ethiopia, Florida, India, Jawa, Kenya, Namibia, Spain, Uganda, and Zimbabwe (1). Recent morphological and molecular markers have reclassified two species of Caesalpinia, namely *C. cacalaco* Bonpl. and *C. vesicaria* L., into the previously described genus Tara (2–4). The genus *Tara* is distinguished from *Caesalpinia* by its indehiscent, fleshy, turgid, and coriaceous pods along with a cucullate lower sepal featuring pectinate/fimbriate margins.

Tara cacalaco (= *Caesalpinia cacalaco*) was first introduced to India in the Royal Botanic Garden at Shibpur, Howrah, West Bengal (now known as A.J.C. Bose Indian Botanic Garden, Howrah) in 1845, sourced from a European nursey as an ornamental plant (5). Subsequently, this species was also observed in various gardens of Kolkata, including Victoria Memorial Garden, Tollygunge Club Ground, and Royal Agri-Horticultural Garden (6–10). To date, this species has not been recorded in any gardens outside Kolkata and Howrah in West Bengal. While exploring the cultivated legumes of Uttar Pradesh, India, we encountered this species growing in the Botanic Garden of

the CSIR-National Botanical Research Institute, Lucknow. Upon searching for relevant information regarding the species introduction to the NBRI Garden, it was confirmed that there is a lack of available literature. Given the limited discussion of this species in the context of Indian flora or revisions, a detailed description is provided. This includes taxonomic notes on its relationship with other allied species, geographical distribution, flowering and fruiting periods, reference to voucher specimens, line drawing illustrations, and colored for easy identification. Furthermore, considering the industrial application of wood and pods of this species in its native habitat, an overview of ethnopharmacognosy, phytochemistry, and pharmacology is also provided.

Materials and Methods

The species was located at the Botanical Garden of CSIR-NBRI, Lucknow, and specimens were collected from November 2019 to February 2020. The identification of the species was confirmed by following the relevant literature (11–14). The protologue of the species was also examined to confirm its identification. Previous collections housed at LWG (Lucknow Wild Herbarium) were reviewed. The type and other specimens of *T. cacalaco*, housed in different herbaria (P, MA, and NMNH), were examined virtually through high-resolution images accessed at NMNH (15). The description was prepared based on freshly collected specimens from the field, using a Leica Stereo Zoom microscope. The herbarium specimens of the collected species were prepared by following standard herbarium protocol (16), and the voucher specimens were deposited at LWG.

Taxonomic Treatment

Key to the species

1a. Margins of sepals entire; fruits winged .....*T. vesicaria*

1b. Margins of sepals pectinate; fruits unwinged……....2

2a. Leaflets petiolulate; racemes unarmed; fruits turgid, constricted between seeds, puberulous…...*T. cacalaco*

2b. Leaflets sessile; racemes armed; fruits laterally compressed, slightly bulges at seeds.....*T. spinosa*

Tara cacalaco (Bonpl.) Molinari & Sánchez Och., Weberbauerella 1(8): 5. 2016; Gagnon *et al*., Phytokeys 771: 51. 2016. Type: Mexico, inter Chilpantzingo et Zumpango, A.J.A. *Bonpland & Humboldt Von* 3939 (Holo: P, digital image! [P00320013] (18); Iso: P, digital image! (P00151683).

Basionym: *Caesalpinia cacalaco* Bonpl., Pl. Aequinoct. 2: 173. 1817; Sen & Naskar, Bull. Bot. Surv. India 7: 36. 1965; Sanjappa, Legum. India 13. 1992; Kumar & Sane, Legum. South Asia: Checkl. 28. 2003. Homotypic synonym: *Russellodendron cacalaco* (Bonpl.) Britton & Rose, N. Amer. Fl. 23(5): 320. 1930. (Fig. 1-3)

