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A conspectus of the lichen genus *Candelariella* (Candelariaceae, Ascomycota) in Southwest Asia with emphasis on Iran

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With 1 figure

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Abstract: A total of 15 *Candelariella* species are listed from Iran, mainly from the north and north-west parts of the country. Four species are reported new to Iran; *C. aggregata*, *C. lutella*, *C. kansuensis* and *C. rosulans*. *Candelariella oleifera* is synonymised with *C. rosulans* which together with *C. aggregata* is reported from Asia for the first time. In addition *C. aggregata* is reported new to Tajikistan and *C. antennaria* new to Afghanistan. *Candelariella kuusamoënsis* is lectotypified. An overview of the genus in south-west Asia is provided, mainly based on literature reports. A preliminary key to *Candelariella* in the region is provided.

Key words: Candelariales, Iran, Lecanoromycetes, lichens, lichenized fungi, Southwest Asia.

Introduction

Floristic knowledge of the cryptogam flora of the Middle-eastern countries is still rather deficient, lichens are no exception. However, the region has an excellent situation from a lichen biodiversity approach, since there are many collections available. The yellow species in *Candelariella* are quite common in Iran and are an especially prominent part of the lichen flora in the dry, montane habitats. *Candelariella* with c. 50 known species world-wide (Westberg 2005) belongs to the small order Candelariales. The order also includes three smaller genera but the phylogeny within the order is in need of further studies and a generic revision is apparently necessary (Westberg et al. 2007). Also the phylogenetic position of Candelariales remains unresolved. Several DNA-based studies have included Candelariales and found a basal position within Lecanoromycetes, either

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as an independent lineage (Miadlikowska et al. 2006, Hofstetter et al. 2007) or forming a clade with Acarosporales (Wedin et al. 2005). Schoch et al. (2009) concluded that the placement of Candelariales was unstable and not supported in their analyses, where it was a poorly supported sister group to all other Lecanoromycetes.

The first record of the genus in Iran is *Candelariella aurella* (as *C. subsimilis*) in a note by Müller (1892) who was the first to publish an annotated report of lichens from the southern part of Iran. Further records include Szatala (1940, 1957). Riedl (1979), Oxner (1946), Sohrabi & Sipman (2007) and Seaward et al. (2004, 2008). A taxonomical treatment of *Candelariella* in this geographical area has, however, never been published and literature reports of *Candelariella* species are notoriously unreliable. In Asia in general there are no studies concerning Candelariales except for Poelt & Reddi (1969) who published a paper on Candelariaceae in the Himalayas describing some new species. There is a need for extensive collections and further revisions in Iran and adjacent areas. In this study our aim is to compile the existing information and to provide a baseline for future taxonomic studies of the genus in SW Asia. We have had the opportunity to study some collections of *Candelariella* from Iran and we are here reporting four species as new to the country: *C. aggregata*, *C. kansuensis*, *C. lutella* and *C. rosulans*. Of these *C. aggregata* and *C. rosulans* are also new to Asia. Based on this study and on literature records from neighbouring countries we also present a preliminary key to all recorded species of *Candelariella* in SW Asia (Fig. 1). There are many dubious literature reports and we have not been able to confirm the presence of several species (*C. coralliza*, *C. medians*, *C. placodizans*, *C. rhodax* and *C. xanthostigma*).

Materials and methods

The study is based on c. 80 *Candelariella* specimens mainly from Iran, Of these, 55 were collected by Sohrabi and co-workers 2001–2006 and are deposited in herb M.Sohrabi (several duplicates at H and LD), while the remaining comes from the collections in B, TUR and W. In addition type material from several other herbaria has been studied. In the literature records we are mainly referring to published checklists for different areas and only for Iran we give more detailed references to the source of the data. When compiling literature data from the region we have found the Checklists of Lichens and Lichenicolous Fungi (Feuerer 2009) and the Recent Literature on Lichens (Culberson et al. 2009) to be very helpful resources on the web. Morphological data presented are based on material from Iran only. Photos of selected species as well as maps of their distribution in Iran, based on this study, are presented at the Myco-Lich website http://www.myco-lich.com (Sohrabi & Ghobad-Nejhad, 2010), under the genus *Candelariella* in Iran (Sohrabi & Westberg 2010). New records to countries were in accordance with the following publications: Iran (Sohrabi et al. 2010), Afghanistan, (Feuerer 2009) and Tajikistan (Kudratov & Mayrhofer 2002).

A provisional key to *Candelariella* in Southwest Asia

Names in bold indicate species which we have confirmed as occurring in the region in this study.

1. Thallus placodioid forming effigurate rosettes with distinct marginal lobes 2
1. Thallus not placodioid and not forming rosettes, if lobate then lobes scattered 5

