



Research article

## New species and new records of *Graphis* (Ostropales: Graphidaceae) from Eastern Ghats, India

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**Abstract:** A new species *Graphis neeladriensis*, and two new records, *G. plumierae* and *G. subalbostrata* are described from the Eastern Ghats of India. The newly described species is characterized by crustose, UV+ yellow thallus, sub-immersed to erumpent, short to elongate and simple to sparingly branched lirellae, 2–4 striate labia, laterally carbonized exciple, clear hymenium and terminally muriform ascospores.

**Keywords:** Rayalaseema - Seshachalam Biosphere Reserve - Lichens - Taxonomy.

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### INTRODUCTION

Recent studies on the global diversity within the lichen family Graphidaceae indicates that there are large numbers of undiscovered species in the family and at least 175 species have been discovered since 2002. Further analysis predicts that geographically Graphidaceae have a concentrated diversity in a few regions of the world including Southern India (Lücking *et al.* 2014). *Graphis* Staiger (2002) is a major genus under the lichen family Graphidaceae, comprising of around 370 species worldwide (Kirk *et al.* 2008, Lücking 2009, Joshi *et al.* 2010, Bárcenas-Peña *et al.* 2014, Singh *et al.* 2014, Joshi *et al.* 2014). 111 species of *Graphis* are known from tropical, subtropical and temperate regions of India (Singh & Sinha 2010) and recent studies added 17 more species to the genus (Chitale *et al.* 2011, Singh & Swanlatha 2011a,b, Gupta & Sinha 2012, Singh *et al.* 2014). Within the genus *Graphis* species having lichexanthone are rare and so far only five species such as *G. stipitata* A. W. Archer, *G. sauroidea* Leight., *G. haleana* R. C. Harris, *G. lucifica* R. C. Harris and *G. flavopalmicola* Y. Joshi, Lücking & Hur are reported (Lücking 2009, Joshi *et al.* 2010).

During the exploration on lichen in Rayalaseema forest of Andhra Pradesh a total of 126 species have been reported (Reddy *et al.* 2011, Nayaka *et al.* 2013, Anjali *et al.* 2013, Mohabe *et al.* 2014a,b & 2016) out of which only a single species *Diorygma junghuhnii* (Mont. & Bosch) Kalb, Staiger & Elix belonged to Graphidaceae. The explorations resulted in collection of several interesting specimens belonging to Graphidaceous taxa of which recently Mohabe *et al.* (2015a) described a new species *Diorygma kurnoolensis* Mohabe, Nayaka & Reddy. In the present communication a new species *Graphis neeladriensis* and new records for India, *G. plumierae* Vain. and *G. subalbostrata* Lücking are reported. The new species is unique in having lichexanthone in chemistry and terminally muriform ascospores.

### MATERIALS & METHODS

The present study is based on recently collected specimens from Neeladri range of Tirumala hills (Fig. 1A) and Mallaiah Konda hills of Thambalapalli from Chittoor district which comes under Seshachalam Biosphere Reserve in Andhra Pradesh of India. The external morphology of the specimens were observed under a Magnis MS 24/13 stereo-zoom microscope while anatomical characters of the thallus and apothecia were observed under a ZEISS Axiostar *plus* compound microscope. Thin hand cut sections of the thallus and apothecia were initially mounted in water to record the colour and measurements of various structures. The apothecial sections were then observed after applying aqueous 10% KOH solution while Lugol's solution (I) was used for iodine

reactions. The colour tests were performed by using routine reagents; aqueous solution of KOH (K), calcium hypochlorite (C), and paraphenylenediamine (P). The lichen substances were identified by thin-layer chromatography following literature (White & James 1985, Orange *et al.* 2001) and specimens were identified through world key to the genus *Graphis* (Lücking *et al.* 2009) and by comparison with the protologues. The nomenclature of Lücking *et al.* (2009) was followed for lirellae morphology. The specimens of the new species have been deposited in the Herbarium of CSIR-National Botanical Research Institute Lucknow (LWG), Uttar Pradesh, India and specimens of new records have been deposited in the Lichen Herbarium, Department of Botany, Yogi Vemana University (YVUH) Kadapa, Andhra Pradesh, India.

