

Nematode Community Structure in a Vineyard Soil

H. FERRIS and M. V. MC KENRY¹

Abstract: Distribution of the nematode community in a California vineyard was studied over a 13-month period. Omnivorous and microbivorous nematodes were similarly distributed in the root zone, with greatest densities occurring between vine rows and near the soil surface. Greatest densities of plant-parasitic nematodes were found in the vine row, with the individual species differing in their vertical distribution. Total nematode biomass was greatest between rows near the surface. Biomass of plant parasites was greatest in the upper 30 cm of soil in the row, whereas biomass of microbivores was greatest in this region between rows. Of the plant-parasitic nematodes, the variability in distribution among vines was greatest for *Paratylenchus hamatus* and least for *Meloidogyne* spp. **Key Words:** *Vitis vinifera*, *Paratylenchus hamatus*, trophic groups, biomass.

A study on the seasonal variation of plant-parasitic nematode populations in a California vineyard (4) also provided data on the distribution, biomass, and population dynamics of the various nematode species and trophic groups in the soil. Such information has been collected in many locations, usually natural woodlands and grasslands (5, 7, 8, 10) rather than in agroecosystems.

This paper includes information on (i) the spatial distribution and seasonal variation of trophic groups of nematode species in the grapevine root zone; (ii) the biomass distribution of nematodes in various trophic groups and taxa; (iii) the variability of distribution of nematodes in and between root zones; and (iv) comparisons between the microbivore and omnivore groups and the plant-parasite group.

MATERIALS AND METHODS

The study was conducted in an own-rooted, 37-year-old irrigated vineyard of 'Thompson seedless' grapevines (*Vitis vinifera* L.). Details of the site, soil physical conditions, vineyard cultural practices, and sampling technique and pattern were presented previously (4). Soil samples were taken from the vineyard 15 times at 28-day intervals from six vines on each date. At the start of the investigation, vines for each date were selected at random. The same vine was never sampled twice in order to avoid errors introduced by root damage

during previous sampling. Sampling positions were 30 and 90 cm from the vine trunk in the row, and 30, 90, and 150 cm from the trunk between rows in a line perpendicular to the row. At each position, samples of about 700 cm³ soil were taken at 15-cm intervals to a depth of 120 cm with a 7.5-cm diam auger. A total of eight samples was taken at each position, and 40 samples were taken from each vine.

Nematodes were extracted from soil samples by sugar-flotation-sieving (3). Estimates of densities of *Meloidogyne* eggs and of the distribution of organic material in the soil were obtained by a modified egg-extraction technique (2). Population densities were determined for each plant-parasitic species, whereas nonparasitic species were assigned to two trophic groups: (i) microbivorous bacterial feeders, and (ii) stylet-bearing omnivorous forms (largely Dorylaimida) which feed primarily on algae, bacteria and fungi (7, 8).

Nematode distribution data for the various trophic groups were summarized as group means over the whole sampling period. The percentage of each trophic group or taxon distributed at each depth across the whole root zone was calculated and correlated with the distribution of organic material. Seasonal fluctuations of nematodes were summarized as an average of the total community for the six vines on each sampling date.

Measurements for the biomass study were made on nematodes collected at the June sampling. Nematodes extracted from each 15-cm depth interval in sampling positions 90 cm from the trunk in the row and 120 cm from the trunk between rows, for each of three vines, were killed and fixed in

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5% formalin. Up to 70 individuals of each type at each depth were measured for length and width. Fewer than 70 were measured when species were scarce at a particular depth or location. Plant parasites were measured by species, whereas microbivores and omnivores were measured by trophic group. Nematode eggs and endoparasitic stages of the life cycle were not included in biomass measurements. Biomass of each group or taxon at each position was determined by using the average of numbers for the months of May, June, and July 1973 at the appropriate depths and positions and computed by the formula of Andrassy (1). Nematode counts were adjusted for extraction efficiency (10) and recorded as number per m² of soil 15 cm thick (150 liters of soil).

