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Occurrence and Diversity of Some Criconematidae and Paratylenchidae in the Adirondack Mountains of New York State

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Twenty nematode species in the Criconematidae and Paratylenchidae were found in 242 soil samples collected in the Adirondack Mountains of New York State during 1974-1979. The most species occurred in the hemlock-hardwood forests. Few species, mainly *Nothocrionema sphagni* and *Crossonema menzeli*, occurred in the spruce-fir zone. Nematode diversity (H') was inversely related to altitude when all samples were considered. When nematode diversity was analyzed with samples around conifers and nonconifers separately, there was no relationship of H' with altitude around confiers, but there was a negative relationship with nonconifers.

Within a distance of 40 km, the Adirondack Mountains rise in northeastern New York State from 30 m above sea level at Lake Champlain to 1,629 m at the summit of Mt. Marcy. The area inside the "blue line," established by the New York State legislature in 1892 for preservation, comprises about 13,000 km² and is a mosaic of private and public lands. Vegetationally, hemlock-hardwoods forests (mixed woods) occupy the lower elevations up to about 760 m, where the boreal forest (spruce-fir zone) begins and continues to the alpine tundra near 1,520 m. The altitude of the transition zones varies with the local environment. Most vegetation is second growth except at high altitudes where the timber is small or in hard-to-reach areas (3, 6). The hemlock-hardwoods include all species listed in Table 2, with *Betula papyrifera* var. *cordifolia* replacing *B. papyrifera* above about 700 m. Balsam fir *(Abies balsamea)* is the dominant tree in the spruce-fir zone, but red spruce *(Picea rubra)* and *B. papyrifera* var. *cordifolia* are common.

Preliminary collections of plant-parasitic nematodes have been made in the Adirondacks and other areas of the northeastern states (4, 8). Members of the Criconematidae and Paratylenchidae were the most common plant-parasitic nematodes encountered in these areas. This report is based on more extensive collections in the Adirondack Mountains during 1974-1979.

MATERIALS AND METHODS

A total of 242 samples were collected in late June to mid-July during 1974-1979. Each sample contained about 500 cm³ of soil and roots, collected where possible to a 15-20 cm depth. Care was taken to sample around fibrous roots of the target plant, usually a tree. Most samples were taken within 1 m of the trunk for ease in following a root from the trunk. Whereas roots of other woody plants and herbs possibly were mixed with those of the target plant, we believe that sampling of mixed roots was kept to a minimum. Samples were placed in polyethylene bags for transport and stored at about 20 C until transported to Iowa. As a check on nematode survival during storage and transport, during two years, three samples were collected from an Iowa woodland. Half of each sample was processed, and nematodes were analyzed before departure. The other half was transported and stored under the same conditions as were the samples from the Adirondack Mountains. Few qualitative and quantitative differences in the plant-parasitic nematode fauna before and after transport were found in the Iowa samples, indicating that the conditions of storage and transport were not seriously detrimental to the fauna.

Reference points for sample collections were made from topographic maps of the U.S. Geological Survey or the Adirondack Mountain Club (8). Locations of collections are depicted in Fig. 1. No more than two samples were taken above the timberline on any mountain because of the fragile nature of the limited tundra. Soil analyses were made for pH by using a 1:1 soil:water ratio, percentage organic matter, percentage sand-silt-clay where possible, and cation exchange capacity. Nematodes were processed by the centrifugal-flotation method (5). Rootlets were processed by the shaker method (2), but because endoparasites

