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SEASONAL TRENDS OF HELMINTH PARASITES OF BOBWHITE QUAIL[1]

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Abstract: Helminthologic examination of 120 adult and 65 juvenile bobwhites *(Colinus virginianus)* from Leon County, Florida, during a one-year period revealed seven common (>30% prevalence) species including *Raillietina cesticillus, R. colinia, Cheilospirura spinosa, Cyrnea colini, Heterakis bonasae, Tetrameres pattersoni,* and *Trichostrongylus tenuis.* Less frequently found helminths included *Hymenolepis* sp., *Rhabdometra odiosa, Mediorhynchus papillosis, Aproctella stoddardi, Dispharynx nasuta, Gongylonema ingluvicola, Strongyloides avium,* and *Subulura* sp. Juvenile bobwhites had acquired infections of 6 of the 7 common helminths by July and all seven species by August. A shift from a predominance of immature to mature parasites was noted with increasing age of juvenile bobwhites. Patterns of acquisition of common helminths by juvenile bobwhites followed both linear and non-linear (plateau effect) trends when compared to age of the host. By mid-winter total helminth burdens of juvenile birds approached levels in adults. *Cheilospirura spinosa, C. colini* and *T. pattersoni* showed marked peaks in transmission between June and September. The two cecal nematodes, *H. bonasae* and *T. tenuis,* showed seasonal shifts in relative abundance with *H. bonasae* predominating during the summer and *T. tenuis* predominating during the winter. Lesions attributable to helminths were rare and involved minimal tissue damage.

INTRODUCTION

The popularity of the bobwhite *(Colinus virginianus)* as a game bird has promoted considerable research on this species. Numerous parasitologic studies have been published on bobwhites and have revealed that they harbor a great variety and number of helminths.[1,2,5,12,14,18,20,21]

Previous investigations, however, have provided little information on the seasonal aspects of helminth infections in these birds. In the present study, bobwhites were collected on a monthly basis for 12 consecutive months in a high-density population[13] to determine seasonal trends in helminth infections.

METHODS

The study was conducted on a 447 ha area of Tall Timbers Research Station, which is located in a limestone region of broken terrain in Leon County, Florida. The topography, vegetation, and bobwhite population density were described previously.[13]

Ten adult birds were shot each month from March, 1968, through February, 1969. Five juvenile birds were obtained during July of 1968, and 10 juvenile birds per month were collected from August, 1968, through January, 1969. All birds were collected between the 10th and 20th of each month. Not more than one adult and one immature bobwhite per covey

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were utilized, and an attempt was made to obtain equal numbers of male and female birds.

Bobwhites were tagged immediately after death, placed in individual plastic bags, and chilled until examined later in the day. Procedures for examination of the viscera and identification of the parasites were those used by Kellogg and Prestwood.[14] When feasible, helminths were classified as immature or mature stages.

Monthly parasite burdens were examined for changes that could be attributed to time of collection by calculation of rank correlation coefficients and comparison with critical r values. Prevalence data were tested for differences attributable to stratifying parameters by the Chi square test.

RESULTS AND DISCUSSION

One hundred and twenty adult and 65 juvenile bobwhites were examined for helminths during the one-year period. Four cestode, one acanthocephalan, and 10 nematode species were found (Table 1). All of these species have been found previously in bobwhites from several localities except for *Raillietina colinia* which has been reported only in Texas.[11,12,19,20] Specimens from this study which earlier were described as *Mediorchynchus bakeri*[3] have been synonymized with *M. papillosis*.[17] Reexamination of specimens collected previously from Tall Timbers Research Station and reported as *Raillietina* sp. and *Tetrameres americana*[14] revealed these helminths to be *R. colinia* and *T. pattersoni*.

All birds harbored at least one species of helminth, and seven species, *R. cesticillus*, *R. colinia*, *Cheilospirura spinosa*, *Cyrnea colini*, *Heterakis bonasae*, *Tetrameres pattersoni*, and *Trichostrongylus tenuis*, were considered to be common (>30% prevalence) in bobwhites on the study area. The remaining species were judged to be infrequent or to represent accidental in-

TABLE 1. Helminths recovered from 120 adult and 65 juvenile bobwhites from Tall Timbers Research Station, Leon County, Florida.

