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Intestinal Helminths as Indexes of Reproduction Dynamics in the Host Population — Common Vole*

[With 4 Tables & 4 Figs.]

A total of 612 parasitological dissections were made in different seasons in two populations of *Microtus arvalis* (Pallas, 1779) confined in 1-hectare enclosures. The intestinal helminths dominating in the parasitocenosis of voles (*Heligmosomum* sp. and *Syphacia obvelata*) are considered to be indexes of the age structure of the host population. The four age classes distinguished for these voles differed in respect of both quantity and quality of invasion. Parasitological data were compared with the voles' age, defined on the basis of eye lens weight. Using parasitological indexes as a basis a description is given of the reproduction dynamics in the vole populations examined. Reproduction was very intensive in 1970, with a distinct peak during the period from July to September. The percentage of young voles in the population exceeded that of adults. The dominating nematode was *Syphacia obvelata*. The following year reproduction was less intensive and the percentage of young voles was no longer greater than that of adults. The dominating helminths were representatives of the genus *Heligmosomum*. Comparison of parasitological data with indirect information on reproduction dynamics of the study populations (percentage of individuals entering the populations) showed that there was considerable agreement between them. The reliability and usefulness of parasitological indexes for estimating the age structure of host populations are discussed.

I. INTRODUCTION

In the previous study on *Microtus arvalis* (Pallas, 1779) it was shown that there is a relation between the age structure of a population of this rodent and the qualitative and quantitative structure of its parasitocenosis (Kisielewska, 1971). The author chose species from among the vole's intestinal helminths which could serve as indexes of the age structure of the host population. These are nematodes of the genus *Heligmosomum*

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spp. characteristic of adult voles, and the nematode *Syphacia obvelata* (R u d o l p h i, 1802) characteristic of young voles.

The above regularities were established on the basis of data for young voles caught three times a year (May, July, October) in a lucerne field several hectares in area (K i s i e l e w s k a, 1971). The only criterion then available — body weight and length — was used to estimate the voles' age at that time.

Now that more accurate estimates of voles' age are possible, using the dry eye lens weight as criterion (M a r t i n e t, 1966), we decided to check the correctness of the regularities observed by K i s i e l e w s k a (1971) on the same species of host, but in an isolated population kept under constant ecological and parasitological inspection. Parasitological indexes were used to describe the reproduction dynamics of the study population of voles.

Table 1

Numbers of common voles dissected.

Month	No. of voles	
	1970	1971
Jan. — Febr.	—	22
March	—	10
April	13	79
May	—	10
June	—	60
July	16	36
August	16	141
September	—	47
October	73	30
November	7	47
December	—	7
Total	130	482

Table 2

Quantitative and qualitative structure of helminthocenosis occurring in the study population of voles.

Species	Infestation
Heligmosomum spp.	74
Syphacia obvelata	35
Trichocephalus muris	2
Aprostatandrya macrocephala	14
Catenotaenia pusilla	3

II. MATERIAL AND METHODS

The data contained in the present study refer to material accumulated during the period from April 1970 to November 1971 in the experimental fields of the Institute of Ecology, Polish Academy of Sciences, at Dziekanów Leśny near Warsaw. Two 1-hectare lucerne fields were enclosed by an impenetrable fence and wooden hauses containing livetraps placed in them near the various vole colonies (determined on the basis of groups of burrows). The animals were caught using the CMR method (Catch--Mark-Release) for two days (morning and evening) each week throughout the year.

Only those voles which died in traps during captures were used for parasitological dissection in 1970. As from June 1971 5% of the current

population numbers were trapped once a month, and a total of 612 individuals used for parasitological dissection (Table 1). We also knew how many young individuals entered the population each month and also population numbers, these parameters being determined by the Calendar of Captures method (Petrusewicz & Andrzejewski, 1962). Data on the voles' age were obtained from the dry eye lens weights elaborated by Adamczewska-Andrzejewska (in press).