## RESULTS & DISCUSSION

### NEW SPECIES

*Graphis neeladriensis* Mohabe S, Anjali DB & Nayaka S *sp. nov.*

(Fig. 1A–F)

MycoBank No.: MB 819499

This species is characterized by sub-immersed to erumpent, short to elongate and simple to branched lirellae, 2–4 striate labia, laterally carbonized exciple, clear hymenium, 8-spored ascus, transversely 4–12 and terminally 1–2(–3) vertically septate ascospores and presence of lichexanthone in thallus.

**Type:** INDIA, Andhra Pradesh, Chittoor district, Tirumala hills, Neeladri range, on bark of *Artocarpus heterophyllus*, alt. ca. 650 m, 06.07.2014, Satish Mohabe & Anjali Devi B. 4097 (holotype-LWG).

*Thallus* greenish grey to grey, smooth to cracked, shiny, 80–160 µm thick, corticated; *cortex* hyaline, 20–35 µm thick; *algal layer* continuous 75–120 µm thick, *medulla* with oxalate crystals, 10–25 µm thick; *prothallus* indistinct or white.

*Ascomata* lirellate, variable, numerous, sub-immersed to erumpent, simple, short to elongate (towards centre) and sparingly branched (towards periphery), 0.2–3.5 mm long, 0.1–0.4 mm wide, end acute to obtuse, laterally covered by thalline margin in younger parts; *labia* epruinose, 2–4 striate; *disc* slit like closed, rarely open, epruinose; *exciple* dark brown to black, 50–90 µm thick, convergent, laterally carbonized; *hymenium* hyaline, clear, without oil globules, 175–225 µm wide, 85–200 µm high; *hypothecium* hyaline; *ascus* cylindrical, 40–150 × 14–20 µm, 8-spored, I–; *ascospores* hyaline, transversely 4–12 and vertical cells 1–3 in end locules (terminally muriform), 24–77 × 7–12 µm, I+ blue.

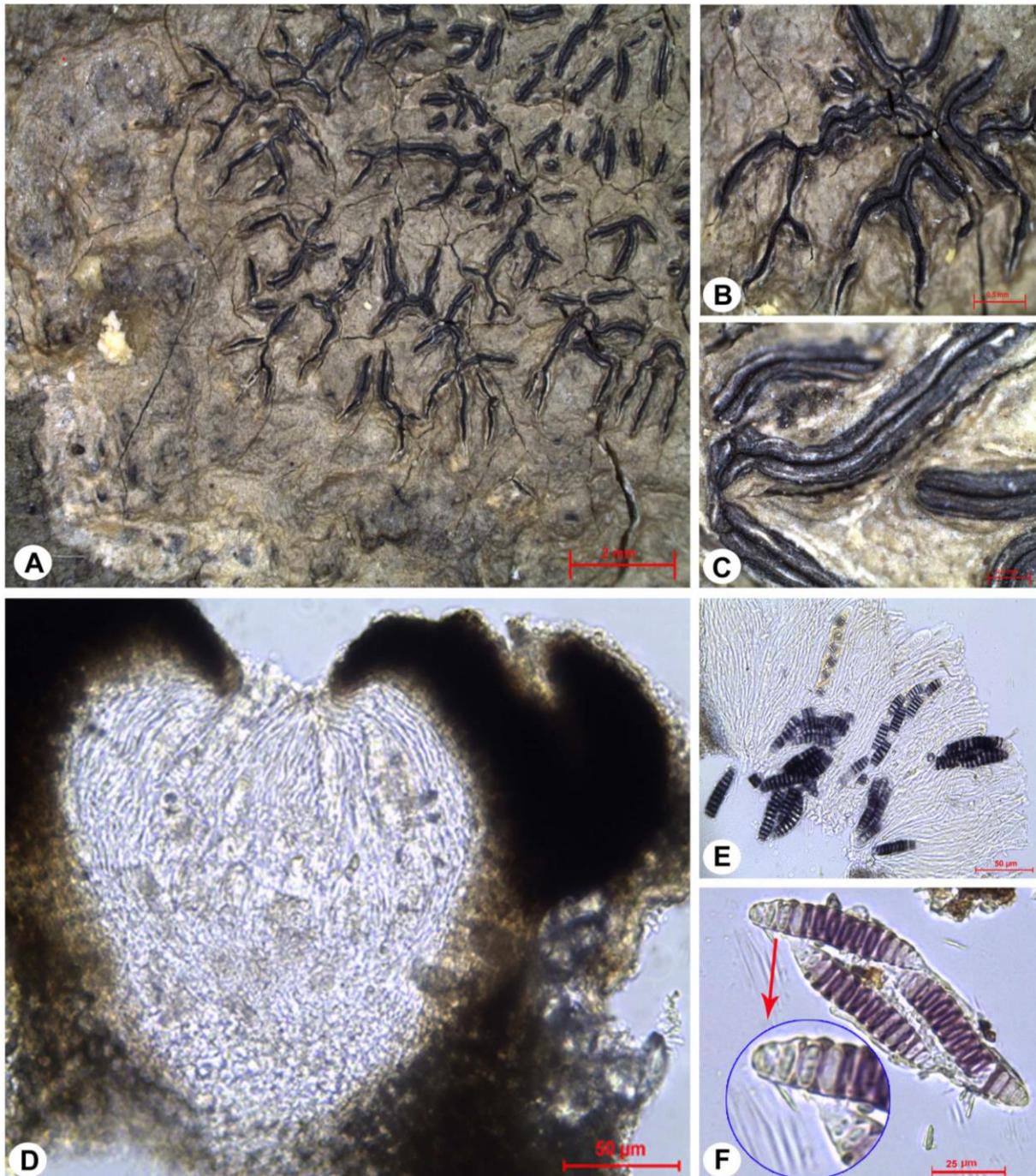
**Table 1.** Comparison of *Graphis* species containing lichexanthone. (New species is in bold)