Helminth	Adult Bobwhites	Juvenile Bobwhites
CESTODA		
Hymenolepis sp.	1 (1) 1*	—
Raillietina cesticillus	32 (14) 1-137	32 (20) 1-124
Raillietina colinia	43 (8) 1-98	52 (6) 1-40
Rhabdometra odiosa	3 (4) 2-8	8 (3) 1-8
ACANTHOCEPHALA		
Mediorhynchus papillosis	1 (2) 2	—
NEMATODA		
Aproctella stoddardi	3 (1) 1	2 (5) 5
Cheilospirura spinosa	72 (5) 1-35	45 (3) 1-26
Cyrnea colini	72 (4) 1-21	85 (5) 1-18
Dispharynx nasuta	2 (1) 1	9 (1) 1
Gongylonema ingluvicola	2 (1) 1	—
Heterakis bonasae	100 (47) 3-198	97 (20) 1-86
Strongyloides avium	22 (5) 1-17	5 (5) 1-10
Subulura sp.	1 (1) 1	2 (1) 1
Tetrameres pattersoni	78 (7) 1-58	71 (10) 1-65
Trichostrongylus tenuis	98 (59) 1-361	42 (16) 1-123

*Percent prevalence (average/per infected bird) range.

fections. The monthly prevalences and intensities of common helminths in juvenile and adult bobwhites are presented in Tables 2 and 3.

By July, juvenile bobwhites had acquired infections of all common helminths except *R. cesticillus* which was first detected in August. During July, infections with *C. spinosa*, *C. colini*, *H. bonasae*, and *T. pattersoni* in juvenile bobwhites were comprised solely or primarily of immature helminths, but thereafter the proportion of immature helminths was lower with infections comprised mainly of mature helminths (Fig. 1). This shift from a predominance of immature to mature helminths was attributed to the time required for helminth growth and maturation. Some reported periods required for maturation of these or closely related species are: *C. spinosa*, 45 days;[4] *C. colini*, 41 days;[4] *T. americana*, 45 days;[4] and *H. bonasae*, 27 days.[6]

From July to August, juvenile bobwhites had sharp increases in the prevalence and intensity of all mature helminths except *T. tenuis*, but thereafter the pattern of acquisition of helminth populations differed among

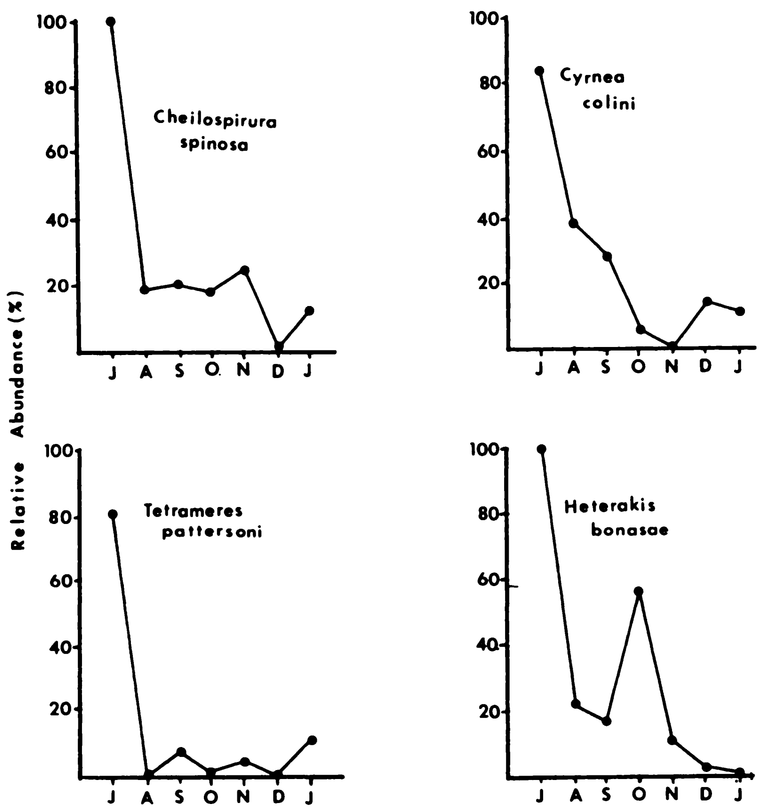

FIGURE 1. The relative abundance (% of population) of immature *Cheilospirura spinosa*, *Crynea colini*, *Tetrameres pattersoni* and *Heterakis bonasae* in juvenile bobwhites during 7 consecutive months.

TABLE 2. Monthly prevalences and intensities of common helminths in 65 juvenile bobwhites.

Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Number examined	5	10	10	10	10	10	10
HELMINTH							
Raillietina cesticillus	0 (0)*	40 (40)	30 (10)	40 (5)	40 (6)	40 (46)	20 (20)
Raillietina colinia	40 (4)	60 (6)	70 (4)	80 (6)	30 (17)	40 (3)	40 (6)
Cheilospirura spinosa (ad.)†	0 (0)	40 (7)	40 (3)	30 (3)	30 (1)	50 (2)	30 (2)
Cheilospirura spinosa (im.)	60 (4)	30 (2)	10 (3)	10 (2)	10 (1)	0 (0)	10 (1)
Cyrnea colini (ad.)	20 (5)	60 (8)	90 (4)	60 (8)	90 (3)	90 (4)	100 (3)
Cyrnea colini (im.)	80 (7)	60 (5)	70 (2)	10 (1)	0 (0)	30 (2)	40 (1)
Heterakis bonasae (ad.)	0 (0)	80 (7)	80 (9)	100 (16)	100 (20)	100 (14)	100 (31)
Heterakis bonasae (im.)	60 (2)	50 (3)	70 (2)	90 (25)	30 (7)	20 (2)	10 (2)
Tetrameres pattersoni (ad.)	20 (4)	80 (8)	70 (18)	60 (11)	70 (9)	70 (5)	70 (7)
Tetrameres pattersoni (im.)	40 (8)	0 (0)	40 (3)	10 (1)	20 (2)	0 (0)	30 (2)
Trichostrongylus tenuis	40 (6)	10 (2)	30 (3)	40 (8)	40 (4)	50 (14)	80 (35)

*Percent prevalence (average per infected bird).
†Designates developmental stage of helminth: ad = adult and im = immature. Those without designation were not classified as to developmental stage.

TABLE 3. Monthly prevalences and intensities of common helminths in 120 adult bobwhites.

Month Number examined	Mar 10	Apr 10	May 10	Jun 10	Jul 10	Aug 10	Sep 10	Oct 10	Nov 10	Dec 10	Jan 10	Feb 10
HELMINTH												
Raillietina cesticillus	30 (3)*	20 (75)	20 (12)	50 (29)	30 (6)	40 (15)	10 (3)	20 (2)	30 (2)	30 (11)	50 (3)	50 (7)
Raillietina colinia	60 (12)	90 (11)	50 (3)	60 (9)	60 (25)	50 (4)	20 (3)	0 (0)	20 (1)	0 (0)	60 (2)	50 (3)
Cheilospirura spinosa (ad.)†	60 (3)	50 (4)	50 (1)	60 (7)	60 (6)	90 (5)	60 (3)	80 (5)	90 (3)	80 (4)	100 (5)	70 (3)
Cheilospirura spinosa (im.)	0 (0)	0 (0)	0 (0)	10 (1)	60 (4)	70 (8)	20 (5)	0 (0)	10 (1)	0 (0)	0 (0)	20 (1)
Cyrnea colini (ad.)	80 (3)	70 (3)	90 (5)	100 (3)	80 (4)	50 (3)	80 (3)	30 (4)	60 (2)	60 (5)	40 (4)	60 (4)
Cyrnea colini (im.)	10 (1)	0 (0)	20 (1)	40 (1)	40 (4)	30 (6)	70 (1)	10 (2)	20 (1)	30 (2)	10 (1)	0 (0)
Heterakis bonasae (ad.)	100 (39)	100 (48)	100 (19)	100 (36)	100 (38)	100 (59)	100 (43)	100 (73)	100 (45)	100 (42)	100 (39)	100 (17)
Heterakis bonasae (im.)	100 (21)	70 (6)	60 (6)	100 (24)	70 (3)	60 (2)	30 (3)	30 (5)	40 (2)	20 (1)	40 (2)	0 (0)
Tetrameres pattersoni (ad.)	80 (5)	70 (5)	60 (5)	80 (3)	80 (11)	100 (5)	60 (6)	80 (9)	80 (7)	70 (7)	90 (6)	80 (12)
Tetrameres pattersoni (im.)	0 (0)	0 (0)	0 (0)	60 (1)	40 (9)	0 (0)	10 (1)	10 (2)	10 (1)	0 (0)	10 (1)	10 (1)
Trichostrongylus tenuis	100 (140)	100 (109)	100 (61)	100 (110)	100 (51)	100 (24)	100 (12)	90 (22)	100 (33)	90 (50)	100 (63)	100 (32)

*Percent prevalence (average per infected bird).
†Designates stage of helminth: ad = adult and im = immature. Species without designation were not classified as to developmental stage.

species. *Cyrnea colini, H. bonasae,* and *T. tenuis* showed continued increases in prevalence that were correlated ($P<0.05$) with time, eventually reaching or approaching a prevalence of 100%. In contrast, *C. spinosa, T. pattersoni* and *R. cesticillus* exhibited a plateau effect with relatively stable prevalence values from August through January. The prevalence of *R. colinia* showed considerable variation, although a case could be made for a trend of an initial increase followed by a decline to a lower stable level.

