Nematode Community Structure of Forest Woodlots. I. Relationships Based on Similarity Coefficients of Nematode Species[1]

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Abstract: Associations among nematode communities were studied in 18 Indiana mixed-hardwood stands of varying composition, soils, physiography, and past management practices. All sites were sampled in April, July, and October of 1968 and 1969. A total of 175 species representing eight orders were found, with 18 species occurring in all 18 sites, and approximately half the total species occurring in more than 50% of the sites. Taxonomic similarity, based on nematode species composition, was determined for the woodlots by means of a resemblance equation. Woodlots containing similar nematode species also showed similarities in dominant tree species and in soil types. Sites that had undergone major disturbances were the most dissimilar.

Key words: Indiana hardwood stands, resemblance equation.

Little is known about the ecology of nematodes of uncultivated areas (10, 11, 16). Researchers (2, 10, 17, 18) have encountered problems in attempting to demonstrate habitat relationships by means of the numerous species and numbers of individuals recovered. Such studies have usually resulted in a mere listing of species, with little attention paid to rarely found species or species that occur in low numbers.

An interest in objective approaches to the classification of plant or animal communities has resulted in the development of mathematical techniques of analysis. One method is the "Resemblance Equation" of Preston (12) which, based on the similarities of the biotas, gives an indication of the relationships between areas. Ferris *et al.* (5), using such similarity indices, found nematode community structure in soybean fields in Illinois and Indiana to be similar on dark-colored, highly productive soils. On lighter soils, the community structure differed from those of darker soils and from each other.

The research reported here was undertaken to study the ecological relationships of nematode populations of selected forest communities, utilizing Preston's techniques of analysis (12, 13). The mixed hardwood stands of this study were sites characterized by MacLean (7) in a study of insect populations. He found little correlation between stands and insect populations, but he demonstrated relationships among sites based on dominant tree species.

MATERIALS AND METHODS

Description of the general area. Tippecanoe County is located in the west central part of Indiana. It is within the Tipton Till Plain, where glacial drift covers the bedrock to depths ranging from 1 to 90 m. The terrain is level to gently rolling, and is divided by the Wabash Valley which extends from the northeastern border to the middle of the western border of the county. The floodplain of the Wabash River extends only 400-800 m from either side, bounded by two levels of terraces separated from the bottom lands by short steep slopes.

About two-thirds of the original vegetation consisted of hardwood forests (15). The dominant species on the well-drained terraces and uplands were white oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), shellbark hickory [*Carya ovata* (Mill.) K. Koch], and pignut hickory [*C. glabra* (Mill.) K. Koch]. Scattered through these forests were sugar maple (*Acer saccharum* Marsh.), beech (*Fagus grandifolia* Ehrh.), walnut (*Juglans nigra* L.), ash (*Fraxinus nigra* Marsh. and *F. americana* L.), elm (*Ulmus rubra* Muhl.), and yellow poplar (*Liriodendron tulipifera* L.). Well-drained but more moist areas contained the same species, but they had a higher proportion of beech and maple (15).

Little of the original vegetation remains, and about 90% of the county is farm land. The remaining wooded areas are usually less than 4 hectares in size, and have been largely cut over or grazed (15).

Description of the sites. MacLean (7)

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TABLE 1. Characteristics of 18 Tippecanoe County, Indiana, forest woodlot sites. All of the sites except C and G are as described by MacLean (7).

