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Texosporium sancti-jacobi, a Rare Western North American Lichen

BRUCE MCCUNE
Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331-2902

ROGER ROSENTRETER
Bureau of Land Management, Idaho State Office, 3380 Americana Terrace, Boise, ID 83706

Abstract. *The lichen* Texosporium sancti-jacobi *(Ascomycetes: Caliciales) is known from only four general locations worldwide, all in western U.S.A. Typical habitat of* Texosporium *has the following characteristics: arid or semiarid climate; nearly flat ground; noncalcareous, nonsaline, fine- or coarse-textured soils developed on noncalcareous parent materials; little evidence of recent disturbance; sparse vascular plant vegetation; and dominance by native plant species. Within these constraints* Texosporium *occurs on restricted microsites: partly decomposed small mammal dung or organic matter infused with soil. The major threat to long-term survival of* Texosporium *is loss of habitat by extensive destruction of the soil crust by overgrazing, invasion of weedy annual grasses and resulting increases in fire frequency, and conversion of rangelands to agriculture and suburban developments. Habitat protection efforts are important to perpetuate this species.*

The lichen *Texosporium sancti-jacobi* (Tuck.) Nadv. is globally ranked (conservation status G2) by the United States Rare Lichen Project (S. K. Pittam 1990, pers. comm.). A rating of G2 means that globally the species is very rare, and that the United States Rare Lichen Project maintains a file on the species, notifies local governmental jurisdictions of occurrences, and, as warranted, seeks listing on the U.S. Fish and Wildlife Service Threatened and Endangered List. The species is also an Idaho BLM Sensitive Species and Idaho Native Plant Society Priority 1 Species (Idaho Native Plant Society 1991; Moseley & Groves 1990).

Texosporium is monotypic. It is known historically from near San Diego, California (Nadvornik 1942; Tuckerman 1883), and more recently from Pinnacles National Monument, California (Smith 1990), near Boise, Idaho (Rosentreter 1986), and north of Bend, Oregon (A. DeBolt, unpubl.). It is part of the biotic crust that covers much of the soil surface in many semiarid and arid sites. Very little has been known about its habitat requirements and the influences of management practices on this species.

The objectives of this study were to gather information on site characteristics, disturbance history, and vegetation at the known locations for *Texosporium,* and attempt to locate additional populations by field and herbarium searches.

METHODS

We visited sites where *Texosporium* had previously been found; however, historic sites near San Diego were not revisited. The early collections from that area have vague location data while more recent collections (1950's–1960's) were from areas that are now heavily developed and presumably do not support the species. New sites were sought in likely areas, especially in southwest Idaho, northern Nevada, and eastern Oregon. At each site where *Texosporium* was found we recorded approximate population size, substrates, site characteristics, and signs of recent disturbance such as fire, grazing, and rodent burrowing.

Additional unreported collections of *Texosporium* were sought from ASU, CANL, COLO, ID, NY, ORE, OSC, SBM, SFSU, SRP, UC, US; the private herbaria of Ann DeBolt, Roger Rosentreter, and Bruce Ryan; and the herbarium (UPS) of the most recent monographer of the order Caliciales (Tibell 1984).

Nomenclature of vascular plants follows Hitchcock and Cronquist (1973), while that of lichens follows Egan (1987).

RESULTS AND DISCUSSION

Descriptions of *Texosporium sancti-jacobi* are in Weber (1967) and Tibell and Hofsten (1968). Briefly, *Texosporium* forms an inconspicuous whitish to grayish crust on soil and organic matter. Its apothecia are quite distinctive and easier to spot in the field than the thallus. The apothecia are typically circular, 0.5–1.5 mm diameter, whitish-margined, and with a dark-blackish, powdery center that is tinged with bright yellow from the secondary product calycin. The apothecia tend to occur in clusters that are seldom more than 1 cm in diameter.

