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South Texas Bobwhites and Eyeworms: Regional History, Prevalence, and Implications for Management

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Eyeworms (*Oxyspirura petrowi*) are frequently claimed as a factor in the decline in Northern bobwhite (*Colinus virginianus*) quail populations during the last decade, particularly in the Rolling Plains Ecoregion of Texas. However, reports of *O. petrowi* infections in bobwhite populations from the South Texas Plains (Fig. 1) do not support this association. In this management bulletin, we provide a summary of the background of O. petrowi infections in the United States, including current knowledge of its pathogenicity and distribution in Texas. We also provide the prevalence results of *O. petrowi* from a large (n=743) and recent (2019–2023) sample of bobwhites harvested in the South Texas Plains to enable managers to make effective decisions on interventions associated with eyeworm parasitism in bobwhites.

WHAT ARE EYEWORMS?

Helminth parasites, commonly referred to as "worms," are characterized by their round (roundworms or nematodes), flat (flukes or trematodes), or segmented bodies (tapeworms or cestodes). Eyeworms are roundworms found in many different species of animals. For example, humans can be parasitized by the eyeworm *Loa loa*, transmitted via biting flies in Africa. The poultry industry first documented the eyeworm *Oxyspirura mansoni* in chickens in the United States in 1904 (Ransom 1904). This discovery was followed by several studies that reported inflammation and damage leading to blindness when chickens were infected with more than 60 *O. mansoni worms* (Kobayashi, 1927; Sanders, 1929; Schwabe, 1950).

Much of what we know about *O. mansoni* in chickens has helped us better understand the eyeworm that parasitizes wild ground-dwelling (Galliform) and tree-dwelling (Passeriform) birds, *Oxyspirura petrowi*. This eyeworm can be found in various tissues within birds' eyes, such as the eyelid, nictitating membrane, nasolacrimal ducts, and Harderian glands. Oxyspiruid species are indirect lifecycle nematodes; an insect serves as an intermediate host for their development before their final host (the bird) ingests them. Understanding the intermediate host is crucial in determining when and where infection can occur. Recently, researchers have identified several potential insect hosts (Almas et al. 2018, Henry et al. 2020), but no specific host has been determined.

HISTORY OF EYEWORM DETECTION

Oxyspirura petrowi was described in 1929 from several bird species (shrikes, night jars, grouse, and prairie chickens) in Germany (Skrjabin 1929). Eyeworms were detected in wild birds in the United States (ruffed grouse, *Bonasa umbellus*) from Michigan in 1935 (Saunders 1935). The history of eyeworm documentation in the U.S. is summarized in Table 1.

