Phytoparasitica (2010) 38:81–93
DOI 10.1007/s12600-009-0073-0

Description of the rusts from Kemaliye (Erzincan, Turkey)

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Received: 21 August 2009 / Accepted: 11 December 2009 / Published online: 14 January 2010

Abstract Twenty-two rust diseases caused by *Melampsora euphorbiae*, *M. lini* var. *lini*, *Phragmidium mucronatum* var. *mucronatum*, *Ph. sanguisorbae*, *Gymnosporangium cornutum*, *G. confusum*, *G. tremelloides*, *Puccinia acarnae*, *P. annularis*, *P. eryngii*, *P. heterophyllae*, *P. hieracii*, *P. jasmini*, *P. menthae*, *P. nigrescens*, *P. pulverulenta*, *P. punctata*, *Uromyces dianthi*, *U. pisi-sativi*, *U. polygoni-avicularis*, *U. striatus* and *Pileolaria terebinthi* were identified from Kemaliye (Erzincan) in Turkey. *Puccinia heterophyllae* is reported for the first time from Turkey.

Keywords New record · *Puccinia heterophyllae* · Rust fungi · SEM · Uredinales

Introduction

Rust fungi (Basidiomycota, Uredinales), with more than 7,000 species, are the largest group of obligate plant pathogens known to date (Aime 2006). About 310 rust species, belonging to the genera *Coleosporium*, *Cerotelium*, *Cumminsiella*, *Endophyllum*, *Gymnosporangium*, *Gymnoconia*, *Hyalopsora*, *Kuehneola*, *Melampsora*, *Melampsorella*, *Melampsoridium*, *Phragmidium*, *Pileolaria*, *Puccinia*, *Pucciniastrum*, *Trachyspora*, *Tranzschelia*, *Uromyces* and *Zaghouania*, have been reported from Turkey (Bahçecioğlu and Gjærum 2003; Hüseyin 2004a, b, c; Hüseyin and Kırbağ 2003; Kırbağ et al. 2001; Tamer et al. 1998). This number is low in relation to the very rich and diverse higher plants of the country, which comprise more than 12,000 species.

Kemaliye (Erzincan) is situated in the Irano–Turanian phytogeographic region, and on the Anatolian Diagonal, which is one of the main endemic centers of Turkey. According to the grid square system adopted by Davis (1965–1985), Kemaliye is located in the squares B7. The study area is mountainous, and elevations range from 600 to 3,500 m. The climate of the province is Mediterranean and continental.

Floristic studies of the parasitic fungal flora are the first and the most important step to controlling the fungal diseases in a country. Although there are numerous studies on macrofungal flora of Turkey, little attention has been given to parasitic fungi of the country. The Kemaliye district was chosen as a research area, because its climatic conditions and plant distributions are suitable for the growth of microfungi.

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Materials and methods

Plant specimens infected with rust fungi were collected from Kemaliye in Erzincan province of Turkey. The host specimens were prepared according to established herbarium techniques. Host plants were identified using the *Flora of Turkey and East Aegean Islands* (Davis 1965–1985). Urediniospores and teliospores were scraped from the specimens and mounted on a microscope slide, and microscopic examination and microphotographs undertaken using a Leica DM E light microscope. The microfungi specimens were identified using the relevant literature (Azbukina 2005; Kuprevich and Ulijanishchev 1975; Ulijanishchev 1978; Ulijanishchev et al. 1985; Wilson and Henderson 1966). All specimens examined were deposited in the mycological collection of the Department of Biology, Arts and Sciences Faculty, Ahi Evran University, in Kırşehir province of Turkey.

For scanning electron microscopy (SEM), 8–10-mm-square pieces of infected leaves bearing uredinia and/or telia were mounted on the SEM stubs with double-sided adhesive tape. They were coated with gold using a Polaron SC 502 Sputter Coater and were examined with a Jeol JSM 6060 scanning electron microscope operated at 15 kW in the Electron Microscopy Unit, Arts and Sciences Faculty, Gazi University (Turkey).

Results and discussion

Twenty-two rust diseases caused by rust fungi were identified in the research area.

Melampsora euphorbiae (Ficinus & C. Schub.) Castagne - Uredinia: amphigenous, generally hypophyllous, rarely on the stems, yellow, scattered, minute, up to 500 µm diam, surrounded by many capitate paraphyses. Urediniospores: yellow, oblong, ellipsoid, 20–22.5 (-25)×(16-) 17.5–20 µm in size, wall densely echinulate, colorless (Fig. 1). Telia: amphigenous, reddish-brown then black, subepidermal, scattered or in small groups, often confluent. Teliospores: reddish-brown or brown, cylindrical–prismatic, ovate, not thickened at the apex, 23–60×8–14 µm in size, wall 1.5–3 µm thick. Host: *Euphorbia macroclada* Boiss., common name spurge; leaves showed pale yellow necrotic spots on the upper surface, often surrounded by a dark red margin. Under favorable conditions for disease spread, defoliation occurred and pustules were found on flowers and fruit.

Fig. 1 *Melampsora euphorbiae*: Urediniospores and paraphyses

Melampsora euphorbiae is reported all continents but Antarctica. The rust fungus occurs on a great number of *Euphorbia* species (Gjærum et al. 2007).

Melampsora lini (Ehrenb.) Lév. var. lini - Uredinia: amphigenous, subepidermal, scattered or in groups, rounded, 300–800 µm diam., surrounded by many capitate paraphyses. Urediniospores: orange–yellow, globoid, ovate or ellipsoid, 20–22.5×15–20 µm in size, wall 2 µm thick, finely echinulate-verruculose, colorless (Fig. 2). Telia: amphigenous, reddish-brown then black, subepidermal, scattered or in groups, confluent, elongate, 500–800 µm diam. Teliospores: brown, cylindrical–prismatic, 32.5–50×10–20 µm in size. Host: *Linum mucronatum* Bertol., common name flax; leaves and stems showed bright-orange pustules. Late in the season the orange pustules, especially those on the stem, became enlarged and dark brown to black.

Melampsora lini, flax rust, occurs throughout flax-growing countries and can cause severe losses in seed yield and fiber quality. The estimated loss in seed yield due to rust damage is 16–100%, depending on the cultivar, stage of plant growth, intensity of infection and environmental conditions (Hora et al. 1962). Direct control of flax rust by chemicals has never been economical and the only way to attempt control is to breed resistant varieties (s'Jacob 1955).

Phragmidium mucronatum (Pers.) Schltdl. var. *mucronatum* - Uredinia: hypophyllous, pale orange,

Fig. 2 *Melampsora lini*: Urediniospores and paraphyse

scattered or in groups, rounded. Urediniospores: pale yellow, globoid, ellipsoid or ovoid, 25–27.5 (-30)× 22.5–25 µm in size, wall echinulate, 2 µm thick, with 6–10 pores. Telia: hypophyllous, scattered or in groups, rounded, black. Teliospores: blackish-brown, ellipsoid to cylindrical, 4- to 9-celled, not constricted, verrucose, 85–100×32.5–37.5 µm in size. The hyaline pedicel was swollen, clavate in lower half (Fig. 3). Host: *Rosa canina* L., common name wild rose; leaves were densely covered with many circular to ellipsoid yellow spots and yellow pustules that turned brown in autumn. Affected leaves dropped prematurely.

