# Relationships of Plant Parasitic Nematodes to Sites in Native Iowa Prairies[1]

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*Abstract*: Soil samples were collected from three native Iowa prairies and analyzed for plant parasitic nematodes and selected soil properties. Sites or nematodes were clustered with similarities related to habitat by a cluster analysis of site by nematode species and of nematodes by site. Some nematodes occurred in a wide range of prairie habitats, whereas others were more restricted. For example, greater numbers of *Xiphinema americanum* were in the low, well-drained sites than in the low wet sites or upland dry sites. Wet sites contained fewer nematodes than well-drained sites. Well-drained sites contained mainly *Tylenchorhynchus maximus, Helicotylenchus pseudorobustus*, and *X. americanum*. Wetter sites contained almost exclusively *X. chambersi, H. hydrophilus, Tetylenchus joctus*, and an undescribed species of *Tylenchorhynchus*. *Key words*: habitat relationships, *H. leiocephalus, Aorolaimus torpidus, T. nudus.*

Investigations of plant parasitic nematodes in native grasslands in the United States have resulted mostly in faunistic lists and associated plants (4, 5, 6, 11). That more nematode studies in native areas have not been made is surprising, since most nematodes in USA cultivated soils probably had their ancestry in virgin areas in relatively recent times. Studies in natural areas perhaps would give insight to the presence and ecology of plant parasitic nematodes in agricultural soils, and to their possible importance in the native ecosystem.

The purposes of this study were to catalog stylet-bearing nematodes and to analyze their prairie relationships by cluster analysis. Emphasis was placed on the Tylenchida, and on *Xiphinema* and *Trichodorus* in the Dorylaimida, since these taxa are associated frequently with cultivated plants and contain economically important species.

## MATERIALS AND METHODS

SITES AND SAMPLE PROCESSING: The three state-owned prairies used in this study have a rolling topography, and are remnants of the once vast tall-grass prairie. Cayler Prairie in Dickinson County and Kalsow Prairie in Pocahontas County, 75 miles to the southeast, are composed of several soil series in the Clarion-Nicollet-Webster soil association. The Cayler Prairie is contained within the Altamont Moraine. Hayden Prairie in Howard County is about 135 miles northeast of the Kalsow Prairie and about 200 miles east of the Cayler Prairie, and is in the Cresco-Lourdes-Clyde soil association. These prairies have never been cultivated, and they have been set aside as preserves, two of them being registered Natural Landmarks. The Kalsow, Cayler, and Hayden prairies consist of 64.74, 42.08, and 97.10 hectares (160, 104, and 240 acres), respectively. Although these prairies have never been cultivated, they are now mowed or burned periodically to maintain their natural state. Sites varied from moraine summits to potholes (undrained depression), with concomitant changes in vegetation.

Samples of 600-700 cc of soil were taken 4 times at 2-month intervals from February through September 1968 from the 0-15 cm (0-6 inch) depth with a 7.6 cm (3-inch) diam soil bucket auger. Nematodes were extracted from the soil within 1 day of sampling by a modification of the Christie and Perry extraction method (1). Briefly, this consisted of wet-sieving 250 cc soil through 35-, 60-, 100-, and 200-mesh sieves. The residue on the 100- and 200-mesh sieves was placed on a Baermann funnel for 44 hr. Then 10 ml of water were tapped from each funnel and the nematodes counted. Roots were collected from the 35-mesh sieve and processed for endoparasitic nematodes by thin-water-film extraction in a petri dish. The residue on the 60-mesh sieve was examined for cyst nematodes. Total nematode numbers were estimated by counting 10% of the nematodes in a sample. Numbers of each species were estimated by identifying 20 specimens of a genus, or all specimens, if fewer than 20 individuals were available. Since the extraction procedures used are inefficient in isolating *Criconemoides* and *Longidorus*

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species, little importance was given to data on these genera. Each soil sample was analyzed for texture (12), pH (7), and organic matter content (7). Since nearly all samples consisted of mixed root systems, a vegetation analysis was made at each site (Table 1).

SIMILARITY COEFFICENTS: Cluster analyses employing samples from 12, 23, and 15 sites from the Cayler, Hayden, and Kalsow prairies, respectively, (Table 1) were made using similarity coefficients to determine a classification scheme of nematode associations (9, 10). Only maximum numbers obtained for a given nematode at each site were used in the cluster analyses, since data from other times of the year usually merely reflected periodicity of population size. Periodicity aspects will be reported elsewhere.

