



## Notes on the genus *Pileolaria* (Pucciniales)

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**Abstract:** The results showed that *Pileolaria terebinthi*, type species of the genus *Pileolaria* is not a hemi-form or brachy-form rust species as mentioned among literature by several authors. Study on miscellaneous specimens collected from Iran and locus classicus of the species, France, revealed that *P. terebinthi* is an automacrocytic rust and its aecial state is not uredinioid as formerly believed. This species has caeoma-type aecial state which differs from its Uredo-type uredinial state by having different spore ornamentation and ontogeny. The genus *Pileolaria* is redefined on the basis of these new findings. Moreover, all spore states of *P. terebinthi*, are documented using microscopy and photomicrography. New information about host range and distribution of *P. terebinthi* in Iran is also provided.

**Keywords:** Taxonomy, rust fungi, mycology, biodiversity

### INTRODUCTION

*Pileolaria terebinthi* (DC.) Castagne, the type species of the genus *Pileolaria*, was originally described based on type specimen collected from Montaud, Southern France. This rust infects species of the genus *Pistacia* and so far has been recorded from Central Europe, Mediterranean region, Northern Africa, Indian subcontinent and China (Farr & Rossman 2018). Different ideas about the life cycle of the rust species have been reported in literature. Early reports considered this species as hemi-form rust comprising II, III and IV (Saccardo 1888). The rust was also considered as brachy-form species (O, II, III, IV) among the 20<sup>th</sup> century literatures (Gäumann, 1959; Kuprevich & Ulyanishchev 1975). *Pileolaria terebinthi* considered as auto-macrocytic rust in two recent editions of fundamental reference about genera

of rust fungi (Cummiss & Hiratsuka 1983, 2003). These references also described genus *Pileolaria* as a rust taxon having uredo-type aecia with aeciospores similar to urediniospores borne singly on pedicels. Hamzehzarghani and Banihashemi (2006) in a comprehensive study on morphology, biology and pathogenicity of *P. terebinthi* in Fars province, Iran, followed the same concept and considered the rust as an automacrocytic species with uredinioid aecium. Study of miscellaneous herbarium specimens of *P. terebinthi* from Iran and France, locus classicus of type species, on *Pistacia* spp., revealed the rust species has ontogenetically and morphologically different aecial and uredinial states. Based on these findings the genus *Pileolaria* is redefined here. Detailed description for *P. terebinthi* and its host range and distribution in Iran are also provided.

### MATERIALS AND METHODS

To examine morphology and structure of states of rust fungus, fresh infected materials and herbarium specimens were sectioned freehand under NTB-3A stereomicroscope. Thin sections were mounted in a drop of lactic acid in glycerol (Abbasi 2013). To examine the morphology and measuring dimensions, rust spores were scraped from sori and mounted as described above. Thirty randomly selected spores were measured in each specimen. Specimens were photographed using a Canon PowerShot G5 digital camera. For scanning electron microscopy (SEM), dry spores were mounted on double-adhesive tape on a specimen holder. The preparations were coated with gold, 3-3.5 min in 29 mA and examined with a LEITZ-AMR 1000 SEM. All examined specimens have been deposited in the fungal reference collection of the Ministry of Jihad-e Agriculture (IRAN), Iran.

### RESULTS

*Pileolaria* Castagne, *Observ. Ured.* 1: 22 (1842), emend.

The spermogonia are subcuticular, determinate, having flat hymenia with peridia [type 7 based on Hiratsuka and Hiratsuka (1980)]. Aecia subepidermal, erumpent, flat, caeoma-type, contain palisade

sporogenous cells which bear aeciospores in chain. Aeciospores wall pigmented, occasionally with apical thickness, variously sculptured (densely verrucose in type species). Uredinia subepidermal, erumpent, uredo-type, urediniospores borne singly on pedicels, wall pigmented, occasionally with apical thickness, echinulate. Telia subepidermal, erumpent, teliospores 1-celled, borne singly on pedicels, with one apical

germ pore. Teliospores wall pigmented, variously sculptured.

