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SPECIES OF PUCCINIA ON CICHORIOIDEAE FROM KRITI*

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ABSTRACT. Eleven species of *Puccinia* on members of the Cichorioideae (Compositae) from the island of Kriti (Crete) are treated, and aspects of their taxonomy are discussed. Use of scanning electron microscope provided new diagnostic characters and supported observations with the light microscope. As a result, the following taxa were set apart from the complex of *Puccinia hieracii* Mart.: *P. canariensis* Syd., *P. chondrillina* Bub. & Syd., *P. hyoseridis-scabrae* Maire and *P. hypochoeridis* Oud. The rust species *P. canariensis* Syd. and *P. lactucarum* Syd. are reported for the first time from Greece, while two more species, *P. chondrillina* Bub. & Syd. and *P. trachyderma* Syd., are new for Kriti. The host plants *Crepis tybakiensis* Vierh. and *Scariola acanthifolia* (Willd.) Sojak are entirely new hosts for rust fungi.

INTRODUCTION

Knowledge of the rust flora of Greece is rather limited, although the higher plants have been extensively investigated. This is especially true for the rust flora of the island of Kriti (Crete), which is known only from the contributions by Petrak (1943b), Brandenburger (1968) and Gjærum & Hansen (1974, 1977), plus a few more records scattered in the literature concerning the fungal flora of Greece.

The phanerogamic flora of Kriti, which includes c.1500 species of flowering plants with some 9% endemic, is particularly interesting and the same is expected for the rust flora. The island of Kriti, which was part of a continental area in the mid-Tertiary and later isolated from the continents, houses special types of biosystems (Greuter, 1972), favourable for evolutionary processes. Kriti is also situated in a phytogeographical region which combines floristic elements from the Balkans, Asia Minor, Middle East, Africa and the Mediterranean region, at least in respect of the higher plants.

Material of rust fungi from Kriti was collected from early spring to late autumn during 1977–1983, mainly in the western part of the island. Of the rusts on hosts from various families, only the *Puccinia* species of hosts of Compositae subfamily Cichorioideae are presented here.

The Compositae is considered to be an advanced plant family which is remarkably homogeneous in basic taxonomic characters. These characters could possibly be regarded as a result of convergent evolution (Wagenitz, 1976), which produced an increasing similarity between members of this group. Therefore, the delineation of taxa is difficult in the Compositae and this complexity is possibly reflected in the systematics of the rust fungi that parasitize them. Actually, a continuous variation exists in

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several morphological characteristics of rust species on compositous hosts, so that their classification is an intricate taxonomic problem which can hardly be resolved.

The eminent mycologist Ivar Jørstad, in his many writings following his huge work on rust taxonomy, evaluated as the most important diagnostic character, the number and position of germ pores on uredospores. Although he was aware of morphological differences among closely related species, he grouped allied taxa under the so-called 'compound species'. This treatment has been presented as a whole, in the classical work by Hylander, Jørstad & Nannfeldt (1953). In the case of rusts on Cichorioideae, Jørstad has lumped a number of species, with two superequatorial pores on their uredospores, under the 'compound species' *Puccinia hieracii* Mart. Unfortunately, detailed descriptions of the species that have been included in this complex are often lacking in the literature, so that justification of their taxonomic status is incomplete. It is mostly in this group, which obviously includes taxa with slight distinctions, that the accurate circumscriptions of taxa are more than necessary before making any decision on their taxonomy. The data provided in modern research, by the use of scanning electron microscope, may be valuable in this respect.

In the study of the material from Kriti, it was found that in most cases morphological differences do exist among rust species that have been included in *P. hieracii* Mart. apart from their host specialization. Examination of representative specimens with the scanning electron microscope for further resolution of spore ornamentation, confirmed the distinctions found with the light microscope and provided new diagnostic characters. We believe that the information obtained permits some taxonomic decisions. Most of the taxa were maintained in their original specific status. It should be admitted that the work by Parmelee & Savile (1981) on North American material helped to evaluate our results, since the criteria based on their findings by SEM coincided in some cases with those found in our collections.

An additional problem which has been encountered in this study, was the evaluation of ecological implications on rust morphology. According to Savile (1970, 1971) many rusts in the Mediterranean region show adaptations to arid summers, which are expressed as increased spore size, and spore walls thickened and more heavily pigmented. The deviations from the known range of variability, found for such characteristics in several of our collections, were attributed to adaptations to the dry summer conditions in Kriti. These deviations have not been considered of sufficient significance to warrant recognizing new taxa, at least for the *Puccinia* species on Cichorioideae.

It should be noted that the conclusions presented here are valid as far as material from Kriti is concerned, since comparative studies with rust specimens from other geographical areas are limited. It is hoped, however, that this study will contribute, together with analogous research efforts, to a better understanding of the taxonomic problems of rusts on Compositae.

For the nomenclature of the host plants and their synonyms, *Flora*

Europaea (Tutin *et al.*, 1976) and *Flora of Turkey and the East Aegean Islands* (Davis, 1975) were followed.

The specimens are deposited in the Mycological Herbarium of the Botanical Museum in Athens University (ATHU-M).

Material & Methods

Uredospores and teleutospores from dried specimens, were mounted in Amann's lactophenol and gently heated, so that the spores swell to their normal size and shape, and the germ pores become more clear. Hoyer's mounting medium, which has been reported (Cunningham, 1968) as a strong clearing agent, was tested with little success. Morphological characters were studied under bright field and phase contrast with a Standard Zeiss microscope. A great number of spores were measured for each specimen, in order to obtain more accurately the range of variability for each character. The mounts were made from sori lying on different parts of the host and in various stages of maturity. The extreme values are given in parentheses if their frequency is less than 10%. Abnormal spores with clearly unusual size and form were disregarded.

For the preparation of spores for scanning electron microscopy (SEM), infected leaf segments were immersed in distilled water for 24 hrs, fixed in 3% gluteraldehyde for 2 hrs, washed in 0·2M sodium cacodylate buffer three times for 10–15 min., dehydrated through a graded acetone series, and dried in a Polaron critical point drier. The spores were then scraped from the sori with a needle and dispersed onto double-sided adhesive tape attached on standard SEM stubs. After coating in a Denton-vacuum DV-502 coating unit with a gold palladium alloy, the spores were examined and photographed with a Cambridge Stereoscan 150 scanning electron microscope at 20 kV.

