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Miliusa gokhalaei, a new species of Annonaceae from India with notes on interrelationships, population structure and conservation status

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Abstract

Miliusa gokhalaei (Annonaceae), a new species from the Western Ghats, India, is described and illustrated. It is distinguished by unequal rounded leaf bases, sessile or shortly pedicellate flowers, thick fleshy petals, glabrous carpel, and included connective of anther. It is closely related to *M. indica* and *M. eriocarpa*, with which it shares sub-sessile or shortly petiolate, hairy-nerved leaves, axillary solitary flowers, and flask-shaped carpel with 1–2 ovules. Notes on interrelationships, population structure, conservation status and an identification key to the taxa of *Miliusa* in peninsular India are also provided.

Key words: Endemic species, Kerala, Peninsular India, Wayanad, Western Ghats

Introduction

The genus *Miliusa* Leschenault ex Candolle (1832: 213) of the pantropical family Annonaceae is restricted in its distribution to the Austral-Asiatic ranges from India, Sri Lanka and Bhutan to Australia through the Malayan Islands, Philippines and Papua New Guinea (Mols & Kessler 2003). Recently the total number of species has reached 50 with four varieties (http://zipcodezoo.com/Key/Plantae/Miliusa_Genus.asp) from earlier records of 40 by Mols & Kessler (2003). Mitra (1993) recognised 15 species in the treatment for the flora of India. During the last decade, three new taxa, viz. *Miliusa velutina* var. *deviyarina* Rajendran *et al.* (2003: 220), *Miliusa tirunelvelica* Murugan *et al*. (2004: 102), and *Miliusa wayanadica* Sujanapal *et al.* in Narayanan *et al.* (2010a: 64) were published from the peninsular Indian region, which has more species than other parts of Asia, and now there are a total of ten species and one variety, viz. *Miliusa eriocarpa* Dunn (1916: 58), *Miliusa indica* Leschenault ex Candolle (1832: 213), *Miliusa montana* Gardner ex Hooker & Thomson (1855: 148), *Miliusa nilagirica* Beddome (1868-1874: 18), *Miliusa tomentosa* (Roxburgh: 1795: 31. t. 35.) Sinclair (1955: 378), *Miliusa velutina* Hooker & Thomson (1855: 151), *Miliusa velutina* var. *deviyarina*, *Miliusa wightiana* Hooker & Thomson (1855: 149), *Miliusa longiflora* Sinclair (1955: 378), *Miliusa tirunelvelica* and *M. wayanadica* in the region.

Of the Indian species, five are endemic to peninsular India, and two have an extended distribution in Sri Lanka. Four species, viz. *M. andamanica* Finet & Gagnepain (1906: 151), *M. mukerjeeana* Mitra & Chakraborty (1994: 326), *M. tectona* Hutchinson ex Parkinson (1923: 75) and *M. jainii* Goel & Sharma (1991: 629) are present in the Andaman and Nicobar Islands with three endemic to the Andaman region. *Miliusa tomentosa*, *M. indica* and *M. zeylanica* Gardner ex Hooker & Thomson (1855: 149) are distributed in Sri Lanka also (Huber 1985). Western Ghats with tropical evergreen and moist deciduous forests are the habitats of *Miliusa* in peninsular India.

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Forests of Wayanad district are rich in diverse flora with several endemics (Sivadasan & Balakrishnan 1989; Sivadasan & Jaleel 2002; Narayanan *et al.* 2010a; Narayanan *et al.* 2010b; Narayanan *et al.* 2011); these are highly fragmented due to large-scale plantations of coffee, tea, cardamom etc., and they form a buffer zone for the Nilgiri Biosphere Reserve. Among the ten species of *Miliusa* of peninsular India, five including the recently published species, viz. *M. wayanadica*, are reported from Wayanad. Recent floristic exploration in the evergreen forests of Wayanad yielded some additional specimens of *Miliusa*. Detailed study and analysis showed their uniqueness; the taxon is distinguished by its unequal rounded leaf bases, sessile or shortly pedicellate flowers, thick fleshy petals, glabrous carpel, and included connective of anther. It is described here as a new species, and a key for identification of the species of *Miliusa* in peninsular India is also provided.

