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Short Communication

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Oxyspirura petrowi and *Aulonocephalus pennula* Infection in Wild Northern Bobwhite Quail in the Rolling Plains Ecoregion, Texas: Possible Evidence of A Die-Off

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Abstract

We have been monitoring wild Northern bobwhite quail (*Colinus virginianus*) on a research transect in Mitchell County, Texas. We captured a total of 51 bobwhites in March-May of 2016 and 2017 and examined them for eyeworm (*Oxyspirura petrowi*) and caecal worm (*Aulonocephalus pennula*) infections. In March 2017, bobwhites averaged 15 ± 10 eyeworms and 269 ± 90 caecal worms, and by mid-April averages had increased to 18 ± 13 eyeworms and 372 ± 144 caecal worms. These averages were much higher than those observed in March 2016 (11 ± 13 eyeworms and 160 ± 57 caecal worms) and April 2016 (12 ± 12 and 216 ± 56, respectively). We observed a precipitous decline in quail numbers by late April 2017, and average infection had dropped to 7 ± 2 eyeworms and 252 ± 109 caecal worms. The number of trapping sessions needed to capture one bobwhite also increased from 14.26 in 2016 to 36.46 in 2017. These observations warrant further investigation into the effects these helminth parasites may have on bobwhites and their populations within the Rolling Plains.

Keywords: *Aulonocephalus pennula*; Bobwhite; Cecal worms; *Colinus virginianus*; Eyeworm; Northern bobwhite; *Oxyspirura petrowi*; Rolling plains; Texas

Introduction

Northern bobwhite quail (*Colinus virginianus*; hereafter, bobwhite) are a well-known game bird in the United States that have been experiencing a steady range-wide decline over the past several decades [1,2]. While this is typically attributed to habitat loss and fragmentation [1,3], bobwhite populations continue to decline even in regions considered to have good quality habitat such as the Rolling Plains ecoregion of Texas [4-6]. This suggests that, at least in some portions of their range, there are other factors affecting bobwhite abundance. Because of their popularity with hunters and economic value to local communities in the Rolling Plains [7], significant efforts have been made to address other factors affecting bobwhite such as contaminants, disease, pathogens, and parasites. One such effort, known as Operation Idiopathic Decline (OID), found 40% of bobwhites were infected with parasitic eyeworms (*Oxyspirura petrowi*) and 73% infected with caecal worms (*Aulonocephalus pennula*) in the Rolling Plains, with 90% prevalence for both parasites in some counties [5,8,9].

The eyeworm is found in the orbital cavity and associated tissues of quail [10-12], while the caecal worm is found within the ceca and intestines [13,14]. These parasites are both thought to have an arthropod intermediate host [14,15], and arthropods such as grasshoppers are an important part of the bobwhite diet in the spring and summer [16]. In fact, Kistler et al. identified the plains lubber grasshopper (*Brachystola magna*) as a potential intermediate host and documented as many as 90 infective L3 eyeworm larvae in a single lubber [17]. Also, the eyeworm is thought to have pathological consequences due to damage observed in the Harderian gland and cornea of infected quail [18,19]. In addition to this, Dunham et al. reported a lack of digesta found in the caecum of infected quail, which suggests that caecum function may be impaired by caecal worms [20].

Despite parasites being documented in bobwhite since the 1920s [21], there have only been sporadic efforts documenting parasites in bobwhite [22-24]. Dunham et al. was the first to report an eyeworm epizootic event and the potential for pathological consequences [12,19]. Further investigation into the impact of parasites on bobwhite in the Rolling Plains is needed when it has been demonstrated that many bobwhite are considered to have a strong infection of both eyeworms (21-40) and caecal worms (101-200) [8]. As helminths have been shown to drive population cycles of another Galliforme, the red grouse (*Lagopus lagopus scoticus*) [25], it is plausible that a similar phenomenon could be occurring in bobwhite in the Rolling Plains. Because of this, the Wildlife Toxicology Laboratory (WTL) at Texas Tech University (TTU) has been involved in a long-term monitoring and research project to document parasitic infection and investigate how these parasites may be affecting bobwhite in the Rolling Plains.

Through extensive research over the last five years, we have been able to monitor parasite burdens in bobwhite within our study area and across the Rolling Plains. These observations provide key insights into factors influencing local bobwhite populations on our study area. Additionally, this permitted us to recognize a precipitous decrease of bobwhite within our study area during April 2017. Here, we will discuss this quail decline and the potential contribution of eyeworm and caecal worm infections to this event by evaluating trap effort and parasite infection from 2016 and 2017.

