



## An updated account on graphidoid taxa from the foot hills of Indian Himalaya

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### Abstract

During the study, we encountered 29 species of graphidoid lichens under 6 genera from 15 localities in Udham Singh Nagar and Jim Corbett National Park in the terai region of Kumaun Himalaya. In addition to this, the graphidaceous taxa from the region were sampled and segregated to provide a detailed account of graphidoid taxa also with their ecology and distribution within the area. The paper mainly emphasizes on the total account of the graphidoid taxa along with an updated taxonomic key, taxonomic treatment and distribution in the study area.

**Key words** – *Graphidaceae* – Jim Corbett National Park – Kumaun Himalaya – Terai – Udham Singh Nagar – Uttarakhand.

### Introduction

The Himalayan region has the longest bioclimatic gradient in the world extending from tropical, temperate to alpine climates. The foothills of Himalaya form a channel connecting higher land to the Indo-Gangatic plane of north India. The foothill region includes unique physiographic ecosystem as bhabhar and terai. The terai acts as a reservoir of all fertile slit and ground water percolating from adjacent zones, thus constitute a unique floristic diversity. Instead of experiencing remarkable anthropogenic activities, the region exhibits different group of organisms including lichens. Though, this part of the foot hills has exhaustively been surveyed for floristic account of angiosperms, fern and fern-allies; only cursory reports are available on the distribution and richness of lichens in terai region (Pant 1987, Singh & Sinha 2010).

In terms of diversity and biomass, lichen family *Graphidaceae* is the dominant component of the Western Ghats, the Eastern Himalayan region and the Andaman Islands, and very little is known about its diversity in the Western Himalayan region or in foot hills. Tropical forests in the foot hills of Uttarakhand provide perfect ground to represent *Graphidaceae* in Western Himalaya, and are the best alternative, as a short-cut, to evaluate or predict the diversity at higher elevations as well. The recent Indian literature catalogued a large number of graphidaceous lichens, and a few of them were reported from the foot hills [Jim Corbett Tiger Reserve and Udham Singh Nagar (Upreti & Chatterjee 1999a, Upreti & Divakar 2003, Upreti & Nayaka 2004, Upreti, et al. 2010, Singh & Sinha 2010, Mishra et al 2012,

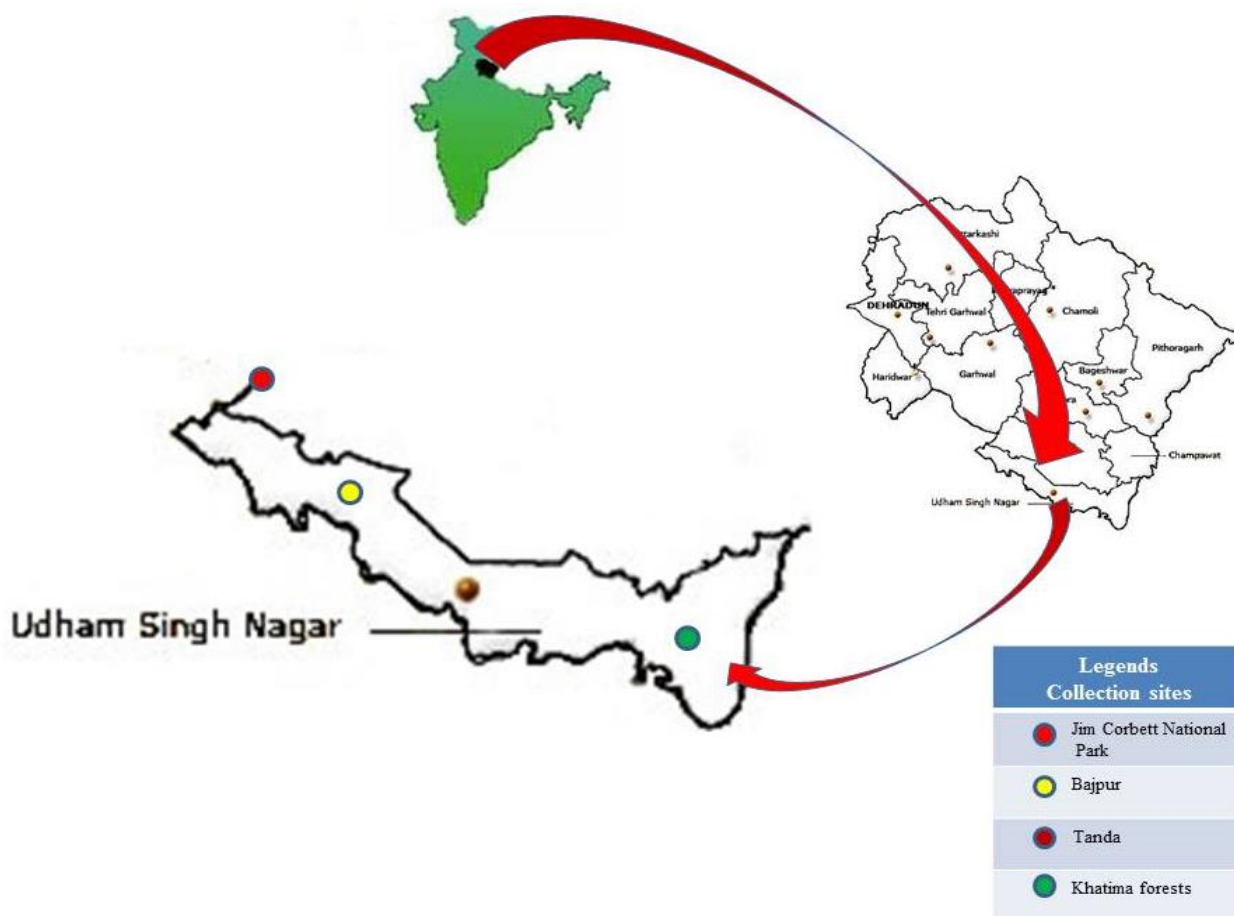


**Fig. 1** – **A.** Khatima forest, Khatima. **B.** Tanda forest, Rudrapur.

Mishra et al 2015)]. The family comprised of ca. 400 species in India, and ca. 280 species are represented by lirellate taxa (Singh & Sinha 2010). Globally, *Graphidaceae* (including thelotremoid) is one of the largest families of crustose lichens with more than 2000 species world-wide (Lücking et al., 2011, 2014). It prefers to grow in tropical and subtropical regions, generally colonize on bark and occasionally on rocks. The members of the family are the characteristic elements of tropical forest ecosystems and are the good indicators of forest type and health. The forests of terai in Kumaun chiefly comprised of *Syzygium cumini*, *Shorea robusta*, *Mallotus philippensis*, *Murraya koengii*, *Terminalia arjuna*, *Ficus benghalensis*, *Toona ciliata*, *Bauhinia* and *Cedrella tuna* (Fig 1)

The present work is the part of ongoing projects on lichen diversity in India. The major aim of which is to develop an annotation on Indian graphidoid taxa and mapping lichen rich sites for the family *Graphidaceae*. In this contribution, we provide data on an artificial *Graphidaceae* key representing graphidoid taxa recorded by far from the foot hills of Western Himalaya in India together with material collected during a field trip to the foot hills of Himalaya and present here in addition to previous reports known from this region.