Armed shrubs to small trees, 4–8 m tall; trunk ca. 75 cm in diam., thorny; thorns hard, with bulbous base, 3–4 cm long; bark brownish-grey, with raised brown or grey lenticels and longitudinal fissures; crown irregular spreading up to 6–7 m in diameter; branches reddish green and prickly; prickles ca. 2.7 mm long, erect, slightly curved at apex, hard, pinkish red. Stipule spiny; spines ca. 4.5 mm long and 2.3 mm broad at the base, straight, flattened at the base, slightly curved at the apex, pinkish red, glabrous. Leaves alternate, bipinnate, ending with a pair of pinnae, 10–15.5 cm long; petiole 1.5–2.6 cm long, glabrous to pubescent; rachis 2.5–10.1 cm long, glabrous to pubescent; pinnae 2–4 pairs, opposite, with the two lowermost pinnae armed with paired prickles; rachilla 5–10 cm long, glabrous to pubescent, pinkish green early, dark green later; petiolule ca. 1.2 mm long, pubescent, pinkish green early, dark green later; leaflets 2–4 pairs, opposite, 1.2–2.1 × 0.8–1.5 cm, obovate to suborbicular, oblique or asymmetrical to rounded at base, obtuse, rounded, truncate or shallowly emarginate at apex, glabrous. Inflorescences axillary or terminal erect racemes, 27.9–35.5 cm long; peduncle 4–7 cm long, glabrous to pubescent, unarmed. Bracts caducous, ovate, ca. 3.5 × 0.8 mm, acuminate at the apex, densely white pubescent on both surfaces. Flowers yellow, 1.1–2.2 cm long; pedicel ca. 5.2 mm long, white pubescent, articulated. Hypanthium turbinate, ca. 5.6 × 5.4 mm, slightly concave toward the anterior margin, white pubescent. Sepals 5, yellow; 2 upper lateral ones ovate to widely oblong, 7.5–7.1 × 5–5.8 mm, rounded at base, obtuse or rounded at apex, sparsely white pubescent outside at base, glabrous within; 2 lower lateral ones oblong, 0.4–8.0 × 1.9–3.9 mm, rounded at base, obtuse at apex, densely pubescent at the base on outer surface, glabrous within; anterior ones hooded/cucullate covering the other 4 sepals in bud condition, 8.4–9.0 × 5.1–7.1 mm, distal margins pectinate or fimbriate, white pubescent without, glabrescent to white pubescent within. Petals 5, yellow, clawed; standard or posterior petal spotted or faintly streaked red, blade cordate to orbicular, ca. 4.8 mm across, auriculate to obtuse at base, entire to slightly crinkle or undulate long margins, obtuse at apex, glabrous, claw ca. 2.3 mm long, sparsely pilose without, densely pilose within; 2 upper lateral ones ovate, 7.5–8.6 × 6.6–7.6 mm, margin wavy, obtuse at apex, glabrous within, sparsely 1/3 white pilose at base without, claw ca. 0.8 mm long, densely pilose within, sparsely pilose without; 2 lower lateral ones oblong, 8.3–8.5 × 5.8–6 mm, entire or undulate along margins, obtuse at apex, glabrous within, sparsely white pilose at the base and middle outside, claw ca. 1.2 mm long, densely pilose inside, sparsely pilose outside. Stamens 10, biseriate, 5 with longer filaments and 5 with shorter filaments; filaments 8.7–10.5 mm long, fattened, or broad at the base, densely white villous on three-quarters of their length; anther oblong to ellipsoid, 2.3–2.5 mm long, basifixed, glabrous, with a longitudinal split. Ovary sessile, linear, oblong, ca. 6.2 mm long, densely white pilose; style ca. 4.3 mm long, slightly curved, sparsely pilose; stigma capitate, ca. 0.8 mm in diameter, glabrous. Pods cylindrical, 7–15 × 0.5–1.1 cm, straight, turgid, constricted between the seeds, puberulous, light brown at maturity, sutures sinuate; article uniform, 7–12, ca. 1.2 × 1.1 cm, quadrangular, indehiscent, coriaceous, veins inconspicuous on the dorsal surface, conspicuous on the ventral surface. Seeds ellipsoid to orbicular, ca. 7.7 mm in diameter, shiny, green to brown, glabrous with a sub-central hilum.