The known distribution (Fig. 1) is very spotty, ranging from the historic sites near San Diego north to central Oregon and southwest Idaho. Site characteristics are summarized in the list of locations below. Further details of locations, collecting history, and ecological data are in McCune (1992).

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LOCATIONS

The following list includes all known sites for *Texosporium,* excluding the historical collections with vague collection data, i.e., "San Diego." Herbaria of the authors are indicated by MCC and RR. "BLM" refers to the United States Department of Interior, Bureau of Land Management.

U.S.A. CALIFORNIA. SAN BENITO CO.: Pinnacles Nat. Mon., Chalone Creek, 293 m, *Desjardin 1274* (SFSU, UPS), *McCune 19114* (MCC, US); Chalone Creek at Bear Valley, Pinnacles Nat. Mon., 290 m, *Desjardin 2055* (SFSU); High Peaks ridge, Pinnacles Nat. Mon., 790 m, *McCune 19139* (MCC, Pinnacles National Monument herbarium, US). SAN DIEGO CO.: Delmar, N of Torrey Pines State Park, *Weber & McCoy 36684* (COLO); Kearney Mesa, *Weber & Santesson 43119* (COLO); Camp Kearney, *Parks L117* (COLO). IDAHO. ADA CO.: 4 km SW of Owyhee, *Rosentreter 1239* (COLO, RR), *Rosentreter 1665* (COLO, MCC, RR), *Rosentreter 3081* (ASU, CANL, COLO, MCC, RR, SFSU, SRP); 4 km ESE of Owyhee, 885 m, *DeBolt & Doremus,* not collected; Pleasant Valley Road, 882 m, *Rosentreter 6815* (RR); Tenmile Ridge, 900 m, *DeBolt 1521* (Boise District BLM herbarium). ELMORE CO.: I-84 & Simco Road, 1,000 m, *Rosentreter 6819b* (RR). OREGON. JEFFERSON CO.: Big Canyon, 730 m, *McCune,* not collected; The Island, 730 m, *DeBolt & Rosentreter 6514* (Prineville District BLM herbarium, RR), *McCune 18973* (MCC, US).

HABITAT

Texosporium was always found in arid to semiarid grasslands, shrublands, or savannas, at elevations up to 1,000 m. Parent materials in all areas were noncalcareous, including basalt, granite, and mixed alluvium. The soils developed on these parent materials varied greatly, from very fine-textured soils on basalt (the Oregon sites and some Idaho sites), to sandy loams (Simco Road, Idaho), to soils high in fine or coarse sand (Pinnacles National Monument). Soil texture appears to be less important than soil chemistry, as no *Texosporium* was found on the numerous calcareous and saline sites examined.

Soil depth at *Texosporium* sites also varied greatly, from thin soils over bedrock (Oregon sites and Pinnacles ridge site), to moderately thick soils restricted by a caliche layer (Snake River Plain sites), and deep alluvial soils (Pinnacles stream terrace).

ASSOCIATED VEGETATION

The associated soil crusts differed between the California sites and the more northern sites. In Idaho and Oregon the soil crust is typically well developed where *Texosporium* is found. Associated lichens in both Oregon and Idaho included *Acarospora schleicheri, Aspicilia reptans, Buellia punctata, Candelariella terrigena, Cladonia pocillum, Collema* sp., *Diploschistes muscorum, Lecanora muralis, Phaeorrhiza sareptana,* and *Psora* species. Additional associated species in Idaho were *Trapeliopsis* sp. and others reported by Rosentreter (1986). The Chalone Creek, California population had very few soil crust associates, mainly the dark K+ red California relative of *Aspicilia reptans* and several small species of *Riccia.* The ridgetop population at Pinnacles in California was also associated with the California relative of *Aspicilia reptans,* but contained numerous additional species not found in the Chalone Creek community: *Cladonia* squamules, *Leptogium sinuatum, Xanthoparmelia coloradoensis,* and several bryophytes.

