

ON RHIZOCARPON VIRIDIATRUM (WULFEN) KÖRB. IN NORTH-EASTERN IRAN

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Morphology, anatomy, chemistry and distribution of the species *Rhizocarpon viridiatrum* (*Rhizocarpaceae*, Lichenized Fungi) in NE Iran are presented based on observations from 357 samples collected in Razavi Khorasan province during 2006-2007, an analysis of lichen substances and a literature survey.

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درباره *Rhizocarpon viridiatrum* (Wulfen) Körb. در شمال شرق ایران

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ریخت‌شناسی، آناتومی، شیمی و توزیع گونه *Rhizocarpon viridiatrum* (*Rhizocarpaceae*, Lichenized Fungi) بر اساس مشاهده ۳۵۷ نمونه جمع‌آوری شده از استان خراسان رضوی در سال‌های ۲۰۰۶ و ۲۰۰۷ به همراه تحلیل ترکیبات گلستنگی در یک نمونه و بررسی منابع ارائه می‌شود.

Introduction

The lichen genus *Rhizocarpon* introduced by Ramond in Flore Francaise ed. III (Lamarck and Candolle, 1805) has been subject to taxonomic debate. Originally its species were included in *Lecidea*, *Buellia* and *Diplotomma*. Since 1871 new attempts have been made to delimit a separate genus *Rhizocarpon* Lam. ex DC. as a cosmopolitan with ca. 200 species (Feuerer, 1978). Traditionally the genus is divided in a group of species with yellow-green thallus and a group with non-yellow-green, generally grayish or brownish thallus (Thomson, 1967). The yellow group is distributed in the Arctic and the Antarctic and the temperate zones of the world, as well as at high elevations in the mountains of warmer zones (Runemark, 1956).

The presence of the genus in Iran is very poorly known, as is knowledge generally for lichens, while recent investigations are beginning to change that situation. The lichenological knowledge in Iran experienced a considerable improvement in the last decade (Seaward et al., 2004; 2008). As a result, the presence of ten species and one subspecies of *Rhizocarpon* in Iran, including six species for Razavi

Khorasan province, have been reported (Seaward et al. 2008; Moniri et al. 2009). Razavi Khorasan province in the northeast of Iran with an area of c. 127,432 km² biogeographically belongs to Irano-Touranian region (Takhtajan, 1977). Razavi and Northern Khorasan provinces have more mountain ranges than any other parts in the country, including Ala Dagh, Binaloud, Hazar Masjid and Kopet Dagh (Zomorodian, 2002), and certainly they must have a greater saxicolous lichen diversity than the little attention to the area has revealed so far.

The present study is a continuation of our analyses of *Rhizocarpon* in Razavi Khorasan province (Haji Moniri et al., 2010; Haji Moniri & Kamyabi, 2010), and deals with morphology, anatomy, chemistry and distribution of *R. viridiatrum* (Wulfen) Körb. The ecology is not yet included because more extensive sampling of other regions of the province, especially mountainous zones, as well as microhabitat studies are needed to improve our knowledge of the species.

Material and Methods

357 samples of *R. viridiatrum* were collected on shaded siliceous and calcareous-siliceous rocks in 19 sampling sites (Fig. 1) during the period from the spring of 2006 to the fall of 2007 by the second author. For more information about the sampling sites see Moniri et al., 2009. The study area is covered by permanent grasslands and permanent pastures in irregular arrangements, and is mostly situated in highlands with cold climate ranging from 960 to 2360 m. Identification and measurements were made using a stereomicroscope and a compound microscope. For the applied spot tests see Orange et al. (2001). TLC of a sample of *R. viridiatrum* was kindly done by Dr. Kukwa in Gdansk, Poland. Original material is deposited in the first author's lichen collection, with a duplicate in MSC.

Results and discussion

Rhizocarpon viridiatrum (Wulfen) Körb.

Description. *Thallus* to 3 cm in diam., initial areola on *Aspicilia* sp. (Fig. 2), with limited number of secondary areoles, without hypothallus and areoles separated by substrate, marginal areoles flattened with indistinct prothallus or without prothallus; not sorediate.

Areoles 0.2-0.6 mm in diam., yellow-green, plane and/or slightly convex, surface pruinose, matt (Fig. 3), secondary areoles angular; cortex ca. 10-25 μm thick, necrotic top layer ca. 10-20 μm thick, medulla white, over 200 μm thick, I -, seldom I + light blue, algal layer ca. 40-90 μm thick (Fig. 4).