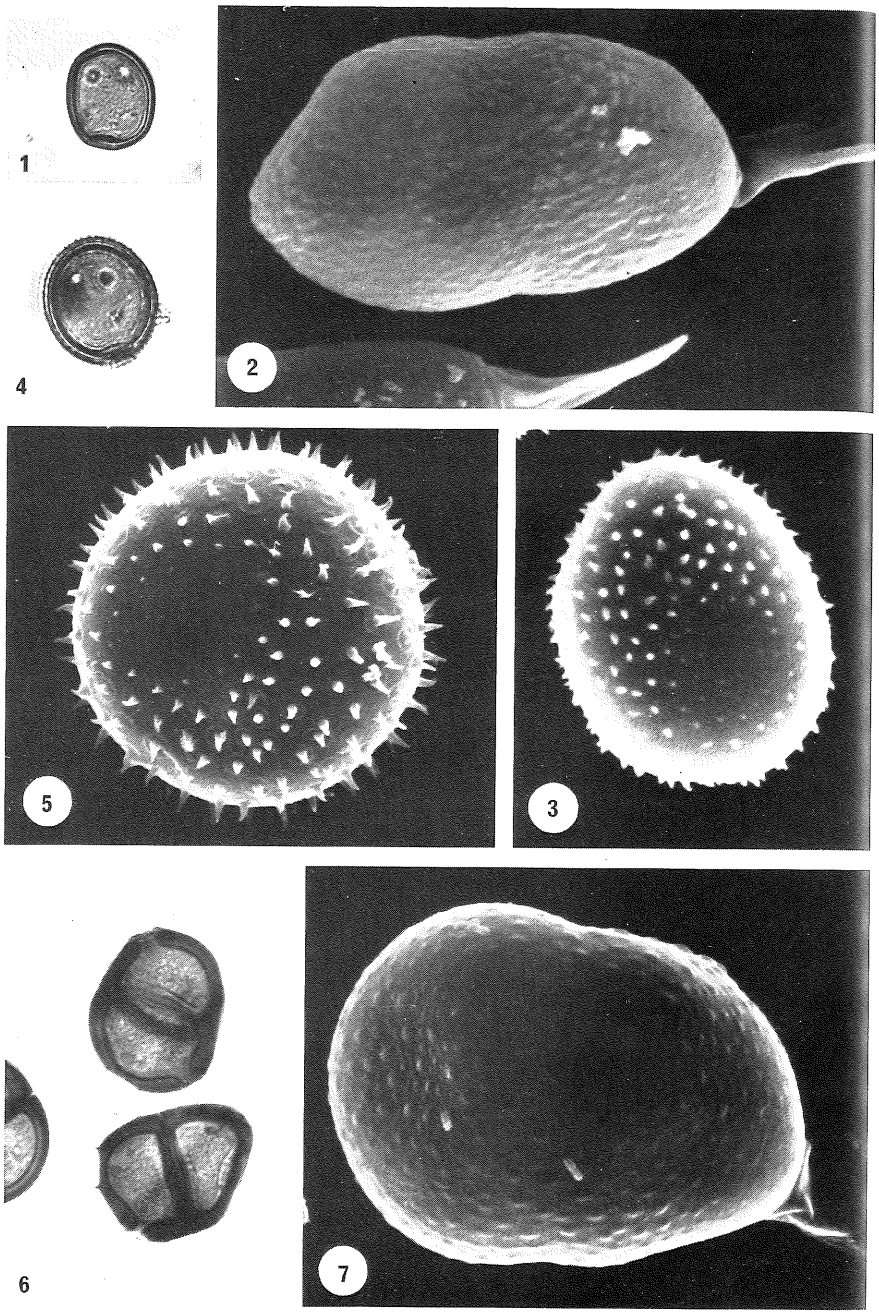
Taxonomic Treatment

Puccinia canariensis P. & H. Syd., Monogr. Ured. 1:166 (1902). Figs 4–7.

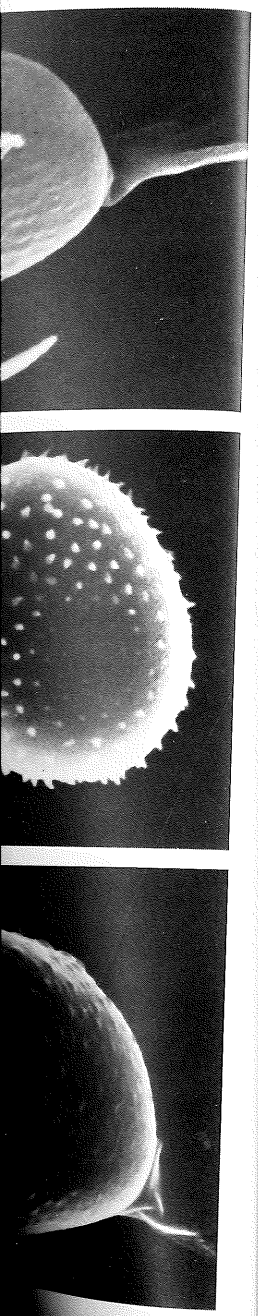
Uredosori rarely present. *Uredospores* globoid to ellipsoid 25–32 × 22–28(–30)μm; wall (1·5–)2–2·5μm thick, echinulate, except for a smooth area on each side 9–10 × 10–12μm, spines 0·6–1·6μm high, 1–4·7μm apart; pores 2, scarcely 3, superequatorial. *Teleutosori* amphigenous and on the stems, rounded, blackish brown, pulverulent. *Teleutospores* broadly ellipsoid, slightly or not constricted at the septum (31–)36–44(–50) × 25–32(–36)μm; wall 2·5–4(–4·5)μm thick, chestnut brown, slightly verrucose; pore subapical to $\frac{2}{3}$ depressed in upper cell and $\frac{1}{4}$ to $\frac{1}{2}$ in lower cell; pedicel hyaline, fragile.

On *Leontodon tuberosus* L.—KHANIA: II, III Evangelistria, Khalepa, 4 v 1978, *Kapsanaki* 68 (ATHU-M 1945); II, III Marathi, Akrotiri, 4 iv 1979, *Kapsanaki* 165 (ATHU-M 2000).

The species of *Puccinia* on *Leontodon* have not been clearly delimited and need taxonomic treatment as a whole. Sydow & Sydow (1902) distinguished *P. canariensis* from *P. leontodontis* Jacky by its broader teleutospores (35–42 × 26–32μm and 30–42 × 21–27μm respectively). In our collections the size of the teleutospores and their wall thickness exceed even the values usually given for *P. canariensis*. Similar deviations were



FIGS 1–3. *Puccinia chondrillina* (ATHU-M 1982). 1, uredospore ×530; 2, teleutospore (SEM) ×2000; 3, uredospore (SEM) ×2000.
FIGS 4–7. *P. canariensis* (ATHU-M 1945). 4, uredospore ×530; 5, uredospore (SEM) ×2000; 6, teleutospores ×530; 7, teleutospore (SEM) ×2000.



teleutospore (SEM)
pore (SEM) × 2000;

reported by Nattrass (1937) for *P. canariensis* found in Cyprus on the same host.

Jørstad (1958) included both *P. canariensis* and *P. leontodontis* in the 'compound' species *P. hieracii* Mart.

In the specimens studied, the size of the teleutospores is (31–)36–44 (–50) × 25–32(–36)μm in *P. canariensis* and (27–)29–42(–47) × (18–)20–25 (–28)μm in *P. hieracii,* while their wall thickness is 2·5–4(–4·5)μm and (1·5–)2–3μm respectively. Study with SEM of both *P. canariensis* and *P. hieracii* revealed more differences in uredospore wall ornamentation. The uredospores of *P. canariensis* have long and fine echinulae 1–4·7μm apart, except for a smooth area on each side 9–10 × 10–12μm, while in *P. hieracii* the echinulae are smaller, (0·7–)1·1–3·3(–3·7)μm apart, and the smooth areas are larger 15–17 × 12–15μm. These distinctions separate *P. canariensis* from *P. hieracii.*

P. canariensis is known in the Mediterranean region from Spain (Fragoso, 1924) to Cyprus (Nattrass, 1937) on *Leontodon tuberosus* (syn. *Thrincia tuberosa* (L.) DC.), but this is the first record from Greece.

Puccinia chondrillina Bub. & Syd. in Öst. Bot. Z. 51:17 (1901). Figs 1–3.

Uredosori scattered on the leaves and mainly on the stems, pale brown, pulverulent. *Uredospores* globoid to ellipsoid 20–29 × 19–23μm; wall echinulate, except for a smooth area on each side 9–11 × 8–10μm; pores 2, superequatorial. *Teleutosori* similar to uredosori, a little darker, sometimes mixed. *Teleutospores* ellipsoid to oblong 27–40 × 19–25μm; wall 1·5–2·5μm thick, chestnut brown, slightly verrucose; pore apical to $\frac{3}{4}$ depressed in upper cell and near the septum to $\frac{1}{2}$ depressed in lower cell; pedicel hyaline, fragile, up to 95μm long. *Mesospores* occasionally present 28–30 × 21–23μm.

On *Chondrilla juncea* L.—KHANIA: II, III Skonizo, 24 vi 1978, *Kapsanaki* 118 (ATHU-M 1982); II between Fournes and Lakkoi, 25 v 1980, *Kapsanaki* 429 (ATHU-M 2180).