Materials and Methods

Birds were captured and handled in accordance with Texas Parks and Wildlife research permits SPR-1098-984 and SPR-0715-095. This

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experiment was approved by Texas Tech University Animal Care and Use Committee under protocols 13066-08 and 16071-08.

Study area

The experimental area was on a private ranch in Mitchell County, Texas and was consistent with that used by Dunham et al. [12].

Quail sampling and parasite assessment

Birds were collected from the same research transect and using the same methods as described in Dunham et al. [12]. Following capture, birds were placed in a cotton cloth bag and weighed using a digital hanging scale. Gender was determined based on the coloration of the head and throat, and the presence or absence of buffed tips on primary wing coverts determined age of the quail [26,27]. Sampling for the present experiment was conducted on a monthly basis during March-May 2016 and March 2017. Because of evidence of strong infection in the March 2017 bobwhites, trapping was adjusted in April 2017 to occur on a bi-weekly basis in order to more closely monitor potentially time-dependent parasite fluctuations within the study area. Mid-month sampling refers to trapping periods that occurred during the 13th-19th, while late month sampling refers to 26th-31st. Eyeworms and caecal worms were extracted in the same manner as described in Dunham et al. [8].

Trapping effort

A trapping session was defined as each time an individual trap was checked for birds. The number of trapping sessions required to capture one bird was used as an index of trapping effort. This was calculated by dividing the total number of trap sessions by the number of birds captured.

Results

Trapping effort

All birds collected in March, April, and May 2016 and 2017 were adult bobwhites. In March 2017, 10 birds were collected and required 14 trapping sessions per bird (Table 1); this was only slightly higher than March 2016. By mid-April 2017, 21 trapping sessions were required to collect 5 birds, and by late April 2017, the number of trapping sessions needed to capture one bird had increased to 56. Late April 2017 trapping required 5 times more effort than April 2016 trapping. Trapping the following month was even more difficult with 105 trapping sessions yielding no birds in early May 2017. Our efforts in mid-May 2017 resulted in 4 birds captured and required 61.25 trapping sessions per bird, which was more than double the effort required in May 2016.

Parasite assessment

In March 2017, mean abundance for caecal worm infection had increased by over 100 compared to March 2016, and by mid-April 2017 mean abundance had increased by over 150 compared to April 2016. Ranges for caecal worm were also much higher in mid-April 2017 than in April 2016, with 208-572 and 146-334, respectively. Additionally, mean eyeworm abundance in mid-April 2017 was more than 1.5 times higher than eyeworm abundance in April 2016. However, by late April mean abundance for both eyeworms and caecal worms had decreased by 60% and 32%. Mid-May 2017 sampling revealed that infections were increasing for both eyeworms and caecal worms, and again, means abundance was higher for both parasites compared to May 2016.

Date	Trapping Sessions	Birds Caught	Average Trapping Sessions/Bird
2016			
March	70	10	7
April	105	10	10.5
May	210	7	30
Total	385	27	14.26
2017			
March	140	10	14
Mid-April	105	5	21
Late April	280	5	56
Early May	105	0	N/A
Mid-May	245	4	61.25
Total	875	24	36.46

Table 1: Quail trapping sessions for March, April, and May 2016-2017

Discussion

During 2013, Dunham et al. reported an epizootic of *O. petrowi* infections in Mitchell County, Texas, speculating that helminths may influence bobwhite declines within the region [12]. After nearly 5 years of continuous monitoring along that same transect, we observed a precipitous drop in bobwhite abundance amidst elevated infections of both eyeworms and caecal worms. In addition to the higher infection levels, collection of bobwhite in March 2017 was more difficult than in 2016 and became progressively more difficult. Furthermore, there were reduced infections in late April which supports Dunham et al. speculation that heavily infected individuals would drop out of the population [8]. Due to the considerable increase in trapping sessions and increased parasite burdens in 2017, we believe that we have witnessed a potential parasite-induced die-off of bobwhites within our study area.

Determining parasite-induced host mortality in the field is very difficult as carcasses are often scavenged in less than 24 hours [28]. For this reason, modeling is often used to demonstrate how parasites may affect wild populations [29]. Dunham et al. estimates of parasite infection levels reflect what is produced by modeling, allowing us to gauge the infection levels on our transect [8]. In March 2016, average caecal worm infections had just reached what Dunham et al. considered a strong infection (101-200), while March 2017 infections were approaching an extreme level (300+) and had exceeded an extreme infection by mid-April [8]. By late April, average caecal worm infection had dropped by nearly 33% and average eyeworm infection had dropped by 60%. This suggests that heavily infected birds were likely eliminated from the population. In addition to the reduction in infection levels, we noted fewer visual observations of quail and a more than two-fold increase in the number of trapping sessions required to capture one quail from mid to late April 2017. Also, late April trapping required five times more effort to capture a single quail than in April 2016, and 105 trapping session in early May yielded 0 quail, which had not been observed in five years of trapping at this location.