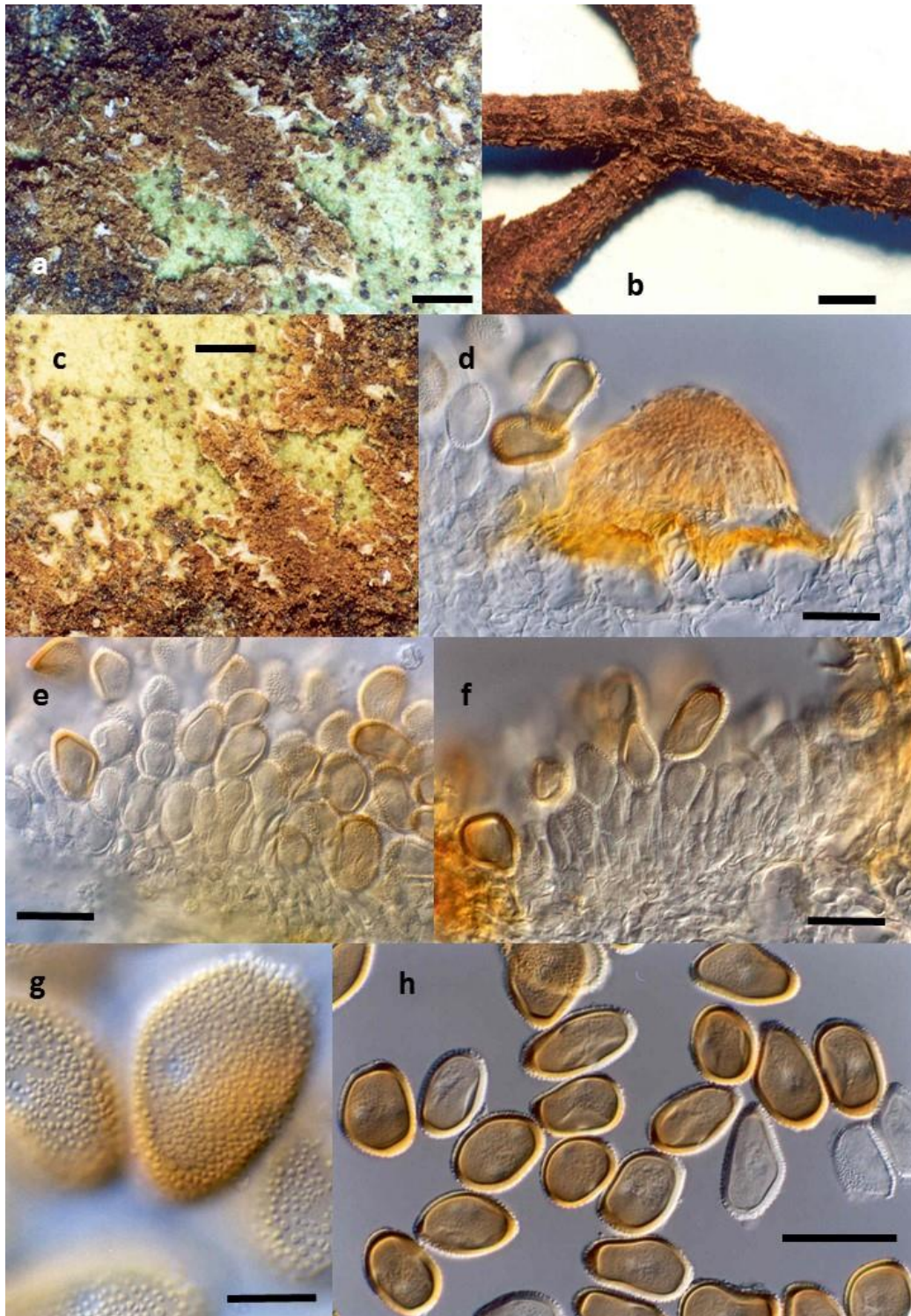
TYPE. *Pileolaria terebinthi*

An extended description of *P. terebinthi* based on current research is also provided:

