

## The lichen genus *Pyxine* (Caliciaceae) in Kerala state with *P. dactyloschmidtii* as new to India

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**Abstract** A total of 12 species of *Pyxine* is reported from Kerala state of which *P. retirugella* Nyl. is new to the region while *P. dactyloschmidtii* Kalb & Mongkolsuk is new to India. *Pyxine dactyloschmidtii* is characterized in having polysidiangia and earlier known from Thailand. Brief descriptions for the novel taxa and a key to all *Pyxine* species occurring in India are provided.

### Introduction

The lichen genus *Pyxine* Fr. is characterized by glaucous white to dark grey, appressed, rhizinate and heteromerous foliose thalli with narrow lobes usually covered with maculae and pruina. Isidia, soredia and polysidiangia are often found on the thalli of various species. Colour of the medulla ranges from white to stramineous or yellow to orange. Most of the species contain atranorin as their secondary metabolite, but some have lichexanthone which is indicated by a yellow fluorescence emitted by the upper cortex of the thalli when viewed under long UV rays. Apothecia are characterized by a lecanorine or lecideine margin, K+ purple epithecium and brown hypothecium. Ascospores are 2-, rarely 4-celled, mischoblastiomorphic, thick-walled and brown in colour. *Dirinaria*, the most closely related genus differs from the latter in chemistry (divaricatic or sekikaic acid is always present in *Dirinaria* species) and arhizinate condition (Awasthi 1982). Molecular phylogenetic studies show that these two genera belong to distinct lineages (Helms *et al.* 2003). Earlier, *Pyxine* was treated under family Physciaceae, however according to recent molecular phylogeny it forms a separate clade within Caliciaceae along with *Diplotomma* and *Dirinaria* (Prieto & Wedin 2017).

*Pyxine* is widely distributed in the tropical and subtropical regions of the world, represented by over 80 species (GBIF 2017). Awasthi (1982) studied the Indian species of *Pyxine* and reported 21 species with six new taxa. Risbud & Patwardhan (1989) studied nine

species of *Dirinaria* and *Pyxine* from the Andaman islands. Later two more species were added by Awasthi (2007). Bajpai *et al.* (2009) added *P. isidiophora* (Müll.Arg.) Imsh. as a new record to India and Nayaka *et al.* (2013) described two new species, *P. punensis* Nayaka & Upreti and *P. yercaudensis* Nayaka & Upreti, from Southern India. According to Singh & Sinha (2010) and Sinha *et al.* (2018), 26 species of *Pyxine* are reported from the country. From them Mongkolsuk *et al.* (2012) synonymized *P. consocians* Vain. with *P. retirugella* Nyl.

From Kerala, earlier Awasthi (1982) listed seven species of *Pyxine*. Later, as part of the biodiversity documentation of Kerala, Easa (2003) compiled a handbook of lichens which included a total of eight species of *Pyxine*. According to the checklists of Indian lichens by Singh & Sinha (2010) and Sinha *et al.* (2018) 12 species of *Pyxine* are reported so far from Kerala. Recently, Zachariah *et al.* (2018) reported two more species of *Pyxine* from Pathanamthitta district as new to Kerala. In continuation of our study on lichens in Kerala, we found two more species of *Pyxine* as new to the state including one new record to India.

## Materials and Methods

Specimens were collected from different localities of Pathanamthitta district, Kerala and were identified at the Lichenology Laboratory, CSIR-NBRI, Lucknow. Morphological characters were studied using a stereo zoom Leica S8APO microscope and anatomical characters were observed under a Leica DM500 compound microscope. The chemistry was studied by spot tests and TLC performed in solvent system C following Orange *et al.* (2001). Awasthi (2007) and Mongkolsuk *et al.* (2012) were used for identification of species. Further, previously published literature containing *Pyxine* from Kerala are referred for updating the species list (Easa 2003; Singh & Sinha 2010; Sinha *et al.* 2018; Zachariah *et al.* 2018). The specimens are preserved in the Regional Herbarium of Kerala (RHK), Department of Botany, SB College, Changanacherry, Kerala and voucher specimens are deposited in the NBRI herbarium, Lucknow (LWG).

## Results

Twelve species of *Pyxine* were encountered during this study out of which one is new to Kerala (*P. retirugella* Nyl.) and one new to India (*P. dactyloschmidtii* Kalb & Mongkolsuk). Addition of two species updates the total number of *Pyxine* known for Kerala to 16 species. List of all the *Pyxine* species recorded from Kerala, their distribution within Pathanamthitta district; Kerala state and elsewhere in India are provided in Table 1.