Taxonomy

Miliusa gokhalaei **Ratheesh, Sujanapal, Anil Kumar & Sivadasan, *sp. nov*., Figs. 1 & 2**

Miliusa indicae et M. eriocarpae similis foliis petiolatis nervis pubescentibus floribus axillaribus solitariis carpellis 1-vel 2-ovularibus infundibularibus, sed foliorum basi inaequaliter rotundata floribus sessilibus vel breviter pedicellatis petalis crasse carnosis carpellis glabris antherae connectivo incluso differt.

Type:—INDIA: Kerala: Wayanad district, Vythiri Ghat, 11° 30′ 24.3″N, 76° 01′ 49.1″ E, 490 m, 26 September 2008 (with flowers). *Sujanapal* & *Narayanan MSSH 4312* (holotype MH, isotypes CAbC- MSSRF Herbarium, Wayanad CAL, CAL, KFRI).

Evergreen trees, to ca. 5 m high; bark black, branches terete, drooping, young parts densely hairy. Leaves simple, alternate, 6.0–12. 0 × 2.5–4. 0 cm, oblong or obovate, glabrous, midrib pubescent below, slightly unequally rounded at base, apex caudate acuminate, subsessile or petiole to 3 mm long, membranous; lateral nerves 10–14 pairs, intramarginal nerves sub-marginal, looping; margins entire, slightly curved, thickened. Flowers solitary, pseudo-terminal (slightly above and opposite the terminal leaf) greenish-yellow; pedicel 2–4 mm long, glabrous; bracts two, small, ovate; bracteoles two at the base, unequal, ovate-triangular, acute, ca. 1.5 mm long, hairy outside; sepals 3, ca. 1.5 × 2.0 mm, broadly ovate, acute, glabrous; outer petals 3, broadly ovate, acute, hairy on margins, slightly hooded, ca. 2.0 × 1.5 mm; inner petals 3, ovate-lanceolate, 2.0–2.4 × 0.8–1.3 cm, thick, fleshy, glabrous, thickly hooded on the lower half, cohering when young along margins, greenish-yellow with brown streaks inside; torus ovoid, long hairy; stamens many, 40–50, anthers in pairs, ca. 1 mm, connective included; staminodes absent; anthers extrorse; carpels 10–15, linear-oblong in outline, slightly curved, ca. 2 mm long, glabrous; stigma ovoid-acute, about half the height of the ovary, with viscous exudate; ovules 1 or 2. Fruiting stalk terete, 8–11 mm long; monocarps usually 8–12, each 10–12 mm across, obovoid, mammose, apex projecting, more or less obturbinate, glabrous, deep pink; stipe ca. 5 mm long. Seeds 1-2.

Phenology:—Flowering and fruiting occur during September to February.

Eponymy:—The specific epithet honors Padmashree Mr. A.M. Gokhalae (IAS, Retd.), former Director of the M.S. Swaminathan Research Foundation, Chennai, India, for being a great lover of plants and plant taxonomy; he prepared a detailed electronic database for more than 7000 species of Indian angiosperms, which is one of the pioneering comprehensive efforts in digitization and digital identification of the group in India.

Distribution and habitat:—Windward side of Wayanad-Silent Valley-Kodagu sub-cluster in the Nilgiri phytogeographical region of the Western Ghats. The range starts in Nadukani forests of Nilambur (Malappuram district) and extends to the Kakkayam and Thusharagiri forests of Kozhikode district through the evergreen forests in the western side of Wayanad Ghats.

