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Studies on the European Hare. IX. Helminth Fauna in the Annual Cycle

[With 10 Figs. & 4 Tables]

The study deals with helminths of the alimentary tract and lungs of 706 hares from the Poznań province, examined over a period of 15 consecutive months (from December 1958 to February 1960), numbering from 34 to 54 individuals a month. Helminths (*Trematoda*, *Cestoda* and *Nematoda*) were discovered in 671 hares (95%). The percentage of infested animals varied in different months from 91 to 100%. Nine species of parasites were found: *Fasciola hepatica* in 2.2% of the hares, *Andrya rhopalocephala* in 1.4%, *Mosgovoyia pectinata* in 8.7%, *Trichostrongylus retortaeformis* in 79.4%, *T. medius* and *Haemonchus contortus* in 0.1%, *Graphidium strigosum* in 3.9%, *Protostrongylus commutatus* in 1.1% and *Trichuris sylvilagi* in 72.8% of the hares. Morphological observations refer to the following: *F. hepatica*, *A. rhopalocephala*, *T. retortaeformis*, *P. terminalis* and *T. sylvilagi*. Variations in the intensiveness and extensiveness of invasion were examined over the year's cycle. In the case of tapeworms strobiles with mature oncospheres were found at different times of the year, which is evidence of the absence of winter destrobilation. Three species were found throughout the year: *M. pectinata*, *T. retortaeformis* and *T. sylvilagi*. Analysis was made of how invasion of different species of helminths depended on the sex and age of the hares, greater intensiveness and extensiveness of invasion by *T. sylvilagi* being found in pregnant than in non-pregnant females. Analysis of the co-occurrence of helminths in one individual host showed that the species of parasites examined do not exclude each other.

I. INTRODUCTION

Studies made so far on the helminth fauna of the hare in areas within the present frontiers of Poland are limited to three publications: Czarnowski & Witkowski (1954), Drygas & Piotrowski (1955a and 1955b). The first of these dealt with pneumonia caused by *Protostrongylus terminalis*, the second with the morphology of *Trichuris sylvilagi*, while the third referred to helminths of the alimentary tract of 617 hares examined over a period of three consecutive years, but during the

shooting season. The investigations revealed the presence of the following species: *Mosgovoyia pectinata*, *Andrya rhopalocephala*, *Trichostrongylus retortaeformis*, *Graphidium strigosum*, *Protostrongylus terminalis* and *Trichuris sylvilagi*. In comparison with the publications of earlier authors our investigations constitute an extension of our knowledge of hare helminth fauna in Poland due to the following species having been added: *Fasciola hepatica*, *Haemonchus contortus* and *Trichostrongylus medius*. The two last species were found for the first time in the hare in two single cases and were probably accidental parasites of the host, and were therefore not taken into consideration in analysing each of the species.

II. MATERIAL AND METHODS

The material used in the present study consisted of 706 hares from the Poznań province, from 34 to 54 specimens being examined every month during the period from December 1958 to February 1960 inclusive. The sex of 592 and age of 572 specimens was determined (young, one-year old and older hares), which had been shot during the period from January to December 1959. It is for this reason that the analysis of the occurrence of each species of parasite in males and females in different age groups refers only to these 572 hares, and not to the total number of specimens.

Examinations included the alimentary tract (oesophagus, stomach, small intestine, liver together with gall bladder, large intestine) and the heart, lungs and trachea. Helminthological dissection, collection, fixing and staining of the material obtained were carried out in accordance with generally accepted principles. The intensiveness of invasion was defined directly by counting all the parasites, or in cases of exceptionally intense invasion, by counting the parasites only in a defined sample of the contents of a whole section of the intestine examined.

The material at our disposal made it possible to analyse the state of invasion by parasites over the course of a whole year and the infestation of pregnant females in comparison with non-pregnant ones, which was not possible in the case of the study made by Drygas & Piotrowski (1956b).

III. DETAILED DESCRIPTION

Trematoda

1. *Fasciola hepatica* Linnaeus, 1758

Morphology: The anatomical structure of 41 specimens of parasites did not differ from that of specimens found in the liver of cattle.

Localisation: bile ducts of the liver.

Intensiveness and extensiveness of invasion: *F. hepatica* was found in 16 hares out of a total of 706 examined (2.2%) in numbers from 1—6 trematodes in one hare. The invasion of the fluke over the yearly cycle is shown in table 1. As can be seen from this table, we found *F. hepatica* in single specimens of hares from December 1958 to June 1959, after which an interval took place in the occurrence of the parasite, which we found only in one hare in November.

Dependence of invasion on the sex and age of the hares. Analysis of this question did not provide sufficient evidence for drawing conclusions, on account of the very slight extensiveness and intensiveness of infestation. In young hares (up to one year old) *Fasciola hepatica* was found in two males (2 and 6 trematodes) in 1 female and 3 male one-year old hares (1—2 trematodes) and in 9 older hares, 4 males and 5 females (1—6 trematodes).

Dependence of invasion on sex was examined in 309 males, of which 9 were infested (2.91%) and in 263 females, *Fasciola hepatica* being found in 6 of these individuals (2.28%), among which were 4 pregnant females. Intensiveness of invasion by *Trematoda* in males and females fluctuated in similar limits, i.e. from 1 to 6 individuals in one host.

Co-occurrence of *F. hepatica* with other species of helminths. Parasitic worms accompanying invasion by *F. hepatica* were found to be as follows: *Trichostrongylus retortaeformis* — in 3 hares, *Trichuris sylvilagi* — in one hare, *Trichostrongylus retortaeformis* and *Trichuris sylvilagi* in 11 hares, *Trichostrongylus retortaeformis*, *Trichuris sylvilagi* and *Protostrongylus terminalis* — in one hare. The other species were not found to occur together with *F. hepatica*. Mixed invasion with *T. retortaeformis* and *T. sylvilagi* was most frequently found.

Cestoda

2. *Andrya rhopalocephala* (Riehm, 1881), Railliet, 1893.

Morphology. The body length of adult individuals containing eggs with oncospheres varies from 60 to 153 mm (after Spassky, 1951) up to 800 mm). The dimensions and shape of each of the organs come within the limits variation given by Spassky (1951). An exception to this is formed by the dimensions of the oncospheres, the diameter of which, in material preserved and submerged in Canadian balsam, was from 11—19 μ , with a mean value of 15 μ . This constitutes a sort of intermediate form of the sizes of the oncospheres *A. cuniculi* (18 μ) and *A. rhopalocephala* (10 μ) given by Spassky (1951). The dimensions of the whole eggs of both species are, according to Spassky, almost identical in the case of *A. cuniculi* 48—60 μ , and 52—60 μ for *A. rhopalocephala*. In our material the dimensions of the eggs varied from 41 to 64 μ . The question of the situation and shape of the prostate gland which, according to Spassky's drawings is long and slender in shape in *A. rhopalocephala* and short and almost round in *A. cuniculi*, deserves attention. We found in our material that the shape and size of this gland frequently varies considerably, even in different segments of the same specimen of tapeworm. Differential diagnosis between *A. rhopalocephala* and *A. cuniculi* is based on the

Table 1.
Extensiveness and intensiveness of invasion by the more frequently occurring
parasite worms of the hare over the yearly cycle.