As with the prevalence of infection, the intensities of *H. bonasae* and *T. tenuis* showed increases that were correlated ($P<0.05$) with time, although *T. tenuis* did not increase sharply until December and January. The intensities of the remaining species did not increase with time ($P<0.05$) but rather exhibited tendencies to (1) peak and decline *(C. spinosa, C. colini,* and *T. pattersoni),* (2) remain relatively stable *(R. colinia),* or (3) fluctuate erratically *(R. cesticillus).*

Mean total helminth burdens in juvenile bobwhites increased from 18 in July to 76 in January, although the increase was not significantly correlated with time ($P<0.05$). The general trend of increasing helminth burdens with age in juvenile birds apparently is a function of length of exposure and was influenced primarily by *H. bonasae* and *T. tenuis* which continued to increase in intensity. By January, the total mean helminth burden in juvenile bobwhites approached levels found in adults.

Each month adult bobwhites harbored infections of all common helminths except for *R. colinia* which was not found in October or December. All differences between adult and juvenile bobwhites in prevalences or intensities of infection with common helminths (Table 1) are attributable to the initial limited exposure of juvenile birds. Adult bobwhites had a significantly lower ($X^2=5.83$; df=1) prevalence of *Dispharynx nasuta* and a significantly higher (X^2=9.27; df=1) prevalence of *Strongyloides avium* than juvenile bobwhites. Fewer *D. nasuta* in adult bobwhites is consistent with reports for other avian species.[7] The higher prevalence of *S. avium* in adults resulted from the frequent occurrence of the parasite from March to July (before collection of juveniles), and thus, whether this difference was due to host age or to a general decline of *S. avium* on the study area is unknown. The occurrence of two species, *Hymenolepis* sp. and *M. papillosis*, in adult but not juvenile bobwhites was not considered significant since both species probably represent accidental infections.

In adult bobwhites, three species of heteroxenous (intermediate host required) helminths, *C. spinosa*, *C. colini*, and *T. pattersoni*, had distinct peaks in the proportion of immature helminths in the population (Fig. 2). These single annual peaks in acquisition of larvae indicate that transmission of these species occurs primarily during the summer. Summer peaks in transmission have obvious survival advantages for these species since this time coincides with an abundance of arthropod intermediate hosts and entrance of juvenile bobwhites into the population. The diet of young bobwhite chicks consists mainly of animal foods[8] and hence chances of infection with heteroxenous helminths are enhanced.

The cestodes, *R. cesticillus* and *R. colinia*, showed erratic fluctuations in prevalence and intensity without any indication of peaks in transmission or seasonal trends in the levels of infection. Analyses of crop contents of birds collected during this study (Whitcomb, unpubl.) revealed three genera of beetles (*Anisodactylus*, *Harpalus*, and *Selenophorus*) which are known intermediate hosts of *R. cesticillus*.[15] The genera *Anisodactylus* and *Selenophorus* accounted for 85% of the arthropods recovered from May through August and probably are important intermediate hosts of *R. cesticillus* on the study area.

In adult bobwhites, *H. bonasae* and *T. tenuis* differed from all other helminths

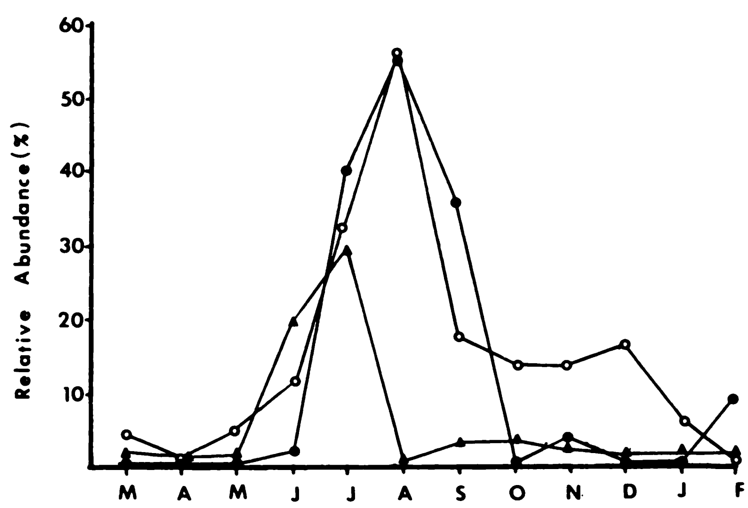

FIGURE 2. The relative abundance (% of population) of immature *Cheilospirura spinosa* (●), *Cyrnea colini* (○) and *Tetrameres pattersoni* (▲) in adult bobwhites during 12 consecutive months.