## Materials & Methods



**Fig. 2** – Map of Terai region of Kumaun Himalaya, Uttarakhand

The study is based on more than 150 specimens collected during the month of September 2015 from the study area (Fig 2) and the old specimens preserved in the herbarium of CSIR-National Botanical Research Institute, Lucknow (LWG). The samples were carefully examined for morphological and anatomical studies using recent microscopic techniques. The external morphology has invariably been studied under dissecting microscope (MSZ-TR). The anatomy of the thallus and apothecia were studied under compound microscope (LEICA DM 500). Thin hand cut sections of the apothecia were initially mounted in plain water to trace the colour and measurements of various structures. The chemical tests were confirmed following protocols provided by Orange et al (2001). The relevant literatures (Awasthi 1991, Staiger 2002, Lücking et al 2009) were consulted to facilitate identification.

## Results

### *Key to the graphidoid taxa in terai region of the Himalaya*

- |  |    |
|--|----|
| 1. Proper exciple carbonized.....                                    | 2  |
| 1. Proper exciple uncarbonized to occasionally carbonized .....      | 16 |
| 2. Labia entire .....  | 3  |
| 2. Labia striate.....  | 13 |
| 3. Labia apically to laterally carbonized.....                       | 4  |
| 3. Labia laterally carbonized, ascospores transversely septate ..... | 5  |

4. Ascospores muriform, lirellae immersed to erumpent, with thick lateral to thick complete thalline margin, elongate and irregularly branched ( <i>subserpentina</i> -morph), 1–2 per ascus, stictic acid present .....	<i>Graphis streblocarpa</i>
4. Ascospores transversely septate, thallus ecorticate, farinose, lirellae immersed to erumpent with lateral thalline margin and <i>glaucescens</i> -morph) .....	<i>Graphis glaucescens</i>
5. Hymenium inspersed .....	6
5. Hymenium clear.....	7
6. Norstictic acid present, disc exposed and white pruinose .....	<i>Graphis crebra</i>
6. Lichen substances absent, disc concealed, labia epruinose .....	<i>Graphis lineola</i>
7. Lichen substances present.....	8
7. Lichen substances absent .....	12
8. Norstictic acid present .....	<i>Graphis pyrrocheiloides</i>
8. Stictic acid present or norstictic acid additionally with stictic acid and/or salazinic acid present .....	9
9. Stictic acid present .....	<i>Graphis longiramea</i>
9. Norstictic and/or stictic acid and/or salazinic acid present .....	10
10. Norstictic and stictic acids present.....	<i>Graphis ajarekarii</i>
10. Norstictic acid, salazinic acid and/or stictic acid present .....	11
11. Norstictic and salazinic acids present .....	<i>Graphis capillacea</i>
11. Norstictic, stictic and salazinic acids present.....	<i>Graphis subasahine</i>
12. Disc concealed, labia epruinose, lirellae with <i>deserpens</i> -morph .....	<i>G. pinicola</i>
12. Disc exposed, white pruinose, labia sometimes thinly pruinose, lirellae with <i>scripta</i> -morph	<i>Graphis scripta</i>
13. Labia laterally carbonized, lirellae with <i>stritula</i> -morph, hymenium clear, lirellae prominent lacking thalline margin, lichen substance absent.....	<i>Graphis duplicate</i>
13. Labia apically to peripherally carbonized.....	14
14. Ascospores muriform, lichen substances absent, lirellae with <i>sympecta</i> -morph	<i>Graphis paraserpens</i>
14. Ascospores transversely septate.....	15
15. Norstictic and stictic acids present, lirellae erumpent to prominent, lacking thalline margin, elongate and irregularly branched, labia epruinose ( <i>striatula</i> -morph), hymenium clear ascospores 30–60 µm long .....	<i>Graphis nigroglauca</i>
15. Lichen substances absent, lirellae with <i>tenella</i> -morph .....	<i>Graphis chlorotica</i>
16. Apothecia fissured, labia weakly develop or absent, disc not visible.....	17
16. Apothecia otherwise but not fissured.....	18
17. Ascospores transversely 3-septate, 10–14 × 4–5 µm, mostly amyloid, apothecial margins concolorous with the thallus .....	<i>Fissurina dumastii</i>
17. Ascospores muriform, 27–35 × 10–18 µm, non-amyloid, apothecial margins slightly paler than the thallus.....	<i>Fissurina cingalina</i>
18. Apothecial disc concealed, labia well developed, ascospores hyaline .....	19
18. Apothecial disc open, labia poorly developed, ascospores hyaline to brown.....	21
19. Lichen substances absent, apothecia upto 10 mm long, divaricately branched, branches compact, labia striate, proper exciple pale brown to yellowish or hyaline, ascospores 4–7-septate, 20–40 × 7–11 µm long .....	<i>Hemithecium divaricoides</i>
19. Norstictic and stictic acids present.....	20
20. Apothecia 2–7 mm long, simple to dendroidally branched, labia entire to indistinctly striate, ascospores transversely septate, 30–40(–60) × 6–9 µm .....	<i>Hemithecium nakanishianum</i>
20. Apothecia mostly simple to branched, labia distinctly striate .....	<i>Hemithecium aphanes</i>
21. Ascospores small, ovoid <25 µm.....	22
21. Ascospores large, if small not ovoid.....	23
22. Apothecia emergent, simple, short, curved, ≤1–5 mm long, labia entire, disc open, grayish, proper exciple pale brown, ascospores brown, transversely 3-septate, 10–15 × 4–6 µm, thallus lacking lichen substances .....	<i>Platythecium albolabiata</i>



