FOURTEEN RUSTS FROM NORTHEAST IRAN

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SUMMARY

Surveys of fields, parks, and forests in the Golestan province of northeast Iran resulted in the record of fourteen rust-induced diseases on weeping willow, black poplar, blackberry, rose, estragon, garlic, wild oat, barley, ryegrass, wheat, peach, plum, alfalfa, and broad bean. Causal agents were identified as *Melampsora coleosporioides, M. allii-populina*, *Phragmidium bulbosum*, *Ph. violaceum*, *Ph. rosae-pimpinellifoliae*, *Ph. tuberculatum*, *Puccinia absinthii*, *P. allii*, *P. coronata* f.sp. *avenae*, *P. coronata* f.sp. *hordei*, *P. graminis* f.sp. *avenae*, *P. hordei*, *P. persistens* subsp. *triticina*, *Tranzschelia discolor*, *Uromyces striatus,* and *U. viciae-fabae.* Weeping willow rust and barley crown rust are reported for the first time from Iran and Asia, respectively.

Key words: Rusts, *Melampsora*, *Phragmidium*, *Puccinia*, *Tranzschelia*, *Uromyces*.

INTRODUCTION

With more than 7000 species, rust fungi (Basidiomycota, Uredinales) are the largest group of obligate plant pathogens known to date (Aime, 2006). Among them, there are disease agents that severely affect field crops, vegetables, ornamentals, fruit, and forest trees (Agrios, 1997). Wheat rusts, for example, have influenced the course of early civilization by destroying a major source of food (Wiese, 1987) and are still most destructive pathogens in all provinces of Iran where, in 1993, have caused more than 1 million tons yield loss (Okhovat, 1999).

About 300 rust species, mostly belonging to the genera *Melampsora, Phragmidium, Puccinia, Tranzschelia,* and *Uromyces*, have been reported from Iran (Ershad, 1995). The most significant studies on rusts conducted in this country include those on *Melampsora* on shade and forest trees (Petrak and Esfandiari, 1941; Viennot-Bourgin, 1958), *Phragmidium* on *Rosa* and *Rubus* (Petrak, 1956), *Puccinia* on cereal crops (Ershad, 1995; Abbasi and Hejaroude, 2004a, 2004b), *Tranzschelia* on *Prunus* (Abbasi and Ershad, 1995; Sadravi, 2001), and *Uromyces* on *Medicago* and *Vicia* (Ershad, 1995; Abbasi and Pooralibaba, 2002).

The Iranian province of Golestan (southeastern shore of the Caspian sea) has a temperate humid climate, that favours the growth of a rich and diversified natural flora and timber trees, and the extensive cultivation of field, fruit and horticultural crops.

Although rusts are widely represented in this area, no specific surveys have been carried out in the past decades. This prompted the senior author to undertake an investigation to this effect, the results of which are reported in the present paper.

MATERIALS AND METHODS

From 2003 to 2005, fields, orchards, forests and parks of the Golestan province were surveyed and plants infected with rust fungi were sampled. Spores from sori were mounted in polyvinyl alcohol-lactic acid-glycerol (Koske and Tessier, 1983) and Melzer's reagent and observed with a bright-field microscope. For scanning electron microscopic examination, urediniospores were fixed in 3% glutaraldhyde in 0.02 M phosphate buffer pH 6, dehydrated in graded ethanol, critical point dried, mounted on aluminium stubs and coated with gold (Blaszkowski, 1997). Subepidermal telia were studied by preparing freehand sections of infected leaf tissues that were stained as described by Shipton and Brown (1962).

RESULTS AND DISCUSSION

Fourteen rust diseases caused by sixteen rust fungi were identified in the surveyed area.

Weeping willow rust. In late spring, leaves of weeping willow (*Salix babylonica* L.) were covered with yellow spots and yellowish-orange powdery pustules on

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their abaxial surface. These spots became necrotic and the pustules turned dark-brown in late summer, while the leaves desiccated and fell in early autumn. The pathogen, identified as *Melampsora coleosporioides* Dietel had the following characteristics: telia hypophyllous, sub-epidermal, dark brown, circular to oval. Teliospores hyaline to pale yellow-brown, one-celled, cylindrical, 21-53 × 4-7 µm in size, arranged in a single row (Fig. 1). Uredinia hypophyllous, yellowish-orange, sub-epidermal, erumpent, powdery, surrounded with many clavate paraphyses (Fig. 2). Urediniospores hyaline to pale-yellow, echinulate, obovoid to pyriform, 16-28 x 12-16 µm in size. (Figs. 3, 4).

Melampsora epitea (Kze. et Schum.) Thüm. is common on various willows (*Salix spp.*) in Iran (Ershad, 1995). *M. coleosporioides* can be distinguished from *M. epitea* by the position of uredinia (mainly hypophyllous in the former and amphigenous in the latter), larger urediniospores and smaller teliospores, and different host specificity (Walker, 1978; Latch, 1980; Spiers and Hopcroft, 1988, 1996; Ono *et al.*, 1992). *M. coleosporioides* can infect weeping willow and its hybrids, *S. fragilis* L. (common crack willow) and *S. matsudana* Koidz. (Peking willow), but *S. matsudana* × *S. alba* hybrid cultivars are highly resistant (Latch, 1980). This rust was reported from Russia (Sydow and Sydow, 1915), Japan (Ono *et al.*, 1992), China and Taiwan (Hiratsuka and Kaneko, 1982), eastern Australia (Walker, 1978), and New Zealand (Latch, 1980), but has not been previously recorded in Iran.

Black poplar rust. Leaves of black poplar (*Populus nigra* L.) trees showed circular to ellipsoid necrotic spots, and dark-orange to black pustules on the abaxial surface. Affected trees suffered heavy defoliation. The pathogen, identified as *Melampsora allii-populina* Kleb. had the following characteristics: telia hypophyllous, black, circular to ellipsoid and sub-epidermal. Teliospores yellowish-brown, one-celled, cylindrical to prismatic, rounded at both ends, 30-62 × 7-12 µm in size, arranged in a single row (Fig. 5). Uredinia hypophyllous, deep orange, sub-epidermal, erumpent, powdery, surrounded by many clavate paraphyses. Urediniospores hyaline, broadly elliptical, echinulate but smooth at the apex, 30-50 x 12-25 µm in size (Fig. 6).