Site	Hectares	Management	Dominant Tree Species	Soil Type	Soil Drainage Rank[a]
A (Stewart Hillside)	16.30	Natural	Sugar maple	Russell silt loam	2
B (Stewart Beech)	16.30	Natural	Beech-sugar maple	Miami silt loam	2
C (Stewart Stream)	16.30	Natural	Beech-sugar maple	Miami silt loam	2
D (Leitner South)	2.88	Cut-grazed	Mixed	Brookston silty clay loam	5
E (Leitner North)	2.88	Cut	Sugar maple	Fincastle silt loam	3
F (McCormick West)	11.39	Cut	Mixed	Brookston silty clay loam	5
G (McCormick Ditch)	11.39	Cut	Mixed	Brookston silty clay loam	5
H (McCormick East)	11.39	Cut	Sugar maple	Miami silt loam	2
I (Livestock)	4.27	Grazed[b]	Mixed	Brookston silt loam	5
J (Workman)	1.40	Grazed	Sugar maple	Brookston silt loam	5
K (Cason)	2.57	Grazed	Beech-sugar maple	Cope silt loam	4
L (Higley)	3.04	Cut	Sugar maple	Fincastle silt loam	3
M (Bramer 26)	3.20	Natural	Sugar maple-oak	Fincastle silt loam	3
N (Starrett)	1.57	Cut	Mixed	Cope silt loam	4
O (Bramer 550)	4.18	Cut-grazed	Mixed	Fincastle silt loam	3
P (Black Locust)	3.21	Cut	Black locust	Russell silt loam	2
Q (Open Oaks)	3.42	Grazed[b]	White oak	Fox loam	1
R (Wabash River)	1.67	Flooded[b]	Silver maple-cottonwood	Genessee silty clay loam	2

[a] Based on Indiana Soil Profile Ranking. Ranges from excessively drained (1) to very poorly drained (5).
[b] Recent (within 1-4 years of this study).

characterized certain features at each of his 16 sites. These are listed in Table 1. Two additional sampling sites included in this study were sites C, located on a natural stream that flowed intermittently along the southern edge of site B; and site G, located on a drainage ditch running east and west across site F. All sites were on the Tipton Till Plain except for site Q, which was on the upper terrace of the Wabash River, and site R, which was located on the Wabash floodplain. Ten of 18 sites occurred on well-drained to imperfectly drained upland soils; six, on poorly drained upland soils; and one each, on well-drained terrace soils and well-drained bottom land soil (Table 1).

MacLean (7) recorded 37 tree species in these woodlots. The six most abundant trees in descending order were sugar maple, white ash, black locust (*Robinia pseudo-acacia* L.), silver maple (*A. saccharinum* L.), red elm, and white oak. The black locust trees were confined to one even-aged stand, site P. Bottom-land species such as silver maple, black ash, pin oak (*Q. palustris* Muench.), cottonwood (*Populus grandidentata* Michx.), swamp white oak (*Q. bicolor* Wild.), and sycamore (*Platanus occidentalis* L.) were confined to flood plains or poorly drained upland sites. Many of the upland sites were similar in appearance due to the gentle relief of the Tipton Till Plain and the dominance of the sugar maple at undisturbed and slightly disturbed stands (Table 1).

Samples to establish species-volume relationships. A center tree was marked in each site, and a circular area 18 m diam plotted around it. Samples were taken within the circular plot. Eight samples consisting of 1, 4, 8, 12, 16, 22, 28, and 32 cores of soil, respectively, were taken in duplicate from the circular plots at each of two sites, site A (Stewart Woods) and site P (Black Locust). Cores 2 cm diam and 10 cm long were taken at intervals of 2 m. Samples were washed separately by the sieve and decant method, and nematodes and debris were collected from the 25, 100, and 270-mesh sieves. Material from the 100 and 270-mesh sieves then was placed on Baermann funnels, and the nematodes collected after 24 and 48 hr and combined with those from the 25-mesh sieve. Nematodes were killed and fixed in 5% Formalin. The number of species in each sample was recorded.

Samples to determine site relationships. The 18 sites were sampled in April, July, and October during 1968 and 1969. Site Q, which was located over a large gravel bed, was excavated for commercial use in the spring of 1969, and thus was sampled only during 1968. A sample consisted of approximately 50 cores of soil. Samples taken at sites C and G consisted of cores taken in the stream or ditch bed, at the junction of the bed and the bank, and at the top of the bank.