### *Species new to India*

#### *Pyxine dactyloschmidtii* Kalb & Mongkolsuk Fig. 1A

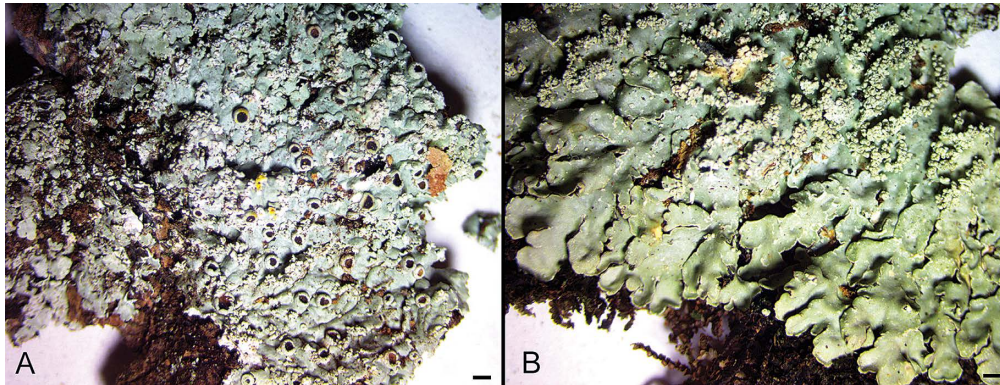
Thallus corticolous, 2–5 cm wide, loosely to completely adnate and subdichotomously branched with radiating lobes of 0.5–1.0(–2.5) mm wide. Upper surface greenish grey, smooth with polysidiangia which are short, nodular and pustulate. True soralia absent, but polysidiangia sometimes appear like soralia when abraded. Medulla white. Apothecial hymenium up to 191–206 µm high, epihymenium 50–56 µm, ascospores 16.6–20.7 × 6.4–9.1 µm.

**Table 1.** List of *Pxyine* species recorded from Kerala, their distribution in Pathanamthitta district, Kerala State and elsewhere in India. (Note: Lat. & Long. = Latitude & Longitude, EL = Elevation, # = New record to India, \* = New record to Kerala, AN = Andaman & Nicobar islands, AR = Arunachal Pradesh, AS = Assam, GA = Goa, HP = Himachal Pradesh, KA = Karnataka, KL = Kerala, LD = Lakshadweep, MP = Madhya Pradesh, MH = Maharashtra, MN = Manipur, NL = Nagaland, OR = Orissa, SK = Sikkim, TN = Tamil Nadu, UK = Uttarakhand, UP = Uttar Pradesh, WB = West Bengal.

Serial no.	Species	Locality within Pathanamthitta district	Lat. & Long.	EL (m)	Earlier reports within Kerala and India
1	<i>Pxyine asiatica</i> Vain.	Maroor, Konni Parakode, Adoor Thekkumala, Puthukulam	9°7'27"N, 76°49'6"E 9°8'49"N, 76°45'59"E 9°19'39"N, 76°49'51"E	29 49 95	WB (Singh & Sinha 2010), KL - Uppupara- Periyar Tiger Reserve, Idukki (Kumar 2000)
2	<i>P. austroindica</i> D.D.Awasthi				Endemic to KL (Singh & Sinha 2010)
3	<i>P. coccifera</i> (Fée) Nyl.				KL, MN, ML, NL, WB (Singh & Sinha 2010)
4	<i>P. cocoes</i> (Sw.) Nyl.	Adoor Mylapra Kuttoor Komdady, Tiruvalla	9°9'42"N, 76°43'33"E 9°17'32"N, 76°48'24"E 9°21'52"N, 76°35'12"E 9°23'3"N, 76°35'42"E	60 220 10 17	AS, GA, KA, KL, LD, MP, MH, MN, OR, TN, UP, WB (Singh & Sinha 2010)
5	<i>P. coralligera</i> Malmé	Mannarappara	9°5'13"N, 77°12'27"E	173	AN, MN (Singh & Sinha 2010), KL - Upper Moozhayar, Kakki dam site, Pathanamthitta (Kumar 2000)
6	<i>P. cylindrica</i> Kashw.	Mannadi, Adoor Parakode, Adoor	9°9'46"N, 76°43'29"E 9°8'49"N, 76°45'59"E	54 49	AN, GA, KA, MP (Singh & Sinha 2010) KL - Eravikulam National Park, Silent Valley Estate - Munnar (Kumar 2000)
7	# <i>P. dactyloschmidii</i> Kalb & Mongkolkeuk	Adoor Maroor, Konni Mannadi, Adoor Koodal, Punnamoodu Thekkumala, Puthukulam Mylapra	9°9'60"N, 76°43'12"E 9°7'27"N, 76°49'6"E 9°53'N, 76°44'38"E 9°7'53"N, 76°51'12"E 9°18'9"N, 76°50'20"E 9°17'32"N, 76°48'24"E	57 29 18 39 133 220	New to India
8	<i>P. cf. endochrypsina</i> Nyl.	Kaviyoor	9°23'33"N, 76°37'5"E	16	MN (Singh & Sinha 2010), KL - Pathanamthitta (Zachariah <i>et al.</i> 2018)
9	<i>P. keralensis</i> D.D.Awasthi	Elanthoor Kuzhikala	9°16'29"N, 76°42'36"E 9°17'13"N, 76°42'42"E	53 33	KL (Singh & Sinha 2010)
10	<i>P. meissnerina</i> Nyl.	Niranam	9°20'25"N, 76°31'47"E	4	AS, MP, MN, TN, UP, UK, WB (Singh & Sinha 2010), KL - Mannavanshola - Marayoor, Idukki (Kumar 2000)