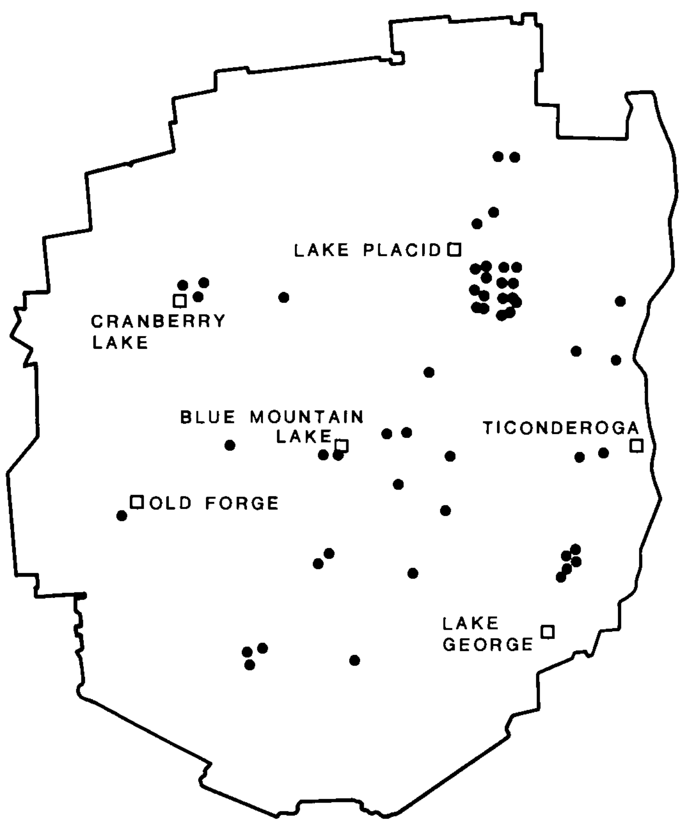

Fig. 1. *Location of soil samples collected in the Adirondack Mountains, New York, 1974-1979. The solid line represents the "blue line." Each dot represents approximately five samples.*

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Table 1. *Frequency, numbers, and highest altitude of nematodes recovered, Adirondack Mountains, New York, 1974-1979.*

Nematode	Frequency	Highest altitude[2] m	Numbers/100cm³ soil			
			Maximum	Mean	(n)	Standard[1] deviation
Nothocriconema sphagni	35.5	1,276	1,030	95	86	194
Crossonema menzeli	26.9	1,408	720	56	65	104
Criconema octangulare	17.4	988	258	49	42	53
Bakernema inaequale	10.3	725	680	110	25	180
Nothocriconema petasum	7.4	818	211	40	18	56
Crossonema fimbriatum	5.8	664	171	32	14	44
Hemicycliophora ferrisae	5.0	1,225	120	28	12	33
Hemicycliophora (unspecified)	5.0	1,268	360	39	12	97
Hemicycliophora #1	3.7	1,109	140	32	9	40
Criconema proclivis	2.9	661	180	46	7	57
Hemicycliophora uniformis	2.5	818	60	25	6	19
Macroposthonia (unspecified)	2.1	579	80	41	5	25
Macroposthonia xenoplax	1.7	626	60	22	4	23
Nothocriconema #1	1.7	1,433	46	24	4	15
Crossonema seymouri	1.2	1,084	7	5	3	4
Nothocriconema jaejuense	1.2	573	129	43	3	14
Gracilacus acicula	1.2	626	2,730	920	3	1,280
Gracilacus straelani	1.2	688	30	14	3	12
Criconema (unidentified)	0.8	688	20	10	2	0
Crossonema cobbi	0.8	390	20	16	2	4
Nothocriconema longula	0.8	1,273	220	115	2	156
Macroposthonia axesta	0.4	543	4	4	1	0
Xenocriconemella macrodora	0.4	404	90	90	1	0
Nothocriconema permistum	0.4	311	60	60	1	0
Macrophosthonia rustica	0.4	530	100	100	1	0
Nothocriconema (unidentified)	0.4	326	1	1	1	0
Hemicycliophora #2	0.4	561	10	10	1	0
Hemicycliophora #3	0.4	623	10	10	1	0
Gracilacus sp.	0.4	738	10	10	1	0

[1]In samples containing that species (n)

[2]Of identified species

were rarely found in the early years of sampling, only spot checks were made for endoparasites later. The Shannon-Weiner diversity index, $H' = -\Sigma P_i \log P_i$ to the base e, where P_i equals the proportion of species i in the sample, was calculated for all samples (9). The prominence value, PV = density $\sqrt{\ }$ frequency (1) was calculated for all identified nematode species. Representative nematodes are deposited in the collection of the Department of Plant Pathology, Seed and Weed Sciences, Iowa State University.

RESULTS

Soil analyses were similar to those reported earlier (4, 8) and only a summary will be made here. Soils were highly organic, consisting mostly of duff. The average pH was 4.1 (range 2.8-6.8). Few samples had sufficient mineral soil to analyze for texture.

Twenty species of the Criconematidae and Paratylenchidae were identified. Other specimens may constitute new species or were unidentifiable for various reasons. The frequencies, numbers, and highest altitude of occurrence are listed in Table 1. *Nothocriconema sphagni*, *Crossonema menzeli*, and *Criconema octangulare* were encountered most frequently. The largest number of any nematode per 100 cm³ of soil was 2,730 *Gracilacus acicula* around grass at South Meadow (626 m). The second largest population was 1,030 *N. sphagni* around *A. balsamea* on Upper Wolf Jaw (1,276 m). Only *C. menzeli* and *N. sphagni* were common in the spruce-fir zone, although six other species were collected in this zone or its transition.