Jørstad (1962) included *P. chondrillina* in *P. hieracii* var. *chlorocrepidis* (Jacky) Jørstad, which he had established (Jørstad, 1958) as being distinct by having the germ pores of the uredospores in intermediate position between the superequatorial of var. *hieracii* and the equatorial of var. *hypochoeridis.* Henderson (1964), in his study of the material from SW Asia, found the rust on *Chondrilla juncea* to be typical of var. *hieracii* with 2 superequatorial pores. Cummins (1978) has also regarded *P. chondrillina* as a synonym of *P. hieracii* var. *hieracii,* although the concept he adopted for this taxon is different from that of Jørstad (1958).

In the collections from Kriti, the uredospores have two distinct superequatorial pores. However, study of the fine structure of their walls with SEM revealed smooth areas with smaller dimensions from those found in *P. hieracii* (9–11 × 8–10μm and 15–17 × 12–15μm respectively). On this basis, *P. chondrillina* is maintained for the present at specific rank.

Parmelee & Savile (1981) distinguished *P. chondrillina* from *P. hieracii* in North American material, by the smaller smooth areas (tonsures) on the uredospore wall and the less conspicuous verrucae on the teleutospores.

The only previous records of *P. chondrillina* from Greece are from Pilion, Mt Parnassos, Sounio and Mt Parnis (Pantidou, 1969).

Puccinia crepidicola Syd. in Öst. Bot. Z. 51:27 (1901). Figs 8–14.

Uredosori amphigenous, abundant, cinnamon-brown, pulverulent. *Uredospores* ellipsoid to globoid or ovoid 20–31 × 18–27 μm; wall echinulate; pores 2–3, rarely 4, superequatorial to equatorial or very rarely up to 5 scattered. *Teleutosori* amphigenous abundant, blackish brown. *Teleutospores* variable in shape and size, broadly ellipsoid to oblong, usually constricted at the septum (26–)29–45 × 21–31(–34)μm; wall 2–4(–5)μm thick, verrucose, dark brown; pore subapical to $\frac{3}{4}$ depressed in upper cell, or near the septum to $\frac{1}{2}$ depressed in lower cell; pedicel hyaline, fragile, sometimes eccentric. *Mesospores* scarcely present, 26–30 × 25–28μm.

On *Crepis foetida* L.—LASITHI: II, III Khokhlakies, 29 v 1980, *Kapsanaki* 484 (ATHU-M 2229).

On *Crepis foetida* subsp. *commutata* (Sprengel) Babcock—KHANIA: II, III Ayios Mattheos, Akrotiri, 23 vi 1978, *Kapsanaki* 112 (ATHU-M 1976); II, III Lendariana, 14 iv 1977, *Kapsanaki* 127 (ATHU-M 1985); II, III Kalami, 3 iv 1979, *Kapsanaki* 150 (ATHU-M 1992); II, III Lendariana, 28 iv 1979, *Kapsanaki* 193 (ATHU-M 2024); II, III Kounoupidhiana, Akrotiri, 29 iv 1979, *Kapsanaki* 202 (ATHU-M 2031); III Mouzouras, Akrotiri, 27 iv 1979, *Kapsanaki* 213 (ATHU-M 2039); II, III Monastery of Guvernetos, Akrotiri, 26 iv 1979, *Kapsanaki* 226 (ATHU-M 2051); III Imbros Sfakion, 31 vii 1979, *Kapsanaki* 315 (ATHU-M 2103); III Ayia Varvara, 12 vi 1979, *Kapsanaki* 329 (ATHU-M 2110). RETHIMNO: II, III Episkopi, 23 iv 1979, *Kapsanaki* 244 (ATHU-M 2066).

On *Crepis* cf. *foetida* subsp. *commutata*—KHANIA: II, III Marathi, Akrotiri, 4 iv 1979, *Kapsanaki* 154 (ATHU-M 1995); III 5km west of Khania (Vrakhakia), 25 iv 1979, *Kapsanaki* 256 (ATHU-M 2073).

On *Crepis tybakiensis* Vierh.—KHANIA: III Imbros Sfakion, 31 vii 1979, *Kapsanaki* 297 (ATHU-M 2095).

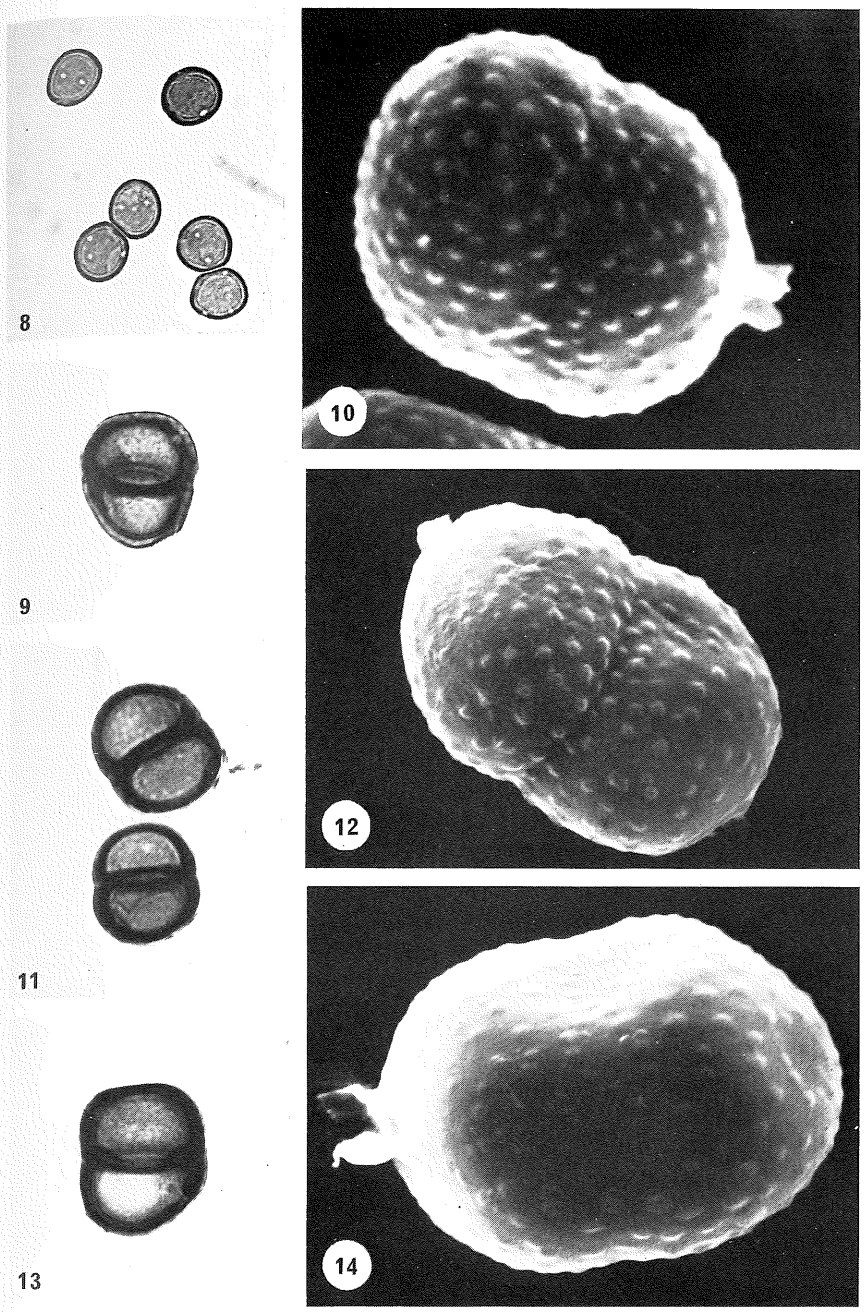
On *Crepis vesicaria* L.—KHANIA: II, III 4km east of Skonizo, 24 vi 1978, *Kapsanaki* 76 (ATHU-M 1949). LASITHI: II, III Sikia, 28 v 1980, *Kapsanaki* 463 (ATHU-M 2211); II, III Mesa Mouliana, 30 v 1980, *Kapsanaki* 490 (ATHU-M 2234).

On *Crepis* sp.—KHANIA: III Ayios Mattheos, Akrotiri, 4 v 1978, *Kapsanaki* 58 (ATHU-M 1936).

