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ANALYSIS OF THE OCCURRENCE OF NEMATODES IN ALFALFA CROPS
II. ABUNDANCE AND QUANTITATIVE RELATIONS BETWEEN SPECIES AND ECOLOGICAL GROUPS OF SPECIES*

Investigations were made of nematode communities in two alfalfa cultures (*Medicago sativa* L.) situated in the Warsaw district. The aim of the study was: 1) to ascertain variations in the total abundance of nematodes during the study years and at different seasons of these years, 2) to trace the reciprocal quantitative relations between species occurring in plants and in the soil in different years of cultivation and 3) to analyse the structure and dynamics of ecological groups of nematodes occurring in plants and in the soil, depending on the age of the culture.

Contents

I. INTRODUCTION

In part I of the study (Wasilewska 1967) the species composition was presented of nematodes occurring both in the upper parts and roots of alfalfa

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plants, and also in the soil of two alfalfa crops. It was found that these crops were characterised by exceptionally great variety of species and of ecological forms of nematodes. It was also found that the majority of the species occurring in the soil penetrated into plants, but only a small number of these species maintained lasting contact with the plants.

The aim of the present study, which forms a continuation of research on the nematodes of the same two alfalfa crops, was as follows:

1. To ascertain variations in the abundance of nematodes occurring in the upper parts and roots of alfalfa plants and the soils of these cultures, both in different years of culture and at different seasons of the year.

2. To analyse the reciprocal quantitative relations between species occurring in plants and soil in different years of culture.

3. To analyse the structure and dynamics of the ecological groups of nematodes occurring in the plant and also the soil habitat, depending on the age of the culture.

II. STUDY AREA AND METHODS

The area covered by the investigations consisted of two alfalfa fields situated in the Warsaw district. A detailed description of the study area and soil profile of the fields examined is given in part I of this study (Wasilewska 1967).

Study methods (the way in which field samples were taken, representative selection from them of samples for species analysis, extraction and preparation of nematodes) were also presented in part I. The results obtained by these methods were used both to present the results discussed in part I and those discussed in the present part of this study. I will only mention that the investigations were made simultaneously in two alfalfa fields as follows:

1. A culture on station *A* during the study period 1960–1961, when the alfalfa was one year old, and in 1962–1963, when it was three years old.

2. A culture on station *B* during the study period 1960–1961, when the alfalfa was three years old, and in 1962–1963, when it was five years old.

Samples were taken once a month over two one-year periods (period I – 1960/1961, period II – 1962–1963), separately for the upper parts and roots of the alfalfa plants and for the soil. Species were identified in samples taken from field samples, i.e. in samples consisting of 5 g of the upper parts plants, 5 g of roots and 20 ml of soil. As shown by the comparison presented in part I of four analogical plant samples from one month, the occurrence of the numerous species of nematodes was fairly even in the plants. As the structure of the nematode community was estimated on the basis of a one-year period (and thus from 12 or 13 monthly samples) the size of the sample was therefore considered as sufficient to enable the quantitative proportions between species and groups of species to be determined.

III. ABUNDANCE OF NEMATODES IN THE ALFALFA CULTURES EXAMINED

Abundance of nematodes will be considered from two aspects: 1) of variations in successive years, 2) of variations over the yearly cycle.

The average density of nematodes over the year was compared for 1960/1961 and 1962/1963. On station *A* during the first study period, i.e. during the first year of culture of the alfalfa crop, the mean abundance of nematodes in the soil was 6.1 individuals per 1 ml; in the second, i.e. the third year of culture, 10.9 individuals per 1 ml. Correspondingly on station *B* in the first study period, i.e. the third year of culture, the figures were 6.4 individuals per 1 ml and in the second period, i.e. the fifth year of culture, 7.7 individuals per 1 ml. The mean density of nematodes were therefore found to increase on both stations over consecutive years of culture. This increase was far greater in the culture on station *A* than in that on station *B*. An analogical situation of increase in the mean density of individuals was observed in the roots during the second period in comparison with the first (Tab. I), but in the culture of younger alfalfa on station *A* this increase was almost five times as great. The low abundance of nematodes in roots during the first year of culture was probably due to the weak development of the root system. A considerable decrease in the average density of nematodes was observed in the upper parts of plants in the second study period in comparison with the first (Tab. I).

Average annual abundance of nematodes in soil (per 1 ml), in roots (per 1 g) and in the upper parts of alfalfa plants (per 1 g) during the two study periods

Tab. I

Study year	Soil		Roots		Upper parts	
	1960–1961	1962–1963	1960–1961	1962–1963	1960–1961	1962–1963
Station *A*	6.1	10.9	4.4	21.5	13.6	8.0
Year of culture	1	3	1	3	1	3
Station *B*	6.4	7.7	20.0	22.0	26.8	14.0
Year of culture	3	5	3	5	3	5

When comparing the two cultures analysed during the first study period it will be seen that despite the fact that the average density of nematodes in the soil did not differ on the two stations, the average density in the roots was five times, and in the upper parts of plants, twice as great in the culture on station *B*. During the second study period, with higher average density of nematodes in the soil, the density in the roots was similar, while in the upper parts of the plants it was almost twice as high in the culture on station *B*. Tulaganov (1949) and Karimova (1957) also observed tendencies to in-

creased abundance of nematodes in older alfalfa cultures. Baranovskaja (1959) and Baranovskaja-Milova (1961) is of a similar opinion as regards grass cultures several years old.

Seasonal variations in the abundance of nematodes will be considered, using as examples the cultures on station *B*. On station *A* the floods caused by rises in the water level of the Vistula contributed to the irregular course taken by variations in abundance during this period. During the period after flooding the abundance of nematodes in the culture on this station decreased considerably, which confirmed the observations made by Imamura (1931), Belaeva (1942) and Zuckerman, Khera, Pierce (1964). The course taken by variations in abundance over the yearly cycle is given for 1960–1961 and 1962–1963 in Figure 1. In all three of the habitats analysed (soil, roots and green parts of plants) the curve of dynamics exhibited two peaks. Increase in the abundance of nematodes in the soil was apparent during the spring (or spring – early summer) period, and during the autumn. Abundance was lowest during the summer and winter periods. A similar situation was observed in roots. The course taken by the curve of dynamics in roots is similar in general tendency to that for the soil. In the upper parts of plants abundance was observed to increase during the late summer period, and at the turning point between winter and early spring. There was a distinct peak in February and March 1961 in the upper parts of plants on station *A*, not discussed here. The absence of cyclic coincidence in increased abundance of nematodes in the upper parts of plants with increase in abundance in roots and soil is difficult to explain, having only the relatively little we know about nematodes at present as a guide. It is probable that these phenomena are affected by the migratory processes of nematodes from the soil to plant tissues (and vice versa) which take place, but not uniformly, in different species occurring in plant organs and soil, and also by the different reproduction rate of these species.

The character described above of the seasonal variations in abundance was in principle similar in the two study years, both in respect of the soil and the roots and upper parts of plants. The effect of temperature on the abundance of nematodes was perceptible mainly during the winter months, when low temperatures limited the abundance of populations in the soil and roots. The relatively low maximum abundance in the upper parts of plants during the winter – early spring period in 1962–1963 is probably connected with the far lower temperature during this period than in 1960–1961. It is possible that differences in abundance between the study years in relation to the upper parts of plants during the late summer peak were due to the difference in the time of occurrence of the greatest rainfall during these periods. The heavy rainfall in June 1960, August 1962 and July 1963 was accompanied by reduction in abundance of nematodes in soil and roots. When, however, rainfall was uniformly heavy reduced abundance was far more marked in some months than in others.

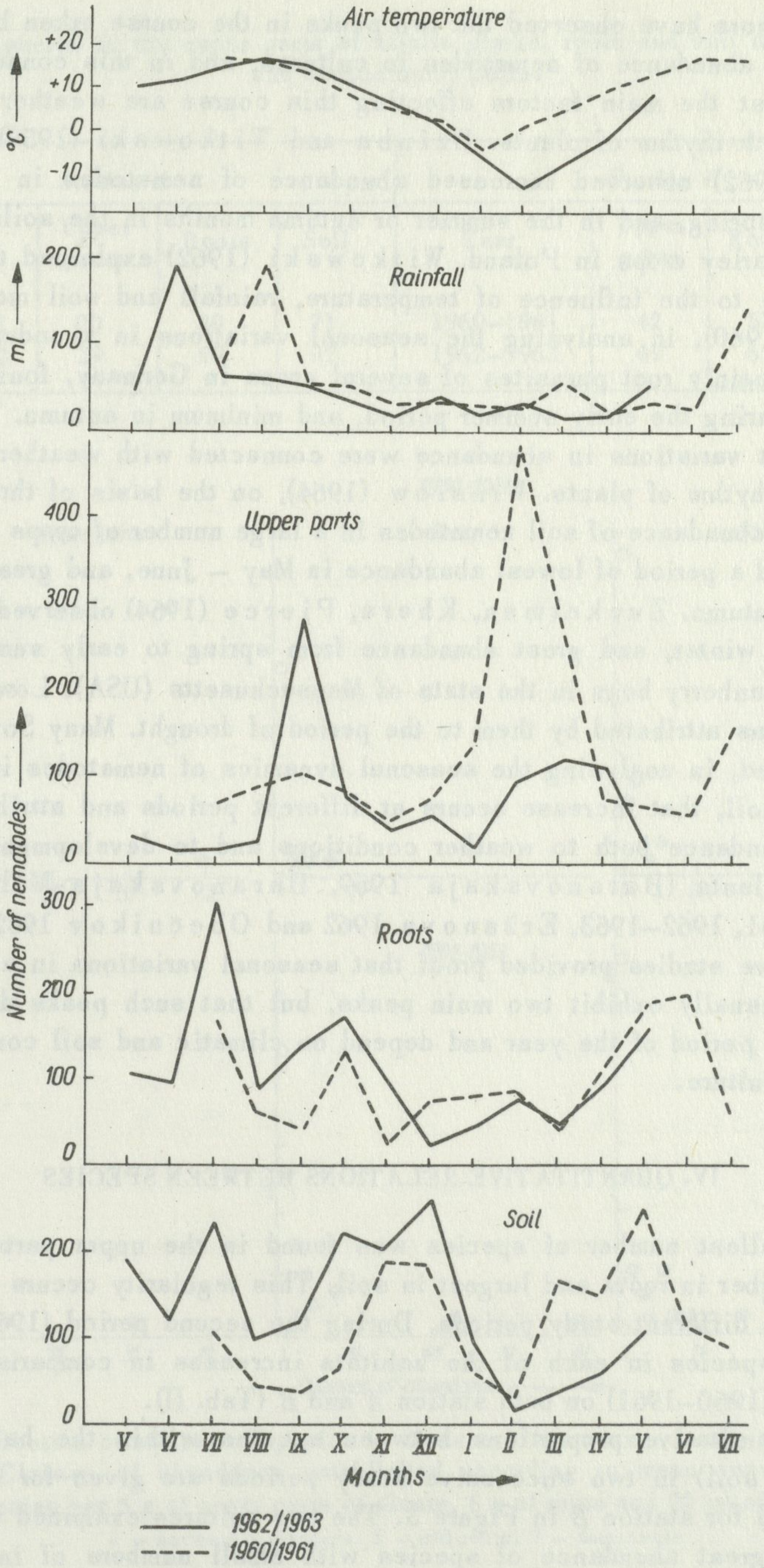

Fig. 1. Seasonal variations in total abundance of nematodes (in the upper parts and roots of plants, per 5 g, in soil, per 20 ml) in an alfalfa crop on station *B*