The soil from each sample was mixed thoroughly, and 1 liter (32 cores) removed and processed. Nematodes were extracted by sieving and Baermann funnels, relaxed by gentle heat, and fixed in 5% Formalin. Nematodes from one-fourth of this material were processed to glycerine by Thorne's method (14) and identified where possible. A camera lucida sketch was prepared for each species (including those which could not be identified from the literature), measurements and other data were recorded, and a species code number was assigned that was used throughout the study. All slides, sketches, and measurements were deposited in the Purdue Nematode Collection, Department of Entomology, Purdue University, Lafayette, Ind.

Construction of the dendrogram. Indices of similarity between sites were determined by Preston's (12) formulae:

$$x = F_1 / (F_1 + F_2 - F_{1+2})$$
$$y = F_2 / (F_1 + F_2 - F_{1+2})$$

where F_1 = number of species in site 1, F_2 = number of species in site 2, and F_{1+2} = number of species sites 1 and 2 have in common.

The x and y values were used to enter Preston's (13) dissimilarity table to obtain the dissimilarity value, z, between two sites. Next a matrix of similarity indices (similarity = 1 - z) was constructed in which the similarity of each site to all other sites was recorded. The two sites with the highest similarity index were united at that level. All similarity values were recalculated, comparing the two united sites to all other sites, and a new matrix was constructed (5, 8). This process was continued until all sites were united at some level of similarity. A dendrogram was constructed as described by Mountford (8) which scaled the clusters of sites by connecting lines at the levels of similarity, beginning with the first pair.

RESULTS AND DISCUSSION

Species-volume relationship. The curve in Fig. 1 is for site P, and is similar to results for site A (data not shown). Ninety-six per cent of the total species present were found in the sample consisting of 16 cores. A twofold increase in sample size to 32 cores resulted in an increase of only 4% of the total species present. According to Cain (3), sampling is adequate when a 10% increase in sample size results in an increase in number of species equaling 10% of the total number of species found. An eight-core sample would thus be adequate according to Cain, since a 50% increase in sample size results in an increase of about 7% of the total species present. Braun-Blanquet (cited in Hopkins) (6) considers the sample adequate when the curve becomes horizontal. A sample of 22 cores would satisfy this requirement.

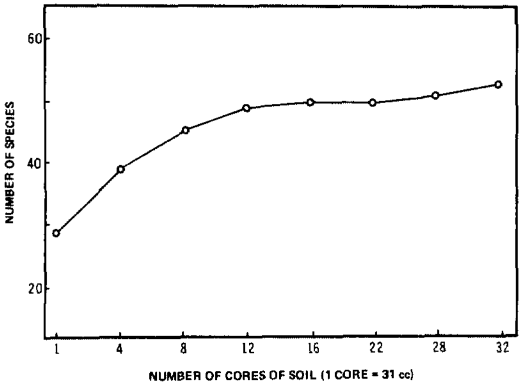

FIG. 1. Influence of the number of soil cores taken at Tippecanoe County, Ind., at site P on the number of nematode species recovered.

Evers (4) suggests that species-area curves also indicate the "smallest representative area", which he defines as the smallest unit containing about one-half the total species. The "minimum area" (adequate sample size) is large enough to include all the important species and a moderate number of minor species. It is an area 5 X as large as the "smallest representative", and usually contains 1.44 to 1.5 X as many species. In our study, a one-core sample contained 53% of the total species found, and thus qualified as the "smallest representative area". The eight-core sample could be considered the representative of the "minimum area", but is 7 X larger in size, rather than the 5 X proposed by Evers.

Bassus (1) found that even smaller soil samples were adequate for determining nematode species composition in some forest soils of central Germany. He found that a sample of 4-5 cm^3 (equivalent to about one-sixth core in the present study) contained an adequate representation of the species in a pine forest. In a beech forest, a larger sample of 10-12 cm^3 (about one-third core) was adequate.

Site relationships. A total of 175 species representing eight orders was found during the

TABLE 2. Nematode species of 18 forest communities in Tippecanoe County, Ind.