The number of nematodes in the 40 samples of 500 cm³ soil processed from a vine were totaled. This total provided a parameter to determine variability of nematode distribution for each species or trophic group. The mean and standard deviation for the totals were calculated for each species or trophic group for each sampling date. A coefficient of variation was calculated from these means and standard deviations. The mean coefficients of variation over the 15 sampling periods were used as measures of variability of distribution for species and trophic groups.

RESULTS

Spatial Distribution: Spatial distribution data are presented as an average over the 15 sampling periods. (In Fig. 1, 2, each bar represents an average of 90 samples). Omnivores and microbivores, being concentrated near the soil surface, (Fig. 1-A, B) were similarly distributed, whereas plant parasites (Fig. 1-C) were spread to greater depths. Densities of plant parasites were greater in the plant row than between rows, but the greatest densities of microbivores and omnivores were found between rows. Microbivores and omnivores showed little variation in horizontal distribution, whereas parasites were in greater densities closer to the vine, at least in the upper 30 cm.

Of the individual plant-parasitic taxa, *Xiphinema americanum* Cobb (Fig. 2-B) was concentrated in the area under the

ridge of soil in the vine row to 45 cm. Although *Meloidogyne* spp. (Fig. 2-A) were more widely distributed, they increased in number closer to the ridge in the upper soil regions. *Paratylenchus hamatus* Thorne & Allen (Fig. 2-C) occurred at all depths except for the top 15 cm between rows. This species, however, was very sporadic in its distribution within an individual root zone and between vines.

The greatest densities of microbivorous nematodes found in the upper regions of soil were closely correlated with percentage of organic material in the soil (Fig. 3-A). Omnivorous nematodes and plant parasites were concentrated in higher numbers at slightly greater depths. Within the parasitic group, the highest numbers of most species were found between 15 and 30 cm, and the proportion distributed below the 100 cm depth was low in all cases except for *P. hamatus* (Fig. 3-B).

Seasonal Variation: Population densities of omnivore and microbivore communities followed similar seasonal patterns (Fig. 4-A, B). The variation among the six vines on each date, as represented by the standard deviation, also followed similar patterns. Differences were greater in population densities within the plant-parasitic group between summer and winter (Fig. 4-C). When counts of *Meloidogyne* spp. eggs were included in the plant-parasitic nematode totals, variability among the six vines increased markedly.

Nematode Biomass: Total nematode biomass in the row (Fig. 5-A) was less than that between rows (Fig. 5-B) near the soil surface, but the decrease with depth was about the same rate. The plant parasites had the greatest biomass near the soil surface in the row, whereas the omnivores had the smallest (Fig. 5-C). Omnivore biomass surpassed that of the parasites and microbivores at 45-cm depth by increasing as the others decreased. All three groups declined to low levels of biomass below 90 cm. The percent contribution of each group to the total nematode biomass in the row (Fig. 5-E) was variable between 30 and 90 cm. Above 30-cm depth, the parasites contributed the most to nematode biomass, whereas the microbivores had the greatest contribution to biomass below 90 cm. Between the rows, the biomass of microbivores

