



RESEARCH ARTICLE

Lemon basil (*Ocimum africanum* Lour.) a new distribution record from North East India with notes on its identity

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Abstract

The odoriferous *Citron basilika*, also known as lemon basil, possesses a distinctive lemony sweetness amidst all the *Ocimum* L. members. While native to India, it has not been formally recognized in India's North Eastern (N.E) region until now. This investigation marks the first documented occurrence of lemon basil, specifically *O. africanum* Lour., in N.E India. This new record has been established through meticulous investigation, comparison, diagnosis, verification using herbarium specimens, and a thorough review of existing literature. The report includes a morphological description, careful scrutiny, identification keys, taxonomic notes, and photographic images of the species. The previously existing confusion regarding its identification alongside *O. americanum* L. and *O. basilicum* L. has been clarified. This study aims to facilitate the accurate identification of these three *Ocimum* L. species.

Keywords

basil; *Ocimum africanum*; distribution; keys; taxonomy; morphology

Introduction

Lemon basil, i.e., *Ocimum africanum* Lour., belongs to the tribe *Ocimeae* Dumort within the subfamily *Nepetoideae* Burnett of the deadnettle, mint, or sage family *Lamiaceae* Martinov (1). This species originated in East Africa and was first documented by Loureiro (1790), typically thriving in uncultivated habitats. *Ocimum africanum* (= *Ocimum*) is native to India and exhibits little variation in its growth habit and physical characterization (2). A nothospecies, *Ocimum* × *africanum*, has emerged through direct hybridization between American basil (*O. americanum* L.) and sweet basil (*O. basilicum* L.). Previously, *Ocimum africanum* was identified as *Ocimum* × *citriodorum* Vis. However, Paton and Putievsky (1996) proposed the correct name for the latter as *O. americanum* sensu Pushpangadan and Sobti non-L. (3). They concluded that the methyl chavicol chemotype of *Ocimum* × *citriodorum* resulted from a hybridization event involving the parent species *O. americanum* and *O. basilicum*, aligning with the postulation made by Pushpangadan and Sobti (1982) (4). The specific epithet *citriodorum* is derived from the citrol and lemony flavor characteristic of this species. The pronounced lemon aroma of *O. africanum* can be attributed to citral, a key component of its essential oil (5). The lemony fragrance can be utilized in tea infusions and as an antioxidant (6). Lemon basil contains bioactive compounds such as caffeic acid, flavonoids, rosmarinic acid, and linalool, which exhibit anti-inflammatory, antioxidant, and antimicrobial properties (7). The name *O. africanum* also refers to plants that are morphologically similar, resulting from the doubling of the F1 chromosome number (3). The parent species, *O. basilicum*, has developed numerous forms over time due

to extensive cultivation practices. Bentham (1832) suggested considering these forms as varieties originating in gardens within the same species, possibly stemming from *O. basilicum* L. var. *pilosum* and *O. basilicum* L. var. *glabratum* (8). He placed *Ocimum africanum* within a section designated as 'species quoad genus vel sectionem dubiae', which includes ten other *Ocimum* (= *Ocimum*) species of certain classification. Paton (1992) acknowledged *O. basilicum* var. *pilosum* (Willd.) Benth. as a type specimen of *O. americanum* var. *pilosum* (Willd.) Paton. Furthermore, he asserted that *O. africanum* and *O. americanum* var. *pilosum* are synonymous species, while proposing two varieties of *O. americanum* (var. *americanum* and var. *pilosum*) based on differences in stem indumentum (9). Nevertheless, the latter variety has been established as a separate species named *O. africanum* and is now considered synonymous with *O. americanum* var. *pilosum* (Willd.) Paton. (10). According to Ryding (1994), these species have chromosome numbers of $2n=48$ or 64 . Ryding also conducted a back cross between *O. americanum* L. var. *pilosum* (= *O. africanum*) and one of its parent species, *O. basilicum*, resulting in sterile hybrids that produced only a few dwarf seeds (11). Paton and Putievsky (1996) suggested a high crossability percentage of 12.5 with *O. basilicum* L. var. *purpurascens* producing viable seeds, whereas non-viable seeds with var. *difforme* (3). The ability of *O. africanum* to readily hybridize with a few varieties of *O. basilicum*, therefore, depends on which variety of the latter is involved as a parent. Suddee et al. (2005) reported that intermediates of *O. africanum* are not uncommon, as they can freely hybridize with *O. basilicum* in cultivation (10).

