Archives of Parasitology

Henry et al., Arch Parasitol 2017, 1:2

Editorial

OMICS International

Helminth Infection and Northern Bobwhite (*Colinus virginianus*)

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Received date: June 02, 2017; **Accepted date:** July 24, 2017; **Published date:** July 27, 2017

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The potential role helminths play in the decline of the northern bobwhite (*Colinus virginianus*; hereafter, bobwhite) has been discussed but is ultimately overshadowed by the conclusion that only range-wide management practices that address habitat loss and fragmentation will produce successful conservation efforts [1]. Although habitat loss and fragmentation are major factors contributing to the decline of bobwhites throughout their range, it does not fully explain population decline in regions considered to have good quality habitat [2,3]. Thus, range-wide management practices may not always be applicable. Here, we evaluate how helminths may be contributing to bobwhite population decline in the Rolling Plains of Texas.

Despite the longstanding idea that parasites regulate host abundance [4], only in recent years have helminths, particularly caecal worms (*Aulonocephalus pennula*) and eyeworms (*Oxyspirura petrowi*), been considered a potential factor causing fluctuations in bobwhite populations [5,6]. While there are field studies that have demonstrated that parasites can reduce survival and fecundity in some species [7], only Hudson et al. has provided experimental evidence that a parasite can regulate an avian species, for instance, the red grouse (*Lagopus lagopus scoticus*) populations [8]. Due to this difficulty in determining parasite-induced host mortality (PIHM) in the field, parasitologists rely on modeling to determine a lethal parasite load and potential impacts on wild populations [9]. Dunham et al. [6] estimate of mild, strong, and extreme infection levels for *A. pennula* and *O. petrowi* mirror the predictions typically generated by the modeling methods described in Wilber et al. [9] suggesting that these parasites have the potential to cause host mortality.

While research regarding *A. pennula* is limited, other intestinal helminths have been shown to impair digestion, reduce feed consumption, decrease nitrogen absorption, and cause nutritional deficiencies [10]. Furthermore, the cecum has a broad range of functions, from production of antibodies to absorption of water, which are thought to be especially important during times of stress [11]. Because high *A. pennula* infections have coincided with lower vitamin A and lack of digesta found in the cecum [12,13], we hypothesize that *A. pennula* is capable of impairing cecum function. In the Rolling Plains of Texas, where bobwhites are frequently subjected to stressors such as drought and extreme temperature, impairment of the cecum may be what drives PIHM.

Additionally, bobwhite in the Rolling Plains are infected with a second helminth, *O. petrowi* [14], which can cause pathological consequences such as lesions on the Harderian gland to corneal epithelial erosions [14]. Damage to the Harderian gland is particularly alarming because it produces lipids important for thermoregulation, secretions for cleaning the eye and is an important site of immune response [15]. Because *O. petrowi* damages the Harderian gland, there are multiple possible consequences of infection that may be detrimental to bobwhite survival: impairment of vision, inability to maintain body temperature, and a decreased ability to protect against infections. These factors, compounded with the possible consequences of *A. pennula* and the extreme conditions of the Rolling Plains, would present substantial challenges to bobwhite survival and likely increase PIHM. This could be further exacerbated as under certain environmental conditions widespread and intense eyeworm infection can occur in wild bobwhites [16].

In conclusion, parasites may not be the ultimate factor in the range-wide decline of bobwhites; however, they may have long-term ramifications in areas such as the Rolling Plains where strong infections can occur throughout most of the region. In these cases, it will be important not to dismiss parasites as it is possible that parasites regulate bobwhite populations similar to how *Trichostrongylus tenuis* regulates red grouse. Furthermore, there is a lack of information pertaining to the interactions of multiple parasitic infections. Unlike the red grouse, bobwhites are commonly infected with multiple parasites and this may be producing a synergistic effect rather than an additive effect. Additional research utilizing a “weight of the evidence” approach is needed to fully understand how *A. pennula* and *O. petrowi* are affecting bobwhites at both the individual and population level. As our research continues to expand our knowledge of parasitic infections in bobwhite, an increased accuracy in assessing the implications these parasites have on bobwhite in the Rolling Plains will be established.

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