2. Thallus centrally dissolving into granular soredia..... *C. medians*
2. Thallus without soredia 3

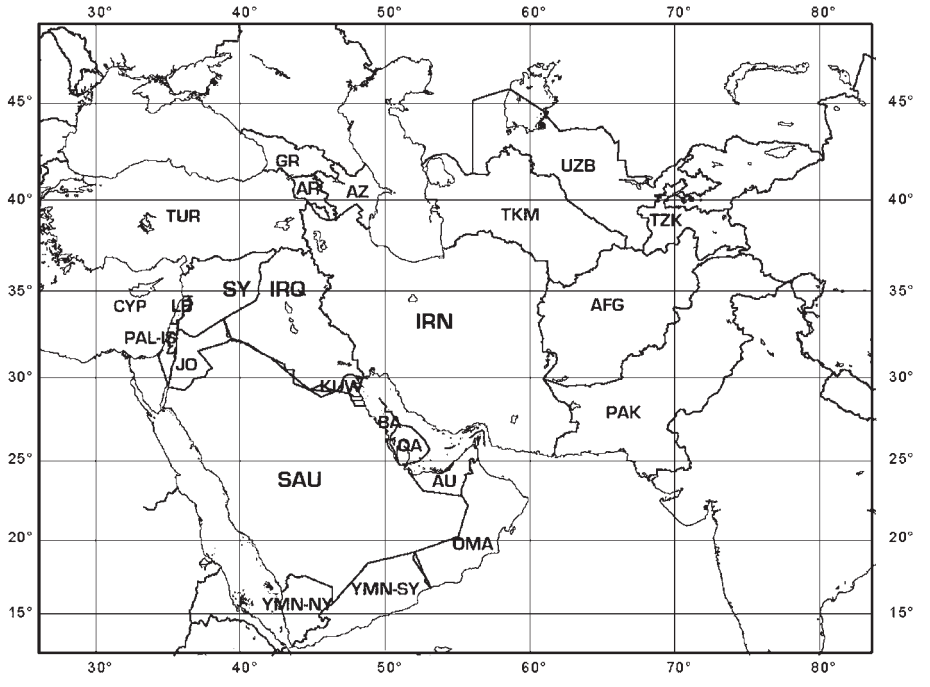

Fig. 1. Map of the region and the individual countries covered by this study.

3. Asci polyspored ..... *C. arctica*
3. Asci 8-spored 4

4. Lobes 1–2 mm long, mostly strongly convex and pruinose ..... *C. rhodax*
4. Lobes up to 3 mm long, flattened and slightly convex, epruinose ..... *C. senior*

5. Thallus on bark or wood 6
5. Thallus on rocks or soil, mosses and plant debris 11

6. Thallus grey or indistinct (always 8-spored) 7
6. Thallus yellow (mostly polyspored species) 8

7. Thallus a continous crust to amorphous or indistinct ..... ***C. antennaria***
7. Thallus mainly of small, up to 0.15 mm wide, granules ..... ***C. viae-lactea***

8. Thallus sorediate, soredia to c. 50 µm diam; asci 8-spored ..... *C. reflexa*
8. Thallus not sorediate, but sometimes uniformly small granular (granules 50–100 µm diam.); asci polyspored 9

9. Thallus uniformly granular, thalline margin granular, often disappearing ..... ***C. xanthostigma***
9. Thallus areolate to minutely subsquamulose, thalline margin entire, persistent 10

10. Apothecia up to 0.4 mm diam.; proper margin indistinct; thallus of minute, flattened areoles, forming small, up to 5 mm wide, yellow-green yellow patches ..... ***C. lutella***
10. Apothecia 0.3–0.8 mm diam.; proper margin distinctly visible; thallus areolate to subsquamulose, often forming up to several cm wide bright yellow patches ..... ***C. vitellina***

11. Thallus on soil, mosses or plant debris on the ground, alpine species 15
11. Thallus on rocks or on soil, mosses or other lichens over rocks 12

12. Asci 8-spored ..... ***C. aggregata***
12. Asci polyspored or lichen sterile 13

13. Thallus squamulose, distinctly raised from substrate; hymenium >90 µm tall; thallus green yellow to pale yellow; partly granular to composed of up to 0.6 mm long squamules with a pulverulent surface..... *C. placodizans*
13. Thallus granular to areolate, adnate to the substrate; hymenium up to 90 µm tall; thallus yellow to orange yellow, composed of small, up to 0.5 mm wide, effigurate, subsquamulose areoles with a smooth surface 14

14. Thallus thin to thick, of scattered to crowded areoles, sometimes forming pulvinate crusts composed of weakly incised areoles/squamules; thallus yellow to orange yellow..... ***C. vitellina***
14. Thallus forming a thick, pulvinate crust composed of strongly incised, almost coralloid to granular squamules; thallus orange yellow..... *C. kuusamoënsis*

15. Thallus yellow, asci 8-spored or polyspored 16
15. Thallus grey or apparently lacking, asci always 8-spored..... 23

16. Apothecia present 17
16. Apothecia lacking 21

17. Asci polyspored 18
17. Asci 8-spored..... 19

18. Thallus forming coralloid cusions ..... *C. coralliza*
18. Thallus formed by adpressed, weakly incised areoles or subsquamules..... ***C. vitellina***

19. Thallus shiny; gelatinous epicortex present, 3–6 µm thick..... ***C. kansuensis***
19. Thallus matte; gelatinous epicortex absent..... 20

20. Thallus often indistinct, of small, scattered to crowded, convex areoles, on calcareous rocks ..... ***C. aurella***
20. Thallus distinct and well-developed, squamulose to rosulate, of convex areoles to lobate squamules; mostly on siliceous rocks ..... ***C. rosulans***

21. Thallus coralloid and often cusion-forming, squamules deeply incised with finger-like lobes to so strongly branched that they appear granular ..... *C. coralliza*
21. Thallus areolate to squamulose, squamules sometimes imbricate but not coralliod or finger-like 22

22. Thallus of minute, up to 0.5 mm wide, effigurate, subsquamulose areoles..... ***C. vitellina***
22. Thallus larger, more distinctly lobate-squamulose, lobes up to 1 mm long ..... ***C. rosulans***

23. Apothecia with a yellow thalline margin; thallus often indistinct, of small, scattered to crowded, convex areoles..... ***C. aurella***
23. Apothecia with a grey thalline margin outside a yellow proper margin; thallus distinct, as a grey, thin to thick crust 24

24. Thallus thick, subsquamulose to squamulose, squamules dividing centrally, spores 13–18 × 4–5 µm ..... ***C. plumbea***
24. Thallus thin, areolate to minutely subsquamulose, squamules entire, spores 15–25 × 4–7 µm ..... *C. oleaginsecens*

Notes on the species

Candelariella aggregata M.Westb. (Westberg 2007b, p. 393)

Type: U.S.A. Colorado: Larimer Co., Trail Ridge, 0.5 mi. SE of Ranger Station, NW of Tombstone Ridge, 11500–11700 ft alt. 30 June 1962, R.A.Anderson 2229 (COLO! holotype, BRY! isotype).