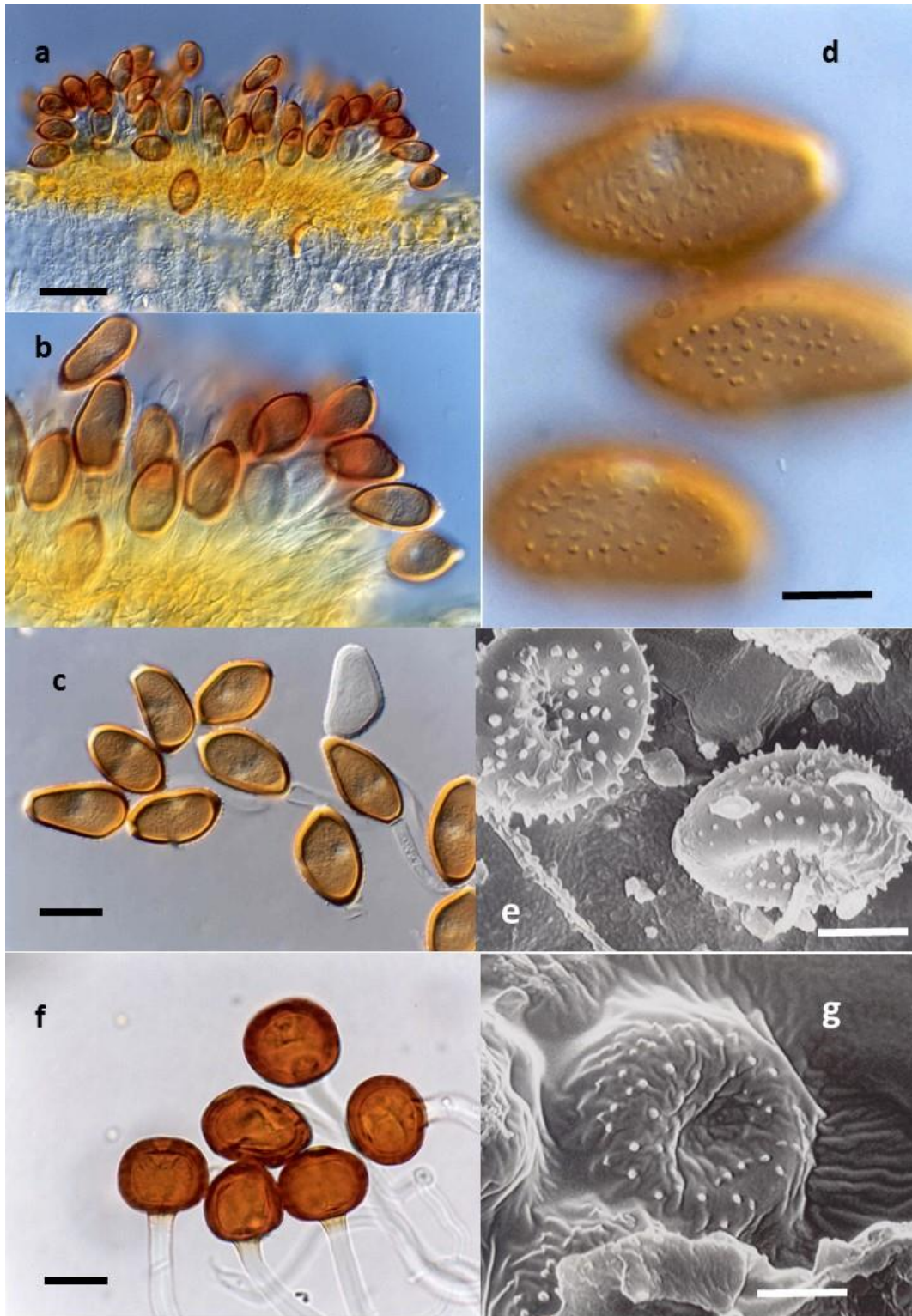
*Pileolaria terebinthi* (Figs. 1–2)

= *Uredo terebinthi* DC.