Month	Month												II	
	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	XI		XII
Number of hares examined	34	48	45	48	53	54	47	46	54	50	48	50	40	AVG.
<i>F. hepatica</i>														
Infested	1	2	1	4	1	5	1				1			
Intensiveness	1	1-6	3	1-5	1	1-4	2				6			2.5
<i>A. rhopalocephala</i>														
Infested		1	1	1						1	2	1	3	
Intensiveness		8	1	1						5	1	1	1-4	2.4
<i>M. pectinata</i>														
Infested	3	4	2	5	6	4	5	1	7	4	6	4	2	
Intensiveness	1-5	1-2	3-7	1-5	1-3	1-5	1-4	1	1-6	1-5	1-7	1-5	1	2.7
<i>T. retortaeformis</i>														
Infested	24	45	43	48	52	51	44	33	47	49	40	23	26	
Intensiveness	19-8000	3-3667	7-3500	33-4500	19-7800	9-4700	1-2400	2-1400	1-2576	2-2100	1-1600	1-980	1-1050	490
<i>G. strigosum</i>														
Infested	3	8	2		1	1		1	6	4	2			
Intensiveness	1-4	1-72	1-2		1	4		3	4-10	1-23	6-22			9.3
<i>T. sylvilagi</i>														
Infested	25	29	36	39	45	47	39	24	30	29	34	38	20	
Intensiveness	2-85	3-150	4-75	4-1230	1-156	1-80	1-115	1-78	1-41	1-62	1-60	1-107	3-143	31.4

usually greater body dimensions, smaller scolex and larger suckers in *A. cuniculi*. The differences given, in addition to these, in the dimensions of the oncospheres and in the shape and size of the prostate gland would not in the light of our investigations appear to be of any value in diagnosis.

Localisation: small intestine.

Intensiveness and extensiveness of invasion. *A. rhopalocephala* was found in 10 out of the total number of 706 hares examined (1.4%), varying in numbers from 1—8 individuals in one hare. The invasion of this tapeworm over the yearly cycle is shown in table 1, from which it will be seen that *A. rhopalocephala* occurred in single cases only during the autumn, winter and early spring months. The frequency of occurrence of this tapeworm suggests, however, that it was entirely accidental. Nevertheless the fact that tapeworms with whole strobilae, often containing mature oncospheres, were found in all periods, is worthy of note.

Dependence of invasion on the sex and age of the hares. Sex and age were determined in only 7 hares out of the 10 specimens infested. We found *A. rhopalocephala* in 3 females (including one pregnant female) and in 4 males. There were no young specimens amongst the infested hares, while 3 were one year old and 4 were old individuals.

Co-occurrence of *A. rhopalocephala* with other species of helminths. Parasite worms accompanying the invasion of *A. rhopalocephala* proved to be *Trichostrongylus retortaeformis* and *Trichuris sylvilagi* in 9 hares, *Trichostrongylus retortaeformis*, *Trichuris sylvilagi* and *Mosgovoyia pectinata* in one hare.

3. *Mosgovoyia pectinata* (Goetze, 1782), Spassky, 1951

Localisation: small intestine.

Intensiveness and extensiveness of invasion. *M. pectinata* was found in 62 out of 706 hares examined (8.7%). Table 1 illustrates the invasion of this tapeworm over the yearly cycle. As can be seen from the table this tapeworm occurs throughout the whole year, and it is noteworthy that whole strobilae with mature oncospheres were found throughout the whole year. In comparison with the results of the investigations made by Drygas & Piotrowski (1955b) during winter periods only the total extensiveness of invasion by tapeworms found in our material is almost identical. In different months of the year the percentage of hares infested by *M. pectinata* exhibits fluctuations, in our opinion insignificant, from 4.4 to 12.9%, which point to the persistent vitality of the tapeworm. It was only in July 1959 that we found 1 infested hare out of 46 examined (2.1%), which might, however, be entirely accidental. Drygas & Piotrowski's conclusion that invasion is markedly reduced in January, confirming the investigations made by Riehm, 1881; Stunkard, 1934; Ze-

der, 1800; would not seem to be thoroughly justified. In their own material the percentage of infested hares varies in December in three successive shooting seasons from 0 to 16.2%, while in November 1951 the percentage of hares invaded by this tapeworm was slightly lower (7.9%) than in January 1953 (8.1%). While it is true that in our material we can find a slight decrease in extensiveness of invasion of *M. pectinata* in January, expressed in comparison with December by a difference of 0.5% and 3.1% in consecutive seasons, yet we consider these differences as non-significant in view of the variations in extensiveness of invasion over 15 successive

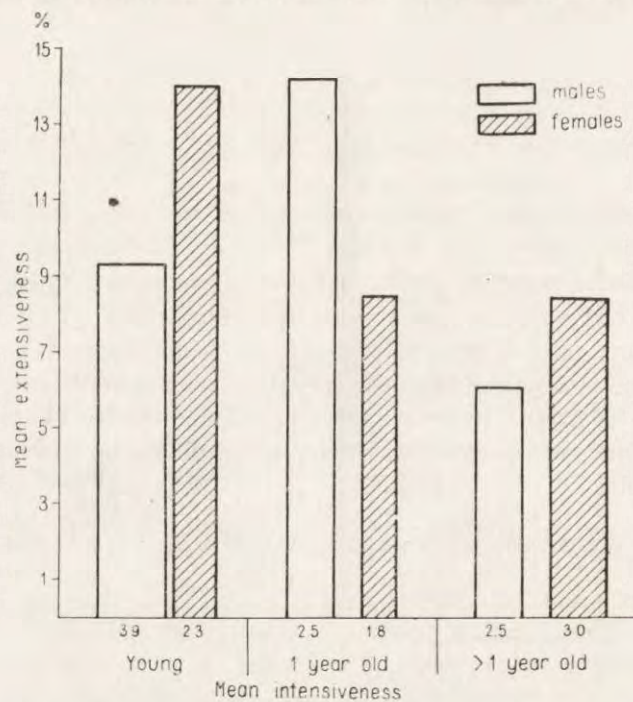


Fig. 1. Extensiveness and intensiveness of invasion by *Mosgovoyia pectinata* depending on the sex and age of the hares.

months illustrated in Table 1. The mean intensiveness of invasion was found in our material to be slightly above (2.7) the results of the above author's examinations, in which they found a mean figure of 2.0 tapeworms in each infested hare.

Dependence of invasion by *M. pectinata* on the sex and age of the hare. The extensiveness of invasion in males is 9.0%, that is, slightly lower than in females, for whom the figure is 9.8%. The mean intensiveness of invasion, on the other hand, is slightly higher in males — 2.9 specimens to each infested host — than in females, for which this value is 2.5. These differ-

ences would not seem to be important, since an analysis of infestation by *M. pectinata* in hares of both sexes and different age classes reveals a different arrangement of figures, illustrated in Fig. 1. As shown by this figure and by previous data, the extensiveness of invasion is not in complete agreement with its intensiveness. The maximum extensiveness occurs in young females and males one year old, being respectively 14.0 and 14.2% and the minimum in old males (6.1%). Maximum intensiveness of invasion was noted in young males (mean number 3.9 tapeworms per 1 hare), and minimum in females one year old (mean number 1.8 tapeworms). Fig. 1 shows the differences in the values expressing intensiveness and extensiveness of invasion in males and females of different ages. In view of the small amount of material available these differences would not appear to provide grounds for drawing definite conclusions. For the same reasons it is also difficult to say whether the pregnancy of females affects invasion by *M. pectinata*. The fact may, however, be recorded that out of the 86 pregnant females examined 5 individuals (5.8%) were infested by this tapeworm, while we found 10 infested specimens, that is, almost 9% out of the 112 non-pregnant females from the same period, from January to September. (The total percentage of all the non-pregnant and infested females examined was even higher, 11.3%).