New to Asia. This species grows on mosses and plant debris in alpine heaths and arid steppe habitats. It was described from North America (Westberg 2007b) and has recently also been reported from Europe (see Westberg & Clerc 2012). It has a yellow, granular thallus often covered by numerous apothecia. The spores are narrowly ellipsoid and in the Iranian specimens rather variable in size, c. 14–22 × 4.5–6(–7) µm long. It can be separated from *C. aurella* which normally grows on calcareous rocks, on the structure of the proper exciple, which has large, thin-walled cells and does not form a distinct stipe below the hymenium (Westberg 2007b). There is a possibility that earlier reports of *C. aurella* var. *unilocilaris* from the region at least partly belongs to *C. aggregata*. The species has been collected in several places in Iran and we have also seen two specimens from Tajikistan.

Specimens examined: IRAN. East Azerbaijan: Jolfa, ca 17 km E of Hadishahr, Daran village, Sohrabi 684 (Hb. Sohrabi, LD); Semnan: N of Semnan, 7 km NE of Shahmirzad, Sohrabi 9281b, Sipman, Søchting & Zare (Herb M.Sohrabi); 40 km ENE of Semnan along road to Damghan, Sohrabi 9319, Sipman, Søchting & Zare (Herb M.Sohrabi); Khorassan: between Torbat-e Heydariyeh and Mashhad, around Robat-e Sefid, Maassoumi, Sohrabi & Safavi 2387 (B, TARI); TAJIKISTAN. N slope of Hissar Range, Anzob Pass, Ahti 30325, 30392 (H).

Candelariella antennaria Räsänen (Räsänen 1939, p. 137)

Type: ARGENTINA. Mendoza: Depto. Las Heras, pr. Quebrada de la Meina la Atala, 2 July 1937, A.Ruiz Leal (H! - holotype).

Candelariella antennaria is a widely distributed species reported from Iran by Seaward et al. (2008) and it is also known from North and South America, Europe and Australia (Westberg 2007b, Vondrák et al. 2008, Filson 1992). We here also report the species for the first time from Afghanistan. It is a corticolous species characterized by a grey, crustose, indistinct to usually rather amorphous thallus. It has a similar proper exciple as in *C. aggregata* (see this species) which separates it from *C. aurella*. The specimens from Iran conform very well with North American material studied earlier by the first author (Westberg 2007b). The variation seen, however, suggests that this may be a species complex where more than one species are involved. Although *C. deflexa* (Nyl.) Zahlbr. is a synonym to *C. aurella* the name has mostly been used for material of *C. antennaria* in North America (Westberg 2007b) and earlier reports of *C. deflexa* probably belongs to this species.

Literature reports: IRAN: Seaward et al. (2008: 475); Moniri et al. (2011: 134). TAJIKISTAN: Kudratov & Mayrhofer (2002, as *C. deflexa*); UZBEKISTAN: Hakulinen (1958, as *C. deflexa*).

Specimens examined: AFGHANISTAN: Samangan, Kotal-i-Mizra Atbili Pass on the road from Pule-Khumri to Samangan (Aybak), Uotila 16704 (H); IRAN: East Azerbaijan, Jolfa district E of Hadishahr, 0.5 km S of Daran village, Sohrabi 10148B, Sipman, Søchting & Asef. (Hb. Sohrabi); Golestan, Gorgan district Shahkuh-e-Bala, c. 33 km S of Gorgan along minor road to Shahrud, Sohrabi 9507B, & Sipman, Søchting & Zare (Hb. Sohrabi).

Candelariella arctica (Körb.) R.Sant. (in Vězda 1966, No. 494).

Candelaria arctica Körb. (Körber 1859, p. 63). Type: unknown.

Candelariella arctica (Körb.) R.Sant. is an arctic species easily recognized by its effigurate thallus and polyspored asci (referens). It is growing on nitrogen-fertilized, coastal rocks. It probably does not occur in the area but has been reported from Tajikistan.

LITERATURE REPORTS: TAJIKISTAN: Kudratov & Mayrhofer (2002).

Candelariella aurella (Hoffm.) Zahlbr. (Zahlbruckner 1928, p. 790)

Verrucaria aurella Hoffm. (Hoffman 1796, p. 197). Type: FINLAND: Regio Aboensis: Tuorula, 13 July 1922, L. E. Kari (TUR! neotype, Hakulinen 1954, p. 44).

Syn. *Candelariella unilocularis* (Elenkin) Nimis (Nimis 1994, p. 28). – *Candelariella cerinella* var. *unilocularis* Elenkin, (Elenkin 1907, p. 273). Type: RUSSIA. Saratov prov. Tsaritsyn distr. [Volgograd region], Orlovka, 1903, Keller (LE-L1471 – lectotype, Khodosovtsev 2005, p 236).

Syn. *Candelariella deflexa* (Nyl) Zahlbr. (see Westberg 2007b).