= *Uromyces terebinthi* (DC.) G. Winter



**Fig. 1.** *Pileolaria terebinthi*. spermogonial and aecial states, a–c. Systemic infection of spermogonia and caeoma-type aecia. — Scale bars = 1 mm (a, c) & 2 mm (b); d. cross-section of spermogonium. — Scale bar = 30  $\mu$ m; e, f. cross-section of caeoma-type aecium. — Scale bar = 30  $\mu$ m; g. densely verrucose ornamentation of aeciospore wall — Scale bar = 10  $\mu$ m; h. aeciospores. — Scale bar = 30  $\mu$ m.



**Fig. 2.** *Pileolaria terebinthi*, uredinial and telial states, a. cross-section of uredinium. — Scale bar = 40 µm; b. urediniospores borne singly on pedicels — Scale bar = 20 µm; c. urediniospores. — Scale bar = 20 µm; d, e. surface ornamentation of urediniospores. — Scale bar = 10 µm; f. teliospores. — Scale bar = 20 µm; g. surface ornamentation of teliospore. — Scale bar = 10 µm.

Spermogonia brown or black, subcuticular, with flat hymenia, peridia present, periphyses absent, amphigenous in small round groups or with systemic pattern covered both sides of the leaves, especially along leaf veins, also on petioles and young shoots. Aecia caeoma-type, erumpent, flat, cinnamon brown

with two local or systemic infection patterns, in small round circle of aecia around spermogonia clusters (local) or covering both sides of leaves, petioles and young shoots, causes witches' broom (systemic), aeciospores 28–34 × 20–26 µm (measured in Lactic acid in glycerol), fusiform, ellipsoid, obovoid,

catenulate, borne on palisade sporogenous cells, wall 2–2.5  $\mu\text{m}$  thick except up to 5  $\mu\text{m}$  at apex, densely verrucose, pale brown to pale cinnamon brown, pores 2–4 equatorial. Uredinia erumpent, amphigenous, scattered, chestnut–brown, produce purple spots on the leaves, urediniospores borne singly on pedicels, 29–31(–45)  $\times$  17.5–22.5  $\mu\text{m}$ , fusiform, oblong or obovoid, wall 2  $\mu\text{m}$  thick except slightly thicker at apex, echinulate, spines smaller towards base, pores 3(–4) equatorial. Telia amphigenous, exposed, blackish, pulverulent, produce purple spots on the leaves, teliospores 28–33  $\times$  17.5–24  $\mu\text{m}$ , globose-lenticular, wall rugose which covered by conical verrucae, pale apical papillae over the pore, pedicels hyaline, thick-walled, smooth, persistent, up to 200  $\mu\text{m}$  long.

Based on a study of herbarium specimens (see specimen examined) and literature review (Abbasi 2004, Abbasi & Aliabadi 2009, Ershad 2009) host range of pistachio rust includes the following host species in Iran:

*Pistacia atlantica* DC., *Pis. khinjuk* Stocks, *Pis. mutica* Raul.ex Boiss. and *Pis. vera* Mill.

Distribution of rust fungus has been shown on Biotic provinces map of Iran (Abbasi & Hedjaroude 2002). Based on this map (Fig. 3) the fungus has been reported from Caspian, Elburzian, Kavirian, Zagrobian, Farsian, Lutian and Azerbaidzhanian provinces.

*Specimens examined.* FRANCE, Valbonne, on *P. terebinthus* L., 23 July 1967, Eskandari, O+I+II (IRAN 15933F); IRAN, Lorestan province, Khorramabad, Siaah Kuh, on *Pistacia atlantica*, 3 July 2011, A. Dehghani, O+I+II+III (IRAN 17007F); IRAN,