Many authors have observed the two peaks in the course taken by seasonal variations in abundance of nematodes in cultures, and in this connection have suggested that the main factors affecting this course are weather conditions and the growth rhythm of plants. Dziuba and Witkowski (1959) and Witkowski (1962) observed increased abundance of nematodes in the winter, or winter – spring, and in the summer or autumn months in the soils of wheat, potato and barley crops in Poland. Witkowski (1962) explained these variations as due to the influence of temperature, rainfall and soil moisture. Cichorius (1960), in analysing the seasonal variations in abundance of soil nematodes, mainly root parasites of several crops in Germany, found maximum abundance during the early summer period, and minimum in autumn. This author assumes that variations in abundance were connected with weather conditions and growth rhythm of plants. Winslow (1964), on the basis of three years of study of the abundance of soil nematodes in a large number of crops in England, distinguished a period of lowest abundance in May – June, and greatest in late summer or autumn. Zuckerman, Khera, Pierce (1964) observed low abundance during winter, and great abundance from spring to early summer and in autumn in cranberry bogs in the state of Massachusetts (USA). Low abundance in summer was attributed by them to the period of drought. Many Soviet authors have observed, in analysing the seasonal dynamics of nematodes in plants, or plants and soil, that increase occurs at different periods and attributed variations in abundance both to weather conditions and to development phases of cultivated plants (Baranovskaja 1959, Baranovskaja-Milova 1961, Krylov 1961, 1962–1963, Eržanova 1962 and Obečnikov 1962).

The above studies provided proof that seasonal variations in abundance of nematodes usually exhibit two main peaks, but that such peaks do not occur at a uniform period of the year and depend on climatic and soil conditions and the kind of culture.

IV. QUANTITATIVE RELATIONS BETWEEN SPECIES

The smallest number of species was found in the upper parts of plants, a larger number in roots and largest in soil. This regularity occurs on both stations in two different study periods. During the second period (1962–1963) the number of species in each of the habitats increases in comparison with the first period (1960–1961) on both station *A* and *B* (Tab. II).

The quantitative proportions between species within the habitats (plant organs and soil) in two successive study periods are given for station *A* in Figure 2 and for station *B* in Figure 3. The two cultures examined were characterised by great abundance of species with small numbers of individuals in each species, and a relatively small number of numerous species. On the basis of discontinuity of distribution of the number of species in classes of abund-

Number of species in the upper parts of alfalfa plants, roots and soil during the first and second study period

Tab. II

Station *A*				Station *B*			
Year	Upper parts	Roots	Soil	Year	Upper parts	Roots	Soil
1960–1961	20	30	71	1960–1961	42	52	70
1962–1963	29	69	97	1962–1963	49	62	81

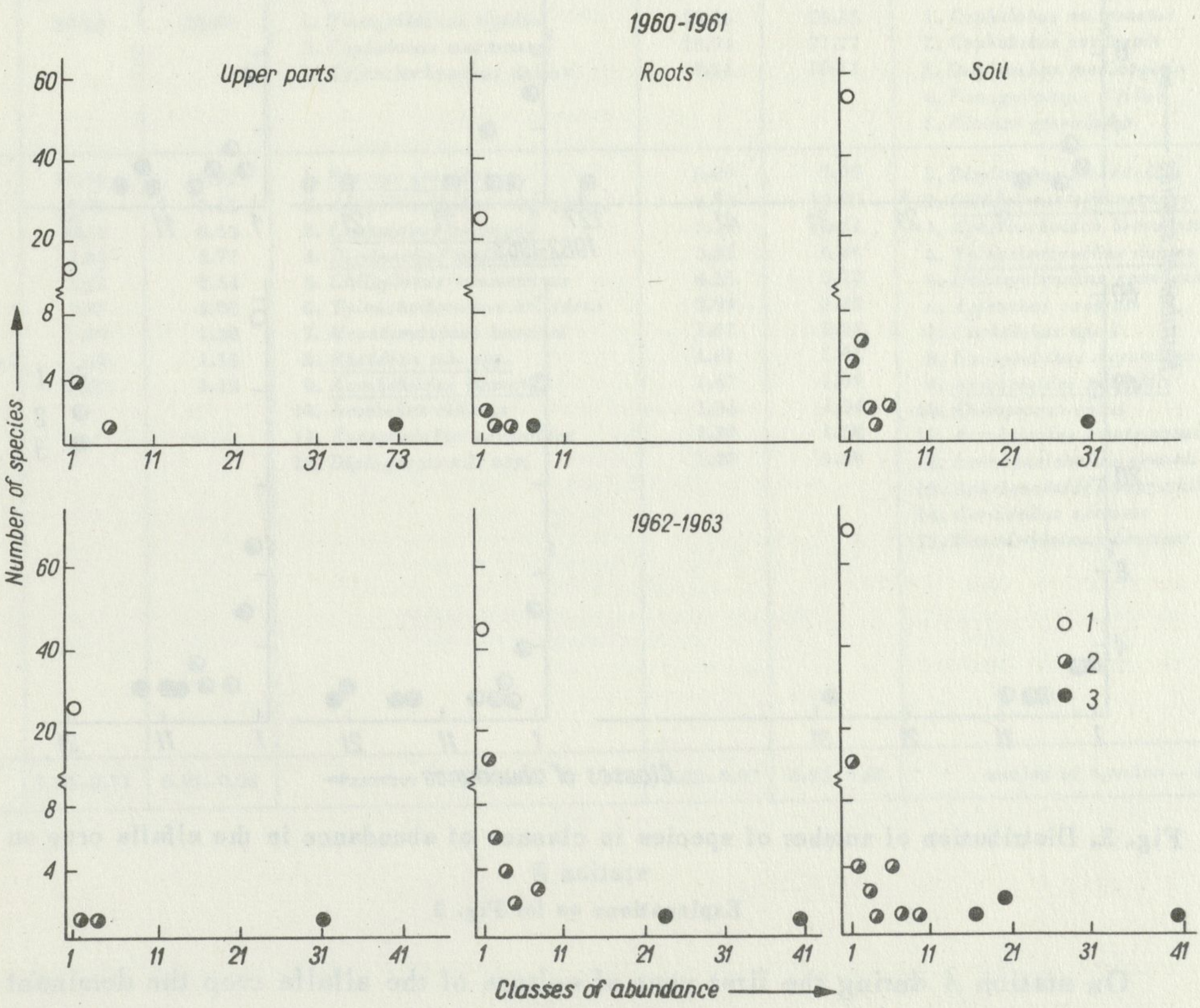

Fig. 2. Distribution of number of species in classes of abundance in the alfalfa crop on station *A*. Classes of abundance established according to mean annual density of species per 5 g of upper parts of plants, 5 g of roots and 20 ml of soil

1 – accessory species, *2* – influents, *3* – dominants

ance (Figs. 2 and 3) it proved possible to distinguish three groups of species: dominants, influents and accessory species. The accessory species occurred

in the class of abundance from 0–1, influents mainly from 1–10, and dominants mainly over 10 individuals per units defined in Figure 2 and 3. Tables III and IV give the names of species, percentage and mean density of the groups of species distinguished.