FIG 1

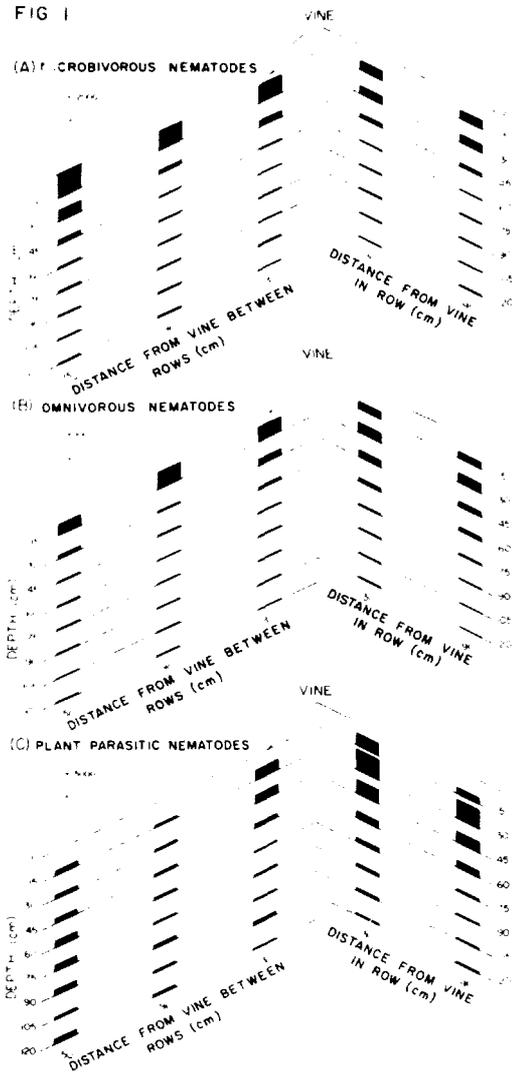


FIG 2

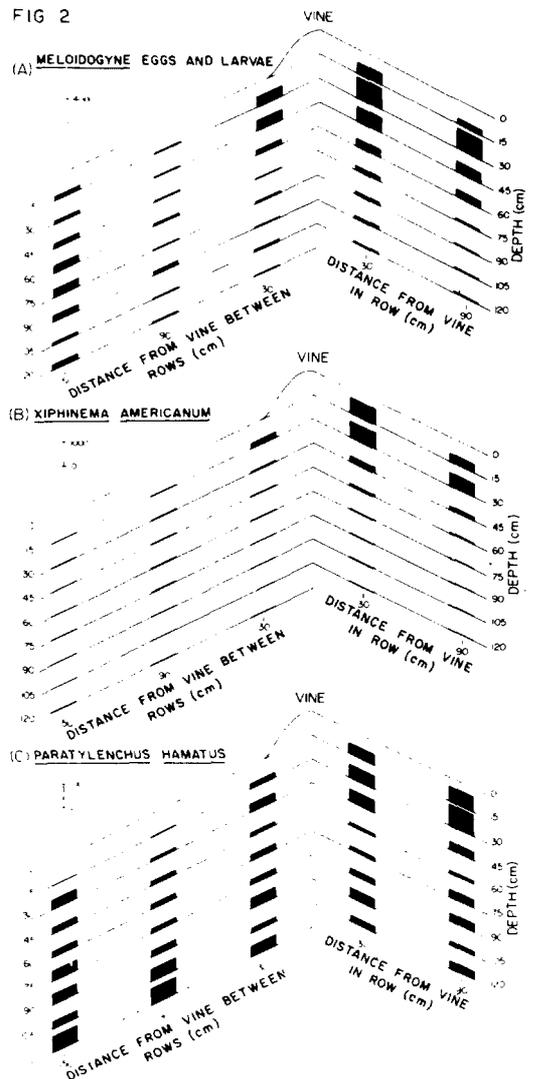


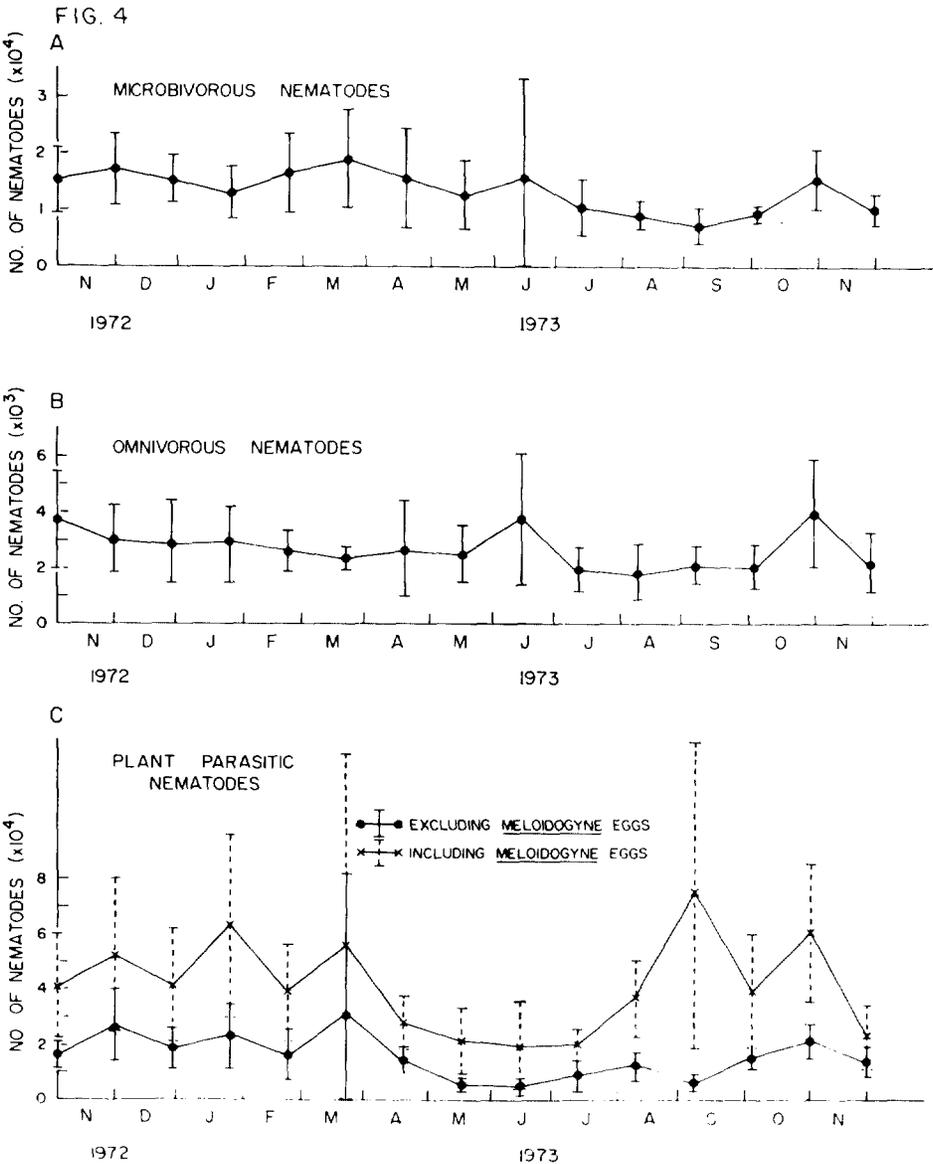
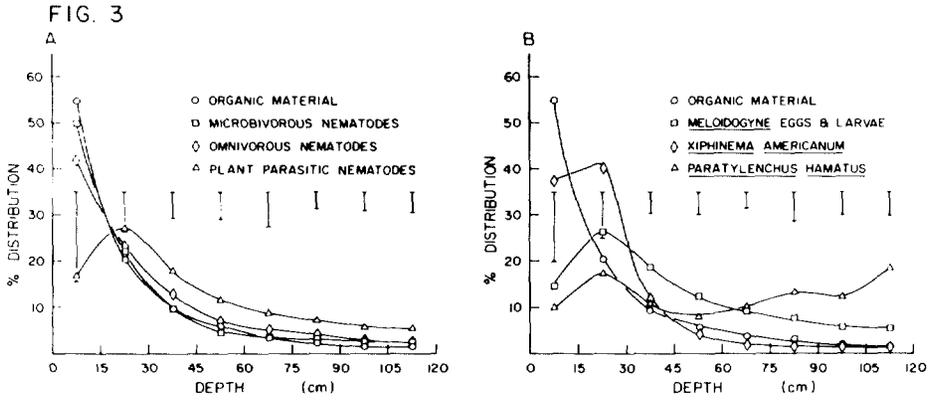
FIG. 1-2. 1) Spatial distribution of nematode trophic groups in a vineyard soil. Each point represents the number of nematodes in 500 cm³ of soil in an average of 90 samples taken at that location over a 13-month sampling period. 1-A) Microbivorous nematodes. 1-B) Omnivorous nematodes. 1-C) Plant-parasitic nematodes. 2) Spatial distribution of components of the plant-parasitic nematode trophic group in a vineyard soil. Each point represents the number of nematodes in 500 cm³ of soil in an average of 90 samples taken at that location over a 13-month sampling period. 2-A) *Meloidogyne* spp. 2-B) *Xiphinema americanum*. 2-C) *Paratylenchus hamatus*.

in the top 45 cm of soil far exceeded that of the omnivores and the parasites (Fig. 5-D). Below 45 cm, the contributions were variable with increasing depth. The contribution of the parasite group to the total nematode biomass between rows was miniscule (Fig. 5-F).

