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Host Habitat and Age as Factors in the Prevalence of Intestinal Parasites of the Muskrat[1]

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ABSTRACT

Muskrats (*Ondatra zibethicus*) collected from three different habitats: river, marshes and streams were examined for helminth parasites. Muskrats were aged by a lens-weight technique. Using the age specific prevalence, transmission rats for *Wardius zibethicus, Quinqueserialis quinqueserialis, Echinostomum revolutum* and the strobilocercus stage of *Hydatigera taeniaeformis* were constructed for stream muskrats. Parasite burdens and the occurrence of multiple infections increased with host age. Differences in prevalence between habitats were observed.

INTRODUCTION

The biological success of a parasite, like that of any free-living species, depends on the parasite's ability to adapt to its environment. The extent to which this success is attained by the parasite can be measured by its prevalence in the host population.

Although many studies deal with the host parasite relationship and the influence of the internal environment, the information obtained has been difficult to relate to the population dynamics of the parasite in nature. Surveys which might be expected to give some insight into such questions have unfortunately seldom touched on the influence of the external environment and often do not even record the habitat in which the survey was made. Consequently, there is little information available on the ecology of parasitism which emphasizes the role of the external environment and, more specifically, the influence of host habitat on parasite success.

The muskrat, *Ondatra zibethicus* (Linnaeus, 1766), affords an opportunity to examine this aspect of parasitism since it is well adapted to a wide variety of habitats, is relatively easy to obtain, and is an animal whose parasite fauna is well known (Takos, 1940; Knight, 1951; Meyer and Reilly, 1950; Barker, 1915). This study attempts to compare the helminth

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parasite infestations of muskrats from three different habitats: river, marsh and stream, and to examine the rate at which a muskrat population becomes infected, i. e., to determine the age specific prevalence for each parasite.

MATERIALS AND METHODS

Muskrats were trapped during a ten-week period extending from December, 1963 to February, 1964.

Marsh animals were all taken by the authors from Black Moshanan Marsh, Centre County, Pa.; river animals were from a section of the Susquehanna, Lycoming County, Pa. and were supplied by an independent trapper; while stream muskrats were obtained in various streams in Centre County, Pa. both by the authors and by other trappers. All areas from which animals were taken were inspected by one of us (D.A.) and all the habitats sampled are part of the same watershed.

Age determination was done by the lens-weight technique described by Lord (1959). Eye lenses were stored in 10% formalin to harden for a week or longer, put into a drying oven at 80 C. for 36 hours and weighed on a Roller-Smith balance immediately upon removal from the oven. Lens weights were recorded to the nearest tenth of a milligram. In aging animals the dry weight of only one lens was used, disregarding any variation in weights of the right and left lens. Analysis of the frequency distribution (Figure 1) of the lens weights follows papers by Cassie (1954) and Davis (1959) that describe a method for separating a polymodal frequency distribution into its components. In Figure 1, the curved line (triangles) is the cumulative percentage distribution. The straight lines (dots) represent the frequencies for three categories of lens weights.

The lens weight technique was used to determine how many muskrats of the group had lens weights in a specific weight class, and for any individual animal the probability that it belongs to a particular class.

Lens weights were grouped as follows: those weighing less than 11 mg., and lenses 12 mg. or over. Ten muskrats had lens weights falling between the two groups (11 mg. to 12 mg) and those with lens weights of 11 to 11.5 mg. were included with the lower weight class while those weighing 11.6 to 12 mg. were included in the upper weight class.

The assignment of an age class to a specific lens weight range may be done on the assumption that each of the three lens weight groups coincide with the first-year, second-year and third-year classes. It is felt this would be a reasonable assumption and is supported by a number of observations. The lens weights when compared to the body weights showed a high degree of correlation ($r = .47$; $p < .01$). In addition, one individual whose age was obviously less than three months old, both according to body weight as well as to the measurements given in Erickson's (1963) growth curve, had a lens weight which fell within the first-year class. Finally, females on which placental scars could be detected, indicating they had experienced at least one breeding season, all had lens weights falling into the second-year class with one exception with a lens of 10 mg. placing it at the extreme upper end of the first-year class. Because of their small number, animals with lenses belonging to the third-class are grouped with those of the second-year class. Since chronological age is difficult to prove without known-age animals, the distinction adult or young will be made in discussing the results.

Routine necropsy protocols were followed. The heart, lungs, liver, stomach, small intestine, caecum, large intestine, urinary bladder, kidneys, salivary glands and mesenteries were examined grossly for helminths. In addition the intestines were separated into three sections and each was flushed with tap water and cut open, as was the stomach to permit closer examination. Contents were washed repeatedly and decanted until clear and were examined for parasites.

Helminths recovered were fixed and studied in the usual manner (Cable, 1958).