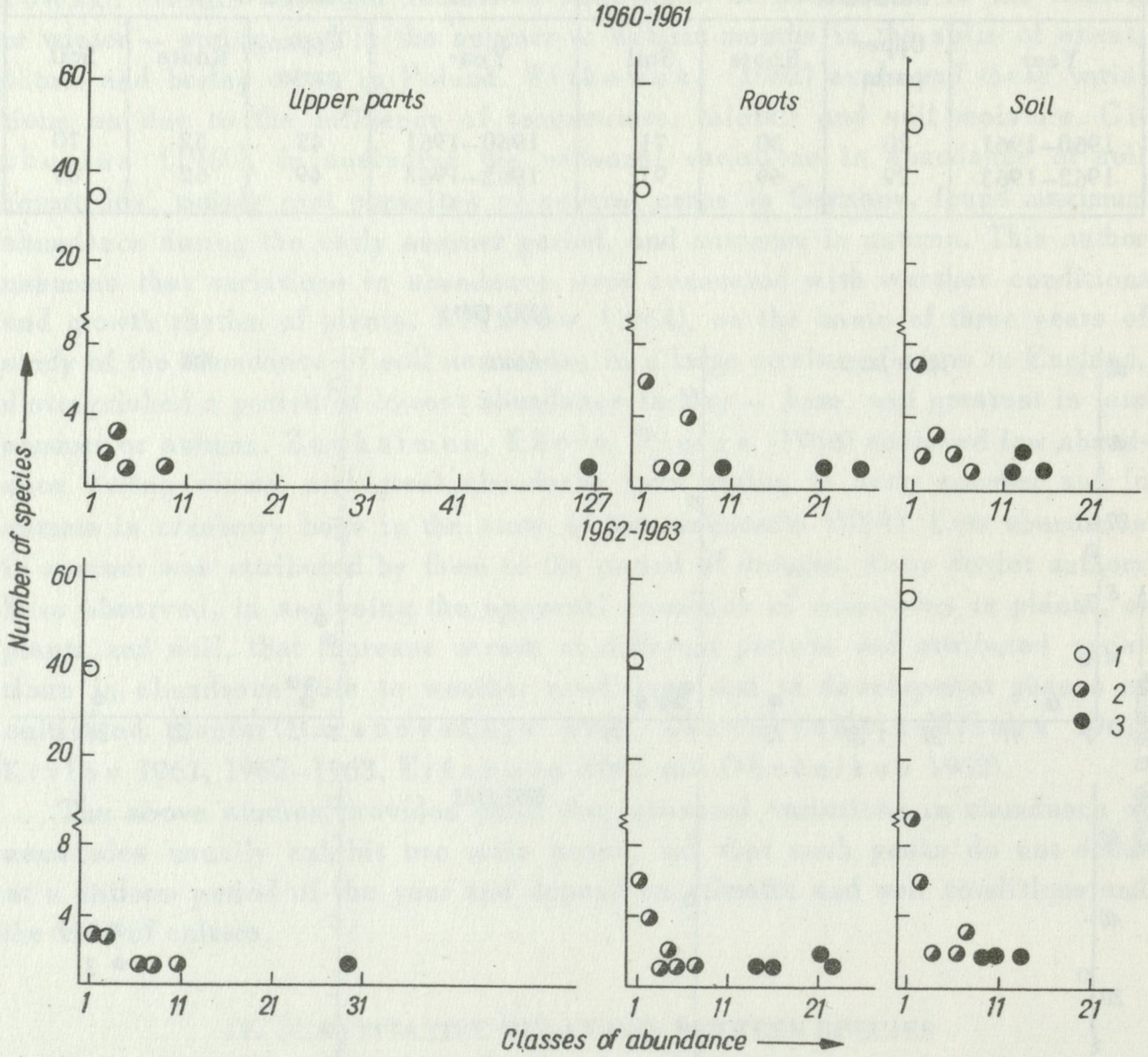

Fig. 3. Distribution of number of species in classes of abundance in the alfalfa crop on station *B*

Explanations as for Fig. 2

On station *A* during the first year of culture of the alfalfa crop the dominant in the upper parts of plants was *Panagrolaimus rigidus*, the percentage of which was about 84%. It continued as the only outstanding dominant during the following years, although its abundance decreased. *P. rigidus* also continued as a dominant in the roots, but the percentage of this species was smaller in comparison with the percentage in the upper parts of plants. In the soil *P. rigidus* occurred as an influent, its percentage being little more than 2%. The second dominant in roots on station *A* during the second study period was *Cephalobus*

Quantitative relations between species of nematodes in alfalfa crop on station *A*

Tab. III

	Upper parts						Roots						Soil					
	1960–1961	*P*	*L*	1962–1963	*P*	*L*	1960–1961	*P*	*L*	1962–1963	*P*	*L*	1960–1961	*P*	*L*	1962–1963	*P*	*L*
Dominants	1. *Panagrolaimus rigidus*	84.18	72.75	1. *Panagrolaimus rigidus*	77.66	31.58	1. *Panagrolaimus rigidus*	31.52	7.91	1. *Panagrolaimus rigidus*	31.41	40.33	1. *Helicotylenchus canadensis*	31.78	30.45	1. *Helicotylenchus canadensis*	19.93	41.42
										2. *Cephalobus mucronatus*	18.30	23.50				2. *Rhabditis* s.l. spp.	10.06	20.92
																3. *Paratylenchus aciculus*	9.86	20.50
																4. *Dorylaimellus parvulus*	8.14	16.22
Influents	1. *Aphelenchoides saprophilus*	6.07	5.25	1. *Aphelenchoides saprophilus*	6.15	2.50	1. *Chiloplacus symmetricus*	19.93	5.00	1. *Chiloplacus symmetricus*	5.91	7.58	1. *Chiloplacus symmetricus*	7.11	6.82	1. *Boleodorus thylactus*	4.45	9.25
	2. *Chiloplacus symmetricus*	2.12	1.83	2. *Cephalobus mucronatus*	2.87	1.17	2. *Cephalobus mucronatus*	10.87	2.73	2. *Aphelenchoides bicaudatus*	5.64	7.25	2. *Boleodorus thylactus*	6.74	6.45	2. *Tylenchus ditissimus*	3.45	7.17
	3. *Plectus cirratus*	1.73	1.50				3. *Cephalobus persegnis*	6.88	1.73	3. *Ditylenchus medicaginis*	3.70	4.75	3. *Paratylenchus aciculus*	4.93	4.73	3. *Paratylenchus microdorus*	3.33	6.92
	4. *Cephalobus mucronatus*	1.25	1.08				4. *Helicotylenchus canadensis*	4.35	1.09	4. *Acrobeloides bütschlii*	2.40	3.08	4. *Cephalobus mucronatus*	3.89	3.73	4. *Chiloplacus symmetricus*	3.29	6.83
	5. *Paraphelenchus pseudoparietinus*	1.25	1.08							5. *Cephalobus persegnis*	2.40	3.08	5. *Rhabditis* s.l. spp.	3.70	3.54	5. *Tylenchus vulgaris*	3.21	6.67
										6. *Plectus granulosus*	2.14	2.75	6. *Tylenchus vulgaris*	3.04	2.91	6. *Paratylenchus nanus*	3.05	6.33
										7. Aphelenchoides *saprophilus*	2.08	2.67	7. *Aphelenchus avenae*	2.94	2.82	7. *Panagrolaimus rigidus*	2.08	4.33
										8. *Aphelenchus avenae*	1.95	2.50	8. *Dorylaimellus parvulus*	2.85	2.73	8. *Tylenchus magnidens*	1.64	3.42
										9. *Tylenchus vulgaris*	1.88	2.42	9. *Acrobeloides bütschlii*	2.47	2.36	9. *Eudorylaimus pratensis*	1.60	3.33
										10. *Mesodorylaimus bastiani*	1.30	1.67	10. *Paratylenchus microdorus*	2.37	2.27	10. *Cephalobus mucronatus*	1.52	3.17
										11. *Laimaphelenchus penardi*	1.23	1.58	11. *Panagrolaimus rigidus*	2.28	2.18	11. *Aphelenchus avenae*	1.40	2.92
										12. *Pratylenchus pratensis*	1.23	1.58	12. *Tylenchus duplexus*	1.61	1.54	12. *Tylenchus minutus*	1.40	2.92
										13. *Chiloplacus bisexualis*	1.23	1.58	13. *Tylenchorhynchus dubius*	1.42	1.36	13. *Pratylenchus penetrans*	1.40	2.92
										14. *Plectus cirratus*	1.17	1.50	14. *Eudorylaimus pratensis*	1.42	1.36	14. *Eudorylaimus monohystera*	1.12	2.33
										15. *Aglenchus costatus*	1.17	1.50	15. *Aglenchus costatus*	1.33	1.27	15. *Tylencholaimellus striatus*	0.84	1.75
										16. *Rhabditis* s.l. spp.	1.04	1.33	16. *Pratylenchus penetrans*	1.14	1.09	16. *Pratylenchus neglectus*	0.76	1.58
										17. *Paraphelenchus pseudoparietinus*	0.97	1.25				17. *Diphtherophora communis*	0.76	1.58
										18. *Acrobeloides emarginatus*	0.97	1.25				18. *Aphelenchoides saprophilus*	0.68	1.42
										19. *Chiloplacus quadricarinatus*	0.91	1.17				19. *Ditylenchus intermedius*	0.64	1.33
										20. *Helicotylenchus canadensis*	0.84	1.08				20. *Acrobeloides bütschlii*	0.64	1.33
										21. *Diplogaster* s.l. spp.	0.84	1.08				21. *Acrobeloides* sp. 2	0.64	1.33
																22. *Tylenchus davainei*	0.60	1.25
																23. *Aphelenchoides bicaudatus*	0.56	1.17
																24. *Tylenchus baloghi*	0.56	1.17
																25. *Tylenchus duplexus*	0.52	1.08
Accessory species	number of species – 14	0.77–0.10	0.67–0.08	number of species – 26	2.05–0.20	0.83–0.08	number of species – 25	2.54–0.36	0.64–0.09	number of species – 45	0.71–0.06	0.92–0.08	number of species – 54	1.04–0.09	1.00–0.09	number of species – 68	0.48–0.08	1.00–0.08

P – percentage of species in relation to abundance of all nematodes, calculated on the basis of average densities in a year.

L – mean density of a species in a year per 5 g of upper parts of plants, 5 g of roots or 20 ml of soil.

Among influents the species have been underlined which occupied the position of dominant in any habitat in 1960–1961 or 1962–1963.