Candelariella aurella is a species with a world-wide distribution growing on exposed calcareous rocks. It can be confused with specimens of *C. rosulans* with a poorly developed thallus but *C. aurella* has a paler yellow color, often greyish to whitish in less exposed parts (the sides) than *C. rosulans* and usually smaller apothecia with an irregular, often partly excluded thalline margin. From the description by Elenkin (1907) and the photographs we have seen of the type of *C. cerinella* var. *unilocularis*, we concur with Khodosovtsev (2005) that this is a synonym to *C. aurella*. However, specimens reported as var. *unilocularis* may not belong to *C. aurella* but perhaps to either an undescribed species and/or to *C. aggregata*.

LITERATURE REPORTS: AFGHANISTAN: Poelt & Wirth (1968); ARMENIA: Barkhalov (1983); Harutyunyan & Mayrhofer (2009); AZERBAIJAN: Barkhalov (1983, also var. *unilocularis*); CYPRUS: Litterski & Mayrhofer (1998); GEORGIA: Barkhalov (1983); SYRIA: John et al. (2004); IRAN: Moniri et al. (2009a, b); Müller (1892: 151, as *Candelaria subsimilis*); Steiner (1910: 237, as *Candelariella subsimilis* incl. f. *alpina*); Oxner (1946: 83); Szatala (1940: 530, 1957: 139, also as var. *decolorans*); Barkhalov (1975: 129); Riedl (1979: 220); Seaward et al. (2004: 551); Moniry et al. (2005: 56); Sohrabi & Sipman (2007: 89); IRAQ: Schubert (1973); ISRAEL: Galun & Mukhtar (1996); JORDAN: El-Oqlah (1992); PAKISTAN: Poelt (1961); TAJIKISTAN: Kudratov & Mayrhofer (2002, including f. *effusa*, f. *lutea* and f. *unilocularis*); TURKEY: John (1989); John & Nimis (1998); TURKMENISTAN: Dzhuraeva (1978); UZBEKISTAN: Hakulinen (1958, as f. *effusa*, f. *lutea*, and var. *unilocularis*).

SPECIMENS EXAMINED: IRAN: EAST AZERBAIJAN: Jolfa, ca 17 km E of Hadishahr, Daran village, Sohrabi 529, 541, 767 (Hb. Sohrabi, LD); Kaleybar district Arasbaran, 11 km S of Asheqlu along road to Aynalu, Sohrabi 10244, Sipman, Søchting & Asef (Hb. Sohrabi); Kaleybar, ca. 10 km from Kaleybar, Hejranduost village, Sohrabi 4347 (Hb. Sohrabi, H); Azerbaijan orient, In declivibus saxosis 20–40 km ENE Tabriz usque 1 km ultra pontem trans fluvium Talkheh Rud (Atschi Tschai). 31 May 1971, Rechinger (W). ARDABIL: Kaleybar district 55 km N of Kaleybar along road to Khomarlu, Sohrabi 10383, Sipman, Søchting & Asef (Hb. Sohrabi); ESFAHAN: Foothills of the Domane mountain, 133 km from Esfahan (Isfahan) on the road to Daran, Alava 14509 (TUR); ca 2 km to Ghohrud from Kamou, Maassoumi & Safavi 1860 (B). GOLESTAN: Azadshahr district Khoshyeylaq, highest pass in road Shahrud – Azad Shahr, Sohrabi 9415, Sipman, Søchting & Zare (Hb. Sohrabi); Inche-Broun to Maraveh-Tapeh, Ca. 6 to Makhtomgoli grave, Sohrabi 2059 (Hb. Sohrabi); Golestan: Maraveh-Tappeh, c. 8 km towards Ghazan Ghayeh, Maassoumi, Sohrabi & Safavi 1920 (B, TARI). Gorgan district Shahkuh-e-Bala, c. 33 km S of Gorgan along minor road to Shahrud, Sohrabi 9503, Sipman, Søchting & Zare (Hb. Sohrabi); ca 15 km to Maraveh-Tappeh fron Inch-e Borun, opposite Hemat Abbad, Maassoumi, Sohrabi & Safavi 1902 (B, TARI).

Candelariella coralliza (Nyl.) H.Magn. (Magnusson 1935, p. 122)

Lecanora coralliza Nyl. (Nylander 1875, p. 15). Type: FINLAND. Hollola 1863. J.P.Norrlin (H-NYL no. 2784a! lectotype, Hakulinen 1954, p. 84).

This species can be confused mainly with *C. vitellina* and *C. kuusamoënsis*. *Candelariella coralliza* is characterized by a finely branched coralloid thallus

forming bright yellow cusions. It is often sterile but when fertile the apothecia are characteristically immersed in the cusions whereas they are sitting on top of the thallus in *C. vitellina*. The species was recently reported from Iran by Valadbeigi et al. (2009). The specimen was not accessible for this study.

Literature reports: ARMENIA: Harutyunyan & Mayrhofer (2009); IRAN: Valadbeigi et al. (2009: 457).

Candelariella deflexa (Nyl.) Zahlbr.

This species is a synonym to *C. aurella*. The name has, however, mostly been used for collections of *C. antennaria* (Westberg 2007b).

Candelariella kansuensis H.Magn. (Magnusson 1940, p. 127)

Type: CHINA. Kansu Province, Ehr-tao-ch'uan (Nan-shan), in latere merid, 2950-3050 m, 28 Dec. 1931. Bohlin 69b (S! holotype).

