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Unusual Lichens under Electricity Pylons on Zinc-enriched Soil

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Abstract. *Two species of lichens,* Vezdaea leprosa *(P. James) Vezda and* Steinia geophana *(Nyl.) B. Stein are here reported as new for North America based on collections from Durham and Orange Counties, North Carolina (U.S.A.). Both species occur frequently in the area on zinc-contaminated soils below galvanized electricity pylons. The species were not found in areas between pylons, suggesting a central role for elevated substrate zinc levels in determining the local distribution of these species. This inference is consistent with the ecology of these species in Britain and Europe.*

Lichens are common colonists of metal enriched substrates, and characteristic lichen floras have been documented from metalliferous sites in North America and Europe (Nash 1990; Purvis & Halls 1996). As is the case for flowering plants, the taxonomic distribution of lichen species in environments enriched with different metals appears to be nonrandom. Purvis and Halls (1996), for example, listed 61 species characteristic of lead-zinc-enriched environments in Britain and Europe. Certain genera are especially well represented, including *Stereocaulon* (eight species) and *Vezdaea* (six species). This is in contrast to copper-enriched substrates, where no species of these two genera are considered characteristic, but the genus *Lecanora* is especially common (five species), and to iron-enriched environments, where *Lecanora, Stereocaulon,* and *Vezdaea* are not typically represented, but some 14 species of *Lecidea* are considered characteristic (Purvis & Halls 1996).

Zinc contaminated soils have been documented below a variety of galvanized metal structures including fences (Antonovics et al. 1971), highway crash barriers (Ernst 1995), and electricity pylons (Al-Hiyaly et al. 1990, 1993; Earland-Bennett 1993). Levels of total and acid-extractable zinc in soils under electricity pylons may be an order of magnitude higher than in adjacent soils not subject to zinc leachate from the overhead galvanized structures (Al-Hiyaly et al. 1990). That levels of contamination are biologically significant in these habitats is evidenced by sparse vegetation cover compared to adjacent sites just a few meters away, by the occurrence of characteristic floras, and by the existence of elevated levels of genetically determined tolerance of zinc in plants growing in contaminated microsites (Al-Hiyaly et al. 1990, 1993; Tabaee, Antonovics & Crone, *pers. comm.*).

While conducting routine explorations of plants, algae, and fungi on soils below electricity pylons in Durham and Orange Counties, North Carolina, we collected two lichens that proved to be species characteristic of zinc-enriched soils, and one of them has not previously been reported from North America. The most common lichen on barren soils below the pylons is *Vezdaea leprosa* (P. James) Vezda. *V. leprosa* has not been reported previously from North America (Coppins 1987; Esslinger & Egan 1995). This species is described by Purvis et al. (1992) as common throughout the British Isles

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TABLE 1. Substrate analysis from seven pylons and adjacent areas. Except for pH, units are in part per million dry weight (mg/kg). Values for Mn are approximate because amounts of 16.1 ppm or greater were recorded as 16.1. * = difference in concentration significant at $p \leq 0.05$.

	N	Ca	K	Mg	Mn*	P*	Zn*	pH
Pylon	21	190.2	19.7	43.3	6.4	5.6	234.7	4.7
Outside	21	185.1	22.6	44.1	11.2	2.3	18.8	4.4

"On disturbed soils and decaying vegetation of transient, open habitats under maritime influence or contaminated by metals such as iron, lead and zinc, particularly old galvanized fencing wires, . . ." Five other species of *Vezdaea* are reported from the British Isles (Purvis et al. 1992), including a species recently described from lead- and zinc-contaminated soil in Wales, *V. cobria* Giralt, Poelt, & Suanjak. Only the largest and most conspicuous British species of *Vezdaea, V. aestivalis* (Ohl.) Tsch.-Woess & Poelt, is typical of base-rich substrates not contaminated by lead or zinc.

Vezdaea leprosa consists of a dark green, granulate (crustose) thallus with scattered pink to brown or red-brown apothecia that are convex and appear rather gelatinous with a hand-lens when moist. The thalli were common on muddy soil under every one of the six pylons that we explored, but the species was not found between pylons in microsites that differed most obviously in zinc levels (Table 1).

The second unusual species we encountered on the zinc-enriched soil below the pylons is *Steinia geophana* (Nyl.) B. Stein. We encountered this minute species mixed with *V. leprosa* under just one of the pylons. The crustose thallus is extremely inconspicuous, but *S. geophana* produces small but conspicuous (with magnification), black, stalked, apothecia that are visible in the field. We did not encounter any other lichen species under the pylons.

Both *Vezdaea leprosa* and *Steinia geophana* are described by Purvis et al. (1992) as ephemerals. Many bryophytes, and probably also lichens, actively grow during the winter months in North Carolina, which are mild and generally moist. We are not able, at this time, to describe the growth and/or reproductive phenology of *V. leprosa* and *S. geophana* in our area. If these species are annuals in our area, their occurrence on zinc contaminated soil requires repeated recolonization. If this is the case, colonization by sexually produced propagules must also require independent lichenization under each pylon (see below).

