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Distribution and Persistence of *Phyllachora* Species on Poaceae in Iowa

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Phyllachora spp. on Poaceae were collected to determine species present, grass hosts and distribution in Iowa. From 1959–1996 the fungus was collected 240 times from 67 different sites in 35 counties. Seven species of *Phyllachora* were collected on 25 species from 13 genera of grasses. *P. graminis* was collected 89 times from 43 sites on four species of *Agropyron*, two species of *Calamagrostis*, three species of *Elymus*, *Hystrix patula*, *Panicum virgatum*, and *Setaria glauca*. Seventy-two specimens of *P. luteo-maculata* on *Andropogon gerardii* or *Schizāchyrium scoparium* were collected from 30 sites. The study included 20 collections of *P. cynodontis* on *Bouteloua curtipendula* from 12 sites. *P. vulgata* was represented by 43 collections from 21 sites on *Muhlenbergia* species, and *P. paspalicola* was collected on *Paspalum* spp. 13 times from five sites. *P. punctum* was collected once on *Dicanthelium oligosanthes* var. *scribnerianum*, and once on *Panicum capillare*. The study included only one collection of *P. phalaridis* on *Phalaris arundinacea*. *P. paspalicola* and *P. phalaridis* are new records for the state.

INDEX DESCRIPTORS: distribution, persistence, *Phyllachora*, Poaceae.

Phyllachora species are obligate host specific fungal pathogens on a range of plants throughout the world (Doidge 1942, Parberry 1967, Swart 1985, Cannon 1991, Hanlin and Tortolero 1991, Pearce and Hyde 1994, Pearce et al. 1995). The disease is characterized by a black "tar spot" on leaves. Sexual structures and in some species, stromata develop in leaves (Orton 1924, Miller 1951, 1954, Orton 1956, Parberry 1963, Gabel 1989). The fungus is primarily a tissue replacement pathogen because host tissue is replaced or relocated to make room for fungal tissue (Luttrell 1981). Spots do not spread to cover major portions of the leaves, and plants typically are not quickly killed by the fungus (Cannon 1991). However, the black stromata do reduce leaf surface area available for photosynthesis, and reduced photosynthetic rates have been demonstrated from infected *Panicum maximum* leaves (Rey and Garnett 1984). Only one species, *P. maydis* Maubl. on *Zea mays* L. is a virulent pathogen (Ceballos and Deutsch 1992, Hock et al. 1992).

Because *Phyllachora* species are biotrophs, distribution is closely related to distribution and availability of hosts (Parberry 1967, Cannon 1991). Members of the Poaceae are common hosts for *Phyllachora* species and *P. cynodontis*, *P. paspalicola* and *P. punctum* have a worldwide distribution on grasses (Parberry 1967). *P. graminis* is widespread in North America and Europe on several genera of grasses, and *P. luteo-maculata* is distributed throughout the central and southern United States, South America and the West Indies (Orton 1944, Parberry 1967). Some *Phyllachora* species are known only from the type locality (Orton 1944, Parberry 1967).

Information about *Phyllachora* species that parasitize grasses in Iowa is sparse even though some hosts are consistently and severely parasitized every year. Early collections made from 1876–1934 are in the Ada Hayden Herbarium of Iowa State University (Table 1). Pammel and Carver (1895) reported *P. graminis* on four species of grasses. Gilman and Archer (1929) reported three species of *Phyllachora* on eighteen species of grasses in Iowa. More recent collections of *Phyllachora* spp. have been included with reports of other parasitic fungi on plants from a variety of families in Iowa and these reports indicate *Phyllachora* species occur predominantly on members of the Poaceae (Tiffany et al. 1985, Tiffany et al. 1990, Tiffany and Knaphus 1995). This report of recent Iowa collections and exsiccatae summarizes species presence, distribution, grass hosts and survival of the fungus in Iowa.