The species concept for the rusts on *Crepis* is still very confusing. It has been generally accepted that presence of aecidia borne on a systemic mycelium together with uredosori and teleutosori distinguishes *P. crepidis* Schroet. from *P. crepidicola* in which aecidia are unknown.

Jørstad (1958) regarded *P. crepidis* as a compound species which embraces various *Crepis* rusts (with the possible inclusion of *P. crepidicola*) regardless of the presence of an aecidial stage.

All 18 specimens of *Puccinia* on the three species of *Crepis* were consistently found with only the uredial and telial stages, and possibly the rust belongs to a hemiform. No aecidial stage was detected, although



FIGS 8–14. *Puccinia crepidicola*. 8, uredospores (ATHU-M 2211) on *Crepis vesicaria* ×270; 9, teleutospores (ATHU-M 1932) on *C. foetida* subsp. *commutata* ×530; 10, teleutospores (ATHU-M 2031) on *C. foetida* subsp. *commutata* (SEM) ×2000; 11, teleutospores (ATHU-M 2095) on *C. tybakiensis* ×530; 12, teleutospores (ATHU-M 2095) on *C. tybakiensis* (SEM) ×2000; 13, teleutospores (ATHU-M 2211) on *C. vesicaria* ×530; 14, teleutospores (ATHU-M 2211) on *C. vesicaria* (SEM) ×2000.

searched for several times from early spring to late summer. All morphological features of uredospores and teleutospores are within the limits of variability of *P. crepidicola* although minor differences were found. The sizes of the teleutospores were: (26–)30–44 × 21–31 μm on *C. foetida*; 29–40(–44) × 21–31 μm on *C. tybakiensis*; and 31–45 × (21–)24–34 μm on *C. vesicaria*; while mesospores were present only on *C. tybakiensis*.

Study with SEM of the collections ATHU-M 1992 and ATHU-M 2031 on *Crepis foetida* subsp. *commutata,* ATHU-M 2095 on *C. tybakiensis* and ATHU-M 2211 on *C. vesicaria* revealed the following variation as to the wall sculpturing of the teleutospores: a) on *C. foetida* subsp. *commutata* the wall is uniformly verrucose with prominent warts and the teleutospores are constricted at the septum (Fig. 10); b) on *C. tybakiensis* the wall ornamentation is almost the same as in the previous, but the constriction at the septum is more pronounced (Fig. 12); c) on *C. vesicaria* the verrucae on the wall are rather inconspicuous and there is a slight or no constriction at the septum (Fig. 14).

Whether the above distinctions provide a basis for differentiating varieties or subspecies in *P. crepidicola* can only be determined after comparative studies with additional material.

P. crepidicola has been previously reported from Greece on *Crepis foetida* from Pilion and Kriti (Pantidou, 1969), on *C. vesicaria* from Kriti (Pantidou, 1969) and on *C. vesicaria* subsp. *typica* (Fiori) Babcock from Kriti (Brandenburger, 1968).

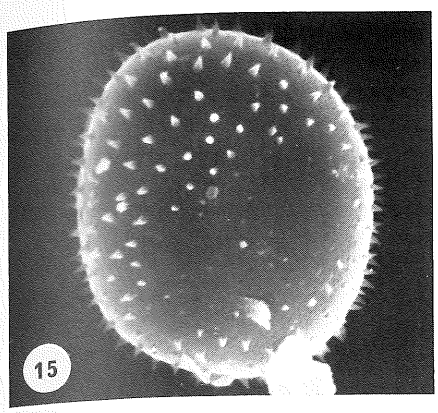
Crepis tybakiensis, an endemic plant of Kriti and Kasos, is an entirely new host for a rust fungus.

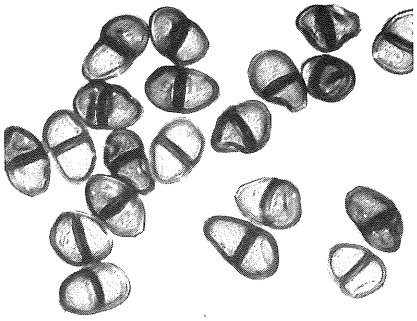
Puccinia hieracii Mart., Prodr. Fl. Mosq. Ed. 2:227 (1817). Figs 15–17.
Syn.: *P. cichorii* Bell ex Kickx., Fl. Crypt. Flandres 2:65 (1867).

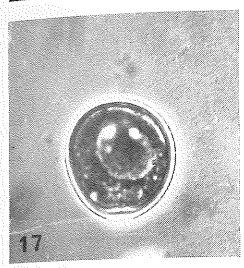
Uredosori scattered, pale brown, pulverulent. *Uredospores* globoid to ellipsoid or ovoid 23–29(–31) × (19–)21–27 μm; wall 1·5–2 μm thick, echinulate except for a smooth area on each side 15–17 × 12–15 μm, spines (0·7–)1·1–3·3(–3·7) μm apart; pores 2, superequatorial. *Teleutosori* amphigenous and on stems, rounded, sometimes confluent, blackish brown. *Teleutospores* ellipsoid or oblong, slightly or not constricted at the septum (27–)29–42(–47) × (18–)20–25(–28) μm; wall uniformly (1·5–)2–3 μm thick, finely verruculose, chestnut-brown; pore $\frac{1}{3}$ to $\frac{3}{4}$ depressed in the upper cell, rarely near the septum, and $\frac{1}{3}$ to $\frac{1}{2}$ depressed in the lower cell with slight or no caps; pedicel hyaline, fragile, up to 30(–130) μm when unbroken. *Mesospores* occasionally present 24–35 × 20–25 μm.

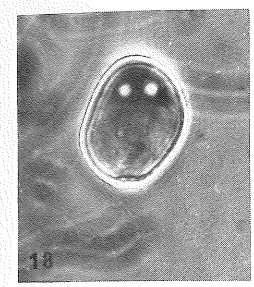
On *Cichorium intybus* L.—KHANIA: II, III Skafidhakia, 25 vi 1978, *Kapsanaki* 114 (ATHU-M 1978); II, III Skonizo, 24 vi 1978, *Kapsanaki* 117 (ATHU-M 1981), II, III 4km south of Tavronitis, 27 iv 1981, *Kapsanaki* 498 (ATHU-M 2241); II, III Katsomatadhos, 10 vi 1979, *Kapsanaki* 278 (ATHU-M 2084). LASITHI: II, III Sikia, 28 v 1980, *Kapsanaki* 458 (ATHU-M 2206); II, III Itanos, 29 v 1980, *Kapsanaki* 471 (ATHU-M 2216).

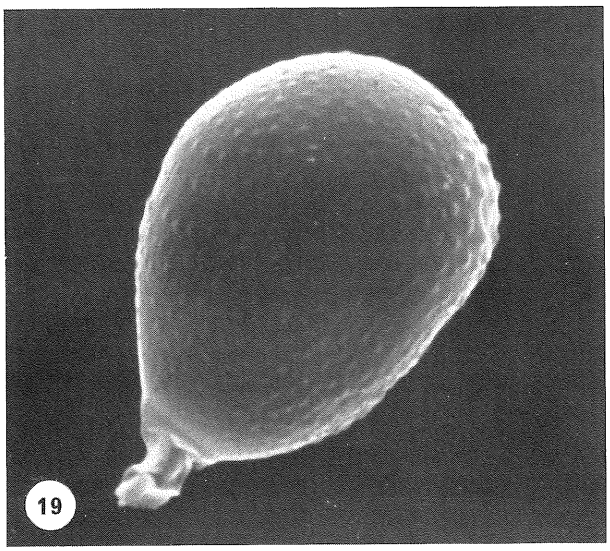
On *Cichorium pumilum* Jacq.—KHANIA: II, III Episkopi Kissamou, 12 viii 1977, *Kapsanaki* 42 (ATHU-M 1931). LASITHI: II, III Monastery of Kapsa, 28 v 1980, *Kapsanaki* 455 (ATHU-M 2203).