Co-occurrence of *M. pectinata* with other species of helminths. Among the 62 hares infested by above tapeworm one hare was found to be infested by *Mosgovoyia pectinata* only. Helminths accompanying the invasion of this parasite were found to be: *Trichostrongylus retortaeformis* — in 3 hares, *Trichuris sylvilagi* — in 13 hares, *Trichostrongylus retortaeformis* and *Trichuris sylvilagi* — in 40 hares, *Trichostrongylus retortaeformis* and *Protostrongylus terminalis* — in one hare, *Trichostrongylus retortaeformis*, *Trichuris sylvilagi* and *Graphidium strigosum* in one hare, *Trichostrongylus retortaeformis*, *Trichuris sylvilagi* and *Protostrongylus terminalis* — in 1 hare, *T. retortaeformis*, *T. sylvilagi* and *Andrya rhopaloccephala* in 2 hares. As shown by the figures mixed infestation of *M. pectinata* with *T. sylvilagi* and *T. retortaeformis* occurs most frequently (64.6%).

Nematoda

4. *Trichostrongylus retortaeformis* (Zeder, 1800), Looss, 1905

Morphology. The morphological structure of the specimens we found agreed with the descriptions so far given. We several times found specimens, however, with swelling of the cuticle on the anterior end of the body (Fig. 2) and undulating course of the pharynx.

Localisation: small intestine, accidentally the stomach.

Intensiveness and extensiveness of invasion. We found *T. retortaeformis* in 561 hares out of 706 examined, i.e. 79.4%, in numbers varying from 1—8000 in one hare. The invasion of this nematode over the yearly cycle is illustrated in table 1, from which it can be seen that *T. retortaeformis* occurs abundantly throughout the whole year. Intensiveness and extensiveness of invasion, determined jointly for all the hares examined, irrespective of their age and sex, are given in Fig. 3. Both the numerical data and the figure show that fluctuations in the intensiveness and extensiveness of invasion exist which do not coincide with each other. Can these fluctuations be considered as connected with the season of the years? Extensiveness of invasion is maintained on a high level throughout the whole year and would not seem to point to any distinct connection with the

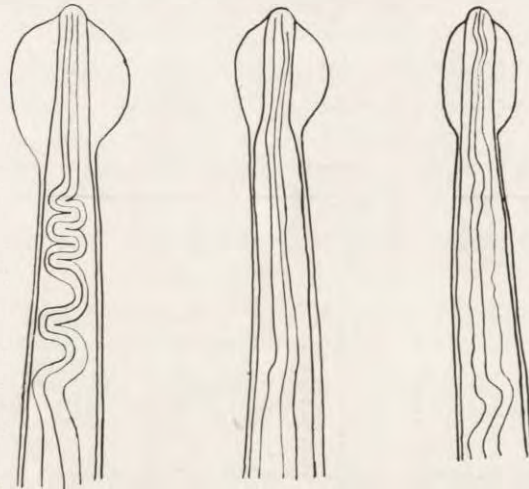


Fig. 2. Anterior end of the body of *T. retortaeformis* with swellings of the cuticle.

seasons. It is true that in December, January and February 1959/60 a decrease was observed in the extensiveness of invasion (respectively 32%, 66% and 60%) but in the same months of the previous year 1958/59 extensiveness of invasion was maintained on the same level as in the spring-summer period. The phenomenon of the seasonal character of invasion by *T. retortaeformis*, on the other hand, can be observed by means of comparison of fluctuations in the mean intensiveness of invasion, which reaches a peak in April and exhibits an uneven decrease in the summer, reaching a minimum in January 1960. The mean intensiveness of invasion in January of the previous year, 1959, was, however, far higher, although it reflected a distinct tendency to decrease, reaching a minimum in February 1959. In general intensiveness of invasion in the winter months of 1958/59 was not only far higher than in the same months in 1959/60 but

also exceeded the intensiveness of invasion by the parasite in the summer months. It must be supposed that intensiveness of invasion in 1958 was far higher than in 1959. Continuous examination carried out over a period of several years would give a fuller picture of seasonal fluctuations in the occurrence of the parasite. In comparison with the investigations made by Drygas & Piotrowski (1955) in three consecutive shooting seasons (November, December and January) from the same area and period a general increase in the intensiveness and extensiveness of invasion by this parasite can be noted. According to the above research workers the

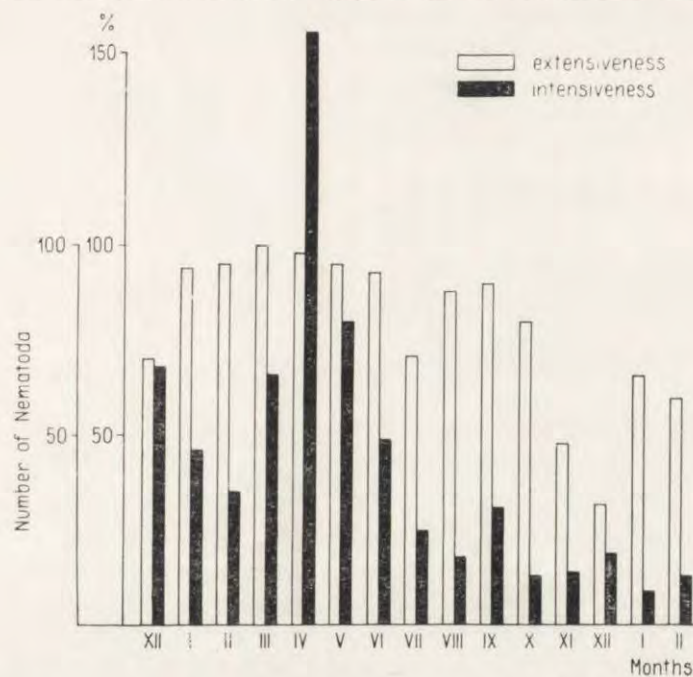


Fig. 3. Extensiveness and intensiveness of invasion by *T. retortaeformis* over the yearly cycle.

mean extensiveness of invasion by these nematodes was 55%, the mean intensiveness approximately 50 specimens in one hare, while in our material the figures were respectively 61% and mean intensiveness about 310 specimens of the parasite in one host.