MATERIALS AND METHODS

Exsiccatae of *Phyllachora* species on grass hosts from the Ada Hayden Herbarium of Iowa State University (ISC) were examined (Table 1). Specimens collected for this study were made throughout the year, but collections from July into October when *Phyllachora* structures are well developed were most common. An effort was made to examine all grass species for the fungus at each site. Diseased leaves were removed in the field, pressed, and dried for microscopic examination of the fungus. Grasses were identified in the field or inflorescences were removed and placed with the diseased leaves for later identification and verification. Specimens were deposited in the mycology section of the Ada Hayden Herbarium. Fungal species identification was based on taxonomic treatments by Farr et al. (1989), Orton (1944), Parberry (1967) and Sprague (1950). Hitchcock (1950) and Pohl (1978) were used for host determinations.

RESULTS AND DISCUSSION

From 1959–1996, 240 specimens of *Phyllachora* spp. were collected from 67 different sites in 35 counties in Iowa (Table 2). Seven species of *Phyllachora* occurred on 25 species from 13 genera of grasses.

The commonest species with the broadest host range was *P. gra-*

Table 1. ***Phyllachora*** **species, grass hosts and counties for Iowa collections from 1879 to 1934.**

FUNGAL SPECIES	GRASS HOST	COUNTY	YEAR
Phyllachora cynodontis (Sacc.) Niessl.	*Bouteloua curtipendula* (Michx.) Torr.	Allamakee	1928
		Dickinson	1925
Phyllachora graminis (Pers.) Fckl.	*Bromus* L.	Allamakee	1930
	Agropyron repens (L.) Beauv.	Warren	1927
	Elymus canadensis L.	Cerro Gordo	1918
		Story	1910
	Elymus virginicus L.	Boone	1913
		Guthrie	1925
		Story	1897, 1909, 1911
		Winneshiek	1879
	Hystrix patula Moench	Boone	1903, 1912
		Johnson	1930
		Story	1892, 1913
	Triticum vulgare Vill.	Story	1882
Phyllachora punctum (Schw.) Orton	*Dicanthelium latifolium* (L.) Gould & Clark	Boone	1927
		Story	1891, 1914
	Panicum agrostoides Spreng.	Story	1892
Phyllachora vulgata Theissen & Sydow	*Muhlenbergia cuspidata* (Torrey) Rydb.	Dickinson	1934
		Lyons	1918
		Story	1876
	Muhlenbergia mexicana (L.) Trin.	Story	1901
	Muhlenbergia racemosa (Michx.) B.S.P.	Dickinson	1932
	Muhlenbergia schreberi J. F. Gmelin	Story	1910
	Muhlenbergia sobolifera (Muhl. ex Willd.)	Story	1892
	Muhlenbergia sp.	Story	1909

minis, represented by 89 collections from 43 different sites, on 12 species of grasses, most of which are in the Aveneae or Triticeae (Gould and Shaw 1983). *P. graminis* was distributed on *Calamagrostis canadensis, Elymus canadensis* and *Elymus virginicus,* all common grasses of wet or mesic prairies, and the common woodland grasses, *Elymus villosus* and *Hystrix patula* were also hosts (Fig. 1) (Hitchcock 1950, Pohl 1978).

P. luteo-maculata was collected 72 times from 30 different sites on either *Andropogon gerardii* or *Schizachyrium scoparium. A. gerardii,* a dominant grass of the tall grass prairie (Hitchcock 1950, Pohl 1978), was by far the more common of the two hosts (Fig. 2). *P. cynodontis* was collected 20 times on *Bouteloua curtipendula* from 12 dry, sandy sites in eight counties (Fig. 3). *P. vulgata* was represented by 43 collections from 21 different sites on species of *Muhlenbergia* (Table 2). *P. paspalicola* occurred 13 times on five dry sandy grasslands where *Paspalum* spp. occur (Hitchcock 1950, Pohl 1978). *P. punctum* was found only twice, once on *Dicanthelium oligosanthes* var. *scribnerianum* and once on *Panicum capillare* (Table 2). The study included only one collection from each of the following grasses: *P. graminis* on *Agropyron subsecundum,* on *Calamagrostis inexpansa* and on *Setaria glauca*; *P. phalaridis* on *Phalaris arundinacea* and *P. vulgata* on *M. mexicana* (Table 2). *P. paspalicola* and *P. phalaridis* are new records for the state.

