Distribution Patterns of Some Criconematinae in Different Forest Associations[1]

JOHN K. HOFFMANN and D. C. NORTON[2]

Abstract: A total of 243 samples from Hemlock-Hardwood, Boreal Forest, and Alpine Tundra associations of New York, Vermont, New Hampshire, and Maine were analyzed for species of *Bakernema, Criconema,* and *Criconemoides* and for selected edaphic factors. The Hemlock-Hardwood formation contained 13 species of these genera, but the Boreal Forest and Alpine Tundra contained only *Criconema menzeli* and *Criconemoides sphagni. Criconemoides axeste, C. rusticum,* and *C. xenoplax* were associated primarily with mineral soils that have high *p*H, low moisture after drainage, and organic matter content of less than 15%. *Criconemoides sphagni* was associated with organic soils that had low *p*H, high moisture after drainage, and organic matter content greater than 15%. *Key Words:* Boreal Forest, Hemlock-Hardwood, Tundra, *p*H, organic matter, *Bakernema, Criconema, Criconemoides.*

Species of the Criconematinae have received much study, but knowledge of their ecology and distribution still remains limited. Lack of suitable extraction techniques has limited many previous studies, but centrifugal-flotation has provided an effective means for extraction of these nematodes (4). Preliminary sampling in Vermont has indicated that members of the Criconematinae are common in Hemlock-Hardwood and Boreal Forest communities, but other plant-parasitic nematodes are scarce. More extensive samplings have been made (in Vermont in 1971), and samples have also been taken from similar habitats in New York, New Hampshire, and Maine. Little has been known about plant-parasitic nematodes in these habitats, and the general occurrence patterns of *Bakernema, Criconema,* and *Criconemoides,* relative to some factors in these soils, are herein documented. The comparative absence of other plant-parasitic nematodes from these habitats has been reported earlier (5).

MATERIALS AND METHODS

A total of 243 soil samples was collected from the Hemlock-Hardwood, Boreal Forest, and Alpine Tundra formations of New York, Vermont, New Hampshire, and Maine. Sampling areas and methods of handling the samples were outlined previously (5), as were infraspecific variations and some of the specific locations of occurrence (3). One-dm^3 samples were collected from the top 15-20 cm depth. Samples were taken close to the trunk so that soil and the fibrous roots emanating from primary roots were sampled. The possible presence of roots of adjacent different tree species could not be eliminated, but it is believed to be unlikely or minimal. The single samples from given sites were subdivided in the laboratory with a 100-cm^3 subsample being processed for nematodes (4), and the remaining portion for soil analyses. Analyses for *p*H (using a 4:1 water:soil ratio) (6), percentage organic matter (2), texture (1), and water content after drainage for 2 days (7) were made on all samples.

RESULTS

Occurrence: We recorded at least one *Criconema* species in 53% of the samples. *Criconema menzeli* (Stefanski) Taylor was the most common species, being present in 27% of the samples. *Criconemoides* species were found in 58% of the samples, and *C. sphagni* (Micoletsky) Taylor was the most common, occurring in 47% of the samples. This species generally was associated in higher frequencies with given species of trees than was any other species (Table 1). At least one species of *Bakernema, Criconema,* or *Criconemoides* occurred in 70.5% of all samples. *Criconema seymouri* Wu, *Criconemoides incrassatus* Raski & Golden, and *C. longula* (Gunhold) Oostenbrink were found only once. No consistent plant associations were found with some species. *Bakernema inaequale* Taylor (Mehta &

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[2] Department of Botany and Plant Pathology, Iowa State University, Ames. This study was supported in part by funds from the DuPont Corporation.

Raski), *Criconema menzeli, C. octangulare* (Cobb) Taylor, and *Criconemoides sphagni* were associated with a wide range of plant species, but other species were more limited in their associations (Table 1). Thirteen species were found in the Hemlock-Hardwood formation, but only *C. menzeli* and *C. sphagni* were found in the Alpine-Tundra and Boreal Forest formations combined (Table 2).

Nematodes and edaphic factors: Analyses of the soils for certain chemical and physical features may provide clues to those factors that partly determine the nematode association patterns (Table 3). Only especially evident nematode-soil associations are mentioned. Seventy-five percent of all soil samples contained more than 15% organic matter and were classified as duff mull. *Bakernema inaequale, Criconema fimbriatum* Cobb in Taylor, *C. proclivis* Hoffmann, *C. menzeli,* and *Criconemoides sphagni* were found in soil samples of which 85% or more were classified as duff mull. Of the soils containing *C. octangulare,* 74% were classified as duff mull. In contrast, *Criconemoides axeste* Fassuliotus & Williams, *C. rusticum* (Micoletsky) Taylor, and *C. xenoplax* Raski were found in soil samples of which 13% or less were duff mull. Soils with these nematodes usually contained a greater mineral fraction or were classified as mineral soils.

Bakernema inaequale, C. menzeli, and *C. sphagni* generally were found in soils with an organic matter content greater than 15%, a *p*H of less than 4.0, and soil moisture minus gravity water greater than 93%. *Criconemoides rusticum* and *C. xenoplax* usually were found in soils with a *p*H greater than 5.0 (Table 3). Other species of *Criconemoides* occurred in soils with *p*H values that deviated from the sample mean (*p*H 4.0), but they were not of the magnitude of *C. rusticum* and *C. xenoplax.*

DISCUSSION

One of the most striking results of this study was the fact that only *Criconema menzeli* and *Criconemoides sphagni* were found in the Boreal Forest and Tundra associations, whereas 13 species were found in the Hemlock-Hardwood formation. Samples were collected around fibrous roots emanating from main roots which were easily discernible and often located in groves with little or no understory of other

TABLE 1. Percentage of times that species of *Bakernema, Criconema,* and *Criconemoides* were associated with trees in the Hemlock-White-Pine, Boreal Forest, or Tundra formations of four northeastern states.