Statistical analysis of prevalence differences between habitats (Table 4) was accomplished by use of a formula given by Pearl (1940) and Hill (1950), whose applications to wildlife studies appeared in a report by Davis and Zippin (1954).

RESULTS

The marsh and stream habitat produced the greatest percentage of parasitized individuals, 85% and 78.5%, respectively. Only 29% of the individuals from the river harbored worms.

The occurrence of particular parasite species by habitat (Table 1) shows that stream muskrats had the most varied helminth fauna with seven species recorded followed by six species from marsh animals and only five species from river muskrats. The trematodes *Wardius zibethicus* (Barker and East, 1915), *Echinostomum revolutum* (Froelich, 1802),

TABLE 1. *Occurrence of the parasites of muskrats of all ages according to host habitat (+ = parasites present; — = parasites absent).*

Parasites	Stream	River	Marsh
Trematodes			
Wardius zibethicus	+	+	+
Quinqueserialis quinqueserialis	+	+	+
Echinostomum revolutum	+	+	+
Plagiorchis proximus	+	—	—
Metorchis conjunctus	+	—	—
Cestodes			
Hydatigera taeniaeformis (strobilocercus)	+	+	—
Andrya macrocephala	—	—	+
Nematodes			
Trichuris opaca	+	—	+
Ascaris lumbricoides	—	+	—
Number of muskrats examined	107	31	20
Number of muskrats aged by lens	84	30	18

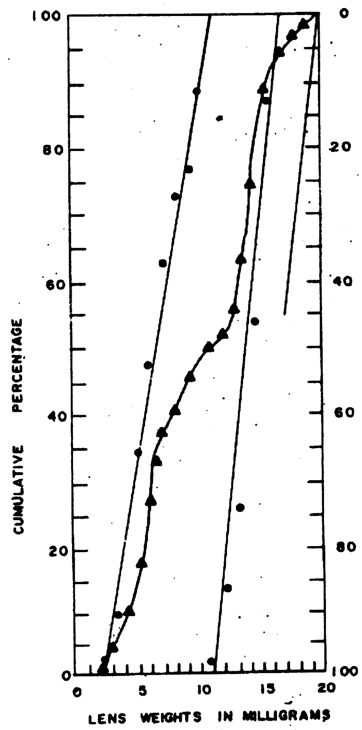

FIGURE 1. *Weights of muskrat lenses showing separation into three normal distributions. The curved line (triangles) is the cumulative percentage distribution. The straight lines (dots) represent the frequencies for three categories of lens weights.*

and *Quinquescrialis quinqueserialis* (Barker and Laughlin, 1911) were found in muskrats from all three habitats though marked differences in the prevalence of each were noted (Figure 2).

The larval stage of *Hydatigera taeniaeformis* (Batsch, 1786) was encountered in the stream and river muskrats but not in the muskrats from marshes, and its prevalence was much higher in the stream muskrats than in those from rivers.

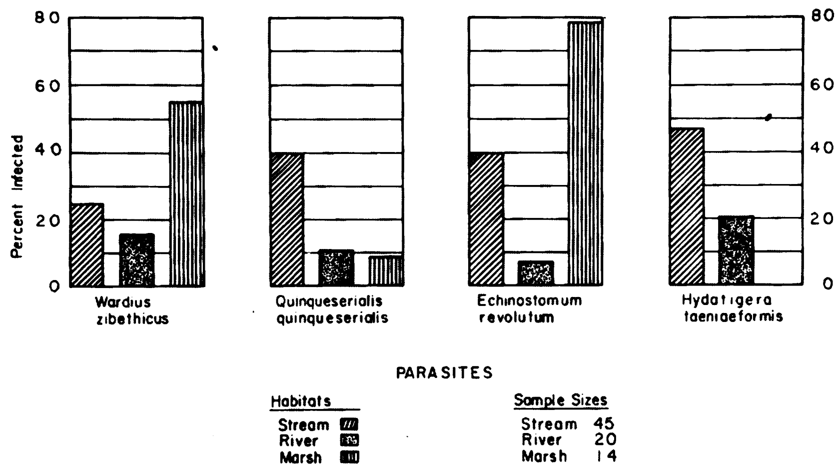

FIGURE 2. *Prevalence of the common parasites infecting adult muskrats compared by habitat.* (*Figure scale* 0-100%)

A nematode, *Trichuris opaca* (Barker and Noyes, 1915), was observed infrequently in muskrats from the streams and marshes and was never found in river animals.

A single animal from a river harbored a lone *Ascaris lumbricoides.* (Mérat, 1821).

The trematodes, *Plagiorchis proximus* (Barker, 1915) and *Metorchis conjunctus* (Cobbald, 1860), occurred only in stream muskrats.

Two muskrats from the marsh were each infected with a single adult cestode, *Andrya macrocephala* Douthitt, 1915, the only adult cestodes encountered in the study.