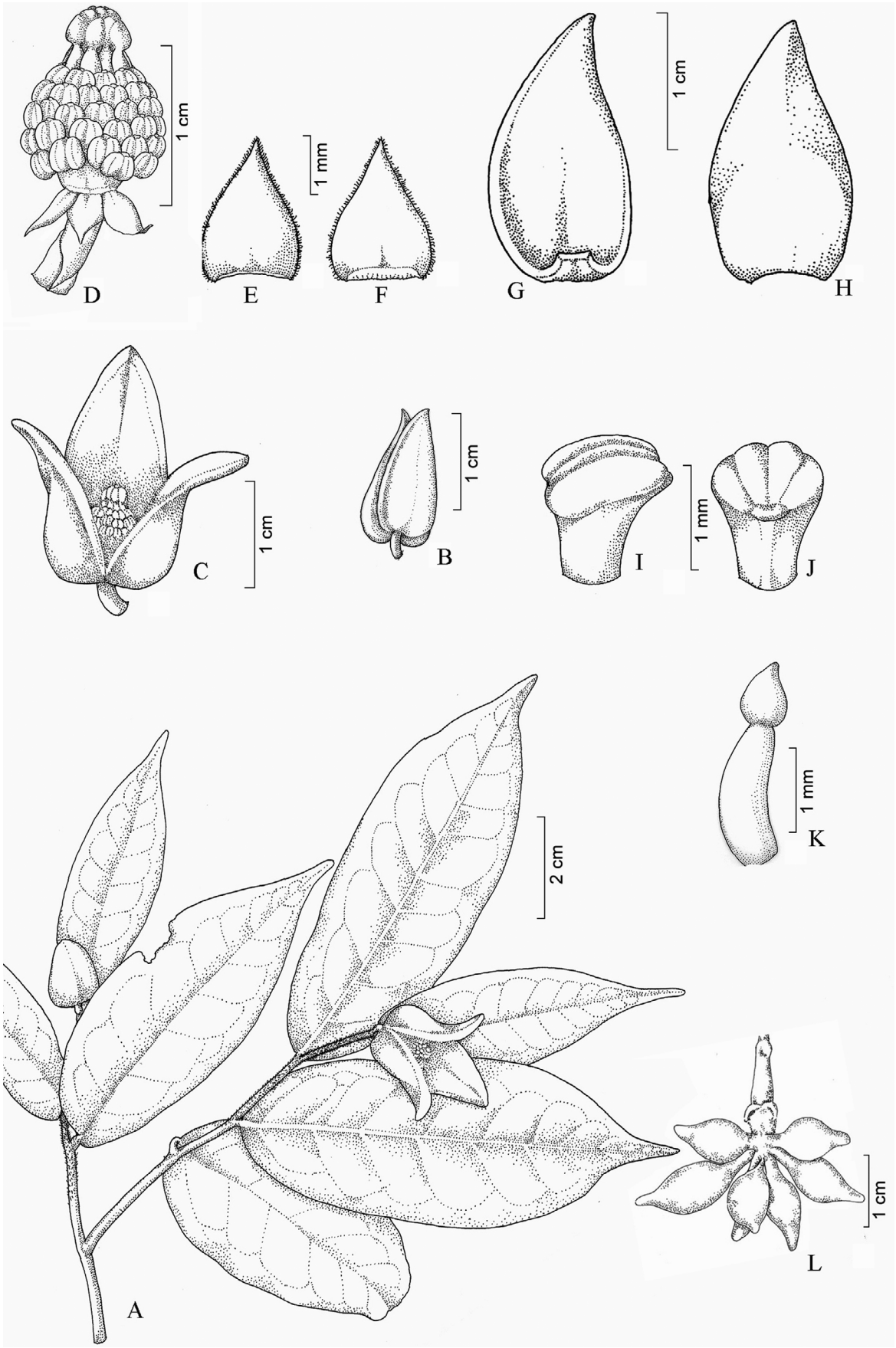

FIGURE 1. *Miliusa gokhalaei* A. Flowering branch. B. Flower bud. C. Mature flower. D. Flower with petals removed. E. Sepal. F. Outer petal. G. Inner petal, ventral view. H. Inner petal, dorsal view. I. Stamen, lateral view. J. Stamen, ventral view. K. Pistil. L. Infructescence with fruits. Drawings by K. M. Manudev from living specimens.