III. RESULTS

1. Species Composition of the Parasitocenosis in Voles

The following species of intestinal helminths were found in the study population of voles:

Cestoda: *Catenotaenia pusilla* (Goeze, 1782) and *Aprostatandrya macrocephala* (Deuthill, 1915).

Nematoda: *Heligmosomum costellatum* (Dujardin, 1845), *Heligmosomum polygyrum* (Dujardin, 1845), *Syphacia obvelata* (Rudolphi, 1802), *Trichocephalus muris* (Schrank, 1788), Tab. 2.

The species composition of the parasitocenosis in an isolated vole population is identical to that in natural population (Kisielewska, 1971), which is a circumstance greatly fascilitating comparative analysis. On this account only those species which were earlier chosen as indexes of the age structure of vole populations, *i.e.* nematodes of the genus *Heligmosomum* nad the nematode *Syphacia obvelata*, were taken into consideration in further discussions.

2. Age Classes in a Population of *M. arvalis* Distinguished on the Basis of Parasitological Indexes

The relation was traced between extensiveness and intensiveness of infestation in voles by means of indicator helminths and the host's age. The results obtained (Fig. 1, 2) confirm Kisielewska's data (1971) that there is a relation between the voles' age and the quantity and quality of invasion, and that the nematode *S. obvelata* dominates (intensively and extensively) in young voles, and *Heligmosomum* spp. in older individuals.

The following groups of voles were distinguished on the basis of the quantitative and qualitative structure of invasion (Fig. 1): (a) not invaded, (b) invaded by *S. obvelata* only, (c) invaded simultaneously by *S. obvelata* and *Heligmosomum* spp., (d) invaded by *Heligmosomum* spp. only. Each of these groups dominates in a different age class of voles (Table 3), as

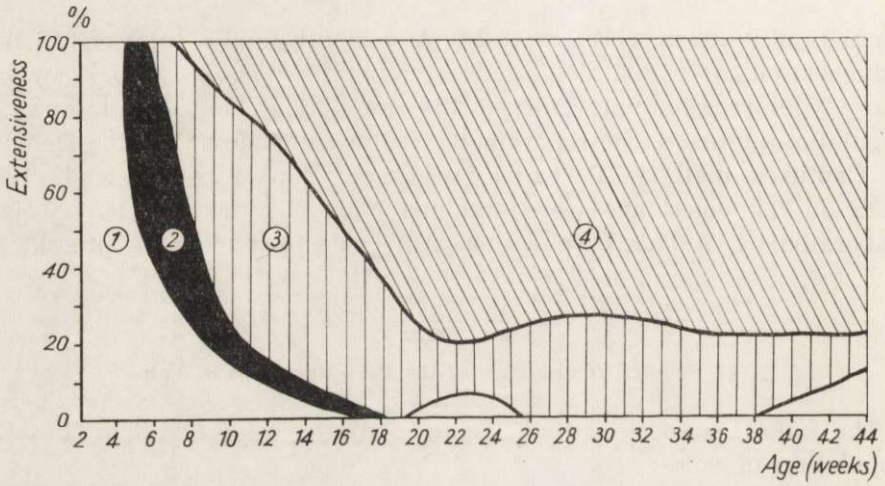

Fig. 1. Extensiveness of invasion of voles by indicator species of nematodes depending on the animals' age.
1 — uninvaded individuals, 2 — individuals invaded by *S. obvelata*, 3 — individuals invaded by *S. obvelata* and *Heligmosomum* spp., 4 — individuals invaded by *Heligmosomum* spp.