Tehran province, Khojir National Park, on *P. atlantica*, 10 July 2003, M. Abbasi, O+I+II+III (IRAN 12321F); IRAN, Tehran province, Khojir National Park, on *P. atlantica*, 15 May 2004, M. Abbasi, O+I (IRAN 12322F); IRAN, Tehran province, Khojir National Park, Baghe-e Shah, on *P. atlantica*, 29 Sept. 2004, M. Abbasi, II+III (IRAN 1848F); IRAN, Tehran province, Khojir National Park, near park entrance, on *P. atlantica*, 16 June 2003, M. Abbasi et al., II+III (IRAN1846F); IRAN, Fars province, Shiraz, Komin, on *P. mutica*, 2 Oct. 1978, Gh. Scharif, (I)+II+III (IRAN 3448F); IRAN, Fars province, Shiraz, Arsanjan, on *P. mutica*, 7 Aug. 1987, M. Mirabolfathy (II)+III (IRAN 7044F); IRAN, Esfahan province, Borojen, Gel-e Shoor, on *P. mutica*, 1 Nov. 1982, J. Khajeddin & M. Nowroozi, III (IRAN 9168F); IRAN, Khuzestan province, on *P. mutica*, 2005, A. Dehghani, II+III (IRAN 1345F); IRAN, Lorestan province, Bisheh, on *P. mutica*, 27 Aug. 1947, Gh. Scharif, II+III (IRAN 3446F); IRAN, Ilam province, Jangal-e Malek Shahi, on *P. mutica*, 15 Sept. 1977, M. Abai, I+II+III, (IRAN 3447F); IRAN, Golestan province, Gonbad-e Kavus, on *P. vera*, 2 Oct. 1955, Gh. Scharif, II+III (IRAN3449F); IRAN, Golestan province, Maraaveh tappeh, on *P. vera*, 2 Aug. 2004, S. Javadi, II+III (IRAN12323F); IRAN, Lorestan province, Veisian, on *P. sp.*, 1 June 2010, R. Ghaedi, III (IRAN 15897F); IRAN, Fars province, Arsanjan, on *P. sp.*, Sept. 1996, M. Parchami, III (IRAN 10514F); IRAN, Kohgiluyeh-Buyerahmad province, Deh–nu, on *P. sp.*, 17 Oct. 1989, M

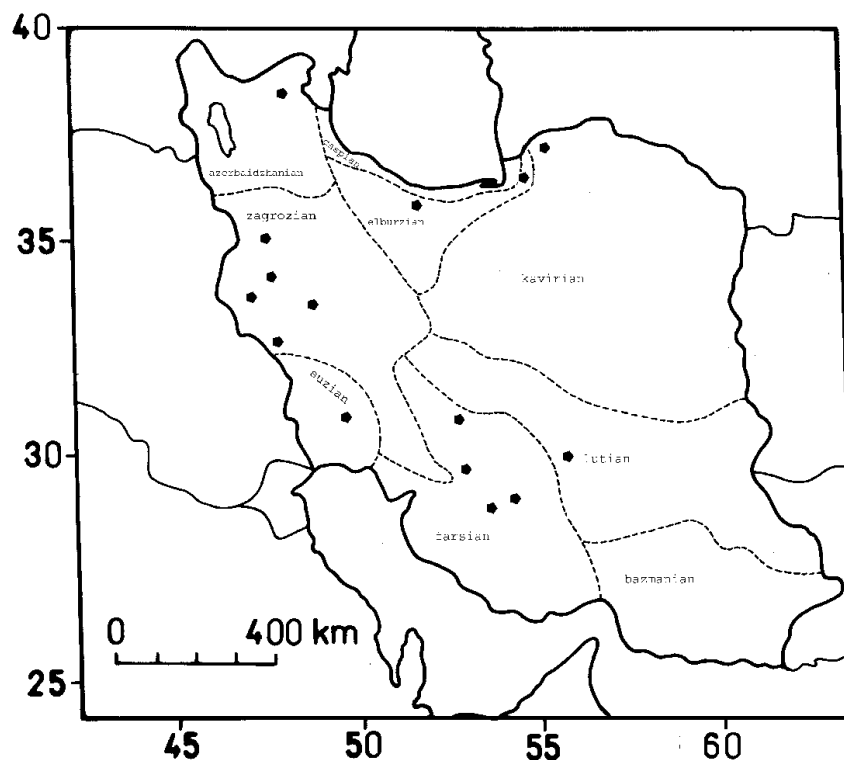


Fig. 3. Distribution of *Pileolaria terebinthi* in Iran based on biotic provinces map

Moghadam, III (IRAN 9169F); IRAN, Ilam province, Ghilan-e Gharb, on *P. sp.*, 12 May 1942, Farahbakhs, I+II+III (IRAN 3450F); IRAN, Golestan province, Gorgan, on *P. sp.*, no date, Farahbakhsh, II+III (IRAN 3451F).