Rust fungi in the genus *Phragmidium* are frequent pathogens of both wild and cultivated roses (Ritz et al. 2005). *Phragmidium mucronatum* is very common everywhere (Ellis and Ellis 1987).

Phragmidium sanguisorbae (DC.) J. Schröt - Uredinia: mostly hypophyllous, pale orange, scattered or in groups, rounded, surrounded by clavoid and curved paraphyses. Urediniospores: orange-yellow, globoid, ellipsoid, ovoid, 15–20 (-22.5)×12.5–17.5 µm in size, wall echinulate, 1–1.5 µm thick, with 6- to 8-pores. Telia: hypophyllous, black, scattered or in groups, rounded, minute, 0.5–1 mm in diam, surrounded by many clavoid paraphyses. Teliospores: blackish brown, ellipsoid to cylindrical, 2- to 5- (mostly 4-) celled, slightly constricted, apex rounded with a hyaline papilla 3–5 µm long, base rounded, (40-) 42.5–57.5×22.5–25 µm in size. The hyaline pedicel was swollen, 20–28×10–12 µm in size (Fig. 4). Hosts: *Sanguisorba* sp., common name salad burnet; and *Rubus sanctus* Schreber, common name blackberry; leaves were covered with circular to ellipsoid dark-purple spots and dark-brown or black pustules.

This rust is reported from Afghanistan (Henderson and Jorstad 1966), Armenia (Simonyan 1981), Balearic Islands (Jorstad 1962), Bulgaria (Petrova and Denchev 2004), Canary Islands (Gjærum 1987), Cyprus (Georghiou and Papadopoulos 1957), Denmark (Hylander et al. 1953), France (Hylander et al. 1953), Germany (Braun 1982), Greece (Gjærum and Hansen 1990), Iran (Gjærum 1986), Iraq (Mathur 1972), Libya (Kranz 1965), Madeira Islands (Gjærum 1982), Morocco (Guyot and Malencon 1963), Norway (Gjærum 1974), Pakistan (Ahmad 1969), Portugal (Gonzalez Fragoso 1918), Romania (Savulescu 1953), Spain (Gonzalez Fragoso 1914), Ukraine (Dudka et al. 2004), United Kingdom (Grove 1913).

Gymnosporangium cornutum Arthur ex F. Kern - Telia: scattered or in groups and confluent, 1.5–4 mm in

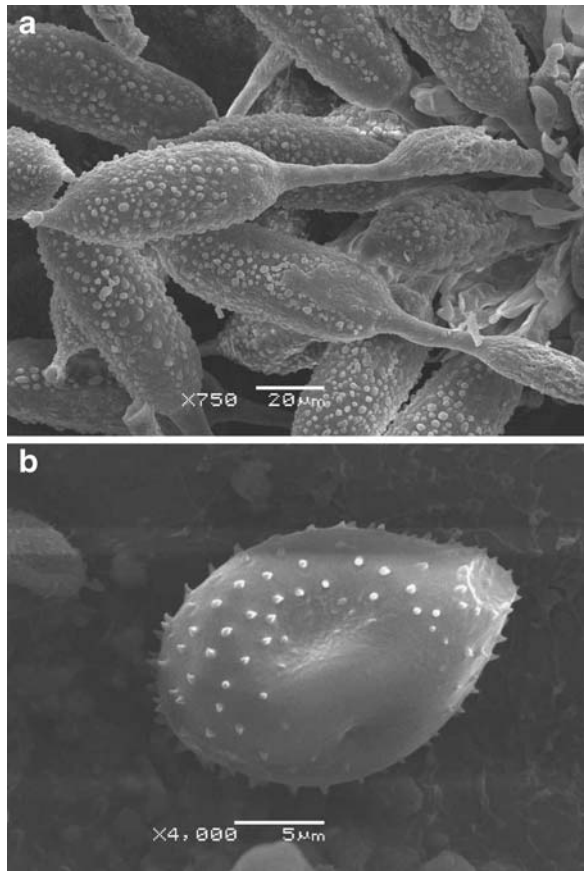

Fig. 3 *Phragmidium mucronatum* var. *mucronatum*: **a** Teliospores (SEM). **b** Urediniospore (SEM)

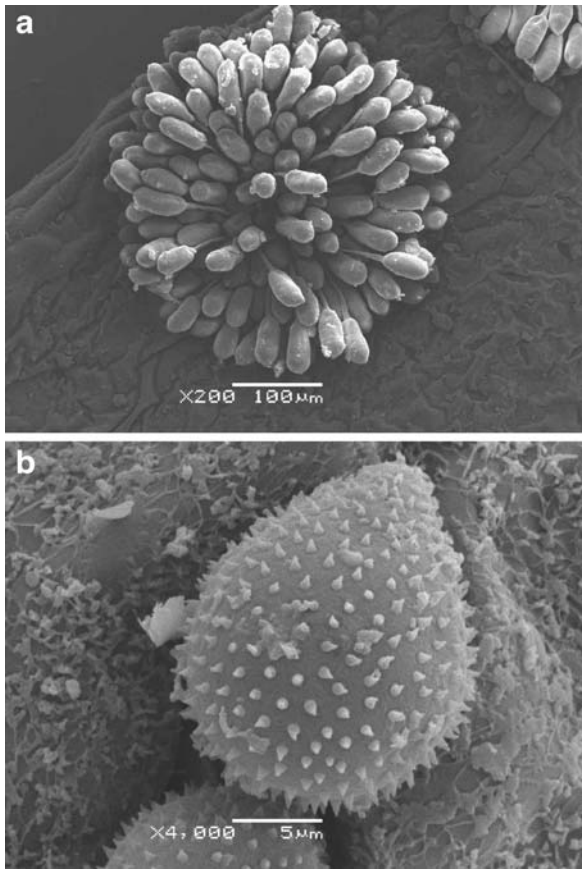

Fig. 4 *Phragmidium sanguisorbae*: **a** Telia and teliospores (SEM). **b** Urediniospore (SEM)

diam, spore mass applanate or hemispherical, at first chocolate-brown then becoming orange, soft and gelatinous when moist. Teliospores: chestnut-brown, ellipsoid, not or scarcely constricted, 25–50×18–30 µm in size, wall 1.5–2.5 µm thick, with 1 or 2 pores, pedicel long, gelatinous. Host: *Juniperus communis* L., common name mountain ash juniper; affected plants were recognizable by their orange horn-like structures on swollen stems.

Gymnosporangium cornutum is one of the first species of the genus to be cultured successfully, by Oersted in 1866 (Oersted 1866). He called the telial stage *Podiostoma juniperinum*, and the aecial stage *Roestelia cornuta*. It is reported from Africa, Asia, Europe, and North America (Kern 1972).