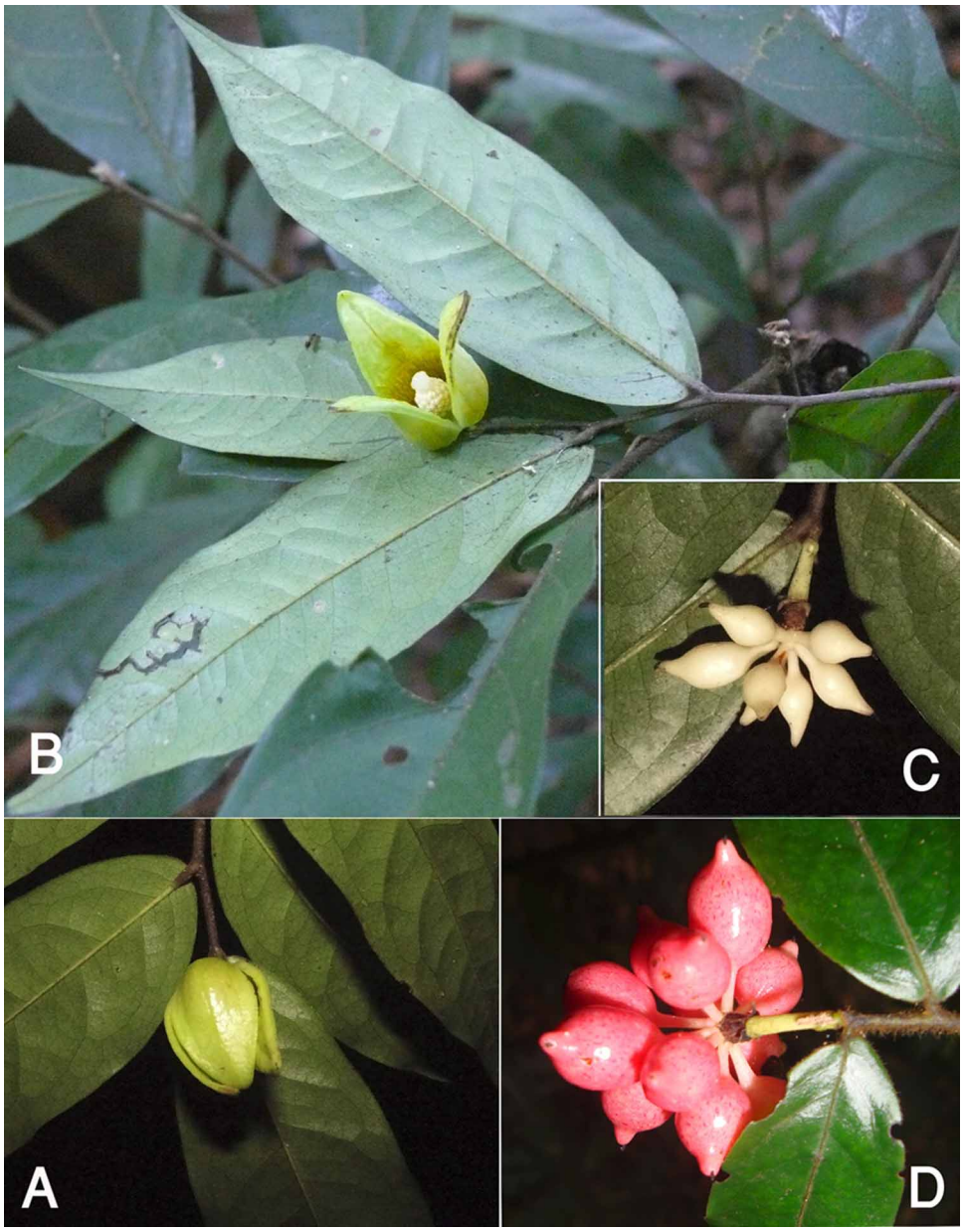

FIGURE 2. *Miliusa gokhalaei* A. Small twig with young flower. B. Branch with mature flower. C. Young fruit with cream-coloured monocarps. D. Mature fruit with pinkish monocarps.

Evergreen forests, at elevations of ca. 400–750 m a.s.l. are the ideal habitat of the new species. It is seen mostly along the slopes as a lower stratum tree or shrub with scandent branches. *Arenga wightii* Griffith (1845: 475) is a common associate in most of its habitats. Rare, endemic and endangered species of Annonaceae such as *Desmos lawii* Safford (1912: 506), *Goniothalamus wynaadensis* Beddome (1868-1874:13), *Meiogyne ramarowii* (Dunn1914: 183) Gandhi (1976: 38), *Orophea malabarica* Sasidharan & Sivarajan (1990: 269), *Polyalthia suberosa* (Roxburgh 1795: 31.t.34) Thwaites (1864: 398), *Sageraea laurina* Dalzell (1851: 207), etc. are also found in its northern distributional ranges. Endangered and economically important trees such as *Cynometra beddomei* Prain (1897: 478), *C. travancorica* Beddome (1873: 316), *Kingiodendron pinnatum* Harms (1897: 194), *Myristica beddomei* King (1891: 291), etc. are common in its habitats. *Artabotrys zeylanicus* Hooker & Thomson (1855: 128), *Desmos lawii*, *Smythea bombaiensis* (Dalzell 1851: 36) Banerjee & Mukherjee (1970: 214), etc. are the woody climbers common in the habitats. In Nadukani forests a critically endangered tree species, *Atuna indica* (Beddome 1864: 45) Kostermans (1969: 422), is seen along with this new species.