Species name	Lirellae morph	Labia	Exciple	Hymenium	Septation	No. of septa	Spore length	Substance
1. <i>Graphis flavopalmiticola</i>	<i>handellii</i> -morph	entire	completely carbonized	clear	transversely septate	5–9-septate	19–27 µm	Unknown
2. <i>Graphis haleana</i>	<i>striatula</i> -morph	striate	completely carbonized	clear	transversely septate	9–19-septate	50–85 µm	Nil
3. <i>Graphis lucifica</i>	<i>striatula</i> -morph	striate	completely carbonized	clear	transversely septate	5–9-septate	20–40 µm	Nil
4. <i>Graphis neeladriensis</i> <i>sp. nov.</i>	<b><i>tenella</i>-morph</b>	<b>striate</b>	<b>laterally carbonized</b>	<b>clear</b>	<b>terminally muriform</b>	<b>4–12 transverse to 1–3 vertical - septate</b>	<b>24–77 µm</b>	<b>Nil</b>
5. <i>Graphis sauroidea</i>	<i>hossei</i> -morph	entire	completely carbonized	clear	transversely septate	4–5-septate	45–60 µm	Nil
6. <i>Graphis stipitata</i>	<i>hossei</i> -morph	entire	laterally carbonized	clear	transversely septate	7–15-septate	15–20 µm	Norstictic, connorstictic acid

**Chemistry:** Thallus K–, P–, C–, KC–, UV+ yellow; TLC: lichexanthone present.

**Distribution and Ecology:** *Graphis neeladriensis* is found growing on bark of *Artocarpus heterophylla* trees growing in the *In-situ* conservation garden of medicinal plants in Neeladri range of Tirumala hills, Chittoor district of Andhra Pradesh at an altitude of around 650 m. It was found growing in association with other crustose lichens such as *Bacidia* sp., *Graphis* sp., *Lecanora achroa* Nyl. and a foliose species *Hyperphyscia adglutinata* (Flörke) H. Mayrhofer & Poelt.

**Etymology:** The specific epithet is named after type locality Neeladri range which is the highest peak of Tirumala hills.