Gymnosporangium confusum Plowr. - Spermogonia: epiphyllous, orange, subepidermal in origin. Aecidia: chiefly hyphophyllous but also on the calyx and fruit, yellowish brown, 4–10×4–5 mm diam. Peridial cells in surface view lanceolate, in lateral view rhombic, 60–95×16–24 µm in size, outer wall smooth, 1–1.5 µm thick, inner walls 5–7 µm thick, with rather large, elongate, obliquely arranged warts and ridges. Aecidiospores: cinnamon-brown, globoid, ellipsoid 20–22.5×18–21.5 µm in size, wall verruculose, with 2 pores (Fig. 5). Host: *Crataegus monogyna* Jacq. subsp. *monogyna*, common name oneseed hawthorn; leaves were covered with brown, thickened, cylindrical to obconical, up to 10 mm long and 4–5 mm wide spots surrounded by a yellowish or orange margin.

The aecidia of *Gymnosporangium confusum* are quite different from those of *Gymnosporangium fuscum* DC. They resemble those of *Gymnosporangium clavariiforme* but are usually shorter, less deeply torn and rather more inflated; the peridial cells have their side-walls marked with elongate, obliquely placed ridges whereas those of *G. clavariiforme* are coarsely warted; the aecidiospores of the latter species

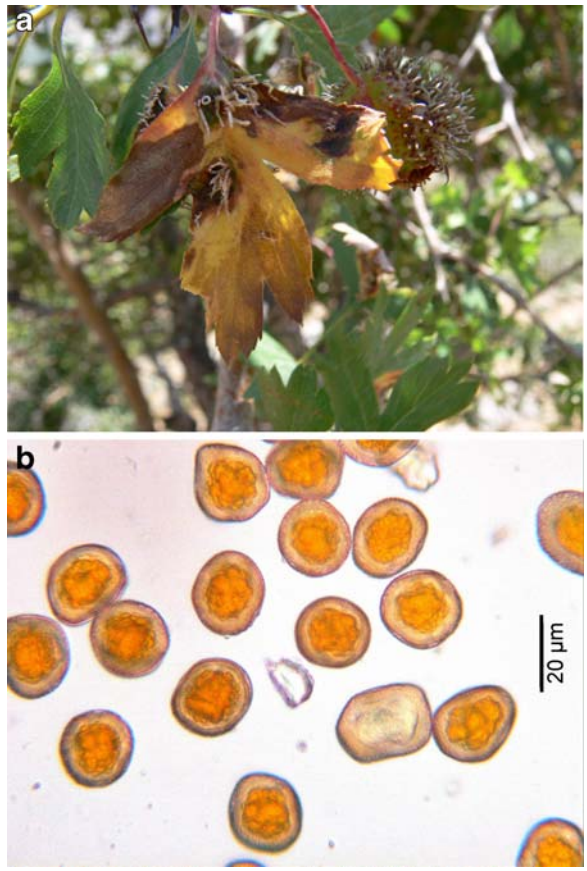

Fig. 5 *Gymnosporangium confusum*: **a** Leaf spot and infected fruit. **b** Aecidiospores

are larger than those of *G. confusum* (Wilson and Henderson 1966).

Gymnosporangium tremelloides R. Hartig - Spermogonia: epiphyllous, subepidermal in origin, yellowish chestnut. Aecidia: hyphophyllous, on the stems, on shoots and on fruits, in groups, 2–6 mm in diam. Peridium: cylindrical, curved, 4–10 mm long, 0.5–1 mm wide, whitish yellow, with outer wall smooth, 2–3 µm thick, 7–10 µm thick, arranged warts and ridges. Aecidiospores: globoid, ellipsoid, 28–45×25–35 µm in size, chestnut-brown, wall densely and finely verruculose, 3–5 µm thick, with 10–14 pores. Host: *Pyrus communis* L. subsp. *communis*, common name European pear; leaves showed yellow, orange or reddish, up to 1 cm diam, roundish spots.

Gymnosporangium tremelloides is reported as having a complex life cycle with spermagonia and aecia developing on *Pyrus* sp., and telia on *Juniperus* sp. (Wilson and Henderson 1966). *Gymnosporangium tremelloides* is reported from Europe, North America, Western Africa and Asia (Kern 1972).

Puccinia acarnae P. Syd. & *Syd.* - Uredinia: amphigenous, yellowish, roundish. Urediniospores: cinnamon-brown, ellipsoid, globoid, (20-) 26–29×21–26 µm in size, wall echinulate, 1–1.5 µm thick, with one pore. Telia: amphigenous, blackish brown, rounded. Teliospores: chestnut-brown, ellipsoid, broadly ellipsoid, ovoid, 38–50×21–26 µm in size, slightly constricted, wall verruculose, 1.5–2 µm thick, pedicel hyaline, short, fragile (Fig. 6). Host: *Picnomon acarna* (L.) Cass., common name soldier thistle; leaves showed blackish brown, circular scattered pustules.

Puccinia acarnae is reported from Bulgaria (Denchev 1995), Cyprus (Georghiou and Papadopoulos 1957), Greece (Gjærum and Hansen 1990), Iraq (Mathur 1972), Italy (Savile 1970), Morocco (Guyot and Malencon 1963), Spain (Gonzalez Fragoso 1918) and Yugoslavia (Savile 1970).

Puccinia annularis (F. Strauss) G. Winter - Telia: hypophyllous, brown, roundish, covered by the epidermis, in orbicular clusters, then naked, confluent, and forming a thick pulvinate mass. Teliospores: oblong, rounded at apex, attenuate at the base, (35-) 40–55×12–18 µm in size, wall smooth, 1–2 µm thick, 6–14 µm thick at apex, pale-yellowish-brown, pedicel 40–100 µm long, hyaline, persistent (Fig. 7). Host: *Teucrium chamaedrys* L., common name wood sage; leaves showed indefinite yellowish or brownish concave spots.

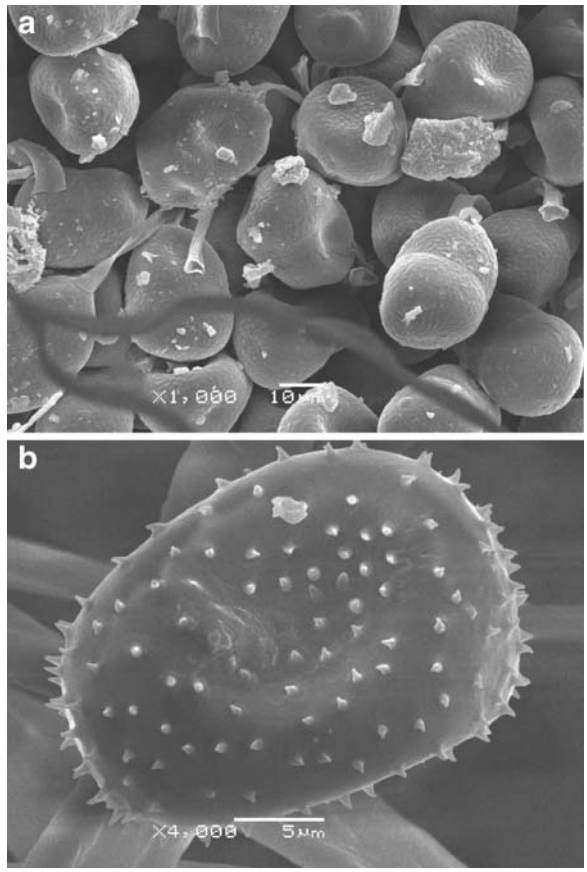

Fig. 6 *Puccinia acarnae*: **a** Teliospores (SEM). **b** Urediniospore (SEM)

Puccinia annularis is reported from Bulgaria (Denchev 1995), Chile (Mujica and Vergara 1945), Germany (Braun 1982), Greece (Pantidou 1973), Iran (Gjærum 1986), Romania (Savulescu 1953), Spain (Gonzalez Fragoso 1918) and Ukraine (Dudka et al. 2004).