Interrelationships:—*Miliusa gokhalaei* is similar to *M. indica* and *M. eriocarpa* in having subsessile or shortly petiolate, hairy-nerved leaves, and axillary solitary flowers, flask-shaped carpel with 1–2 ovules. However, it differs in its unequal rounded leaf bases, sessile or shortly pedicellate flowers, thick fleshy petals, glabrous carpel and included connective of anther. The other related species is *Miliusa montana*, and the diagnostic morphological characters of the new species and the related species are given in table 1.

TABLE 1. Diagnostic morphological characters of *Miliusa ghokhalaei* sp. nov. and related species.

Characters	***M. gokhalaei***	***M. indica***	***M. Montana***	***M. eriocarpa***
Habit	Small trees, branches drooping, young parts densely hairy	Small trees, branches spreading, young parts pubescent	Shrubs, branches spreading, young parts glabrous	Shrubs, branches spreading, young parts strigose
Leaf shape and size	Oblong or obovate, caudate acuminate at apex, 6.0–12.0 × 2.5–4.0 cm	Oblong-elliptic or oblong-lanceolate, obtuse or acute at apex, 4.0–9.0 ×1.5–3.0 cm	Ovate or ovate-lanceolate, acute to shortly acuminate at apex, 5.0–7.0 × 2.0–2.7 cm	Elliptic-oblong to oblong-lanceolate, acute or slightly acuminate at apex, 4.5–9.0 × 2.5–2.8 cm
Position of intra-marginal looping nerves	Sub-marginal	Marginal	Marginal	Marginal
Petiole	Glabrous, 2–3 mm long	Pubescent, 1–2 mm long	Pubescent, 1–2 mm long	Tomentose, 1-2 mm long
Flowers	Pseudo-terminal, greenish yellow	Axillary, green	Leaf-opposed, white	Axillary, greenish pink
Pedicel	2–4 mm long, glabrous, greenish	3–6 mm long, glabrous, greenish	0.7–1.5 cm long, glabrous, greenish	2–3 mm long, pubescent, reddish
Sepals	Glabrous, sub-equal	Pubescent outside, equal	Pubescent outside, equal	Glabrous, sub-equal
Outer petals	Ovate, hairy on margins	Ovate, glabrous	Linear-lanceolate, ciliate	Lanceolate, glabrous
Inner petals	2.0–2.4 × 0.8–1.3 cm	1.2–1.6 × 0.6–0.7 cm	1.5–2.0 × 0.6–1.0 cm	1.0–1.7 × 0.3–0.5 cm
Stamens	With included connectives	With connectives rounded apiculate at top	With connectives slightly apiculate at top	With connectives rounded apiculate at top
Carpels	Linear-oblong, glabrous	Linear-oblong, densely pilose	Ovate, glabrous	Oblong, grey tomentose
Monocarps	Obovoid, apex projecting, more or less obturbinate, glabrous, deep pink	Ovoid or obovoid, apex acute or obtuse, silky pubescent, red	Sub-globose, apex obtuse, glabrous, red	Obliquely ellipsoid or oblong, apex apiculate, pubescent, red

Van Heusden (1992) studied morphology and evolution of flowers in Annonaceae and assigned key features for *Miliusa* group. Based on her characterization and structure of inner petals, the southern Indian-Sri Lankan and Andamanese species of *Miliusa* can be broadly classified into three groups - *Miliusa nilagirica* group, *Miliusa indica* group and *Miliusa velutina* group. *Miliusa nilagirica* group is peculiar among these because of the presence of recurved petals. However, van Heusden never noticed recurved petals in *Miliusa* group. This group is distinct from all others of the region in having fewer stamens. The peculiarity of *Miliusa velutina* group is the presence of flat inner petals. *Miliusa mukerjeeana* is the only other member of this group. All other species belong to *Miliusa indica* group in having saccate, sub-saccate or pouched petals. The new species also belongs to the *Miliusa indica* group in having saccate petals and numerous stamens.