With the relative ease of trapping in spring 2016 and local hunters reporting substantial quail populations during winter 2016, we would have expected a stronger quail population in spring 2017. However, the above-average precipitation in late summer 2016 [30] likely facilitated a robust increase in intermediate hosts as Guo et al. and Lenhart et al. observed increases in diversity and survival of arthropods with increased rainfall [31,32]. We believe this facilitated infection going into winter 2016 and lead to the subsequent events during spring 2017. These observations of increased infection following rainfall are similar to those of Dunham et al., who saw higher infection in July and August after heavy rains, followed by reduced infection in September [12]. We likely did not observe this reduced infection due to the parasites entering a state of diapause or arrested development, which are often induced by seasonal variation and diet [33]. Because infection would have occurred going into the fall, changes in bobwhite diet and different seasonal conditions likely provided the environment needed to induce a diapause state in eyeworms and caecal worms [16,34].

Furthermore, this decline in bobwhite prevalence was likely not due to bobwhites leaving transects as bobwhites are not known to have extensive home ranges [35]. We also know that these quail have a high affinity for the areas in which they were trapped based on extensive work on this ranch over several years, and with over 300 radioed birds for tracking, we have data to support our speculation. Haines et al. noted bobwhite ranges in areas that are regularly baited are smaller, and our trap locations are baited regularly [36]. Also, while habitat loss and extreme weather have been cited as causes for bobwhite declines [1,37,38], our study zone has remained stable, and there was no severe weather between early March and late April to adversely affect local quail populations; therefore, habitat loss and weather were not considered to be contributors to this decline. Additionally, we did not encounter mosquitos during trapping in March, April, or May 2017, suggesting avian diseases such as West Nile Virus likely did not contribute to our observed decline as previously postulated [39]. These factors, along with the consistent habitat within our experimental area, suggest that parasites may indeed be responsible for the potential die-off in April 2017 (Table 2).

		Eyeworm			**Caecal Worm**		
	Sample Size	**%**	**Mean Abundance**	**Range**	**%**	**Mean Abundance**	**Range**
2016							
March	10	90	11.3 ± 13.4	0-38	100	159.9 ± 57.1	70-273
April	10	80	11.7 ± 11.8	0-30	100	216.0 ± 55.8	146-334
May	7	100	16.4 ± 19.5	2-58	100	110.9 ± 53.3	51-208
Total	27	90	12.8 ± 14.2	0-58	100	168.0 ± 68.2	51-334
2017							
March	10	100	15.2 ± 10.1	6-37	100	268.6 ± 90.2	110-454
Mid-April	5	100	18.4 ± 12.7	3-34	100	371.8 ± 144.4	208-572
Late April	5	100	7.4 ± 2.1	5-10	100	252.4 ±109.0	146-393
Mid-May	4	100	26.25 ± 9.8*	17-40	100	259.0 ± 110.7*	101-351
Total	24	100	16.1 ± 10.8	3-40	100	285.1 ± 112.1	101-572

Table 2: Eyeworm (*Oxyspirura petrowi*) and caecal worm (*Aulonocephalus pennula*) prevalence, mean abundance (± standard deviation), and ranges for March, April, and May of 2016 and 2017. *Approximately 30% of both eyeworms and caecal worms in mid-May were immature worms, suggesting new infection.

In conclusion, we believe that eyeworms and caecal worms are capable of causing parasite-induced die-offs in bobwhites when conditions support extreme infection levels, particularly when compounded with other factors such as predators. This is consistent with previous studies in red grouse (*Lagopus lagopus scoticus*) in Scotland, where elevated levels of infection with *Trichostrongylus tenuis* caused population crashes by increasing grouse vulnerability to predators and reducing fecundity [25,40]. Thus, it is plausible that eyeworms and caecal worms affect bobwhite abundance in the Rolling Plains in a similar manner, and parasites, although previously disregarded as a contributor, may have a substantial effect on bobwhite in the Rolling Plains. Studies on the impacts of multiple parasites are limited and additional studies are needed, particularly since pathological consequences are possible for both eyeworms and caecal worms.

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