- DORYLAIMIDA Pearse, 1942
  - DORYLAIMOIDEA (de Man) Thorne, 1934
    - DORYLAIMIDAE de Man, 1876
      - *Amphidorylaimus* sp. (1)[a]
      - *Eudorylaimus symmetricus* (13)[b]
      - *E. carteri* (8)[b]
      - *E. circulifer* (14)
      - *E. consobrinus* (15)
      - *E. curvatus* (16)[b]
      - *E. granuliferus* (12)
      - *E. minor* (22)[b]
      - *E. monhystera* (9)
      - *E. nodus* (17)
      - *E. nothus* (18)
      - *E. paracirculifer* (19)
      - *Eudorylaimus* sp. (7)
      - *Eudorylaimus* sp. (10)[c]
      - *Eudorylaimus* sp. (11)
      - *Discolaimus texanus* (1)
      - *Labronema ferox* (1)
      - *Laimydorus* sp. (1)
      - *Mesodorylaimus bastiani* (3)
      - *Mesodorylaimus* sp. (2)
      - *Mesodorylaimus* sp. (4)
      - *Longidorella* sp. (2)
      - *Pungentus monohystera* (2)
      - *P. pungens* (1)
      - *Pungentus* sp. (3)
      - *Pungentus* sp. (4)
      - *Enchodelus hopedorus* (3)
      - *Enchodelus* sp. (1)
    - TYLENCHOLAIMIDAE (Filipjev) Siddiqi, 1969
      - *Tylencholaimus congestus* (1)
      - *T. proximus* (3)
      - *Tylencholaimus* sp. (4)
      - *Tylencholaimus* sp. (5)
    - APORCELAIMIDAE Heyns, 1965
      - *Aporcelaimellus obscurus* (1)[c]
      - *Aporcelaimus pachydermis* (7)
      - *Aporcelaimus* sp. (2)
      - *Aporcelaimus* sp. (5)
      - *Sectonema ventralis* (2)
    - NYGOLAIMIDAE (Thorne) Meyl, 1961
      - *Nygolaimus (Parvulus) hartingii* (3)
      - *N. (Laevides) laevis* (6)
      - *Nygolaimus* sp. (1)
      - *Nygolaimus* sp. (2)
      - *Nygolaimus* sp. (4)
      - *Nygolaimus* sp. (5)
    - LONGIDORIDAE (Thorne) Meyl, 1961
      - *Longidorus elongatus* (1)
      - *L. longicaudatus* (2)
      - *Xiphinema americanum* (2)[c]
      - *X. bakeri* (6)
      - *X. chambersi* (5)
  - LEPTONCHOIDEA (Thorne) Ferris, 1971
    - LEPTONCHIDAE Thorne, 1935
      - *Leptonchus granulosus* (1)
      - *Leptonchus* sp. (2)
    - BELONENCHIDAE Thorne, 1964
      - *Basirotyleptus basiri* (1)
  - DIPHTHEROPHOROIDEA Clark, 1961
    - DIPHTHEROPHORIDAE (Micoletzky) Thorne, 1955
      - *Diphtherophora* sp. (1)[b]
      - *Triplonchium cylindricum* (1)
      - *T. minor* (2)
  - BELONDIROIDEA Thorne, 1964
    - BELONDIRIDAE Thorne, 1939
      - *Belondira* sp. (5)
    - AXONCHIIDAE (Thorne) Siddiqi, 1968
      - *Axonchium micans* (3)
    - DORYLAIMELLIDAE (Jairajpuri) Thorne, 1964
      - *Dorylaimellus aequalis* (6)
      - *D. occidentalis* (8)
      - *D. parvulus* (3)
      - *D. virginianus* (9)
      - *Dorylaimellus* sp. (13)
    - OXYDIRIDAE (Jairajpuri) Thorne, 1964
      - *Oxydirus oxycephalus* (2)
- TYLENCHIDA Thorne, 1949
  - TYLENCHOIDEA Chitwood and Chitwood, 1937
    - TYLENCHIDAE Oerley, 1880
      - *Tylenchus cylindricus* (2)[b]
      - *T. exiguus* (1)[c]
      - *T. hamatus* (8)
      - *Tylenchus* sp. (3)
      - *Tylenchus* sp. (12)
      - *Tylenchus* sp. (13)
      - *Aglenchus costatus* (1)[b]
      - *Psilenchus hilarulus* (1)