The percentage of infected muskrats belonging to the adult age class is compared by habitat for the four most common helminths in Figure 2. It was not possible to determine a reliable prevalence for young animals from either marsh or river due to the inadequacy of the sample size; thus, the transmission rate was only determined for parasites of stream animals (solid line, Figure 3). If the assumption is made that the prevalence in young animals represents the rate at which susceptibles become infected upon entering the population, then a theoretical prevalence may be calcu-

TABLE 2. *Prevalence of multiple infections with parasitic worms by age group of muskrat according to habitat.*

Habitat	Age Group	Sample Size	Percent of Group Having number of species 0	1	2	3	4
Marsh							
	yg	4	50	25	25	0	0
	ad	14	7.1	28.6	57.1	7.1	0
River							
	yg	10	90	10	0	0	0
	ad	20	60	25	15	0	0
Stream							
	yg	39	25.6	51.2	20.5	2.6	0
	ad	45	17.7	31.1	28.8	20.0	2.2

TABLE 3. *Average number of parasites per infected muskrat host by parasite species (number infected given in parentheses).*

Habitat	Age Group	W.Z.	Q.Q.	E.R.	H.T.
Marsh	yg	3.0(1)	0	28.5(2)	0
	ad	4.5(8)	8.3(1)	28.6(11)	0
River	yg	0	0	0	2.0(1)
	ad	5.0(3)	38.0(2)	4.0(1)	6.8(4)
Stream	yg	6.9(11)	28.7(9)	8.9(14)	2.3(3)
	ad	7.5(11)	60.3(18)	12.2(18)	2.2(21)

W.Z. = *Wardius zibethicus*
Q.Q. = *Quinqueserialis quinqueserialis*
E.R. = *Echinostomum revolutum*
H.T. = *Hydatigera taeniaeformis*

lated for each subsequent age class.

Theoretical prevalence is based on the simplified situation in which the remaining susceptibles, i. e., those not infected as yearlings, become infected each year and postulates the same rate of infection for all susceptibles regardless of their age class, according to the laws of chance and ignoring all other factors such as parasite longevity, changes in host susceptibility and so forth. Thus, in a hypothetical population of 100 animals, a parasite which successfully infected 40 animals in the first year could be expected, under the stipulations drawn, to increase its prevalence by an additional 40% of the remaining 60 uninfected individuals or an increase of 24 new infections for a total prevalence of 64% by the second year. This projected prevalence and theoretical transmission rate is shown for stream muskrats (broken line, Figure 3).

The occurrence of multiple infections and the average number of parasites per infection are given in Tables 2 and 3, respectively.

DISCUSSION

Only four species of parasites occurred often enough in stream animals to permit a detailed analysis by age group. Of these four species, only in the case of *Q. quinqueserialis* was the observed prevalence in adult animals essentially the same as the theoretical prevalence (Figure 3). This observation coupled with the finding that the mean number of worms per infection doubled from 28.7 in young animals to 60.3 in the adult class strongly suggests that exposure to this helminth remains more or less constant in stream muskrats, regardless of age; that these helminths are able to survive in the host for periods exceeding one year; and that immunity on a population basis fails to develop.

A comparison of the prevalence of *Wardius zibethicus* and *E. revolutum* by age group shows no increase in prevalence in the adult class, nor did any significant increase in the mean number of parasites per infection occur in this class. These two species must therefore have a maximum longe-

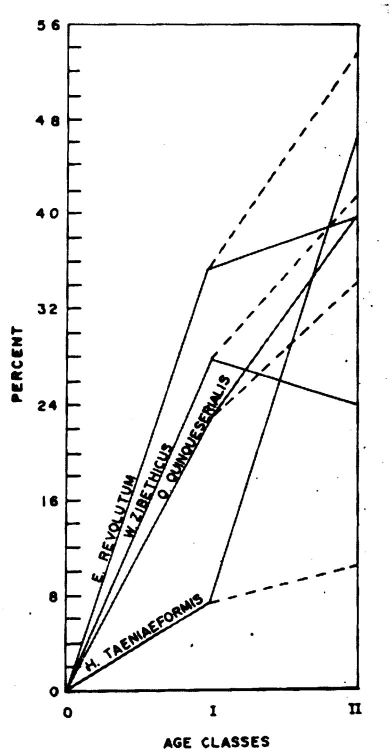

FIGURE 3. *Transmission rates for parasites of stream-inhabiting muskrats.* Observed rates are represented by straight lines. Theoretical rates are represented by dashed lines.

vity of less than a year in the definitive host in nature, and apparently both fail to elicit any lasting immunity.