In India, seven species of *Ocimum* L. have been documented (12). Among these, four species of *Ocimum* (*O. americanum* L., *O. basilicum* L., *O. gratissimum* L., and *O. tenuiflorum* L.) are naturally found in N.E India, while *O. africanum*, *O. filamentosum* Forssk. and *O. kilimandscharicum* Gurke are not. *O. africanum* had, at the time, been classified as a variety (*pilosum*), such as *O. americanum* var. *pilosum* and *O. basilicum* var. *pilosum*. The varietal epithet *pilosum* suggests a soft hairy surface. Notably, the staminal, floral appendages, and inflorescences of *O. africanum* are densely covered in hairs compared to *O. americanum* and *O. basilicum*, making them distinguishable as distinct species. To clarify these distinctions and alleviate confusion, we have provided a detailed comparative analysis of all three species (Fig. 1). Additionally, we have outlined the distinctive characteristics of all three species (Table 1).

O. africanum has often been confused with its familial species viz. *O. americanum* and *O. basilicum*. Many authors have used the name *O. americanum* to refer to both *O. americanum* and *O. africanum*. Furthermore, *O. africanum* Lour. has been insufficiently specified, leading to misidentification where *O. americanum* was mistakenly labelled as *O. africanum* by some authors (13,14). In a recent publication, Misra et al. (2022) erroneously reported the new distribution record of *O. africanum* from Odisha, India, and indicated its presence in Manipur and Tripura based on habit photographs (14). However, the images they presented are of *O. americanum*. It's worth noting that lemon basil (*O. africanum*) has not yet been reported from the North Eastern province of India