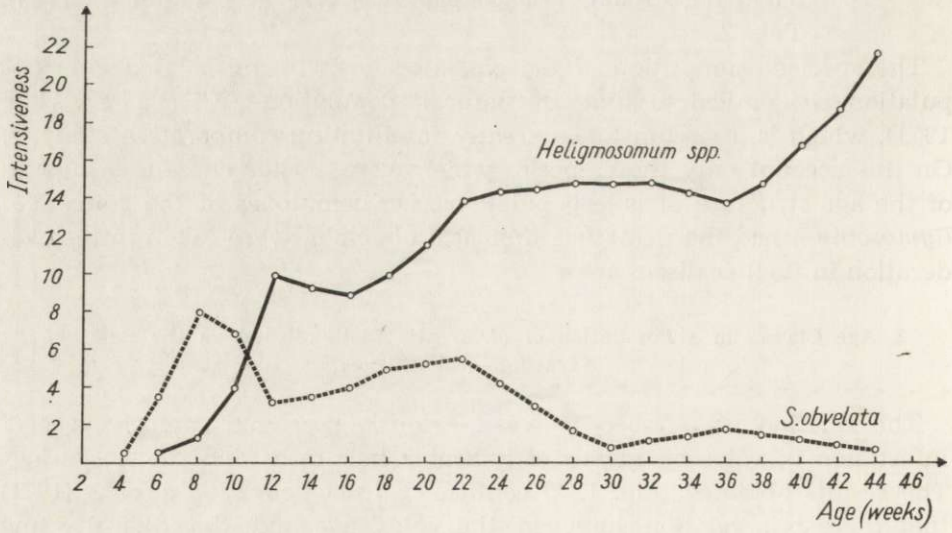

Fig. 2. Intensiveness of invasion of voles by indicator species of nematodes depending on the animals' age.
1 — intensiveness of invasion by *S. obvelata*, 2 — intensiveness of invasion by *S. obvelata* and *Heligmosomum* spp.

follows: very young voles are generally free of intestinal helminths. In the subsequent age classes the percentage of uninvaded individuals gradually decreases, becoming practically non-existent in the old class. In young voles, in addition to uninvaded individuals (40%), animals invaded

by *S. obvelata* only decidedly predominate (43%). In adult voles (usually sexually active) mixed invasion predominates (57%). In old voles it is mainly individuals invaded by *Heligmosomum* spp. which are encountered (76%). In addition average intensiveness of invasion by *S. obvelata* decreases in successive classes, while invasion by *Heligmosomum* spp. increases (Fig. 2).

Analysis was also made of the relation between the host's age and number of helminth species occurring in single host individuals (Table 4), taking into consideration here all species included in the composition of the parasitocenosis present in the study population of voles (cf. Table 2). In general it may be said that the qualitative invasion of a host increases

Table 3

Parasitological description of different age classes of *M. arvalis*.

Age group	Lens weight (mg)	Age (weeks)	Percentage of voles infested*				Intensiveness	
			Un.	*S.o.*	*H.*+ *S.o.*	*H.*	*S.o.*	*H.*
Very young	1.2—1.5	4	100	—	—	—	—	—
Young	1.6—2.5	4— 8	40	43	12	5	5	0.1
Adult	2.6—3.8	8—16	5	8	57	30	7.8	2.4
Old	>3.8	>16	2	2	20	76	3.1	7.0

* Un. — uninfested, *S.o.* — *S. obvelata*, *H.* — *Heligmosomum* spp.

Table 4

Numbers of parasite species in different age classes of *M. arvalis*.

Age group	Percentage of individuals invaded by:			
	1 species	2 species	3 species	4 species
Very young	—	—	—	—
Young	55	5	—	—
Adult	38	37	16	4
Old	35	47	14	2

with the latter's age (that is, invasion by more than one species is more often encountered in old individuals). The results obtained, however, are not sufficiently characteristic to be able to distinguish one age class from another on these grounds.

Calculation was made for each of the above age classes, using the t Student test to check significance, of the average eye lens weight and standard deviation (Fig. 3). No statistically significant differences was found between the average eye lens weight in the very young and young classes (Fig. 3), and consequently these two classes were combined. After

making this change the differences between average dry eye lens weights in the combined class (5) and the other classes are statistically significant.

