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Morphometric Variation and Biogeography of *Ogma menzeli* and *Criconema sphagni*[1]

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Abstract: Morphometrics of *Ogma menzeli* from woodlands in the Adirondack Mountains of New York State and in Iowa were compared. Specimens from the Adirondacks were significantly greater in mean total body length, stylet length, the b, R, and RV values, body width, and esophagus length than specimens from Iowa. The V value was significantly greater in the Iowa than in the Adirondack specimens. The two populations are considered ecotypes of *O. menzeli*. *Criconema sphagni* morphometric measurements differed significantly for the RV value (negative) and V value (positive) relative to elevation in the Adirondacks. There was a positive regression correlation for the RV value of *O. menzeli* and elevation in the Adirondack Mountains.

Key words: biogeography, *Criconema sphagni*, ecology, morphometrics, nematode, *Ogma menzeli*.

The reported distributions of *Ogma menzeli* (Stefánski, 1924) Sch. Stekhoven & Teunissen, 1938 and *Criconema sphagni* Micoletzky, 1925 are between 47 and 52 degrees north latitude in the Nearctic and Palearctic biogeographical zones. The two species in North America are generally sympatric, occurring in the northeastern and east central part of the United States and adjacent Canada and extending westward into Iowa and Minnesota. They are usually associated with woody plants in undisturbed areas. Differences in morphometrics of criconematid species from different localities have been reported frequently and are to be expected (10,12,27). Composite morphometrics of 54 females of *O. menzeli* from Europe and North America (19) provide the overall ranges of measurements but do not consider regional and local differences that may benefit the biogeographer. Morphometric values for *O. menzeli* from Bulgaria (1), France (26), Germany (18,23), Switzerland (15), and Korea (4) differ, but are based on 2 to 12 specimens each negating meaningful comparisons. Thus, it is not known if these differences are random or if they possibly represent ecotypes or a species complex.

The purposes of this research were i) to compare morphometrics of *O. menzeli* associated with different tree species under natural forest conditions in the Adirondack Mountains of New York State with those in Iowa woodlands, and ii) to see if morphometrics of *O. menzeli* and *C. sphagni* in the Adirondack Mountains vary with elevation.

Materials and Methods

Morphometric data were obtained from randomly selected preserved adult females collected from the Adirondack Mountains in New York State (22) and Iowa (20). These areas are at or near the extreme longitudinal locations of the known distribution of the nematodes in North America and are about 1,600 km apart. The Adirondack Mountains are generally colder, especially at the higher elevations, than in Iowa, have a shorter growing season at elevations above 460 m, and have a greater relief, more soil organic matter, lower soil pH, and greater precipitation (Table 1) and less evaporation than Iowa habitats (5,21). Snow can occur in the higher elevations in the Adirondack Mountains in every month of the year, and winter temperatures above timberline are similar to those in the Arctic Circle (6). Soil temperatures vary considerably with the amount of snow cover at both sampling locations. The vegetation in the Adirondacks is basically hemlock–hardwood at the lower elevations merging to the boreal forest above 760 m. Woodlands in Iowa are generally a transition between the more mesic climate of the eastern states and the decreasing westward

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TABLE 1. Habitat comparisons between the Adirondack Mountains and Iowa woodlands.

	Adirondack Mountains	Iowa woodlands
Vegetation association	Hemlock-hardwood, boreal forest	Oak-hickory, maple-basswood
Soil	Highly organic, duff	Organic, mineral
Soil pH (range)	4.0 (2.8–6.9)	6.1 (4.4–7.8)
Average January air temperature (C)	−7 (Kenne Valley)	−7 (Ames)
Average July air temperature (C)	20 (Keene Valley)	24 (Ames)
Average annual precipitation (mm)	940 (Keene Valley)	774 (Ames)
Growing season (days)	85–100	159 (Ames)
Relief (meters)	290–1400	100–500

Sources: Climate and man (5), Norton and Hoffmann (21).

precipitation resulting in the prairies that originally covered much of Iowa.