Plant species	Number sampled	Percentage of total samples	*Bakernema inaequale* (%)	*Criconema* (% per species) *fimbriatum*	*menzeli*	*proclivis*	*octangulare*	*seymouri*	*Criconemoides* (% per species) *axeste*	*incrassatus*	*longula*	*petasus*	*rusticum*	*sphagni*	*xenoplax*
Abies balsamea (L.) Mill.	32	13.2	28	0	31	3	6	0	0	0	0	0	3	59	0
Acer pensylvanicum L.	4	1.6	100	0	0	0	50	25	0	0	0	0	0	50	0
Acer rubrum L.	7	2.9	0	0	0	14	0	0	0	0	14	0	0	71	0
Acer saccharum Marsh.	30	12.3	17	20	20	13	57	0	0	3	0	13	0	47	7
Betula lutea Michx.	28	11.5	14	4	39	4	14	0	0	0	0	4	0	93	4
Betula papyrifera[a] Marsh.	29	12.0	3	3	24	0	3	0	0	0	0	0	0	62	3
Fagus grandifolia Ehrh.	22	9.1	18	27	23	18	27	0	0	0	0	9	0	36	5
Picea rubens Sarg.	28	11.5	14	0	61	0	4	0	0	0	0	0	0	29	0
Pinus strobus L.	10	4.1	0	10	10	0	0	0	10	0	0	0	20	20	10
Populus tremuloides Michx.	6	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis (L.) Carr.	22	9.1	14	5	23	0	5	0	0	0	0	5	5	45	9
Miscellaneous	25	10.2	0	0	16	0	4	0	8	0	0	0	8	12	0

[a]Includes *B. papyrifera* Marsh. var. *cordifolia* (Reg.) Fern.

TABLE 2. The occurrence of species of *Bakernema*, *Criconema*, and *Criconemoides* in three vegetational formations.

Nematode species	No. of samples containing species	Percentage of total samples in vegetational group	Mean number per sample[a]
	Boreal Forest-Alpine Tundra		
Criconema menzeli	21	37	14
Criconemoides sphagni	31	54	55
	Hemlock-Hardwood		
Bakernema inaequale	36	19	26
Criconema			
fimbriatum	16	8	18
menzeli	45	23	14
octangulare	35	17	27
proclivis	11	6	15
seymouri	1	1	18
Criconemoides			
axeste	3	2	29
incrassatus	1	1	14
longula	1	1	43
petasus	8	4	4
rusticum	8	4	113
sphagni	85	44	31
xenoplax	8	4	13

[a]Based upon samples containing each species.

plants. Although it is possible that roots of other plant species were included in a few samples, we think that careful sampling reduced this possibility to a minimum. A high degree of association between a nematode and a tree species probably reflects parasitism. Although host susceptibilities may be a factor in the nematode distribution pattern (in that more heterogenous plant communities occur in the Hemlock-Hardwood formation than in the Boreal Forest and Alpine Tundra), it is thought

TABLE 3. Average soil analyses of sites containing species of *Bakernema*, *Criconema*, and *Criconemoides* in Maine, New York, Vermont and New Hampshire, 1971[a].

Nematode species	Number of samples containing species	Duff mull (% of samples)	*p*H[b]	Moisture after two days drainage %
Bakernema				
inaequale	36	97	3.6(3.1-4.5)	92.8(18.0-317.0)
Criconema				
fimbriatum	16	100	3.5(3.0-4.1)	107.9(45.0-317.0)
menzeli	66	85	3.8(2.8-6.9)	120.9(12.3-338.3)
octangulare	35	74	4.1(3.0-6.2)	75.5(13.8-183.5)
proclivis	11	91	3.3(2.8-3.8)	82.8(24.0-223.1)
seymouri	1	100	4.2	33.9
Criconemoides				
axeste	3	0	4.4(4.3-4.8)	18.4(6.7-30.2)
incrassatus	1	0	4.7	39.8
longula	1	100	3.5	52.4
petasus	8	50	4.1(3.1-4.4)	41.2(13.8-66.7)
rusticum	8	13	5.6(3.2-6.8)	34.3(15.6-59.6)
sphagni	116	88	3.7(2.9-6.7)	108.7(12.3-338.3)
xenoplax	8	13	5.3(4.1-7.2)	33.2(15.6-52.4)

[a]Mineral analyses not included; see text.
[b]Ranges in parentheses.

that other factors are more important. *Abies balsamea, Betula lutea,* and *B. papyrifera* are abundant in both formations and were sampled frequently in Hemlock-Hardwood and Boreal forest communities; yet, differences existed in nematode distribution patterns between the two community types. Of the 13 species of the Criconematinae recovered in this study, all but *Criconema seymouri, Criconemoides axeste, C. incrassatus,* and *C. longula* were associated with the three tree species. These four species were recovered less frequently than any of the others; thus, the probability of recovery in either formation is small. That some of the more abundant nematodes were not found in the Boreal Forest, even though the hosts were there, indicates that other factors are operating.

The data provide no evidence that soil factors are responsible for the separation of species between the Hemlock-Hardwood and Boreal Forest-Tundra communities. Higher winds, colder temperatures, and shorter growing seasons, among other parameters of the higher elevations where the Tundra and Boreal Forest occur, may combine to form a too rigorous habitat for many species of nematodes.

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