**Table 1.** Continued.

Serial no.	Species	Locality within Pathanamthitta district	Lat. & Long.	EL (m)	Earlier reports within Kerala and India
11	<i>P. minuta</i> Vain.				KA, UP (Singh & Sinha 2010, Sinha <i>et al.</i> 2018), KL- Pullukuthimala, New Amarambalam Reserve Forest, Malappuram (Kumar 2000; Kumar & Sequeira 2001)
12	<i>P. petricola</i> Nyl.				KA, MP (Singh & Sinha 2010, Sinha <i>et al.</i> 2018), KL- Siruvani, Palakkad; Kakki, Pathanamthitta (Kumar 2000)
13	<i>P. philippina</i> Vain.	Mannarapara	9°5'13"N, 77°1'27"E	173	MN, UP, WB (Singh & Sinha 2010, Sinha <i>et al.</i> 2018), KL- Siruvani, Palakkad; Kakki, Pathanamthitta (Kumar 2000)
14	<i>P. reticulata</i> (Vain.) Vain.	Kuttiyoor Mylapra Niranam Parakode, Adoor	9°21'52"N, 76°3'51"E 9°17'34"N, 76°48'23"E 9°20'40"N, 76°3'121"E 9°8'49"N, 76°45'59"E	11 220 8 49	AN, KA, TN (Singh & Sinha 2010), KL- Pathanamthitta (Zachariah <i>et al.</i> 2018)
15	* <i>P. retrugella</i> Nyl.	Kaviyoor Kombady Enathu, Adoor Mylapra Parakode, Adoor Koodal- Punnamoodu Thalachira Thekkumala, Puthukulam Vennikulam	9°23'3"N, 76°36'55"E 9°23'3"N, 76°35'42"E 9°5'26"N, 76°44'54"E 9°17'32"N, 76°48'24"E 9°8'46"N, 76°46'5"E 9°7'53"N, 76°51'12"E 9°18'7"N, 76°48'59"E 9°19'2"N, 76°48'53"E 9°24'28"N, 76°40'32"E	12 17 32 220 48 39 141 51 56	AN, MN, NL, SK (Singh & Sinha 2010), New to Kerala
16	<i>P. soledata</i> (Ach.) Mont.	Koodal Mallapally	9°9'2"N, 76°52'50"E 9°25'33"N, 76°40'15"E	98 16	AR, HP, KA, MP, MN, NL, SK, UK, WB (Singh & Sinha 2010), KL- Mannavanshola- Marayoor, Idukki & Kakki dam site, Pathanamthitta (Kumar 2000)



**Figure 1.** *Pyxine dactyloschmidtii* Kalb & Mongkolsuk (A) and *P. retirugella* Nyl. (B). Bars=10  $\mu$ m.

**Chemistry:** Cortex K + yellow, C – , KC – , P + yellow, UV – ; medulla K – , C – , P + orange-red; atranorin, testacein and some terpenes are present in TLC.