Quantitative relations between species of nematodes in alfalfa crop on station *B*

Tab. IV

	Upper parts						Roots						Soil					
	1960–1961	*P*	*L*	1962–1963	*P*	*L*	1960–1961	*P*	*L*	1962–1963	*P*	*L*	1960–1961	*P*	*L*	1962–1963	*P*	*L*
Dominants	1. *Panagrolaimus rigidus*	76.64	126.69	1. *Panagrolaimus rigidus*	39.62	28.62	1. *Panagrolaimus rigidus* 2. *Cephalobus mucronatus* 3. *Tylenchorhynchus dubius*	22.76 18.94 9.24	26.15 21.77 10.61	1. *Cephalobus mucronatus* 2. *Cephalobus persegnis* 3. Ditylenchus *medicaginis* 4. *Panagrolaimus rigidus* 5. *Plectus granulosus*	14.96 13.98 13.46 10.26 9.13	22.30 20.84 20.07 15.30 13.61	1. *Rhabditis* s.l. spp. 2. *Acrobeloides bütschlii* 3. *Chiloplacus symmetricus* 4. *Aphelenchus avenae*	13.54 11.27 11.27 10.63	14.69 12.23 12.23 11.54	1. *Aphelenchus avenae* 2. *Chiloplacus symmetricus* 3. *Rhabditis* s.l. spp.	10.44 8.00 7.39	13.15 10.08 9.31
Influents	1. *Aphelenchoides saprophilus* 2. *Tylenchorhynchus dubius* 3. *Cephalobus mucronatus* 4. *Paraphelenchus pseudoparietinus* 5. *Ditylenchus medicaginis* 6. *Deladenus durus* 7. *Plectus granulosus*	5.40 2.79 2.28 2.23 2.14 1.67 1.63	8.92 4.62 3.77 3.69 3.54 2.77 2.69	1. *Ditylenchus medicaginis* 2. *Plectus granulosus* 3. *Cephalobus mucronatus* 4. *Cephalobus persegnis* 5. *Aphelenchoides saprophilus* 6. *Aphelenchoides bicaudatus* 7. *Chiloplacus symmetricus* 8. *Paraphelenchus pseudoparietinus* 9. *Ditylenchus intermedius*	15.12 9.90 8.52 3.83 3.51 2.87 1.92 1.60 1.60	10.92 7.15 6.15 2.77 2.54 2.08 1.38 1.15 1.15	1. *Plectus granulosus* 2. *Apchelenchoides saprophilus* 3. *Cephalobus persegnis* 4. *Ditylenchus' medicaginis* 5. *Chiloplacus symmetricus* 6. *Tylenchorhynchus brevidens* 7. *Mesodorylaimus bastiani* 8. *Rhabditis* s.l. spp. 9. *Acrobeloides bütschlii* 10. Acrobeles *ciliatus* 11. *Eucephalobus oxyuroides* 12. *Diplogaster* s.l. spp.	6.09 6.02 5.76 5.62 4.55 2.94 1.67 1.61 1.47 1.34 1.20 1.20	7.00 6.92 6.61 6.46 5.23 3.38 1.92 1.85 1.69 1.54 1.38 1.38	1. *Ditylenchus intermedius* 2. *Chiloplacus symmetricus* 3. *Aphelenchoides bicaudatus* 4. *Tylenchorhynchus dubius* 5. *Helicotylenchus canadensis* 6. *Aglenchus costatus* 7. *Cephalobus* sp. 1 8. *Eucephalobus oxyuroides* 9. *Acrobeloides bütschlii* 10. *Chiloplacus soosi* 11. *Acrobeloides emarginatus* 12. *Laimaphelenchus penardi* 13. *Aphelenchoides saprophilus* 14. *Cervidellus serratus* 15. *Mesodorylaimus bastiani*	5.05 3.51 3.14 2.84 2.17 1.91 1.86 1.75 1.65 1.34 1.29 1.13 1.03 0.93 0.88	7.54 5.23 4.69 4.23 3.23 2.85 2.77 2.61 2.46 2.00 1.92 1.69 1.54 1.38 1.31	1. *Tylenchorhynchus brevidens* 2. *Panagrolaimus rigidus* 3. *Tylenchorhynchus dubius* 4. *Cephalobus mucronatus* 5. *Paratylenchus nanus* 6. *Acrobeles ciliatus* 7. *Pratylenchus neglectus* 8. *Acrobeloides setosus* 9. *Eucephalobus oxyuroides* 10. *Cephalobus persegnis* 11. *Eucephalobus striatus* 12. *Apheloncholdes saprophilus* 13. *Plectus cirratus* 14. *Cervidellus serratus* 15. *Aglenchus costatus*	7.37 5.17 4.82 3.40 3.05 2.98 2.05 1.91 1.56 1.56 1.42 1.35 1.27 1.20 1.13	8.00 5.61 5.23 3.69 3.31 3.23 2.23 2.08 1.69 1.69 1.54 1.46 1.38 1.31 1.23	1. *Meloidogyne hapla* 2. *Tylenchorhynchus dubius* 3. *Aglenchus costatus* 4. *Acrobeloides bütschlii* 5. *Pratylenchus neglectus* 6. *Eucephalobus oxyuroides* 7. *Helicotylenchus canadensis* 8. *Tylenchorhynchus brevidens* 9. *Eudorylaimus pratensis* 10. *Cervidellus serratus* 11. *Cephalobus mucronatus* 12. *Tylenchus vulgaris* 13. *Acrobeles ciliatus* 14. *Acrobeloides setosus* 15. *Panagrolaimus rigidus* 16. *Aphelenchoides saprophilus* 17. *Wilsonema otophorum* 18. *Diphtherophora brevicolle* 19. *Diphtherophora communis* 20. *Tylenchus minutus* 21. *Tylenchus sandneri* 22. *Cephalobus persegnis*	6.23 5.98 5.86 5.19 4.82 3.17 3.17 2.38 2.26 2.26 2.14 1.65 1.65 1.53 1.46 1.28 1.28 1.16 1.10 0.98 0.85 0.85	7.85 7.54 7.38 6.54 6.08 4.00 4.00 3.00 2.85 2.85 2.69 2.08 2.08 1.92 1.85 1.61 1.61 1.46 1.38 1.23 1.08 1.08
Accessory species	number of species – 34	0.60–0.05	1.00–0.08	number of species – 39	1.28–0.11	0.92–0.08	number of species – 37	0.80–0.07	0.92–0.08	number of species – 42	0.67–0.05	1.00–0.08	number of species – 51	0.78–0.07	0.85–0.08	number of species – 56	0.79–0.06	1.00–0.08

Explanations as for Table III.

mucronatus, which occurred as an influent in roots during the first period and also as such in the upper parts of plants and in the soil. Other species were dominants in the soil than in plants. During the first study period the only outstanding dominant was *Helicotylenchus canadensis*, but in the second period, in addition to this species, *Rhabditis* s.l. spp., *Paratylenchus aciculus* and *Dorylaimellus parvulus* shifted from the position of influents to that of dominants. *H. canadensis* occurres in roots also as an influent species.

In the older alfalfa crop on station *B*, as in the younger alfalfa crop, the only dominant in the upper parts of plants was *P. rigidus*. The percentage of this species during the first period was about 77%, and about 40% during the second. *P. rigidus* maintained its position of dominant in roots (its percentage was 23% in the first period, and 10% in the second), and the position of influent in the soil. The number of dominants was greater in the roots of plants on station *B* than on station *A*. During the first period, apart from the above-mentioned *P. rigidus*, two species: *C. mucronatus* and *Tylenchorhynchus dubius* were also dominants. *C. mucronatus*, which also dominated in roots during the second study period, was, as on station *A*, an influent in the upper parts of plants and in the soil. During the second period *T. dubius* was less numerous in roots and occupied the position of influent. It was also among the influents in the soil of this station. During the second study period, in addition to *C. mucronatus* and *P. rigidus*, which were dominants in first study period, *Ditylenchus medicaginis*, *Cephalobus persegnis* and *Plectus granulosus* also occupied the position of dominants in roots. *D. medicaginis* was an influent in the upper parts of plants (with a far higher density during the second period) and in the first period in roots, while it occurred as one of the group of accessory species in the soil. *C. persegnis* occurred as influent in the remaining habitats. *P. granulosus* was an influent in the first study period in roots and in upper parts of plants. Species dominating in the soil on this station were not among the dominants in plants, but belong to the group of influents or accessory species. *Rhabditis* s.l. spp. was a dominant in the soil in two periods and an influent in roots. *Acrobeloides bütschlii* was a dominant in the soil during the first period, and an influent in the second, and was also an influent in roots. *Chiloplacus symmetricus* and *Aphelenchus avenae* dominated in the soil over the whole study period. The first of these was an influent in roots and the upper parts of plants, while the second was an accessory species in these habitats.

Although a relatively large number of species common to soil, roots and the upper parts of plants occurred in the group of dominants and influents, the quantitative relations between these species in each of the habitats were not uniform. The differences were due to the different character of domination. The most sharply defined domination was observed in the upper parts of plants, less distinct in roots and least distinct in soil. Evidence of this is provided by the percentage of the most numerous dominants in the upper parts of plants,

roots and soil. During the first period (1960–1961) this percentage was approximately: on station *A* – 84.2%, 31.5%, 31.8%; on station *B* – 76.6%, 22.8%, 13.5%. Corresponding values for the second period were: on station *A* – 77.6%, 31.4%, 19.9%; on station *B* – 39.6%, 15.0% and 10.4%.

The joint number of dominants and influents was lowest in the upper parts of plants, higher in roots and highest in the soil on both station *A* and station *B* (Tab. V). In addition to the percentages given above for the most numerous dominants this also shows that domination is more sharply defined in the upper parts of plants than in roots and soil. During the second study period the joint number of dominants and influents increased in comparison with the first period in all the habitats on both stations (Tab. V). An exception to this was the higher number of dominants and influents in the upper parts of plants on station *A*. during the first study period. In the second period, however, the absolute abundance and percentage of the only dominant – *Panagrolaimus rigidus* – were considerably reduced (Fig. 2 and Tab. III). The above facts point to weakening of domination in the upper parts and roots of plants and in the soil during the second study period in comparison with the first period on both stations.

Combined number of dominants and influents

Tab. V

Year	Station *A*			Station *B*		
	upper parts	roots	soil	upper parts	roots	soil
1960–1961	6	5	17	8	15	19
1962–1963	3	23	29	10	20	25

Conclusions as to the sharper nature of domination of species in the upper parts of plants than in the roots and soil, and sharper in roots than in the soil, and also as to weakening of domination during the second study period, are confirmed by comparison of the mean percentage for one species in a group of dominants (Tab. VI). Higher values of the mean percentage for one dominating

Mean percentage for one dominant

Tab. VI

year	Station *A*			Station *B*		
	upper parts	roots	soil	upper parts	roots	soil
1960–1961	84.2	31.5	31.8	76.4	17.0	11.7
1962–1963	77.7	24.8	12.0	39.6	12.4	8.6

species indicates more sharply defined domination relations. Comparison of the mean percentage for one dominant between stations *A* and *B* respectively for the upper parts, roots and soil, indicates more sharply defined domination relations on station *A* in both study periods.