Of the parasite group, *X. americanum* dominated the biomass in the top 45 cm of soil in the row (Fig. 5-G). *Paratylenchus hamatus* had little contribution to the total

biomass. *Meloidogyne* spp. larval biomass generally varied little with depth but was very low in the top 15 cm of soil. Biomass values between rows were low for all species of the parasitic group (Fig. 5-H).

Variability of Nematode Distribution: The mean coefficient of variation for the groups of six vines was higher for *P. hamatus* than for the other parasitic nematodes, including *Meloidogyne* eggs, as evaluated by Duncan's Multiple Range Test



(Table 1). The coefficient of variation for *X. americanum* was greater than that for *Meloidogyne* larvae. The coefficients of variation among vines for the trophic groups and higher parasitic taxa were not significantly different (Table 1).

DISCUSSION

Distribution of microbivorous, omnivorous, and parasitic nematodes in the soil was compatible with the distribution of their food sources. Organic litter resulting from fallen leaves and berries was concentrated near the soil surface in the row. The associated microflora and microfauna provided a food source for the microbivores and omnivores in this region. Soil microbes associated with annual surface applications of chicken manure and vine prunings between the rows provided food for microbivores and omnivores in this area. Greatest densities of root material occurred in the plant row (4).

The use of biomass in community structure studies gives a better indication than does numerical data of the total metabolism attributable to each trophic group and its importance in organic turnover and oxygen consumption in the soil ecosystem. Biomass also gives a better indication of the amount of food material required to support each group. However, the metabolic rate of the individual species in each trophic group is also important in such studies and has not been considered here. Generally, the smaller the organism, the greater its metabolism per gram of biomass (11), and thus the smaller the biomass which can be supported at a particular trophic level.

The microbivorous nematodes were not only abundant but had a large biomass near the soil surface, particularly between rows. In contrast, the omnivores, also abundant near the surface, had a relatively small biomass in the upper 20-30 cm of the soil.

However, individuals in this trophic group were larger at greater depths and contributed more to the total biomass. This fact emphasizes the importance, as shown by Wasilewska (8), of body size as well as numbers in biomass determinations.

This relationship between body size and population density was also noted with the parasitic group. *Xiphinema americanum* was numerically fewer than the *Meloidogyne* larvae in the upper soil region but made a far greater contribution to the parasitic nematode biomass. This occurrence does not suggest that the biomass of a parasitic species supported by a plant is proportional to the damage caused. Inclusion of endoparasitic stages and eggs of *Meloidogyne* spp. in the determinations would have given a more accurate determination of biomass of this taxon. It would also have increased the proportional contribution of the plant parasites to the total nematode biomass at all depths sampled. In June, there probably were relatively few active *Meloidogyne* females in the roots and egg densities were at their lowest level (4). The influence of females and eggs on biomass would have been greater in September.

The microbivorous and omnivorous nematodes were at their greatest densities during the fall and winter months after the annual replenishment of organic material to the soil. These trophic groups also probably responded to the postharvest irrigation after the warm dry soil conditions prior to harvest. Production of feeder roots by grapevines in the spring (9) causes a seasonal variation in food availability for parasites. This is one of the factors determining seasonal changes in parasitic nematode densities and biomass.

Paratylenchus hamatus was less uniformly distributed than the other parasitic nematodes in the vineyard. There were large variations in numbers between vines, and the distribution within the root zone



FIG. 3-4. 3) Percent distribution with depth. Points are based on 450 samples taken at each depth over a 13-month period. 3-A) Nematode trophic groups. 3-B) Components of the plant-parasite trophic group. Bars denote LSD values ($P=0.05$) for comparisons between nematode groups at each depth. 4) Seasonal variation in nematode trophic groups in a vineyard soil. Points plotted represent the total nematode counts from 40 samples of 500 cm³ soil taken throughout the root zone and averaged across six vines on each date. Bars represent the standard deviation for the six vines on each date. 4-A) Microbivorous nematodes. 4-B) Omnivorous nematodes. 4-C) Plant-parasitic nematodes.