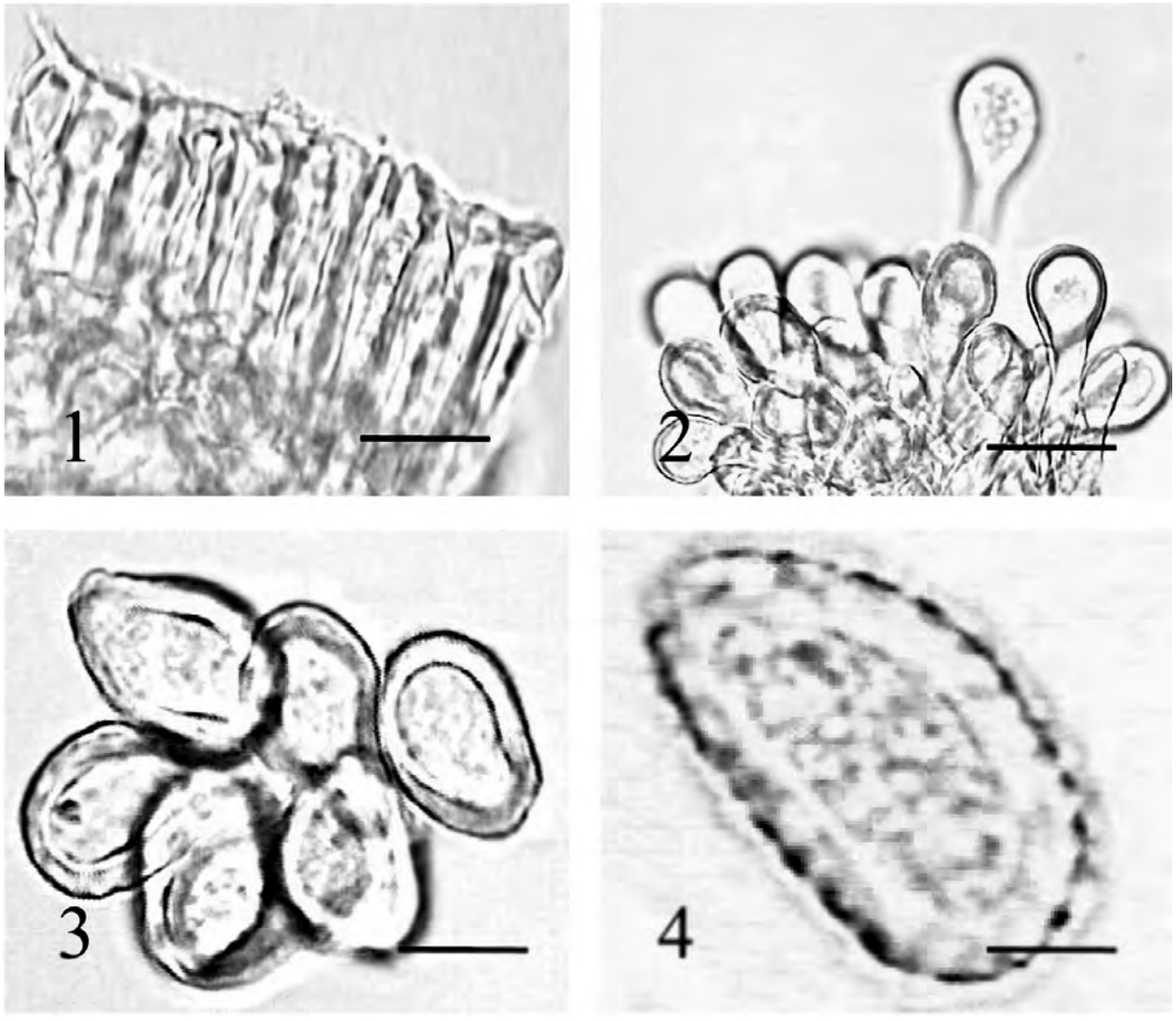
M. allii-populina can be distinguished from the six *Melampsora* species recorded from black poplar by its teliospore morphology and the evenly thick-walled, apically smooth urediniospores. This fungus can also infect *P. deltoids* Marsh. and *P. balsamifera* L. Its aecial stage, which was not observed in Iran, develops on *Allium spp.* and *Arum spp.* (Wilson and Henderson, 1966). *M. allii-populina* was reported from western, central and eastern Iran (Petrak and Esfandiari, 1941; Viennot-Bourgin, 1958), Russia, Africa, Australia, New Zealand and Britain (Sydow and Sydow, 1915; Gäumann, 1959; Wilson and Henderson, 1966; Viljanen-Rollinson and Cromey, 2002).

Blackberry rust. Blackberry (*Rubus fruticosus* L.) leaves showed circular to ellipsoid dark-purple spots on the upper surface, and yellow, orange-yellow and black pustules on the abaxial surface. Two *Phragmidium* species were identified on this host. The first, *Phragmidium bulbosum* (Strauss) Schlechtend, had the following characteristics: telia hypophyllous, black, circular to ellipsoid, and erumpent. Teliospores orange-brown, with a conical hyaline apical papilla, 2-7-celled, ellipsoid, verrucose, 37-113 × 25-35 µm in size (Fig. 7). The hyaline pedicel was swollen, clavate in the lower half. Uredinia, mixed with telia, were yellow, erumpent, powdery, and surrounded by many hyaline clavate paraphyses. Urediniospores hyaline to pale-yellow, globose to ovate, densely echinulate, bearing an indistinct germ pore, 17-25 × 17-20 µm in size (Fig. 8). *Ph. bulbosum* is new addition to the Iranian mycoflora.

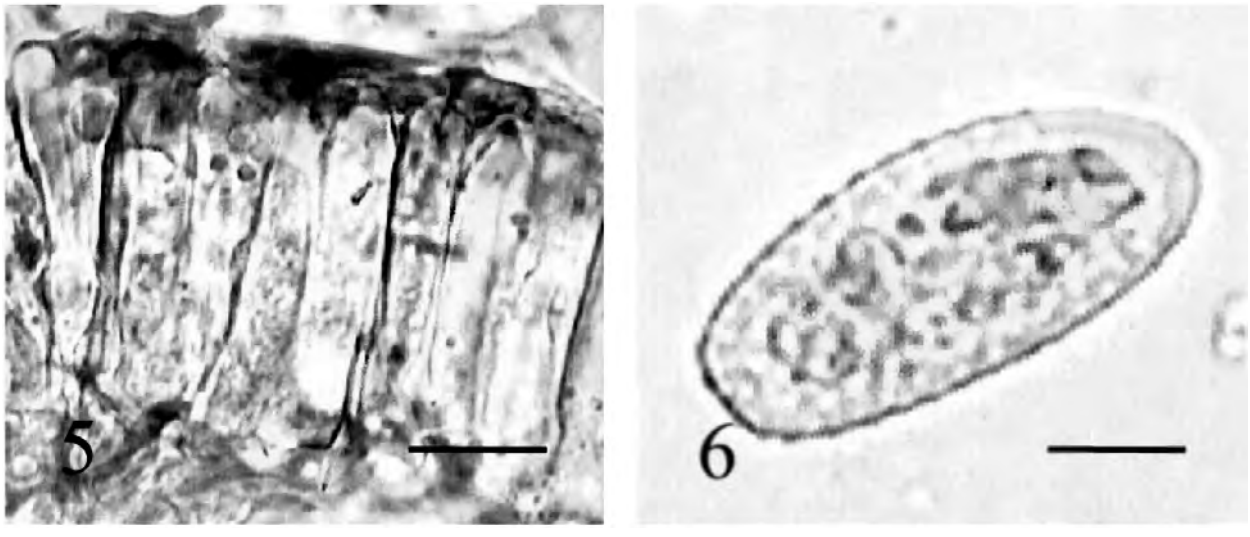
The second species was *Phragmidium. violaceum* (Schultz) Winter, characterized by hypophyllous, black, and erumpent telia. Teliospores dark-brown, with a rounded hyaline apical papilla, 1- to 5-celled, ellipsoid, verrucose, 28-92 × 23-37 µm in size (Fig. 9). The hyaline pedicel was swollen to narrowly clavate in the lower half. Uredinia hypophyllous, orange-yellow, erumpent, powdery, surrounded by many clavate hyaline paraphyses. Urediniospores 20-32 × 13-25 µm in size, hyaline, mostly ellipsoid, densely echinulate with long spines, bearing an indistinct germ pore (Fig. 10).