Two closely related species were found in distinctly different maximum altitudes, and with different mean and maximum populations. The highest altitude at which *C. menzeli* was found was 1,408 m, and the maximum and mean numbers per 100 cm³ soil were 720 and 67, respectively (Table 1). The closely related *C. fimbriatum* generally occurred at lower altitudes and had smaller maximum and mean populations. *C. fimbriatum* was never found in the spruce-fir zone, but *C. menzeli* was common there.

The prominence values relative to plant associates are listed in Table 2. The largest PVs of a nematode and tree associates were with *N. sphagni*, and *Acer rubrum*, and *B. papyrifera*. Some nematode species associated with closely related tree species had very different PVs. For

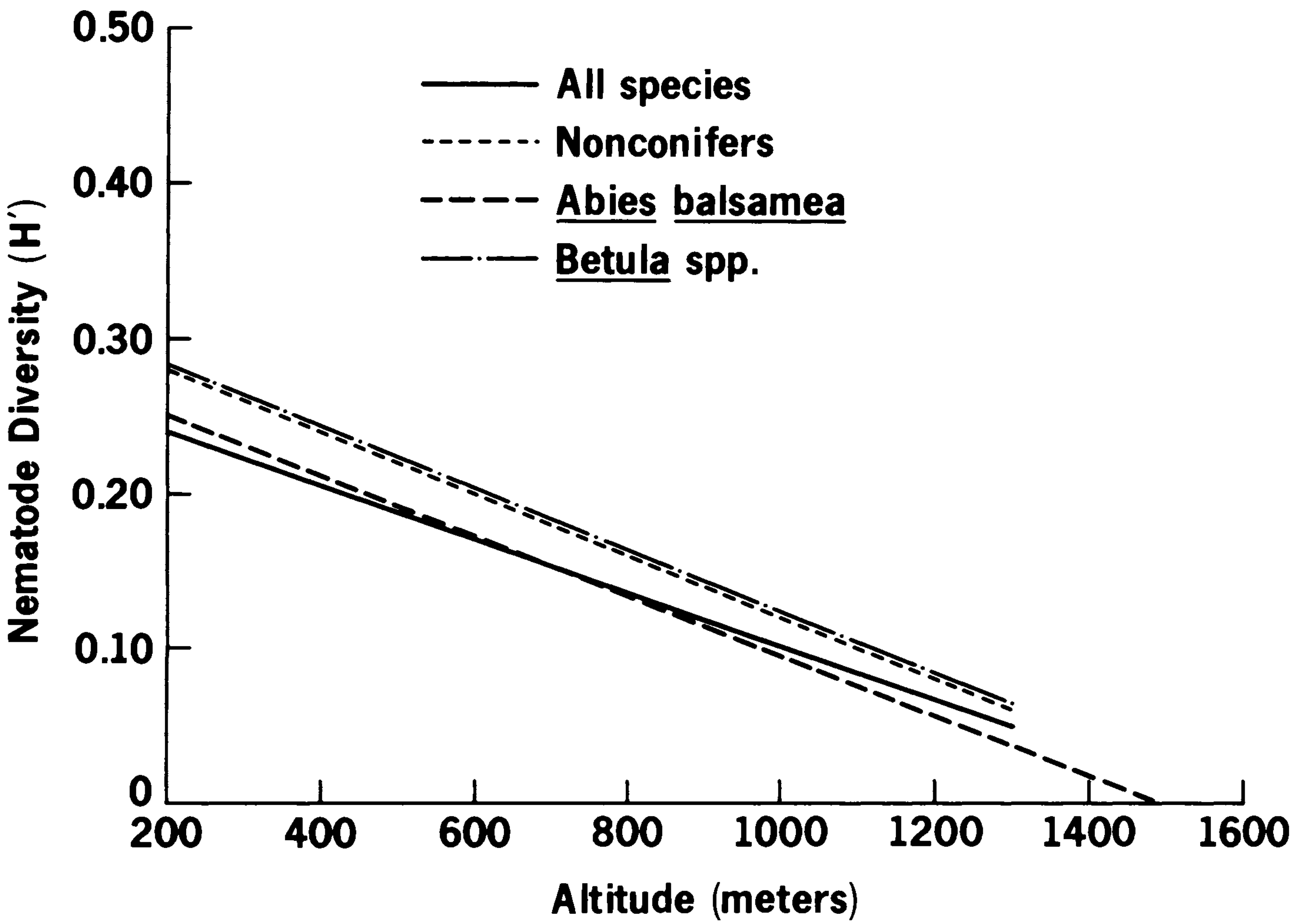

Fig. 2. *Nematode diversity associated with different plants plotted with altitude. See text for significance.*

example, the PV for *N. sphagni* was large around *Acer rubrum*, but small around *A. saccharum*. Similarly, closely related nematodes (e.g., *C. fimbriatum* and *C. menzeli*) had markedly different PVs around all seven common tree associates.

