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Are Helminths Contributing to the Population Fluctuations of Northern Bobwhite Quail (*Colinus virginianus*) from the Rolling Plains Ecoregion of West Texas?

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Abstract

The question of whether parasites can significantly influence host population dynamics is complex and debated. Since Anderson and May's groundbreaking theoretical work revealed the potential of parasites to influence host populations, several studies have demonstrated this potential experimentally, leading to an increased consideration of parasites in this regard. One species in which this needs further study is the Northern bobwhite quail (*Colinus virginianus*), a declining game bird that has been found to exhibit intense parasitic infections in some portions of its range, such as the Rolling Plains of West Texas. As part of a long-term effort monitoring parasitic infection of bobwhite in the Rolling Plains, we received 3 hunter-harvested bobwhite from Mitchell County, Texas in February 2018 and 9 bobwhite were captured from a research transect in the same county in March 2018. Eyeworm (*Oxyspirura petrowi*) and caecal worm (*Aulonocephalus pennula*) burdens for hunter-harvested bobwhite averaged 65 and 830, respectively, while captured bobwhite averaged 49 and 381, respectively. Additionally, an average of 71 trapping sessions were required to capture one bobwhite during March 2018, which was considerably higher than previous reports from this area. These extreme infection levels, as well as the increased effort required to capture a single bobwhite, coincided with widespread reports of dramatically decreased bobwhite abundance. While the sample size presented here is small, the consistency between these observations and recent reports demonstrates the need to continue investigating the effects parasites may be having on bobwhite in the Rolling Plains.

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Introduction

The potential of macroparasites to influence host populations has been a longstanding topic of contention amongst researchers. While factors such as resource availability, predator-prey interactions, and competition have typically taken precedence as drivers of population dynamics [1-3], the regulatory capacity of parasites has begun to garner credence in more recent times. In 1978, Anderson and May laid the theoretical groundwork demonstrating that parasites have the potential to impact host population abundance [4,5]. Since then, a number of empirical studies have shown that parasites are indeed capable of affecting host population dynamics [6], including a long-term study by Hudson., *et al*. [7] which found a helminth to be the underlying cause of cyclical population fluctuations of red grouse (*Lagopus lagopus scoticus*) on game preserves in Scotland.

Unfortunately, our understanding of the effects parasites have on populations of free-ranging wild hosts remains limited [8,9], and this is largely due to the difficulty of unraveling the complex associations of multiple variables acting on wild systems [10-12]. An example of the need for additional research into this topic is evident in populations of another galliform, the Northern bobwhite quail *(Colinus virginianus*; hereafter bobwhite), specifically those from the Rolling Plains of West Texas. Bobwhite are a well-studied game bird with a particularly strong sporting heritage in the Rolling Plains [13]. Because of this, considerable efforts have been made to understand the ecology of bobwhite and to develop conservation strategies that would lead to consistent and sustainable bobwhite populations [14,15]. Nevertheless, bobwhite populations in the Rolling Plains are unstable and have been declining since the 1960s [16].

In 2010, a rapid and inexplicable decrease in bobwhite abundance spurred a collaborative research initiative, known as Operation Idiopathic Decline (OID), that assessed quail populations in the Rolling Plains for the presence of disease. A significant finding of OID was widespread infection of caecal worms (*Aulonocephalus pennula*) and eyeworms (*Oxyspirura petrowi*) in quail throughout the region [17,18]. While the presence of these helminths in the Rolling Plains was not a novel discovery, as the first documented reports occurred in the 1960s [19], OID marked a turning point in the attitudes of researchers with respect to the potential impacts of parasites on wild quail populations.

Since OID, additional studies have confirmed pathological consequences associated with eyeworm infection [20-22]. There have also been suspicions of caecal worms leading to decreased vitamin A levels and malnutrition [22,23]. However, because there are a multitude of variables that affect bobwhite survival in the Rolling Plains [13], isolating and quantifying the effects parasites may have on wild bobwhite population dynamics continues to challenge researchers. While trying to determine how parasites affect quail, the Wildlife Toxicology Laboratory at Texas Tech University has documented potential impacts of parasites on bobwhite abundance and received reports from hunters and landowners expressing concerns about parasites contributing to quail mortalities in the Rolling Plains during 2017-2018 [24-26]. Here, we will discuss our continued monitoring of bobwhite and helminths during the spring of 2018 and how the perpetuation of high parasite loads amidst decreased bobwhite abundance may indicate that helminths can contribute to bobwhite population fluctuations in the Rolling Plains.