TABLE 1. Dominant vegetation, nematodes, and soil pH, texture, and percentage organic matter in the Cayler, Hayden, and Kalsow prairies, Iowa, 1968.

| Site clusters in Fig. 2 | Dominant vegetation[a] | Dominant stylet-[b] bearing nematodes | Percentage sand-silt-clay | pH | Percentage organic matter |
|---|---|---|---|---|---|
| A | *Solidago canadensis* L. | *Xiphinema americanum* | 23-40-37 | 5.6 | 7.8 |
| | *Poa pratensis* L. | | to | to | to |
| | | | 39-49-12 | 6.2 | 10.6 |
| B | *Andropogon gerardi* Vitman | *Helicotylenchus* | 27-39-34 | 5.7 | data |
| | *Poa pratensis* | *pseudorobustus* | to | to | |
| | *Solidago canadensis* | *Tylenchorhynchus* | 42-55-3 | 6.9 | lost |
| | | *nudus* | | | |
| C | *Poa pratensis* | *Xiphinema americanum* | 22-38-40 | 5.6 | 8.7 |
| | | | to | to | to |
| | | | 34-48-17 | 6.8 | 11.5 |
| D | *Poa pratensis* | *Aorolaimus* sp.[b] | 27-43-30 | 5.4 | 7.2 |
| | *Salix humilis* Marsh. | *Helicotylenchus* sp. | to | to | to |
| | | *Aphelenchus* sp. | 36-39-25 | 5.8 | 7.6 |
| | | *Xiphinema americanum* | | | |
| E | *Achillea lanulosa* Nutt.[b] | *Tylenchorhynchus* | 28-39-33 | 5.6 | 8.5 |
| | *Cirsium arvense* (L.) Scop. | *nudus* | to | to | to |
| | *Poa pratensis* | *Aphelenchus* sp. | 36-39-25 | 7.6 | 9.2 |
| | *Setaria viridis* (L.) Beauv. | | | | |
| | *Solidago canadensis* | | | | |
| F | *Achillea lanulosa*[b] | *Helicotylenchus* | 12-21-67 | 5.5 | 5.7 |
| | *Andropogon gerardi* | *dihystera* | to | to | to |
| | *Lathyrus venosus* Muhl. | *Helicotylenchus* | 27-48-24 | 5.9 | 9.8 |
| | *Poa pratensis* | *pseudorobustus* | | | |
| | *Spartina pectinata* Link | | | | |
| | *Sporobolus heterolepis* Gray | | | | |
| G | *Andropogon gerardi*[b] | *Helicotylenchus* | 27-44-28 | 5.2 | 6.3 |
| | *Poa pratensis* | *digonicus* Perry | to | to | to |
| | *Salix humilis* | *Xiphinema americanum* | 27-40-33 | 5.5 | 6.9 |
| | *Sporobolus heterolepsis* | | | | |
| H | *Carex* sp.[b] | *Helicotylenchus*[b] | 29-38-33 | 5.1 | 8.0 |
| | *Baptisia leucophaea* Nutt. | *dihystera* | to | to | to |
| | *Fragaria virginiana* Duchesne | *Helicotylenchus* | 39-44-17 | 6.2 | 11.8 |
| | *Poa pratensis* | *pseudorobustus* | | | |
| | *Spartina pectinata* | *Heterodera* sp. | | | |
| | | *Aphelenchus* sp. | | | |
| | | *Aphelenchoides* sp. | | | |
| I | *Carex* sp.[b] | *Tylenchorhynchus* sp.[b] | 20-37-43 | 5.0 | 5.4 |
| | *Poa pratensis* | *Tylenchorhynchus* | to | to | to |
| | *Polygonum coccineum* Muhl. | *nudus* | 39-41-20 | 7.5 | 12.5 |
| | *Salix interior* Rowlee | *Tetylenchus joctus* | | | |
| | *Scirpus fluviatilis* (Torr.) Gray | *Helicotylenchus* | | | |
| | | *hydrophilus* | | | |
| | | *Xiphinema americanum* | | | |
| | | *Xiphinema chambersi* | | | |

[a]Species listed were dominant in most of the sites in a given cluster.

[b]No common dominant species but includes species listed.

The cluster analysis measures only positive associations in the range $0 \leq S \leq 1$ by the equation:

$$S_{(ij)} = \sum_{k=1}^{n} \frac{2W_k}{a_{ik} + b_{jk}}$$

where S = similarity between sites or species i and sites or species j; n = number of sites or species; $a_{ik}$ = value of either site or species i, or species or site k; $b_{jk}$ = value of either site or species j, or species or site k; and $W_k$ = value in common between site or species i and species or site j for species or site k.