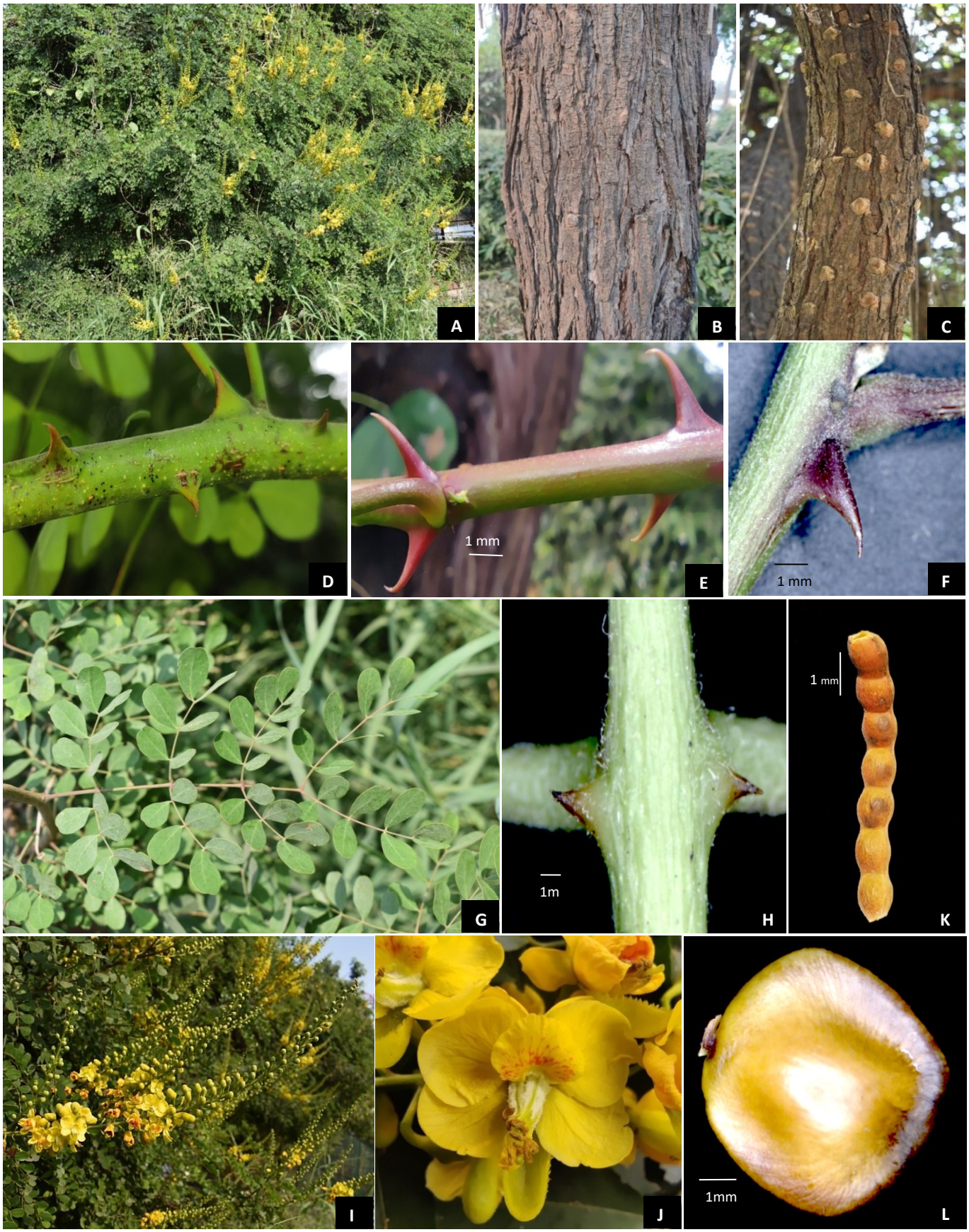

Fig. 1. *Tara cacalaco* (Bonpl.) Molinari & Sánchez Och. **A:** Habit; **B:** Bark; **C:** Armed Trunk; **D & E:** Prickly branches; **F:** Thorny stipule; **G:** Part of bipinnate leaf; **H:** Pinnae armed with spines; **I.** Inflorescence; **J:** Flower; **K:** Fruit; **L:** Seed.

Note

Tara cacalaco can be differentiated from other species [i. e. *T. spinosa* (Molina) Britton & Rose and *Tara vesicaria* (L.) Molinari, Sánchez Och. & Mayta] of the genus based on its various unique morphological features. Key differentiators include terminal pinnae that are paired, leaflets that are obovate to suborbicular and petiolulate, a lower sepal that is cucullate with pectinate/fimbriate margins, and fruits that are indehiscent, turgid, constricted between seeds.