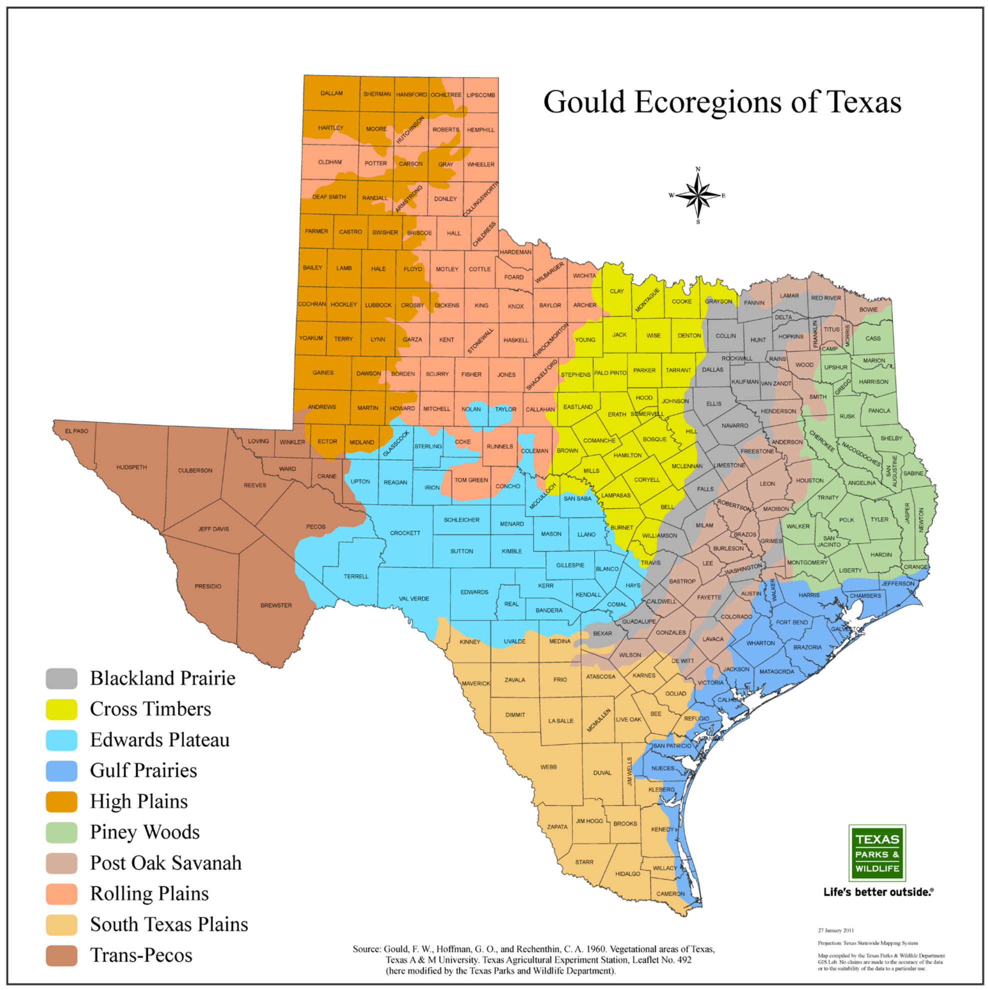

Figure 1. Map of Gould et al. (1960) Ecoregions of Texas reprinted from Texas Parks and Wildlife (2011).

EYEWORM PRESENCE IN TEXAS

The first detection of *O. petrowi* in any quail species was in the Trans-Pecos region of Texas in scaled quail (*Callipepla squamata*) in 1956 (Wallmo 1956), and in Texas bobwhites from 11 counties in the Rolling Plains Ecoregion of Texas (Jackson and Green 1965). From 1961 to 1964, Jackson and Green (1965) reported prevalence (percent infected out of the total sample) of 44% (out of 605 birds) in bobwhites. The prevalence of eyeworms in West Texas, Northwest Texas, and the Texas Panhandle was subsequently confirmed in Montezuma (*Cyrtonyx montezumae*) and scaled quail (Pence 1975, Dancack et al. 1972), lesser prairie chickens (*Tympanuchus pallidicinctus*; Pence and Sell 1979), and ring-necked pheasants (*Phasianus colchicus*; Pence et al. 1980).

After being documented, additional information on the prevalence and intensity of infection in bobwhites didn't resurface until a survey was completed in Fisher County, Texas, seasonally across a year in 2010 (Villarreal et al. 2016). This study reported an average prevalence of 47% (out of 142 birds), with higher prevalence and abundance of *O. petrowi* in adult vs. juvenile bobwhites. This pattern was confirmed in subsequent studies in the Rolling Plains Ecoregion (and northern Edwards Plateau) through a large-scale, multi-year survey (2011–2013) of bobwhites. Prevalence in these studies (Dunham et al. 2016a, Bruno et al. 2018, Bruno et al. 2019) was 40% (out of 348), 41% (out of 161), and 66% (out of 128), which is within the range observed in the Fisher County study (Villareal et al., 2016). However, the intensity of infection (the average number of individual worms per infected bird) increased from 5.6 ± 0.7 (Mean ± SE; Villareal et al. 2016) to as high as 14.2 ± 0.2 (Bruno et al. 2019). This was likely due to more intensive necropsies discovering worms in new tissues (see Bruno et al. 2015 and Dunham et al. 2016b).

With the observation of high prevalence and intensity of infection in bobwhites from the Rolling Plains, researchers in the region conducted a wide range of studies to describe the lifecycle and seasonality of infection of *O. petrowi* in bobwhites. Important findings from this research include identifying 18 potential insect intermediate hosts for *O. petrowi*, of the order of insects that includes crickets and grasshoppers (Orthoptera; Henry et al. 2020).

Interestingly, *O. petrowi* prevalence and intensity in South Texas Plains bobwhite populations are much lower. Large-scale hunter-harvested surveys from South Texas have resulted in prevalence estimates of 4% (out of 356) and 9% (out of 244), with 4.9 ± 1.7 and 1.2 ± 0.1 mean worms per infected bird (Olsen et al. 2016, Shea et al 2020, respectively).

WHAT IS THEIR EFFECT ON BOBWHITES?