Diversity. — When nematode community diversity (H') was examined over all plant species, there was an inverse relationship of diversity with altitude (Fig. 2). Nematode diversity plotted with altitude was not significant when all conifers were analyzed collectively, but it was when only samples around *A. balsamea* (P = 0.05) or all *Betula* species (P = 0.05) were used in the calculations.

DISCUSSION

Why only a few species, especially *C. menzeli* and *N. sphagni*, were found in the spruce-fir zone is not clear. One could conjecture that part of the answer lies in the colder temperatures and shorter growing season for the host associates at higher altitudes. These environmental factors may restrict nematode, as well as vegetation, growth. In addition, a determination of the host ranges of the nematodes would help solve this problem. However, nematodes, such as *Bakernema inaequale*, are not found in the spruce-fir belt (Table 1) but are common associates at lower altitudes of the same tree species, e.g., *A. balsamea*. These associations indicate that factors other than host susceptibilities are operative.

That nematode diversity was not significant at different altitudes when populations around all conifers were analyzed collectively, but was significant around all plant species and nonconifers, agrees with the hypothesis that the presence of conifers decreases diversity. However, when nematode diversity was measured only with *Abies balsamea* and *Betula* spp. (Fig. 2), species that occur over most of the mountain profiles, the significant (P = 0.05) relationship of less diversity with altitude suggests that climate is a reason for lower nematode diversity at higher altitudes.

Similar diversity indices probably occur in other mountain areas in the northeastern states because of a) vegetational similarities among the White, Green, and Adirondack mountains and the upland areas of

Table 2. *Prominence value of nematodes associated with different plants. Adirondack Mountain, New York. 1974-1979.*

Plant (number sampled)	**Nothocriconema sphagni**	**Crossonema menzeli**	**Criconema octangulare**	**Bakernema inaequale**	**Nothocriconema petasum**	**Crossonema fimbriatum**	**Hemicycliophora ferrisae**	**Criconema proclivis**	**Hemicycliophora uniformis**	**Macroposthonia xenoplax**	**Crossonema seymouri**	**Nothocriconema jaejuense**	**Gracilacus acicula**	**Gracilacus straelani**	**Crossonema cobbi**	**Nothocriconema longula**	**Macroposthonia axesta**	**Xenocriconemella macrodora**	**Nothocriconema permistum**	**Macroposthonia rustica**
Abies balsamea (47)	756	317	190	620	42	7	14		14		11						6			
Fagus grandifolia (25)	243	144	179	256	14	35	20	80								440				
Acer saccharum (23)	66	101	636	366	341	20		110	80			123						180	120	200
Tsuga canadensis (22)	353	177	127	75		48	157	20	105		16									
Betula lutea (20)	460	657	167	389	174	395	22	402						2						
Betula papyrifera var. *cordifolia* (17)	951	65	20				24									24				
Betula papyrifera (15)	1176	139	24	1028		47	223		26			127		22						
Pinus strobus (12)	195		209	194	105		28													
Picea rubra (8)	735	230					144													
Thuja occidentalis (8)	65	36		36																
grass (8)	36						10	36	72	30			6104		72					
Acer pensylvanicum (5)	171	277	112			192														
Acer rubrum (4)	1619	75			5															
heath (4)	50	30		84																
Populus tremuloides (3)													172	172						
Quercus rubra (2)				127		14														
Larix laricina (2)		7																		
sphagnum (2)		636	200							424										
Populus grandidentata (2)																				
miscellaneous (13)	68		34							32					25					

adjacent Canada (3, 10), but with local modifications; b) similarity of the Criconematinae fauna of the Adirondack, Green, and White mountains (4, 8); c) climatic similarities among these areas (10); and d) steep topographical gradients common to many areas.

The impact of nematodes on vegetational growth in these mountains has yet to be assessed. Large numbers of nematodes, for example high on Upper Wolf Jaw Mountain, might be a stress on the host in addition to the climatic stresses.

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