

Note added in proof. After the preparation of this report, our attention has been called to a paper from von Frisch's department, in which the results of an exploration of mannose toxicity in a number of insects are reported [T. Staudenmayer, *Z. vergleich. Physiol.* **26**, 644 (1939)]. Mannose was to be toxic to several apidae examined and to *Vespa vulgaris*, but not to other Hymenoptera.

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Identity of a Rust on *Ephedra*

Abstract. The aecial stage of a rust on *Ephedra* has been called a *Peridermium*. Clues as to its telial stage have been lacking. It is here described as resembling more a form of *Roestelia*, and the reasons for its possible relation to *Gymnosporangium multiporum* Kern are presented: the two sets of hosts have similar distributions; the two rust stages have the same geographic range; they have been found in close proximity in the field.

Ephedra is a genus of the joint-fir family (Ephedraceae) distributed over the arid regions of the northern hemisphere. The drug ephedrin, administered as an astringent, is obtained from a Chinese species. The small scale-like leaves and jointed stems of these plants make them resemble somewhat the horsetails. Botanically the joint-firs are classed with the gymnosperms, which

bear naked seeds in contrast to the angiosperms, with seeds enclosed in an ovary. The joint-fir family has points of agreement with both Gymnospermae and Angiospermae, making the group in some ways an intermediate one between the two classes.

A rust fungus (order Uredinales) has been known as a parasite on species of *Ephedra* since 1877. This rust has been reported as, "A common and conspicuous species along the southwestern border of the United States and southward into Mexico" (1). It is usually listed as *Peridermium ephedrae* Cooke (2). In the *Natürlichen Pflanzenfamilien*, Dietel referred to it as *Aec. [Aecidium] Ephedrae* Cke. (3).

This rust on *Ephedra* is an aecial (or aecidial) stage only, and without a known perfect (telial) stage can be referred only to a form genus. *Peridermium* is a form genus name for various aecia on gymnospermous hosts, whose telial connections are unknown. Many of the forms temporarily placed here have been connected to telial stages. All of these aecial forms have been on coniferous hosts (order Coniferales), and their telial stages belong to the rust family Melampsoraceae.

The *Ephedra* rust doubtless has been called a *Peridermium* chiefly because the host is classed as a gymnosperm. *Ephedra*, however, is not a conifer and the aecial stage on it is in certain respects unlike the forms of *Peridermium* on these hosts.

It more closely resembles some of the highly differentiated species of the form genus *Roestelia*, in which the peridium (outer coat or investment of the sorus) is cylindrical, elongated (up to 5 mm), and dehiscent at the apex. For many years the forms of *Roestelia* were believed to have a restricted host range: species of the tribe Pomeae or family Malaceae (depending on the classification used). We now know that a few species with *Roestelia*-like aecia in habit not only Malaceae but other families—Rosaceae, Hydrangiaceae, Myricaceae—belonging to the angiosperms. These rusts are heteroecious and those for which a telial stage is known belong to the genus *Gymnosporangium*. Without exception species of *Gymnosporangium* have their telial stages on the family Juniperaceae which is a part of the Gymnospermae. Here we have heteroecious rusts alternating between angiosperms and gymnosperms.

We are now strongly suggesting that the rust on *Ephedra* is a *Roestelia* and that it is the aecial stage of a *Gymnosporangium* on a *Juniperus* species. We are aware that this will create an anomalous situation. It will be the first case where aecial and telial stages of a

heteroecious rust inhabit two families both belonging to the Gymnospermae. Perhaps this may be regarded as supporting the view that the *Ephedra* family is not truly gymnospermous, as has been pointed out by some taxonomists.

The species of *Gymnosporangium* believed to be the telial stage of the *Ephedra* aecial stage is *G. multiporum* Kern (4). The geographical range of these two stages is essentially the same. The similar distribution of the two sets of hosts—the various species of *Ephedra* and *Juniperus deppeana* Steud. (*J. pachyphlaea* Torr.), *J. monosperma* (Engelm.) Sarg., and *J. osteosperma* (Torr.) Little [*J. utahensis* (Engelm.) Lemmon]—and their association on desert lands make possible the harboring of a fungus which must pass from one set to the other. This lends credence to the suggestion that *Gymnosporangium multiporum* is the telial stage of the *Ephedra* rust. Not only do the ranges and distribution of these rust stages and of their hosts favor this conjecture, but there is additional evidence from field observations. *Gymnosporangium multiporum* and the aecia on *Ephedra* have been found in proximity in an area of the South Rim of the Grand Canyon, Coconino County, Arizona. Our prediction is made with much confidence. Proof can be had only through cultures, involving inoculations under controlled conditions.

It is pertinent to note that there are numerous collections of the rust on *Ephedra* but that there has been no suggestion till now of a possible telial stage. *Gymnosporangium multiporum* is so inconspicuous as to elude easy detection even when present. Relatively few collections of *G. multiporum* have been made. In any event its collectors would doubtless have sought *Roesteliae* on Malaceae (the usual alternate stages for *Gymnosporangium*) and naturally would have disregarded the *Ephedra* as being of no concern. These facts may help explain why the present hypothesis has not been suggested sooner (5).

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