Puccinia eryngii DC. - Telia: amphigenous, dark-brown, scattered, at first covered by the epidermis. Teliospores: chestnut-brown, ellipsoid, oblong, 36–50×23–30 µm in size, rounded at apex, attenuate at the base, slightly constricted, wall smooth, 1–1.5 µm in diam, pedicel short, hyaline, fragile (Fig. 8). Host: *Eryngium campestre* L., common name sea holly; leaves showed rounded to oblong, densely, scattered or confluent, 0.5–3 mm in diam, black pustules.

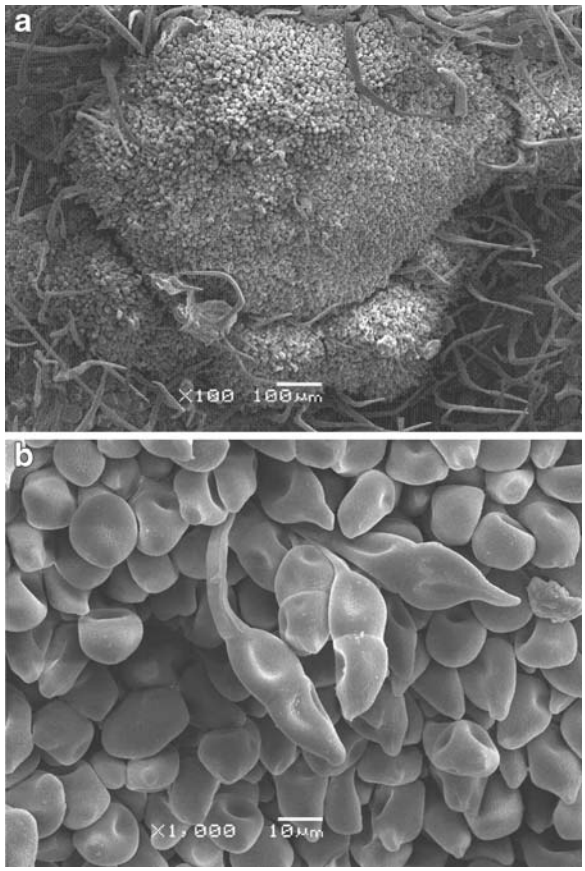

Fig. 7 Puccinia *annularis*: **a** Telia (SEM). **b** Teliospores (SEM)

Puccinia eryngii is known on *Ammi majus*, *Eryngium barrelieri* (Mathur 1972), *E. amethystinum* (Pantidou 1973), *E. caeruleum* (Koshkelova and Frolov 1973), *E. campestre* (Denchev 1995), *E. creticum* (Georghiou and Papadopoulos 1957), *E. kotschy* (Bahçecioğlu et al. 2006), and *E. tricuspidatum* (Guyot and Malencon 1957).

Puccinia heterophyllae Cooke - Uredinia: hypophyllous, sometimes epiphyllous, roundish, in groups, chestnut-brown, pulverulent. Urediniospores: globoid, 22.5–25 × 22.5–25 µm in size, wall echinulate, pale brown, with 3 pores. Telia: hypophyllous and on the stems, dark-brown, often confluent, pulverulent. Teliospores: ovoid, ellipsoid, oblong, 32.5–37.5 × 22.5–25 µm in size, rounded or attenuate at both ends, chestnut-brown, constricted or not constricted, wall verruculose, thickened at the apex, pedicel short, hyaline (Fig. 9). Host: *Serratula cerinthifolia* (Sm.) Boiss., common name saw-wort; leaves, petioles and stems showed chestnut-brown, circular, densely, often confluent, 0.5–2 mm in diam pustules.

This rust was reported from Cyprus (Georghiou and Papadopoulos 1957) and Iraq (Mathur 1972), but has not been previously recorded in Turkey.

Puccinia hieracii (Röhl.) H. Mart. f. *hieracii* - Uredinia: amphigenous, yellowish, small, scattered, pulverulent. Urediniospores: cinnamon-brown, ellipsoid, globoid, 26–34 × 22–30 µm in size, wall echinulate, 1–2.5 µm thick. Telia: amphigenous, blackish brown, scattered, pulverulent. Teliospores: chestnut-brown, ovoid, ellipsoid, 26–42 × 24–32 µm in size, rounded at both ends, sometimes attenuate at the base, wall verruculose, 1.5–2 µm in diam, pedicel short, hyaline (Fig. 10). Host: *Taraxacum* sp., common name dandelion; leaves showed yellowish brown irrregular spots and rounded to oblong, densely, scattered or confluent, 0.5–2 mm in diam, black pustules.

Puccinia hieracii is common on Asteraceae throughout the world. It is known from Turkey on *Acroptilon*

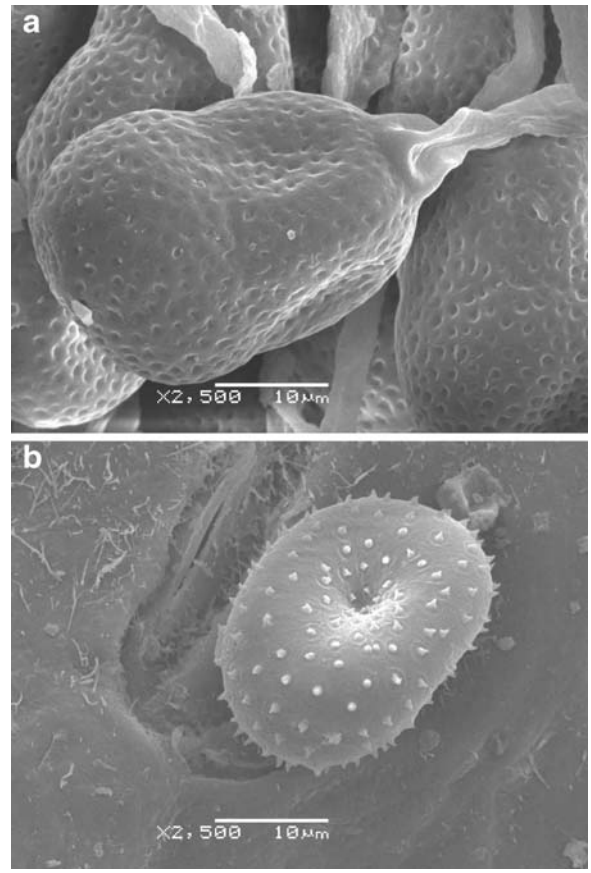

Fig. 8 *Puccinia eryngii*: **a** Teliospores (SEM). **b** Urediniospore (SEM)