Tylenchus sp. (4)
Tylenchus sp. (5)[c]
Tylenchus sp. (6)
Tylenchus sp. (7)
Tylenchus sp. (9)
Tylenchus sp. (10)
Tylenchus sp. (11)
Basira graminophila (1)
Clavilenchus sp. (1)
Tylenchorhynchus silvaticus (5)[b]
Pratylenchus scribneri (2)
Hoplolaimus galeatus (1)
Helicotylenchus platyurus (1)[c]
H. pseudorobustus (3)

HETERODERIDAE Skarbilovich, 1947
Heterodera sp. (1)
Meloidogyne sp. (4)

CRICONEMATIDAE Thorne, 1943
Criconema cobbi (4)
C. octangulare (1)
Criconema sp. (2)
Criconema sp. (3)
Criconemoides macrodorum (2)
Criconemoides sp. (1)
Criconemoides sp. (3)
Criconemoides sp. (4)
Hemicycliophora similis (3)
Hemicycliophora sp. (1)
Hemicycliophora sp. (2)
Paratylenchus projectus (1)
Gracilacus audriellus (1)[b]

NEOTYLENCHIDA Thorne, 1949
Boleodorus similis (1)[b]
Ecphyadophora tenuissima (1)
Nothotylenchus acris (1)

APHELENCHOIDEA (Fuchs) Thorne, 1949
APHELENCHIDAE (Fuchs) Steiner, 1949
Aphelenchus avenae (1)[c]

APHELENCHOIDIDAE (Skarbilovich) Paramanov, 1953
Aphelenchoides clarus (1)[c]
A. sacchari (2)[b]

PARAPHELENCHIDAE (T. Goodey) J. B. Goodey, 1960
Paraphelenchus myceliophthorus (1)

RHABDITIDA (Oerley) Chitwood, 1933
RHABDITOIDEA (Oerley) Travassos, 1920
RHABDITIDAE Oerley, 1880
Rhabditis sp. (2)[b]
Rhabditis sp. (3)
Rhabditis sp. (4)
Rhabditis sp. (5)[b]
Rhabditis sp. (6)
Rhabditis sp. (7)
Mesorhabditis sp. (1)[c]
Diploscapter sp. (1)

PANAGROLAIMIDAE (Thorne) Paramanov, 1956
Panagrolaimus sp. (1)[c]
Panagrellus sp. (1)

CEPHALOBIDAE (Filipjev) Chitwood & Chitwood, 1934
Eucephalobus oxyuroides (2)[c]
E. striatus (1)[b]
Acrobeles sp. (1)
Acrobeloides nanus (1)[c]
Cervidellus cervus (1)[c]

DIPLOGASTEROIDEA Paramanov, 1952
DIPLOGASTERIDAE (Micoletzky) Steiner, 1929
Mesodiplogaster sp. (1)

TERATOCEPHALIDA (Andrássy) J. B. Goodey, 1963
TERATOCEPHALIDAE Andrássy, 1958
Teratocephalus sp. (1)
Euteratocephalus sp. (1)

ARAEOLAIMIDA Schuurmans Stekhoven and de Coninck, 1933
PLECTOIDEA (Oerley) Chitwood, 1937
PLECTIDAE Oerley, 1880
Plectus armatus (5)[b]
P. elongatus (2)
P. parietinus (3)[b]
P. rhizophilus (4)[c]
Plectus sp. (6)
Plectus sp. (7)
Plectus sp. (8)
Plectus sp. (9)
Plectus sp. (10)
Anaplectus similis (1)
Chronogaster sp. (1)
Wilsonema sp. (1)
Wilsonema sp. (2)