by consistently maintaining high prevalences of infection (90-100%) throughout the period of study. The most plausible reason for the higher prevalences of infection with these species is their monoxenous life cycle (intermediate hosts not required). Although acquisition probably occurred to some extent each month, *H. bonasae* and *T. tenuis* were acquired in substantial numbers during different periods of the year. For *H. bonasae* this period was between March and July as evidenced by the higher proportions ($P<0.05$) of immature worms. The much higher intensity of *H. bonasae* larvae during certain collection periods (March and June) is similar to the peaks in acquisition of *H. gallinarum* larvae by free-ranging galliform birds that have been attributed to consumption of earthworm transport hosts.[16] In contrast to *H. bonasae*, burdens of *T. tenuis* declined from March to September ($P<0.01$) and rose from September through February ($P<0.05$). Hon *et al.*[10] reported a similar trend of a winter peak for *T. tenuis* in wild turkeys *(Meleagris gallopavo)* in south central Florida. These opposing trends of *H. bonasae* and *T. tenuis* produced a dramatic shift in the composition of cecal worm populations with *H. bonasae* predominating during the summer and *T. tenuis* predominating during the winter (Fig. 3).

During a three-year, fall-to-spring study on helminthiases in bobwhites from Kansas, Hanson and Robel[9]

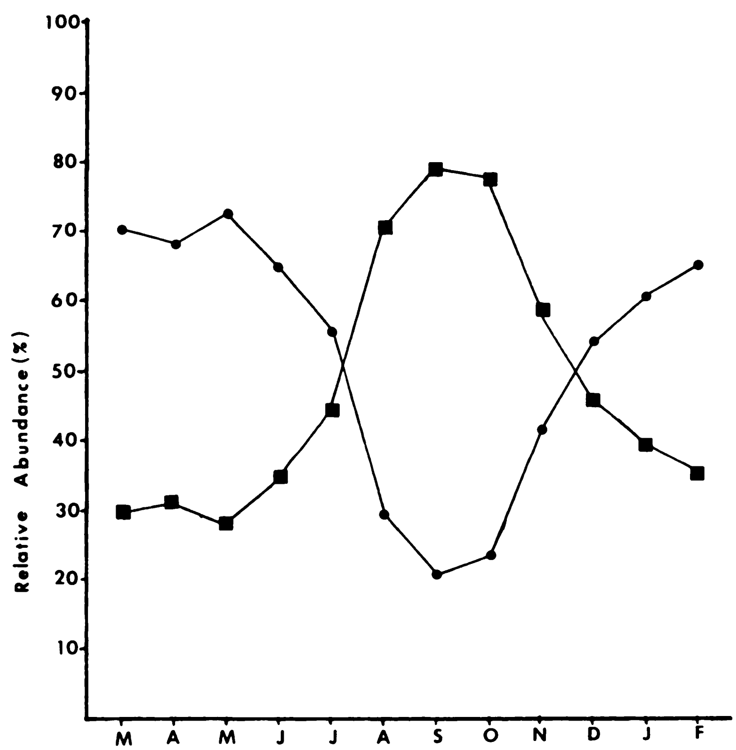

FIGURE 3. The relative abundance of cecal nematodes, *Heterakis bonasae* (■) and *Trichostrongylus tenuis* (•), in adult bobwhites during 12 consecutive months.

measured seasonal trends by changes in the total prevalences of all cestodes and all nematodes. Their study revealed a peak prevalence of cestodes in the spring and peak prevalences of nematodes in November and February. The total prevalence of helminthiases in their study was only 23% compared to 100% every month in our study, and therefore prevalence was not a valuable basis for comparison of the two sets of data. In addition, the helminth fauna of bobwhites in the Kansas study differed markedly in species composition. Equivalent prevalences of helminthiases in juvenile and adult birds during fall and winter in the Kansas study, however, does suggest a similarity to our study where helminth infections in juveniles approached levels in adults during the winter.

Lesions attributable to helminths were rare. Minor proliferation of the gizzard lining due to *C. spinosa* and *C. colini* occurred occasionally. Ulceration of the proventriculus at the point of attachment of *D. nasuta* also was noted infrequently. Two birds had greatly enlarged proventriculi due to heavy infections of *T. pattersoni,* and large numbers of *R. colinia* in two birds caused marked distention of the small intestine. Based on the severity and frequency of associated lesions helminths were not considered to be important mortality factors during the present study.

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