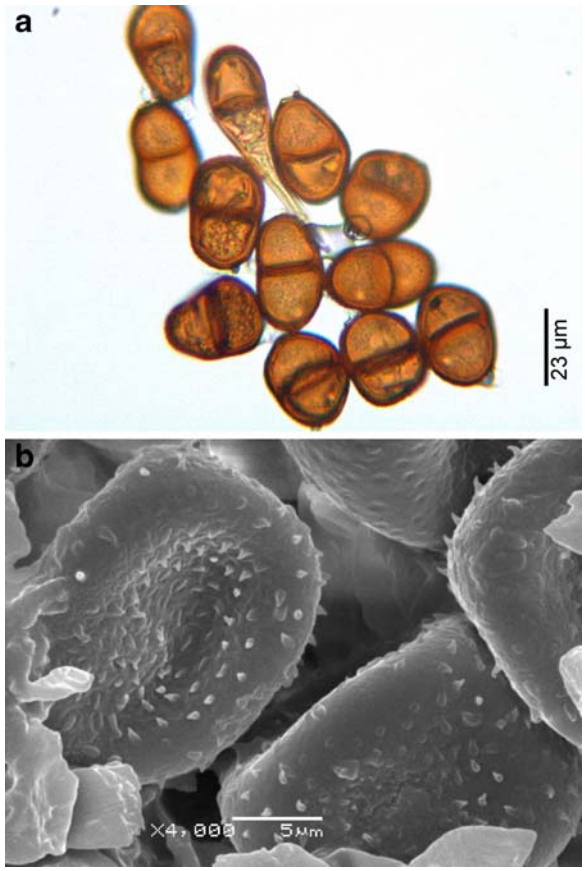

Fig. 9 *Puccinia heterophyllae*: **a** Teliospore. **b** Urediniospore (SEM)

repens, *Centaurea cheirolopha*, *C. lycopifolia*, *C. mucronifera*, *C. solstitialis*, *Chondrilla juncea*, *Cichorium intybus*, *C. pumilum*, *Hieracium pannosum*, *Picris strigosa*, *P. hieracioides*, *Pilosella auriculoides*, *Pilosella x fallax*, *Serratula cerinthifolia*, *S. oligocephala*, *Taraxacum assemanii*, *T. montanum*, *T. scaturiginosum*, *T. serotinum* and *T. syriacum* (Bahçecioğlu and Işıloğlu 1995; Bahçecioğlu and Yıldız 2005; Bahçecioğlu et al. 2006; Erdoğdu and Hüseyin 2008).

Puccinia jasmini DC. - Telia: amphigenous, generally hypophyllous, in dense groups on the stems and petioles, rounded or ovoid, gray or black. Teliospores: oblong, ellipsoid or ovoid, 40–43×21–30 µm in size, brown, apex often tapering, conic or obtuse, narrowed below, constricted, wall up to 3.5 µm thick at the side, 7.5 µm thick at the apex, pedicel up to 80 µm long, filiform, hyaline, strong (Fig. 11). Host: *Jasminum fruticans* L., common name jasmine; leaves were covered with black, rounded to oblong pustules.

Puccinia jasmini is known from Bulgaria (Denchev 1995), Canary Islands (Gjærum 1987), Madeira Islands (Gjærum and Sunding 1986), Morocco (Guyot and Malencon 1957), Portugal (Gonzalez Fragoso 1918) and Ukraine (Dudka et al. 2004) on *Jasminum fruticans* and *J. odoratissimum*.

Puccinia menthae Pers. - Uredinia: hypophyllous, brown, scattered or in groups, 1,5 mm in diam, roundish, sometimes confluent. Urediniospores: pale brown, ellipsoid, subgloboid, 26–35×19–23 µm in size, wall echinulate (Fig. 12). Telia: hypophyllous, scattered or in groups, rounded, black. Teliospores: dark brown, subgloboid, ovoid, rounded at both ends, 26–35×19–23 µm in size, wall verruculose, sometimes smooth, pedicel slender, longer than spore. Hosts: *Mentha pulegium* L., common name mint; and *Clinopodium vulgare* L., common name wild basil; shoots became pale, swollen and twisted and orange,

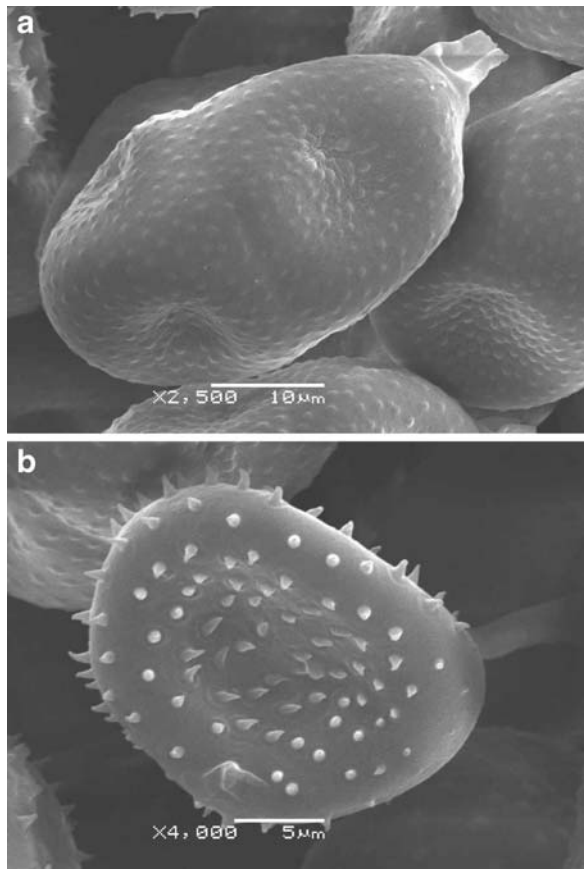

Fig. 10 *Puccinia hieracii* f. *hieracii*: **a** Teliospores (SEM). **b** Urediniospore (SEM)

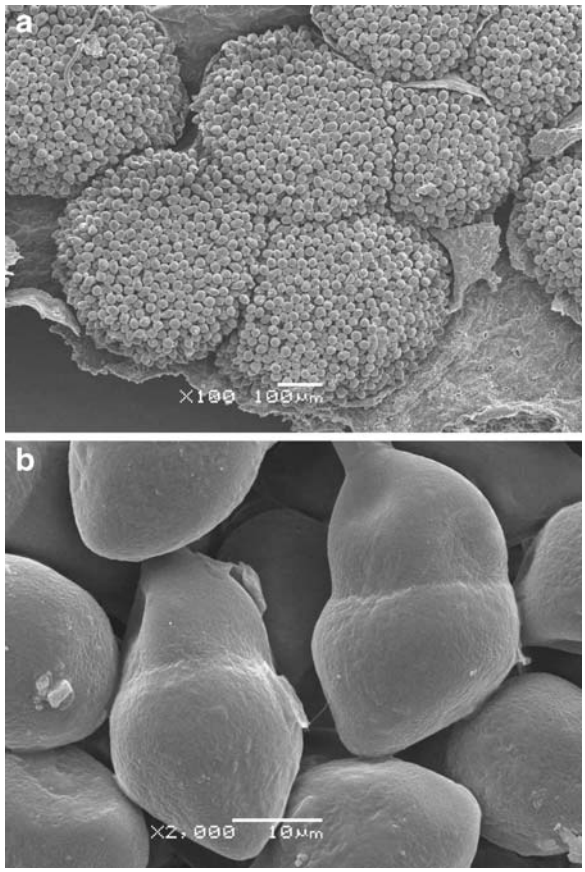

Fig. 11 *Puccinia jasmini*: **a** Telia (SEM). **b** Teliospores (SEM)

yellow or black pustules develop on the undersides of the leaves and on the stems, which often die.