**Notes:** It is earlier known from Thailand as a very rare species on bark in lower montane scrub (Mongkolsuk *et al.* 2012) and in the present study it is found on bark of various tropical trees, including *Areca catechu*, *Hevea brasiliensis* and *Mangifera indica* in the cropland areas of Pathanamthitta district, Kerala. It is morphologically similar to *P. coralligera* Malme, but differs in having a white medulla whereas the latter has a yellow to orange medulla. It also has the same array of terpenes as *P. asiatica* Vain., but this species has soralia (Mongkolsuk *et al.* 2012).

**Representative specimens examined:** India, Kerala, Pathanamthitta district, Adoor, 18 October 2018, *Zachariah L0311* (RHK), on bark of *Mangifera indica*; India, Kerala, Pathanamthitta district, Mylapra, 26 October 2018, *Zachariah L0343* (RHK), 35838 (LWG), on bark of *Hevea brasiliensis*.

### *Species new to Kerala*

*Pyxine retirugella* Nyl. Fig. 1B

Thallus corticolous or saxicolous, 1.0–2.5 cm across, lobes 0.8–1.5 mm wide, upper side greyish with reticulate pseudocyphellae. Polysidiangia laminal and orbicular, medulla white, upper cortex UV – ; medulla K + yellow turning red, C – , P + yellow. Norstictic acid, testacein and terpenes present in TLC.

**Representative specimens examined:** India, Kerala, Pathanamthitta district, Tiruvalla, Kombady, 10 October 2018, *Zachariah L0256* (RHK), on bark of *Artocarpus hirsutus*; India, Kerala, Pathanamthitta district, Mylapra, 26 October 2018, *Zachariah L0337* (RHK), 35843 (LWG), on bark of *Hevea brasiliensis*.

***An updated key to the species of Pyxine in India***

1	Thallus with vegetative propagules .....	2
1	Thallus lacking vegetative propagules .....	19
2	Thallus with isidia or polysidiangia .....	3
2	Thallus with soredia .....	12
3	Isidia cylindrical, slender, filiform .....	4
3	Isidia globose, nodular to clavate or polysidiangia .....	6
4	Medulla K + red, P + orange, containing norstictic acid, corticolous .....	<i>P. cylindrica</i> Kashiw.
4	Medulla K – , P – .....	5
5	Medulla yellow, isidia filiform, upper side with pseudocyphellae in axils of lobes, corticolous .....	<i>P. keralensis</i> D.D.Awasthi
5	Medulla white, isidia mostly cylindrical, occasionally globose, upper side lacking pseudocyphellae, corticolous .....	<i>P. isidiophora</i> (Müll.Arg) Imsh.
6	Thallus UV + yellow, lichexanthone and terpens present, medulla yellow, saxicolous .....	<i>P. punensis</i> Nayaka & Upreti
6	Thallus UV – , lichexanthone absent, atranorin present .....	7
7	Medulla white .....	8
7	Medulla yellow to orange .....	9
8	Medulla K + yellow turning red, P + yellow, norstictic acid and testecein present, polysidiangia bursting apically to produce soredia, corticolous or saxicolous .....	<i>P. retirugella</i> Nyl. (= <i>Pyxine consocians</i> Vain.)
8	Medulla K – , P + yellow, norstictic acid absent, testacein present, polysidiangia not producing soredia (but abraded part may appear like soredia), corticolous .....	<i>P. dactyloschmidtii</i> Kalb & Mongkolsuk
9	Medulla P + orange, testacein present, polysidiangia bursting apically to release corticate fragments but no soredia. corticolous .....	<i>P. coralligera</i> Malme
9	Medulla P – .....	10
10	Medulla K + faint pink, orange-yellow to ochraceous, saxicolous or corticolous .....	<i>P. endochrysina</i> Nyl.
10	Medulla K – .....	11
11	Thallus corticolous, maculae and pseudocyphellae distinct .....	<i>P. austroindica</i> D.D.Awasthi
11	Thallus saxicolous, maculae and pseudocyphellae indistinct .....	<i>P. palniensis</i> D.D.Awasthi
12	Thallus UV + yellow, lichexanthone present .....	13
12	Thallus UV – , lichexanthone absent .....	14
13	Medulla white to off-white, corticolous or saxicolous .....	<i>P. cocoes</i> (Sw.) Nyl. [Note: In India, two varieties are recognized within this species. <i>P. cocoes</i> var. <i>prominula</i> (Stirton) D.D.Awasthi differs from var. <i>cocoes</i> in having slightly larger (>2 mm), flabellate, intricate lobes and marginally distributed soralia]
13	Medulla yellow, corticolous .....	<i>P. subcinerea</i> Stirton
14	Soralia and soredia bright red, medulla deep yellow to reddish .....	<i>P. coccifera</i> (Fée) Nyl.
14	Soralia and soredia white, grey, bluish grey or yellow .....	15