Dependence of invasion on the sex and age of the hares. Sex was determined in 592 hares. Out of 320 males examined 266 (83.1%) were infested. The percentage of infested females was slightly lower: out of 272 examined 221 (81.3%) had been invaded. The mean intensiveness of invasion was 531 nematodes in males, which is a slightly higher figure than in females, in which an average of 501 nematodes were found in one infected

female. Over the yearly cycle extensiveness and intensiveness of invasion is slightly different in males and females. In males the maximum extensiveness of invasion occurs in February and March (100%), in females in March and April (100%). The decrease in extensiveness of invasion begins in both the sexes in October and reaches a minimum in December — in males 39.1%, in females 26%. Mean intensiveness of invasion attains its maximum in both sexes in April (1511 in males and 1730 in females), after which it decreases sharply and reaches a minimum in males in August (63 nematodes), but in the case of females not until December (53 nematodes) (Fig. 4). The delay in the decrease in invasion intensity in females

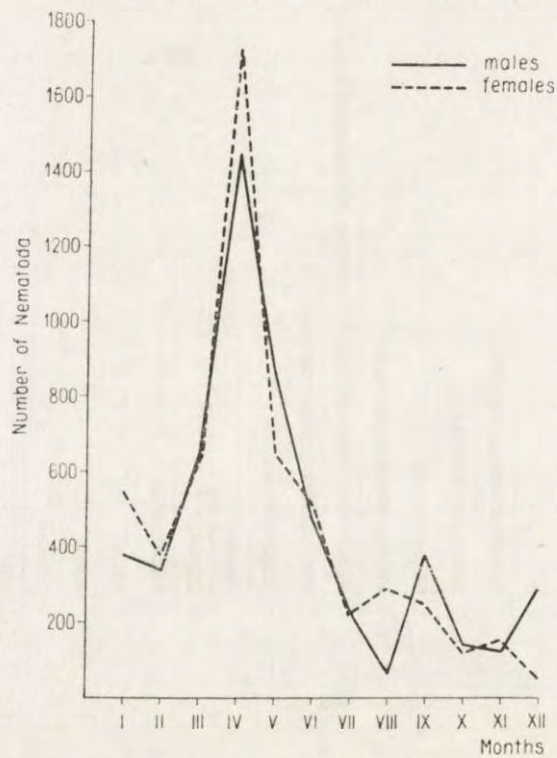


Fig. 4. Intensiveness of invasion by *T. retortaeformis* in males and females over the yearly cycle.

may be connected with the fact (accepted with some reserve as to the significance of these differences) that from January to September we encountered a considerable percentage of pregnant females, in which mean intensiveness of invasion proved to be higher (600 nematodes) than in non-pregnant females (565 nematodes) at the same time. Infestation by *T. retortaeformis* in the different age groups is illustrated by table 2. The maximum extensiveness of invasion is found in hares one year old, and

the minimum in young hares. Intensiveness of invasion follows a similar pattern although differences are less distinct in this case. The relations of these same age group in both sexes are somewhat different (Fig. 5). Extensiveness of invasion is almost identical in both sexes in different age groups, but intensiveness of invasion is markedly lower in young females than in young males (shown by thickness of column on the diagram). The

Table 2.

Extensiveness and intensiveness of invasion by *T. retortaeformis* depending on the age of the hares.

Age	Young	Yearlings	Old adult
No. of hares examined	150	147	257
No. of hares infested	96	146	229
Extensiveness	64 %	99 %	83 %
Mean intensiveness	480	533	530

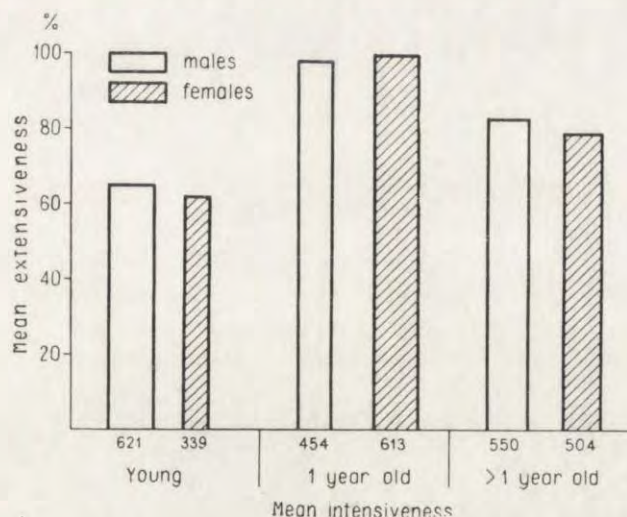


Fig. 5. Extensiveness and intensiveness of invasion by *T. retortaeformis* depending in the sex and age of the hares.

course taken by the invasion of *T. retortaeformis* in both sexes in the three age groups of the hares over the yearly cycle is illustrated by Fig. 6. This diagram confirms the previous observation that variations in the intensity of invasion are connected with the season of the year. The maximum intensiveness of invasion was found in all the hares in April and May. This phenomenon is most distinctly marked in young males and females. Pregnant females form a separate group in which we wanted to

trace the occurrence of *T. retortaeformis*, since we had collected suitable comparative material. During the period from January to September we examined 86 pregnant females, of which 80 (93.7%) were infested, the mean intensiveness of invasion in the animals being 600 nematodes per

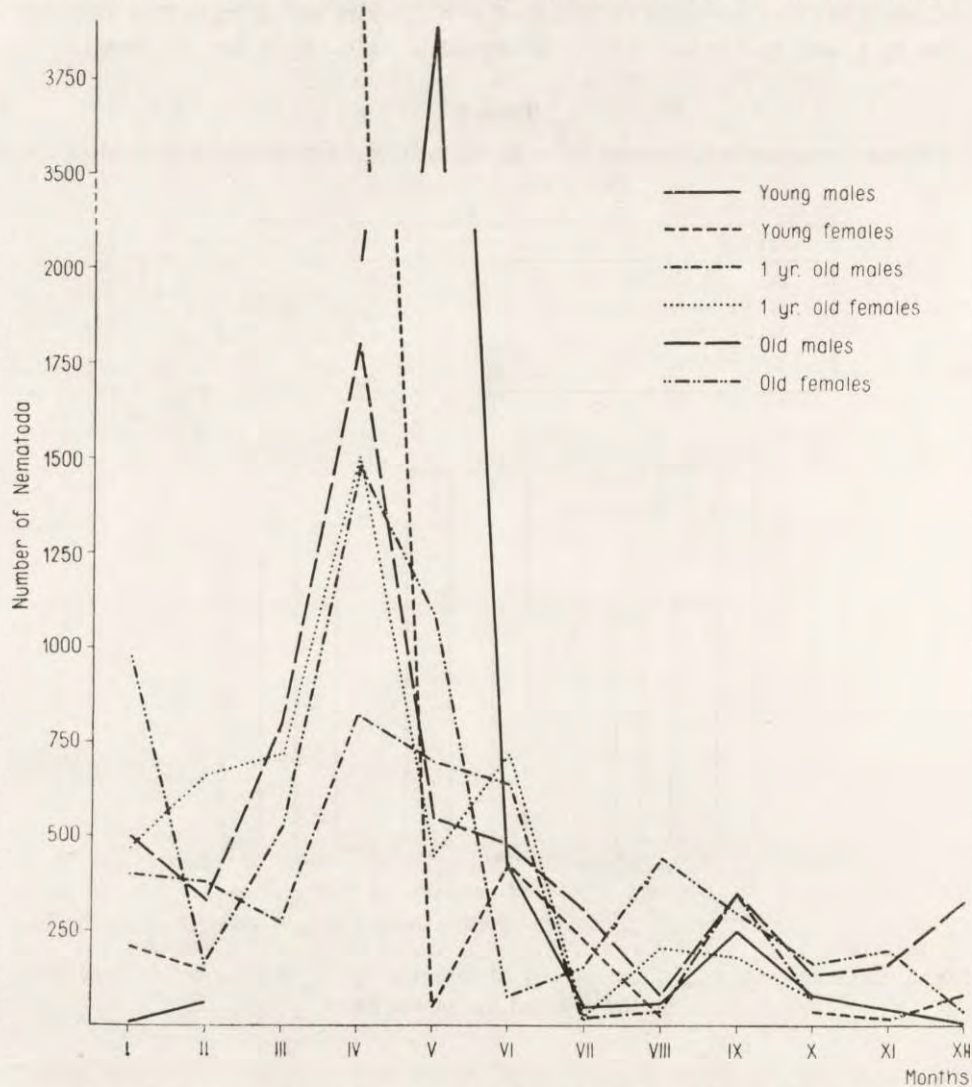


Fig. 6. Intensiveness of invasion by *T. retortaeformis* in yearly cycle.

female. Corresponding data for 186 non-pregnant females were 141 (75%) infested animals and 450 nematodes per female. Both the extensiveness and intensiveness of invasion by *T. retortaeformis* is therefore lower in non-pregnant than in pregnant females. It is however necessary to em-

phasise that non-pregnant females, examined over the course of a whole year, i.e. also during the period from October to December inclusive when there are no pregnant females, were used for comparison of the infestation of pregnant and non-pregnant females by *T. retortaeformis*. In view

Table 3.