3. Reproduction Dynamics in an Isolated Population of *M. arvalis* in Relation to Parasitological Data

Variations in intensity of invasion by indicator helminths (*S. obvelata* and *Heligmosomum* spp. were traced in consecutive months of the study period (Fig. 4), and also the percentage of groups of voles differing in respect of the type of invasion characteristic of the given age classes (Fig. 4B). It was assumed in the light of the discussion given in the preceding section, that increase in the number of uninfested voles and voles infested by *S. obvelata* only, may be taken as indicating that very young and young individuals are present in the given population (Fig. 4B,

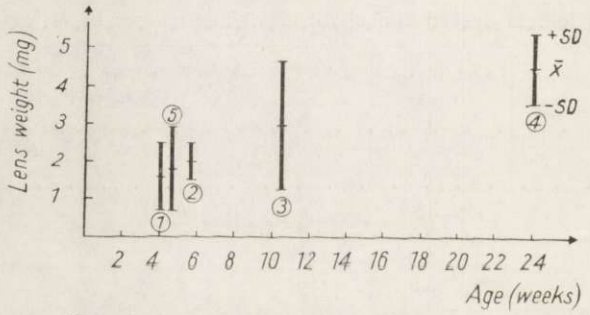

Fig. 3. Averages $\bar{X}$ and standard deviation *SD* of lens weight in *M. arvalis* of different age groups.
1 — very young, 2 — young, 3 — adult, 4 — old, 5 — very young + young.

July—October 1970 and April—September 1971). The percentage of these young animals in relation to the older groups (invaded by a mixture of parasites, or by *Heligmosomum* spp. only) can be taken as a measure of reproduction intensity in the population. The decided domination of the type characteristic of adult and old voles (Fig. 4B, November 1970 — February 1971) shows that the population is growing older as a result of earlier inhibition of reproduction.

The above assumptions were used to describe the reproduction dynamics of a vole population in two successive reproduction seasons (1970 and 1971):

1. In 1970 reproduction was very intensive, with a distinct peak during the period from July to September. The percentage of young animals in the population exceeds the number of adult individuals during this period. The dominating parasite in the vole population was *Syphacia obvelata*.

2. In 1971 the course taken by reproduction was more even (without a distinct peak) and the small increases in the number of young animals did not result in their dominating over the older part of the population.