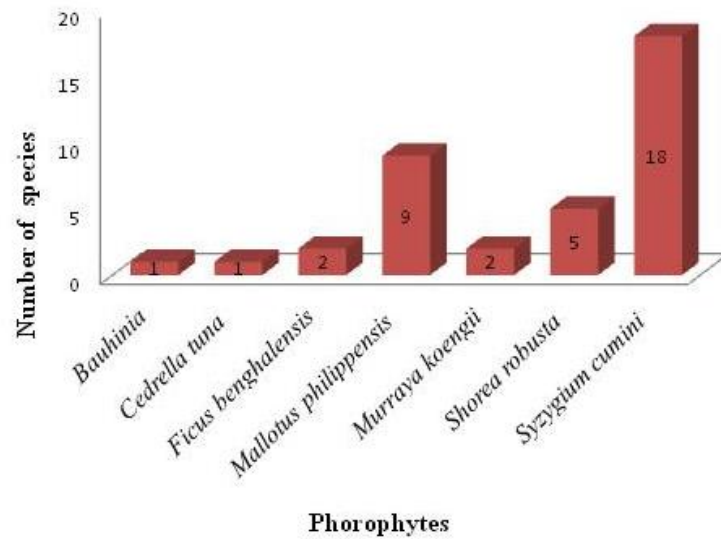
22. Apothecia emergent, simple to irregularly branched, $\leq 10$ mm long, labia crenate, disc open, reddish brown, proper exciple pale brown, ascospores hyaline, $15\text{--}17 \times 1\text{--}8 \mu\text{m}$ , thallus producing norstictic acid.....	<i>Platythecium dimorphodes</i>
23. Thallus mostly loose, dull, pseudocortex visible or not .....	<b>24</b>
23. Thallus glossy, corticated .....	<b>26</b>
24. Thallus producing norstictic acid as major lichen substance, ascospores muriform, hyaline, $\leq 135 \mu\text{m}$ long.....	<i>Diorygma junghuhnii</i>
24. Thallus producing stictic acid as major lichen substance .....	<b>25</b>
25. Lirellae immersed with indistinct thalline margins, disc open, ascospores 2–6 per ascus, $80\text{--}220 \times 21\text{--}55 \mu\text{m}$ .....	<i>Diorygma megasporum</i>
25. Lirellae mostly immersed with indistinct thalline margins, disc broad, ascospores 1 per ascus, $95\text{--}150(170) \times 30\text{--}45 \mu\text{m}$ .....	<i>Diorygma hieroglyphicum</i>
26. Ascospores muriform.....	<b>27</b>
26. Ascospores transversely septate.....	<b>28</b>
27. Lirellae emergent to sessile, scattered straight, curved or sinous, disc white pruinose, ascospores pale brown, muriform, $3\text{--}7 \times 1\text{--}2$ septate, $23\text{--}35 \times 10\text{--}13 \mu\text{m}$ , thallus lacking lichen substances .....	<i>Phaeographis caesioradians</i>
27. Lirellae immersed, simple to dichotomously branched, 1–5 mm long.....	<i>Phaeographis formula</i>
28. Lirellae dispersed, stellate, radiate, dendroid or divaricately branched and flexuose, labia convergent, proper exciple pale brown to brown, disc caesiopruinose, blackish, ascospores brown, 4–8-septate, $28\text{--}38 \mu\text{m}$ long.....	<i>Phaeographis instrata</i>
28. Lirellae uniformly distributed throughout the thallus, simple to furcate, elongate, labia narrow, labia vertical to divergent, proper exciple brown, ascospores brown, 4–5-septate, $16\text{--}22 \mu\text{m}$ long .....	<i>Phaeographis subdividens</i>

## Result & Discussion

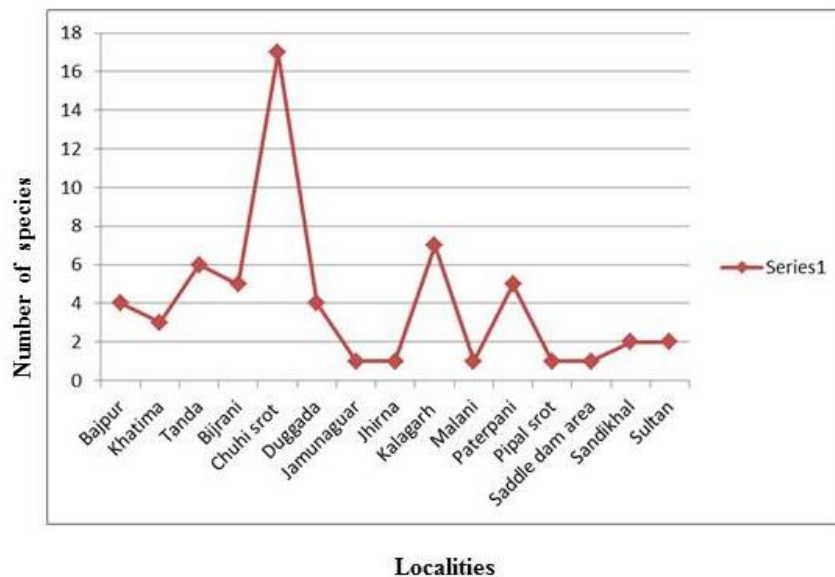
The study revealed an occurrence of 29 species belonging to 6 genera under the family *Graphidaceae*. Lichen genus *Graphis* with 15 species exhibits its dominance followed by *Phaeographis* represented by 4 species. The genera *Diorygma* and *Hemithecium* represents each with 3 species, whereas *Fissurina* and *Platythecium* exhibit 2 species each.

A distinct distribution pattern of trees have been observed in the localities surveyed, which largely influenced the distribution of graphidoid taxa. The evergreen *Syzygium cumini* trees are the most common associates of *Shorea robusta* in moist places and also along the streams. Both the trees provide suitable condition for colonization of different lichen genera including *Graphidaceae*. About eighteen species of *Graphidaceae* were found growing on *Syzygium cumini*, followed by *Shorea robusta* represented by five lichen species. Both the trees offer variable habitats from tree trunks up to the branches. In 2005, Satya et al, reported occurrence of 60 lichen species individually on *Shorea robusta* which confirms the tree as a perfect host for lichens in terai region. Members of *Graphidaceae* in general prefer semi-exposed habitats and their distribution on the trees varies among different species. Most of the taxa were collected from the smooth bark of tree twigs, while some prefer to grow in the crevices of undulating hard tree trunks. *Mallotus philippensis* trees have hard wood with a thin, smooth upper surface preferred by nine species of *Graphidaceae* out of total lichen species recorded from the region. Two species of *Graphidaceae* (*Diorygma hieroglyphicum* & *Graphis chlorotica*) were found growing on a small shrubby plant *Murraya koengii*. *Ficus benghalensis*, commonly growing in the Udham Singh Nagar district inhabits two species of *Graphis*. The herbaceous *Bauhinia* and *Cedrella tuna* along roadside plantations were inhabited by single species of *Diorygma* and *Graphis* respectively (Fig. 3).

Fifteen sites were explored to study the distribution of graphidaceous taxa in the terai region of Kumaun Himalayas in order to provide the status of graphidaceous rich sites. The Chuhi srot area has the maximum diversity of graphidoid taxa represented by 17 species. Kalagarh, Tanda forests, Bijrani and Paterpani were surveyed for seven, six species and five species each respectively. Bajpur presents four graphidaceous lichens, while the dense canopied forest of Khatima appeared less favourable for



**Fig. 3** – Distribution of graphidaceous taxa in Terai region



**Fig. 3** – Distribution of graphidaceous taxa in different sites in Terai region

*Graphidaceae*, therefore, represented by only three species of *Graphis* and Duggada shows four species of *Graphidaceae* under the three genera separately viz. *Diorygma*, *Graphis*, *Hemithecium*. The Bijrani & Paterpani are the important grasslands of the Jim Corbett National Park. The Sandikhal and Sultan is represented by two species of graphidioid taxa whereas the four sites were comparatively poorer in lichen growth and represented by only single species in *Graphidaceae* are Jhirna, Jamunaguar, Malani, Pipal srot and Saddle area dam. The taxa growing in these sites are *Platythecium albolabiatum*, *Phaeographis caesioradians*, *Hemithecium aphanes* and *Graphis duplicata* respectively (Table1, Fig 4).