LEPTOLAIMIDAE Oerley, 1880
Leptolaimus sp. (1)
Rhabdolaimus sp. (1)

BASTIANIIDAE de Coninck, 1935
Bastiania exilis (1)

AXONOLAIMOIDEA (Schuurmans Stekhoven and de Coninck) Chitwood, 1937
AXONOLAIMIDAE Schuurmans Stekhoven and de Coninck, 1933
Cylindrolaimus sp. (1)
Cylindrolaimus sp. (2)
Cylindrolaimus sp. (3)
Cylindrolaimus sp. (4)

MONHYSTERIDA (Oerley) Schuurmans Stekhoven and de Coninck, 1933
MONHYSTERIDAE Oerley, 1880
Monhystera sp. (1)
Monhystera sp. (2)[b]
Prismatolaimus sp. (1)[c]
Prismatolaimus sp. (2)

CHROMADORIDA (Filipjev) Chitwood, 1933
CYATHOLAIMIDAE (Micoletzky) Schuurmans Stekhoven and de Coninck, 1933
Achromadora sp. (1)
Achromadora sp. (2)
Achromadora sp. (3)
Monochromadora sp. (1)
Odontolaimus sp. (1)
Prodesmodora sp. (1)

ENOPLIDA (Baird) Chitwood, 1933
TRIPYLOIDEA (Oerley) Chitwood, 1937
TRIPYLIDAE Oerley, 1880
Tripyla sp. (1)
Tripyla sp. (2)
Tripyla sp. (3)
Tobrilus sp. (1)
Trischistoma monohystera (1)

IRONIDAE de Man, 1876
Ironus sp. (1)

ALAIMIDAE Micoletzky, 1922
Alaimus arcuatus (4)[c]
A. parvus (7)
A. primitivus (3)[c]
Alaimus sp. (5)
Alaimus sp. (6)
Amphidelus elegans (4)
A. pusillus (7)
Amphidelus sp. (5)
Amphidelus sp. (6)

MONONCHIDAE Chitwood, 1937
Mononchus papillatus (2)[c]
M. truncatus (1)
Miconchus trionchus (1)
Mylonchulus brachyurus (3)[b]
M. sigmaturus (2)
Prionchulus punctatus (1)

[a] Number in parentheses is code number of species in Purdue Nematode Collection.
[b] Found in 17 of the sites.
[c] Found in all 18 sites.

2-year period of this study (Table 2). Sixty-three species in 25 genera of the Dorylaimida were present. The order Tylenchida was represented by 44 species in 22 genera. The remaining six orders each contained 20 or fewer species.

The total number of species found at each site over the 2-year period ranged from 59 at site P (Black Locust) to 105 at site C (Stewart Woods Stream), but fewer species were found in any one sample. An average high of 54 species/sample was found at site C, and an average low of 33 species/sample was found at site R on the Wabash River floodplain. The average for all sites was 43 species/sample.

Evidently this fluctuation in number of species is not unusual. Bassus (1) shows about 25 species for a pine forest and about 45 species for a beech forest at one sampling time when the populations were at a maximum, but reports a total of 119 species over a four-year period. Orr and Dickerson (9) found that fall samples taken from a prairie area in Kansas averaged a few more species than samples taken at other times of the year.

Of the 175 species found in this study, 18 were found in all 18 sites and an additional 18 species occurred in 17 of the 18 sites. These species are noted in Table 2. Almost one-half the total species were found in 50% of the sites.

Relationships among sites based on similarities of nematode species are presented on the dendrogram in Fig. 2. The sites are joined vertically according to the per cent similarity. Sites that are more than 73% similar are considered essentially identical by Preston (13), and representative of a larger area. When the value is less than 73%, but greater than zero, there has been isolation of varying degrees of the two faunas. A value of 73% indicates that the isolates are in equilibrium.