Apothecia 0.5-1 mm in diam., 0.8 mm thick, round or angular, disk initially flat but soon strongly convex, without margin, epruinose, matt. Exipulum very thin with a black margin, 10 μm thick; hymenium 80-120 μm thick, hyaline, uppermost part dark red; paraphyses colourless, slightly branched, apical cells clavate; epihymenium dark reddish-brown with black granules, K + red, usually 15-30 μm thick; asci clavate, ca. 80-115 \times 28-33 μm , containing 8 spores; ascospores submuriform to muriform, black or dark brown, 12-25 \times 7-13 μm (Fig. 5). Pycnidia not studied.

Lichen substances. Rhizocarpic acid and an unknown fatty acid, identified by TLC on the specimen no. 2354, collected from Torbat-e Jam, Bezd, UTM 41S, 261304 3899185, 1562 m elev., 19. Jul. 2007 (hb. Haji Moniri, hb. Kukwa).

Ecology. *R. viridiatrum* has been found in quite concave depressions of siliceous and calcareous rocks, in which rainwater accumulates.

Distribution. *R. viridiatrum* is mainly found in the northern areas of the province and has few localities in the central and south-eastern parts (Fig. 1), (Table 1). It

is restricted to the slightly and markedly wet zones with annual precipitation 100-300 mm. Among the known species of the genus *Rhizocarpon*, *R. viridiatrum* is the most frequent below 1000 m in the province (Kamyabi, 2009; Moniri et al., 2009).

The Iranian record of *R. viridiatrum* (Szatala, 1940) is also from the northeast of Iran. Evidently, the species is much more common in Razavi Khorasan province than elsewhere in Iran, as it has not been reported from other provinces yet (Seaward et al., 2008).

At the world level, the species is widespread, being reported from Africa, Asia, the Arctic, Australia, Europe, and North and South America (Anonymous, 2011; Thomson 1997; Nash et al., 2004). As to neighboring countries, the species is reported from Tajikistan, Kazakhstan and Turkey (Wagner & Spribille 2005; Anonymous 2011).

Notes. *Rhizocarpon viridiatrum* is readily recognized by being lichenicolous, by its convex and immarginate apothecia and its pale greenish yellow thallus. The dark olivaceous to brown ascospores are suggestive of *R. saurinum*, but that species has less septate smaller ascospores (Moniri et al. 2009) and lacks black granules in the epihymenium.

Rhizocarpon viridiatrum belongs to the "Viridiatrum group" of species. These have multiseptate ascospores, an epihymenium with dark granules, and a medulla reacting negatively with Lugol's iodine (Runemark, 1956). *R. viridiatrum* in this group is distinguished by its very dark ascospores, so that the septa are not recognized easily, at least in Iranian collections (Kamyabi, 2009). In addition, its prothallus is thin and not always distinguishable while it is always lichenicolous (Runemark, 1956).

Most of the investigated Khorasan samples are lichenicolous on thalli of *Aspicilia* spp. (259) while a good number grows associated with the areoles of *Acarospora* spp. (46) (Kamyabi, 2009).

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Table 1. Distribution and abundance of *Rhizocarpon viridiatrum* (Wulfen) Korb. in Razavi Khorasan province.

Locality/ Elevation (m)	Total Thallus of <i>Rhizocarpon</i>	Thallus of <i>R. viridiatrum</i>	Frequency % <i>R. viridiatrum</i>
Mashhad-Kordineh/ 1763-1873	78	25	32.06
Mashhad-Taraghdar-Dehbar/ 1600-1710	93	24	25.81
Mashhad-Zoshk/ 1700	41	10	24.36
Mashhad-Kang/ 1750-1850	83	18	21.68
Torbatjam-Bezd/ 1540	117	20	17.09
Torbatjam-Palangavar/ 1560	31	23	76.19
Khaf-Arzaneh/ 1070-1340	64	32	50
Neyshabour-Darroud/ 1700	27	10	37.04
Neyshabour-Boujan/ 1750	53	10	18.86
Kallat-Ghalenow/ 1350	63	12	19.04
Kallat-Zavin/ 1500	18	11	61.12
Kashmar-Kariz/ 1560	32	26	81.25
Kashmar/Chehelpou/ 1820	68	68	100
Chenaran- Baroo/ 1260	25	25	100
Torbathaidarie-Roudmaajan/ 1630	12	12	100
Sabzevar-Shareh/ 1300-1530	17	17	100
Quchan-Dorbadam/ 2300	9	9	100
Daregaz-Chehelmir/ 1300	5	5	100