New to Iran. A characteristic species with a shiny, lobate thallus growing on calcareous rocks. Compared to North American specimens, the specimens here studied have a smaller thallus and a thinner cortex (up to 25 µm thick vs up to 60 µm think in N. American specimens). A thin (up to 6 µm) but distinct epicortex is always present. The spores in the Iranian specimens are rather variable in size; (11–)12–20(–22) × (3.5–)4.0–6.0(–7.0) µm (N = 60). Earlier reports of *C. lambii* from Asia possibly refer to this species.

Literature reports: AFGHANISTAN: Poelt & Wirth (1968); TAJIKISTAN: Kudratov & Mayrhofer (2002).

Specimens examined: IRAN: East Azarbaijan: Jolfa, 20 km of E Jolfa, beside the road to Marazad village, Sohrabi 2574 (Hb. Sohrabi, LD); Kaleybar, ca.10 km from Aras River, between Khoda-afrin to Jolfa, Daraghzi Village, Sohrabi 3608 (Hb. Sohrabi, H); Ahar, Varzegan, ca 26 km from west of Varzegan and ca 6 km east of Joshin village (Kharvana), Sohrabi 3535 (Hb. Sohrabi). Golestan: Incheh-Broun to Maraveh Tappeh, Ca. 6 to Makhtomgoli grave, Sohrabi 2041, 2059 (Hb.Sohrabi, LD); Eshafan: Foothills of the Domane mountain, 133 km from Esfahan on the road to Daran, Alava 14490 (TUR); Semirom region, Kuhe Pashmaku mountains, 5 kilometers west of the village of Semirom, Alava 14408, 14431 (TUR).

Candelariella kuusamoënsis Räsänen (Räsänen 1939, p. 56)

Type: [RUSSIA]. Ks. Kuusamo, Rukatunturi, supra muscos destructos in fissuris rupibus umbros. 8 July 1934, V.Räsänen (H! lectotype, here designated, H! isolectotype). Note on the typification: There are two specimens at H with the annotation "Orginal!". One of these, marked "2", was fertile and had an annotation of spore size on the label by Räsänen's hand. This specimen is here selected as the lectotype.

Candelariella kuusamoënsis is a poorly understood name that has been used rather randomly for various specimens on soil, plant debris, bark, wood and rock of e.g., *C. placodizans*, *C. vitellina* and *C. coralliza*. Morphologically, the type appears intermediary between *C. vitellina* and *C. coralliza* but has an unusually dark yellow, almost orange colour. It forms a thick, pulvinate crust composed of small effigurate to almost granular areoles. There appear to be no other character apart from the growth form and substrate separating it from *C. vitellina* but *C. vitellina* also grows on soil and the status of this species appear uncertain to us. It has been reported from Tajikistan by Kudratov & Mayrhofer (2002).

Literature reports: TAJIKISTAN: Kudratov & Mayrhofer (2002).

Candelariella kuusamoënsis var. areolata Hakul. (Hakulinen 1958, p. 55)

Type: UZBEKISTAN. In promontorium jugi Alajensis, montes Kadamzhaj, 7 Mar 1949, N.Schafeev (TUR!, holotype).

The holotype of this taxon is very small and sterile and comprises a few orange-colored lobes which are more similar to *C. rosulans* in appearance than to C. *kuusamoënsis* (Westberg 2007a).

Candelariella lambii Hakul. (Hakulinen 1954, p. 36)

This large, lobate, polyspored, South American species is today recognized as *Placomaronea lambii* (Hakul.) R.Sant. (Westberg et al. 2009). Reports of this species may belong to *C. kansuensis* which also has a lobate shiny thallus with a gelatinuous epicortex (Westberg 2007b). It has been reported from Tajikistan (Kudratov & Mayrhofer 2002) and Uzbekistan (Hakulinen 1958). We consider these reports dubious but we have not studied the material.

Literature reports: TAJIKISTAN: Kudratov & Mayrhofer (2002); UZBEKISTAN: Hakulinen (1958).

Candelariella lutella (Vain.) Räsänen (Räsänen 1939, p. 57)

Lecanora xanthostigma var. *lutella* Vain. (Vainio 1878, p. 102). Type: FINLAND. Tavastia australis: Hollola, Hersala, *ad cortici alni*, 1873, Vainio (TUR-V 4227! lectotype, Hakulinen 1954, p. 100).

New to Iran. *Candelariella lutella* is a widely distributed, but neglected species. It grows on bark, usually on twigs, especially at the base of branches or uneven portions of the bark. It is characterized by its small size and polyspored asci. It has a pale yellow to greenish yellow thallus of small scattered to crowded areoles and small apothecia 0.2–0.4(–0.65) mm wide.

Specimens examined: IRAN: East Azarbaijan: Kaleybar, 21 km south of the road of Khoda-afarin to Jolfa, Aynaloo, Sohrabi 3694,Ghobad-Nejhad (Hb. Sohrabi).

Candelariella medians (Nyl.) A.L.Sm. (Smith 1918, p. 228)

Lecanora medians Nyl. (Nylander 1866, p. 367). Type: Not seen – Hakulinen (1954, p. 39) selected H-NYL No. 29126 as a neotype. This specimen is from Germany (Arnold Lich. Exs. No. 222c) but the only locality mentioned by Nylander in the protologue is "Luxembourg Parisis". The only specimen where this locality is noted was collected in 1878, 12 years after the species was published. A specimen without locality but with an annotation by Nylander of the spore size identical to that in the protologue may be an acceptable lectotype but the herbarium in Paris (PC) should be searched first.