Details of sampling are given elsewhere (20,22). Briefly, 200–500 cm^3 samples were taken at a 15–30 cm depth, care being taken to collect only from the fibrous root zone of the target tree. All samples were taken in late June to late September in the deciduous forest formation plus an extension in the boreal forest formation in the higher elevations of the Adirondacks (3,13). Iowa samples were usually processed within 2 days after sampling; samples from the Adirondacks were kept cool during transport and were processed soon after. Nematodes were extracted from the soil by centrifugal flotation (17). All specimens were fixed in 2–3% formalin at 40 C for 10 minutes and transferred to glycerin by Seinhorst's (24) method. Too few specimens of *C. sphagni* were found in Iowa to permit comparisons with those from the Adirondacks. Width measurements were taken of the body proper and do not include the cuticular fringes or retrorse emanations. Some values, such as the position of the excretory pore and anus, were visible only in a few specimens. Table 2 gives the total number of specimens measured and the number of locations from which the specimens were samples.

The species used were chosen because they were found from the valleys to timberline in the Adirondacks and could serve to evaluate possible effects of elevation on morphometrics. Significance tests for the difference between the Adirondack and Iowa regions used location means as data in unpaired Student's *t*-tests. The same location means were used as data in a one-way analysis of variance to test significance of differences among associated tree species within each region. The strength of the dependence of any given morphometric measurement on elevation for *O. menzeli* and *C. sphagni* in the Adirondacks was determined by simple linear regression of location means versus elevation.

Voucher specimens have been deposited in the USDA Nematode Collection, Beltsville, Maryland and the Department of Plant Pathology at Iowa State University.

RESULTS

Comparison of Adirondack and Iowa specimens: The morphometric means of *O. menzeli* female specimens from the Adirondack Mountains were significantly greater than those from Iowa in all instances except for the vulva value, which was significantly smaller, and the 'a', Rex, and Ran values, which were nonsignificant—the latter two being based on relatively few specimens (Table 3). The fringes on the first head annule were generally longer in the Adirondack than in the Iowa specimens, although gradations from long (5.5 μm) to short (3.1 μm) occurred within given samples in each area.

Sufficient males or juveniles were not recovered to make valid comparisons between the two areas. The morphometrics of eleven juveniles from Iowa include J2 (?), J3, and J4 as follows: L = 248 μm (178–289); a = 9.2 (7.1–11.4); b = 2.7 (2.2–3.4); longitudinal scales 64 (61–69), stylet = 68 μm (59–78); 10–12 longitudi-

TABLE 2. Number of specimens of *Ogma menzeli* and *Criconema sphagni* measured for morphometrics and the associated trees in the Adirondack Mountains in New York State and in Iowa.

Adirondack Mountains			Iowa		
Associated tree species	Number of specimens examined	Number of sampling locations	Associated tree species	No. of specimens examined	No. of sampling locations
		Ogma menzeli			
Abies balsamea	48	9	*Ostrya virginiana*	22	8
Betula papyrifera	23	3	*Quercus alba*	11	2
Acer saccharum	9	1	*Acer saccharum*	8	3
Fagus grandifolia	9	3	*Betula papyrifera*	8	1
B. papyrifera cordifolia	5	1	*Juniperus virginiana*	7	1
Thuja occidentalis	4	1	*Tilia americana*	7	3
Tsuga canadenis	4	2	*Quercus rubra*	6	3
Betula lutea	3	1	*Taxus canadensis*	6	2
Picea rubra	2	2	*Juglans nigra*	5	1
Acer pensylvanicum	1	1	*Carya ovata*	4	2
			Celtis occidentalis	3	1
			Ulmus americana	2	1
			Acer nigrum	1	1
			Carpinus carolineana	1	1
Total	108	24		91	30
	Criconema sphagni				
Betula papyrifera cordifolia	54	4			
Betula papyrifera	32	1			
Abies balsamea	25	7			
Picea rubra	21	3			
Betula lutea	16	3			
Fagus grandifolia	7	2			
Acer saccharum	3	2			
Total	158	22			

nal scale rows. In six molted J4, not included in previous measurements, longitudinal scales = 63–66; prorhabdion = 51–65 μm. Short spines on the fringes were more difficult to see on the Iowa than on the Adirondack material.

Three males were available from Iowa, and they conform closely to those described by Hopper (16), although they were slightly smaller: L = 317–343 μm; a = 12.8–15.1; c = 8.4–10.2; spicules = 41–42 μm; gubernaculum a rod-like plate.

TABLE 3. Morphometrics of *Ogma menzeli* in the Adirondack Mountains in New York State and in Iowa.