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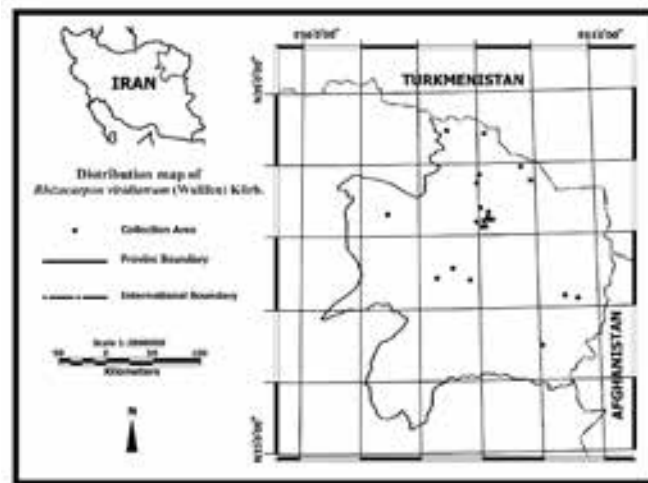


Fig. 1. Distribution map of *Rhizocarpon viridiatrum* in Razavi Khorasan Province (Kamyabi, 2009).

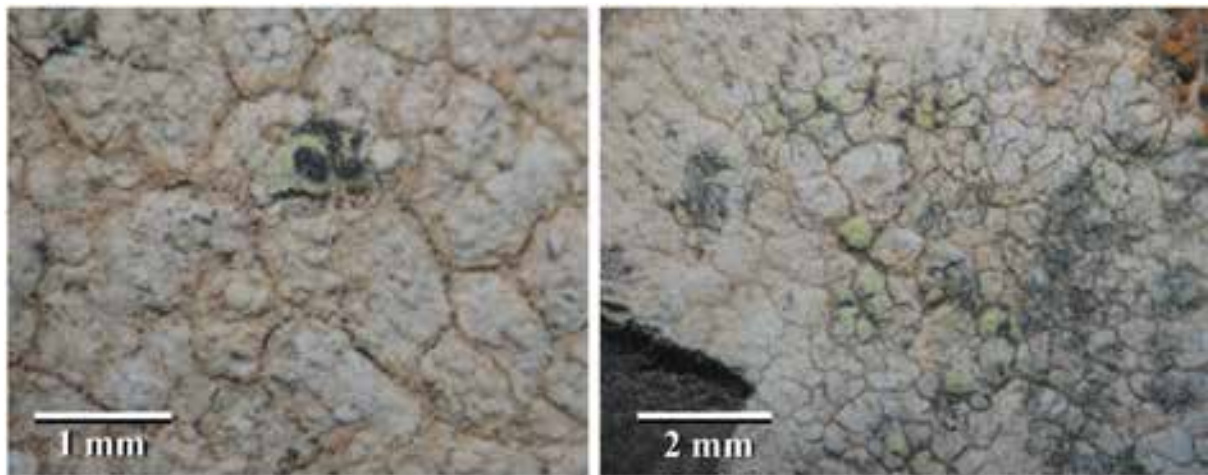


Fig. 2. Primary areoles of *Rhizocarpon viridiatrum* on *Aspicilia* sp. (Kamyabi, 2009).

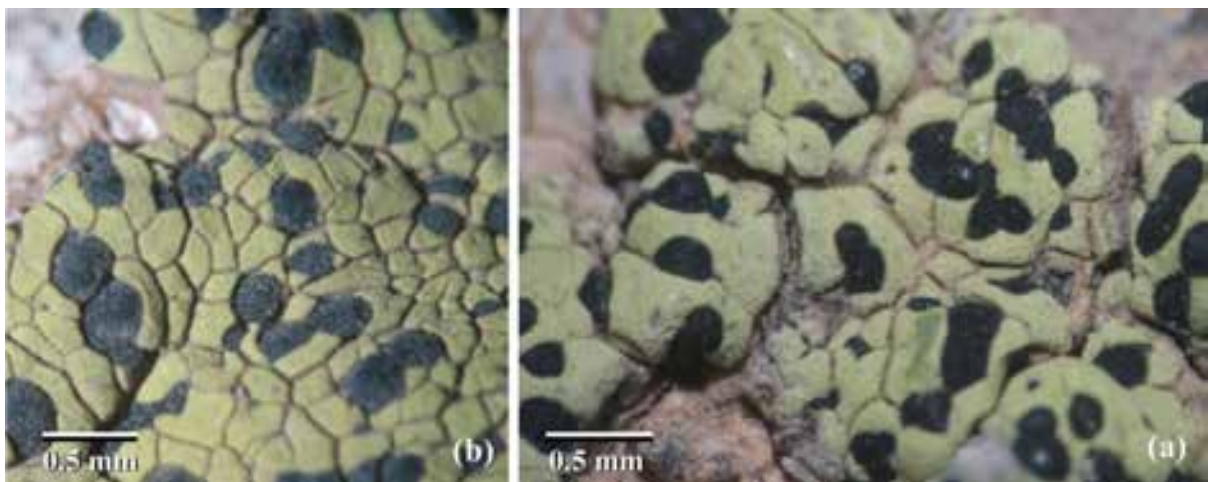


Fig. 3. Areolate thallus of *Rhizocarpon viridiatrum*, the absence of a prothallus (Kamyabi, 2009).