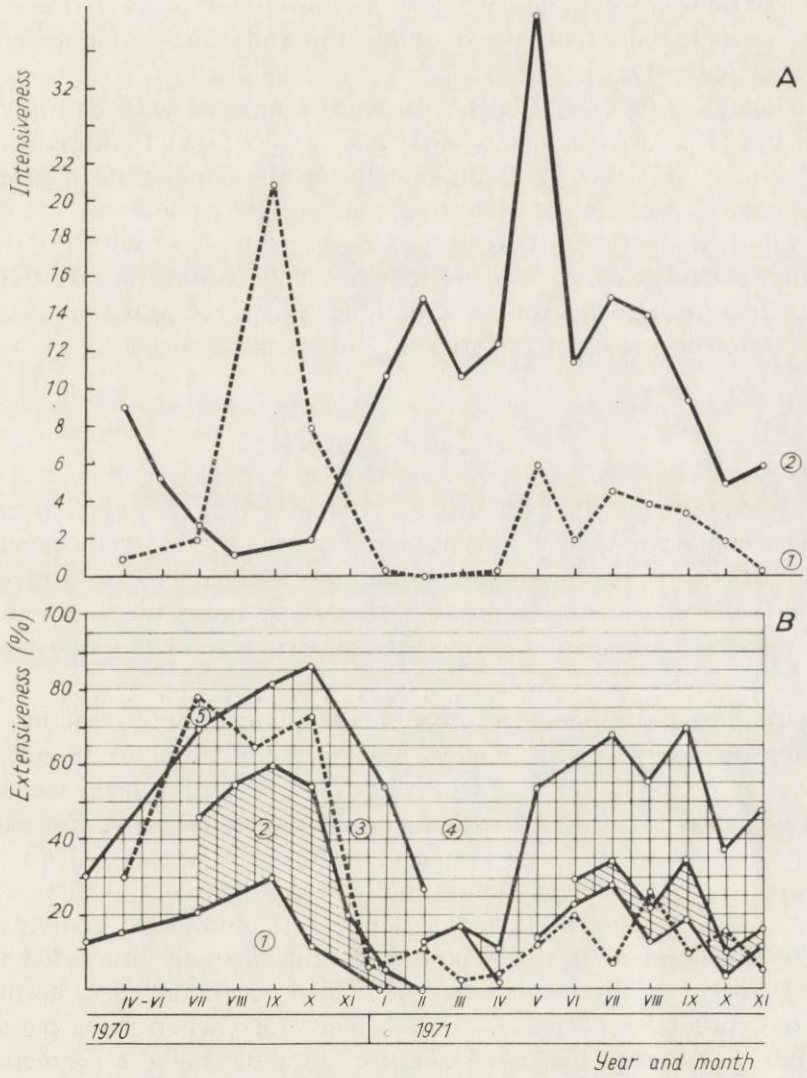

Fig. 4. Dynamics of invasion of population of *M. arvalis* by indicator species of nematodes in 1970 and 1971.

A — intensiveness of invasion: 1 — intensiveness of invasion by *S. obvelata*, 2 — intensiveness of invasion by *Heligmosomum* spp. *B* — extensiveness of invasion: 1 — uninvaded individuals, 2 — individuals invaded by *S. obvelata*, 3 — individuals invaded by *S. obvelata* and *Heligmosomum* spp., 4 — individuals invaded by *Heligmosomum* spp., — 5 — % of individuals entering the population.

During this reproduction season the helminths dominating in the vole population were nematodes of the genus *Heligmosomum*.

3. Parasitological data suggest that in the winter of 1971 (February—March) reproduction took place under the snow cover (appearance of uninfested individuals).

Parasitological indexes (Fig. 4A, B) were compared with data given by Adamczewska-Andrzejewska & Jurgiel (unpubl. data) on the number of young individuals entering the population in successive months, and it was found that the dynamics of appearance of newly-marked individuals (Fig. 4B) agree to a significant extent with the changes presented above in parasitological indexes. This would indicate that it is possible to estimate the course and intensity of reproduction in a vole population on the basis of the structure of its parasitocenosis.

IV. DISCUSSION

The parasitological indexes discussed above can be applied only to statistical elaborations of material representative of the study population of the host, since it is impossible to allocate a given vole to a given age class on the strength of such indexes, that is, to assess the vole's absolute age in this way, but only to define the age structure of the study population.

It must also be remembered that an estimate of this structure made solely on the basis of parasitological indexes (*i.e.* if there are no additional data available on dry eye lens weight, or at least on the body weight and length of voles) is burdened with a certain degree of error. For instance it is known that in the very young class (up to 4 weeks old) all individuals are free of intestinal helminths, but this does not justify arriving at the simple conclusion that the number of uninvaded individuals is equal to the number of very young individuals, since uninvaded individuals also occur in the young class (40%) and occasional cases occur even in the old class (about 2%), cf. Table 3. Therefore, when using parasitological indexes for assessing age structure, we must make a correction for the overestimated percentage of very young individuals in relation to the factual state, and this error will be far smaller if we consider uninfested individuals in general as very young and young combined. The case is analogical in groups of individuals infested by *Syphacia obvelata* only (young voles), by mixed invasion (adult voles) or only by *Heligmosomum* spp. (old voles). Each of these types of infestation is characteristic of a given age class and dominates in it, but also occurs in the other classes (cf. Table 3).