This fungus differs from *Ph. bulbosum* by the lower number of cells in teliospores (1-5 vs. 2-7), the colour of teliospore wall (dark- brown vs. orange-brown), and the rounded vs. conical apical papilla at the teliospore apex. Further differences reside in the urediniospore shape and their denser, longer, and sharper spines. *Ph. violaceum* was reported earlier from western Iran (Ershad, 1995). Both fungi also attack *R. laciniatus* Willd., and are common throughout Europe, the Middle East, Chile, Australia and New Zealand (Ellis *et al.*, 1991; Bahcecioglu, 2001).

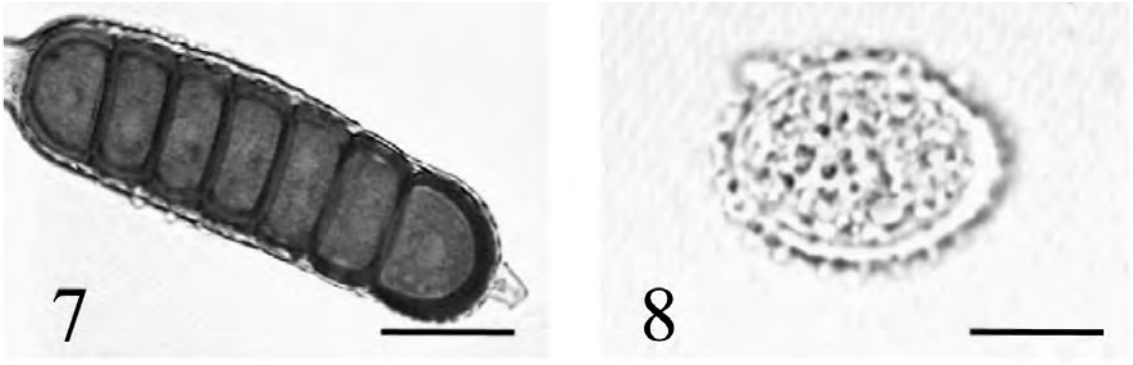
Rose rust. In late spring, rose (*Rosa gallica* L.) leaves were densely covered with many circular to ellipsoid orange spots and pale yellow pustules 1-2 mm in diameter, that turned dark brown to black in late summer. Symptomatic leaves desiccated and dropped in early autumn. Two *Phragmidium* species were found on diseased plants, one of them being *Phragmidium rosae-pimpinellifoliae* Dietel with the following characteristics: telia hypophyllous, black and erumpent, containing chestnut-brown teliospores with a hyaline conical apical papilla, 5- to 7-celled, ellipsoid to cylindrical, verrucose, 65-95 x 25-33 µm in size (Fig. 11). The hyaline pedicel was swollen, clavate in the lower half. Uredinia circular, hy-



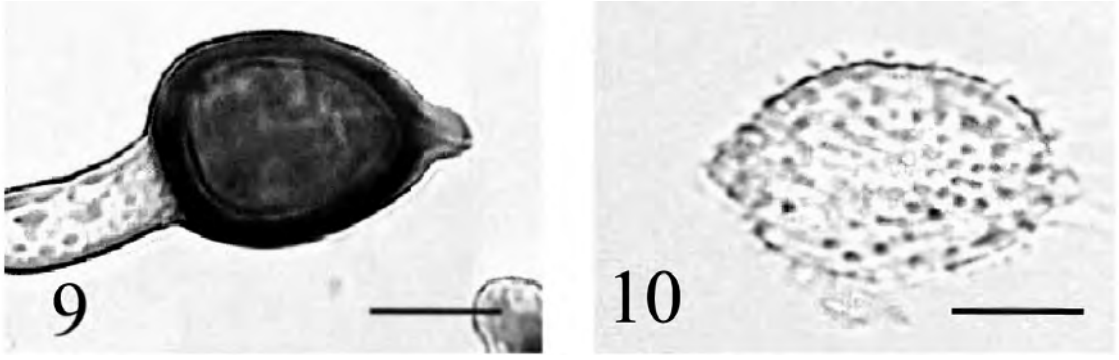
Figg. 1-4. *Melampsora coleosporioides*: **1.** Teliospores (Bar = 15 µm), **2.** Paraphyses (Bar = 27 µm), **3.** Urediniospores (Bar = 18 µm), **4.** Urediniospore with echinulate surface (Bar = 20 µm).



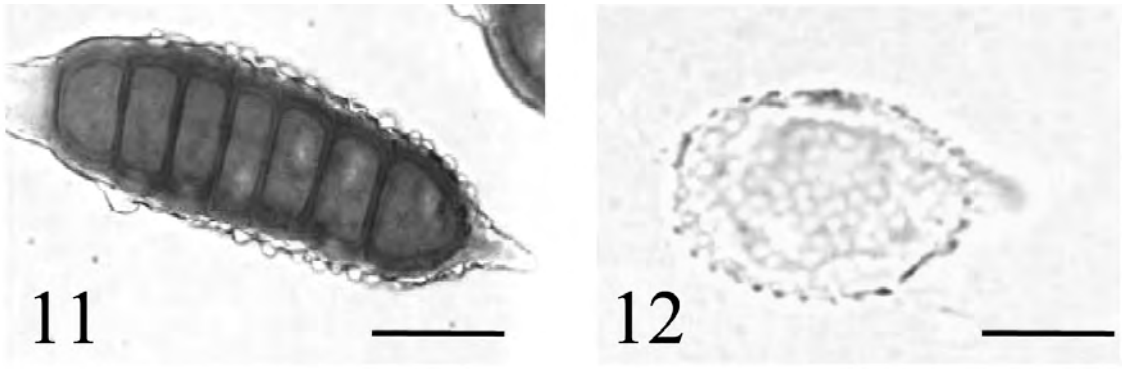
Figg. 5-6. *Melampsora allii-populina*: **5.** Teliospores (Bar = 18 µm), **6.** Urediniospore with smooth apex (Bar = 6 µm).