## REFERENCES

- Abbasi M. 2004. Study on the morphology of *Pileolaria terebinthi* in Iran. Proceedings of the 16th Iranian Plant Protection Congress, 28 Aug.–1 Sept., University of Tabriz, Iran: 466.
- Abbasi M. 2013. New reports of rust fungi for mycobiota of Iran. Iranian Journal of Plant Pathology 49 (3): 351–356.
- Abbasi M, Hedjaroude GA. 2002. Some ecological aspects of rust fungi (Uredinales) in Iran. The Scientific Journal of Agriculture 25: 127–143.
- Abbasi M, Aliabadi F. 2009. The list of fungi recorded in proceedings of 12th to 18th Iranian Plant Protection Congress (1995–2008). Science and Art Publication, Tehran, Iran.
- Cummins GB, Hiratsuka Y. 1983. Illustrated Genera of Rust Fungi (Revised ed.), American Phytopathological Society Press, USA.
- Cummins GB, Hiratsuka Y. 2003. Illustrated Genera of Rust Fungi (3<sup>rd</sup> ed.). American Phytopathological Society Press, USA.
- Ershad D. 2009. Fungi of Iran. Iranian Research Institute of Plant Protection, Iran.
- Farr DF, Rossman AY. Fungal Databases, U.S. National Fungus Collections, ARS, USDA. Retrieved March 12, 2018, from <https://nt.ars-grin.gov/fungaldatabases/>.
- Gäumann E. 1959. Die Rostpilze Mitteleuropas. Beiträge zur Kryptogamenflora der Schweiz (Band XII), Böhler und Co. Swiss.
- Hamzehzarghani H, Banihashemi Z. 2006. Morphology, biology, and pathogenicity of *Pileolaria terebinthi* the cause of Beneh rust in Fars province of Iran. Iranian Journal of Plant Pathology 42: 71–84.
- Hiratsuka Y, Hiratsuka N. 1980. Morphology of spermogonia and taxonomy of rust fungi. Reports of the Tottori Mycological Institute 18: 257–268.
- Kuprevich VF, Ulyanishchev VI. 1975. Opredelitel rzhavchinnykh gribov SSSR. I. Nauk, USSR.
- Saccardo PA. 1888. Sylloge Fungorum VII: 552.

## ملاحظات در مورد جنس *Pileolaria* (Pucciniales)

مهرداد عباسی

بخش تحقیقات رستنیها، مؤسسه تحقیقات گیاه پزشکی کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، تهران، ایران

**چکیده:** نتایج تحقیق حاضر نشان داد گونه مولد زنگ پسته *Pileolaria terebinthi* به عنوان گونه تیپ جنس *Pileolaria* یک زنگ hemi-form یا آرایه ای با مرحله اسیومی uredinoid نبوده و اسیوم ها از نوع Caeoma می باشند. این مرحله زنگ با دو تیپ آلودگی موضعی و سیستمیک گیاه میزبان را آلوده می سازد. اسیوسپوره های گونه زنگ فوق دارای تزئینات زگیل دار و متفاوت از تزئینات اوردینوسپورها که از نوع خار است، می باشند. شرح جنس *Pileolaria* بر اساس این یافته ها اصلاح گردید. مراحل اسپوری این گونه زنگ بر اساس مشاهدات میکروسکوپی و فتومیکروگرافی مستند سازی شدند. شرح گونه *P. terebinthi* بر اساس این یافته ها تکمیل گردید. همچنین اطلاعات تکمیلی در مورد دامنه میزبانی و پراکنش زنگ پسته در ایران آرایه گردید.

**واژه های کلیدی:** تاکسونومی، زنگ ها، قارچ شناسی، تنوع زیستی