## RESULTS

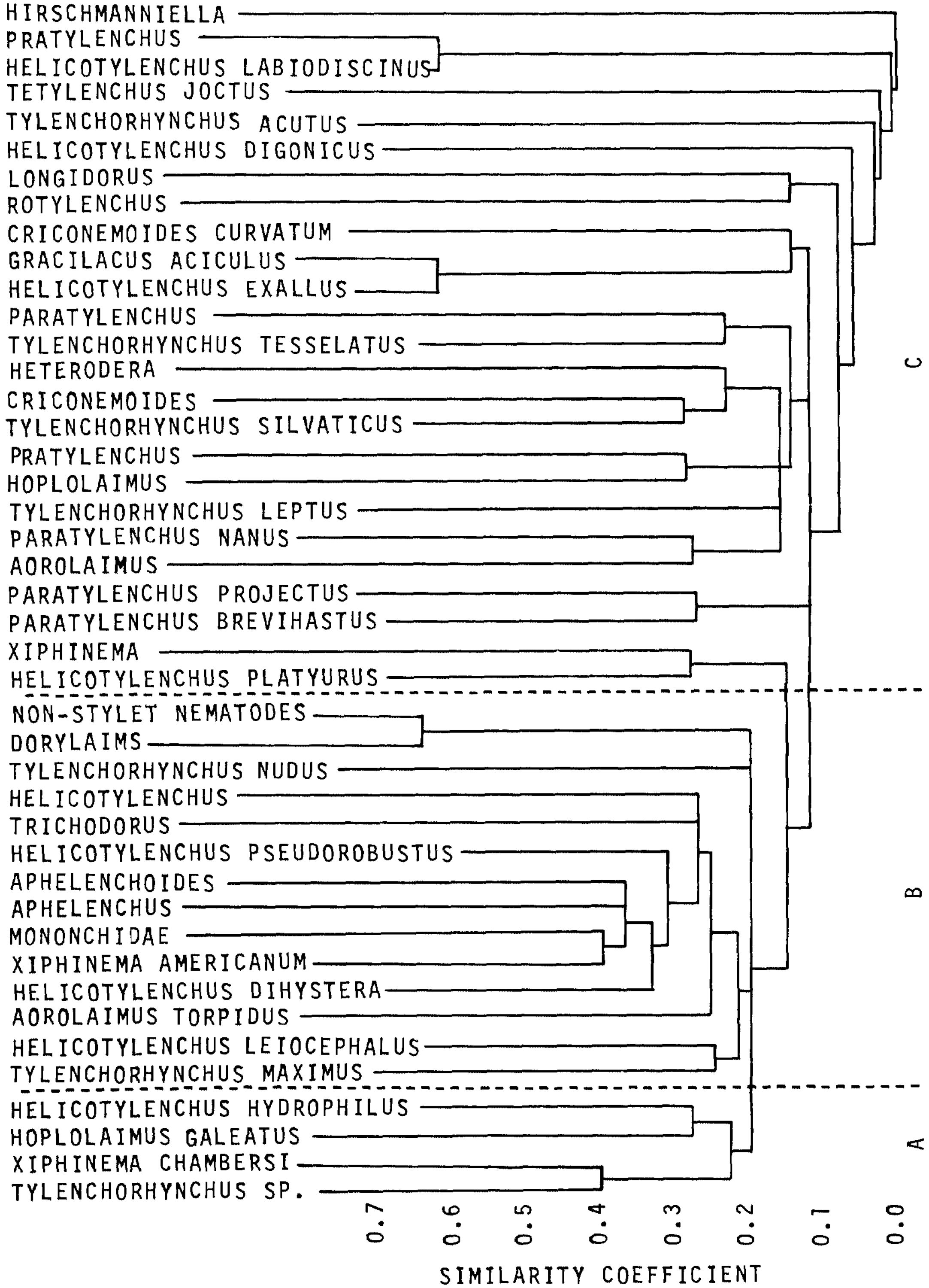
The classification of nematode species by site clustering based on presence-absence and population size is presented in Fig. 1. Basically, three groups of nematodes were formed: (i) pothole-area-inhabiting species (Fig. 1A); (ii) species that occurred together frequently in well-drained areas (Fig. 1B); and (iii) nematodes that occurred infrequently but clustered together once with another species (Fig. 1C). In Fig. 1A-C, the closer the connecting lines between two nematode taxa and the higher the similarity coefficient (0.0-0.7), the more closely associated were the taxa by presence-absence and abundance. A high similarity coefficient (maximum 1.0) indicates that (i) the nematodes either were found together consistently as with the dorylaims and non-stylet nematodes, although in varying numbers; or (ii) they were present in large numbers at one site but few occurred independently elsewhere, as with *Helicotylenchus exallus* Sher and *Gracilacus aciculus* (Brown) Raski; or (iii) they were found only once in low numbers at the same site but not at all elsewhere, as with *H. labiodiscinus* Sher and *Pratylenchus* sp.