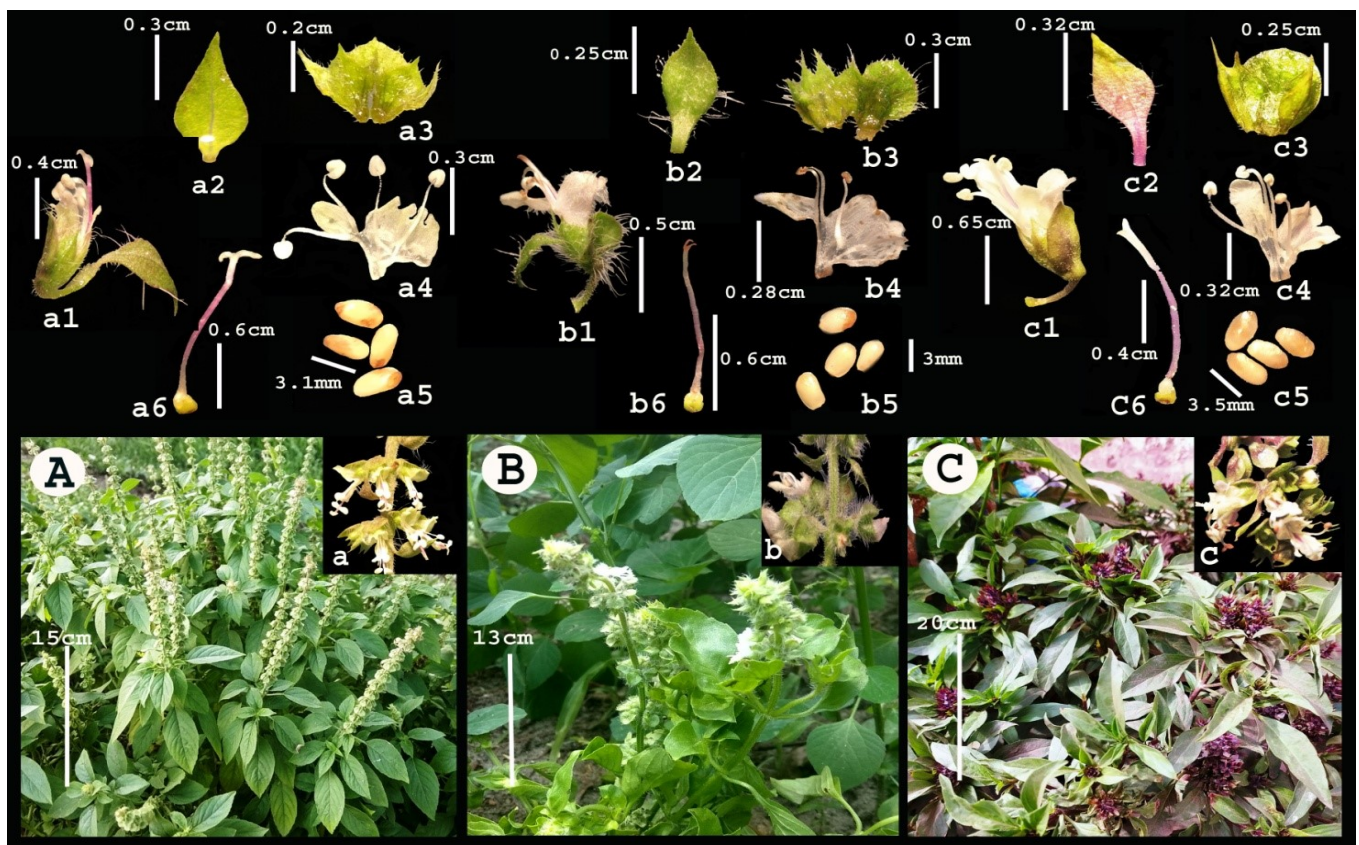


Figure 1. Habit and floral morphology of three *Ocimum* L. species. **A** *Ocimum americanum* L. (UGOA01). **B** *Ocimum africanum* Lour. (KMOA01) and **C** *Ocimum basilicum* L. (CCOB07) showing magnified view of inflorescence architecture and floral arrangement **a**, **b** **c** respectively. Each of the species have been represented with its complete flower (a1,b1,c1), flower bract (a2,b2,c2), calyx (a3,b3,c3), corolla showing epipetalous stamen (a4,b4,c4), nutlets (a5,b5,c5), gynoecium exhibiting gynobasic style and bifid stigma (a6,b6,c6). ©Mamita Kalita

Table 1. Characteristic differences between three species of *Ocimum* L.

Characteristics	<i>O. americanum</i> L.	<i>O. africanum</i> Lour.	<i>O. basilicum</i> L.
Aroma	strong pungent odor	lemony or citral	sweet or spicy like sweet fennel/aniseed
Inflorescence	10–15 cm long; verticils 0.8–1.5 cm apart; moderately pubescent	8–12 cm long; verticils 1–3 cm apart; pubescent	5–8 cm long; verticils 0.5–1.2 cm apart; sparsely pubescent or glabrous
Bract	0.48–0.65 cm long; thin hair present; sub-sessile; bract stalk less than 0.2 cm in length	0.45–0.6 cm long; pubescent; bract stalk 0.1–0.3 cm in length	0.5–0.7 cm long; glabrous; bract stalk 0.15–0.35 cm in length
Flower	pinkish or crimson white, smaller; moderately hairy	colorless or pinkish white, moderate size; densely pubescent	crimson white; comparatively larger; less hairy
Nutlets	ovoid; 3–3.5 mm in length	oblong; 3–3.2 mm in length	ovoid; 3.2–3.5 mm in length

and is also absent from the Plants of World Online (POWO) database (15). Despite its presence and common usage, the taxonomic identity of *O. africanum* remains unclear. The study aims to address this taxonomic uncertainty by reporting the first distributional record of *O. africanum* from the North Eastern part of India, based on collections from three districts of Assam. This finding represents a valuable addition to the flora of Assam and North East India.