During this study common native grasses, *Sorghastrum nutans* (L.) Nash and *Spartina pectinata* Link (Hitchcock 1950, Pohl 1978) were frequently observed. *Phyllachora* spp. have been reported on *S. nutans* in Iowa (Farr et al. 1989, Sprague 1950) and on *S. pectinata* in the midwest (Farr et al. 1989), but no *Phyllachora* spp. were collected on these hosts.

Phyllachora spp. were collected consistently for several years from diseased grasses in the same prairies (Table 2). Floral lists for three of these prairies were examined and hosts infected with *Phyllachora* and potential available hosts were noted. Both *Andropogon gerardii* and *Schizachyrium scoparium* were listed as abundant in Caylor Prairie, but *P. luteo-maculata* was collected six years only on *A. gerardii* and never found on *S. scoparium. P. vulgata* was collected four years on *Muhlenbergia cuspidata,* but never on *M. racemosa.* Both species occur frequently in Caylor Prairie (Aikman and Thorne 1956). Glenn-Lewin (1976) does not indicate frequency or abundance of grass species at Stinson Prairie, but *Calamagrostis inexpansa* and *E. virginicus* were present, and *P. graminis* was collected for several years only on *C. canadensis* or *E. canadensis. P. luteo-maculata* was collected six years on *A. gerardii,* which was listed as a dominant grass on Kalsow Prairie. Although less common, *S. scoparium* was present, but never infected (Brotherson 1969). These data indicate *Phyllachora* species may be selective pathogens on potential hosts. There may be differential pathogenic ability on some hosts or pathogenic races within morphological species of *Phyllachora.* Poor ascospore dispersal, or inadequate inoculum levels may be responsible for lack of spread to available hosts.

Both C_3 and C_4 grass species (Gould and Shaw 1983, Hattersley and Perry 1984, Smith and Brown 1973) were hosts for *Phyllachora* species. Fifty percent of the species were C_3 and 50% of the species were C_4. *Schizachyrium scoparium* was not classified.

Table 2. ***Phyllachora*** species, grass hosts and site numbers for Iowa collections from 1959–1996.

FUNGAL SPECIES	HOST	SITE #[a]	YEAR
Phyllachora cynodontis (Sacc.) Niessl.	*Bouteloua curtipendula* (Michx.) Torr.	40	60, 83
		13, 28, 39	60, 62, 82, 83
		63	87
		55	91
		38	81, 82, 95
		50	82
		47	93
		25	87, 88, 90, 91
		22, 66	60, 73, 78
Phyllachora graminis (Pers.) Fckl.	*Agropyron repens* (L.) Beauv.	5	59, 60
	Agropyron smithii Rydb.	28	86
		6	86
		5	59
	Agropyron subsecundum (Link) Hitchc.	49	59
	Agropyron trachycaulum (Link) Malte	67	59
		18	60
		24	82
	Calamagrostis canadensis (Michx.) Beauv.	14	83
		12	60
		17	86
		13, 28	83, 86, 88
		31	86, 87, 95
		15, 16	95
		60	83, 86, 87
		37	86
		23	86
	Calamagrostis inexpansa A. Gray	14	95
	Elymus canadensis L.	17	86
		28	86
		6	86, 87
		55	83, 86
		51	60
		31	81, 82, 83, 86
		60	86
		37	82
		23, 33	80, 82, 95
		66	60
	Elymus villosus Muhl. ex Willd.	9	95
		7	95
		64	83
		27	88
		63	84, 87
		51	95
		56	79
		2, 3	83
	Elymus virginicus L.	67	59
		11	60, 80
		55, 58	83, 86, 89
		51	60
		65	81
		41	78
		29	62
		25	87, 91
		3, 54	59, 60, 84, 95

Table 2. Continued.