Candelariella medians is easily recognized by its yellow, effigurate thallus which is dissolved into soredia in the central parts. It grows on nitrogen-fertilized calcareous rocks and is mainly known from the central and mediterranean parts of Europe reaching north to southern Scandinavia and south to northern Africa (Poelt & Vězda 1977, Arup & Westberg 2005). The species was reported from Iran by Moniri et al. (2009a).

Literature reports: AZERBAIJAN: Barkhalov (1983); IRAN: Moniri et al. (2009a); ISRAEL: Galun & Mukhtar (1996); TAJIKISTAN: Kudratov & Mayrhofer (2002); TURKEY: John (1989); TURKMENISTAN: Dzhuraeva (1978); UZBEKISTAN: Hakulinen (1958).

Candelariella minuta nom. inval. (Galun & Reichert 1960, p. 135)

Type: None designated.

From the original description this appears to be similar to *C. aurella*. It has a grey thallus and small, up to 0.5 mm wide apothecia. We have not seen any specimens identified as *C. minuta* and cannot say wheather this may be a distinct species. If so, the name has to be validated as no type was designated in the protologue.

Literature reports: ISRAEL: Galun & Reichert (1960); Galun & Mukhtar (1996).

Candelariella oleaginescens Rondon (in Vězda, 1965, No. 341)

Type: GALLIA [FRANCE]. Provence: Bouches-du-Rhône, Marseille, in collibus Marseilleveyre, prope Puits de Lierre, alt. 300 m s. m. 17 Nov. 1964, G.Clauzade & Y.Rondon (H! LD! isotypes).

This may be a lichenicolous species, at least initially. The thallus is grey and appear to be derived from an infection of the thallus of a host species but this requires further studies. The isotypes show a rather thin thallus compared to *C. plumbea* and the apothecia has a thalline margin that is rounded and not convoluted as in *C. plumbea* (Poelt & Vězda 1976). The apothecia have a grey thalline margin outside a yellow proper margin that surrounds the disc, a character which appear to separate *C. oleaginescens* from *C. aurella*.

Literature reports: IRAN: Vondrák et al. (2010); ISRAEL: Galun & Mukhtar (1996).

Candelariella oleifera H.Magn.

This species is here treated as a synonym to *C. rosulans* (see that species).

Candelariella placodizans (Nyl.) H.Magn. (in Lynge 1935, p. 23)

Lecanora vitellina var. *placodizans* Nyl. (Nylander 1861, p. 290). Type: NORWAY. Oppland: Dovre, Lilla Nystuhøe, 1858, J.E.Zetterstedt (H-NYL 29138! lectotype, Hakulinen 1954, p. 78).

Syn. *Candelariella septentrionalis* Hakul. (see Westberg 2007a)

This is an arctic-alpine species growing on the ground on mosses and plant debris in alpine belts. Its greenish yellow, subsquamulose thallus with a "pruinose" surface gives the species a distinct and characteristic appearance (Westberg 2007a). It has a circumpolar arctic distribution and also occurs in the Himalayas in Asia and the Rocky Mountains in North America (Westberg 2007a, Westberg 2010). In Iran, it has been reported from a locality between Semnan and Golestan Province by Szatala (1957).

Literature reports: AZERBAIJAN: Barkhalov (1983, as *C. septentrionalis*); IRAN: Szatala (1957: 137); TAJIKISTAN: Kudratov & Mayrhofer (2002); UZBEKISTAN: Hakulinen (1958, as *C. septentrionalis*).

Candelariella plumbea Poelt & Vězda (Poelt & Vězda 1976, p. 88)

Type: ROMANIA. Dobrogea: Tirgusor, Valea Baba prope pagum Cheia, c. 50 m s. m. ad saxa calcarea, 2 May 1974, Vězda [Vězda, Lich sel. No. 1381] (H! LD! isotypes).

Candelariella plumbea is possibly a lichenicolous species. It has a thick, grey thallus of various appearance but often indistinctly squamulose to partly granular. It appears to us that the thallus is derived from an infection of another lichen, whose thallus quickly turn grey and becomes rather amorphous in appearance. It's distinction from *C. oleaginescens* is not clear but the type has a thicker thallus and an apothecium margin that is convoluted whereas it is more rounded in *C. oleaginescens.*

Literature reports: IRAN: Seaward et al. (2008: 476); TAJIKISTAN: Kudratov & Mayrhofer (2002).

Specimens examined: IRAN: Lorestan: slopes of river valley near Dorud, 58 km W of Aligudarz on road to Kali Kuh, Alava 14563a (TUR); Kohgiluyeh and Boyer-Ahmad: ca 30 km on the road from Yassuj to Semirom, Maassoumi & Safavi 1835 (B).

Candelariella reflexa (Nyl.) Lettau (Lettau 1912, p. 196)

Lecanora vitellina var. *reflexa* Nyl. (Nylander 1866, p. 241). Type: FRANCE. Fontainebleau, ad Robiniam, 1854, W.Nylander [Nylander: Lich. Parisien No. 121] (H-NYL 29179! lectotype, Hakulinen 1954, p. 53).

The name *C. reflexa* has for a long time been applied to small sorediate specimens of *Candelariella*. This species grows on bark and has a characteristic appearance with, small, lobate areoles that produce soredia in the center of the lobes from soralia that typically become somewhat excavate. There is a lot of 8-spored material from different parts of the world that is not morphologically similar to *C. reflexa* and the name *C. xanthotigmoides* is a more appropriate name for at least part of this material (Lendemer & Westberg 2010). The group is in need of a revision but as far as we know there are no reliable records of *C. reflexa* from outside of Europe.