**Figure 1.** *Graphis neeladriensis* (holotype): **A–C**, Habit showing variations in lirellae; **D**, transverse section of lirellae; **E**, ascus with ascospores; **F**, terminally muriform ascospores in iodine.

**Remark:** *Graphis neeladriensis* resembles *Graphis neolongata* Lücking and *Graphis dichotoma* (Müll. Arg.) Lücking in having striate labia, laterally carbonized exciple, clear hymenium, terminally muriform or submuriform ascospores but both the species differs chemically by lacking lichexanthone in thallus. The lichexanthone containing species, *G. haleana*, and *G. lucifica* differs from new species with completely carbonized exciple and transversely septate ascospores, while *G. stipitata* differs in having entire labia, smaller ascospores and presence of norstictic and connorstictic acid. Further *G. flavopalmicola* and *G. sauroidea* have entire labia, completely carbonized exciple, transversely septate and smaller to medium ascospores. The comparative status of the new species among other lichexanthone containing species are given in table 1.

**Additional specimen examined:** INDIA, Andhra Pradesh, Chittoor district, Tirumala hills, Neeladri range, on bark of *Artocarpus heterophyllus*, alt. ca. 650 m, 06.07.2014, Satish Mohabe & Anjali Devi B. 4098 (isotype-LWG).

## NEW RECORDS

**1. *Graphis plumierae* Vain. Ann. Acad. Sci. fenn., Ser. A 6(7): 161 (1915). (Fig. 2A)**

*Thallus* whitish to greenish grey, smooth to cracked, corticated, 190–297  $\mu\text{m}$  thick; *cortex* hyaline, 23–39  $\mu\text{m}$  thick; *medulla* white with many crystals, 10–28  $\mu\text{m}$  wide; *algal layer* continuous 75–95  $\mu\text{m}$  thick; *prothallus* indistinct to brownish.

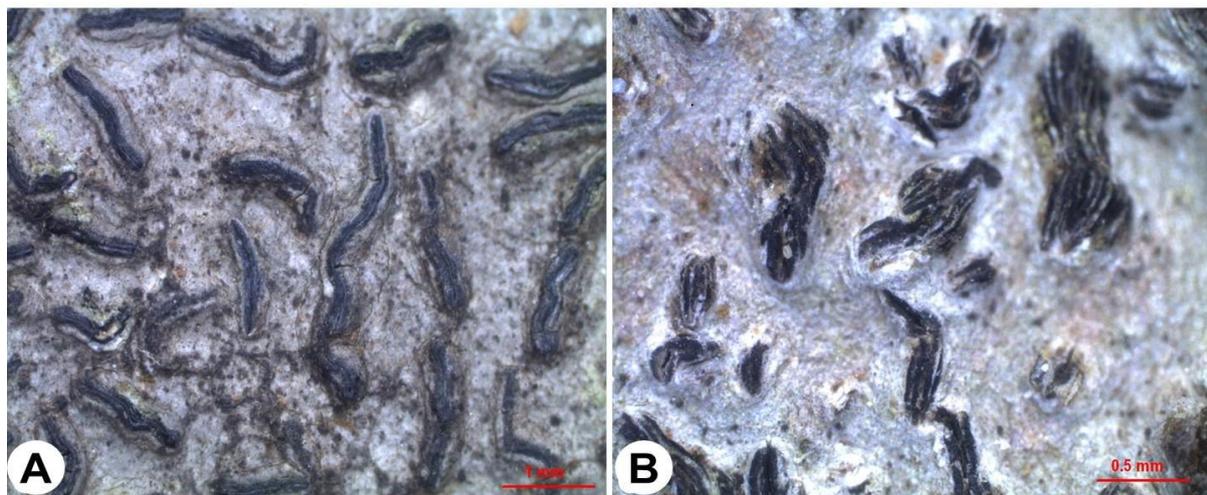
*Apothecia* lirellate, numerous, immersed to sub-immersed, simple to branched, 1.0–2.5 mm long, 0.3–0.7 mm wide, with rounded to acute ends; *labia* pruinose, laterally covered by thalline margin; *disc* concealed, epruinose; *epihyemium* 14–19  $\mu\text{m}$ , exciple dark brown to black, laterally carbonized, 25–62  $\mu\text{m}$  thick; *hymenium* inspersed, with oil globules, 122–149  $\mu\text{m}$  wide; *hypothecium* hyaline to yellowish brown 20–36  $\mu\text{m}$  high; *ascus* cylindrical, 64–100  $\times$  9–16  $\mu\text{m}$ , 8-spored; *ascospores* colourless, transversely 5–11 septate, 18–58  $\times$  6–10  $\mu\text{m}$ .