Materials and Methods

The species were collected during a comprehensive Ph.D. field survey between 2019 and 2022 from the Goalpara, Hojai, and Kamrup districts of Assam. The representatives of *O. africanum* were collected in the flowering and fruiting stages. Field photographs and GPS locations were recorded using a digital camera. The micro-morphological features were investigated using a Labomed CZM4 stereo zoom binocular microscope. Further photo plates were prepared using Adobe Photoshop 7.0. A complete characterization was made with examination of all the possible morphological characters. The species was identified with the help of its type specimen available at the Royal Botanic Gardens, Kew (K), K000911679. Further regional and national herbaria, such as ARUN, ASSAM, CAL, and GUBH, were consulted for affirmation and identification. Also, relevant literature (Floras, Journals, and Revisions) and microfilms of specimens from online herbaria databases BSI-IVH, G, JSTOR, KEW, LINN, MNHN, MO, and NY were conferred for accurate identification. The new distributional record of the species was confirmed through verification of the taxonomic and other relevant literature and herbarium specimens deposited in different regional and national herbariums. The common and vernacular names of the species are given in English (E), Hindi (H), and Assamese (A).

Results and Discussion

Taxonomic treatment

***Ocimum africanum* Lour.** Fl. Cochinch. 2:370.1790; DC, Prodr. 42.1873; Merr. In Trans. Amer. Philos. Soc. 24 (2): 343 (1935); Suddee, Paton & Parnell. KB. 60:28.2005. — ***Ocimum africanum* Lour.** Bentham, Lab. Gen. Specs. 16.1832. — ***Ocimum* × *pilosum* Roxb.** Asiat. Res. 11: 173.1810. — ***Ocimum pilosum* Willd.** Enum. Pl. 2:629.1809;

Wallich, Pl. Asiat. Rar. 2:13.1830; Roxb, Fl. Ind. 3:16.1832. — ***Ocimum pilosum* Willd.** A. J. Paton, KB.47.3:426.1992. — ***Ocimum americanum* Auct. ex. Benth.** Labiat. Gen. specs. 13.1832. — ***Ocimum americanum* var. *pilosum* (Willd.) Paton** KB. 47:426.1992. — ***Ocimum anisatum* Benth.** Labiat. Gen. specs. 4.1832. — ***Ocimum citriodorum* Vis.** Index. Seminum (PAD, Patavium) 9.1840. — ***Ocimum citriodorum* L.** DC, Prodr. 39.1873. — ***Ocimum* × *graveolens* A. Br.** Flora 24:265.1841. — ***Ocimum petitianum* A. Rich** Tent. Fl. Abyss. 2:176.1850.

Type Neotype (NT): Vietnam, 1868, Dr. Talmy–76 (K000911679), designated by Suddee and Paton, Kew Bulletin, 60:28.2005. K!