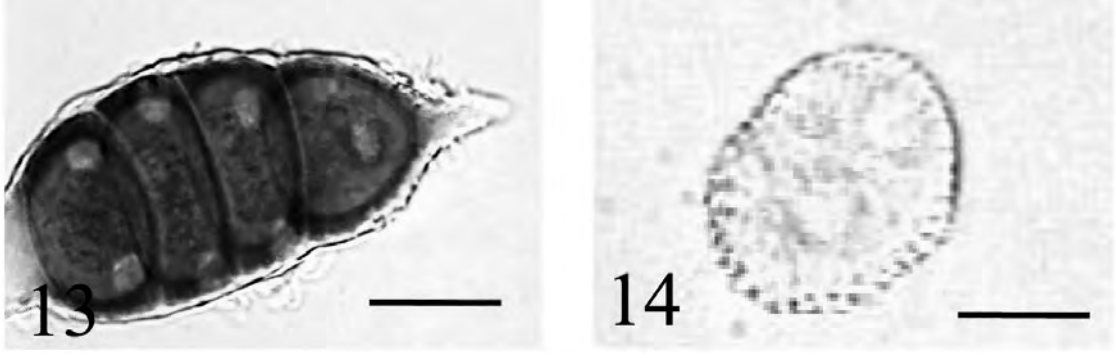
Figg. 7-8. *Phragmidium bulbosum*: **7.** Teliospore (Bar = 8 µm), **8.** Urediniospore (Bar = 8 µm).



Figg. 9-10. *Phragmidium violaceaum*: **9.** Teliospore (Bar = 8 µm), **10.** Urediniospore (Bar = 7 µm).



Figg. 11-12. *Phragmidium rosae-pimpinellifoliae*: **11.** Teliospore (Bar = 21 µm), **12.** Urediniospore (Bar = 8 µm).



Figg. 13-14. *Phragmidium tuberculatum*: **13.** Teliospore (Bar = 19 µm), **14.** Urediniospore (Bar = 11 µm).

pophyllous, pale-yellow, erumpent and minute. Urediniospores hyaline, ellipsoid to obovate, 19-28 x 19-22 µm in size, densely echinulate, and bearing an indistinct germ pore (Fig. 12).

The nearest species to this fungus is *Ph. montivagum* Arthur which has teliospores of similar in size but with a lower number of cells (5-7 vs. 5-9) and a different colour of the wall (chestnut-brown vs. chocolate-brown) (Cummins, 1931; Wahyuno *et al.*, 2001). *Ph. rosae-pimpinellifoliae* occurs on *Rosa pimpinellifolia* L. and cultivated roses in northwest Iran, North America and Britain (Cummins, 1931; Wilson and Henderson, 1966; Ershad, 1995).

The second species, *Ph. tuberculatum* Muller, had the following characteristics: telia hypophyllous, ellipsoid, dark brown sub-epidermal, becoming erumpent. Teliospores brown, with a pointed, hyaline apical papilla, 5- to 6-celled, ellipsoid to cylindrical, verrucose, 37-81 × 14-32 µm in size (Fig. 13). The hyaline pedicel was swollen to broadly clavate in the lower half. Uredinia hypophyllous, minute, circular, yellow, subepidermal, erumpent and powdery. Urediniospores hyaline to pale-yellow, ellipsoid to ovate, echinulate, 23-28 × 16-23 µm in size. Germ pores conspicuously intruding into the lumen (Fig. 14) constitute a unique differential character of this species (Wilson and Henderson, 1966).

Ph. tuberculatum is common on more than 200 cultivars of bush rose in England, on *Rosa webbiana* Wallich ex Royle in Pakistan and *R. macrophylla* Lindl. and *R. seriacea* Lindl. in Nepal (Horst, 1989; Ono and Kakishima, 1992; Kakishima *et al.*, 1993; Ono *et al.*, 1995). It occurs also in central and western Iran (Petrak, 1956; Ershad, 1995), Ukraine (Semina *et al.*, 1991), East Europe (Susuri and Doda-Gashi, 1999), Austria (Bedlan, 1980), Portugal (Dias *et al.*, 1982), Belarus (Gorlenko and Podobnaya, 1981), Estonia (Rumberg and Semenova, 1974) and the British Isles (Howden and Jacobs, 1973).

Estragon rust. Leaves of estragon (*Artemisia dracunculus* L.) were infected with brown circular to ellipsoid sori mostly confined to the abaxial surface. Dark brown, oblong sori appeared on the stems in the late growing season. Yield loss caused by this disease were estimated to *ca.* 30% in most fields. The pathogen, identified as *Puccinia absinthii* (Hedw.) DC, had the following characteristics: telia dark brown, oblong, and erumpent. Teliospores pale-yellow to brown, two-celled, ellipsoid, finely verrucuose, 28-60 × 7.5-30 µm in size, with wall thickness averaging 6 µm at the apex and 3 µm on the sides (Fig. 15). Uredinia mostly small, hypophyllous, brown, erumpent, circular to ellipsoid. Urediniospores golden-yellow to yellow-brown, ellipsoid, 17-43 × 12-28 µm in size, echinulate with minute spines, and bearing 2 to 3 equatorial germ pores (Fig. 16).

P. absinthii infects *A. absinthium* L. and *A. dubia* Wallich ex Besser in Pakistan (Ono and Kakishima, 1992; Ono and Okane, 1995), and was recorded from central Iran (Ershad, 1995), Turkey (Bahcecioglu, 2001), and Nepal (Ono *et al.*, 1995).

Garlic rust. Circular to ellipsoid cream-coloured sori were plentiful on garlic (*Allium sativum* L.) leaves, which turned yellow and desiccated. Plant mortality was higher than 70% in some fields.

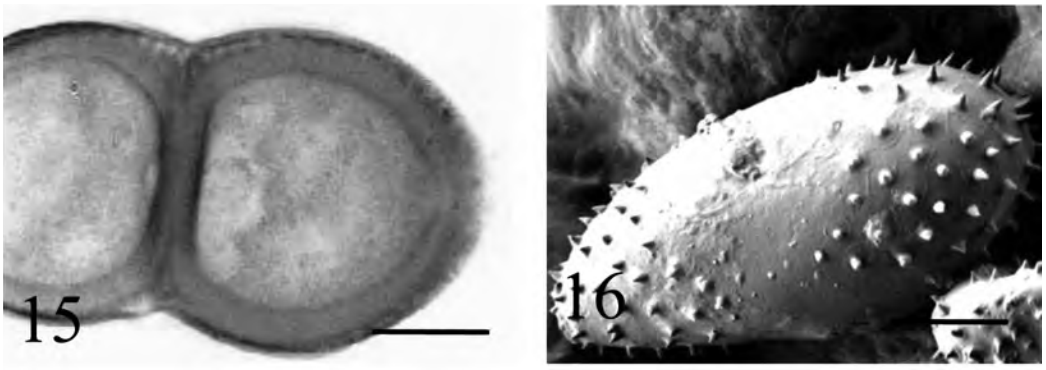
Puccinia allii (DC.) Rud, the identified pathogen, had these characters: telia minute circular to ellipsoid, epiphyllous, black, subepidermal, erumpent, containing brown, fused paraphyses. Teliospores pale-brown, mostly two-celled, ellipsoid to oblong, 34-67 × 13-28 µm in size, slightly constricted in the middle, with a flat to slightly raised beak (Fig. 17). Uredina minute, circular, epiphyllous, cream-coloured, erumpent. Urediniospores pale-yellow, subglobose to ovoid, echinulate, with 5 scattered germ pores, and a size of 20-32 × 18-25 µm (Fig. 18). The taxonomic position of this fungus is under discussion due to variation in the host range, morphological characters and DNA sequence of its isolates (Metcalf and Napier, 2002; Anikster *et al.*, 2004; Lupien *et al.*, 2004).