Co-occurrence of *T. retortaeformis* with other species of helminths.

Species	No. of hares	%
<i>T. retortaeformis</i> — one-species invasion	133	23.6
<i>T. retortaeformis</i> + <i>F. hepatica</i>	3	0.53
<i>T. retortaeformis</i> + <i>T. sylvilagi</i>	330	58.9
<i>T. retortaeformis</i> + <i>P. terminalis</i>	2	0.36
<i>T. retortaeformis</i> + <i>G. strigosum</i>	9	1.6
<i>T. retortaeformis</i> + <i>M. pectinata</i>	3	0.53
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>M. pectinata</i>	40	7.1
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>T. terminalis</i>	2	0.36
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>G. strigosum</i>	13	2.3
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>F. hepatica</i>	11	2.0
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>A. rhopalocephala</i>	9	1.6
<i>T. retortaeformis</i> + <i>P. terminalis</i> + <i>M. pectinata</i>	1	0.18
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>M. pectinata</i> + <i>A. rhopalocephala</i>	2	0.36
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>M. pectinata</i> + <i>G. strigosum</i>	1	0.18
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>M. pectinata</i> + <i>P. terminalis</i>	1	0.18
<i>T. retortaeformis</i> + <i>T. sylvilagi</i> + <i>F. hepatica</i> + <i>P. terminalis</i>	1	0.18
Total	561	100.00

of the fact that it is during this particular period that a decrease occurs in the extensiveness and intensiveness of invasion, it is essential to accept a correction to the above statement, resulting from comparison of the infestation of non-pregnant and pregnant females only during the period from January to September inclusive. If then appears that the extensiveness of invasion in both the groups of females examined is almost identical, being 93% in pregnant and almost 92% in non-pregnant females. The mean intensiveness of infestation of non-pregnant females during this same period remains, however, slightly lower (565 nematodes) than in the pregnant females (600 nematodes) — per one female. Such differences do not, however, justify the conclusion being drawn that the pregnancy of the host creates better living conditions for *T. retortaeformis*, since not infrequently completely opposite relations are observed, and in view of the considerable variations in intensiveness of invasion in different individual hosts the difference in the mean intensiveness of invasion would not appear in this case to be significant. The infestation of pregnant females is different in different age groups. In young hares and one-year old pregnant females we found 100% infestation, and in old hares 86%,

whereas the mean intensiveness of invasion was lowest in young females (205 nematodes), higher in one-year old hares (600 nematodes) and highest in old hares (720).

Co-occurrence of *T. retortaeformis* with other species of helminths. In the total number of 561 hares infested by *T. retortaeformis* there was a predominance of mixed invasion, as can be seen from Table 3, which shows that in 58.9% of the hares there was mixed invasion by *T. retortaeformis* and *T. sylvilagi*, whereas there was one-species invasion in only 23.6%. Mixed invasion by *T. sylvilagi* and *M. pectinata* came third in order of frequency of occurrence (7.1%), while the remaining combinations of mixed invasion were only found sporadically.

5. *Trichostrongylus medius* Oligier, 1952

We found one male of this species in the small intestine among numerous specimens of *T. retortaeformis*. The former species has been described so far in *Lyrurus tetrrix* from the Soviet Union. The hare probably played the part of an accidental host in this case.

6. *Graphidium strigosum* (Dujardin, 1845), Railliet et Henry, 1909

The morphology of the specimens we found did not differ from the known descriptions of the species.

Localisation: stomach.

Intensiveness and extensiveness of invasion. We found *G. strigosum* in 28 out of 706 hares examined (3.9%), in numbers varying from 1—72 individuals in one infested hare, with a mean figure of 9.4. The invasion of this nematode over the yearly cycle is shown in table 1, from which it can be seen that this nematode occurred sporadically, with certain intervals, over the whole year. The low intensiveness and extensiveness of invasion did not permit of drawing conclusions as to the seasonal nature of the parasite's occurrence. It is interesting to note that we found relatively numerous specimens of the nematode in December 1958, January and February 1959, while during the same months of the following winter 1959/60 we did not discover any invasion at all by this parasite.

Dependence of invasion on the sex and age of the hares. Sex and age were examined in all the 28 infested hares. Out of a total number of 330 males examined 17 were infested by *G. strigosum* (5.3%), while amongst the 284 females examined only 11 proved to be invaded (3.9%). The mean intensiveness of invasion, however, was found to be lower in males (5 nematodes) than in females (15 nematodes). Of the 11 females infested one

was a young specimen, 2 one-year old and 8 older hares (including one pregnant female), while of the 17 males infested 5 were one-year old and 12 old hares. These data suggest that *G. strigosum* occurs more frequently in older hosts.

Co-occurrence of *G. strigosum* with other species of helminths. Out of a total number of 28 hares infested, there was a predominance of mixed infestation:

<i>G. strigosum</i>	—	one-species invasion			2	
"	+	<i>T. sylvilagi</i>			3	
"	+	<i>T. retortaeformis</i>			9	
"	+	"	+	<i>T. sylvilagi</i>	13	
"	+	"	+	"	+ <i>M. pectinata</i>	1
				Total	28	

The above list shows that joint invasion by *G. strigosum* with *T. retortaeformis* and *T. sylvilagi* and *G. strigosum* with *T. retortaeformis* only was most frequently encountered.

7. *Haemonchus contortus* (Rudolphi, 1803) Cobb, 1898

As in the case of *Trichostrongylus medius*, we also found only one male in the small intestine in the case of *H. contortus*. The hare has not hitherto been recorded as a host of *H. contortus* and is probably an accidental host of this parasite.

8. *Protostrongylus terminalis* (Passerini, 1884) Kamensky, 1095 = *P. commutatus* (Diesing, 1851)

Morphology. In view of certain divergences in morphometric data for *P. terminalis* given by different authors, we have given below our own results of measurements made of 7 males and 11 females. The male was 23—35 mm in length and 0.13 mm in breadth, pharynx 0.36 mm long (after Hall, 1916, from Sulc, 1932 — 0.665 mm) ornamented spicula 0.16—0.18 mm in length, telamon 0.044 mm in length. Female — 45—59 mm in length and 0.18—0.2 mm in breadth, pharynx — 0.42—0.45 mm in length, vagina 2.2—2.4 mm in length, distance from female genital pore to end of body 0.24—0.28 mm, eggs oval 0.090—0.096 × 0.060—0.080 mm.

Localisation: bronchi.

Intensiveness and extensiveness of invasion. Of the 706 hares examined it was only in 8 (1.1%) that we found invasion by *P. terminalis*, in numbers from 1—6 individuals in one hare. Mean intensiveness of invasion was 3.5 nematodes in one infested hare. Over the yearly cycle we discovered invasion by *P. terminalis* in single cases, i.e. in 1—2 hares in each month in January, April, May, June and August.