The vascular vegetation likewise had many commonalities among the northern sites but little in common between the northern and the California sites. All of the northern sites were dominated by some species of *Artemisia,* including *A. tridentata* subsp. *wyomingensis* (most commonly) and subsp. *tridentata* and *A. arbuscula,* often with *Chrysothamnus nauseosus,* a seral species. All northern sites had *Poa sandbergii* and other bunchgrasses, especially *Agropyron spicatum, Sitanion hystrix,* and *Stipa* species. The Oregon locations also had widely scattered *Juniperus.* The sites at Pinnacles had widely scattered *Adenostoma fasciculatum* but otherwise had little in common with each other or the Oregon and Idaho sites. The Chalone Creek site was largely bare, with a few sprigs of *Festuca octoflora* and *Bromus rubens,* bordered by *Adenostoma* and *Eriogonum fasciculatum.* On the ridge at Pinnacles, *Texosporium* was intimately associated with a large mat of *Selaginella,* surrounded by widely scattered *Adenostoma* and *Pinus sabiniana.*

DISTURBANCE HISTORY

The sites with *Texosporium* had few signs of recent disturbance, although all had been grazed by wild animals. Most of the sites from which *T. sanctijacobi* is known have had little or no grazing by domestic animals in recent years. The fair to poor range condition at two of the Idaho locations suggests a past history of intensive grazing or fire followed by a prolonged period (>20 years) without severe disturbance (Rosentreter 1986). This suggests that *Texosporium* populations can recolonize areas following severe disturbance, although the process is slow. The apparent recolonizing ability suggests that *Texosporium* would respond favorably to improved management practices and habitat protection efforts.

Examination of a recently burned site formerly occupied by *Texosporium* and adjacent to an existing *Texosporium* site showed that the population had been completely eliminated by the fire. When burned sites become dominated by *Bromus tectorum,* the predominant pattern in recent years, it is

not clear whether *Texosporium* and other soil crust species can reestablish.

CAUSES OF RARITY AND MEANS OF SURVIVAL

Texosporium has an unusual type of rarity (Rabinowitz et al. 1986), having wide (but disjunct) geographic distribution, restricted habitat, and a local population size that everywhere is small. Although it has a wide range in North America (1,300 km north to south), it is rare both regionally (Fig. 1) and locally. That is, populations are difficult to find, and when they are found, the colonies tend to be few, small, and dispersed.

Several factors may act to produce the regional rarity of *Texosporium*. It appears to be intolerant of calcareous, saline, and heavily disturbed sites. Numerous calcareous and saline sites with well-developed soil crusts were examined in Idaho and Nevada, but no *Texosporium* was found on those sites. Grazing tends to disrupt the soil crust and promote conversion from bunchgrasses to weedy annual alien grasses (especially *Bromus* species and *Elymus caput-medusae*) which promote frequent burning (Whisenant 1990). *Texosporium* and the biotic soil crust in general are essentially absent from these semiarid sites dominated by annual grasses. The widespread conversion of sagebrush–bunchgrass communities to alien annual grasslands has been promoted by overgrazing and fire (Whisenant 1990; Yensen 1982).

Texosporium is always rare locally. Even in sites where it is known to occur, it may take a trained observer an hour to locate a colony. This local rarity is probably the result of a very restricted range of suitable microhabitats. There is always an organic component to its substrate, although the particular class of acceptable substrates is seldom abundant. Two particular substrates are most commonly colonized by *Texosporium*: dead bunchgrass stubble that is thoroughly impregnated with soil, and old partly decomposed small-mammal dung, especially that of jackrabbits (*Lepus*) and rabbits (*Sylvilagus*). It was not observed growing on old dung of domestic animals or wild ungulates. In Idaho and Oregon, *Texosporium* was most often found on the typically 2–10 cm diameter lumps formed by dead *Poa sandbergii*. These are often somewhat pedestalled and typically are fragile and susceptible to destruction by grazing animals. On the same lumps other soil crust species are common, especially *Diploschistes muscorum* and *Buellia punctata*.