Some of the most consistent clustering occurred in the potholes and their peripheral zones in which an undescribed species of *Tylenchorhynchus*, *Helicotylenchus hydrophilus* Sher, *Hoplolaimus galeatus* (Cobb) Thorne, and *Xiphinema chambersi* Thorne were closely associated (Fig. 1A). Another hierarchy was established by nematodes recovered from the well-drained sites (Fig. 1B). Here, *X. americanum* Cobb-*Mononchidae*, *Aphelenchus-Aphelenchoides* groups clustered with *Helicotylenchus dihystera* (Cobb) Sher and *H. pseudorobustus* (Steiner) Golden because they occurred together frequently.

Most clusters in Fig. 1C probably indicate that these species prefer different ecological niches, since the species of a cluster occurred together only once and independently several times, often in low numbers. A possible exception is the clustering of *H. exallus* and *G. aciculus*, which occurred together in large numbers once in an isolated habitat containing upland vegetation, such as *Poa pratensis* and *Solidago canadensis*; the site was located at the bottom of a slope near an intersection of two drainage systems.

The clustering of nematode species by sites as in Fig. 1A-C brings together certain associations of nematodes, but provides only general information of nematode clustering by habitat. The habitat relationships are further elucidated by clustering sites by nematode species (Fig. 2A-I). Some sites were combined for statistical purposes. Ecological data are summarized in Table 1. Five clusters of habitats considered meaningful (Fig. 2A-I) were: (i) the drier low areas of the Kalsow and Hayden prairies where relatively large numbers of *X. americanum*, other dorylaims, and non-stylet nematodes, and the consistent small population size of the *Mononchidae* were responsible for the clustering (Fig. 2A); (ii) the summit and high shoulder sites of the Kalsow and Cayler prairies, characterized by *Tylenchorhynchus nudus* Allen, *H. pseudorobustus*, moderately high numbers of dorylaims and non-stylet nematodes, and consistent presence but low numbers of *X. americanum* (Fig. 2B); (iii) slopes scattered throughout the prairies, characterized by low to moderately low numbers of stylet and non-stylet nematodes (Fig. 2C); (iv) mixed sites that contained small to medium size populations of many nematodes

FIG. 1. Cluster analysis classification of nematodes by sites in Kalsow Prairie, Pocahontas County, Iowa; Cayler Prairie, Dickinson County, Iowa; and Hayden Prairie, Howard County, Iowa. 1968. Genera listed with and without species indicate different taxa, the latter being mostly unidentifiable by us and possibly new species. **A.** Pothole area-inhabiting species; **B.** species that occurred together frequently in well-drained sites; **C.** nematodes that occurred infrequently but clustered together once with another species. See text for details.