Having rich diversity of phorophytes, only the bark inhabiting (corticolous) lichens are dominant growing along the roadside in semi-exposed conditions. The possibility behind the maximum diversity in Chuhi srot and species splendidly growing on *Syzygium cumini* may be attributed due to moist and shady site as well as abundance of both the trees in the surveyed area.

**Table 1** Distribution of graphidaceous taxa in Udham Singh Nagar district and Localities of Jim Corbett National Park

S. No.	Lichen Taxa	GF	Substrate	Localities														
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	<i>Diorygma hieroglyphicum</i> (Pers.) Staiger & Kalb.	Cr	<i>Mallotus philippensis</i> , <i>Murraya koengii</i>		+													
2.	<i>Diorygma junghuhnii</i> (Mont & Bosch.) Kalb. Staiger & Elix	Cr	<i>Syzygium cumini</i> <i>Mallotus philippensis</i>	+				+				+						
3.	<i>Diorygma megasporum</i> Kalb. Staiger & Elix	Cr	<i>Bauhinia</i>							+								
4.	<i>Fissurina cingalina</i> (Nyl.) Staiger	Cr	On bark					+										
5.	<i>Fissurina dumastii</i> Fée	Cr	<i>Syzygium cumini</i>					+										
6.	<i>Graphis ajarekarii</i> Patw. & C. R. Kulk.	Cr	<i>Syzygium cumini</i>					+				+						
7.	<i>Graphis capillacea</i> Stirt.	Cr	<i>Syzygium cumini</i>					+				+						
8.	<i>Graphis chlorotica</i> A. Massal.	Cr	<i>Murraya koengii</i> , <i>Mallotus philippensis</i>	+		+												
9.	<i>Graphis crebra</i> Vain.	Cr	<i>Shorea robusta</i> , <i>Mallotus philippensis</i>		+	+											+	
10.	<i>Graphis duplicata</i> Ach.	Cr	On bark					+									+	
11.	<i>Graphis glaucescens</i> Fée	Cr	<i>Cedrella tuna</i>									+						
12.	<i>Graphis lineola</i> Ach.	Cr	<i>Ficus bengalensis</i>	+	+													
13.	<i>Graphis longiramea</i> Müll Arg.	Cr	<i>Ficus bengalensis</i>		+													
14.	<i>Graphis nigroglauca</i> Leighton	Cr	<i>Syzygium cumini</i>					+										
15.	<i>Graphis paraserpens</i> Lizano & Lücking	Cr	<i>Syzygium cumini</i>					+	+									
16.	<i>Graphis pinicola</i> Zahlbr.	Cr	<i>Syzygium cumini</i>					+				+						
17.	<i>Graphis pyrrocheiloides</i> Zahlbr.	Cr	<i>Syzygium cumini</i> , <i>Shorea robusta</i> , <i>Mallotus philippensis</i>		+		+										+	

S. No.	Lichen Taxa	GF	Substrate	Localities										
18.	<i>Graphis scripta</i> (L.) Ach.	Cr	<i>Syzygium cumini</i> , <i>Shorea robusta</i> , <i>Mallotus phillipensis</i>	+	+	+	+	+	+	+	+	+	+	+
19.	<i>Graphis streblocarpa</i> (Bél) Nyl.	Cr	<i>Syzygium cumini</i>										+	
20.	<i>Graphis subashinae</i> Nagarkar & Patw.	Cr	<i>Syzygium cumini</i>										+	
21.	<i>Hemithecium aphanes</i> (Mont.) Nakan. Kashw.	Cr	<i>Mallotus phillipensis</i> , <i>Syzygium cumini</i>											
22.	<i>Hemithecium divaricoides</i> (Räsänen) V. Tiwari & Upreti	Cr	<i>Syzygium cumini</i>											
23.	<i>Hemithecium nakanishianum</i> (Patw. & C.R. Kulk.) Makhija & A. Dube.	Cr	<i>Syzygium cumini</i> , <i>Mallotus phillipensis</i>											
24.	<i>Phaeographis caesioradians</i> (Leight.) A. W. Archer	Cr	<i>Syzygium cumini</i>											+
25.	<i>Phaeographis firmula</i> (Stirton) V. Tewari and Upreti	Cr	<i>Syzygium cumini</i>											
26.	<i>Phaeographis instrata</i> (Stirton.)6Zahlbr.	Cr	<i>Shorea robusta</i>											
27.	<i>Phaeographis subdividens</i> (Leighton) Müll. Arg.	Cr	<i>Syzygium cumini</i>											
28.	<i>Platythecium albolabiatum</i> (Patw. & C.R. Kulk.) A.W. Archer	Cr	<i>Shorea robusta</i>											
29.	<i>Platythecium dimorphodes</i> (Nyl.) Staiger	Cr	<i>Syzygium cumini</i> , <i>Mallotus philippensis</i>											

Abbreviations : GF-Growth form, 1 Bajpur, 2 Khatima, 3 Tanda, 4 Bijrani, 5 Chuhi srot, 6 Duggada, 7 Jhirna, 8 Kalagarh, 9 Malani, 10 Paterpani, 11 Pipal srot, 12 Saddle dam area, 13 Sandikhal, 14 Sultan, 15 Jamunagaur.



1. *Diorygma heiroglypticum* (Pers.) Staiger & Kalb in Kalb, Biblioth. Lichenol. 85: 151. 2002. Fig. 5

The species is characterized by greenish to whitish tinge smooth, often with finely cracked, 120–140 µm thick thallus, immersed to semi-emergent lirellae with indistinct thalline margins, entire pruinose labia, broad disc (0.2–0.4), brown, non-carbonized, poorly developed exciple, clear hymenium, 1-spored asci, muriform, hyaline, 95–150 (–170) × 30–45 µm ascospores and the presence of stictic acid in the thallus. In the study area, the species was found growing on two different phorophytes (*Mallotus philippensis* and *Murraya koengii*) in Tanda forests near Rudrapur.

Material examined – India: Uttarakhand, Udham Singh Nagar district, Tanda forests near Rudrapur, alt. 260 m, 27.10. 2009, on *Mallotus philippensis* bark, D. K. Upreti et al 09–012712, 09–012711 (LWG); – on *Murraya koengii* bark, D. K. Upreti et al 09–012714 (LWG).