Puccinia menthae causes the most important disease of cultivated *Mentha* species. Overwintering rhizomes are infected by teliospores in the soil and give rise to pale, swollen, distorted shoots in the spring. Aecia form on the leaves of these shoots, and the rust then spreads from leaf to leaf by aecidiospores and then urediniospores. Infected rhizomes can be heat-treated (44°C for 1 min) before planting (Smith et al. 1988).

Puccinia nigrescens Kirchn. - Uredinia: amphigenous, dark brown, scattered or in groups, rounded. Urediniospores: cinnamon-brown, globoid, subgloboid, 17–28×17–26 µm in size, wall echinulate, 2–3 µm thick, with 2 or 3 pores. Telia: amphigenous, scattered or in groups, rounded, brown. Teliospores: cinnamon-brown, ellipsoid, rounded at both ends, slightly constricted, 35–46×20–30 µm in size, wall verruculose, 4–6 µm thick, pedicels short, fragile, hyaline (Fig. 13). Host: *Salvia* sp., common name sage; leaves and petioles exhibited orbicular or oblong, scattered or in groups, sometimes confluent, black pustules.

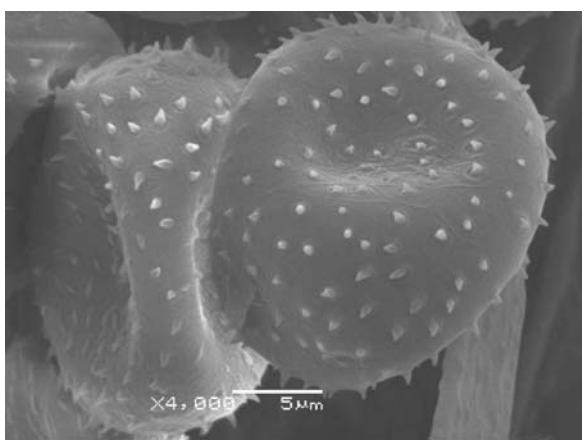

Fig. 12 *Puccinia menthae*: Urediniospores with echinulate surface (SEM)

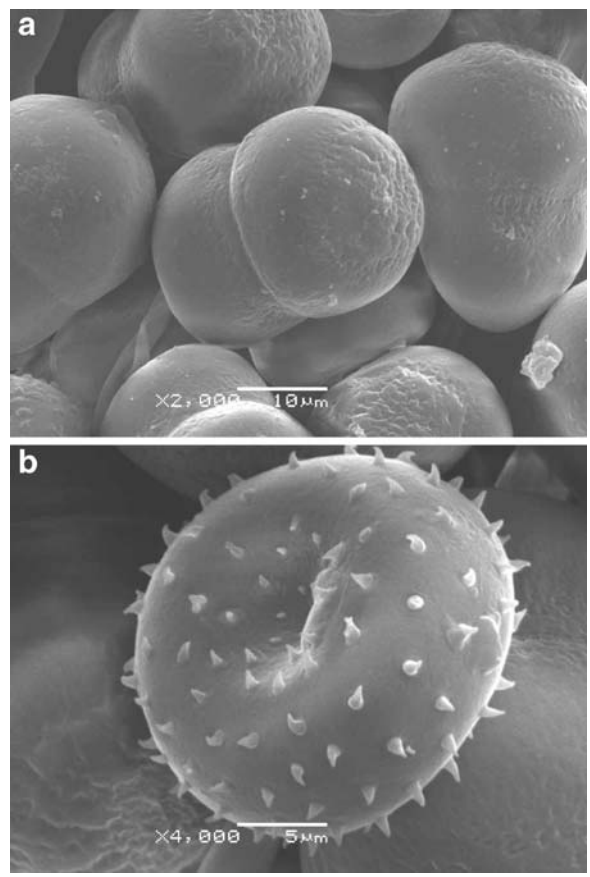

Fig. 13 *Puccinia nigrescens*: **a** Teliospores (SEM). **b** Urediniospore (SEM)

Puccinia nigrescens infects *Salvia amasiana* in Iran (Jorstad 1960), *S. napifolia* in Greece (Pantidou 1973), *S. vertisillata* in Armenia (Simonyan 1981), Bulgaria (Denchev 1995), Germany (Braun 1982), Lithuania (Ignataviciute and Minkevicius 1993), Norway (Gjærum 1974), Romania (Savulescu 1953), Serbia (Baxter 1955), Sweden (Jorstad and Nannfeldt 1958) and Ukraine (Dudka et al. 2004). It was observed on *Salvia amasiana*, *S. multicaulus* and *S. vertisillata* in Turkey (Bahçecioğlu and Yıldız 2005; Kabaktepe and Bahçecioğlu 2006; Tamer et al. 1998).

Puccinia pulverulenta Grev. - Uredinia: hypophyllous, chestnut-brown, scattered or in groups, sometimes confluent, pulverulent, 0.3–1 mm in diam. Urediniospores: brown, globoid to ovoid, 25–30×14–23 µm in size, wall remotely echinulate, 2–2.5 µm thick (Fig. 14). Telia: hypophyllous, dark brown, scattered, pulverulent. Teliospores: brownish, ellipsoid, rounded at both ends, slightly constricted, 30–32.5×20–22.5 µm in size, wall smooth, 1.5–3.5 µm thick, pedicels hyaline, fragile. Host: *Epilobium hirsutum* L., common name great willow-herb; easily recognizable by their much paler and yellowish color.

This rust is common on great willow-herb in Asia, North America, South America, Europe, Australia and New Zealand (Azbukina 2005).

Puccinia punctata Link - Uredinia: amphigenous, cinnamon-brown, minute, roundish, on the stems linear, often confluent. Urediniospores: pale-brown, globoid to ovoid, (20-) 22–30×17–23 µm in size, wall 1.5–2 µm thick. Telia: amphigenous, chocolate-brown

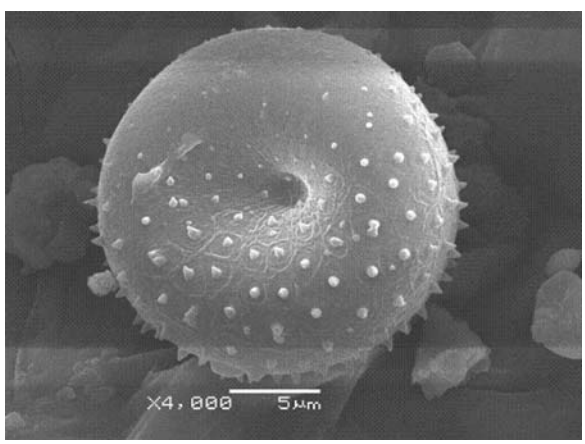

Fig. 14 *Puccinia pulverulenta*: Urediniospores with remotely echinulate surface (SEM)