Description

Annual herbs or sub-shrubs typically reaching heights of 20–70 cm. Stems are round to quadrangular and have a puberulent texture. Leaves are arranged in an opposite decussate pattern, ovate in shape, measuring 4–5 × 2–3 cm. They are acute at the tips, with nearly equal sides, shallow serrations along the edges, and are smooth on the upper surface while having pubescence along the veins on the underside. The petioles are slender, 3–5 cm long, and puberulent. The inflorescence is lax, measuring 8–12 × 2–3 cm, with verticils spaced approximately 1.5–3 cm apart. The axis of the inflorescence is lanate. Bracts are ovate, measuring 0.4–0.5 × 0.1–0.25 cm, and have acute tips, covered in villous hairs. Pedicels are recurved and shorter than the calyx, with a pubescent texture. The calyx is campanulate, measuring 0.4–0.6 × 0.3–0.45 cm, and covered in villous hairs. The posterior lip is rounded with an apiculate tip and extends along the tube slightly. The anterior lip has two median lanceolate teeth that are acuminate and longer than the posterior lip. The lateral tooth is broad and acute, nearly equal in size to the posterior tooth. There are villous hairs at the throat. The corolla is colorless or pinkish-white, measuring 0.4–0.8 × 0.5–1.2 cm. The lobes are entire and villous on the back. The anterior lip is boat-shaped, while the posterior lip has two median oblong lobes and two lateral obovate lobes. The tube is pubescent and straight. Stamens are didynamous, measuring 0.4–1.5 cm long, with a villous base on the posterior side. The gynoecium has two equal lobes, and the style is bifid, measuring 0.8–1.2 cm long. Nutlets are narrowly oblong, black, measuring 0.25–0.3 × 0.1–0.15 cm, minutely tuberculate, and become mucilaginous when wet (Fig. 2).