V. ECOLOGICAL GROUPS

Three main groups can be distinguished among plant and soil nematodes on the basis of their food preferences and morphological structure: 1) saprobionts, possessing a simple stoma without spear or teeth and feeding chiefly on organic residues and bacteria, 2) predators, the stoma of which is provided with teeth or denticles – they attack minute soil animals and 3) parasites of higher plants, fungi and animals, possessing a stylet. Plant parasites feed on the fluid contents of living plant cells. This classification has been used by many authors (Christie 1959, Winslow 1960, 1964, Wallace 1963).

Paramonov, who used a different classification (1952, 1962, 1964), accepted the degree of attachment between nematodes and plants as a criterion. He established the following general classes:

1. Pararhizobionts – free-living soil nematodes exhibiting a tendency to living near the root system of plants and passing through their whole ontogenesis in a soil habitat. Many species in this group are distinguished by their capacity for sucking the juices from roots and other plant organs, part lead a predatory way of life.

2. Eusaprobionts – saprobiotic forms, living in a habitat formed of decomposing organic residues and feeding on bacterial flora and detritus.

3. Devisaprobionts (non-typical saprobionts) – encountered not only in a saprobiotic habitat, but also in tissues which optically appear healthy. Their significance to plants has not as yet been sufficiently investigated. It is highly probable that they feed on plant tissue, damaging it mechanically but not having any pathogenic significance to plants.

4. Phytohelminths – attacking healthy plant tissue and transforming it into diseased tissue. Among phytohelminths facultative or obligatory ecto- and endoparasites, feeding at the expense of plants, are distinguished. The majority of phytohelminths repeat their ontogenetic cycles in host plants or in soil and host plants. The effect of phytohelminths on plants, in Paramonov's opinion, consists in causing mechanic damage, introducing infection and causing pathological processes. This last property applies to pathogenically specific phytohelminths.

A more detailed discussion of Paramonov's classification is given in a separate article (Roguska-Wasilewska 1961). His classification is characterised by the fact that the relation of a given group of nematodes to

a plant is conditioned not only by the properties of this group, but also by the group's connection with other groups of nematodes. Processes directing variation of ecological groups in time may be analysed on this basis. Research of this type in phytonematology has only just begun and is applied only by the Paramonov school.

According to Paramonov (1962) the occurrence of defined relations between different ecological groups of nematodes is connected with the physiological condition of the plants in which they occur. Particularly sharp differences occur in this respect between healthy and diseased plants. In this connection Paramonov (1962) distinguished three patterns of occurrence of nematodes, characterised by definite relations between different groups, and also by specific quantitative relations within the ecological groups. These are as follows: heterotypical, monotypical and secondary heterotypical pattern of occurrence in plants. The first of these is characteristic of healthy, and the other two of diseased, plants.

The heterotypical pattern of occurrence of nematodes in plants is characterised by the small number of species in the eusaprobiont group, far higher number of species in the group of devisaprobionts and largest number of species in the phytohelminth group. On the other hand the abundance of individuals is greatest in the devisaprobiont group and lowest in the eusaprobiont group. Relatively low abundance occurs in the phytohelminth group within the numerous species forming this group. Pararhizobionts are not excluded from this pattern of occurrence. Many Soviet faunistic studies on the entire nematofauna of certain crops, based on quantitative data, show that it is this pattern of occurrence of nematodes which is frequent. The heterotypical pattern of occurrence was observed in many cultivated plants, including alfalfa (Meržeevskaja 1953, Karimova 1957, Tulaganov 1960, Baranovskaja 1958, 1959, 1960, Baranovskaja-Milova 1961).

The monotypical pattern of occurrence was observed during intensive invasion of plants by one of the species from the phytohelminth group with pathogenic properties. The population of such a species completely occupies the plant or its organs. When nematonecrosis is created the reproductive energy of the pathogen decreases, and eusaprobionts appear, at first scantily, and later abundantly.

The secondary heterotypical pattern of occurrence is characterised by a large number of species and great abundance, chiefly of eusaprobionts, then phytohelminths feeding on the hyphae of fungi. The participation of pathogenic phytohelminths is slight, and in any case their abundance decreases together with the process of forming the above pattern of occurrence. The genesis of the secondary heterotypical pattern of occurrence may be of two kinds. Occurrence of this kind may form as the result of mycosis and bacteriosis or as the result of nematonecrosis resulting from monotypical occurrence.

The quantitative relations between ecological groups in plants and soil, way in which the nematodes occur in plants and variations in the way of occurrence between the two study periods were examined in the alfalfa cultures under discussion.

Paramonov's classification was applied in analysing the ecological groups of nematodes occurring in crops examined, but nomenclature was accepted after Tischler (1965). The following groups were distinguished: 1) pararhizobionts, 2) eusaprobionts, 3) hemisaprobionts (according to Paramonov's nomenclature – devisaprobionts) and 4) plant parasites. Facultative and obligatory parasites were distinguished among the latter, which correspond to pathogenically non-specific and pathogenically specific phytohelminths. Species of the genus *Tylenchus* and *Aglenchus* were allocated to the group of facultative parasites. In part I of this study (Wasilewska 1967) the appurtenance to an ecological group was given with the description of each species. It is not a simple matter to allocate different species to their proper ecological group, chiefly on account of insufficient knowledge of their way of life. Many of the species referred to in this study were found for the first time since they were first described, several were new species with unknown biology and unknown significance to plants. In such cases their presumable appurtenance to a group was marked with a questionmark.

Reciprocal relations between ecological groups in the upper parts and roots of plants and the soil were illustrated both on the basis of the number of species in a given group (Fig. 4) and the abundance of individuals in a given group, presented in percentages in relation to the abundance of all nematodes (Fig. 5). Two periods were considered, as in the case of domination: 1960–1961 and 1962–1963. Comparison for each of the periods was made on the basis of 12 months for station *A* and 13 months for station *B*.

Representatives of all the ecological groups were found in the upper parts of plants, roots and soil. The percentage of these groups (Fig. 5 *A* and 5 *B*) and the number of species in each of the groups (Fig. 4 *A* and 4 *B*)[1] were not, however, the same:

1. Pararhizobionts. The greatest number of species of this group and its highest percentage were found in the soil, less in roots and lowest in the upper parts of plants both on station *A* and station *B* in the two study periods. The percentage of pararhizobionts did not exceed 1.5% in the upper parts, but reached up to 15.5% in the soil.

2. Eusaprobionts. The participation of this group was slight in relation to the other groups. The highest percentage of this group was found in the soil, far less in roots and minimum in the upper parts of plants on both stations during the two study periods. The percentage of this group did not exceed 0.6%

[1] The group of eusaprobionts was not taken into consideration in Figure 4-*A* and 4-*B* on account of the lack of complete identification as to species.

in the upper parts of plants, and in the roots the maximum value 2.8% occurred on station *B* in 1960–1961, while in the soil the greatest percentage 14% of this group was noted during the same period and on the same station. The low percentage of this group in the cultures examined, particularly in plants, was evidence of the low degree of intensity of decomposition processes.

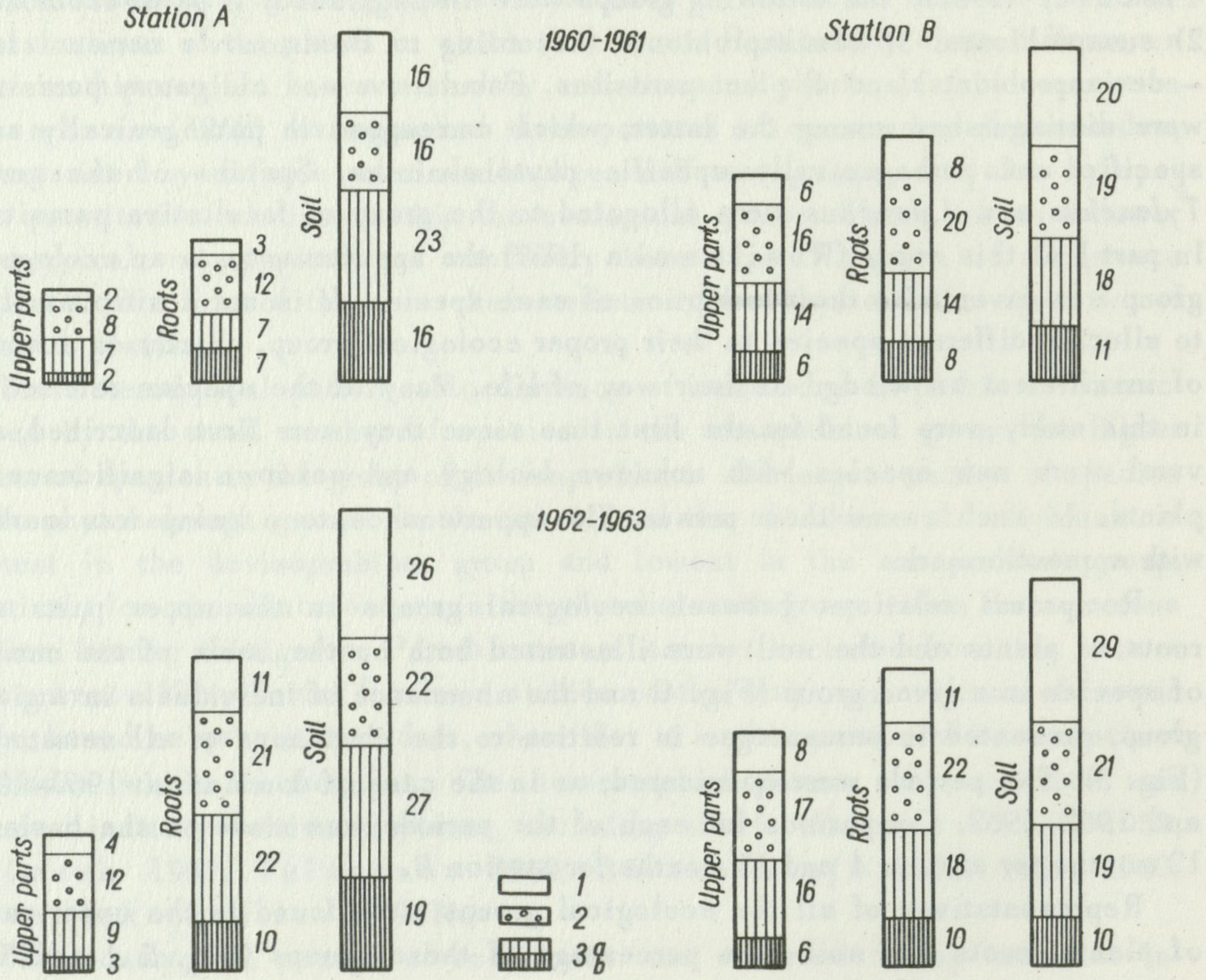

Fig. 4. Number of nematode species in ecological groups in alfalfa crops on stations *A* and *B*