2. *Diorygma junghuhnii* (Mont. & Bosch) Kalb, Staiger & Elix. Symb. Bot. Upsal. 34(1): 157. 2004. Fig. 6

The taxon exhibits creamy, white pale grey or greenish grey, rough, dull, 80–90 µm thick thallus uneven often along the lirellae, non-carbonized, slightly divergent, poorly developed proper exciple, clear hymenium, 1–2-spored asci, muriform, hyaline 25–31 × 6–10 locular ascospores of 84–134 × 29–42 µm and the presence of norstictic and constictic acids. Previously, it has been collected from the trees of *Syzygium cumini* near Kalagarh and Chuhi Srot along the stream in Jim Corbett National Park; however, recorded on *Mallotus philippensis* in Bajpur, on the way to Kaladhungi in Udham Singh Nagar.

Material examined – India: Uttarakhand, Jim Corbett National Park, Kalagarh, Chuhi srot along the stream, on Jamun tree, 09.11.1997, D. K. Upreti 214026/C (LWG); India Utter Pradesh, Jim Corbett National Park, Kalagarh, Chuhi Srot, along the stream, on *Syzygium cumini* tree trunk, 09.11.1997, D. K. Upreti 214015 (LWG); India: Uttarakhand, Udham Singh Nagar, Bajpur, on the way to Kaladhungi, on bark of *Mallotus philippensis* 03.09.2015, S. Mishra & G. K. Mishra 027712 (LWG).

3. *Diorygma megasporum* Kalb. Staiger & Elix. Symb. Bot. Upsal. 34(1): 160. 2004. Fig. 7

The species is characterized by whitish cream coloured to pale grey or greenish grey, rough uneven, continuous or cracked, 50–100 µm thick thallus, irregularly flexuous branched and immersed, 0.5–4 mm long lirellae with indistinct thalline margin, non-carbonized, pruinose labia, exposed disc, hyaline and clear hymenium, 2–6-spored asci, muriform 28–57 × 7–12 locular ascospores of 80–170(–220) × 21–55 µm size, and a thallus producing stictic, constictic, norstictic and hypostictic acids. Upreti & Tandon (1999) collected the species from the foothills, where it was found growing on *Bauhinia* in Duggada, area of Jim Corbett National Park.

Material examined – India: Uttar Pradesh, Jim Corbett Tiger Reserve, Duggada, 900m, on *Bauhinia* species tree trunk, 03.12.1999, D. K. Upreti & Jyoti Tandon 217451(LWG).

4. *Fissurina cingalina* (Nyl.) Staiger Biblioth. Lichenol. 85: 128. 2002. Fig 8

The species exhibits greenish grey, cracked, smooth, glossy thallus, brownish branched, 1–4 mm long immersed lirellae covered by thalline margin, entire, epruinose labia, convergent non-carbonized proper exciple, hyaline and clear hymenium, 8-spored asci, hyaline, muriform (7–9 × 2–3 septate), 27–35 × 10–18 µm ascospores, and no lichen substances in thallus. In the foothills, the species has been collected from Chuhi srot, Jim Corbett National Park.

Material examined – India: Uttarakhand, Jim Corbett Tiger Reserve, Chuhi srot, on bark, 08 .03.2002, D. K. Upreti & Fazal Hussain 217492 (LWG).

5. *Fissurina dumastii* Fée, Essai sur les cryptogames des écorces exotiques officinales: 90. 1825. Fig 9

The species is well characterized by brown uneven slightly glossy thallus, simple to branched, immersed to raised lirellae, fissured, 3–7 mm long, non-carbonized, brown to hyaline, proper exciple, hyaline and clear hymenium, 8-spored asci, hyaline transversely 3-septate ascospores of 10–14 × 4–5 µm size, and a thallus lacking lichen substances. In the foothills, the species has been collected from Chuhi srot, Jim Corbett Tiger Reserve, where it was found growing on phorophyte *Syzygium cumini*.

Material examined – India: Uttarakhand, Jim Corbett Reserve National Park, Chuhi srot, on *Syzygium cumini*, 08.03.2002, D. K. Upreti & F. Hussain 219423 (LWG).

**6. *Graphis ajarekarii*** Patw. & C. R. Kulk., Norwegian Journal of Botany 26 (1): 45 1979.

Fig 10

The major distinguishing characters of the species include: olive-grey thallus producing dichotomously branched, flexuous 0.5–1.7 mm long lirellae covered at base with thallus, entire and epruinose labia, laterally carbonized proper exciple, concealed disc, clear hymenium, small transversely septate (20–) 30–40 × 6–8 µm ascospores and a thallus containing constictic, norstictic and stictic acids. In terai region, *Graphis ajarekarii* has a wide distribution on trees of *Syzygium cumini* in Kalagarh and near Chuhi Srot in the Jim Corbett Tiger Reserve.

Material examined – India: Uttarakhand, Jim Corbett National Park, Kalagarh, Chuhi Srot, along the stream, on *Syzygium cumini* bark, 09.11.1997, D. K. Upreti 214006 (LWG).

**7. *Graphis capillacea*** Stirton, Proc. Roy. Soc. Glasgow 11: 315. 1879.

Fig 11

The species is known for its short simple to stellately branched 0.9–2.3 mm long lirellae, entire labia, laterally carbonized proper exciple, clear hymenium, small transversely septate, 23–44 × 6–8 µm ascospores, norstictic and salazinic acids. It was found growing luxuriantly in the studied area of foothills, on the bark of *Syzygium cumini*.

Material examined – India: Uttar Pradesh, Jim Corbett National Park, Kalagarh, Chuhi srot, on young jamun tree in closed moist shaded areas, 09.11.1997, D. K. Upreti 214016 (LWG).

**8. *Graphis chlorotica*** A. Massal, Verh. K. K. Zool.-Bot. Ges. Wein. 21:865. 1871.

Fig 12

This species has an erumpent, short to elongate and sparsely to irregularly branched lirellae with lateral thalline margin, striate epruinose labia, apically carbonized proper exciple, clear hymenium, 4–8-spored asci 10–13-trans-septate, 28–45 × 9–11 µm spores and a thallus lacking lichen substances. It has a wide distribution in Tanda forests and on the way to Kaladhungi, Bajpur on trees of *Murraya koengii* and *Mallotus philippensis*.

Material examined – India: Uttarakhand, Udham Singh Nagar, Rudrapur, Tanda forests, on twig of *Mallotus philippensis*, 03.09.2015, S. Mishra & G. K. Mishra 15–027703 (LWG); India: Uttarakhand, Udham Singh Nagar, Bajpur, on the way to Kaladhungi, on *Murraya koengii*, 03.09.2015, S. Mishra & G. K. Mishra 15–027701/A (LWG); India: Uttarakhand, Udham Singh Nagar, Bajpur, on the way to Kaladhungi, on *Murraya koengii*, 03.09.2015, S. Mishra & G. K. Mishra 15–027701/B (LWG).