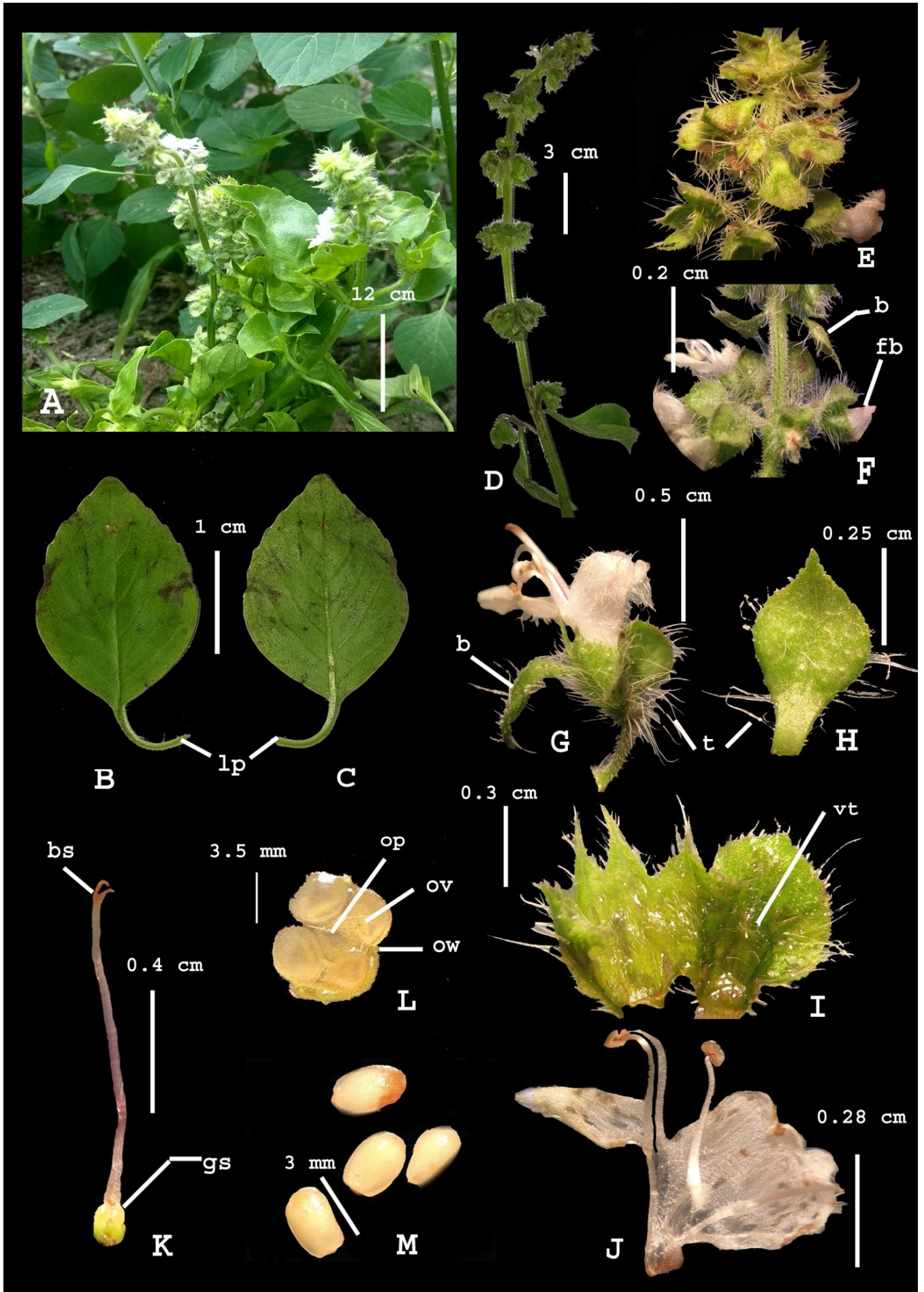


Figure 2. *Ocimum africanum* Lour. (KMOAf01) **A** habit **B** adaxial and **C** abaxial view of leaf with leaf petiole (lp) **D** inflorescence **E** inflorescence tip **F** closure view of inflorescence showing floral arrangement, bract (b) and floral bud (fb) **G** complete flower along with bract (b) and densely covered trichomes (t) **H** bract **I** calyx having villous throat (vt) **J** corolla showing epipetalous stamen **K** gynoecium exhibiting gynobasic style (gs), and bifid stigma (bs) **L** transverse section of ovary revealing ovules (ov), ovary wall (ow) and ovary placenta (op) **M** nutlets. ©Mamita Kalita

Specimen Examined

Africa: Sudan, Kotchy, C.G.T. 30 Sept 1839. W0006986! Mozambique, Mayotte, 30 March 1975, P. Coulon, Coll. No. 21. MNHN-P-P00184722! **Cambodia:** Kampong Cham, Sopheas, 17 December 1965, J.E Vidal, Coll. No. 4746. MNHN-P-P00131438! **Madagascar:** Toliara, 17 March 1994, 30-50m, 24° 49' 49"S, 46° 32' 15"E, M. Randriambololona et al. Coll No. 93. MO-694054! **USA:** New York Botanical Garden, S. Longmuir, 8 Sept 1943. NY 03066781! **Vietnam:** Cochinchine, 1868, Dr. Talmy, Neotype (NT), Coll. No. 76. K000911679! **India, Gujarat:** 24° 23' 17.5"N 72° 31' 43.86"E, Priyanka Mikwana, 2 Nov 2013, BIOMTFR-HER-002458! **Assam:** Hojai, Kurkut, 25° 56' 49.4"N 92° 49' 18.2"E, 79m, 25 August 2019, Mamita Kalita, Coll. No. 42 (HJOAf06); Goalpara, Jobepara, 25° 56' 34.9"N 91° 7' 33.3"E, 58m, 13 July 2019, Mamita Kalita, Coll. No. 06 (GPOAf03); Kamrup Metropolitan, Kallapara, 26° 3' 24.6" N 91° 36' 34.3"E, 56m, 18 June 2019, Mamita Kalita, Coll. No. 14 (KMOAf01).

Common names Citronbasilika, Hoary basil, Lao basil, Lime/Lemon basil, Sweet lemon, Thai lemon basil (E), Nimboo tulsi, and Lebu tulsi/toolsee (H).

Vernacular names Mayang, Lebu toolakhi, and Nemu toolakhi (A).

Phenology The flowering and fruiting have been observed from April to August.

Habitat Growing in disturbed ground, damp, and forest floors.

Distribution Africa, China, Taiwan, Malaysia, Sri Lanka, India (Andhra Pradesh, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, West Bengal); Assam (Goalpara, Hojai, Kamrup, new distribution record reported for first time here).