FUNGAL SPECIES	HOST	SITE #[a]	YEAR
	Hystrix patula Moench	67	59
		34, 40	59, 60, 82
		9	95
		7	95
		45	60, 84
		64	79, 83
		27	60, 83, 88
		51	60
		36	75
		16	95
		41	72
		26	84
		22	59
	Panicum virgatum L.	13, 39	60
		37	59
	Setaria glauca (L.) Beauv.	67	59
Phyllachora luteo-maculata (Schw.) Orton	*Andropogon gerardii* Vitman	1	94
		14	81, 82, 84, 86, 95
		11, 40	59, 60, 83, 84
		8, 17	83, 86, 95
		59	82, 87, 88, 91, 93
		13, 28, 39	60, 70, 72, 80
		57	81, 82, 83, 84, 86, 87, 88, 90, 95, 96
		52	
		55, 58	90, 91, 92, 93, 96
		20, 31	86, 87, 95
		16, 38	95
		65	81
		60	82, 86
		29	62
		62	82
		48	
		25	86, 87, 93
		37	59, 83, 84, 86, 87, 93
		19	83
		23, 53	60, 84, 86, 95
		42	82, 83, 87, 88, 91, 93
	Schizachyrium scoparium (Michx.) Nash	59	87, 91, 93
		61	83
		31	86
		25	86
Phyllachora paspalicola P. Henn.	*Paspalum ciliatifolium* Michx.	14	82, 86
		25	86, 87
	Paspalum setaceum Michx.	14	82, 83, 95
		38	82
		44	82
	Paspalum L.	14	86, 87
		35	87
		38	82

Table 2. Continued.

FUNGAL SPECIES	HOST	SITE #[a]	YEAR
Phyllachora phalaridis Orton	*Phalaris arundinacea* L.	67	59
Phyllachora punctum (Schw.) Orton	*Dicanthelium oligosanthes* (Schultes) Gould var. *scribnerianum* (Nash) Gould	28	86
	Panicum capillare L.	50	82
Phyllachora vulgata Thiessen & Sydow	*Muhlenbergia cuspidata* (Torrey) Rydb.	13, 28	82, 83, 84, 86, 89, 95
		24	82
		30	82
		43	82
		25	82
		21	81
	Muhlenbergia frondosa (Poir.) Fern.	40	59
		46	82
		2, 32	95
	Muhlenbergia glomerata (Willd.) Trin.	10	81
		31	86
	Muhlenbergia mexicana (L.) Trin.	31	81
	Muhlenbergia racemosa (Michx.) B.S.P.	28, 57	83, 84, 86, 95
		55	91
		31	81, 87
		60	82
		37	61, 93
		3	84
	Muhlenbergia Schreber	13, 28	87, 88, 90, 95
		6	96
		25	86, 87, 88, 89, 90, 91, 93
		4, 23	79, 80, 81

[a]See Appendix for site information

Ninety-two percent of grass hosts were perennials. Only two annuals, *Setaria glauca* and *Panicum capillare* were hosts (Hitchcock 1950, Pohl 1978). This distribution would be expected since 70% of common grasses in Iowa are perennials (Pohl 1978). However, the high percentage of perennial hosts might also be explained by the fact that perennial grasses are persistent with herbaceous culms with attached leaves which die back each year (Gould and Shaw 1983), and these senesced overwintered leaves may provide inoculum the following spring. In addition to sexual reproduction, perennial grasses reproduce vegetatively by rhizomes which can spread or form dense colonies (Gould and Shaw 1983, Clark and Pohl 1996). Plants arising from a susceptible colony would maintain susceptibility to the fungus. Annual grasses reproduce strictly by seeds, resulting in plants with potentially new genetic combinations each year. This would presumably increase chances of genetic resistance in the population (Gould and Shaw 1983).

Eighty-eight percent of the grass species collected were native to Iowa. Only *Agropyron repens, A. subsecundum* and *Setaria glauca* are introduced (Eilers and Roosa 1994). *Phyllachora* species are biotrophs, and most species have a clearly defined geographical range (Cannon 1991). It is not known if *P. graminis* was introduced again with these hosts or moved from closely related native plants, which were infected.

Phyllachora species collected in Iowa from 1876–1934 include seven specimens over 100 yrs old (Table 1). The earliest record of *Phyllachora* in the state is a 1876, C. E. Bessey collection of *P. vulgata* on *Muhlenbergia cuspidata* from Ames, Iowa. *P. vulgata* on *Muhlenbergia cuspidata* was collected in 1934 in Dickinson County and again in that county several times since 1982. *P. vulgata* was collected on *M. racemosa* at Silver Lake Fen in Dickinson County in 1932 and again from this site in 1995. *P. graminis* was collected in Story County on *Elymus canadensis* in 1910 and again in 1980, 1982, and 1995, on *E. virginicus* in 1897, 1909, and 1911, and again in 1959, 1960, 1984 and 1995, and on *Hystrix patula* from Boone County in 1903, 1912, 1959, 1960, and 1982 (Tables 1 and 2). *Phyllachora* species have persisted in these areas. Eleven of the 30 specimens collected from 1876–1934 were from Story County, in the vicinity of Ames, Iowa.