**9. *Graphis crebra*** Vain., Hedwigia 38:256. 1899.

Fig 13

The taxon is recognized by an erumpent, short to elongate, sparsely to irregularly branched, lirellae with lateral thalline margin, entire, white pruinose labia, exposed disc, laterally carbonized proper exciple, inspersed hymenium, transversely 5–9-septate, 29–33 × 8–9 µm ascospores and thallus containing norstictic acid. The species has luxuriant distribution on the tree trunks and twigs of *Mallotus philippensis* and *Shorea robusta* growing in the forests Sandikhal of Jim Corbett National Park, Khatima and Tanda of Udham Singh Nagar district.

Material examined – India: Uttar Pradesh, Jim Corbett Tiger Reserve, Sandikhal, 900m, on *Mallotus philippensis* twigs, 03.12.1999, D. K. Upreti & Jyoti Tandon 217440/A (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15–019917 (LWG); India: Uttarakhand, Udham Singh Nagar,

Khatima, Khatima forests, on twig of *Shorea robusta*, 03.09.2015, S. Mishra & G. K. Mishra 15–019918 (LWG); India: Uttarakhand, Udham Singh Nagar, Rudrapur, Tanda forests, on bark, 03.09.2015, S. Mishra & G. K. Mishra 15–027702 (LWG); India: Uttarakhand, Udham Singh Nagar, Rudrapur, Tanda forests, on twig, 03.09.2015, S. Mishra & G. K. Mishra 15–027711 (LWG); India: Uttarakhand, Udham Singh Nagar, Rudrapur, Tanda forests, on bark of *Shorea robusta*, 03.09.2015, S. Mishra & G. K. Mishra 15–027710 (LWG).

**10. *Graphis duplicata* Ach., Synopsis Methodica Lichenum:81. 1814. Fig 14**

The taxon is characterized by an erumpent to prominent, elongate & irregularly branched lirellae lacking thalline margin, striate labia, concealed disc, laterally carbonized proper exciple, clear hymenium, 8-spored asci, muriform ascospores measuring  $25\text{--}45 \times 6\text{--}8 \mu\text{m}$  and a thallus lacking lichen compounds. In the foothills, the species is well known near Saddle dam area of Jim Corbett National Park.

Material examined – India: Uttaranchal, Jim Corbett Tiger Reserve, National Park, Saddle Dam area, on bark, 08.03.2002, D. K. Upreti & Fazal Hussain 219425 (LWG).

**11. *Graphis glaucescens* Fée, Essai. Crypt. Ècorc. 36. 1825. Fig 15**

The species is characterized by an ecorticate, farinose thallus producing immersed to erumpent lirellae with lateral thalline margin, entire and pruinose labia, apically carbonized proper exciple, clear hymenium, 3–15-trans-septate,  $25\text{--}40 \times 6\text{--}10 \mu\text{m}$  ascospores, and thallus lacking lichen substances. Upreti (1997) collected the species from Paterpani in Jim Corbett National Park of the foothills, on phorophyte *Cedrella tuna*.

Material examined – India: Uttarakhand, Jim Corbett National Park, near Paterpani on *Cedrella tuna*, 08.11.1997. D. K. Upreti L69888 (LWG).

**12. *Graphis lineola* Ach., Lichenogr. Universalis: 264. 1810. Fig 16**

The species is recognized by an erumpent, 0.5–3 mm long lirellae with lateral thalline margin, concealed disc, entire non-pruinose labia, laterally carbonized proper exciple, interspersed hymenium, small, 5–11-trans-septate, ascospores of  $20\text{--}40 \times 6\text{--}9 \mu\text{m}$  in size. It was collected from the Tanda, Bajpur and Nainital forests in terai, where it was growing on trunk & branches of *Ficus benghalensis*.

Material examined – India: Uttarakhand, Udham Singh Nagar district, Bajpur to Nainital, 27.10.2009, D. K. Upreti 09–012736/B, 09–012736/C (LWG), Tanda forests near Rudrapur, alt. 260 m, 27.10.2009, on bark, D K Upreti et al 09–012702, 09–0127033 (LWG).

**13. *Graphis longiramea* Müll. Arg., J. Linn. Soc., Bot. 29: 225. 1892. Fig 17**

The taxon is characterized by an elongate to very long and irregularly to radiately branched lirellae with thick lateral thalline margin, often slightly exposed disc, entire labia, laterally carbonized excipulum, clear hymenium, 7–23-trans-septate,  $10\text{--}20 \times 4.5\text{--}8 \mu\text{m}$  ascospores, and the presence of stictic acid in thallus. It is reported from Tanda forests of terai.

Material examined - India: Uttarakhand, Udham Singh Nagar district, Tanda forest near Rudrapur, alt. 260 m, 27.10.2009, on bark, D. K. Upreti et al 09–012704 (LWG).

**14. *Graphis nigroglauca* Leight., Trans. Linn. Soc. London 27: 174. 1869.**

This species produces 0.5–5 mm long, erumpent, elongate and irregularly branched lirellae lacking thalline margin, striate pruinose labia, apically to peripherally carbonized proper exciple, clear hymenium, transversely septate ascospores measuring  $26\text{--}50 \times 5\text{--}9.5 \mu\text{m}$ , and a thallus producing norstictic and constictic acids. In the studied area, it was found growing on *Syzygium cumini* in Chuhi, Jim Corbett National Park (Upreti & Chatterjee 1999- a, Upreti & Divakar 2003).



**Figs - 5-24.** Graphidaceous taxa in terai region of Kumaun Himalayas. **5.** *Diorygma heiroglyphicum*. **6.** *Diorygma junghuhnii*. **7.** *Diorygma megasporum*. **8.** *Fissurina cingalina*. **9.** *Fissurina dumastii*. **10.** *Graphis ajarekarii*. **11.** *Graphis capillacea*. **12.** *Graphis chlorotica*. **13.** *Graphis crebra*. **14.** *Graphis duplicate*. **15.** *Graphis glaucescens*. **16.** *Graphis lineola*. **17.** *Graphis longiramea*. **18.** *Graphis paraserpens*. **19.** *Graphis pinicola*. **20.** *Graphis pyrrocheiloides*. **21.** *Graphis scripta*. **22.** *Hemithecium aphanes*. **23.** *Hemithecium divaricoides*. **24.** *Phaeographis formula*.

**15.** *Graphis paraserpens* Lizano and Lücking, Fieldiana Botany 46(1): 96. 2008. Fig 18

The taxon is recognized by an erumpent, elongate and irregularly branched lirellae with apically thin complete thalline margin, striate labia, apically carbonized proper exciple, clear hymenium, small, muriform, 25–45 × 9–15 µm ascospores, and the absence of lichen substances. The species was abundantly growing on bark of *Syzygium cumini* in Duggada, Jim Corbett Tiger Reserve.

Material examined – India: Uttarakhand, Jim Corbett Tiger Reserve, National Park, Chuhi Srot area, on bark, 08.03.2002, D.K. Upreti & D. K. Upreti & Fazal Husain 217498 (LWG); India: Uttar Pradesh, Jim Corbett Tiger Reserve, Duggada, on *Syzygium cumini* tree trunk, 03.12.1999, D.K. Upreti & Jyoti Tandon 217412 (LWG); India: Uttar Pradesh, Jim Corbett Tiger Reserve, Duggada, ± 900m, on bark, 03.12.1999, D.K. Upreti & Jyoti Tandon 217468/A (LWG).