The colonies found in Pinnacles National Monument in California were always on partly decomposed small-mammal dung. *Texosporium* was also seen occasionally on those substrates in Oregon and Idaho. Typically the pellets of dung were decomposed to the point that they crumbled with gentle finger pressure. Some of them had begun to lose their original form in situ. It seems likely that where small bunchgrasses such as *Poa sandbergii* are absent, *Texosporium* occurs primarily on small-mammal dung.

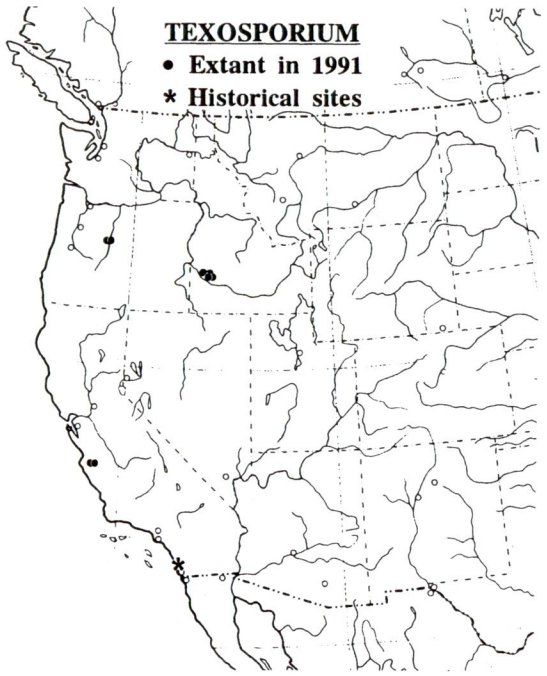

FIGURE 1. Known world distribution of *Texosporium sancti-jacobi*. Solid circles indicate populations confirmed in the last few years. The star near San Diego indicates historical populations that have probably been extirpated. Small empty circles are major cities. The map was developed from a Goode basemap, copyright University of Chicago Press.

Several life history characters favor its long-term persistence, despite its rarity and habitat restrictions. The unusual spore characteristics of this species may provide critically important reproductive traits. We hypothesize that the spores have an unusually high desiccation resistance and longevity, and that these characteristics are provided by the combination of large spore size and the thick hyphal coating of the spores. The fungal coat may provide some measure of protection against desiccation. This protection would not only allow longer spore viability in place, but should also improve survival during long-distance dispersal.

The spore mass is densely infused with calycin. Presumably this substance increases the likelihood of maturation and longevity of the spores by providing some antibiotic activity (e.g., see Lawrey 1989).

The spore coat is very dark at maturity. This may provide some protection against the high levels of

radiation in exposed, sunny habitats. This feature may promote spore longevity by protecting the nucleic acids from damaging radiation.

STATUS SUMMARY

Although records of *T. sancti-jacobi* have increased in recent years, this reflects an increase in scrutiny of possible sites by lichenologists rather than any real increase in population size. To the contrary, relatively intact steppe and savanna ecosystems, of the kind from which *Texosporium* is known, have been reduced to isolated remnants (detailed further below).

Texosporium is uncommon at all sites where it is known. Where it occurs it constitutes much less than 1% of the biotic crust. Most of the sites from which *Texosporium* is known have had little or no grazing by domestic animals in recent years (perhaps 10 or more years). Its occurrence in fragile microsites that are readily destroyed by grazing and other soil disturbance suggests that its future is in jeopardy. However, it occurs at several sites in Idaho that were historically heavily grazed or burned but have had little or no grazing or fire in recent years (Rosentreter 1986). This suggests that *Texosporium* can respond favorably to habitat protection and restoration efforts, at least in those areas where remnant populations exist (such as southwest Idaho).