Materials and Methods

During March 26-30 2018, 9 bobwhite were collected from two transects in Mitchell County in the Rolling Plains of West Texas. Birds were captured using walk-in double funnel traps baited with milo (*Sorghum bicolor*) as described by Dunham., *et al*. [18]. Trapping effort required to capture birds was calculated by dividing the total number of trapping sessions by the total number of birds collected according to Henry., *et al*. [24]. An additional 3 bobwhite, shot in Mitchell County during February 2018, were donated by hunters, assigned unique identification numbers detailing date and location harvested, and returned to the lab at Texas Tech University for processing in the same manner as described by Brym., *et al*. [25]. The heads and caeca of all birds were dissected and examined for caecal worms and eyeworms at the lab at Texas Tech University following methods used by Dunham., *et al*. [27]. Bobwhite were captured, handled, and processed according to Texas Parks and Wildlife Research Permit No. SPR-0715-095 and under Texas Tech Animal Care and Use Committee protocols 16071-08.

Results and Discussion

When Henry., *et al*. [24] reported increased trapping effort that coincided with elevated parasite burdens in the spring of 2017, it was suspected that a parasite-induced die-off was occurring. Furthermore, this preceded a downward turn in bobwhite populations in the region [28]. The following winter, Brym., *et al*. [25] documented elevated parasite burdens along with hunters reporting drastically reduced bobwhite abundance in Mitchell County. Now in the spring of 2018, monitoring of this same area has shown a perpetuation of high parasite loads as well as further increased difficulty trapping bobwhite (Table 1). While the intense parasitic infections presented here may be biased due to the small sample size, the consistency of this finding with reports from the past year support the possibility that the parasite loads we documented were representative and may be contributing to concurrent bobwhite declines.

Location	Sample Size	Trapping Effort		Eyeworms		Caecal worms	
		Trapping Sessions	Trapping Session/Bird	Mean Abundance	Range	Mean Abundance	Range
Total	9	640	71.1	49	23-83	381	109-935
East	6	300	50.0	60	23-83	462	170-935
West	3	340	113.3	27	25-30	220	109-350

Table 1: *Trapping effort and parasite abundance by location.*

Furthermore, Dunham., et al. [27] found that only 4% of bobwhite sampled in 2014-2015 possessed an extreme infection of caecal worms (300+) or eyeworms (60+), while 67% of our samples were in the extreme infection category. They also hypothesized that eyeworms and caecal worms were long lived and infections would gradually increase to exert an unsustainable strain on bobwhite. This is supported by models that have demonstrated high parasite densities are followed by declining host numbers [4,5]. This density-dependent negative feedback mechanism has been confirmed in populations of sheep and red grouse where infection is prevalent and intense [7,29]. Consequently, it is possible that bobwhite populations from the Rolling Plains may experience a similar feedback loop, as they are also subject to widespread and intense parasitic infection.

Additionally, we recorded large differences in both parasite loads and trapping effort between our eastern and western trapping locations in Mitchell County, separated by approximately 20 km, which may provide further insight into the potential of these infections to affect bobwhite populations. Capture of birds on the western transect of our study area required approximately double the effort of the eastern transect, and the western birds possessed parasite loads less than half that of eastern birds (table 1). The difference for the eastern transect may have occurred because the critical threshold of infection necessary to precipitate a decline in local bobwhite abundance had not been met. Hunter reports for the area also indicated that bobwhite numbers were low at the beginning of the season for the western transect, while the eastern transects decrease in abundance did not occur until the end of the season (personal communication, Kendall).

Because the die-off reported for the spring of 2017 occurred on the western transect [24], it is possible that more heavily infected birds did not survive until the following year. This could explain the reduced numbers reported by hunters, as well as the trapping difficulty and lower parasite burdens we encountered. Furthermore, the hunter-harvested samples were from the eastern transect and possessed very high caecal worm and eyeworm burdens, averaging 830 (363-1722) and 65 (48-95), respectively. These extreme parasite loads, that Dunham., *et al*. [27] postulated would begin to have lethal consequences, continued into March.