HIRSCHMANNIELLA
PRATYLENCHUS
HELICOTYLENCHUS LABIODISCINUS
TETYLENCHUS JOCTUS
TYLENCHORHYNCHUS ACUTUS
HELICOTYLENCHUS DIGONICUS
LONGIDORUS
ROTYLENCHUS
CRICONEMOIDES CURVATUM
GRACILACUS ACICULUS
HELICOTYLENCHUS EXALLUS
PARATYLENCHUS
TYLENCHORHYNCHUS TESSELATUS
HETERODERA
CRICONEMOIDES
TYLENCHORHYNCHUS SILVATICUS
PRATYLENCHUS
HOPLOLAIMUS
TYLENCHORHYNCHUS LEPTUS
PARATYLENCHUS NANUS
AOROLAIMUS
PARATYLENCHUS PROJECTUS
PARATYLENCHUS BREVIHASTUS
XIPHINEMA
HELICOTYLENCHUS PLATYURUS
NON-STYLET NEMATODES
DORYLAIMS
TYLENCHORHYNCHUS NUDUS
HELICOTYLENCHUS
TRICHODORUS
HELICOTYLENCHUS PSEUDOROBUSTUS
APHELENCHOIDES
APHELENCHUS
MONONCHIDAE
XIPHINEMA AMERICANUM
HELICOTYLENCHUS DIHYSTERA
AOROLAIMUS TORPIDUS
HELICOTYLENCHUS LEIOCEPHALUS
TYLENCHORHYNCHUS MAXIMUS
HELICOTYLENCHUS HYDROPHILUS
HOPLOLAIMUS GALEATUS
XIPHINEMA CHAMBERSI
TYLENCHORHYNCHUS SP.
C
B
A
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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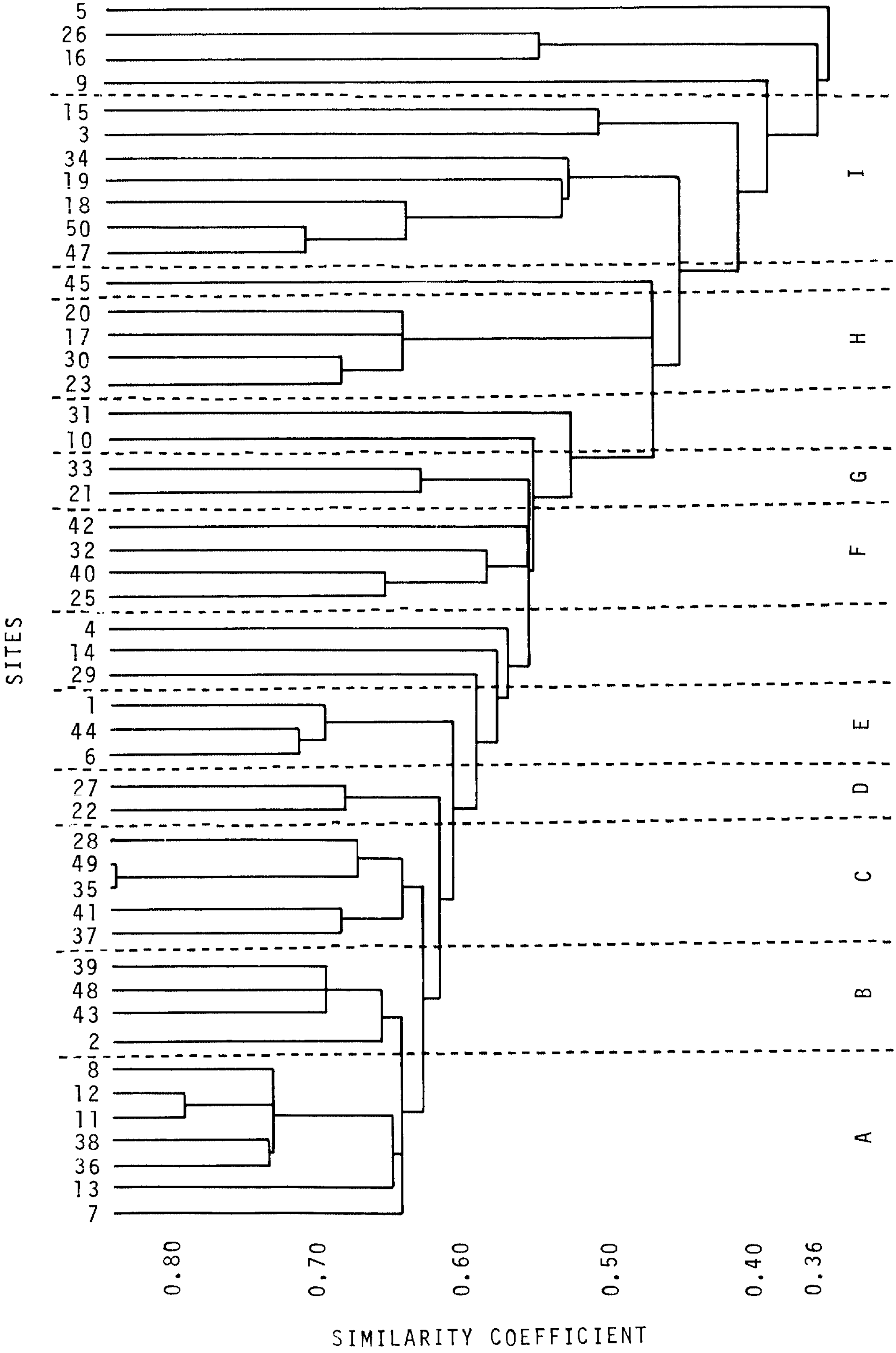
SIMILARITY COEFFICIENT