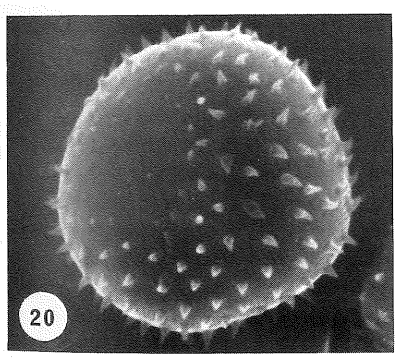












FIGS 15–17. *Puccinia hieracii*. 15, uredospore (ATHU-M 1931) on *Cichorium pumilum* (SEM) ×2100; 16, teleutospores (ATHU-M 1931) on *C. pumilum* ×270; 17, uredospore (ATHU-M 2206) on *C. intybus* ×530.

FIGS 18–21. *P. hyoseridis-scabrae*. 18, uredospore (ATHU-M 2002) on *Hyoseris radiata* subsp. *graeca* ×530; 19, teleutospore (ATHU-M 2037) on *H. scabra* (SEM) ×2000; 20, uredospore (ATHU-M 2037) on *H. scabra* (SEM) ×2100; 21, teleutospore (ATHU-M 2002) on *H. radiata* subsp. *graeca* ×530.

The rust is foliicolous on *Cichorium intybus* and caulicolous on *C. pumilum* except for the collection ATHU-M 2216 on *C. intybus* in which the sori occurred both on leaves and stems. The morphological features of uredospores and teleutospores are within the range of variability of both *Puccinia cichorii* and *P. hieracii*. Hylander *et al.* (1953) included *P. cichorii* in the compound species *P. hieracii* Mart., and Jørstad (1962) noticed that '*P. cichorii* is of true *P. hieracii* type'.

The collections ATHU-M 1981, ATHU-M 2206 on *C. intybus* and ATHU-M 1931 on *C. pumilum* were studied with SEM. The size of the smooth areas on the uredospore wall is greater than in any other member of the group in the present study, namely 15–17 × 12–15μm. This value is almost the same as that reported by Parmelee and Savile (1981) for *P. hieracii*.

The present rust is known from several localities in Greece. From Kriti it was reported as *P. cichorii* (DC.) Bell on *C. intybus* from Rethimnon (Sarejanni, 1939) and on *C. pumilum* from Psiloritis (Petrak, 1943b).

Puccinia hyoseridis-scabrae Maire in Bull. Soc. Mycol. Fr. 21:219 (1905). Figs 18–21.

Syn.: *P. hyoseridis-radiatae* Maire in Bull. Soc. Mycol. Fr. 21:220 (1905).

Uredosori amphigenous, dark brown, pulverulent. *Uredospores* sometimes mixed with teleutospores, globoid 25–30 × 22–28μm; wall 1·5–2·5μm thick, echinulate, yellow-brown; pores 2, very rarely 3, superequatorial. *Teleutosori* similar to uredosori, blackish. *Teleutospores* ellipsoid to oblong, slightly or not constricted at the septum (30–)35–46 (–52) × 20–29(–32)μm; wall (2–)2·5–3·5(–4)μm thick, slightly verrucose, chestnut-brown; pore rarely apical, usually $\frac{1}{4}$ to $\frac{2}{3}$ depressed in upper cell and $\frac{1}{3}$ to $\frac{1}{2}$ depressed in lower cell; pedicel hyaline, fragile, up to 80μm long.

On *Hyoseris radiata* L. subsp. *graeca* Halacsy—KHANIA: II, III Kato Dharatso (Glaros), 5 iv 1979, *Kapsanaki* 167 (ATHU-M 2002); II, III ibid., 25 iv 1979, *Kapsanaki* 255 (ATHU-M 2072).

On *Hyoseris scabra* L.—KHANIA: II, III Monastery of Guvernetos, Akrotiri, 26 iv 1979, *Kapsanaki* 210 (ATHU-M 2037).

Puccinia hyoseridis-scabrae and *P. hyoseridis-radiatae* were described by Maire (1905) on *Hyoseris scabra* and *H. radiata* respectively, although Arwidsson (1940) and Petrak (1943b) assumed the two species to be identical. Maire (1905) reported two equatorial pores on the uredospores in both species, but Jørstad (1962) stated that the pores were decidedly superequatorial and he placed both species in the complex of *P. hieracii*.

The uredospores in our collections are slightly narrower on *H. scabra* than on *H. radiata* viz. 22–25μm and 23–28μm respectively and the teleutospores slightly broader viz. 24–29(–32)μm and 20–29(–31)μm respectively. These differences are not considered significant for delineating the two species. The name *P. hyoseridis-scabrae* Maire is used here as it was the one adopted by Arwidsson (1940) (Art. 57).

Compared with *P. hieracii,* the present rust has teleutopores with greater dimensions and thicker walls. Moreover, study with SEM of the collections ATHU-M 2002 on *H. radiata* subsp. *graeca* and ATHU-M

2037 on *H. scabra* has added the following criteria: a) the size of the smooth areas on the uredospores of *P. hyoseridis-scabrae* are smaller than in *P. hieracii* viz. 11–14 × 7–10μm and 15–17 × 12–15μm respectively; b) the echinulae on the uredospores of *P. hyoseridis-scabrae* are more conspicuous and broader at the base than in *P. hieracii*. This last feature was not measurable accurately.

The differences found are sufficient to distinguish *P. hyoseridis-scabrae* from *P. hieracii* and maintain it as a separate species.

P. hyoseridis-scabrae is known from Greece on *Hyoseris lucida* L. (syn. *H. radiata* subsp. *graeca*) from Lafonisi Selinou Kriti (Petrak, 1943b), and on *H. scabra* from Vouliagmeni Attiki (Durrieu, 1968). It has also been cited as *P. hieracii* on *H. scabra* from Ithaki and Attiki (Pantidou, 1969).

Puccinia hypochoeridis Oud. in Ned. Kruidk. Arch., ser. 2, 1:175 (1874). Figs 22–26.

Syn.: *P. hieracii* Mart. var. *hypochoeridis* (Oud.) Jørstad in Norske Vidensk. Selsk. Skrift. 38:27 (1935).

Uredosori amphigenous and on stems, pale brown, pulverulent. *Uredospores* globoid to broadly ellipsoid, 24–30(–35) × 23–28(–31)μm; wall uniformly echinulate, 2–2·5μm thick, yellow-brown; pores 2, equatorial. *Teleutosori* amphigenous and on stems, blackish brown, pulverulent. *Teleutospores* ellipsoid, slightly or not constricted at the septum, 28–40 × 20–26(–28)μm; wall 1·5–3μm thick, chestnut-brown, almost smooth or slightly verruculose; pore apical to ½ depressed in upper cell and near the septum to ⅓ depressed in lower cell; pedicel hyaline, fragile, up to 106μm long.

On *Hypochoeris achyrophorus* L.—KHANIA: II, III Monastery of Gonia, Kolimbari, 1 iv 1979, *Kapsanaki* 169 (ATHU-M 2003); II, III Therisso gorge, 2 iv 1979, *Kapsanaki* 183 (ATHU-M 2016); II, III Monastery of Guvernetos, Akrotiri, 26 iv 1979, *Kapsanaki* 225 (ATHU-M 2050); II, III Imbros Sfakion, 31 vii 1979, *Kapsanaki* 293 (ATHU-M 2093); III Stalos, 23 v 1980, *Kapsanaki* 414 (ATHU-M 2168).

On *Hypochoeris radicata* L.—KHANIA: II Miloniana, 22 vi 1978, *Kapsanaki* 129 (ATHU-M 1987); II Liyidhes, 24 iv 1979, *Kapsanaki* 252 (ATHU-M 2069); II Fasas valley, near Skines, 24 iv 1981, *Kapsanaki* 497 (ATHU-M 2240).