The age of individuals in the study population and reproduction dynamics are not the only factors affecting the parasitocenosis structure in *M. arvalis*. Invasion by the nematode *Syphacia obvelata* spreads by means of contacts between individual hosts. The frequency of such contacts is connected not only with the mating period (as shown in the present study), but also with the social and spatial structure of the host population, and its density etc. An important role is also played by the habitat in which the given population lives (Erhardova, 1958, Prokopič, 1972). Further studies are, however, essential in order to obtain a better knowledge of these relations.

Parasitological indexes should therefore be used primarily to confirm and supplement descriptions of the age structure of vole populations, based on more accurate methods. When used independently such indexes may be useful for comparative analysis either of two different host populations, or the same population at different times, but even so such comparison can be limited only to the descriptive form (more or fewer young or old individuals).

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HELMINTY JELITOWE JAKO WSKAŹNIKI DYNAMIKI ROZWOJU POPULACJI ŻYWICIELA — POLNIKA ZWYCZAJNEGO

Streszczenie

W okresie od IV 1970 do XI 1971 roku zbadano 612 osobników *Microtus arvalis* (Pallas, 1779) pochodzących z dwóch izolowanych populacji zasiedlających uprawę lucerny. Populacje te były pod stałą kontrolą ekologiczną i parazytologiczną.

Sekcje parazytologiczne wykazały w badanych populacjach nornika obecność pięciu gatunków helmintów jelitowych (Tabela 2), z których nicienie *Syphacia obvelata* oraz dwa gatunki z rodzaju *Heligmosomum* uznano za Kisielewską (1971), jako wskaźniki struktury wiekowej i dynamiki rozrodu populacji żywiciela. Rzeczywisty wiek norników uzyskano na podstawie ciężaru suchej masy soczewek oka, opracowanych przez Adamczewską-Andrzejewską (1973).

Na podstawie ilościowej i jakościowej struktury zarażenia (Ryc. 1) wyodrębniono następujące grupy norników: (a) niezarażone, (b) zarażone tylko nicieniem *Syphacia obvelata*, (c) zarażone jednocześnie *S. obvelata* i nicieniami z rodzaju *Heligmosomum*, (d) zarażone tylko *Helighosomum* spp. Każda z wymienionych grup jest charakterystyczna dla innej klasy wiekowej norników i w niej dominuje (Tabela 3). Ponadto stwierdzono, że średnia intensywność inwazji maleje wraz z wiekiem żywiciela dla *S. obvelata*, a wzrasta dla *Heligmosomum* spp. (Ryc. 2), oraz, że u starych osobników częściej spotyka się inwazje więcej niż jednogatunkowe (Tabela 4). Dla każdej z klas wiekowych obliczono średni ciężar suchej masy soczewki oka oraz odchylenie standardowe (Ryc. 3) w celu ustalenia statystycznej różnicy między tymi klasami.

Prześledzono w kolejnych miesiącach badanego okresu zmienność intensywności inwazji helmintów wskaźnikowych (Ryc. 4) oraz procentowy udział norników różniących się typem zarażenia właściwym określonym klasom wiekowym (Ryc. 4). Na tej podstawie scharakteryzowano dynamikę rozrodu populacji nornika w dwóch kolejnych sezonach rozrodczych (1970 i 1971); w 1970 roku rozród był bardzo intensywny (z wyraźnym szczytem w okresie od lipca do września). Procentowy udział młodych w populacji przewyższał w tym okresie pokolenie rodzicielskie, pasożytem dominującym w populacji nornika był *S. obvelata*. W 1971 roku przebieg rozrodu miał charakter bardziej jednostajny (bez wyraźnego szczytu), nieliczne przyrosty młodzieży nie dominowały nad starszą częścią populacji, dominantami spośród pasożytów były nicienie z rodzaju *Heligmosomum*. Wskaźniki parazytologiczne zestawiono z danymi dotyczącymi liczby osobników młodych, wchodzących do populacji (nieopublikowane dane Adamczewskiej-Andrzejewskiej & Jurgiela, Ryc. 4).

Dyskutowano wiarygodność i przydatność wskaźników parazytologicznych przy ocenie struktury wiekowej populacji żywiciela.