This rust is common in southwest Iran (Ershad, 1995), Japan (Ono *et al.*, 1992), China (Liu and Hu, 1987), India (Singh and Basandrai, 1988), Australia (Metcalf and Napier, 2002), France (Monnet and Thibault, 2001), Germany (Bedlan, 1986), Britain (Wilson and Henderson, 1966), and North America (Arthur, 1934; Griesbach *et al.*, 2001; Koike *et al.*, 2001).

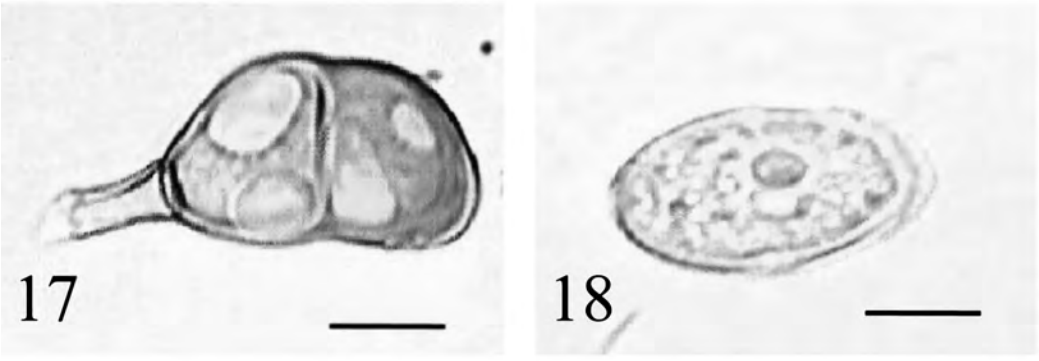
Wild oat crown rust. Leaves of wild oat (*Avena fatua* L.) were covered with orange, circular to oblong pustules surrounded by black oblong pustules. The pathogen, identifiedas *Puccinia coronata* Corda f.sp. *avenea* Erikss was characterized by hypophyllous, black, sub-epidermal, erumpent, and oblong telia. Teliospores brown, two-celled, 40-50 × 15-20 µm in size, with 3 to 5 fine hyaline apical appendages (Fig. 19). Uredinia circular to oblong, hypophyllous, orange, sub-epidermal, erumpent. Urediniospores hyaline to pale-yellow, spherical to ellipsoid, echinulate, 12-30 × 17-28 µm in size, with 2 to 8 scattered germ pores (Fig. 20).

This rust attacks cultivated and wild oats (*Avena spp.*) in North America, Canada, Australia, northwest Europe, South Africa and Japan (Wilson and Henderson, 1966; Gareth Jones and Clifford, 1983; van Niekerk, 2001; Ono *et al.*, 1992), and *Phalaris sp.* in Iran (Abbasi and Hejaroude, 2004a).

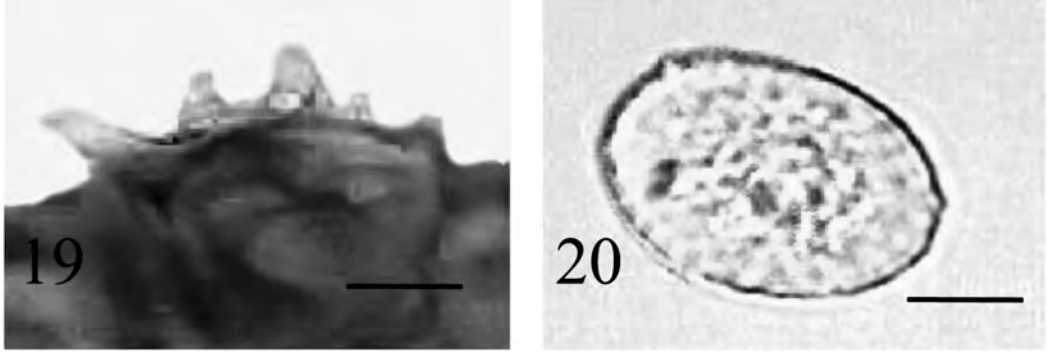
Barley crown rust. Leaves of barley (*Hordeum vulgaris* L.) showed orange brown ellipsoid to oblong pustules around which dark-brown to black, small, linear pustules arose. Attacks of little economic consequence were observed in some fields. This is the first record of this barley rust in Asia. The pathogen, identified as *Puccinia coronata* Corda f.sp. *hordei* Jin and Steffenson, had the following characteristics: small, linear, hypophyllous,



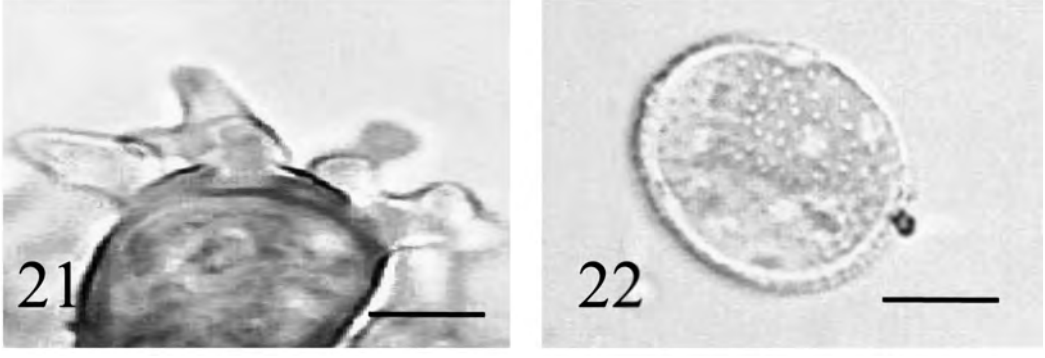
Figg. 15-16. *Puccinia absinthii*: **15.** Teliospore (Bar = 10 µm), **16.** Urediniospore (SEM, Bar = 7 µm).



Figg. 17-18. *Puccinia allii*: **17.** Teliospore (Bar =15 µm), **18.** Urediniospore (Bar = 9 µm).