In contrast, *Hydatigera taeniaeformis,* present as a strobilocercus in the liver, exhibited a phenomenal rise in prevalence in the adult class. The increase was far greater than the theoretically expected ($p < .01$). Since infection with this stage of the parasite undoubtedly persists for the length of the life of the host, the increase in prevalence should have been accompanied by a similar increase in mean number of parasites per infection. This was not the case. The discrepancy between the mean number of strobilocerci per infection and the increase seen in the second group is accounted for in part by an immunity developing in infections with this parasite as suggested by Olivier (1962).

A higher mortality in infected juveniles or an increase in exposure of adult animals may likewise be a factor, adding to the increase noted.

Discussion of differences between habitats will be restricted to animals in the second-age group, since as already shown, differences peculiar to specific parasites exist between age groups, and sample sizes of young from the marsh and river environments are too small to be meaningful.

The stream situation afforded the most favorable conditions for transmission of parasites followed by the marsh and river in order. Not only did stream animals harbor the greatest number of species (Table 1), but likewise they showed a greater percentage of multiple infections (Table 2). In addition, stream animals ranked significantly higher in prevalence than either of the other two habitats, although the marsh provided evidence of a higher transmission rate in two instances, *W. zibethicus* and *E. revolutum.* The animals from the river consistently had lower prevalences for all parasites than were observed in the animals from either of the other two habitats.

Differences in the density of the muskrat populations in each of the habitats cannot alone account for the differences in observed preva-

TABLE 4. *Statistical analysis of prevalence differences between muskrats from each of the habitats sampled for adult animals indicated in Figure 2.*

Parasite	Habitats	Sample Size	Percent Infected	Value of R
Wardius zibethicus	Stream	45	24.5	
	River	20	15.0	0.23
	Stream	45	24.5	
	Marsh	14	57.0	2.21*
	Marsh	14	57.0	
	River	20	15.0	2.72*
Quinqueserialis quinqueserialis	Stream	45	40.0	
	River	20	10.0	3.06*
	Stream	45	40.0	
	Marsh	14	7.0	3.33*
	Marsh	14	7.0	
	River	20	10.0	0.31
Echinostomum revolutum	Stream	45	40.0	
	River	20	5.0	4.02**
	Stream	45	40.0	
	Marsh	14	78.5	2.96*
	Marsh	14	78.5	
	River	20	5.0	6.12**
Hydatigera taeniaeformis	Stream	45	46.5	
	River	20	20.0	2.28*

* R = > 1.96 p < .05
** R = > 3.67 p < .01

lence, since prevalence differences were not consistent. Thus *Q. quinqueserialis* had a significantly higher prevalence in streams compared to animals from the marsh, while the opposite held true for *W. zibethicus*. The high prevalence of *E. revolutum* in the marsh may reflect the presence of numerous vertebrate species which in addition to muskrats may serve as part of the reservoir for this parasite (Beaver, 1937). These potential hosts include a great number of waterfowl which use the marsh extensively during migration. Comparable use of the streams and river by these migrants is uncommon. It is conceivable that the birds serve to increase the density of infected individuals shedding eggs and hence cause a substantial increase in the number of infected snails. Also, suitable hosts for cercarial encystment, such as tadpoles, are much more dense in the marsh than in either of the other two habitats. Nor should the physical characteristics of the habitat be ignored, since they may exert a strong influence on the success of the parasite (Bauer, 1962; Dogiel, 1947), since these affect the density or even the presence of suitable hosts.

The results obtained in this study agree essentially with those of Hunter and Quay (1953), who compared the parasites in Macgillivray's seaside sparrow from two different ecological habitats and found significant differences in the parasitism of the two populations.

Finally, this study underlines the importance of including ecological data in reporting the results of surveys

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BOOK REVIEW CONTINUED FROM PAGE 51—

Fenner and Ratcliffe are well qualified to write this volume because of their close association with the Australian studies. Fenner is Professor of Microbiology at the Australian National University and Ratcliffe was formerly Officer-in-charge of the Wildlife Survey Section of the Australian Commonwealth Scientific and Industrial Research Organization. They and their staffs were responsible for most of the research on myxonatosis in Australia. The history of myxomatosis during the past decade and a half establishes a classic of the development of a disease agent as a control mechanism of a wild animal population. The first part of the book outlines the history of the spread of the wild European rabbit in Australia and presents a detailed account of recent research on the biology of the wild rabbit. This is followed by a technical description of the myxoma virus, its transmission by mosquitoes and other insects, the course of the disease in the European rabbit, and subsequent changes in the virulence of the virus and in the resistance of the rabbits to it. The final chapters document the history of the disease in the four continents where it occurs, and discuss its continuing evolution.

The authors have done an excellent job of telling this story in a concise and interesting fashion. It is well documented with a complete bibliography and a helpful index. Illustrations, charts and tables increase the value of the book. The reader's interest is enhanced by inclusion of photographs of many of the personalities who were involved in the research and operations that provided the data for this monumental work. Carleton M. Herman.