P. luteo-maculata, a ubiquitous species on *Andropogon gerardii* was first collected in the state from Boone County in 1959 and from Dickinson County in 1960, (Table 2) and first reported by Tiffany et al. (1985). No earlier exsiccatae exist in the herbarium, but the absence of earlier collections may be related to a lack of earlier sampling of diseased plants from prairies rather than absence of the fungus.

No records of *Phyllachora* species on grasses collected from 1934–

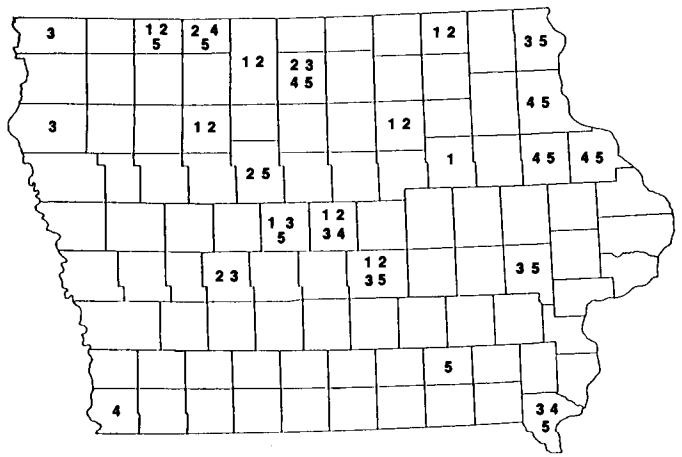

Fig. 1. Counties where *Phyllachora graminis* was collected on *Calamagrostis canadensis, Elymus canadensis, Elymus virginicus, Elymus villosus and Hystrix patula* from 1959–1996 in Iowa. 1 = *Calamagrostis canadensis*; 2 = *Elymus canadensis*; 3 = *Elymus virginicus*; 4 = *Elymus villosus*; 5 = *Hystrix patula*. Each number represents one or more collections from that county.

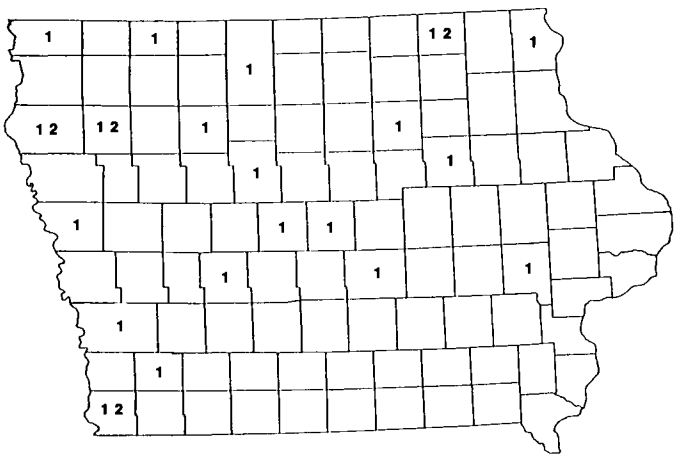

Fig. 2. Counties where *Phyllachora luteo-maculata* was collected on *Andropogon gerardii* and *Schizachyrium scoparium* in Iowa from 1959–1996. 1 = *Andropogon gerardii;* 2 = *Schizachyrium scoparium*. Each number represents one or more collections from that county.