Figg. 19-20. *Puccinia coronata* f.sp. *avenae*: **19.** Teliospore (Bar = 6 µm), **20.** Urediniospore (Bar = 13 µm).



Figg. 21-22. *Puccinia coronata* f.sp. *hordei*: **21.** Teliospore (Bar = 6 µm), **22.** Urediniospore (Bar = 9 µm).

black, sub-epidermal and erumpent telia. Teliospores brown, two-celled, 32-63 × 10-27 µm in size, with 3 to 5 clearly defined, apical, hyaline and branched appendages (Fig. 21). Uredinia hypophyllous, orange-brown, sub-epidermal, erumpent and ellipsoid. Urediniospores pale-yellow, echinulate, subglobose to ellipsoid, 17-33 × 15-25 µm in size, with 1 to 6 scattered germ pores (Fig. 22). This species can be distinguished from *P. coronata* Corda f.sp. *avenea* because of the longer teliospores with prominent branched appendages.

In the northern Great Plains of the USA, this rust naturally infects *Hordeum vulgare*, *H. jubatum*, *Bromus tectorum*, *Elymus canadensis*, *Elymus trachycaulus*, *Elymus virginicus*, *Elytrigia intermedia* [*Elymus hispidus*], *Elymus repens*, *Leymus angustus*, *L. cinerius*, *L. dahuricus*, *L. racemosus*, *Pascopyrum smithii*, *Psathyrostachys juncea* and *Secale cereale*. Susceptible to artificial inoculation are: *Aegilops*, *Agropyron*, *Elymus*, *Elytrigia*, *Leymus*, *Pascopyrum*, *Psathyrostachys*, *Secale*, and *Triticum* in the tribe *Triticeae*, some species of *Brachypodium*, *Bromus*, *Festuca* and *Lolium* in the tribe *Poaceae*, and *Phalaris* in the tribe *Avenae* (Jin and Steffenson, 1999). It was observed on *Bromus tomentosus* in Iran (Abbasi and Hejaroude, 2004a).

Wild oat black rust. Leaf sheath and stems of wild oat showed orange-brown, oblong, powdery pustules becoming dark-brown to black in early autumn. Severely affected plants turn yellow and desiccate. Characteristics of the pathogen, identified as *Puccinia graminis* Pers.: Pers. f.sp. *avenae* Eriks. and Henn. were: telia on leaf sheath and stems dark orange-brown to black, oblong, and erumpent. Teliospores orange-brown, two-celled, 30-65 × 15-25 µm in size, with apical projected wall (Fig. 23). Uredinia in the same position, orange-brown, oblong, and erumpent. Urediniospores yellow, oblong ellipsoid, echinulate, 22-43 × 10-25 µm in size, with 1 to 4 equatorial germ pores (Fig. 24). Distinct features of this fungus are the teliospore's apical projected wall, and the oblong ellipsoid shape of urediniospores with equatorial germ pores.

P. graminis f.sp. *avenae* infects *Avena sativa, Alopecurus pratensis, Arrhenatherum elatius, Dactylis glomerata, Trisetum flavescens* and *Festuca rubra* in Britain (Wilson and Henderson, 1966), *Avena byzantina* and *A. sterilis* in South Africa (van Niekerk, 2001) and occurs in Canada (Harder, 1999) and Australia (Adhikari *et al.*, 1999).

Barley and ryegrass leaf rust. Minute circular to ellipsoid pale yellow-brown pustules turning black later in the season, were present on the leaves of barley and ryegrass (*Lolium rigidum* Gaudin). Whereas ryegrass leaves turned yellow and desiccated, damage to barley appeared negligible. Relevant features of the pathogen identified as *Puccinia hordei* Otth., were: telia minute circular, mostly epiphyllous, black, sub-epidermal, erumpent. Teliospores yellow, one- to two-celled, 30-63 × 15-25 µm in size (Fig. 25). Uredinia epiphyllous, pale yellow-brown, sub-epidermal, becoming erumpent and ellipsoid. Urediniospores hyaline to pale-yellow, echinulate, ellipsoid to ovoid, 15-24 × 10-20 µm in size, with 1 to 3 scattered germ pores (Fig. 26).

P. hordei is closely related to *P. recondita*, from which it is readily differentiated by the high proportion single-celled teliospores. It also infects *Hordeum bulbosum*, *H. glaucum*, *H. khaburense*, *H. leporinum, H. spontaneum, H. violaceum, H. murinum*, *H. distichon, Lolium persicum*, *L. temulentum*, *Lophochloa obtusiflora*, *Lo. phleoides*, *Bromus tomentellus* and *Trisetum flavescens***.** Its aecial stage, which develops on *Ornithogalum pyrenaicum* and *O. umbellatum* (Wilson and Henderson, 1966) has not been observed in Iran.

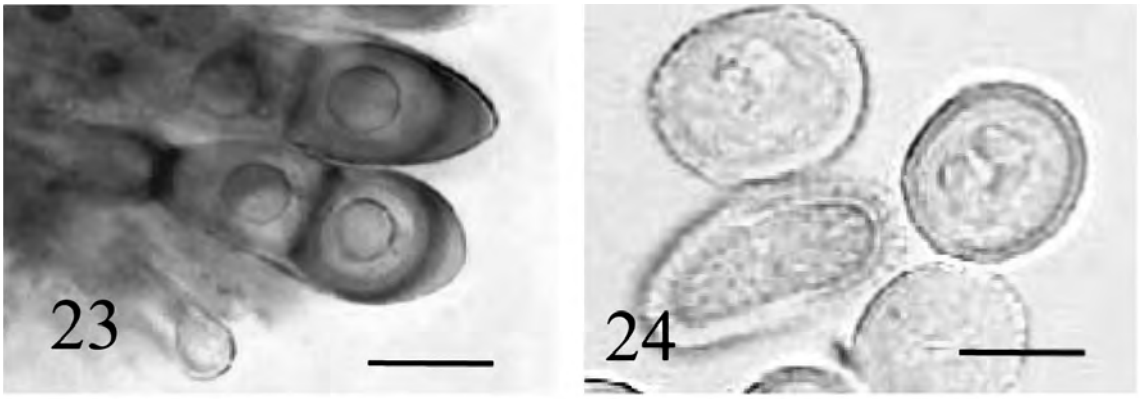
This rust is common on barley in Iran (Okhovat, 1999), Japan (Ono *et al.*, 1992), Australia (Park *et al.*, 2003), South Africa (van Niekerk *et al.*, 2001), New Zealand, Europe, north Africa, Argentina, and north America (Mathre, 1985).