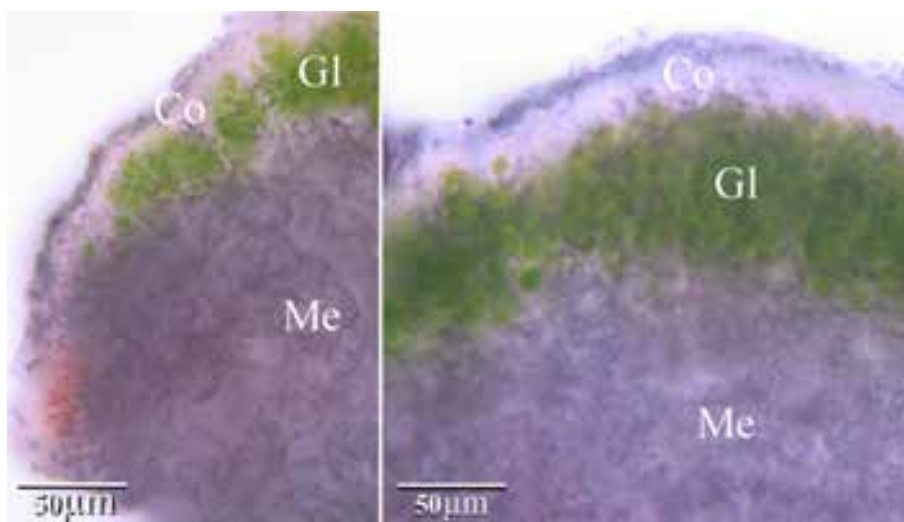


Fig. 4. Longitudinal section of an areole of *Rhizocarpon viridiatrum*, Co: cortex, Gl: algal layer, Me: medulla (Kamyabi, 2009).

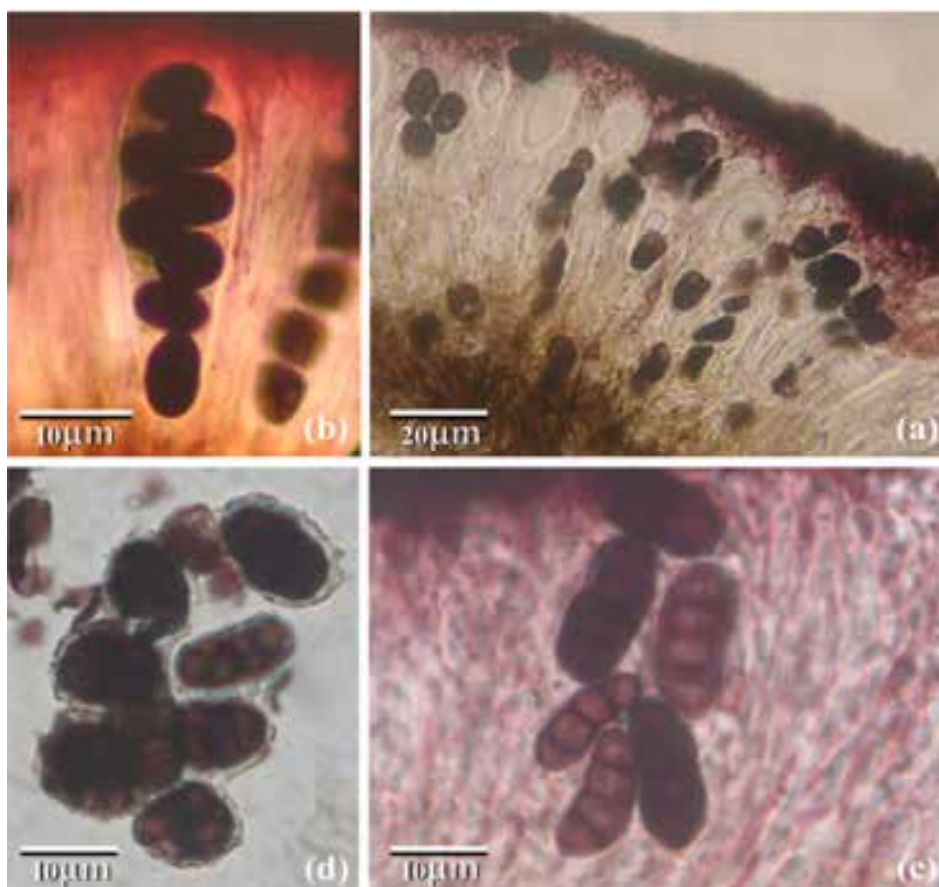


Fig. 5. *Rhizocarpon viridiatrum* (Kamyabi, 2009) (a): Hymenium; (b): Clavate ascus containing 8 dark ascospores; (c): Muriforme ascospores (d): Submuriforme ascospores.