Literature reports: ARMENIA: Harutyunyan & Mayrhofer (2009); AZERBAIJAN: Barkhalov (1983); TAJIKISTAN: Kudratov & Mayrhofer (2002); UZBEKISTAN: Hakulinen (1958).

Candelariella rhodax Poelt & Vêzda (Poelt & Vězda 1976, p. 89)

Type: ROMANIA. Dobrogea: distr. Tulcea, in valle fluminis Casimcea, prope introitum rivi Tirgusor, inter pagos Gura Dobrogea et Tirgusor, alt. 50 m s. m. Ad saxa calcarea. 12 July 1973, Vězda [Vězda, Lich sel. No. 1184, as *C. senior*] (H! isotype)

This species has short, but distinctly developed, up to 2 mm long marginal lobes. It is normally pruinose especially towards the central parts but does not always form clearly rosette-like thalli. It grows on calcareous rocks in arid parts of central Europe (references). It has been reported from one locality in Iran (Seaward et al. 2008).

Literature reports: IRAN: Seaward et al. (2008); TAJIKISTAN: Kudratov & Mayrhofer (2002).

Candelariella rosulans (Müll.Arg.) Zahlbr. (Zahlbruckner 1928, p. 802)

Candelaria vitellina var. *rosulans* Müll.Arg. (in Britton & Murray 1895, p. 200). Type: U.S.A. Colorado: Flagstaff Hill, 6000 ft., 1891, E.Penard (G! lectotype, Westberg 2007b, p. 411). ?Syn. *Candelariella oleifera* H.Magn. (Magnusson 1940, p. 126). Type: CHINA. Kansu: Ping-tsao-ho (Shargaltein), alt. 4200 m. 18 Aug. 1932, B.Bohlin 88f (S! holotype).

This is a common species in western North America showing a wide range of variation in both morphology and ecology. A large part of the material is sterile but can be identified by the scattered, lobate areoles/subsquamules that never forms distinctly rosette–like thallus as is often seen in e.g., *C. rhodax*. The material agrees well in both morphology and ecology to the populations seen by the second author in the Sonoran and Great Basin deserts in western U.S.A. *Candelariella rosulans* and the closely related species *C. kansuensis* (Westberg et al. 2007) apparently belong to a steppe–desert element present both in western America and central Asia, a distribution pattern discussed in detail by Weber (2003). The material here identified as *C. rosulans* is variable and in addition often collected on calcareous rocks, a substrate that it rarely grows on in North America (Westberg 2007b). In addition, while the majority of the specimens are sterile, the fertile specimens show a large variation in spore size, (10–)12–20(–25) × (3–)4–6(–7) µm. All this clearly indicates that *C. rosulans* is in need of a revision. We here consider, somewhat tentatively, *C. oleifera* as a synonym to *C. rosulans*. The type of *C. oleifera* is very small, comprising some large apothecia

and a few thallus fragments. It was collected on granitic rock in the Kansu province in China. There are no characters separating it from *C. rosulans* which, however, is a very variable species probably comprising several taxa not yet recognized.

Literature reports: IRAN: Seaward et al. (2004: 476, as *C. oleifera*); AFGHANISTAN: Poelt & Wirth (1968, as *C. oleifera*).

Selected Specimens examined: IRAN: East Azarbaijan: Jolfa to Siahrood ca. 5 Km to Siahrood, Sohrabi 1099 & Reza Sohrabi (Hb. Sohrabi, LD); Jolfa towards Khoda-Afarin, Missan village, Sohrabi 1390 (Hb. Sohrabi, LD); Kaleybar, ca.10 km from Aras River, between Khoda-afrin to Jolfa, Daraghzi Village, Sohrabi 3644 (Hb. Sohrabi); Esfahan: Foothills of the Domane mountain, 133 km from Esfahan on the road to Daran, Alava 14494, 14515 (TUR); Ghohrud, c. 10 km on the road to Kashan, Shahsavaran Pass, Maassoumi & Safavi 1873 (B, TARI). Fars: Bolhayat Pass, between Shiraz and Kazeroun, Maassoumi & Safavi 2720 (B, TARI). North Khorassan: Bujnourd, towards Sisab station, Maassoumi, Sohrabi & Safavi 2398 (B, TARI); Bojnourd, ca. 20 km toward Sissab village, Sohrabi 6660 (Hb. Sohrabi, LD); Hamadan: Hamadn region, Foothills of the mountains above the village of Gholi-Abad, c. 60 km N of Hamadan, Alava 14744 (TUR). Zandjan: Zanjan-Hamadan road. Hills abover the village of Dashti on the lower slopes of Qeydar mountains, Alava 14652, 14663 (TUR). Lurestan: Aligudarz region, 58 km from Aligudarz on the road to Kali Kuh. Slopes in the river valley, Alava 14528, 14535, 14563 (TUR); Mazandaran: Chalus valley. River Gorge between the villages of Siah Bisheh and Pol-e-Zanguleh, Alava 14590 (TUR); Amol, to Tehran, Larijan district,Vana & Akha villages, Sohrabi 2638 (Hb. Sohrabi); Golestan: Golestan National park, Allmeh valley, 7–8 km from Mirza-Baylu Station, Sohrabi 1272 (Hb. Sohrabi, LD, H) and Sohrabi 1336 (Hb.Sohrabi): Incheh-Broun to Maraveh Tappeh, Ca. 6 to Makhtomgoli grave, Sohrabi 2041 (Hb. Sohrabi, LD); Razavi Khorassan: Gonabad, c. 21 km toward Qayen (Ghaen), Maassoumi, Sohrabi & Safavi 2299 (Hb. Sohrabi, TARI); c. 130 km to Sabvezar from Shahrud, Maassoumi, Sohrabi & Safavi 2142 (Hb. Sohrabi, TARI); West Azarbaijan: ca. 15 km SE of Maku on the road no. 4 from Bazagaran to Tabriz, Uotila 15660 (H); Uromieh, Sero, Neychalan, Mt Marmisho, Sohrabi & Edisho 818 (B, TARI)

Candelariella senior Poelt (Poelt 1958, p. 440)

Type: [SPAIN] SO-Spanien: Felskuppe einer halbwüstennaften Höhe bei Lorca, Prov. Murcia. 4. 1953, J.Poelt (M–0099854! holotype).