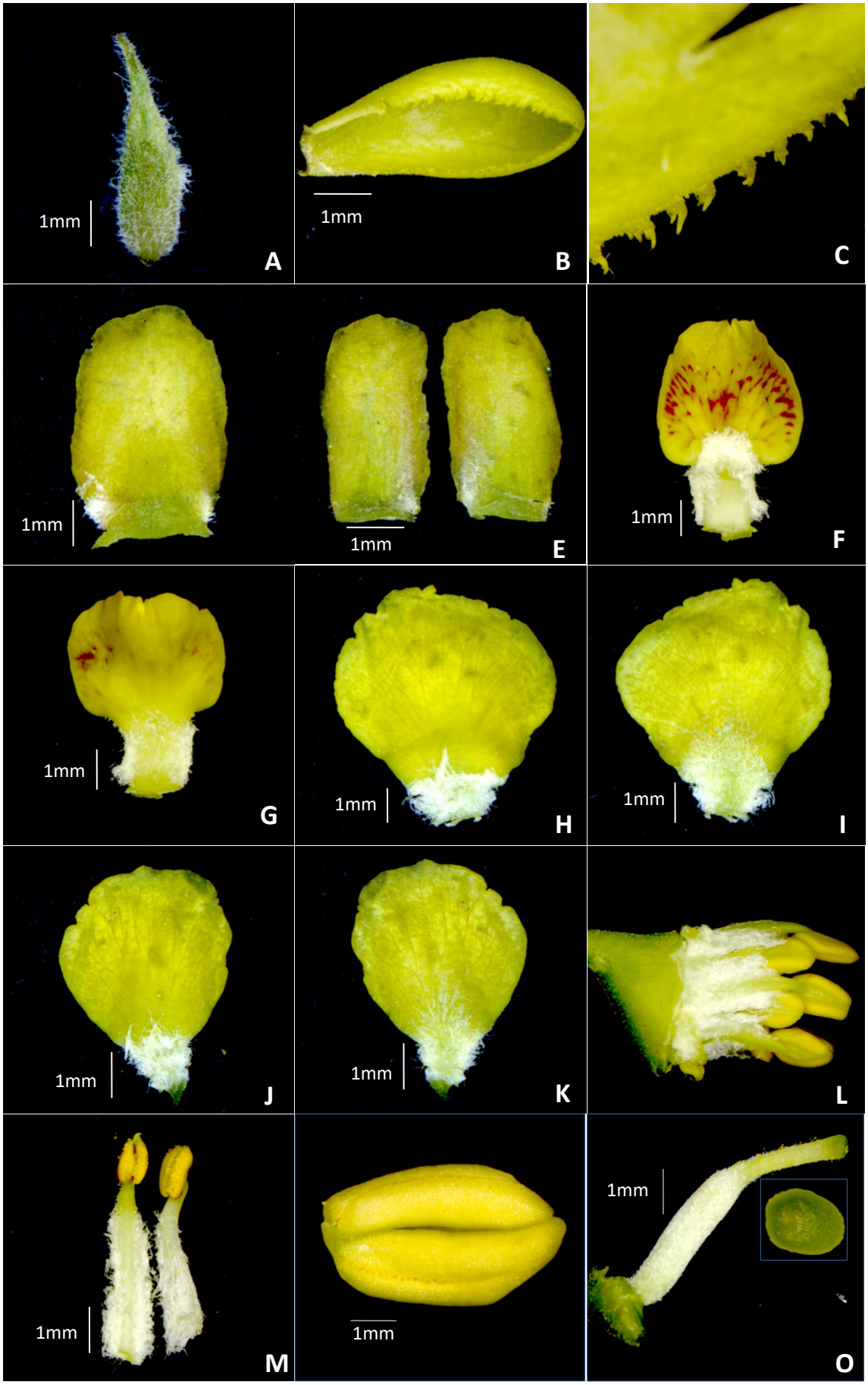

Fig. 2. *Tara cacalaco* (Bonpl.) Molinari & Sánchez Och.—**A:** Bract; **B:** Anterior sepal; **C:** Anterior sepal margin; **D:** Upper lateral sepal; **E:** Lower lateral sepal; **F & G:** Standard petal inner and outer surface; **H & I:** Upper lateral petal inner and outer surface; **J & K:** Lower lateral petal inner and outer surface; **L:** Stamens arrangement; **M:** Stamen; **N:** Anther; **O:** Carpel.