15	Medulla white .....	16
15	Medulla yellow .....	17
16	Medulla P+ yellow to orange, K+ yellowish, corticolous .....	<i>P. asiatica</i> Vain.
16	Medulla P- , K- , corticolous .....	<i>P. reticulata</i> (Vain.) Vain.
17	Soralia laminal, orbicular-capitate to cup shaped, soredia farinose to yellowish, corticolous .....	<i>P. farinosa</i> Kashiw.
17	Soralia marginal to submarginal, linear .....	18
18	Soralia grey to bluish grey, upper side with diffused pruina, corticolous or saxicolous .....	<i>P. soredata</i> (Ach.) Mont.
18	Soralia yellowish, upper side with adglutinated plaques of pruina, corticolous .....	<i>P. meissnerina</i> Nyl.
19	Thallus UV+ yellow, lichexanthone present .....	20
19	Thallus UV- , lichexanthone absent .....	24
20	Medulla white to stramineous .....	21
20	Medulla yellowish, deep yellow, orange to rust coloured .....	22
21	Lobes small (up to 1.0 mm wide), medulla P+ yellowish, apothecia with lecideine margin, saxicolous .....	<i>P. minuta</i> Vain.
21	Lobes slightly larger (up to 1.5 mm wide), medulla P- , apothecia with lecanorine margin when young, corticolous or saxicolous .....	<i>P. petricola</i> Nyl.
	[Note: In India, two varieties are recognized within this species. <i>P. petricola</i> var. <i>pallida</i> Swinsc. & Krog. differs from var. <i>petricola</i> in having narrower lobes, laminal to marginal subreticulate maculae, internal stipe hyaline to light brown]	
22	Medulla orange to rust coloured, corticolous .....	<i>P. cognata</i> Stirton
22	Medulla yellow .....	23
23	Internal stipe K+ purple, pale brown, saxicolous .....	<i>P. nilgiriensis</i> D.D.Awasthi
	[Note: In Awasthi (1980, 2007) this species is keyed out as medulla white to stramineous, however in the description it is clearly mentioned medulla is yellowish]	
23	Internal stipe K- colourless to brown, corticolous .....	<i>P. berteriana</i> (Fée) Imsh.
	[Note: Earlier two varieties are recognized within this species. <i>P. berteriana</i> var. <i>himalaica</i> D.D.Awasthi in having agglutinated pruina in apical region, maculae not developing pseudocyphellae, hypothecium K+ reddish violet. This variety is a synonym of <i>P. cognata</i> (Mongkolsuk <i>et al.</i> 2012)]	
24	Medulla white to stramineous, corticolous or rarely saxicolous .....	<i>P. philippina</i> Vain.
24	Medulla dark yellow to orange .....	25
25	Thallus saxicolous, ascospores 13–16 × 5–7 μm .....	<i>P. yercaudensis</i> Nayaka & Upreti
25	Thallus corticolous, ascospores 16–23 × 6–8 μm .....	<i>P. himalayensis</i> D.D.Awasthi

## Discussion

India, being a tropical country, members of the lichen families Caliciaceae and Physciaceae are well represented. Among them *Buellia s.lat.*, *Dirinaria*, *Heterodermia*, *Phaeophyscia* and *Pyxine* are more conspicuous genera. It has been observed that there is a constant addition of new taxa to these genera for India. In the present study, *Pyxine* species

occurring in Kerala state was given emphasis and collections were made mostly from Pathanamthitta district. As mentioned above a total of 12 species encountered in the study out of which two are new to Kerala. Thus the total number of *Pyxine* species known in Kerala has raised to 16. Three species (*P. austroindica*, *P. coccifera*, and *P. minuta*) earlier reported elsewhere from Kerala (Palakkad district) are not occurring in Pathanamthitta district. *P. petricola* reported earlier from the Kakki area of Pathanamthitta was not found during our exploration in that place. The reason for its disappearance is a subject for detailed ecological studies. *P. austroindica* is an endemic species known only by type collection from Kerala (Awasthi 2007). Survey in more areas of Kerala may yield missing and additional species.

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