1 – pararhizobionts, *2* – hemisaprobionts, *3* – plant parasites, *a* – facultative, *b* – obligatory

3. Hemisaprobionts. These nematodes formed the most numerous group in the upper parts and roots of plants. The greatest percentage of hemisaprobionts was found in the upper parts of plants, smaller in roots and smallest in the soil on both stations during both periods. The number of species forming this group was smallest in the upper parts and far greater in roots and soil. The greatest percentage of hemisaprobionts in the upper parts of plants, with simultaneously the lowest number of species in this group in comparison with the number of species in roots and soil, was connected with the intensive do-

mination of one the representatives of this group, *Panagrolaimus rigidus* (Tabs. III, IV). The dominants from the hemisaprobiont group in roots were mainly two species: *P. rigidus* and *Cephalobus mucronatus* (Tabs. III, IV). Many Soviet authors also observed a large percentages of representatives of the hemisaprobiont group in plant tissues (Meržeevskaja 1953, Karimova 1957, Baranovskaja 1958, 1959, 1960 and Balbaeva 1962–1963). The Paramonov (1962) school holds the opinion that hemisaprobionts occur in plant tissue undamaged by decomposition processes.

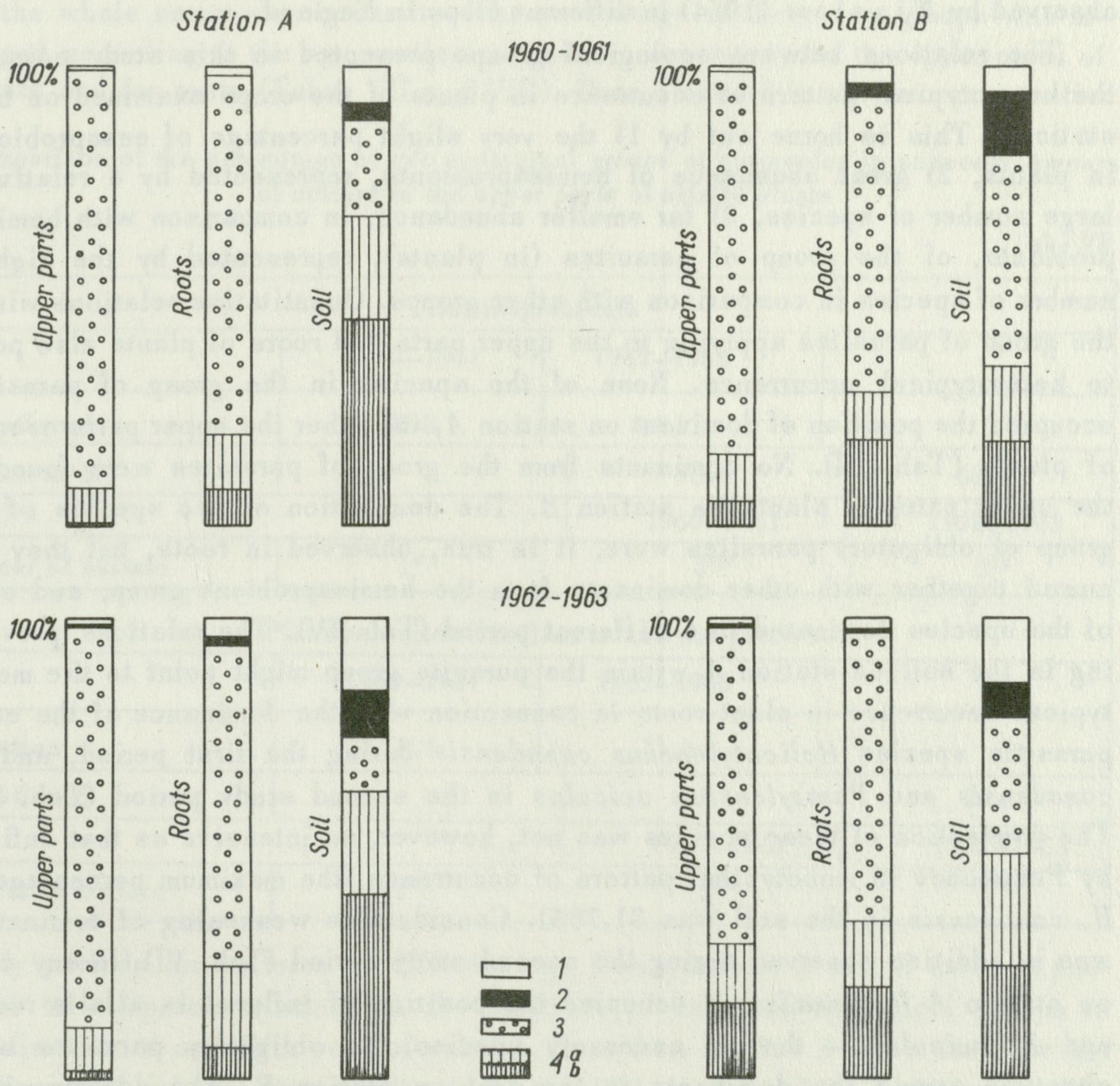

Fig. 5. Quantitative relations between ecological groups of nematodes in alfalfa crops (expressed in percent) on stations *A* and *B*

1 – pararhizobionts, *2* – eusaprobionts, *3* – hemisaprobionts, *4* – plant parasites, *a* – facultative, *b* – obligatory

4. Plant parasites. The largest number of species of this group were found in the soil, a smaller number in roots and fewest in the upper parts of plants. The percentage of this group was also highest in the soil, lower in roots and lowest in the upper parts of plants on both stations in both the study periods. Relations among the obligatory parasites distinguished within this group were similar. The high percentage of plant parasites in the soil is simultaneously connected with the relatively large number of species in this group, and also the greatest variety of species in this group in comparison with other groups was found in roots and the upper parts of plants. The great abundance of plant parasites in the soil in relation to the total abundance of nematodes was also observed by Winslow (1964) in different crops in England.

The relations between ecological groups presented in this study point to the heterotypical pattern of occurrence in plants of the crops examined on both stations. This is borne out by 1) the very slight percentage of eusaprobionts in plants, 2) great abundance of hemisaprobionts, represented by a relatively large number of species, 3) far smaller abundance, in comparison with hemisaprobionts, of the group of parasites (in plants), represented by the highest number of species in comparison with other groups. Quantitative relations within the group of parasites applying to the upper parts and roots of plants also point to heterotypical occurrence. None of the species in the group of parasites occupied the position of dominant on station *A*, in either the upper parts or roots of plants (Tab. III). No dominants from the group of parasites were found in the upper parts of plants on station *B*. The domination of two species of the group of obligatory parasites were, it is true, observed in roots, but they occurred together with other dominants from the hemisaprobiont group, and each of the species dominated in a different period (Tab. IV). The relations prevailing in the soil on station *A* within the parasite group might point to the monotypical occurrence in plant roots in connection with the dominance of the ectoparasitic species *Helicotylenchus canadensis* during the first period, and *H. canadensis* and *Paratylenchus aciculus* in the second study period (Tab. III). The domination of these species was not, however, so intensive as that defined by Paramonov in monotypical pattern of occurrence (the maximum percentage of *H. canadensis* in the soil was 31.78%). Considerable weakening of domination was in addition observed during the second study period (Tab. VI). In any case on station *A H. canadensis* occupied the position of influent in alfalfa roots, and *P. aciculus* – that of accessory species. No obligatory parasites were observed among the dominants in the soil on station *B*. The decomposition processes of organic matter are not of course excluded with this type of occurrence in plants, as is shown by the presence of the species *Rhabditis* s.l. spp. in the soil and partly of the mycophagous species *Aphelenchus avenae*.

It appears that the heterotypical pattern of occurrence does in fact apply to optically healthy plants, but that with this type of occurrence losses caused

by the nematodes occurring in the crop are not absolutely excluded. The complex co-occurrence of nematodes of different species belonging to different ecological groups presents considerable difficulty, however, in evaluating their activity (Deubert 1960, Hollis 1963).

The heterotypical pattern of occurrence in plants was maintained during both the study periods, nevertheless comparison of reciprocal quantitative relations between different ecological groups in 1960–1961 and 1962–1963 points to certain trends in the variations in these relations taking a similar course on both stations. The comparison was made in relation to hemisaprobionts and plant parasites, the combined percentage of which in plants forms over 90% of the whole nematode community. The percentage of these two groups was arranged according to the age gradient of culture, separately for the upper parts of plants and for roots (Tabs. VII and VIII). Data obtained in the two consecutive

Comparison of the percentage of two ecological groups of nematodes in successive years of culture in the upper parts of alfalfa plants

Tab. VII

Hemisaprobionts			
	1960–1961	1962–1963	
Station *A*	90.8	87.1	
Station *B*		83.3	68.2
		1960–1961	1962–1963
Year of culture	1st	3rd	5th
Plant parasites (facultative and obligatory)			
	1960–1961	1962–1963	
Station *A*	8.5	11.2	
Station *B*		15.4	29.6
		1960–1961	1962–1963
Year of culture	1st	3rd	5th

study periods for cultures of different age from stations *A* and *B* made it possible to compare variations in the relations of selected ecological groups in the first, third and fifth year of culture. Data from station *A* were used for the first year of culture, from station *B* for the fifth year and from both stations for the third year. In the last case the alfalfa crop on station *B* was 3 months older than on station *A*, which has duly marked on the diagram (Tabs. VII and VIII).