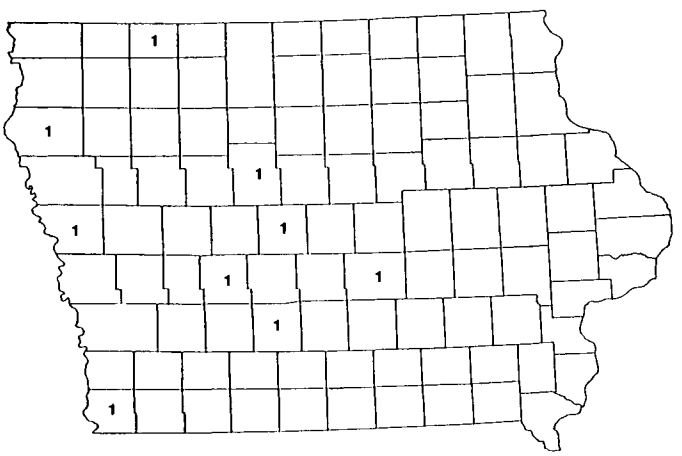

Fig. 3. Counties where *Phyllachora cynodontis* was collected on *Bouteloua curtipendula* in Iowa from 1959–1996. Each number represents one or more collections from that county.

1959 exist in the herbarium or are reported in the literature. The absence of specimens during this period is more likely related to lack of collecting rather than absence of the fungus.

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LITERATURE CITED

AIKMAN, J. M. and R. F. THORNE. 1956. The Caylor Prairie: an ecologic and taxonomic study of a northwest Iowa prairie. Proceedings of the Iowa Academy of Science 63:177–200.

BROTHERSON, J. 1969. Species composition, distribution, and phytosociology of Kalsow prairie, a mesic tall-grass prairie in Iowa. Ph.D. Dissertation, Iowa State University.

CANNON, P. F. 1991. A revision of *Phyllachora* and some similar genera on the host family Leguminosae. Mycological Paper No. 163. CAB International, Wallingford, Oxon.

CEBALLOS, H. and J. A. DEUTSCH. 1992. Inheritance of resistance to tar spot complex in maize. Phytopathology 82(5):505–512.

CLARK, L. G. and R. W. POHL. 1996. Agnes Chase's first book of grasses. Smithsonian Institution Press, Washington.

DOIDGE, E. M. 1942. Revised desriptions of South African species of *Phyllachora* and related genera. Bothalia 4:421–463.

EILERS, L. J. and D. M. ROOSA. 1994. The vascular plants of Iowa: an annotated checklist and natural history. Univ. of Iowa Press, Iowa City.

FARR, D. F., G. F. BILLS, G. P. CHAMURIS and A. Y. ROSSMAN. 1989. Fungi on plants and plant products in the United States. Publ. no 5, Contributions from the U. S. National Fungus Collections. American Phytopathological Society, St. Paul, Minnesota.

GABEL, A. 1989. Host-parasite relations of *Phyllachora* species on native grasses. Mycologia 81(5):702–708.

GILMAN, J. C. and W. A. ARCHER. 1929. The fungi of Iowa parasitic on plants. Iowa State Journal of Science, No. 4:299–502.

GLENN-LEWIN, D. 1976. Stinson prairie vegetation. Proceedings of the Iowa Academy of Science 83:89–93.

GOULD, F. W. and R. B. SHAW. 1983. Grass systematics. Texas A & M, University Press, College Station.

HANLIN, R. T. and O. TORTOLERO. 1991. Icones ascomycetum Venezuelae: *Phyllachora fusicarpa*. Mycotaxon 41:19–26.

HATTERSLEY, P. W. and S. PERRY. 1984. Occurrence of the suberized lamella in leaves of grasses of different photosynthetic type. II in herbarium material. Australian Journal of Botany 32:465–473.

HITCHCOCK, A. S. 1950. Manual of the grasses of the United States. 2nd Ed. (Revised by Agnes Chase). U. S. Department of Agriculture, Miscellaneous Publication 200.

HOCK, J., J. KRANZ and B. L. RENFRO. 1992. Tests of standard diagrams for field use in assessing the tarspot disease complex of maize (*Zea mays*). Tropical Pest Management 38:314–318.

LUTTRELL, E. S. 1981. Tissue replacement diseases caused by fungi. Annual Review of Phytopathology 19:373–389.

MILLER, J. 1951. Studies in the Phyllachoraceae. I. *Phyllachora ambrosiae* (Berk. & Curt.) Sacc. American Journal of Botany 38: 830–834.

MILLER, J. 1954. Studies in the Phyllachoraceae. II. *Phyllachora lespedezae*. American Journal of Botany 41: 825–828.