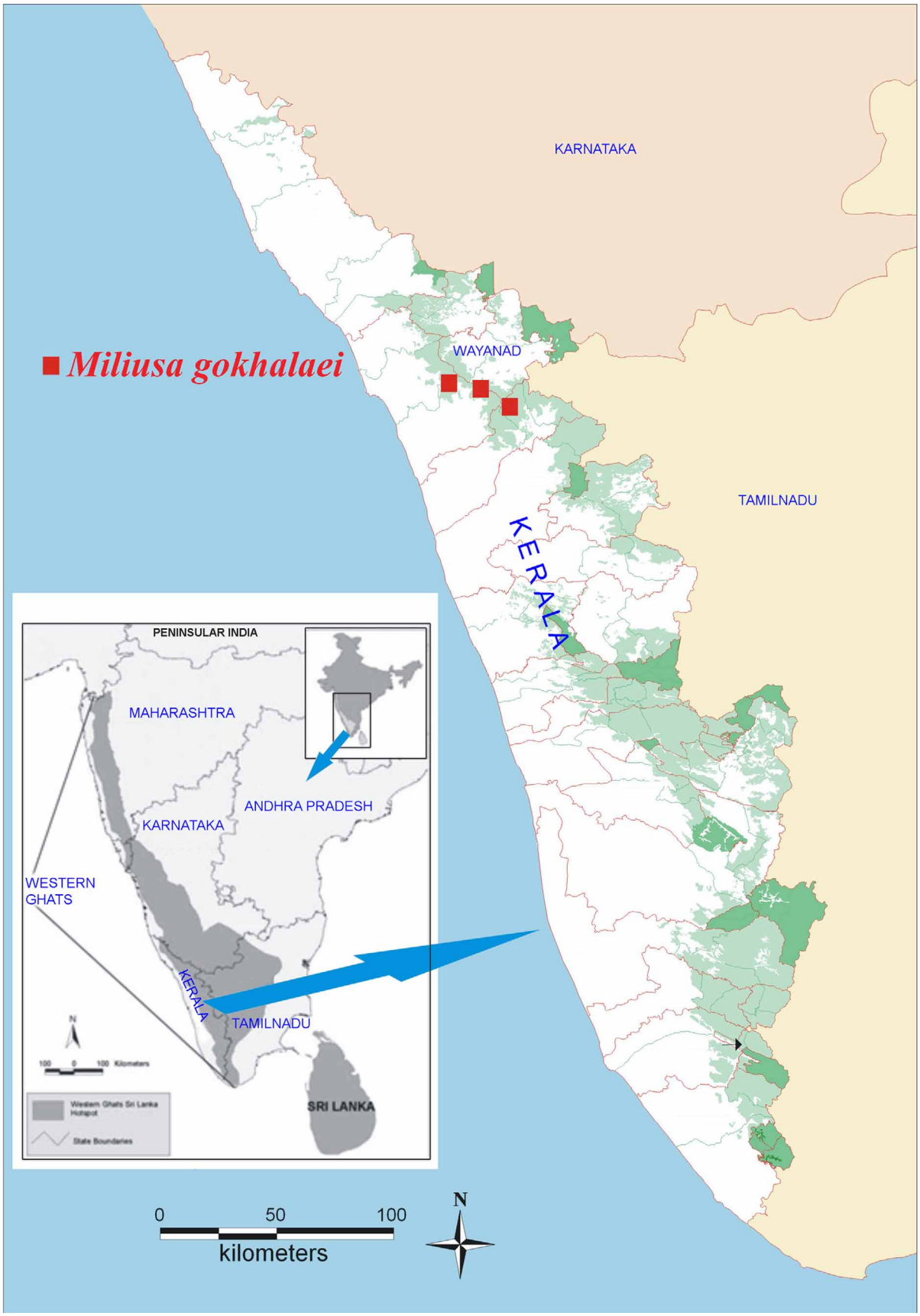

FIGURE 3. Distribution of *Miliusa gokhalaei* in India.

Additional specimens examined:—INDIA: Kerala: Wayanad District, Vythiri Ghats, 11° 30′ 24.3″ N, 76° 01′ 49.1″ E, 490 m, 30 September 2008 (with flowers), *Sujanapal & Narayanan MSSH 4320; Ibid*., 27 August 2009, *Sujanapal & Narayanan MSSH 4388* (with flowers); Malappuram District, Nadukani Forests (Nilambur), 11° 29′22.6″ N, 76° 15′ 19.4″ E, ± 510 m, 01 January 2009, *Sujana MSSH 4382* (with fruits); Kozhikode District, Kakkayam Forests 11° 32′ 12.2″ N, 75° 55′ 12.2″ E, ± 525 m, 22 October 2008 (with flowers), *Sujanapal & Narayanan MSSH 4378* (with flowers); Thusharagiri Forests, 11° 28′ 12.7″ N, 76° 08′ 11.2″ E, ± 450 m, 12 October 2008, *Sujanapal & Narayanan MSSH 4372* (Herbarium of CAbC-MSSRF, Wayanad).