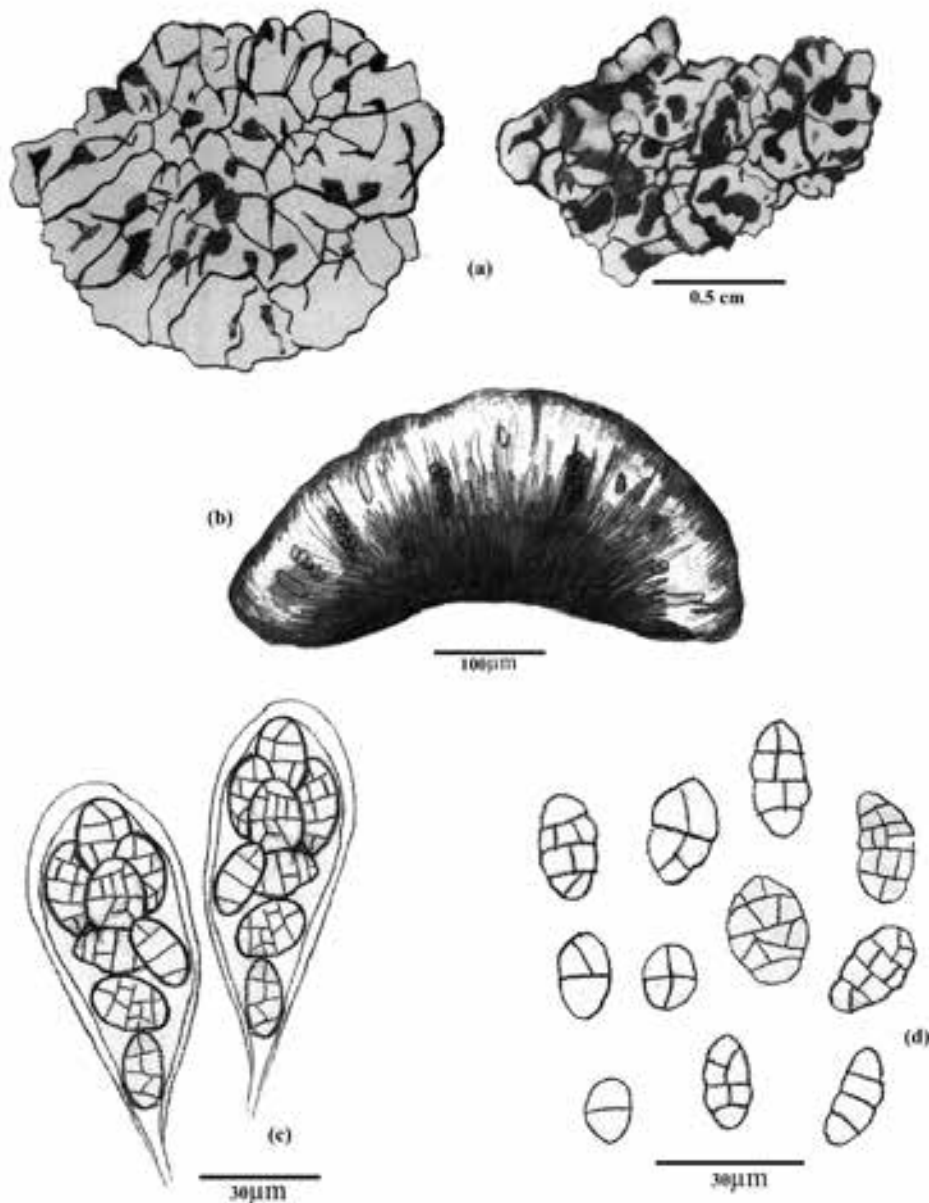


Fig. 6. Schematic pictures of thallus and reproductive organ in *Rhizocarpon viridiatrum*: (a). Thallus with flattened marginal areoles, (b). Longitudinal section of apothecium, (c). Ascus containing 8 muriforme ascospores and (d). Different shapes of ascospores (Kamyabi, 2009).

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