Wheat leaf rust. Orange-brown, circular pustules turning black later in the season, were present on the leaf blade and sheath of wheat (*Triticum aestivum* L.). Attacks were sporadic and of little economic importance. Characteristics of the pathogen, identified as *Puccinia persistens* Plow. subsp. *triticina* (Erikss.) Urban et Markova, were: telia on the leaf blade and sheath, black, erumpent, and circular. Teliospores pale-yellow to brown, two-celled, 42-70 × 15-23 µm in size, with hyaline pedicel and a conical deposit at the base (Fig. 27). Uredinia circular, epiphyllous, orange-brown, erumpent. Urediniospores hyaline to pale-yellow, oval to oblong, echinulate, 25-45 × 15-30 µm in size, with 4 scattered germ pores (Fig. 28).

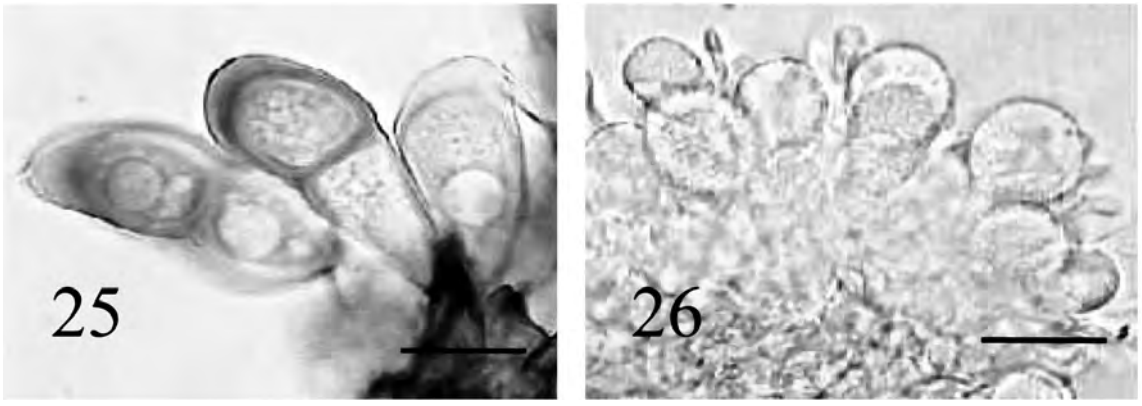
The taxonomic classification of this fungus has been in flux for more than a century but in recent years DNA sequence analysis showed that it is distinct from other leaf rust species of cereals and grasses, being more related to *P. persistens* than to the *P. recondita* complex. Hosts other than *T. aestivum* are *T. durum, T. boeoticum*, *T. urartu*, *T. dicoccoides*, *Aegilops longissima*, *A. ovata*, *A. sharonensis, A. bicornis, A. speltoides*, *A. taushii*, *A. squarrosa*, *Thalictrum minus* and *T. speciosissimum* (Goodwin *et al.*, 2001; Abbasi and Hedjaroude, 2004b; Szabo *et al.*, 2004).

Leaf rust has a worldwide distribution (Wiese, 1987). In past decade, it used to be the second important wheat rust after yellow rust in Iran, but its economic relevance has decreased since resistant cultivars are grown (Okhovat, 1999).

Stone fruit trees rust. Leaves of peach (*Prunus persica* (L.) Batsch) and plum (*Prunus domestica* L.) show circular yellow spots, which exhibit on their abaxial surface orange-brown to dark-brown or black pustules. Severely affected leaves, especially those of the highly sus-



Figg. 23-24. *Puccinia graminis* f.sp. *avenae*: **23.** Teliospores (Bar = 14 µm), **24.** Urediniospore (Bar = B10 µm).

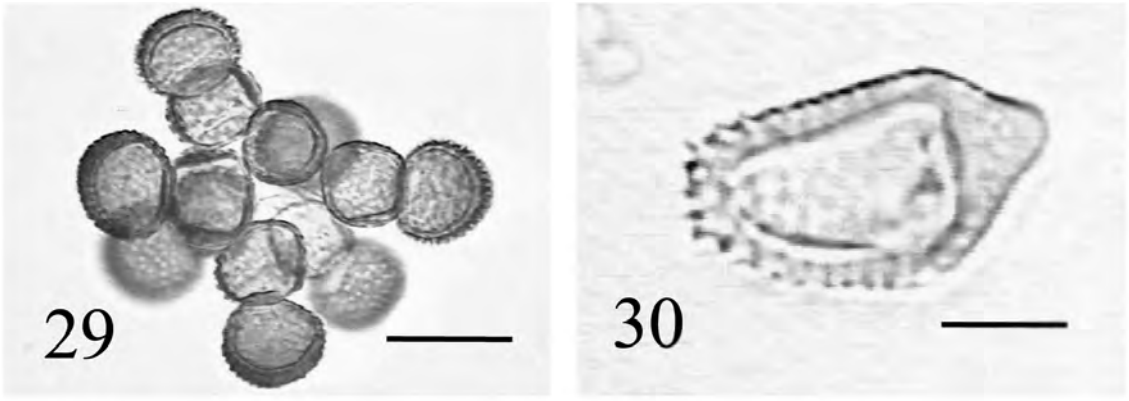


Figg. 25-26. *Puccinia hordei*: **25.** One- and two-celled teliospores (Bar = 19 µm), **26.** Uredinium (Bar = 24 µm).

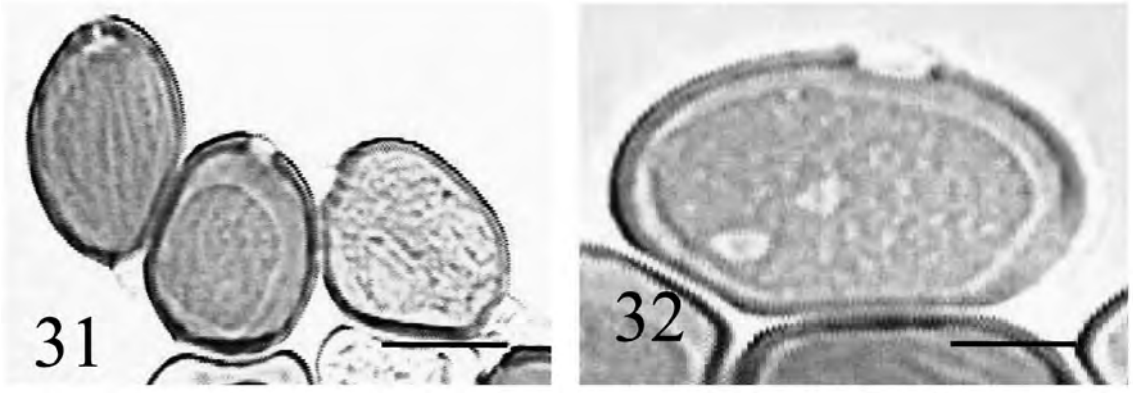
Figg. 27-28. *Puccinia persistens* subsp. *triticina*: **27.** Teliospore with conical deposit at the spore (Bar = 15 µm), **28.** Urediniospore (Bar = 12 µm).

ceptible peach, desiccate and drop.