**16.** *Graphis pinicola* Zahlbr. in Hand.-Mazz., Symb. Sin. 3: 40 & 43. 1930.

Fig 19

This species has an erumpent to prominent, short to elongate, sparsely to irregularly branched lirellae with lateral thalline margin, entire labia, concealed disc, laterally carbonized proper exciple, clear hymenium, 7-septate,  $25\text{--}35 \times 10\text{--}12 \mu\text{m}$  ascospores, and a thallus lacking lichen substance. In the foothills, it is known from Kalagarh, Chuhi srot of the Jim Corbett National Park, on *Syzygium cumini* trees.

Material examined – India: Uttar Pradesh, Jim Corbett National Park, Kalagarh, Chuhi srot, on *Syzygium cumini*, 09.11.1997, D. K. Upreti 214017/B (LWG).

**17. *Graphis pyrrocheiloides*** Zahlbr., Cat. Lich. Univ. 2: 321. 1923.

Fig 20

The taxon is well known for its irregularly branched, 1–5.5 mm elongate lirellae, entire white pruinose labia, laterally carbonized proper exciple, exposed disc, clear hymenium, transversely septate  $18\text{--}55 \times 8\text{--}5 \mu\text{m}$  ascospores, and norstictic acid in the thallus. Previously, it has been reported from Bijrani, Jim Corbett Tiger Reserve and Khatima forests in terai of Indian Himalaya and was collected from trees of *Syzygium cumini* and young tree bark of *Shorea robusta*.

Material examined – India: Uttaranchal, Jim Corbett Tiger National Park, Bijrani area, on *Syzygium cumini* tree trunk, 05.11.1997, D. K. Upreti L69818, L69818/A (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15–027704/A, 15–027704/B, 15–027704/C, 15–027704/D, 15–027704/E (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15–027705 (LWG).

**18. *Graphis scripta*** (L.) Ach., Kongliga Vetenskaps Academiens Nya. Handlingar 30: 145. 1809.

Fig 21

The taxon is the commonest among Indian *Graphis*, and easily identified by its erumpent, 0.5–5 mm long lirellae with lateral thalline margin, entire labia, exposed, white pruinose disc, apically carbonized proper exciple, clear hymenium, transversely septate ascospores measuring  $18\text{--}60 \times 6\text{--}8.5 \mu\text{m}$ , and thallus lacking lichen substances. The species is abundant in the studied area and distributed widely in Bijrani, Chuhi srot Jim Corbett Tiger Reserve, Khatima, Tanda forests and Bajpur, Udham Singh Nagar, where it was found growing on *Syzygium cumini*, *Shorea robusta* and *Mallotus philippensis*.

Material examined – India: Uttarakhand, Jim Corbett National Park, Bijrani area, on *Syzygium cumini* tree trunk, 05.11.1997, D. K. Upreti, L69818/B (LWG); India: Uttarakhand, Jim Corbett National Park, Kalagarh Chuhi srot, along the stream, on *Syzygium cumini* tree trunk, 09.11.1997, D. K. Upreti, 214007 (LWG); India: Uttarakhand, Jim Corbett National Park, Kalagarh Chuhi srot, along the stream, on *Syzygium cumini* tree trunk, 09.11.1997, D. K. Upreti, 214014 (LWG); INDIA: Jim Corbett Tiger Reserve National Park, Chuhi Srot, on *Syzygium cumini* tree trunk, 08.03.2002, D. K. Upreti & Fazal Husain, 219426 (LWG); India: Jim Corbett Tiger Reserve, National Park, Chuhi Srot, on bark, 08.03.2002, D. K. Upreti & Fazal Husain 217497 (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15-027706/A (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15-027706/B (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15-027706/C (LWG); India: Uttarakhand, Udham Singh Nagar, Khatima, Khatima forests, on twig of *Shorea robusta*, 02.09.2015, S. Mishra & G. K. Mishra 15-027706/D (LWG); India: Uttarakhand, Udham Singh Nagar, Bajpur, enroute to Kaladhungi, on twig of *Mallotus philippensis*, 03.09.2015, S. Mishra & G. K. Mishra 15-027707 (LWG); India: Uttarakhand, Udham Singh Nagar, Rudrapur, Tanda forests, on twig of *Shorea robusta*, 03.09.2015, S. Mishra & G. K. Mishra 15-027708 (LWG).

**19. *Graphis streblocarpa*** (Bél.) Nyl., Flora 49: 133. 1866.

The species is separated in having an immersed to erumpent, elongate and irregularly branched lirellae with thick lateral to complete thalline margin, entire labia, concealed disc,

laterally carbonized proper exciple, clear hymenium, 1–(2) spored asci, large muriform, 25–75 × 13–20 µm ascospores and a thallus containing stictic acid. The species has been collected on *Syzygium cumini* from Duggada in Jim Corbett National park (Upreti & Divarkar, 2003).

**20. *Graphis subasahinae*** Nagarkar & Patw., Biovigyanam 8 : 130. 1982.

This norstictic, stictic, salazinic acids containing species is recognized by an olive-grey thallus, sparse to densely branched, 1–3 mm long lirellae, entire, epruinose labia, laterally carbonized proper exciple, clear hymenium, elongate-ellipsoid to fusiform, hyaline, transversely 5–8-septate, 18–25 × 5–7 µm ascospores. In the foothills, it was collected on *Syzygium cumini* in Chuhi srot of Jim Corbett National Park (Upreti & Divarkar, 2003).

**21. *Hemithecium aphanes*** (Mont.) Nakan. and Kashiw., Bull. Of the Nat. Sci. Museum

Tokyo 29: 88. 2003.

Fig 22

The species is characterized by buff to whitish-green thallus, mostly simple to furcate straight to flexuous sometimes curved prominent immersed to semi-emergent lirellae, distinctly striate, epruinose labia, concealed disc, non-carbonized proper exciple, clear hymenium, 6–8-spored asci transversely 6–20-septate, ascospores of 55–105 × 6–10 µm in size and the presence of norstictic and stictic acids in the thallus. It was collected around the forests near Chuhi and Paterpani srots in Jim Corbett National Park, where it was found growing on two different phorophytes *Mallotus philippensis* and *Syzygium cumini*.