Decrease in the percentage of hemisaprobionts and increase in that of plant parasites with increasing age of the culture was found both in the upper parts and roots of plants. Differences between the values of percentages calculated

Comparison of the percentage of two ecological groups of nematodes in successive years of culture in the roots of alfalfa plants

Tab. VIII

Hemisaprobionts			
	1960–1961	1962–1963	
Station *A*	78.0	69.4	
Station *B*		64.2	62.6
		1960–1961	1962–1963
Year of culture	1st	3rd	5th
Plant parasites (facultative and obligatory)			
	1960–1961	1962–1963	
Station *A*	12.0	24.7	
Station *B*		29.1	34.3
		1960–1961	1962–1963
Year of culture	1st	3rd	5th

for different years of culture on each of the stations were checked by means of the Student test; they were statistically significant at a level $\alpha = 0.05$. Increase in the percentage of plant parasites was evident here to a far greater degree than the decrease in the percentage of the hemisaprobiont group. The values for the percentages of the ecological groups under discussion referring to the third year of culture are similar on stations *A* and *B* despite the fact that they come from different years (1960–1961 on station *B* and 1962–1963 on station *A*) and that the soil conditions on the two stations (type of soil and humidity) also differed considerably. This confirmed that it is correct to consider the variations discussed in the quantitative proportions between ecological groups of nematodes as being connected with the age of the culture.

In view of the great importance to plants of nematodes of the group of obligatory parasites the absolute abundance of this group in successive years of culture was analysed on stations *A* and *B* (Tab. IX). It was found that the abundance of obligatory parasites in plants increased together with increasing age of the culture, irrespective of the level of abundance of this group of nematodes in the soil on both stations during the first study period. On station *A* while the abundance of the group of obligatory parasites in the soil was very great, abundance in plants was relatively low. The reverse relations prevailed on station *B*.

Irrespective of the trends in variations of quantitative proportions found in the two most numerous groups: plant parasites and hemisaprobionts, the

Comparison of average annual abundance (per 5 g of upper parts of plants, 5 g of roots or 20 ml of soil) of nematodes from the group of obligatory parasites in successive years of cultures on station *A* and *B*

Tab. IX

Upper parts			
	1960–1961	1962–1963	
Station *A*	0.5	0.8	
Station *B*		9.1	12.0
		1960–1961	1962–1963
Year of culture	1st	3rd	5th
Roots			
	1960–1961	1962–1963	
Station *A*	2.2	9.2	
Station *B*		21.6	29.6
		1960–1961	1962–1963
Year of culture	1st	3rd	5th
Soil			
	1960–1961	1962–1963	
Station *A*	44.4	85.0	
Station *B*		20.0	31.7
		1960–1961	1962–1963
Year of culture	1st	3rd	5th

distribution of the percentage of each of these groups in the parts and roots of plants, and in the soil, was similar during the two study periods on both station *A* and *B*. This distribution – conversely for parasites and hemisaprobionts – remained similar in both periods (1960–1961 and 1962–1963) despite the very considerable differences in the distribution of the mean density in each of these groups in the first and second period (Fig. 6 and 7). This stability of percentage distribution in the upper parts and roots of plants and the soil during the first and second period, occurring independently of the diametrically different distributions of mean density of these groups in the same habitats in two different periods points to the existence of reciprocal interaction of the ecological groups of nematodes.

To sum up it must be said that nematodes which occur in the alfalfa crops examined were characterized both by great variety of species and variety of ecological forms. The presence of parasitic species, particularly of those

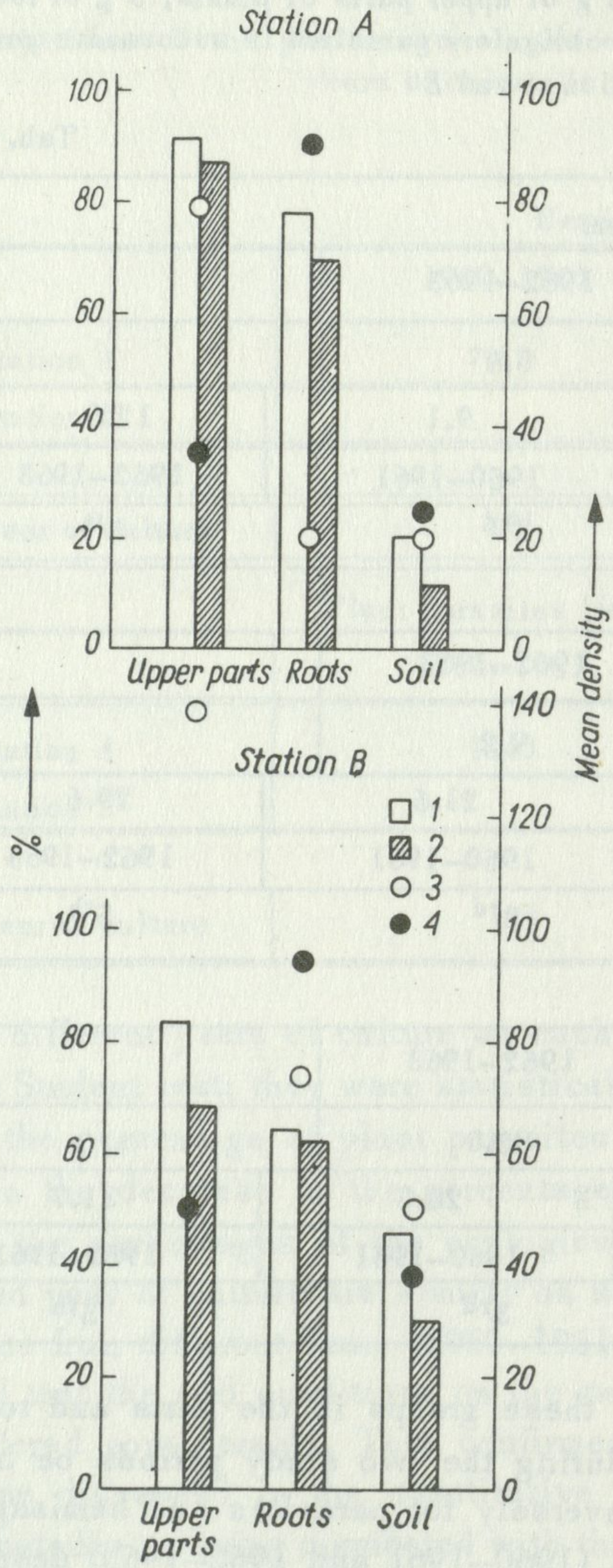

Fig. 6. Comparison of the percentage and mean density of nematodes from the hemisaprobiont group in the upper parts of plants (per 5 g), roots (per 5 g) and soil (per 20 ml) in alfalfa crops on stations *A* and *B*

1 – percentage in 1960–1961, *2* – percentage in 1962–1963, *3* – mean density in 1960–1961, *4* – mean density in 1962–1963

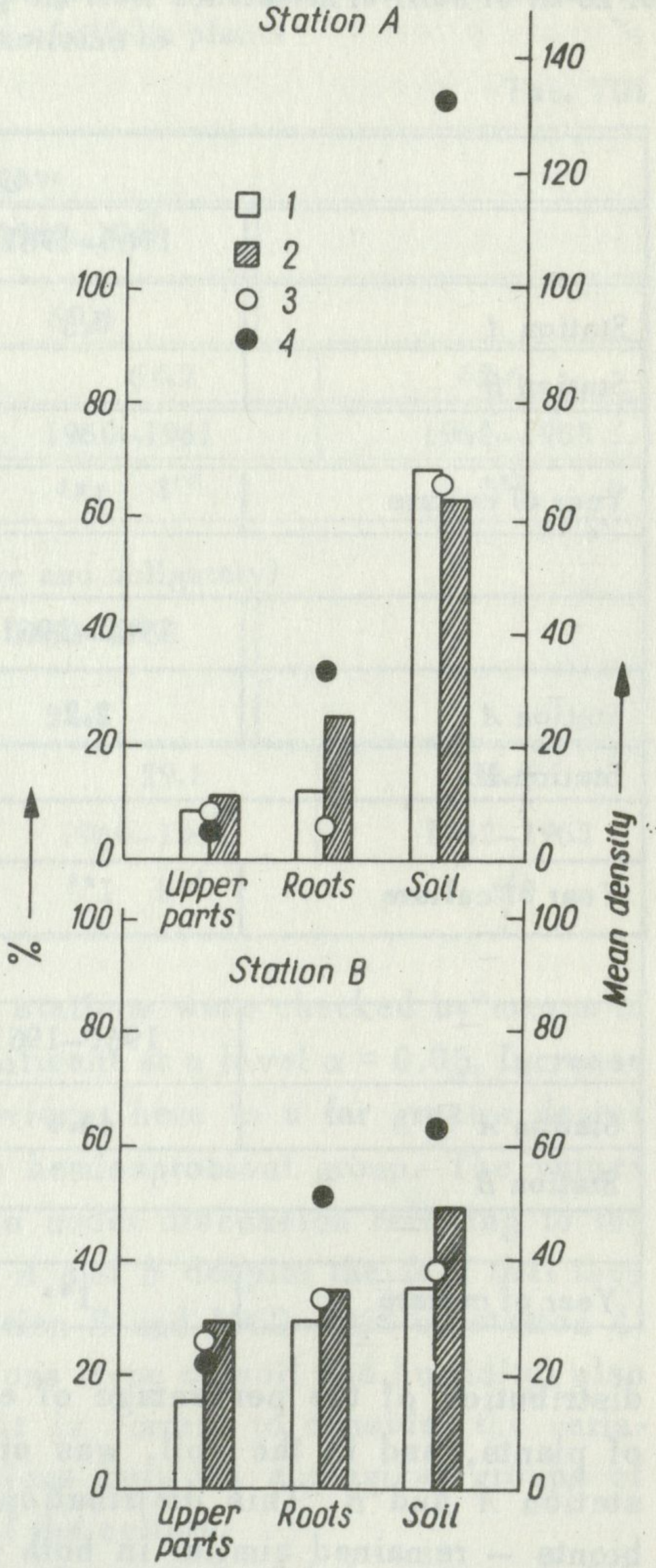

Fig. 7. Comparison of the percentage and mean density of nematodes from the plant parasite group in the upper parts of plants (per 5 g), roots (per 5 g) and soil (per 20 ml) in alfalfa crops on stations *A* and *B*

Explanations as for Fig. 6

which have been proved to be pathogenic, leads to the assumption that they have a harmful effect on alfalfa also. The significance to cultivated plants,

and in this connection the economic significance of species of the hemisaprobiont group, so numerous in the crops examined has not hitherto been elucidated, and requires further investigation.

