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

Satish Mohabe¹, Anjali Devi B.¹, Sanjeeva Nayaka² and A. Madhusudhana Reddy¹*  
¹Department of Botany, Yogi Vemana University, Vemanapuram, Kadapa-526003, Andhra Pradesh, India  
²Lichenology Laboratory, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow-226001, Uttar Pradesh, India  
*Corresponding Author: grassced@yahoo.com  
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Abstract: A new species Graphis neeladriensis, and two new records, G. plumierae and G. subbalbo striata 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.

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-Peñta 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 junghuhnnii (Mont. & Bosch) Kalb, Staiger & Elix belonged to Graphidaceae. The explorations resulted in collection of several interesting specimens belonging to Graphidaceae 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. subbalbo striata 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 Mallalah 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 Magnús MS 24/13 stereo-zoom microscope while anatomical characters of the thallus and apothecia were observed under a ZEISSL 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
our 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)

<table>
<thead>
<tr>
<th>Species name</th>
<th>Lirellae morph</th>
<th>Labia</th>
<th>Exciple</th>
<th>Hymenium Septation</th>
<th>No. of septa</th>
<th>Spore length</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Graphis flavopalmicola</em></td>
<td>handeli-morph</td>
<td>entire</td>
<td>completely carbonized</td>
<td>transversely septate</td>
<td>5–9-septate</td>
<td>19–27 µm</td>
<td>Unknown</td>
</tr>
<tr>
<td>2. <em>Graphis haleana</em></td>
<td>striatula-morph</td>
<td>striate</td>
<td>completely carbonized</td>
<td>transversely septate</td>
<td>9–19-septate</td>
<td>50–85 µm</td>
<td>Nil</td>
</tr>
<tr>
<td>3. <em>Graphis lucifera</em></td>
<td>striatula-morph</td>
<td>striate</td>
<td>completely carbonized</td>
<td>transversely septate</td>
<td>5–9-septate</td>
<td>20–40 µm</td>
<td>Nil</td>
</tr>
<tr>
<td>4. <em>Graphis neeladriensis</em></td>
<td>tenella-morph</td>
<td>striate</td>
<td>laterally carbonized</td>
<td>terminally muriform</td>
<td>4–12 transverse to 1–3 vertical - septate</td>
<td>24–77 µm</td>
<td>Nil</td>
</tr>
<tr>
<td>sp. nov.</td>
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<tr>
<td>5. <em>Graphis sauroidea</em></td>
<td>hossei-morph</td>
<td>entire</td>
<td>completely carbonized</td>
<td>transversely septate</td>
<td>4–5-septate</td>
<td>45–60 µm</td>
<td>Nil</td>
</tr>
</tbody>
</table>

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

**Distribution and Ecology:** *Graphis neeladriensis* is found growing on bark of *Arctocarpous 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.

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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 neoelongata* 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

   (Fig. 2A)
   Thallus whitish to greenish grey, smooth to cracked, corticated, 190–297 µm thick; cortex hyaline, 23–39 µm thick; medulla white with many crystals, 10–28 µm wide; algal layer continuous 75–95 µm 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; epihymenium 14–19 µm, exciple dark brown to black, laterally carbonized, 25–62 µm thick; hymenium inspersed, with oil globules, 122–149 µm wide; hypothecium hyaline to yellowish brown 20–36 µm high; ascus cylindrical, 64–100 × 9–16 µm, 8–spored; ascospores colourless, transversely 5–11 seporate, 18–58 × 6–10 µm.

   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).

   (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 µm thick; hymenium clear, without oil globules; ascus cylindrical, 125–235 × 20–30 µm, 8–spored; ascospores colourless, fusiform, transversely 5–11 seporate, 45–95 × 8–12 µm.

   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. subalbostriata* is close to *G. patwardhanii* Kulk. but latter species has isidiate thallus. *G. subalbostriata* 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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