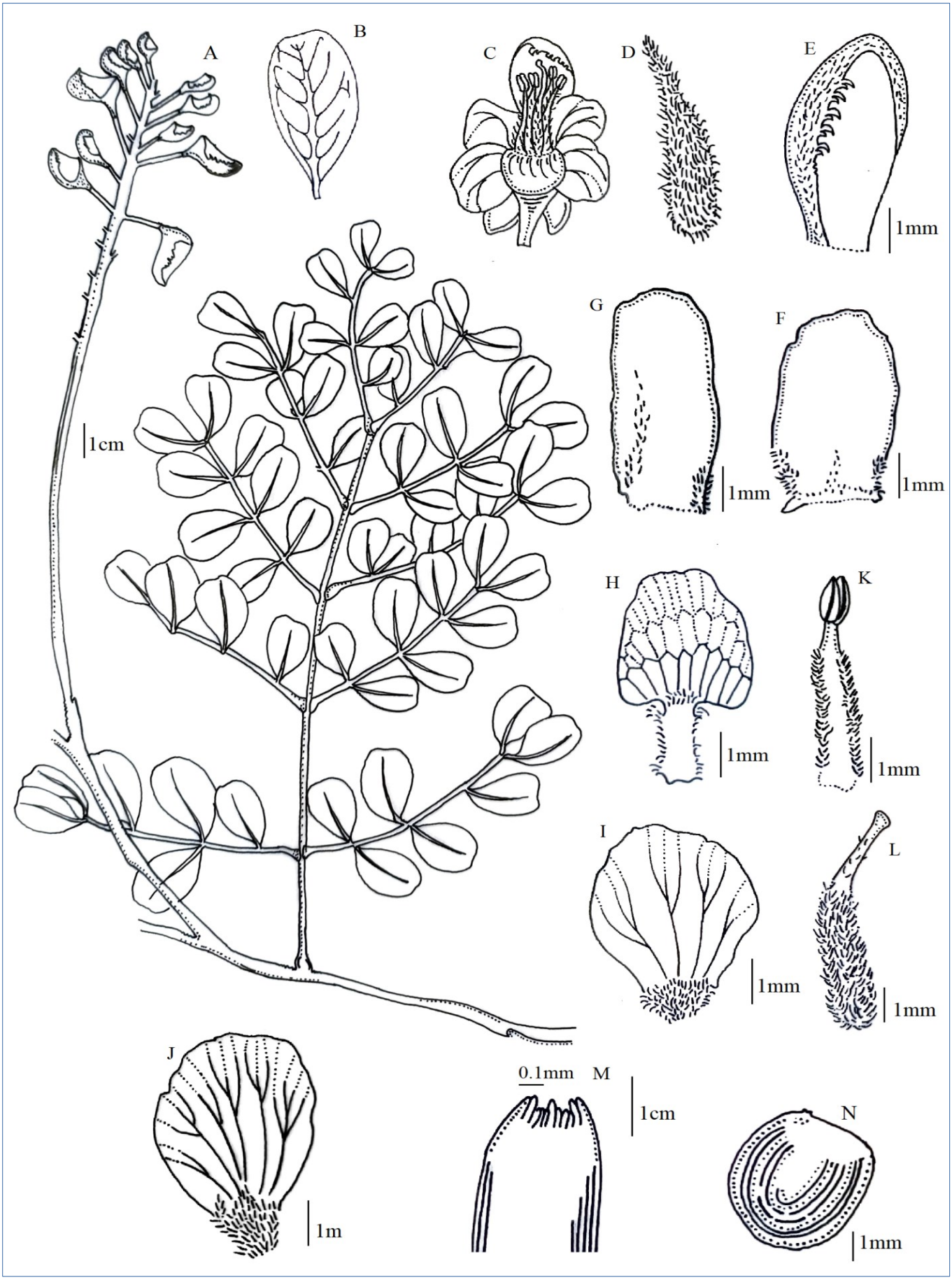

Fig. 3. *Tara cacalaco* (Bonpl.) Molinari & Sánchez Och.- **A:** Habit; **B:** Leaflet; **C:** Flower; **D:** Bract; **E:** Anterior sepal**;** **F:** Upper lateral sepal; **G:** Lower lateral sepal; **H:** standard petal; **I:** Upper lateral petal; **J:** Lower lateral Petal; **K:** Stamen; **L:** Carpel; **M:** Stigma; **N:** Seed.