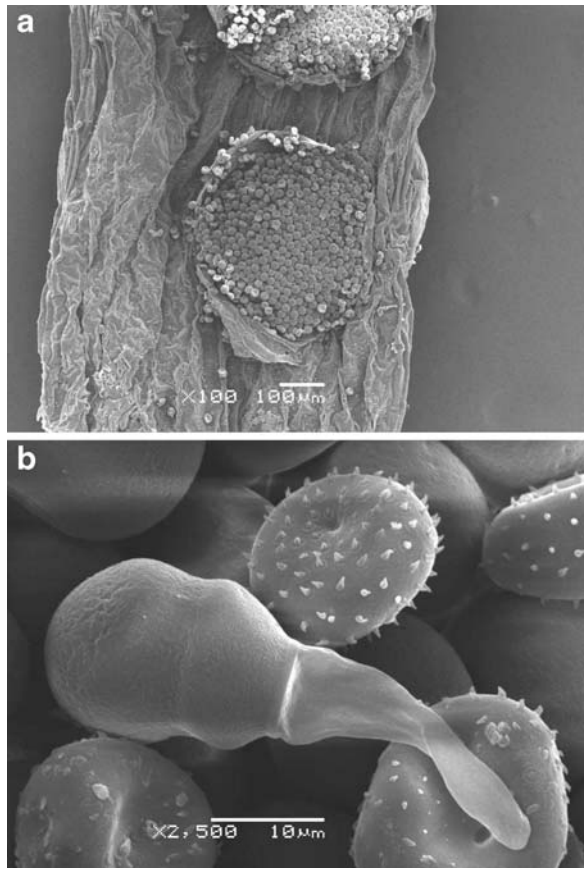

Fig. 15 *Puccinia punctata*: **a** Telia (SEM). **b** Teliospore and urediniospores (SEM)

to black, oblong or suborbicular. Teliospores: brownish, ellipsoid to clavoid, truncate, rounded or attenuate above and often darker, slightly constricted, tapering below, 30–56×14–24 µm in size, wall smooth, 1.5–2 µm thick, pedicels hyaline, fragile (Fig. 15). Host: *Galium* sp., common name bedstraw; leaves and stems showed black, circular, oblong or elongate pustules.

This rust is common in North America, Central and South America, Africa, Asia, Australia, Europe and New Zealand (Farr et al. 1995).

Uromyces dianthi (Pers.) Niessl. - Uredinia: amphigenous, cinnamon-brown, minute, rounded or oblong, pulverulent. Urediniospores: yellowish-brown, globoid, ellipsoid, ovoid, (18-) 20–35 18–25 µm in size. Telia: amphigenous, brownish-black, confluent, oblong, surrounded, subpulverulent. Teliospores: chesnut-brown, globoid, ovoid, 20–31×18–24 µm in size, wall 2–3 µm

thick, hyaline, densely and minutely echinulate, pedicels short, hyaline, deciduous (Fig. 16). Host: *Dianthus calocephalus* Boiss., common name carnation; leaves, buds and stems showed chocolate-brown, circular or oblong pustules. Leaves curl up, often die.

Uromyces dianthi is of worldwide distribution, causing carnation rust. This important disease occurs all the year round on the leaves and stems of the cultivated carnation (Smith et al. 1988).

Uromyces pisi-sativi (Pers.) Liro - Uredinia: hypophyllous, roundish, scattered, up to 1–1.5 mm in diam. Urediniospores: broadly ellipsoid, 18–25×13–21 µm in size, wall finely echinulate, 1.5–2 µm thick (Fig. 17). Telia: hypophyllous, irregularly scattered, chestnut brown. Teliospores: brown, broadly ellipsoid, slightly bullate at the apex, 25–27.5×17–21.5 µm in size, wall 2–3 µm thick at the sides, 4–5 µm thick at the apex, pedicels almost hyaline, fragile, short. Hosts: *Genista sessilifolia* DC., and *Astragalus* spp.; leaves showed bright-brown, circular or oblong, sometimes confluent pustules. This rust causes leaf deformation.

Uromyces pisi-sativi is reported as having a complex life cycle with spermagonia and aecia developing on *Euphorbia cyparissias* L., and uredinia and telia on the Fabaceae hosts (Wilson and Henderson 1966). This rust of pea, vetches and broad bean has only occasionally been reported as causing serious losses. It is largely a European pathogen but has also been reported from Africa, Asia (including Turkey) and S. America; it appears to be absent from North and Central America (Holliday 1980).

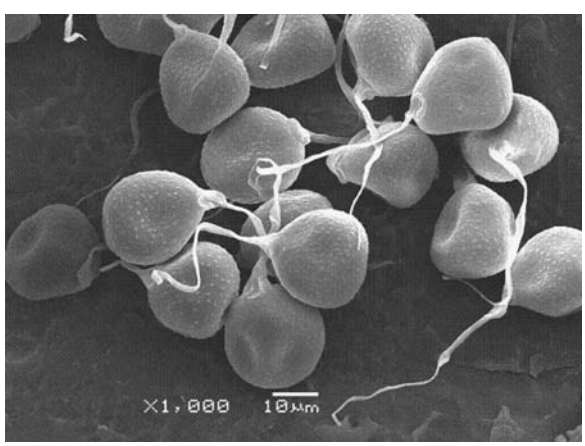

Fig. 16 *Uromyces dianthi*: Teliospores (SEM)

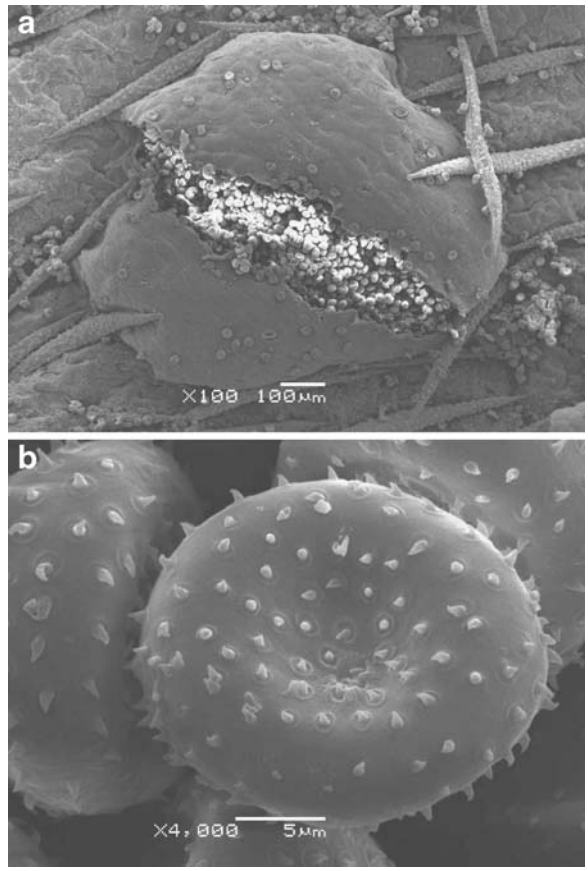

Fig. 17 *Uromyces pisi-sativi*: **a** Uredinia (SEM). **b** Urediniospores (SEM)

Uromyces polygoni-avicularis (Pers.) P. Karst.- Uredinia: amphigenous, cinnamon-brown, scattered, pulverulent. Urediniospores: pale-brown, globoid, ellipsoid, 18–26×17–24 µm in size, wall echinulate, 1.5–2.5 µm thick, with 3 or 4 pores (Fig. 18). Telia: amphigenous, dark-brown, scattered, pulverulent. Teliospores: chestnut-brown, globoid, obovoid, 22–38×14–22 µm in size, wall smooth, 6 µm thick at the apex, with one pore, pedicels hyaline, up to 90 µm long, persistent. Host: *Rumex acetosella* L., common name knot-grass; leaves showed small, irregular, brown or pale-yellow spots.