The earliest known populations of *T. sancti-jacobi* were from near San Diego, especially in the Kearney Mesa area. Because of suburban development in this area, most or all of those populations may have been destroyed. However, this area was not visited in the course of this study. Attempts should be made to locate remnant populations in the San Diego area.

The populations in Pinnacles National Monument appear healthy and are likely to persist under Monument protection. The overgrazing and soil disturbance observed outside the Monument have been so thorough that populations are probably few and far between. No *Texosporium* was found in grazed areas examined outside the Monument.

More populations of *Texosporium* are known in southwestern Idaho than from any other area. This may be due partly to favorable habitat and partly to the extensive observations in that area by Rosentreter and A. DeBolt. Despite the relatively large number of populations known for this area, the populations are clustered in only three sites. *Texosporium* is threatened by the ongoing loss of good-condition *Artemisia tridentata* subsp. *wyomingensis* rangelands on the Snake River Plain. Although *Artemisia* steppe was historically the dominant vegetation on the valley floor, most of this ecosystem has been destroyed or severely degraded (Yensen 1982). Large areas have been converted to agricultural uses. The remaining area has mostly been transformed by fire and *Bromus tectorum* into an exotic-annual grassland with a high fire frequency (Whisenant 1990) and almost no biotic soil crust, or overgrazed to the point of destruction of the biotic crust. Thus, ensuring the long-term persistence of *Texosporium* in southwestern Idaho will require some habitat protection efforts (e.g., see Pellant 1990).

Texosporium is known from only two populations in Oregon, both on the dissected basalt plateaus near the confluence of Crooked River, Deschutes River, and the Metolius River in central Oregon. The two populations are about 6 km apart.

One site ("The Island") is in an Area of Critical Environmental Concern managed by the Bureau of Land Management and has historically been protected from domestic grazing by topography making it inaccessible to domestic animals. It is a nearly flat remnant of dissected basalt plateau surrounded by cliffs. The other site, on the rim of Big Canyon northwest of The Island is apparently used on occasion for hunting camps. *Texosporium* is absent from the immediate vicinity of the camps, probably due to disturbance by horses. The population is best developed in very rocky, thin-soil areas near the rim that probably have had less horse and cattle use in the past and have probably burned less often because of sparse fuels. These natural protections will probably continue to foster *Texosporium* in this area.

IS THIS SPECIES IMPORTANT?

Is *Texosporium* a significant resource, such that efforts and expense should be expended to ensure its survival as a species? Although the species has no direct economic value at present, it does have considerable scientific importance.

Texosporium is important to science in part because it is the only known species of its genus. Furthermore, its habitat and growth form are unusual for the Caliciales. But the most distinctive feature of this species is its spores, which are quite different from those of virtually all other spore-producing organisms. As the spores of *Texosporium* develop, the ascus bursts, then the surrounding hyphae in the mazedium reorganize to form a thick tight covering over each spore (Tibell & Hofsten 1968).

Functionally, the fungal spore coat may be similar to the protective coverings found in seed plants. This lichen has evolved a structure apparently analogous to the seed coat or dry fruits of many flowering plants. As such, it appears to provide an extreme example of convergent evolution, in this case between organisms from two different kingdoms.

Perhaps the morphology of the spores is intimately related to *Texosporium*'s ability to survive over a broad area despite its rarity. Two possible functions for the fungal coat are providing resistance to excessive drying and protecting the spore during passage through the gut of an animal.

Texosporium is also potentially valuable as an indicator of long periods without overgrazing and fire in sagebrush steppe communities. Although its rarity and inconspicuousness lessen its utility as a general indicator of range condition, it may be one of a collection of species that in various combinations indicate disturbance history. However, we need to learn much more about the dynamics of biotic crusts and their initial reaction and resilience to various kinds of disturbances before we can fully appreciate *Texosporium*'s place in arid ecosystems of the West.

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