ORTON, C. R. 1924. Studies in the morphology of the ascomycetes I. The stroma and the compound fructification of the Dothideaceae and other groups. Mycologia 16:49–97.

ORTON, C. R. 1944. Graminicolous species of *Phyllachora* in North America. Mycologia 36(1):18–53.

ORTON, C. R. 1956. The morphology and life history of *Phyllachora punctum*. Phytopathology 46:441–444.

PAMMEL, L. H. and G. W. CARVER. 1895. Fungus diseases of plants at Ames, Iowa, 1895. Proceedings of the Iowa Academy of Science 3:140–148.

PARBERRY, D. G. 1963. Studies on graminicolous species of *Phyllachora* Fckl. II. Invasion of the host and development of the fungus. Australian Journal of Botany 11:131–140.

PARBERRY, D. G. 1967. Studies on graminicolous species of *Phyllachora* NKe. in Fckl. V. A taxonomic monograph. Australian Journal of Botany 15:271–375.

PEARCE, C. A. and K. D. HYDE. 1994. The genus *Phyllachora* from Australia: two new taxa, *P. velatispora* var. *velatispora* and *P. velatispora* var. *hillianae,* on *Grevillea* and notes of *P. grevilleae.* Mycological Research 98(12):1402–1408.

PEARCE, C. A., K. D. HYDE and R. G. SHIVAS. 1995. *Phyllachora* from Australia. *Phyllachora sageretiae* sp. nov. from *Sageretia hamosa.* Mycological Research 99(5):554–556.

POHL, R. W. 1978. How to know the grasses. Wm. C. Brown, Dubuque.

REY, M. E. C., and H. M. GARNETT. 1984. A physiological study of *Panicum maximum* infected with *Phyllachora paspalicola.* Canadian Journal of Botany 62: 2283–2289.

SMITH, B. N. and W. V. BROWN. 1973. The Kranz syndrome in the gramineae as indicated by carbon isotopic ratios. American Journal of Botany 60(6):505–513.

SPRAGUE, R. 1950. Diseases of cereals and grasses in North America. Ronald Press Co., New York.

SWART, H. J. 1985. Australian leaf-inhabiting fungi. XX. Some observations on *Phyllachora ficuum.* Transactions of British Mycological Society 85(3):552–555.

TIFFANY, L. H. and G. KNAPHUS. 1995. Fungus pathogens of prairie plants in Iowa. Proceedings of 14th North American Prairie Conference, pp 49–54.

TIFFANY, L. H., J. F. SHEARER, and G. KNAPHUS. 1990. Plant parasitic fungi of four tall grass prairies of northern Iowa: distribution and prevalence. Journal of Iowa Academy of Science 97(4):157–166.

TIFFANY, L. H., J. F. SHEARER, A. W. GABEL, and G. KNAPHUS. 1985. Fungi of the Iowa Loess Hills. Proceedings of Iowa Academy of Science 92(5):180–185.