Co-occurrence of *P. terminalis* with other helminths was as follows:

<i>P. terminalis</i>	—	one-species invasion			1	
"	+	<i>T. retortaeformis</i>			2	
"	+	"	+	<i>T. sylvilagi</i>	2	
"	+	"	+	<i>M. pectinata</i>	1	
"	+	"	+	"	+ <i>T. sylvilagi</i>	1
"	+	"	+	<i>F. hepatica</i>	"	1
Total					8	

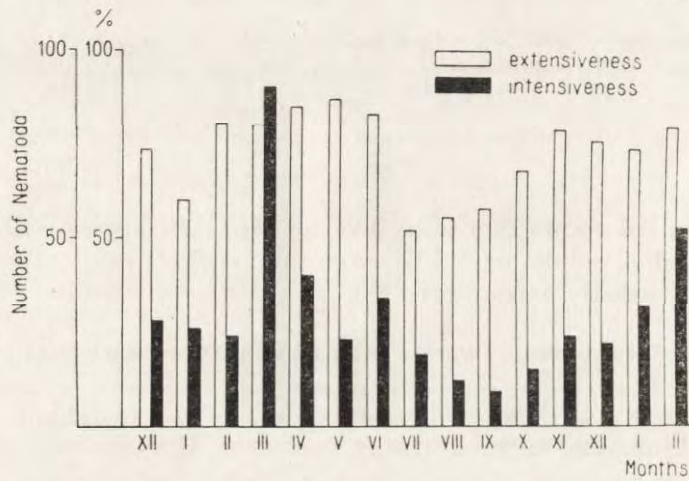


Fig. 7. Extensiveness and intensiveness of invasion by *T. sylvilagi* over the yearly cycle.

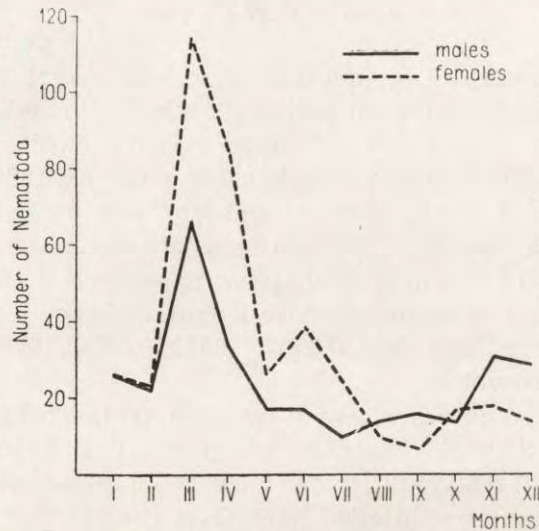


Fig. 8. Intensiveness of invasion by *T. sylvilagi* in the yearly cycle, depending on the sex of the hares.

9. *Trichuris sylvilagi* Tiner, 1950

Morphology. Of the morphometric data obtained in our material (50 males and 50 females) the following are worthy of note. Variations in length of the spicula from 5.6—8.2 mm (after Drygas & Piotrowski, 1955 — 6.5—8.8 mm). Earlier research workers had not drawn attention to a character of importance in *Trichocephalata*, that is the structure of the pharynx. Our observations showed that the pharynx consisted of a very short muscular part about 0.5 mm long, while the number of stichocytes varies within limits of 60—73 in males and 70—73 in females. Tiner (1950) in describing *T. sylvilagi* as a new species, based his description chiefly on the length of the spicula, which character makes it easy to distinguish *T. sylvilagi* from *T. leporis*, which has a short spicula (1.6—3.2 mm). Earlier authors, who did not differentiate between these two species, classified them under the name of *T. leporis*, recording the existence of the armature of the spicular sheath and the vulva (Chandler, 1930; Szulc, 1931). Neither Tiner (1950) nor Drygas & Piotrowski (1955) refer to this character. As we had no specimens of *T. leporis* available we were unable to state whether the armature of the spicular sheath and vulva occur in this species. *T. sylvilagi* has a spicular sheath and vulva in which the armature consists of distinct spines.

Localisation: large intestine.

Intensiveness and extensiveness of invasion. We found *T. sylvilagi* in 514 out of the 706 hares examined (72.8%), in numbers from 1—1230 specimens in one hare. The mean intensiveness of infestation per one infested hare was 31.4 nematodes. Table 1 illustrates the state of invasion by the parasite over the yearly cycle, from which it will be seen that *T. sylvilagi* occurs abundantly throughout the year. Variations in intensiveness and extensiveness of invasion over the yearly cycle are more distinctly evident in Fig. 7, showing that extensiveness of invasion is maintained on a high level throughout the year, exhibiting fluctuations from 52% in July to 87% in May. During 1959 we observed a decrease in the extensiveness of invasion in the summer months (July, August, September respectively 52, 55, 58%) and an increase, greater in the spring months from March to May (80—87%), and slightly smaller in the autumn-winter months from October 1959 to February 1960 (68—80%). Fluctuations in the mean intensiveness of invasion do not coincide with the fluctuations in invasion extensiveness, but clearly point to the existence of a peak in March and decrease during the turning point between summer and autumn (minimum in September). In comparison with the results of the studies made by Drygas & Piotrowski

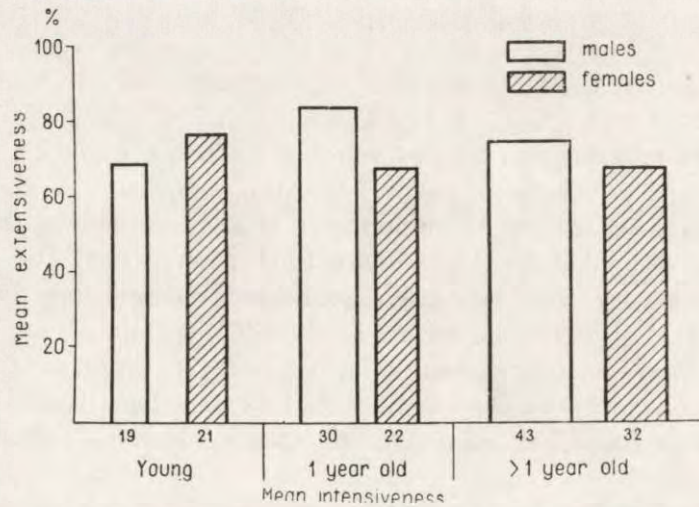


Fig. 9. Extensiveness and intensiveness of invasion by *T. sylvilagi*, depending on the sex and age of the hares.