Site H, at the east end of McCormick Woods, and site L, in Higley Woods, had the highest number of species in common, being

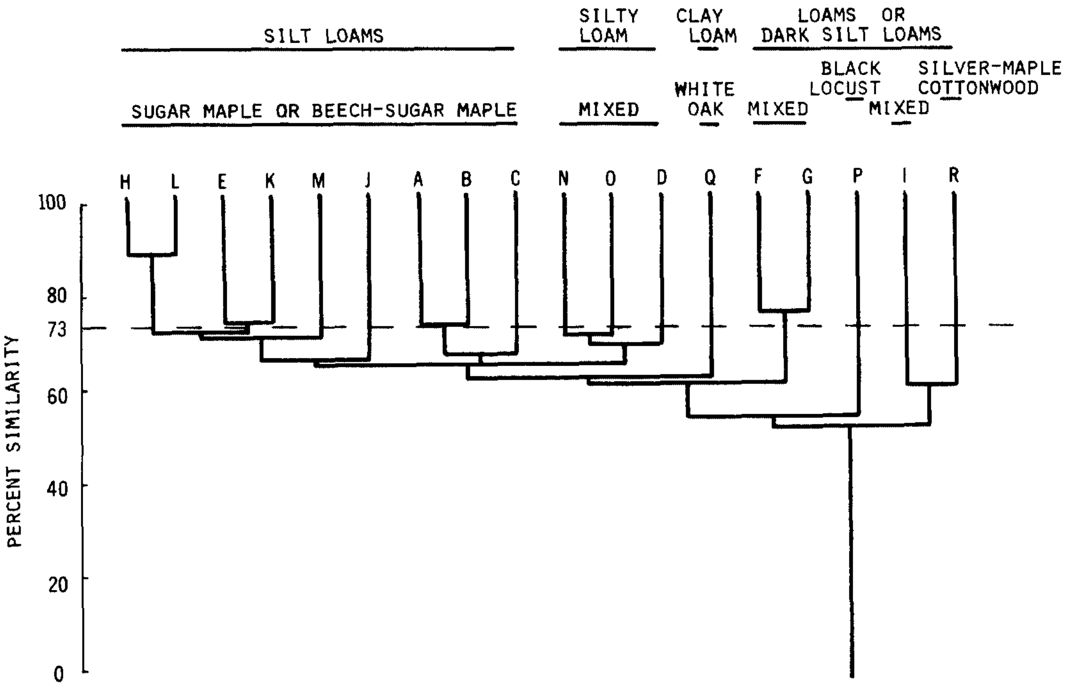

FIG. 2. Dendrogram of forest sites in Tippecanoe County, Ind., based on similarity indices of nematode species.

88% similar. These two sites are located in different woodlots 3.2 km apart, but both are on well-drained silt loam soils with sugar maple the dominant tree species. Site E, in the north end of Leitner Woods, and site K, in Cason's Woods, were 74% similar. Site E is a woodlot on a well-drained silt loam soil about 2.9 km from site K, a woodlot on a more poorly drained silt loam. Sugar maple is the dominant tree species at site E, and beech and maple are the two major dominants at site K. Sites H, L, E, and K are all quite similar, as the four united at 72% similarity. Sites F and G were 75% similar. Site G was included in the study to determine any influence a drainage ditch might have on the nematode species present in an adjacent woodlot. Ninety-nine species were found at site F, and 89 species at site G. The addition of the drainage ditch might have disturbed the natural habitat enough to cause the reduction in number of species, but according to Preston, these sites are similar enough in species composition to be considered parts of the same area.