VI. CONCLUSIONS

Investigations made for a period of two years of two alfalfa crops of different age showed that:

1. A large number of species with small numbers of their representatives, and relatively few species forming numerous populations, occurred in the two crops.

2. The domination structure differed in the three habitats of nematodes which were examined. The most sharply defined nature of domination of species was that in the upper parts of alfalfa plants, being less sharply defined in roots and least sharply defined in the soil. Only one saprobiotic species (hemisaprobiont) dominated in the upper parts of plants in both crops, which was distinguished by its capacity for leading a probably semiparasitic way of life. Hemisaprobiotic species dominated in the roots of the younger crop and hemisaprobiotic and typical parasitic species in the older crop. Parasitic species and a group of typically saprobiotic species (eusaprobionts) dominated in the soil of the younger crop. A group of typically saprobiotic species, hemisaprobiotic species and one species considered to be a facultative parasite dominated in the soil of the older crop.

3. The occurrence of nematodes in plants in the crops examined was defined as heterotypical (Paramonov 1962). This was borne out by the maximum abundance of the hemisaprobiont group in plants and the far lower abundance of the plant parasite group. The numerous species of the group of obligatory and facultative parasites did not form numerous monospecies populations in plants. The group of hemisaprobionts and plant parasites formed over 90% of the whole community of nematodes in plants. The group of pararhizobionts occurred scantily in plants, as did the group of typical saprobiotic species. Plant parasites formed a numerous group in the soils of the crops examined (from 35% to 68%), while the other groups were less numerously represented.

4. The total abundance of nematodes in soil and plants was subject to seasonal variations which were repeated in the study years analysed. The course taken by these variations was characterised by two main peaks and two minima of abundance. Low temperatures during the winter and abundant rainfall in the summer probably had an inhibiting effect on the abundance of nematodes in the soil and plants.

5. The following relations were connected with the age of the culture:

a. The total abundance of nematodes in the soil increased slightly over

the course of consecutive years of culture on both stations. A very intensive increase of abundance of nematodes was observed in roots between the one-year old and three-year old cultures, but a very slight increase between the three-year old and five-year old cultures. The abundance of nematodes was higher in the upper parts of plants in the case of the older crop.

b. The number of species increased with increasing age of the culture on both stations.

c. The structure of the nematode community was subject to variation, which chiefly affected the domination relations. The number of dominants and influents increased with age in plants and soil, which weakened domination relations.

d. The trends in the variations in plant nematofauna connected with the age of the culture applied also to variations in the proportions of the most numerous ecological groups. They consisted in increase in the percentage of the plant parasite group and reduction in the percentage of the hemisaprobiont group in relation to the whole nematode community.

e. The abundance of obligatory parasites in plants increased over the consecutive years of culture irrespective of the initial level of numbers of this group of nematodes in the soil of the two stations.

6. The distribution of percentages of the most numerous ecological groups of nematodes was found to be stable in the habitat system: upper parts of plants – roots – soil, whereas the distribution of density of the groups in this system varied in different years. This suggests reciprocal interaction between ecological groups of nematodes.

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ANALIZA ZASIEDLENIA NICIENI W UPRAWACH LUCERNY. II. LICZEBNOŚĆ I STOSUNKI ILOŚCIOWE POMIĘDZY GATUNKAMI ORAZ EKOLOGICZNYMI GRUPAMI GATUNKÓW

Streszczenie

Praca stanowi kontynuację badań nad nicieniami dwóch upraw lucerny. Po zapoznaniu się ze składem gatunkowym i różnorodnością form ekologicznych nicieni zasiedlających części nadziemne lucerny, korzenie i glebę, jak również po określeniu penetracji poszczególnych gatunków z gleby do roślin (Wasilewska 1967) podjęto dalsze opracowania, których celem było:

1. Ustalenie zmian liczebności nicieni zasiedlających części nadziemne lucerny, korzenie i glebę tych upraw, zarówno w poszczególnych latach uprawy jak i porach roku.

2. Analiza wzajemnych stosunków ilościowych pomiędzy gatunkami zasiedlającymi rośliny i glebę w różnych latach uprawy.

3. Analiza struktury i dynamiki grup ekologicznych nicieni zasiedlających środowisko roślinne jak i glebowe, zależnie od wieku uprawy.

Badania przeprowadzono na dwóch polach lucerny położonych w okolicach Warszawy. Opis terenu badań i metodyka badań została przedstawiona w części I pracy (Wasilewska 1967). Zebrany materiał faktyczny posłużył do przedstawienia wyników zarówno w części I, jak i niniejszej pracy. Wspomnę tylko, iż badania prowadzono równocześnie na dwóch polach lucerny. W analizowanym okresie 1960–1961 r. na jednym z pól była uprawa jednoroczna, na drugim – trzyletnia, zaś w następnym okresie badań 1962/1963 r. – odpowiednio uprawa trzy- i pięcioletnia. Próby pobierano w odstępach miesięcznych oddzielnie z części nadziemnych roślin lucerny, korzeni i gleby. Z prób pobranych bezpośrednio w polu, pobierano mniejsze próby do analiz szacujących liczebność i do analiz gatunkowych. Ocenę reprezentatywności tych prób przedstawiono w części I (Wasilewska 1967).

Podziału na grupy ekologiczne dokonano według klasyfikacji Paramonova (1952), wyróżniając grupę przykorzeniowych nicieni (pararizobionty), grupę typowych saprobiotycznych gatunków (eusaprobionty), grupę nietypowych saprobiontów, odznaczających się zdolnością przenikania do tkanek roślinnych (hemisaprobionty) oraz grupę pasożytów fakultatywnych i grupę pasożytów obligatorycznych.

Na podstawie dwuletnich badań dwóch różniących się wiekiem upraw lucerny stwierdzono:

1. W obydwu uprawach występowało dużo gatunków o małej liczebności oraz stosunkowo mało gatunków tworzących liczne populacje (fig. 2 i 3 oraz tab. III i IV).

2. Struktura dominacji przedstawiała się różnie w trzech analizowanych środowiskach życia nicieni. Najostrzejszy charakter dominacji gatunków zaznaczył się w częściach nadziemnych lucerny, słabszy w korzeniach i najsłabszy w glebie (tab. V i VI). W częściach nadziemnych roślin w obu uprawach dominował tylko jeden gatunek – hemisaprobiont. W korzeniach dominowały gatunki hemisaprobiotyczne w młodszej uprawie oraz gatunki hemisaprobiotyczne i typowo pasożytnicze w starszej uprawie. W glebie uprawy młodszej dominowały gatunki pasożytnicze oraz eusaprobionty. W glebie uprawy starszej dominowała grupa gatunków eusaprobiotycznych, gatunki hemisaprobiotyczne oraz jeden gatunek uznawany za pasożyta fakultatywnego (tab. III i IV).

3. Zasiedlenie roślin w badanych uprawach określono jako heterotypowe (Paramonov 1962). Przemawiała za tym najwyższa w roślinach liczebność grupy hemisa-

probiontów i dużo od niej niższa liczebność grupy pasożytów roślin. Liczne gatunki grupy pasożytów obligatorycznych i fakultatywnych nie tworzyły w roślinach licznych populacji jednogatunkowych. Grupa hemisaprobiontów i pasożytów roślin stanowiła w roślinach ponad 90% całego zgrupowania nicieni. Nielicznie występowała grupa parazobiontów i eusaprobiontów. W glebie badanych upraw pasożyty roślin stanowiły liczną grupę (od 35 do 68%), natomiast mniej licznie reprezentowane były pozostałe grupy (fig. 4 i 5).

4. Ogólna liczebność nicieni w glebie i roślinach podlegała wahaniom sezonowym, które powtarzały się w analizowanych latach badań (fig. 1). Przebieg tych zmian charakteryzował się dwoma głównymi maksimami oraz dwoma minimami liczebności. Niskie temperatury w okresie zimy oraz obfite opady latem wpływały prawdopodobnie ograniczająco na liczebność nicieni w glebie i roślinach.

5. Z wiekiem uprawy wiązały się następujące zależności:

a. Ogólna liczebność nicieni w glebie wzrastała nieznacznie w ciągu kolejnych lat uprawy na obu stanowiskach. Porównując uprawy jedno- i trzyletnią zaobserwowano bardzo silny wzrost liczebności nicieni w korzeniach, zaś między uprawą trzy- i pięcioletnią – nieznaczny. Liczebność nicieni w częściach nadziemnych roślin była wyższa w uprawie starszej (tab. I).

b. Wraz z wiekiem uprawy na obu stanowiskach nastąpił wzrost liczbowy gatunków (tab. II).

c. Struktura zgrupowania nicieni podlegała zmianom, dotyczącym głównie stosunków dominacji; wraz z wiekiem wzrastała liczba dominantów i influentów w roślinach i glebie, z czym wiązało się osłabienie stosunków dominacji (tab. V).

d. Kierunkowe zmiany w nematofaunie roślin, związane z wiekiem uprawy, dotyczyły również zmian w proporcji najliczniejszych grup ekologicznych. Polegały one na zwiększeniu udziału grupy pasożytów roślin i zmniejszeniu udziału grupy hemisaprobiontów w stosunku do całego zgrupowania nicieni (tab. VII i VIII).

e. Liczebność pasożytów obligatorycznych w roślinach wzrastała w ciągu kolejnych lat uprawy, niezależnie od początkowego poziomu liczebności nicieni tej grupy w glebie obu stanowisk (tab. IX).

6. Stwierdzono stabilność rozkładu udziałów najliczniejszych grup ekologicznych nicieni w układzie środowiskowym: części nadziemne – korzenie – gleba. Rozkład zagęszczenia grup w tym układzie był odmienny w różnych latach (fig. 6 i 7). Sugeruje to istnienie wzajemnych oddziaływań pomiędzy grupami ekologicznymi nicieni.

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