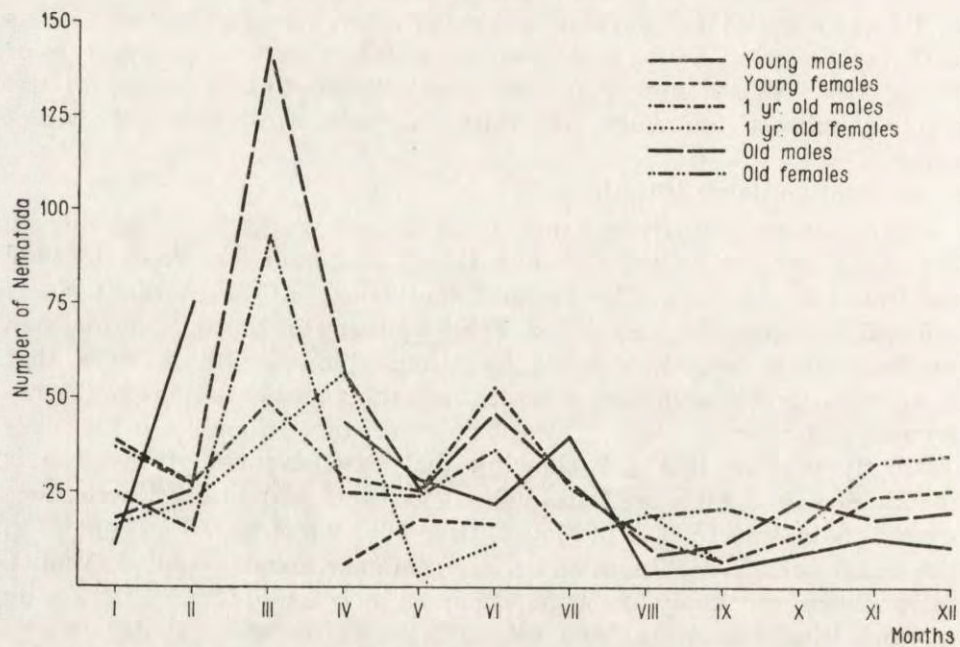


Fig. 10. Intensiveness of invasion by *T. sylvilagi* over the yearly cycle.

our observations from the same period point to a similar extensiveness of invasion and slightly lesser intensiveness.

Dependence of invasion on the sex and age of the hares. Out of 320 males examined we found invasion by *T. sylvilagi* in 231 (74.4%), and out

of 272 females examined 190 (70%) proved to be infested. Mean intensiveness of invasion was 32 nematodes per one hare in the case of males, and 27 nematodes in the case of females. It is therefore clear that both extensiveness and intensiveness of infestation by *T. sylvilagi* is slightly higher in males than in females. Over the yearly cycle the extensiveness of invasion by the parasite reveals no significant differences in either sex. Intensiveness of invasion, on the other hand, is markedly higher in males in the spring months (March—April) and summer months (June and July) than in females. As from August until the end of the year the reverse applies: mean intensiveness of invasion proved on the whole to be greater in females than in males (Fig. 8).

Age was determined in 572 hares. Infestation by *T. sylvilagi* in hares divided into three age groups is illustrated by Table 4. This shows that extensiveness of invasion is almost identical in all the age groups. Intensiveness of invasion, on the other hand, increases slightly with age. Fig. 9 presents the intensiveness and extensiveness of invasion by *T. sylvilagi* in

Table 4.
Extensiveness and intensiveness of invasion by *T. sylvilagi* depending on the age of the hares.

Age	Young	Yearlings	Old adult	Total
No. of hares examined	150	147	275	572
No. of hares infested	108	111	195	414
Extensiveness	72 %	75 %	71 %	
Mean intensiveness	20	26	37	

both sexes of hares divided into three age groups. It can be seen from this figure that in the group of young hares intensiveness and extensiveness of invasion is almost identical in both sexes, although slightly lower in males than in females, while in the remaining groups the reverse is the case: both these values are greater for males than for females. The question of whether the variations in intensiveness of invasion over the yearly cycle are connected with the season or with the sex or age of the hares was investigated (Fig. 10). From this figure it can be seen that the generally maximum level of mean intensiveness of invasion in March is accounted for by the old hares, both males (to a greater degree) and females (to a lesser degree). The absence of young males and females (less than a year old) in March made it impossible to compare infestation in the youngest and oldest hares at this time. In the remaining months of the year the intensiveness of invasion by *T. sylvilagi* is on the whole greater in one-year old and old hares than in the young ones.

Pregnancy of females and invasion by *T. sylvilagi*. Out of 86 pregnant females examined between January and September 1959—63 (73.2%) were infested. Out of the total number of 112 non-pregnant females examined during the same period we found infestation by *T. sylvilagi* in 67 (59.8%). The mean intensiveness of invasion in pregnant females was 35 nematodes per female, whereas in non-pregnant females the number is 20. *T. sylvilagi* therefore occurs more frequently and numerously in pregnant females than in non-pregnant ones. This statement is also confirmed by an analysis of the state of invasion by *T. sylvilagi* in pregnant and non-pregnant females divided into age groups. In each of these groups both the percentage of pregnant females infested and the mean intensiveness of invasion by the parasite is higher than in the non-pregnant females.

Co-occurrence of *T. sylvilagi* with other helminths was as follows:

<i>T. sylvilagi</i> one-species invasion	87
„ + <i>G. strigosum</i>	3
„ + <i>T. retortaeformis</i>	330
„ + <i>M. pectinata</i>	13
„ + <i>F. hepatica</i>	1
„ + <i>T. retortaeformis</i> + <i>G. strigosum</i>	13
„ + „ + <i>M. pectinata</i>	40
„ + „ + <i>F. hepatica</i>	11
„ + „ + <i>A. rhopalocephala</i>	9
„ + „ + <i>P. terminalis</i>	2
„ + „ + <i>M. pectinata</i> + <i>A. rhopalocephala</i>	2
„ + „ + „ + <i>G. strigosum</i>	1
„ + „ + „ + <i>P. terminalis</i>	1
„ + „ + „ + <i>F. hepatica</i> + „	1
Total	514

As can be seen from the above list we found *T. sylvilagi* most frequently jointly with *T. retortaeformis*, then in order of frequency, in the second place we found one-species invasion, and in the third mixed invasion with *T. retortaeformis* and *M. pectinata*. The remaining combinations of mixed invasion occurred in cases from 1—13 in number.

IV. RESULTS

A. Morphological

1. The anatomical structure of *Fasciola hepatica* from the hare does not differ from that of individuals found in the liver of cattle.

2. The differences, presented by Spassky (1951) in the dimensions of oncospheres and the shape and size of the prostate gland, supposedly making it possible to distinguish *Andrya rhopalocephala* from *Andrya cucinuli* would seem, in the light of our investigations, to be of no value for diagnosis on account of the individual variability of these characters.

3. We several times observed in *T. retortaeformis* a symmetrical and lasting swelling of the cuticle at the anterior end of the body of *T. retortaeformis*, not recorded in any of the descriptions known to us.

4. We found differences in comparison with Hall's (1916) data in the dimensions of the pharynx of male and female specimens of *Protostrongylus terminalis*.

5. In the case of *Trichuris sylvilagi* we established a degree of variation in the length of the spicula greater than that hitherto recorded and we drew attention to the armature of the spicular sheath and vulva.

B. Intensiveness and extensiveness of invasion over the yearly cycle

1. On account of their relatively rare occurrence it was not possible to arrive at any conclusions as to the seasonal character of invasion by *F. hepatica*, *A. rhopalocephala*, *M. pectinata*, *G. strigosum* and *P. terminalis*. Only in the case of *M. pectinata* did we find that it occurred throughout the year uninterruptedly, without discovering any significant seasonal variations.

2. We found strobilae with mature oncospheres in *Andrya rhopalocephala* and *Mosgovoyia pectinata* at different times of the year, which is evidence that winter destrobilisation does not occur in these species, at least not under Polish climatic conditions.

3. The maximum intensiveness of invasions is found in the case of *T. retortaeformis* in April, and of *T. sylvilagi* in March. During the peak period of intensive invasion the young males and females are most intensively infested by *T. retortaeformis*, and the old males and females by *T. sylvilagi*.