	Adirondack Mountains				Iowa			Significance of means between regions	
Property	*N*	Mean	SD	(Range)	*N*	Mean	SD	(Range)	*P*
L (μm)	108	416	50.2	(305–544)	91	365	42.9	(269–445)	0.0001
Stylet (μm)	108	98	4.5	(82–108)	91	93.9	3.4	(82–101)	0.0001
a	92	10.8	1.2	(8.6–15.0)	82	10.4	1.4	(6.7–13.3)	0.20
b	100	3.3	0.3	(2.6–4.3)	49	3.1	0.3	(2.3–3.5)	0.01
R	108	66	4.3	(57–75)	91	60	1.8	(55–66)	0.0001
Rex	13	22	1.4	(20–24)	16	22	1.0	(20–24)	0.95
RV	108	12	1.6	(8–15)	91	10	0.5	(9–11)	0.0001
Ran	20	7	1.5	(4–8)	15	5	0.8	(4–6)	0.44
V	108	83	1.8	(79–87)	91	85	1.5	(81–90)	0.0001
Body width (μm)	92	39	5.7	(30–51)	82	35	4.2	(29–51)	0.02
Esophagus (μm)	100	127	10.1	(86–152)	49	119	4.8	(108–130)	0.01

Three incisures occur in the lateral field and the tail is constricted at the anus. No males were preserved from the Adirondack Mountains, but the spermathecas were full of sperm.

Morphometrics and associated tree species: Based on the statistical analyses of the females in both the Adirondack and Iowa regions, no evidence was found to suggest that the morphometric values were affected by their associated tree species or the habitat in which they lived.

Differences of morphometric values and elevation: Results of morphometric measurements of *C. sphagni* and *O. menzeli* relative to elevation are presented in Table 4. The value of the slope was significantly different from zero for the RV value (negative) and the V value (positive) for *C. sphagni* and for the RV value (positive) for *O. menzeli.* Slopes for all other measurements were not significant. There was no evidence to suggest that the biomass of the species measured is affected by elevation.

Discussion

The means of the Iowa and Adirondack specimens fit well with measurements of 54 specimens by Mehta and Raski (19). There were only slight extensions of some measurements in our material. Although Ebsary (7,8) separates, in part, *O. menzeli* from *O. capitospinosum* (Ebsary, 1979) Raski & Luc, 1987 on the length of the head annule fringes, short in the former and long in the latter, we do not accept this distinction because *O. menzeli* is variable in this character as found in our material, as well as those of Hoffmann (14) and Mehta and Raski (19).

In our work, highly significant larger female body lengths, longer stylets, greater number of body annules, and greater R, RV, and V values occurred in specimens from the Adirondacks than in the Iowa specimens of *O. menzeli.* De Grisse and Loof (12) noted that stylets of *Mesocriconema sphaerocephalum* were generally longer in specimens in temperate than in tropical countries. Although other workers have found that nematode morphometrics will vary on different hosts under controlled conditions (2,9,11,25), varying physical and chemical edaphic conditions under natural conditions might alter biological responses that become evident morphologically.

Although we cannot determine reasons for the differences in morphometrics of *O. menzeli* in Iowa and the Adirondack Mountains, environmental differences between the two areas might provide clues for further study and controlled tests. There are many instances in the literature, including the criconematids, where difference in

Table 4. Regression analyses of *Ogma menzeli* and *Criconema sphagni* relative to elevation in the Adirondack Mountains.

	O. menzeli			*C. sphagni*		
Property	Intercept	Slope	Significance level for slope†	Intercept	Slope	Significance level for slope†
Length (μm)	423	−0.037	0.89	359	0.305	0.21
Body width (μm)	37	0.021	0.54	31	0.012	0.21
Esophagus length (μm)	124	0.046	0.38	139	0.032	0.59
a	11.2	−0.004	0.56	11.5	0.005	0.38
b	3.5	−0.002	0.17	2.6	0.002	0.29
Stylet length (μm)	96.4	0.015	0.46	118	−0.004	0.90
R	61	0.051	0.07	91	−0.020	0.27
RV	10	0.023	0.02	15	−0.012	0.005
V	84	−0.011	0.27	83	0.007	0.001
Biomass (μg)	0.38	<0.001	0.61	0.22	<0.001	0.16

† Slope is expressed in character units per 100 m elevation.

measurements no greater than we found for *O. menzeli* were considered different species. Although many morphometric means differed significantly between Iowa and Adirondack specimens, we consider the two populations ecotypes of *O. menzeli* because of the frequent overlap of measurements between areas and the sometimes marked gradations within samples.

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