Note The specific epithet '*africanum*' indicates its native origin and widespread distribution in tropical Africa. Historically, the species was annotated as '*Ocimum*'. In 1747, the earliest reference to *O. africanum* was made as *Ozimum citratum* Rumph. (16). Louriero (1790) placed the species in the '*Calyces bilabiati*' section with a two-lipped calyx within the class of Gymnospermia (2). As stated by Paton (1992), *O. kenyense* Ayob. ex Paton can be easily confused for *O. africanum* (9). However, the former can be distinguished by its short petioles and obtuse leaves. Regarding the type specimen (K000911679), Dr. Talmy (1868) collected the species in Cochinchine, Vietnam, and initially identified it as *O. basilicum*. Suddee (2001) identified the same specimen as *O. americanum* L. var. *pilosum* (Willd.) A. J. Paton, while in 2002, Paton himself identified it as *Ocimum* × *citriodorum* (17). The correct identification and designation as a neotype were established by Suddee and Paton (2005) during their taxonomic revision of the Ocimeae tribe in Southeast Asia (10). The respective collectors have identified the herbarium specimens MNHN-P-P00184722!, MNHN-P-P00131438!, and MO-694054! under the name of *O. americanum* L. var. *pilosum* (Willd.) Paton.

The first author was unable to locate any physical herbarium specimens of *O. africanum* in ARUN, ASSAM, CAL, and GUBH except for one specimen at CAL, collected by T. Chowdhury (recorded as *O. citriodorum*, DDTC-317, 22-10-2015, from Dinajpur, West Bengal, without a CAL accession number). We have confirmed its identity as *O. africanum*. The present study marks the first-ever record of this species in the N.E India province. As a result, it represents a new distributional record for the flora of Assam and North East India.

Key to the species of *Ocimum* L. in N.E India

1. Pedicel longer than*O. tenuiflorum*
1. Pedicel shorter than calyx
 2. Fruiting calyx open; annual herbs; leaves 2–6 × 1–3 cm
 3. Two median anterior lips are almost equal to the posterior lip of calyx.....*O. africanum*
 3. Two median anterior lips are more prolonged than the posterior lip of calyx
 4. Inflorescence 7–12 cm; fruiting calyx 2.7–3.7 mm; bract elliptic.....*O. americanum*
 4. Inflorescence 5–9 cm; fruiting calyx 2.7–4.9 mm; bract lanceolate.....*O. basilicum*
 2. Fruiting calyx closed; perennial shrubs or under shrubs; leaves 5–13 × 3–5 cm*O. gratissimum*

Conclusion

Lemon basil holds significant importance in the pharmaceutical, chemical, and food industries. Its potential to contribute to the economy through large scale cultivation is noteworthy. A better understanding of its identification and distinction can facilitate the implementation of effective cultivation practices. The recent documentation of the occurrence of *Ocimum africanum* Lour. in Assam marks the first recorded instance and adds to the flora of North East India. Our study aims to elucidate the distinction between *O. africanum* and its allied species, enabling the proper utilization and management of these economically valuable plants.

Abbreviations

L./LINN–Linnaeus; F1–First filial generation; POWO–Plants of the World Online; GPS–Global Positioning System; K/KEW–Royal Botanic Garden, Kew; ARUN–Arunachal Pradesh Regional Centre, Itanagar, Arunachal Pradesh; ASSAM–Eastern Regional Centre, Shillong, Meghalaya; CAL –Central National Herbarium, Howrah, West Bengal; GUBH –Gauhati University Botanical Herbarium; BSI–Botanical Survey of India; IVH–Indian Virtual Herbarium; G–Conservatoire et Jardin botaniques de la Ville de Genève; JSTOR–Journal Storage; MNHN–Muséum national d'Histoire naturelle; MO–Missouri Botanical Garden's Herbarium; NY–New York Botanical Garden Herbarium.

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Authors' contributions

MK has carried out the field work and collected the specimen. ND has designed the study and contributed by giving important suggestions. MK has drafted the manuscript and ND has made corrections. ND and MK have finalized the manuscript for correspondence. Both authors have read and approved the final 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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