**Chemistry:** K+ yellow turning red, P+ yellow, KC–, C–; TLC: Norstictic acid, stictic and salazinic acid present.

**Distribution:** It is a Neotropical species earlier known from Guadeloupe, Mexico and in the present study it is found on tree trunks in tropical forests of Eastern Ghats in India.

**Remark:** *G. plumierae* Vain. has resemblance to *G. brevicarpa* M. Nakan., Kashiw. & K.H. Moon and *G. crebra* but differs by its concealed disc, white pruinose labia, immersed lirellae with lateral thalline margin and presence of norstictic acid with stictic and salazinic acid. Further *G. brevicarpa* differs by its apically thick complete thalline margin, epruinose labia and smaller ascospores while *G. crebra* has erumpent lirellae with lateral thalline margin, exposed disc with white pruina (*scripta*-morph).

**Specimens examined:** INDIA, Andhra Pradesh, Chittoor district, Thambalapalli, Mallaiah Konda Hills, alt. ca. 956 m, on bark, 05.01.2013, A. Madhusudhana Reddy & Satish Mohabe 2812 (LWG); Tirumala hills, Dharmagiri, alt. ca. 937 m, on bark, 07.02.2013, Anjali Devi B. & Satish Mohabe 3414 (YVUH).



**Figure 2.** Habit of *Graphis* species **A**, *Graphis plumierae* Vain.; **B**, *Graphis subalbostrata* Lücking.

**2. *Graphis subalbostrata* Lücking, Lichenologist 41(4): 363–452 (2009). (Fig. 2B)**

*Thallus* crustose, corticolous, whitish grey, thin, shiny, smooth to rough, continuous to discontinuous ecorticated; *prothallus* indistinct or absent.

*Apothecia* lirellate, lirellae simple, small, rarely branched, 0.5–1.5 mm long, 0.1–0.5 mm wide, erumpent to prominent, laterally covered by thallus; *disc* concealed, epruinose; *labia* partially black, with 7–8 striation, distinct white lines in-between striation, formed by clusters of calcium-oxalate crystals; *exciple* apically to peripherally carbonized, 21–27  $\mu\text{m}$  thick; *hymenium* clear, without oil globules; *ascus* cylindrical, 125–235  $\times$  20–30  $\mu\text{m}$ , 8-spored; *ascospores* colourless, fusiform, transversely 5–11-septate, 45–95  $\times$  8–12  $\mu\text{m}$ .

**Chemistry:** Thallus K–, KC–, C–, P–; TLC: No chemicals.

**Distribution:** It is a Neotropical species earlier recorded from Guadeloupe and in the present study it was found on tree trunks in tropical forest of Eastern Ghats in India.

**Remark:** *G. subalbostrata* is close to *G. patwardhanii* Kulk. but latter species has isidiate thallus. *G. subalbostrata* is also close to *G. olivacea* but it has dark olive-grey thallus, erumpent lirellae with apically thin and complete thalline margin, elongate and irregularly branched lirellae.

**Specimen examined:** INDIA, Andhra Pradesh, Chittoor district, Tirumala hills, Dharmagiri, on bark, alt. ca. 937 m, 07.02.2013, Anjali Devi B. & Satish Mohabe 3396, 3449, 3402, 3420 (YVUH); Shilathoranam, on bark, alt. ca. 958 m, 05.07.2013, Satish Mohabe & Anjali Devi B. 4034 (YVUH).

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