SITES
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12
11
38
36
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7
I
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D
C
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A
0.80
0.70
0.60
0.50
0.40
0.36
SIMILARITY COEFFICIENT

(Fig. 2H); and (v) low, poorly drained areas containing marsh to semi-aquatic plant species (Fig. 2I). The site clustering in Fig. 2I can be subdivided into potholes which are characterized by *Tylenchorhynchus* sp., *Tetylenchus joctus* Thorne, *H. hydrophilus*, and *X. chambersi*, and poorly drained non-pothole areas which contained few nematodes of any kind.

The clusters in Fig. 2D-G were formed mainly by similar numbers of dorylaims (excluding *Xiphinema*, *Trichodorus*, and *Longidorus*) and non-stylet nematodes. There is little similarity between the stylet-bearing nematode taxa. This has little meaning with regard to the data collected for this study.

## DISCUSSION

Due to the complexity of the biological and physical components of the rhizosphere, it is difficult to categorize nematodes into habitats being governed by a single or few factors. Cluster analysis enables one to look for groupings which aid in a clearer perspective than does a statistic such as correlation coefficients. Ferris, et al. (2) showed that a similar analysis was useful in grouping nematodes in soybean fields by location in Illinois and Indiana. The main basis of clustering was on light- and dark-colored soils.

The type of cluster analysis employed in our study uses population levels as well as presence-absence data. Habitat is probably the most relevant consideration involved in the separation of groups. Nematode habitat differences were evident in the classification scheme (Fig. 1, 2; Table 1).

The hierarchial scheme resulting from cluster analysis should provide a means of predicting the probability of finding certain nematodes. For example, one would expect to find *X. americanum* in low, well-drained areas, and the likelihood of finding *X. americanum* and Mononchidae together are good in the prairies, but *Tylenchorhynchus maximus* Allen occurring with *H. leiocephalus* is less probable. The lower the acceptance level, the more heterogeneity is involved. Many other types of predictions are conceivable from studies ~f this type, such as changes in nematode faui with concurrent changes of habitat by cultıvation, soil conservation, and other cultural practices.

The various ranges of soil texture, pH, organic matter, and vegetation may be indicative of certain relationships of nematodes to the ecosystem. Further experimentation is necessary, however, before conclusive cause and effect relationships can be accepted with confidence. Soil pH, percentage of sand, and organic matter were reported earlier to be correlated with certain nematode abundance in the Kalsow Prairie (8). Such correlation aids in the interpretation of data, but does not reveal the perspective that cluster analysis does. Whereas topographic and vegetational relationships appear to be the most important factors governing nematode populations in this study, sufficient information was not obtained concerning other factors and the interrelationships involved to state that other factors are not important. Kimpinski and Welch (3) concluded that the amount of plant material was the most important factor influencing nematode populations in Manitoba in which *Bromus inermis* and *Poa compressa* constituted 88-95% of the vegetation. Differences in nematode numbers were correlated with nitrogen, potassium and soluble salts, but not with soil texture.

The types of clustering of sites by species and species by sites indicates that the prairies are more heterogeneous within a prairie than among prairies, and that one can expect to find similar species in similar habitats in all prairies of the type studied.

FIG. 2. Cluster analysis classification of sites by nematode species in the Kalsow Prairie (sites 1-15), Pocahontas County, Iowa; Cayler Prairie (sites 39-50), Dickinson County, Iowa; and Hayden Prairie (sites 16-38), Howard County, Iowa. 1968. **A.** Drier low sites of the Kalsow and Hayden prairies consisting of relatively large numbers of *Xiphinema americanum*, other dorylaims, non-stylet nematodes, and consistent small population size of the Monochidae; **B.** summit and high shoulder position sites of the Kalsow and Cayler prairies, characterized by *Tylenchorhynchus nudus, Helicotylenchus pseudorobustus*, moderately high numbers of dorylaims and non-stylet nematodes, and consistent presence but low numbers of *X. americanum*; **C.** scattered slopes characterized by low to moderately low numbers of stylet and non-stylet nematodes; **D-G.** Clusters containing too few nematodes for meaningful interpretations; **H.** sites on various slope positions that contained small to medium-sized populations of many nematodes; **I.** low, poorly drained sites containing marsh to semi-aquatic plant species. See text for details.

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