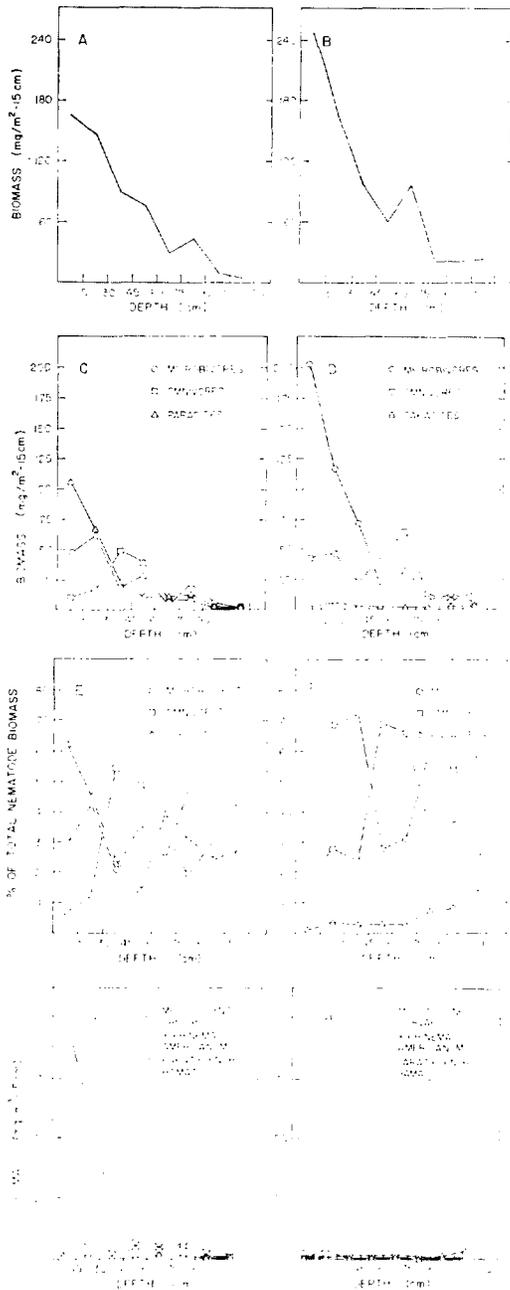


FIG. 5 (A-H). Nematode biomass studies in a vineyard soil. *A*) Total nematode biomass in the row. *B*) Total nematode biomass between rows. *C*) Biomass of trophic groups in the row. *D*) Biomass of trophic groups between rows. *E*) Percent distribution with depth of trophic group biomass in the row. *F*) Percent distribution with depth of trophic group biomass between rows. *G*) Biomass of the components of the plant-parasitic group in the row. *H*) Biomass of the components of the plant-parasitic group between rows. Biomass data are given at a location 90 cm from the vine in the row and 150 cm from the vine between rows. Data are based on m² of soil 15 cm thick.

TABLE 1. Mean coefficients of variation across 15 groups of six vines for total numbers of plant-parasitic nematodes, nematode higher taxa, and trophic groups in 40 samples from each vine.

Nematode group	Coefficient of variation ^a
<i>Plant-parasitic nematodes</i>	
<i>Meloidogyne</i> larvae ^b	58.1 x
<i>Meloidogyne</i> eggs	75.3 xy
<i>Meloidogyne</i> eggs and larvae	63.2 xy
<i>Xiphinema americanum</i>	82.9 y
<i>Paratylenchus hamatus</i>	150.4 z
L.S.D. (<i>P</i> = 0.05)	21.4
<i>Trophic groups and higher taxa</i>	
Microbivores	42.1
Omnivores	43.6
Plant parasites (— <i>Meloidogyne</i> eggs)	49.5
Plant parasites (+ <i>Meloidogyne</i> eggs)	54.7
Tylenchida (— <i>Meloidogyne</i> eggs)	56.7
Tylenchida (+ <i>Meloidogyne</i> eggs)	58.5

^aNumbers with common letters are not significantly different based on Duncan's Multiple Range Test. ^bSecond-stage larvae in soil samples.

of individual vines was more variable than with other parasitic species. We are unable to define the factors governing the densities of *P. hamatus*.

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