Material examined – India: Uttarakhand, Jim Corbett National Park, Bijrani area, on *Syzygium cumini* tree, 05.11.1997, D. K. Upreti L69819, L69823 (LWG); India: Uttarakhand, Jim Corbett National Park, Sultan area, on *Syzygium cumini* tree trunk, 06.11.1997, D. K. Upreti L69854/A (LWG); India: Uttarakhand, Jim Corbett National Park, Paterpani, Pipal Srot along the stream, on *Syzygium cumini* twigs, 08.11.1997, D. K. Upreti L69892, L69892/A, L69893, L69894/A, L69896 (LWG); India: Uttarakhand, Jim Corbett National Park, Kalagarh, Paterpani, Pipal Srot along the stream, on *Mallotus philippensis* tree trunk, 08.11.1997, D. K. Upreti 214034 (LWG); India: Uttarakhand, Jim Corbett National Park, Paterpani, Pipal Srot along the stream, on *Syzygium cumini* bark, 08.11.1997, D. K. Upreti L69900/C (LWG); India: Uttarakhand, Jim Corbett National Park, Kalagarh, Chuhi srot, on *Syzygium cumini*, 09.11.1997, D. K. Upreti 214008, 214005, 027286 (LWG); India: Uttarakhand, Jim Corbett National Park, Kalagarh, Chuhi srot along the stream, on young Jamun tree trunk in closed, moist shaded area, 09.11.1997, D. K. Upreti 214010 (LWG).

**22. *Hemithecium divaricoides*** (Räsänen) V. Tiwari & Upreti, Singh & Sinha. 2010: 342.

Fig 23

The taxon is characterized by prominent to emergent, divaricately branched lirellae, striate labia, non-carbonized proper exciple, 4–7-trans-septate, 25–40 × 7–11 µm ascospores and lacking lichen substances. In the terai, it was collected from the trees of *Syzygium cumini* distributed in the forest near Kalagarh, Chuhi srot of the Jim Corbett National park.

Material examined - India: Uttarakhand, Jim Corbett National Park, Kalagarh, Chuhi srot along the stream, on *Jamun* tree, 09.11.1997, D. K. Upreti 214026/A (LWG).

**23. *Hemithecium nakanishianum*** (Patw. & C.R. Kulk.) Makhija & A. Dube in Makhija & al., Mycotaxon 93 : 370. 2005.

The taxon has greenish glaucous to pale olivaceous, buff, continuous to cracked, smooth thallus, semi-emergent to emergent flexuous to dendroidally branched 2–7 mm long lirellae, entire to indistinctly striate, convergent labia, narrow slit-like disc, non-carbonized proper exciple, hyaline and clear hymenium, 4–8-spored asci, hyaline, transversely 8–10 (–15)-septate ascospores measuring 30–40 (–60) × 6–9 µm, and the presence of constictic, norstictic and stictic acids. It had shown wide range of distribution in Jim Corbett National Park, where it preferred to grow on trees of *Syzygium cumini* and *Mallotus philippensis*. Anonymously, the species was



previously recorded by Upreti & Chatterjee (1999a) & Upreti & Divakar (2003) from the Jim Corbett National Park.

**24. *Phaeographis caesioradians*** (Leight.) A.W. Archer, *Telopea* 11: 75. 2005.

The species is characterized by a glossy, corticate thallus, emergent to sessile, scattered, straight, curved or sinuous lirellae, poorly developed labia, non-carbonized proper exciple, white pruinose exposed disc, large, hyaline to brown muriform, 3–7 × 1–2 septate ascospores of 23–35 × 10–13 in size, and the absence of lichen substances. The species has been previously reported on *Syzygium cumini* from Jamunagaur area of the Jim Corbett National Park (Upreti & Divarkar 2003).

**25. *Phaeographis firmula*** (Stirt.) V. Tewari and Upreti comb. Nova *Stirt. Proc. Phil. Soc.*

*Glasgow*, 13: 186. 1881.

Fig 24

The species is well recognized by a glossy, corticate thallus, immersed, simple to dichotomously branched, 1–5 mm long lirellae, entire, divergent labia, non-carbonized proper exciple, widely exposed disc, clear hymenium, 8-spored asci, brown, oblong to ellipsoid, muriform transversely 8 × 1–2 locular ascospores measuring 25–35 × 8–11 µm in size and a thallus producing no lichen substances. In the study area, it was collected from the bark of *Syzygium cumini* in the forests near Chuhi srot, Jim Corbett National Park.

Material examined – India: Uttar Pradesh, Jim Corbett National Park, Kalagarh, Chuhi srot, along the stream on *Syzygium cumini*, 09.11.1997, D. K. Upreti 21401 (LWG).

**26. *Phaeographis instrata*** (Stirt.) Zahlbr., *Cat. Lich. Univ.* 2: 374. 1924.

The species thallus is known for its glossy and corticate thallus producing dispersed, stellate, radiate, dendroid or divaricately branched and flexuose lirellae, convergent labia, pale brown to brown, proper exciple, blackish, caesiopruinose disc, brown, transversely 4–8-septate septate 28–38 µm long ascospores. The species was earlier reported on *Syzygium cumini* in the forests near Chuhi srot of the Jim Corbett National Park (Upreti & Chatterjee, 1999a; Upreti & Divarkar, 2003).

**27. *Phaeographis subdividens*** (Leight.) Müll. Arg., *Flora* 65: 383. 1882; *Zahlbr., Cat. Lich.*

*Univ.* 2: 387. 1923.

The species is well known for its glossy and corticated thallus, elongate, scattered to aggregated simple to furcate lirellae, divergent, brown, proper exciple, brown, transversely 4–5-septate ascospores, 16–22 µm long. It has been reported from the forests near Chuhi srot of Jim Corbett National Park, where it was found growing on *Syzygium cumini* (Upreti & Chatterjee, 1999a; Upreti & Divarkar, 2003).

**28. *Platythecium albolabiatum*** (Patw. & C.R. Kulk.) A.W. Archer, *Syst. Biodivers.* 5(1): 20.

2007.

The species is identified by its glossy and corticate thallus lacking lichen substance, an emergent, simple, short and curved ≤1–5 mm long lirellae, entire labia, exposed greyish disc, pale brown proper exciple, small, ovoid, transversely 3-septate, 10–15 × 4–6 µm ascospores.

It has been collected from the bark of *Shorea robusta* from the terai forests of Jhirna in Jim Corbett National Park (Upreti & Chatterjee, 1999a; Upreti & Divarkar, 2003).

**29. *Platythecium dimorphodes*** (Nyl.) Staiger, *Biblioth. Lichenol.* 85: 383. 2002.

The taxon has an emergent, simple to irregularly branched ≤ 10 mm long lirellae, poorly developed, striate labia, exposed disc, reddish brown proper exciple, hyaline to pale brown ascospores measuring 15–17 × 1–8 µm in size and a thallus producing norstictic acid. It was recorded from three various sites *viz.* Bijrani, Malani & Paterpani of the Jim Corbett National

Park and was found growing on a common habitat *Syzygium cumini* (Upreti & Chatterjee, 1999a; Upreti & Divarkar, 2003).

Note – *Graphis implexula* Stirt. was collected in 1881 from Assam, India and later reported by Upreti & Chatterjee (1999a) and Upreti & Divarkar (2003) from the Jim Corbett National Park, but has been excluded in this study due to its dubious identity.

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