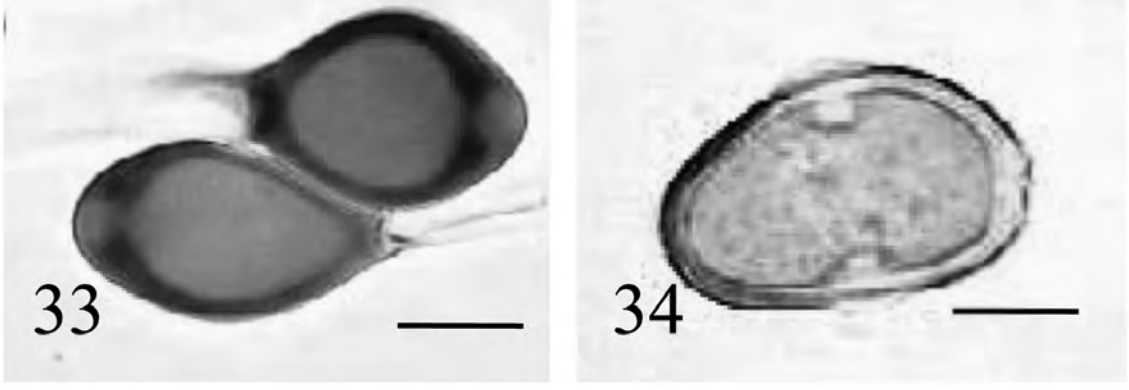
Features of the pathogen, identified as *Tranzschelia discolor* (Fuckel) Tranzschel and Litv., were: telia minute, circular, hypophyllous, dark brown to black. Teliospores dark orange-brown, two-celled, 25-46 × 15-23 µm in size, deeply constricted at the septum. Teliospore cells differ in colour and shape, the basal cell being pale-yellow to orange-brown, oblong or ovate oblong, slightly verrucose, whereas the apical cell is pale-orange to orange-brown, sub ellipsoid, and coarsely verrucose. (Fig. 29). Uredinia hypophyllous, yellow to cinnamon brown, erumpent, circular, and surrounded by paraphyses. Urediniospores pale-yellow to yellow, ellipsoid to ovoid, 18-32 × 11-18 µm in size, with 3 to 4 equatorial germ pores, with thicker wall at the apex, and spiny for 2/3 of the surface (Fig. 30).



Figg. 29-30. *Tranzschelia discolor*: **29.** Teliospores (Bar = 25 µm), **30.** Urediniospore (Bar = 8 µm).



Figg. 31-32. *Uromyces striatus*: **31.** Teliospores with longitudinal striations (Bar = 16 µm), 32. Urediniospore (Bar = 6 µm).



Figg. 33-34. *Uromyces viciae-fabae*: **33.** Teliospores (Bar = 11 µm), **34.** Urediniospore (Bar = 9 µm).

Two related species of *Tranzschelia* attack *Prunus* trees, i.e. *T. pruni-spinosae* (Pers.) Diet. and *T. discolor*. Teliospore cells of the former species are similar, whereas in *T. discolor,* the light-coloured and smoother lower cell contrasts sharply with the dark verrucose upper cell. Most authors agree that *T. pruni-spinosae* attacks wild species of *Prunus*, whereas *T. discolor* occurs on cultivated types (Wilson and Henderson, 1966). *T. discolor* infects also nectarine, apricot and almond, but cross inoculation experiments done in India, USA, and Australia with urediniospores from different hosts, showed that it has physiological specialization. New names were therefore proposed: *T. discolor* f.sp. *persicae* (for peach isolates), *T. discolor* f.sp. *domesticae* (for plum isolates), *T. discolor* f.sp. *armeniacae* (for apricot isolates), and *T. discolor* f.sp. *dulcis* (for almond isolates)

(Bolkan *et al*., 1985; Ved *et al*., 1999).

T. discolor occurs on plums in northwest Iran (Abbasi and Ershad, 1995) and Germany (Scholler, 1992), peach and plum in Mexico (Mendoza-Zamora *et al*., 1992), Montenegro (Mijuskovic, 1992), the warmer areas of Himalaya (Gupta and Sharma, 1991), Japan (Ono *et al.*, 1992), Ukraine (Voronin *et al.,* 1982), UK (Wilson and Henderson, 1966), Bulgaria (Khristov, 1976), USA and Australia (Bolkan *et al*., 1985).

Alfalfa rust. Rust-infected alfalfa (*Medicago sativa* L.) plants showed abundant circular brown pustules on the underside of the leaves, which turned yellow, dried up, and dropped. The most severe attacks occurred in late spring at the time of first harvest. The alfalfa rust pathogen, identified as *Uromyces striatus* Schroet, had the following characteristics: sori hypophyllous, brown, erumpent, circular to ellipsoid, containing both urediniospores and teliospores. Teliospores pale- to dark-brown, one-celled, ovate, 20-28 × 19-31 µm in size, with longitudinal striations and an apical pore (Fig. 31). Urediniospores pale-yellow to pale-yellow brown, echinulate, subglobose to ellipsoid, 16-28 × 17-25 µm in size, with 3 to 4 equatorial germ pores (Fig. 32). Hosts range is limited to *Medicago* species, and its aecial stage, not observed in Iran, develops on *Euphorbia spp.* (Graham *et al.*, 1987).

This rust is common in central, northwest and southeast Iran (Ershad, 1995) and throughout the world (Graham *et al.*, 1987).

Broad bean rust. Red brown, minute circular scattered pustules were present on the leaves of broad bean (*Vicia faba* L.), whereas dark-brown and oblong sori appeared on the stems later in the season. Although rust attacks were common in broad bean fields in the suveyed area, their economic impact appeared to be negligible. The pathogen, identified as *Uromyces viciae-fabae* (Pers.) Schroet., had the following characteristics: telia on stems oblong, dark-brown, sub-epidermal, erumpent. Teliospores brown, single-celled, with rounded or truncate apex, subglobose to obovoid, 25-48 × 20-28 µm in size (Fig. 33). Their morphology is a main identification feature (Chauhan and Singh, 1995). Uredinia minute circular, epiphyllous, red brown, erumpent. Urediniospores pale-yellow brown, echinulate, ellipsoid to ovoid, 25-37 × 18-25 µm in size, with 2 equatorial germ pores (Fig. 34).

This fungus infects lentil in west Iran (Abbasi and Pooralibaba, 2002), Ethiopia (Bejiga and Anbessa, 1999), India (Singh and Kant, 1999) and Pakistan (Mohy-ud-Din *et al.*, 1999), pea (Bains *et al.*, 1995) and *Vigna radiata* in India (Madhu *et al*, 1998). It has a worldwide distribution (Sillero and Rubiales, 2002), and is important in northern New South Wales, Australia (Marcellos *et al.*, 1995), China (Liang, 1986), Tunisia (Nasraoui, 1991), Bangladesh (Mian and Tsuno, 1989), Syria (Akem and Bellar, 1999), Japan (Ono *et al.*, 1992) and Europe (Sache and Zadoks, 1996; Simay, 1989).

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