Sites A and B, located in Stewart Woods, were 73% similar and would be considered as isolates in equilibrium by Preston. Site A is on the southern slope of a ridge running through the woodlot, and site B is 915 m away on the southern slope of another ridge. These two sites are separated by the ridge on which site A is located and by a small natural stream on which site C is located. Site C contained the most species (105) of any of the sites studied over the 2-year period. Interestingly, the nematode species of sites A and B are in equilibrium, yet these sites are only 67% similar to the stream that separates them. The method of sampling site C might have increased the apparent similarity between this site and sites A and B. Since the sample included soil from the stream bed and the bank, it probably contained representative species of two fairly distinct habitats. This is supported by the fact that 84% of the species found at site A and 78% of the species found at site B were found at site C, yet site C was only 69% similar to A and 64% similar to B. Apparently, a characteristic nematode fauna has developed along the natural stream at site C. Sugar maple was the dominant tree species at site A, and beech and sugar maple the co-dominants at site B.

A comparison of the dendrogram (Fig. 2) for the nematode species with the dominant tree species found at each site shows that nine of the sites that group together on the left have sugar maple alone or beech plus sugar maple as major dominants. Three of the four pairs of sites with similarities 73% or higher in nematode species composition were in this group. Beech-sugar maple forests were some of the original climax communities of Tippecanoe County, and were part of the beech-sugar maple climax forest of central Indiana (15). Six sites (N, O, D, F, G, I) which group on the right side of the dendrogram have a mixture of tree species, and there are three sites on this side of the figure which have white oak, black locust, or silver maple-cottonwood as the major dominant species. Site P, almost totally even-aged black locust, and site Q, predominantly white oak, were the most homogeneous sites with regard to tree species.

Some physical characteristics of the sites also correlate with the nematode dendrogram (Fig. 2). Seven of the nine sites on the left side of the dendrogram represent the better-drained sites with light-colored silt-loam soils (Table 1). Sites J and K are on poorly drained soils, but are closely bordered by better-drained soils and share some characteristics of both types. Soil at both sites is lighter in color than is characteristic for the poorly drained soil (7). Those sites on the right side, with the exception of sites Q, P, and R, are the most poorly drained sites with dark silt loam or silty clay loam soils. Although the soil type at site O is generally among the better-drained types (Table 1), the site is located in a shallow, poorly drained depression (7). Some muck was found at site F. The location on Fig. 2 of site Q, a well-drained loam, might have been nearer the left if we had had data for both years. However, site Q was heavily grazed each spring and summer, and, because of this, the soil became extremely compacted. Site P was on a well-drained silt loam soil with a silty clay loam texture, but its homogeneity with regard to tree species is probably the most important feature determining its location on the dendrogram. Site R on the extreme right of the dendrogram represents a well-drained silty clay loam, but it is located on the floodplain of the Wabash River and is flooded each spring.

Most of the sites have been subjected to disturbances of some type in the past by different management practices (Table 1). Sites A, B, C, and M are the most natural sites, as there is no record or evidence of past disturbances. Site R could be considered undisturbed, but large amounts of silt, driftwood, and brush are brought in by the spring flood waters. All the other sites have been cut, grazed, or both, at some time in the past. In general, the undisturbed and slightly disturbed sites are on the left side of the dendrogram whereas the more recently disturbed sites are on the right side.

CONCLUSIONS

Based on nematode species composition, this group of deciduous hardwood stands in close geographical proximity showed a fairly high degree of similarity. However, despite the similarities, several distinct groupings were apparent. Sites with sugar maple or beech-sugar maple as the dominant tree species were more similar to each other in nematode composition than they were to sites with a mixture of tree species; and sites with better-drained soils were more similar to each other than to sites with poorly drained soils. Sites I and P, which have undergone major disturbances, and site R on the Wabash River floodplain were the most dissimilar to all other sites.

Results of this study agree with the findings of previous workers that many nematode species are well-distributed among natural habitats which are not strikingly dissimilar (2, 10, 17, 18). However, in previous studies, the relationships which do exist among these habitats have been largely obscured by almost exclusive reliance on the presentation of data in tables or long lists of species. The coefficients of similarity, determined using Preston's resemblance equation, and the resulting dendrogram provide a method whereby relationships based on all species can be shown clearly in one graphic figure.

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