The original description of *P. hypochoeridis* on *Hypochoeris radicata* was incomplete. Saccardo (1888) treated this species as a synonym of *P. hieracii* Mart. and was followed by Arthur (1934). However, Sydow (1902), Trotter (1908), Fragoso (1924), Guyot (1952), Gäumann (1959) and many others considered the two species to be different. The existence of differences was observed by Jørstad (1935) who, although including *P. hypochoeridis* in *P. hieracii,* erected three varieties: differentiating var. *hypochoeridis* for the rust on *Hypochoeris,* by it having two equatorial pores on the uredospores. This treatment was followed by Hylander, Jørstad & Nannfeldt (1953), Jørstad (1958, 1962), and Wilson & Henderson (1966).

In the collections from Kriti, the uredospores not only have 2 equatorial pores, but are also slightly larger, and have thicker walls than

in *P. hieracii*. Study of the collection ATHU-M 2016 on *Hypochoeris achyrophorus* with SEM, resolved the uredospore ornamentation (Figs 25, 26) and the following differences from *P. hieracii* were observed: a) uredospore wall entirely echinulate, there being no smooth areas, in contrast to the conspicuous, large ones in *P. hieracii*; b) spines on the uredospore wall more closely spaced than in *P. hieracii*, viz. (0·5–)0·8–2·8μm and (0·7–)1·1–3·3(–3·7)μm respectively; c) the rings around the base of the spines form a net of polygonal ridges which has possibly resulted from the wall expansion during the maturation of the spore. Such a configuration has not been observed in *P. hieracii,* in which the rings around the spines are more widely separated and never meet. It has to be stressed, however, that it appears that both *P. hypochoeridis* and *P. hieracii* are able to attack species of *Hypochoeris*; this was realized during our study on various herbarium specimens in Edinburgh (E). It is interesting that one specimen of *P. hypochoeridis* on *Hypochoeris radicata,* England, Yorkshire, Richworth Valley, 8 v 1954, *R. Watling* 291/1 (E) and another of *P. hieracii* on *Hypochoeris maculata* L., Fennia, Regio aboensis, Kakskerta, Kulho, 25 vii 1934, *L. Kari,* Fungi Exc. Fennici 19/920 (E), examined with SEM, exhibited the same differences as the ones previously mentioned.

The completely echinulate uredospores with equatorial pores in *P. hypochoeridis* have been considered by Parmelee & Savile (1981) to indicate that '*P. hypochoeridis* is unrelated to *P. hieracii* and somewhat related to the *P. helianthi* complex'.

Previous records of *P. hypochoeridis* from Greece include: on *Hypochoeris achyrophorus* (syn. *H. aethnensis* (L.) Ball; *Seriola aethnensis* L.) from Ikaria (Petrak, 1943a), Sitia, Kriti (Petrak, 1943b), Vouliagmeni, Attiki (Durrieu, 1968), Pilion, Methana, Alonissos, Evvoia (Pantidou, 1969); on *H. radicata* L. from Manoladha, Ilia (Maire & Politis, 1940), Omalos, Kriti (Petrak, 1943b).

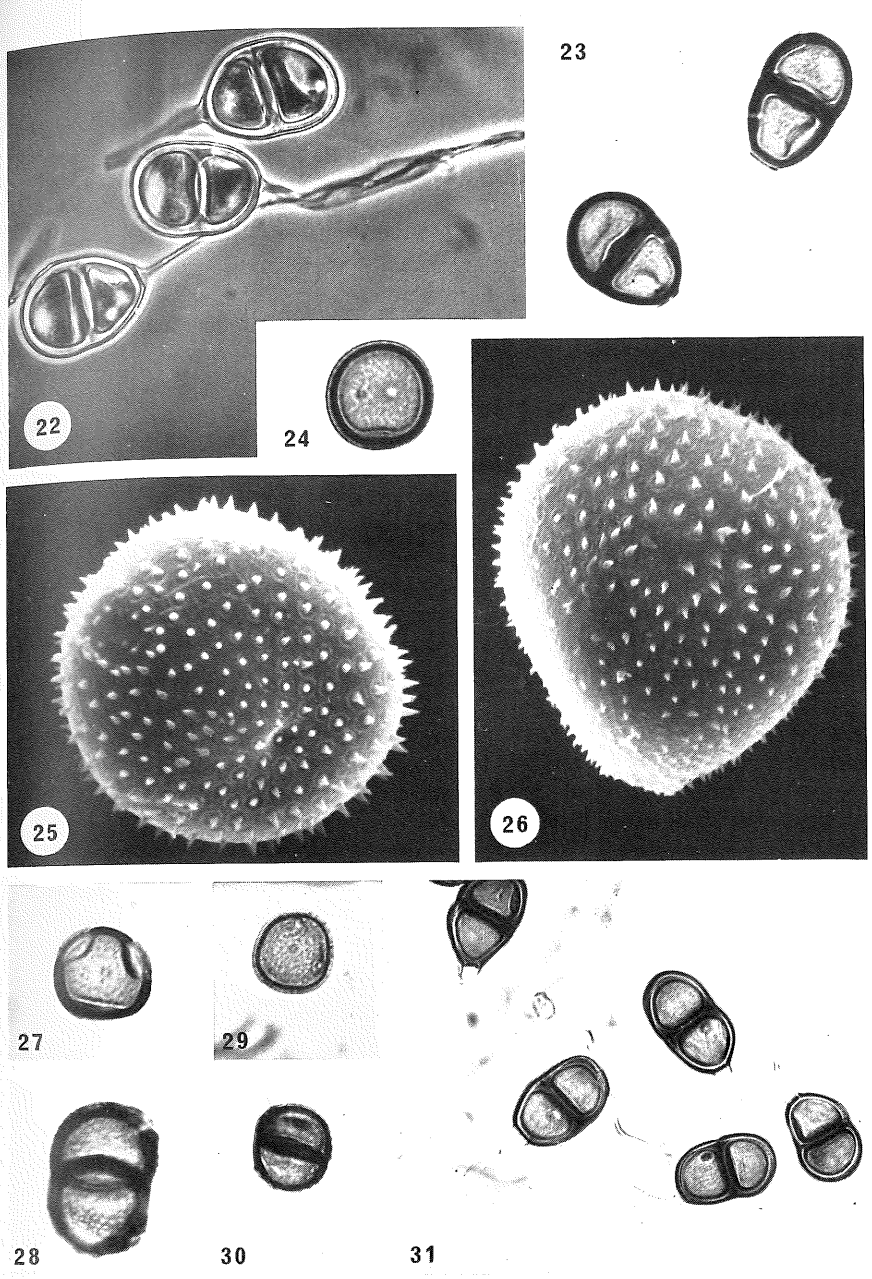
Puccinia lactucarum Syd. in Öst. Bot. Z. 51:17 (1901). Figs 27, 28.

Uredosori rare. *Uredospores* usually intermixed with teleutospores, ellipsoid to globoid 22–28 × 19–23μm, wall minutely echinulate, 1·5–2·5 (–3)μm thick; germ pores (2–)3(–4) with a prominent papilla which is c.1·5–3·5μm high and 8–15μm wide. *Teleutosori* hypophyllous, usually grouped, blackish brown, pulverulent. *Teleutospores* ovoid to ellipsoid, usually rounded at the apex or at both ends, usually not constricted at the septum (30–)32–44(–49) × (20–)23–32(–34)μm, wall (2–)2·5–4(–4·5)μm thick, verrucose with prominent warts; germ pore subapical to $\frac{1}{2}$ depressed in upper cell and $\frac{1}{2}$ to $\frac{2}{3}$ depressed in lower cell; pedicel hyaline, fragile, usually short, occasionally measured up to 90μm.

On *Lactuca viminea* (L.) J. & C. Presl—KHANIA: II, III Embrosneros Apokoronou, 19 vi 1979, *Kapsanaki* 351 (ATHU-M 2124); II, III Malaxa, 18 vi 1979, *Kapsanaki* 383 (ATHU-M 2147).

On *Scariola acanthifolia* (Willd.) Sojak—KHANIA: II, III Katsomatadhos, 10 vi 1979, *Kapsanaki* 369 (ATHU-M 2136).

Several rusts attack species of *Lactuca* and the related genera *Scariola, Prenanthes, Mycelis* etc.