Appendix—Site locations for numbered sites listed in Table 2

1 = Allamakee County
2 = Ames, in or in vicinity of Brookside Park, T84N, R24W, Story County.
3 = Ames, River Valley Park, T84N, R24W, Story County.
4 = Ames, south of, T83N, R24W, Story County.
5 = Ames, in vicinity, T83–84N, R24W, Story County.
6 = Anderson Prairie, Sec. 33, T100N, R34W, Emmet County.
7 = Backbone State Park, T90N, R6W, Delaware County.
8 = Big Marsh, 1 mi. east of intersection of Hwy 14 and C51, Sec. 25, T91N, R17W, Butler County.
9 = Bixby State Park, Sec. 22, 23, 26, T91N, R5W, Clayton County.
10 = Boone 4-H Camp, T82N, R26W, Boone County.
11 = Boone Railroad Prairie, Boone County.
12 = Boxholm, T85N, R28W, Boone County.
13 = Caylor Prairie, Sec. 17, T99N, R37W, Dickinson County.
14 = Cedar Hills Sand Prairie, Sec. 19, T90N, R14W, Black Hawk County.
15 = Chichaqua Trail, between Mingo and Ira, T80N, R20–21W, Jasper County.
16 = Chichaqua Trail, between Ira and Baxter, T81N, R20W, Jasper County.
17 = Clay Prairie, Sec. 18, T91N, R16W, Butler County.
18 = Clear Lake, T96N, R22W, Cerro Gordo County.
19 = Cresent Hill Ski area, Sec. 12, T76N, R44W, Pottawattamie County.
20 = Crossman Prairie, Sec. 11, T99N, R14W, Howard County.
21 = Des Moines, along old railroad track north of Lower Beaver Rd, T79N, R24W, Polk County.
22 = Dolliver State Park, T88N, R27–28W, Webster County.
23 = Doolittle Prairie, Sec. 25, T85N, R24W, Story County.
24 = Earlville, east of town along Highway 20, T89N, R3W, Delaware County.
25 = Five Ridge Prairie, T91N, R48W, Plymouth County.
26 = Forest Lake Camp, south of Ottumwa along Des Moines River, Wapello County.
27 = Fort Defiance State Park, T99N, R34W, Emmet County.
28 = Freda Hafner Kettlehole, Sec. 33, T99N, R37W, Dickinson County.
29 = Gitchie Manitou State Park, Sec. 11, T100N, R49W, Lyon County.
30 = Harrison County.
31 = Hayden Prairie, Sec. 33, T100N, R13W, Howard County.
32 = Heart of Iowa Trail, east of Slater, T82N, R24W, Story County.
33 = Heart of Iowa Trail, in Huxley, T82N, R24W, Story County.
34 = Holtz State Forest, southwest of Frazier, T84N, R27W, Boone County.
35 = Jackson County.
36 = Johnson County.
37 = Kalsow Prairie, Sec. 36, T90N, R32W, Pocahontas County.
38 = Kish-Ke-Kosh, Sec. 14, T78N, R19W, Jasper County.
39 = Lakeside Laboratory Prairie, Sec. 23, T99N, R37W, Dickinson County.
40 = Ledges State Park, T83N, R26W, Boone County.
41 = Lee County.
42 = Liska-Stanek Prairie, Sec. 21, T88N, R29W, Webster County.
43 = Little Sioux Scout Ranch, 4 miles northeast of Pisgah, Sioux Twnp., Sec. 28, T82N, R43W, Monona County.
44 = Marietta Sand Prairie, Sec. 11, T84N, R19W, Marshall County.
45 = Milford Woods, west of Milford along east side of Little Sioux River, T98N, R37W, Dickinson County.
46 = Minburn, north side of road, 1 ½ miles west of road running north and south, Sec. 24, T80N, R29W, Dallas County.
47 = Monona County.
48 = Montgomery County.
49 = Osage, in vicinity, T98N, R17W, Mitchell County.
50 = Peru, near gravel quarry, Sec. 27, T75N, R27W, Madison County.
51 = Pilot Knob State Park, T97–98N, R23W, Hancock County.
52 = Possum Creek, Sec. 18, T69N, R42W, Fremont County.
53 = Prairie Rail Trail, 1 mile west of McCallsburg along E18, Sec. 21, T85N, R22W, Story County.
54 = Prairie Rail Trail, 2 ½ miles west of McCallsburg along E18, Sec. 18, T85N, R22W, Story County.
55 = Sheeder Prairie, T80N, R32W, Guthrie County.
56 = Shimek State Forest, T67–68N, R7W, Lee County.
57 = Silver Lake Fen, Sec. 32, T100N, R38W, Dickinson County.
58 = Springbrook State Park, T80–81N, R31W, Guthrie County.
59 = Steele Prairie, T93N, R40W, Sec. 15, 16, Cherokee County.
60 = Stinson Prairie, Sec. 13, T95N, R30W, Kossuth County.
61 = Thurman, near Knox Churchyard, SE ¼, Sec. 32, T68N, R42W, Fremont County.
62 = Turin Wildlife Area, north of Turin, T83N, R44W, Monona County.
63 = Waubonsie State Park, Sec. 31, T68N, R42W, Fremont County.
64 = White Pine Hollow, Sec. 5–8, T90N, R2W, Dubuque County.
65 = Williams Prairie, Sec. 5, T80N, R8W, Johnson County.
66 = Woodman Hollow, Sec. 22, T88N, R28W, Webster County.
67 = Yellow River State Forest, T96–97N, R3–4W, Allamakee County.