This is one of the lobate species in the genus. The marginal lobes are epruinose, up to 3 mm long and rather broad and flattened. *Candelariella rhodax* has a pruinose thallus and short, up to 2 mm long, and rather convex lobes.

Literature reports: TAJIKISTAN: Kudratov & Mayrhofer (2002).

Candelariella unilocularis (Elenkin) Nimis

This species is a synonym to *C. aurella* (see that species).

Candelariella viae-lactea G.Thor & V.Wirth (Thor & Wirth 1990, p. 2)

Type: HUNGARY. Bács-Kiskun prov.: Kecskemét area, Fülöpháza (20 km W of Kecskemét). Sand dunes with scattered *Populus* sp. Alt. 150 m. 26 May 1987, G.Thor 7015 (S! holotype).

This species is characterized by 8-spored asci, a grey thallus and by growing on bark and wood. Compared to *C. antennaria* which has a thin to thick, often rather amorphous thallus, *C. viae-lactea* has a thallus mainly composed of granules, c. 50–150 µm wide but may also partly develop larger areoles. The proper exciple of this species is similar to that in *C. antennaria* (Westberg 2007b).

Literature reports: IRAN: Moniri et al. (2011: 134). TURKEY: John (1999, Lich. Anatol. Exs. No. 17).

Candelariella vitellina (Hoffm.) Müll.Arg. (Müller 1894, p. 47)

Patellaria vitellina Hoffm, (Hoffman 1794, p. 5). Type: [on wood], Ehrhart Pl. Cryptog. Linn. No. 155 (UPS! lectotype, Westberg 2007a, p. 384).

A common, world-wide polyspored species growing mainly on siliceous rocks but may also be found on bark, wood and on mosses. It has a yellow, usually well-developed thallus composed of granules to minutely lobate areoles sometimes forming cusions on the substrate. It is a variable species and *C. vitellina* is likely to be a species complex. The distinction between *C. vitellina* and *C. kuusamoënsis* is not clear.

Literature reports: AFGHANISTAN: Riehmer (1938, not seen); ARMENIA: Barkhalov (1983); Harutyunyan & Mayrhofer (2009); AZERBAIJAN: Barkhalov (1983); CYPRUS: Litterski & Mayrhofer (1998); GEORGIA: Barkhalov (1983); IRAN: Barkhalov (1975: 129); Moniri et al. (2009a, b); Seaward et al. (2004: 551); Sohrabi (2005: 106); Sohrabi & Sipman (2007: 89); JORDAN: El-Oqlah (1992); SYRIA: John et al. (2004); ISRAEL: Galun & Mukhtar (1996); PAKISTAN: Poelt (1961); SAUDI ARABIA: Abu-zinada et al. (1986); TAJIKISTAN: Kudratov & Mayrhofer (2002, also var. *assericola* and *C. kuusamoënsis*, var. *kuusamoënsis* and var. *areolata*); TURKEY: John (1989); John & Nimis (1998); TURKMENISTAN: Dzhuraeva (1978); UZBEKISTAN: Hakulinen (1958, *C. kuusamoënsis*, var. *kuusamoënsis* and var. *areolata*).

Selected specimens examined: IRAN: Ardabil: In collibus trachytis 37–40 km NNW Ardabil versus Germi. 18 May 1971, Rechinger (W). East Azarbaijan: Kaleybar, ca. 10 km from Kaleybar, Hejranduost village, Sohrabi 4287 (Hb. Sohrabi, H); Kaleybar district 55 km N of Kaleybar along road to Khomarlu, Sohrabi 10381, Sipman, Søchting & Asef, (Hb. Sohrabi). Mazandaran: Amol, to Tehran, Larijan district,Vana & Akha villages, Sohrabi 2271 & Pasha, (Hb. Sohrabi, LD).

Candelariella xanthostigma (Ach.) Lettau (Lettau 1912, p. 196)

Lecanora xanthostigma var. *citrina* Ach. (Acharius 1810, p. 149). Type: "Suecia" [on wood]. (H-ACH 1244C! lectotype, Laundon 1963, p. 18).

Candelariella xanthostigma is a small species growing on bark or wood. It has a yellow thallus composed of small, more or less spherical granules and has polyspored apothecia but is often sterile. It has been reported from Iran (see below) but we have not seen any collections from Iran during this study.

Literature reports: ARMENIA: Barkhalov (1983); Harutyunyan & Mayrhofer (2009); AZERBAIJAN: Barkhalov (1983); CYPRUS: Litterski & Mayrhofer (1998); GEORGIA: Barkhalov (1983); IRAN: Oxner (1946: 83); Barkhalov (1975: 129, as *C. vitellina* var. *xanthostigma*); ISRAEL: Temina et al. (2005); PAKISTAN: Poelt (1961); SYRIA: John et al. (2004); TURKEY: John (1989); John & Nimis (1998); TURKMENISTAN: Dzhuraeva (1978).

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