Moreover, amidst the extreme infection levels we documented in hunter-harvested samples, hunters reported an increased occurrence of feather piles (personal communication, Kendall). This suggests bobwhite were more susceptible to predation during this time, which may have been exacerbated by parasitic infection, as helminths can increase vulnerability to predators [30]. This is further exemplified by a hunter-harvested sample that harbored an immense load of 1722 caecal worms (figure 1) and 95 eyeworms and was sufficiently impaired and emaciated (figure 2) as to be captured by a hunting dog. Although we cannot be certain that parasites were the determining factor of this bird's condition, it is a possibility as there is documentation of another wild bobwhite with similar parasite loads and condition that was hand captured in the Rolling Plains [26]. Furthermore, eyeworms have been associated with instances of bobwhite refusing to fly when pursued by dogs [31], and intestinal parasites akin to caecal worms are known to cause weight loss, lethargy, and even death in game birds [32,33].

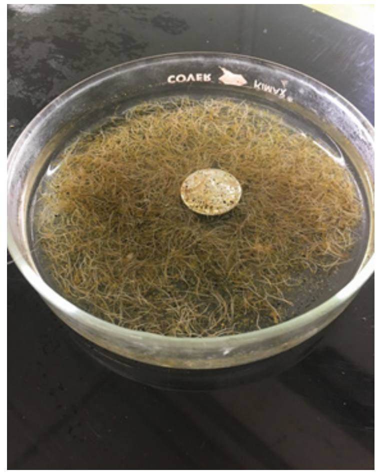

Figure 1: *Caecal worms (n = 1722) extracted from one Northern bobwhite quail (Colinus virginianus) collected from Mitchell County, Texas in February 2018.*

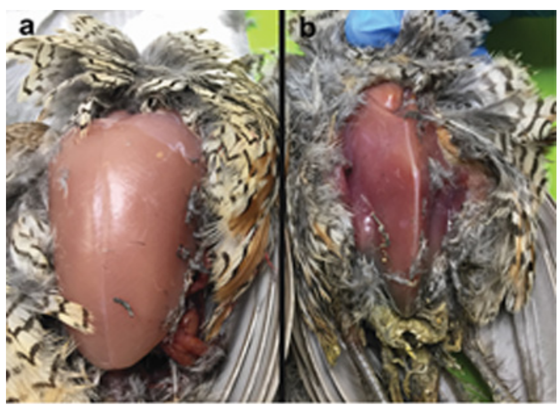

Figure 2: *Comparison of breast tissue of Northern bobwhite quail (Colinus virginianus) between a (a) typical adult and (b) heavily parasitized individual collected from Mitchell County, Texas in February 2018.*

Parasites may also suppress the immune systems of their hosts [34]; thus, it is plausible that the extreme infection found in that specimen may have led to compromised immune function and susceptibility to other infections. However, research into the consequences of these parasites on bobwhite immune function is lacking, and further studies into this topic may reveal important insight into the potential of helminths to affect such a critical aspect of fitness. Furthermore, warmer winters can extend transmission and survival of parasites [35,36], and drought has been associated with greater caecal worm burdens [25]. This is concerning, as the winter of 2017-2018 in the Rolling Plains was mild and dry [37], which could have intensified the severity of these infections. For example, higher winter temperatures can prolong the life cycle and increase overwinter survival of orthopterans [38]. Because several species of orthopterans have been identified as potential intermediate hosts for both eyeworms and caecal worms [39-41], with one species that overwinters [42], extended transmission and survival may have facilitated the increased proportion of extreme infections we observed.

Unfortunately, this and many other aspects as to how parasites may be impacting avian wildlife have been neglected due to the idea that parasites are generally inconsequential in terms of population management [11,43]. While it is true that bobwhite in the Rolling Plains are often subject to a number of challenges such as scarcity of food, predators, periods of drought, and extreme temperatures [13], it is also likely that the effects of parasites do not act in isolation, but rather compound with these stressors and vice versa [44]. It is this very possibility of compounding and interdependent interactions between parasites and other variables that demands a comprehensive approach to understand bobwhite population dynamics in the Rolling Plains. While the small sample size and inferences made based on anecdotal accounts should not be misinterpreted as conclusive evidence, proactive reports such as this can provide a valuable supplement to researchers investigating the subtle yet potentially significant impacts of parasites [11,26]. Most importantly, these efforts may serve to stimulate more careful consideration of the importance of parasites as a contributing factor to bobwhite population dynamics.

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