Uromyces polygoni-avicularis is currently known as a widely distributed species worldwide. It is known from Turkey on *Polygonum aviculare*, *P. bellardii*, *P. cognatum* and *P. polycnemoides* (Bahçecioğlu et al. 2006; Kabaktepe and Bahçecioğlu 2006; Pekel and Azaz 2003; Tamer et al. 1998).

Uromyces striatus J. Schröt. - Uredinia: hypophyllous, cinnamon-brown. Urediniospores: pale-cinnamon-

brown or golden-brown, subglobose to ellipsoid, 16–28×17–25 μm in size, wall echinulate, 1.5–2.5 μm thick, with 3 or 4 equatorial germ pores. Telia: hypophyllous, darker brown than uredinia, erumpent, circular to ellipsoid, pulverulent. Teliospores: pale- or dark-brown, ellipsoid, obovoid or globoid, 20–28 × 19–31 μm in size, with longitudinal striations and an apical pore (Fig. 19). Host: *Medicago varia* Martyn, common name alfalfa; leaves showed abundant circular brown pustules. Infected leaves turned yellow, dried up, and dropped early. The most severe attacks occurred in late spring at the time of first harvest.

Host range is limited to *Medicago* species, and its aecial stage develops on *Euphorbia* spp. This rust is common throughout the world (Graham et al. 1987). Serious losses have been reported from Iran (Sadravi et al. 2007), Israel, South Africa, Sudan, Uganda and USSR (Holliday 1980).

Pileolaria terebinthi (DC.) Castagne - Uredinia: mostly epiphyllous, reddish-brown, irregular or roundish, often on veins and petioles, elongate, merged then naked, 1.5–3 mm in diam. Urediniospores: brown, yellowish-brown, spherical, ellipsoid, pyriform or oblong, 27.5–36×(15-) 20–24 μm in size, wall densely and minutely verruculose, 4–5 μm thick, slightly thickened apically up to 6 μm, with 4 equatorial pores. Telia: mainly epiphyllous, dark-brown to black, irregular or roundish, merged, dusty, 1–2 mm in diam. Teliospores: chestnut-brown, lenticular, globose-lenticular, 30–32.5×22.5–25 (-31.5) μm in size, wall sparsely-verruculose, pedicels up to 450 μm long, filiform, hyaline, strong. Host: *Pistacia terebinthus* L., common name pistachio; leaves and petioles showed black, circular, oblong or elongate pustules.

This rust, caused by *Pileolaria terebinthi*, is one of the major diseases of pistachio. The disease is widespread in the Mediterranean region, and in Egypt (Corazza and Avanzato 1985).

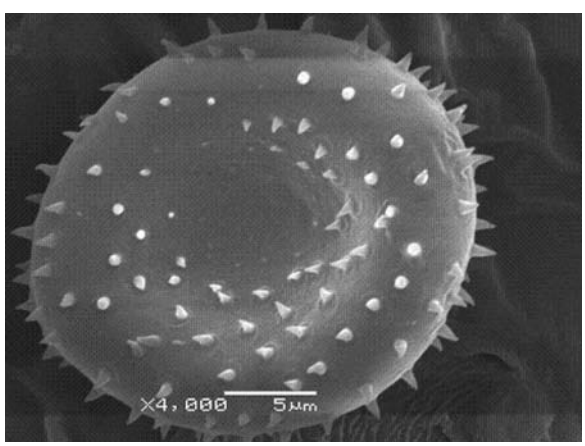

Fig. 18 *Uromyces polygoni-avicularis*: Urediniospores (SEM)

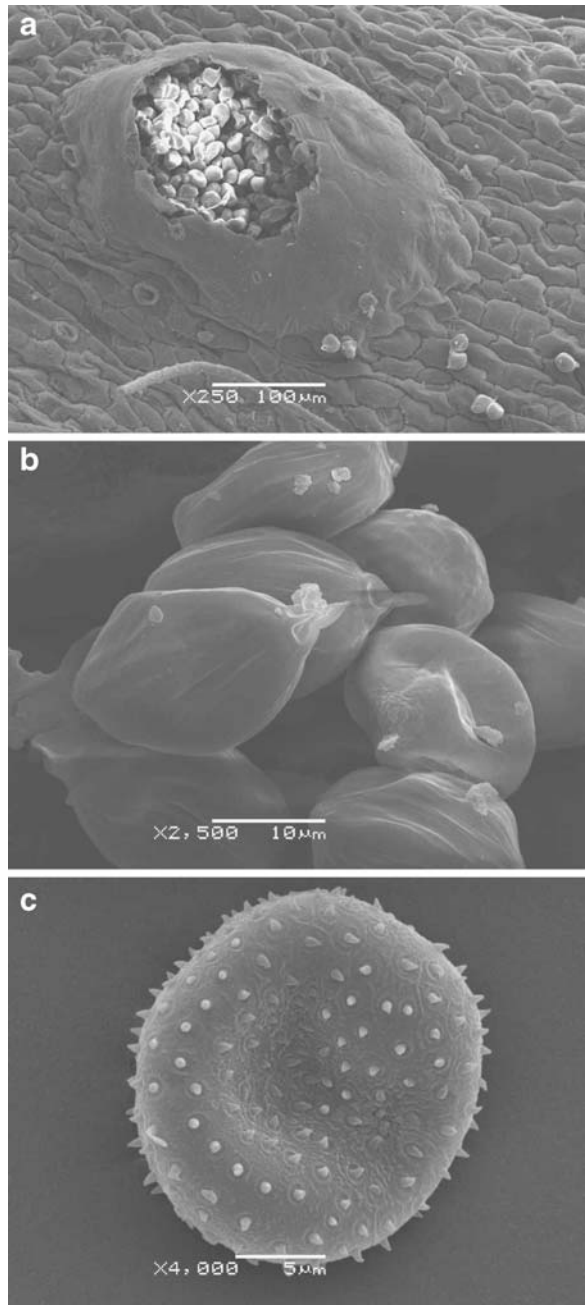

Fig. 19 *Uromyces striatus*: **a** Telia (SEM). **b** Teliospores (SEM). **c** Urediniospore

Acknowledgments We would like to thank TÜBİTAK (The Scientific and Technological Research Council of Turkey) for financial support of this project (ÇAYDAG-105Y016).

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