C. Dependence of invasion on the sex and age of the hares

1. Low extensiveness and intensiveness of invasion did not permit of reaching conclusions on the subject of the dependence of invasion by parasites on the sex and age of hares in the case of the following species: *F. hepatica*, *A. rhopalocephala*, *M. pectinata*, *G. strigosum* and *P. terminalis*.

2. Mean intensiveness and extensiveness of invasion is slightly higher in males than in females in the case of *T. retortaeformis* and *T. sylvilagi*.

3. Extensiveness of invasion by *T. retortaeformis* is lowest in young hares, higher in old ones and highest in one-year old hares. Mean intensiveness of invasion is slightly lower in young and almost uniform in old and one-year old hares.

4. Extensiveness of invasion by *T. sylvilagi* is almost uniform in all three age groups, but intensiveness increases markedly with age: in young specimens 20 nematodes, in old ones 37 nematodes in one hare.

5. Comparison of infestation of non-pregnant and pregnant females during the period from January to September revealed an absence of differences in the extensiveness of invasion by *T. retortaeformis* in both groups (92% and 93%). Extensiveness of invasion by *T. sylvilagi* was markedly higher in pregnant females (73%) than in non-pregnant ones (59.8%). The mean intensiveness of invasion by both species of parasites was greater in pregnant than in non-pregnant females, but there were significant differences only in the case of *T. sylvilagi*.

D. Co-occurrence of helminths

We did not find reciprocal exclusion of species of parasites infesting the hares examined. When analysing each species we most often found mixed invasions by *Trichostrongylus retortaeformis* and *Trichuris sylvilagi*.

REFERENCES

1. Czarnowski, A. & Witkowski, E., 1954: Zapalenie płuc u zająca wywołane przez larwy *Protostrongylus commutatus*. Med. wet., 10, 2: 63—64.
2. Chandler, A. C., 1930: Specific characters in the genus *Trichuris* with a description of a new species *T. tenuis* from a camel. J. Parasit., 16.
3. Drygas, M. & Piotrowski, F., 1955a: Z morfologii *Trichuris sylvilagi* Tiner, 1950. Acta parasit. pol., 2, 18: 343—359. Warszawa.
4. Drygas, M. & Piotrowski, F., 1955b: Materiały do fauny robaków pasożytniczych przewodu pokarmowego zająca *Lepus europaeus* L. Acta parasit. pol., 3, 15: 377—396. Warszawa.
5. Skrjabin, K. I., Šihobalova, N. P. & Šulc, R. S., 1954: Osnovy nematologii. III. Trihostrongylidy životnyh i čeloveka. Izd. AN SSSR. Moskva.
6. Skrjabin, K. I., Šihobalova, N. P., Šulc, R. S., Popova, T. I., Boev, S. N. & Delamure, S. L., 1952: Opredelitel paraziticheskih nematod. III, Strongylaty. Izd. AN SSSR. Moskva.
7. Spassky, A. A., 1951: Osnovy cestodologii. 1—286.
8. Šulc, R. S., 1931: Parazitičeske červi krolikov i zajcev i vyzyvaemye imi zabolvanija. Selhozgiz. Moskva.
9. Tiner, J. D., 1950: Two new species of *Trichuris* from North America with redescription of *T. opaca* and *T. leporis* (Nematoda, Aphasimidia). J. Parasit., 36.

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BADANIA NAD ZAJĄCEM SZARAKIEM. IX. HELMINTOFAUNA
W CYKLU ROCZNYM

Streszczenie

A. Morfologia

1. Budowa anatomiczna *Fasciola hepatica* z zająca nie różni się od osobników stwierdzanych w wątrobie bydła.
2. Wysuwane przez Spasskiego (1951) różnice dotyczące rozmiarów onkosfer kształtu i wielkości gruczołu kroczonego pozwalające rzekomo odróżnić *Andrya rhopalocephala* od *Andrya cuniculi* wydają się w świetle naszych badań nie mieć żadnej wartości rozpoznawczej ze względu na zmienność indywidualną tych cech.
3. U *Trichostrongylus retortaeformis* zaobserwowaliśmy kilkakrotnie symetryczne i trwale wzdęcie oskórkowe przedniego końca ciała nie notowane w znanych nam opisach.
4. U *Protostrongylus terminalis* stwierdziliśmy różnice w rozmiarach gardzieli u samców i samic w porównaniu z danymi Halla (1916).
5. U *Trichuris sylvilagi* wykazaliśmy większą od dotychczas znanej zmienność długości szczecinek kopulacyjnych i zwróciliśmy uwagę na uzbrojenie pochewki spikularnej i wulwy.

B. Intensywność i ekstensywność inwazji w cyklu rocznym

1. Ze względu na stosunkowo rzadkie występowanie nie można wnioskować na temat sezonowości inwazji *F. hepatica*, *A. rhopalocephala*, *M. pectinata*, *G. strigosum* i *P. terminalis*. Jedynie *M. pectinata* stwierdzaliśmy przez cały rok bez przerwy nie wykrywając istotnych zmian sezonowych.
2. U *Andrya rhopalocephala* i *Mosgovoyia pectinata* znajdowaliśmy w różnych porach roku strobile z dojrzałymi onkosferami co świadczy, że destrobilacja zimowa nie występuje u tych gatunków przynajmniej w krajowych warunkach klimatycznych.
3. Największa intensywność inwazji przypada dla *T. retortaeformis* w kwietniu, dla *T. sylvilagi* w marcu. W okresie szczytowego nasilenia inwazji najintensywniej zarobaczone są przez *T. retortaeformis* młode samce i samice, przez *T. sylvilagi* zaś stare samce i samice.

C. Zależność inwazji od płci i wieku zająca

1. Mała ekstensywność i intensywność inwazji nie pozwala na wnioskowanie na temat zależności inwazji pasożytów od płci i wieku zająca dla następujących gatunków: *F. hepatica*, *A. rhopalocephala*, *M. pectinata*, *G. strigosum* i *P. terminalis*.
2. Średnia intensywność i ekstensywność inwazji jest nieznacznie wyższa u samców niż u samic dla *T. retortaeformis* i *T. sylvilagi*.
3. Ekstensywność inwazji *T. retortaeformis* jest najniższa u młodych zająca, wyższa u starych, najwyższa u jednorocznych. Średnia intensywność inwazji jest nieco niższa u młodych a prawie jednakowa u starych i jednorocznych.

4. Ekstensywność inwazji *T. sylvilagi* jest niemal jednakowa we wszystkich trzech grupach wieku, jednak intensywność wzrasta wyraźnie z wiekiem.

5. Porównanie stanu zarobaczenia samic nieciążarnych i ciężarnych w okresie od stycznia do września wykazało brak różnicy w ekstensywności inwazji *T. retortaeformis* u obu grup (92% i 93%). Ekstensywność inwazji *T. sylvilagi* była wyraźnie wyższa u samic ciężarnych (73%) niż nieciążarnych (59,8%). Średnia intensywność inwazji obu gatunków pasożytów była wyższa u samic ciężarnych niż nieciążarnych. Istotne różnice dotyczą jednak *T. sylvilagi*.

D. Współwystępowanie helmintów

Nie stwierdziliśmy wzajemnego wykluczania się gatunków pasożytów znajdujących u badanych zajęcy. Analizując poszczególne gatunki najczęściej notowaliśmy inwazje mieszane z *Trichostrongylus retortaeformis* i *Trichuris sylvilagi*.