FIGS 22–26. *Puccinia hypochoeridis* on *Hypochoeris achyrophorus*. 22–23, teleutospores (ATHU-M 2050) ×530; 24, uredospore (ATHU-M 2050) ×530; 25–26, uredospores (ATHU-M 2016) (SEM) ×2000.
FIGS 27–28. *P. lactucarum* (ATHU-M 2124) on *Lactuca viminea*. 27, uredospore ×530; 28, teleutospore ×530.
FIGS 29–30. *P. melitellae* (ATHU-M 2019) on *Melitella rechingeri*. 29, uredospore ×530; 30, teleutospore ×430.
FIG. 31. *P. scolymi* (ATHU-M 2184) on *Scolymus hispanicus*, teleutospores ×270.

In order to determine which of the rust species occur in our collections, and especially that on the entirely new host *Scariola acanthifolia,* these were compared with the following herbarium specimens:

Puccinia lactucarum. On *Lactuca perennis* L.: Neuchatel Suisse, vi 1912, *Eug. Major,* Vestergren micromycetes rariores selecti No. 1573 (K). On *Lactuca quercina* L.: Bohemia, Kuchelbad ad Pragam, 3 v 1902, *Fr. Babuk,* Sydow Uredineen No. 1720 (K). On *Lactuca sagittata* Waldst. & Kit.: Russland, Prov. Charkow, Starobjelsk, vii 1903, *J. Schirajewsky,* Petrak Mycotheca Gen. No. 881 (E). On *Lactuca quarcina* L.: Dobrogea-Babadag, 11 vi 1963, *O. Constantinescu,* Herb. Mycol. Romanicum 37/1837 (E). On *Lactuca quercina* L.: Kromau in Mahren, vii 1927, *J. Hruby,* Petrak Fl. Bohemiae et Moraviae Exs. 51/2517 (E).

Puccinia ankarensis Bremer & Petrak. On *Lactuca cataonica* Boiss. & Hausskn.: Prov. Junali Hoyat Ovacik, Turkey, 14 vii 1957, *P. Davis* 31101 (E); on *Lactuca brevirostris* Fenzl ex Boiss., Antalya, Anatolia, 30 viii 1947, *P. Davis* 14692, IMI 70617 (E).

Puccinia maculosa (Strauss) Rohling on *Prenanthes purpurea* L., Gori Tismana, 8 vii 1972, *Constantinescu & Negrean,* Herb. Mycol. Romanicum 44/2154 (E).

Puccinia prenanthis (Pers.) Lindr. On *Lactuca muralis* (L.) Gaertner: Teplitz Schonau in Bohmen, vii 1896, *G. A. Eichler,* Petrak Fl. Bohemiae et Moraviae Exs. 8/396 (E). On *Mycelis muralis* (L.) Rchb: Benmore Garden, Argyll, 15 ix 1959, *D. M. Henderson* 4831 (E).

The rust on *Lactuca viminea* and *Scariola acanthifolia* fitted well into the range of variability of *P. lactucarum.* In subsequent comparison with the type specimen of *P. lactucarum* Syd. on *Lactuca perennis* L. (Tirolia austr., Nesselbrunn pr. Boren, 5 vii 1900, Sydow Uredineen 1476 (K)) it was noted that the teleutospores in the collections from Kriti have slightly greater size and a thicker, more heavily pigmented wall. These deviations could be attributed to an adjustment to the dry Mediterranean climate, which according to Savile (1971) favours exactly such characteristics.

P. lactucarum is reported for the first time from Greece. It is known from central, eastern and southern Europe up to Palestine. The present report adds to the known pattern of its geographical distribution.

Scariola acanthifolia, an endemic plant of Kriti and the S Aegean region, is an entirely new host for a rust fungus.

Puccinia melitellae Pantidou & Henderson in Notes RBG Edinb. 35:409 (1977). Figs 29, 30.

Uredosori amphigenous, very small, not easily visible, pale brown, erumpent. *Uredospores* ellipsoid, ovoid or irregular 19–25 × 16–21 μm; wall (1–)1·5–2μm thick, echinulate; pores obscure 3–4(–5), scattered. *Teleutosori* mainly hypophyllous, dark brown erumpent, becoming pulverulent. *Teleutospores* broadly ellipsoid to subgloboid, not constricted at the septum 25–36(–38) × (18–)20–28μm; wall 1·5–2·5μm thick, coarsely verrucose, dark brown; pore subapical to $\frac{1}{2}$ depressed in upper cell and $\frac{1}{4}$ to $\frac{3}{4}$ depressed in lower cell; pedicel hyaline, fragile, short, slightly eccentric.

On *Melitella rechingeri* Zaffran.—KHANIA: III Perivolitsa, Akrotiri,

29 iv 1979, *Kapsanaki* 155 (ATHU-M 1996); II, III Korakies, Akrotiri, 29 iv 1979, *Kapsanaki* 187 (ATHU-M 2019).

The specimens here cited are the only ones of this taxon, after its original description by Pantidou & Henderson (1977).

Puccinia rhagadioli Thuem. in Rev. Mycol. 2:150 (1880). Figs 32, 33.
Syn.: *P. rhagadioli* (Pass.) P. & H. Syd., Monogr. Ured. 1:139 (1902).

Uredosori amphigenous, rounded, dark brown, pulverulent. *Uredospores* globoid to broadly ellipsoid 20–26 × 19–25μm; wall 1·5–2·5μm thick, coarsely echinulate; pores obscure usually 2–3, rarely 4–5, more or less equatorial. *Teleutosori* amphigenous, blackish brown, pulverulent. *Teleutospores* broadly ellipsoid to ovoid, not constricted at the septum 25–36(–40) × 22–30μm; wall 2·5–3·5(–4)μm thick, verrucose with conspicuous warts; pore subapical to $\frac{3}{4}$ depressed in upper cell, and near the septum to $\frac{1}{4}$ depressed in lower cell; pedicel short, deciduous.

On *Rhagadiolus stellatus* (L.) Gaertner var. *edulis* (Gaertner) DC. (syn. *R. edulis* Gaertner)—KHANIA: II, III Therisso gorge, 3 v 1978, *Kapsanaki* 63 (ATHU-M 1940); III Orthuni, 25 vi 1978, *Kapsanaki* 78 (ATHU-M 1951); II, III Katsomatadhos, 10 vi 1979, *Kapsanaki* 268 (ATHU-M 2077); II, III Imbros gorge, Sfakia, 28 iv 1981, *Kapsanaki* 510 (ATHU-M 2250).

The probable relation of *P. rhagadioli* with *P. calcitrapae* DC. was suggested by Henderson (1964) after detecting three equatorial pores on the uredospores in material from SW Asia.

The uredospores in the collections on *Rhagadiolus stellatus* var. *edulis* from Kriti possess rather inconspicuous germ pores, without consistency as to their number and position. Usually there are two or three pores, more rarely four to five. As to their position they are often almost equatorial, in some two equatorial and one superequatorial or scattered.

The collection ATHU-M 1940, examined with SEM, gave the following information: a) uredospore wall has large spines, slightly curved, with a broad base and a multidirectional pattern in space (Fig. 32); b) the smooth areas on the uredospore wall are small in the range 7–12 × 4–7μm, or absent; c) teleutospores have no constriction at the septum and their wall has conspicuous, closely arranged verrucae, 0·9–2·5μm apart (Fig. 33).