Flowering period

November–December.

Fruiting period

December– February.

Distribution

Tara cacalaco is indigenous to various regions in Mexico, including Campeche, Chipas, Colima, Jalisco, Guerrero, Guerrero, Guerrero, Jalliso, Michoacán, Oaxaca, Pubela, Dorantes Sinaloa, Veracruz, and Yucatán. Despite its native distribution, it has been introduced to several other countries such as Columbia, Spain, the United States, Iran, and India (Fig. 4), indicating its adaptability and potential for cultivation outside its natural range.

Specimens examined

Fig. 4. Distribution of *T. cacalaco.*

INDIA, West Bengal: Howrah, Shibpur, Indian Botanic Garden, 20. 08. 1967, *J. K. Maheshwari* 85358 (LWG). Uttar Pradesh: Lucknow, CSIR- NBRI Botanic Garden, 15. 12. 2019, *Anu Verma* 323937 (LWG).

Ethnopharmacognosy

T. cacalaco fruits are very rich in tannin and gallic acids and are used as an astringent and for tanning purposes (17). The bark of the stem is used as an infusion to treat kidney problems (18).

Phytochemistry

The preliminary phytochemical screening of phenolic extracts from the pods of *T. cacalaco* recorded a significant amount of Gallic (90%) and tannic (10%) acids (19, 20). Galactomannan isolated from its seed exhibited a Gal/Man ratio of 2.5 (21, 22).

Pharmacological activities

Antimicrobial

The phenolic extract of *T. cacalaco* pods exhibited antimicrobial activity against *Colletotrichum lindimuthianum*, both *in vitro* and *in vivo*. This fungus causes anthracnose disease in common beans (*Phaseolus vulgaris*). The authors confirmed *in vitro* fungistatic activity against the fungus and observed significant protection against anthracnose severity in the *in vivo* assays (20).

Antimutagenic

The phenolic extract of *Tara* fruits demonstrates antimutagenic potential against Aflatoxin B_1 (AFB_1). The extract exhibited dose-dependent antimutagenic properties against AFB_1 (19).

Antioxidant

The antioxidant and anti-radical activities of the phenolic extract from *T. cacalaco* pods were evaluated using the β -Carotene bleaching and 2,2-diphenyl-1-picrylhydrazyl (DPPH) methods. It was reported that antioxidant activity was dose-dependent, exhibiting 73.5%, 60 %, 45.2 %, and 31.1 % antioxidant activity at 1.2 mg, 0.6mg, 0.3mg, and 0.15mg of extract tested, respectively. These values were comparable to those of different pomegranate seed extracts. Similarly, antiradical activity was also dose-dependent; the lower the concentration of phenolic acid, the lower the antiradical activity. Phenolic acids extract at doses of 1.2 mg, 0.6 mg, 0.3 mg, and 0.15 mg showed antiradical activities of 75.3%, 65.2%, 39.6%, and 18.1%, respectively (19).

Ethnobotany

Mexican citizens utilize the wood of *T. cacalaco* for carpentry or dyeing purposes (23). The tannin content from *Tara* pods is extensively utilized in Mexico, especially in the shoe industry, where pod extracts are employed in tanning cow or pig skins for shoe manufacture. Approximately 20,000 tonnes of *T. cacalaco* pods are reportedly produced in Mexico each year (19). In Sinaloa, the bark is used as a treatment for toothaches. The seeds are supposedly edible, and the pods are used to make dyes (24).

Other uses

T. cacalaco is planted as an ornamental plant, for creating living fences, and as shade trees (25).

Conclusion

T. cacalaco pods represent an outstanding source of phenolic compounds, specifically Gallic acid and Tannic acids. Research has demonstrated that the phenolics from its pods exhibit antimutagenic, antioxidant, and antibacterial activities. Further research efforts could lead to the identification of novel bioactive substances from additional plant parts and contribute to advancements in utilizing phenolics in the agrochemical and nutraceutical industries.

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Authors' contributions

AV first identified the plant, conducted the necessary research, and drafted the manuscript. SK, CKS, and VNP provided important suggestions to enhance the manuscript. LBC finalized the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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