The occurrence of *V. leprosa* and *S. geophana* under multiple pylons, in some cases separated by up to 25 km, raises interesting questions regarding the evolution of zinc tolerance in these species. Tabaee, Antonovics, and Crone (unpublished) found that plants of the grass, *Panicum scoparius* Lam., growing under the same pylons where we collected the lichens, exhibited elevated levels of zinc tolerance relative to nearby plants outside the area of contamination. Al-Hiyaly et al. (1990) demonstrated that individuals of *Agrostis stolonifera* L., *A. capillaris* L., *Anthoxanthum ordoratum* L., and *Festuca ovina* L., growing under galvanized electricity pylons in Britain displayed elevated levels of tolerance to zinc under experimental conditions. Based on erection dates for the different pylons, they inferred that tolerance had evolved within 35 years, and in some cases in as little as 20 years. Artificial selection experiments described by Al-Hiyaly et al. (1993) demonstrated that elevated zinc tolerance can evolve in as little as two generations in *A. capillaris.* Work by these authors on *Agrostis capillaris* suggested that tolerance evolved independently under different pylons, and that the evolution of tolerant plants under each pylon depended on the occurrence of genes for tolerance in plants adjacent to each. The only pylon that lacked tolerant plants of *Agrostis capillaris,* for example, was also the only one that lacked plants with genetic variation for tolerance in adjacent populations.

Little is known about evolutionary processes involved in the occurrence of metal tolerance in lichens (Nash 1990). Independent unicells of the alga, *Pleurastrum terrestre,* which is known as a phycobiont only from the lichen genera, *Vezdaea* and *Thrombium,* occur frequently in soils (Friedl & Büdel 1996). It may be noteworthy that Purvis and Halls (1996) report *Thrombium epigaeum* (Pers.) Wallr. as one of the lichens characteristic of zinc contaminated soils.

The evolution of metal tolerance in lichens represents an intriguing but barely tapped area for basic research, especially because of complexities added by symbiotic interactions between the component organisms. Just a few questions that are raised by lichens on contaminated soils in general, and by our observations in particular, include the following. Are thalli of *Vezdaea leprosa* and *Steinia geophana* under galvanized pylons genetically adapted to elevated zinc levels? If so, did tolerance evolve once with subsequent spread of tolerant individuals to other sites, or did tolerance evolve independently under different pylons? Are both the mycobiont and phycobiont tolerant? Is there genetic variation for tolerance in naturally occurring populations of the mycobiont and phycobiont? Can a tolerant mycobiont that sequesters metals "protect" a physiologically nontolerant phycobiont, yielding a tolerant lichen? Are coevolutionary processes between tolerant genotypes of myco- and phycobiont crucial for the evolution of tolerant lichens? By what reproductive/dispersal mechanisms do these lichens reach pylons? Is lichenization required for successful colonization? What are physiological mechanisms of tolerance?

Specimens examined.—Vezdaea leprosa: U.S.A. NORTH CAROLINA. Durham Co., Durham, 0.2 km W of LaSalle Street on Kangaoo Street, S side of road under electricity pylon, *Shaw 9338* (DUKE), *Buck 33466* (NY); Durham, Durham Division of the Duke Forest, under electricity pylons E of where the power line intersects NC 751 N of Duke University, *Shaw 9339–9343* (DUKE), *Buck 33451, 33452, 33454–33456* (NY). Orange Co., Just N of Chapel Hill city limits on NC 86 where power line crosses road, under pylon, *Shaw 9346* (DUKE). *Steinia geophana:* Durham, Durham Division of Duke Forest, under electricity pylons E of where power line interects NC 751, N of Duke University, *Buck 33453* (NY).

LITERATURE CITED

AL-HIYALY, S. A. K., T. MCNEILLY & A. D. BRADSHAW. 1990. The effect of zinc contamination from electricity pylons. Contrasting patterns of evolution in five grass species. New Phytologist 114: 183–190.

ANTONOVICS, J., A. D. BRADSHAW & R. G. TURNER. 1971. Heavy metal tolerance in plants. Advances in Ecological Research 7: 1–85.

COPPINS, B. J. 1987. The genus *Vezdaea* in the British Isles. Lichenologist 19: 167–176.

EARLAND-BENNETT, P. M. 1993. Lichens under metal electricity pylons. British Lichen Society Bulletin 72: 23.

ERNST, G. 1995. *Vezdaea leprosa*—Spezialist am Strassenrand. Herzogia 11: 175–188.

ESSLINGER, T. L. & R. S. EGAN. 1995. A sixth checklist of the lichen-forming, licheniocolous, and allied fungi of the continental United States and Canada. THE BRYOLOGIST 98: 467–549.

FRIEDL, T. & B. BÜDEL. 1996. Photobionts, pp. 8–23. *In* T. H. Nash III (ed.), Lichen Biology. Cambridge University Press.

———, ———, ——— & A. M. MORTIMER. 1993. The effect of zinc contamination from electricity pylons. Genetic constraints on selection for zinc tolerance. Heredity 70: 22–32.

NASH III, T. H. 1990. Metal tolerance in lichens, pp. 119–1131. *In* A. J. Shaw (ed.), Heavy Metal Tolerance in Plants: Evolutionary Aspects. CRC Press, Boca Raton.

PURVIS, O. W., B. J. COPPINS, D. L. HAWKSWORTH, P. W. JAMES & D. M. MOORE (Eds.). 1992. The Lichen Flora of Great Britain and Ireland. The British Lichen Society, London.

——— & C. HALLS. 1996. A review of lichens in metal-enriched environments. Lichenologist 28: 571–601.

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