Population structure and conservation status:—Populations of the new species are fragmented and seen in the lower storey, mainly along the western slopes of the Western Ghats between 400 m and 750 m a.s.l. in evergreen forests; they are represented by a few scattered mature individuals. There is no continuity in distribution from the southern to the northern populations. The southern-most population is located in the evergreen forests of Nadukani (Nilambur, Malappuram District). The major central population is in the Vythiri Ghats of Wayanad district and Thamarassery Ghats up to Kakkayam and Thusharagiri Range of Kozhikkode district at the northern tip.

In all locations, populations of this new species are small. Our observations showed that there were only nine mature individuals in a 1 km^2 area of Nilambur. Compared to Nilambur, the population is comparatively large in Wayanad and Kozhikkode forests with more or less continuous distribution from Thamarassery up to Peruvannamuzhi. Altogether the distribution of this new species is restricted to 50 km^2. None of the localities is protected. The population at Nilambur is adjacent to human habitation, and waste disposal, pollution and degradation of habitat due to the nearby Sate Highway-28 are the main threats to this population. Increased anthropogenic interference in the form of firewood collection deepens the crisis. In Thamarassery Ghats the population is near to the National Highway-212, and the area is highly subject to various kinds of disturbances. The habitats in Kakkayam and Peruvannamuzhi ranges are highly disturbed due to construction activities related to two reservoirs and the forthcoming hydroelectric project. These construction activities promote calamities like landslides, soil erosion, etc. since it is lying along the sharp western slopes. By following IUCN criteria (IUCN, 2001) for assessing the status of Rare and Threatened plants, *M. gokhalaei* is assessed as belonging to Critically Endangered (CR) category. Its range (extent of occurrence) is less than 100 km^2, the population is severely fragmented and the quality of habitat is declining continuously.

Key to the species and varieties of *Miliusa* in peninsular India

Subsequent to the discovery of the new species, the total number of species in peninsular India has been increased to 11 species and one variety, and a key is provided to facilitate easy identification of the taxa.

1. Medium trees, 7–20 m tall 2
- Shrubs or small trees, up to 5 m tall..... 5
2. Inner petal largely pouched below; ovules 6 or more..... 3
- Inner petal flat or shortly saccate below; ovules 1 or 2 4
3. Branchlets puberulous; pedicels to 1 cm long ..... *Miliusa longiflora*
- Branchlets tomentose; pedicels more than 1 cm long..... *Miliusa tomentosa*
4. Leaves velutinous; pedicel 4–8 cm long..... *Miliusa velutina* var. *velutina*
- Leaves glabrescent; pedicel to 4 cm long ..... *Miliusa velutina* var. *deviyarina*
5. Stamens 6–12, uni- or biseriate..... 6
- Stamens more than 15, many-seriate 7
6. Leaves cuneate at base; flowers purplish brown; stamens 8–12, uniseriate..... *Miliusa nilagirica*
- Leaves rounded at base; flowers green; stamens 6+3, biseriate ..... *Miliusa wayanadica*
7. Pedicels 2–4 cm long; monocarp pisiform 8
- Pedicels 0.2–1.5 cm long; monocarp globose, ovoid or obovoid..... 9
8. Branchlets glabrous; monocarp-apex apiculate. ..... *Miliusa wightiana*

- Branchlets hairy; monocarp-apex obtuse. ..... *Miliusa tirunelvelica*

9. Young branches strigose; sepals glabrous, subequal. ……. ..... ……. 10
- Young branches glabrous or puberulous; sepals pubescent, equal..... 11

10. Leaves with sub-marginal looping nerves; pedicel glabrous, greenish; carpels linear-oblong, glabrous..... ..... *Miliusa gokhalaei*
- Leaves with marginal looping nerves; pedicel pubescent, reddish; carpels oblong, grey tomentose .... *Miliusa eriocarpa*

11. Leaf tip obtuse or acute; carpels pilose. ..... *Miliusa indica*
- Leaf tip long acuminate; carpels glabrous. .... *Miliusa montana*

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