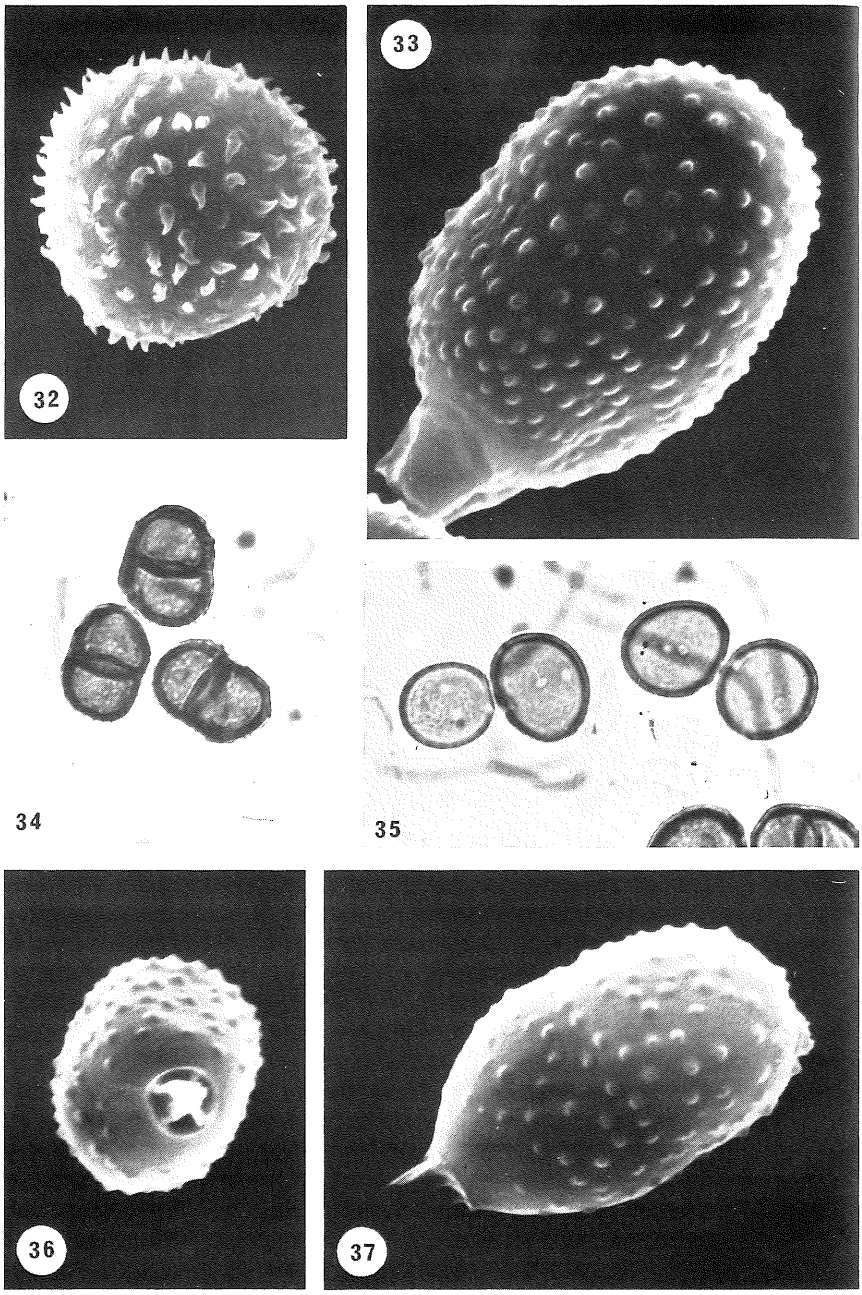
From this data, there is no doubt that *P. rhagadioli* is not related to *P. calcitrapae*. The latter has also been examined with SEM, and the morphology of the uredospores showed an entirely different pattern (data to be presented in a future publication).

A problem over the nomenclature of *P. rhagadioli* Thuem. has been discussed extensively by Gjærum & Hansen (1982).

P. rhagadioli is known from Greece on *R. stellatus* from Koropi (Maire & Politis, 1940), Kandhanos Khania (Brandenburger, 1968), Kriti and Delphi (Pantidou, 1969), and Kos (Gjærum & Hansen, 1982).

Puccinia scolymi P. & H. Syd., Monogr. Ured. 1:141 (1902). Fig. 31.

Uredosori amphigenous, scattered, pale brown, pulverulent. *Uredospores* subgloboid to broadly ellipsoid 26–32 × 24–30μm; wall 1–2μm thick,



FIGS 32–33. *Puccinia rhagadioli* (ATHU-M 1940). 32, uredospore (SEM) ×2000; 33, teleutospore (SEM) ×2000.
FIGS 34–37. *P. trachyderma* (ATHU-M 1998). 34, teleutospores ×530; 35, uredospores ×530; 36, teleutospore (SEM) ×1700; 37, teleutospore (SEM) ×2000.

echinulate; pores 2, rarely 3, superequatorial. *Teleutosori* amphigenous, rounded, dark brown, pulverulent. *Teleutospores* ellipsoid or oblong rounded at both ends, not constricted at the septum 30–44 × 21–29 μm; wall uniformly 1·5–3 μm thick, verruculose; pore ½ to ¾ depressed in upper cell, and ¼ to ½ depressed in lower cell; pedicel hyaline, fragile, up to 50 μm long, sometimes eccentric.

On *Scolymus hispanicus* L.—RETHIMNON: II, III Bali, 26 v 1980, *Kapsanaki* 434 (ATHU-M 2184).

The only previous record of *P. scolymi* from Greece is that by Petrak (1943b) on the same host from Kissamos, Khania.

Puccinia trachyderma Syd. in Svensk Bot. Tidskrift 29:75 (1935. Figs 34–37.

Uredosori mostly hypophyllous, small, pale brown, on minute spots under the leaf, pulverulent. *Uredospores* ellipsoid to ovoid, sometimes subgloboid, 21–30 × 18–24 μm; wall 1·5–2 μm thick, echinulate; pores 2–3 (–4), equatorial to slightly superequatorial. *Teleutosori* amphigenous, mostly hypophyllus, dark brown, pulverulent. *Teleutospores* ellipsoid, rounded at both ends, usually not constricted at the septum 24–35(–38) × 19–27 μm; wall 2–3·5 μm thick, verrucose with well-developed warts, dark brown; pore apical to ¾ depressed but usually ½ depressed in upper cell and up to ½(–¼) depressed in lower cell, sometimes covered by a hyaline papilla; pedicel short, hyaline, deciduous usually eccentric.

On *Crepis fraasii* Schulz Bip.—KHANIA: II, III Katsomatadhos, 1 v 1978, *Kapsanaki* 64 (ATHU-M 1941); II, III Therisso gorge, 3 v 1978, *Kapsanaki* 65 (ATHU-M 1942); III Katsomatadhos, 21 vi 1978, *Kapsanaki* 113 (ATHU-M 1977); II, III Therisso gorge, 2 iv 1979, *Kapsanaki* 163 (ATHU-M 1998).

Puccinia trachyderma, which was described by Sydow (1935) from Greece on *Crepis sieberi* Boiss. (syn. *C. fraasii* Schulz Bip.) is characterized by the thick-walled teleutospores with prominent verrucae. Gäumann (1959) presented the possibility of it being related to *P. crepidicola* Syd. which also attacks species of *Crepis*. The present study was directed to clarify this aspect.

A common character in both *P. trachyderma* and *P. crepidicola* is the indefinite number and unfixed position of the germ pores on the uredospores. This is probably an indication of a common lineage. However, the teleutospores in *P. trachyderma* are smaller than in *P. crepidicola* and usually lack a constriction at the septum; a constriction to varying degrees is found in *P. crepidicola.*

Study of the collections ATHU-M 1941 and ATHU-M 1998 with SEM revealed: a) the verrucae in *P. trachyderma* are more distantly located from those in *P. crepidicola*; the diameter of the verrucae at their base is 0·7–1·5 μm in *P. trachyderma* and 0·6–1(–1·2) μm in *P. crepidicola,* and their distance (1·4–)1·7–4·3(–5.2) μm and (1–)1·5–3·8(–4·4) μm respectively; b) a smooth zone, 3–4 μm wide, has been observed just above the base of the teleutospores in *P. trachyderma.* No such area exists in *P. crepidicola* where the verrucae cover the whole surface of the teleutospores.

×2000; 33,

uredospores

Crepis fraasii is an endemic confined to Greece, Cyprus and W Turkey and, therefore, *P. trachyderma* seems to be a rust with a limited geographical distribution. *P. trachyderma* is previously known only from Pikermi (Sydow, 1935) and Evvoia (Petrak, 1956).

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