Prior to 2015, assumptions about *O. petrowi*'s pathological effects on bobwhites were based on our knowledge of detailed studies concerning *O. mansoni*. For *O. petrowi*, Saunders (1935) reported ocular irritation via gross pathology (e.g., the macroscopic observations of disease) in the eyes of parasitized sharp-tailed grouse (*Tympanuchus phasianellis*) and greater prairie chickens (*Tympanuchus cupido*). However, two other publications on ring-necked pheasants (McClure 1949) and passerine birds (Pence 1972) found that *O. petrowi* caused no gross or pathological changes. Detailed studies (histopathology, the examination of cells under a microscope) of *O. petrowi* effects were conducted by Bruno et al. (2015) and Dunham et al. (2016b). These studies documented cellular damage to eye tissue, corneal scarring, and loss of cell structure in the eye's lubrication gland (i.e., the Harderian gland).

Despite these findings, no published literature has shown that *O. petrowi* regulates bobwhite populations (i.e., survival and fitness). Any suggested implications about mortality effects are speculative, not conclusive. This speculation tends to be based on correlations with worm intensity and trapping success during the breeding season rather than direct experimental removal studies and are not long enough in duration to rule out the effects of precipitation on both parasite intensity and mortality (Dunham et al. 2014, Henry et al. 2017, Commons et al. 2019).

A manipulative study is necessary to show a direct causal relationship between the damage shown in pathology and any related impairment and the reduction in bobwhite numbers in the Rolling Plains (beyond typical mortality factors such as predation, weather, and harvest). For example, one of the few studies demonstrating regulatory effects on a wild population from a helminth parasite was published in the United Kingdom on the effects of cecal worms (*Trichostrongylus tenuis*) on red grouse (*Lagopus laopus*) populations (Hudson et al. 1992, Dobson and Hudson 1992). In a 10-year study, experimental reduction in worm burdens (via anthelmintic treatment using levimasole hydrochloride) improved breeding production and winter survival of grouse compared to untreated grouse; in the absence of infection, drastic population fluctuations outside of ordinary did not occur (Hudson et al. 1992). To date, no direct, manipulative studies evaluating the effects of eyeworm infection in bobwhites have been conducted to demonstrate these sorts of direct effects.

Date	Host Species	Micro-habitat	Location	Literature Cited
1929	lesser grey shrike, red-backed shrike, little night jar, ruffed grouse, greater prairie chicken, sharp-tailed grouse	Orbital cavity	Germany	Skrjabin, 1929
1935	ruffed grouse	Eyelids, nictitating membrane	Michigan	Saunders, 1935
1937	prairie chickens, sharp-tailed grouse	Eyelids, nictitating membrane	Michigan	Cram, 1937
1949	ring-necked pheasant	Eyelids, nictitating membrane	Nebraska	McClure, 1949
1949	ruffed grouse	N/A	Minnesota	Erickson et al., 1949
1953	Macgillivary's seaside sparrow	Conjunctiva or the eyelids and naso-lacrimal ducts	North Carolina	Hunter and Quay, 1953
1956	scaled quail	N/A	Trans Pecos, Texas	Wallmo, 1956
1960	common yellowthroat	Eyelids, nictitating membrane	North Carolina	Goodchild, 1960
1965	lesser grey shrike	Orbital cavity	Czechoslovakia	Barus, 1965
1969	lesser prairie chicken, sharp-tailed grouse, sage grouse, ruffed grouse	Orbital cavity	Oklahoma Panhandle	Addison and Anderson, 1969*
1969	northern bobwhite	Nictitating membrane	Cottle County, Texas	Jackson, 1969†
1970	northern bobwhite	N/A	Louisiana	Palermo and Doster, 1970‡
1972	passerines	N/A	Louisiana	Pence, 1972
1973	brown-headed cowbird	N/A	Ohio	Cooper et al., 1974
1975	scaled quail, Montezuma quail	N/A	West Texas	Pence, 1975
1979	lesser prairie chicken	N/A	Texas Panhandle	Pence and Sell, 1979
1980	ring-necked pheasant	N/A	Texas Panhandle	Pence et al., 1980
1982	scaled quail	Nictitating membrane	Northwest Texas	Dancak et al., 1982
1983	lesser prairie chicken	N/A	Yoakum, Texas	Pence et al., 1983
1991	northern bobwhite	N/A	Leon County, Florida	Davidson et al., 1991‡
2003	lesser prairie chicken	Eyelids, nictitating membrane, lacrimal ducts	Kansas	Robel et al., 2003
2013	masked shrike	Orbital cavity	Iraq	Al-Moussawi and Mohammad, 2013
2014	northern bobwhite	Eyelid, nictitating membrane, nasal sinuses	Mitchell County, Texas	Dunham et al., 2014

* *O. lumsdeni* (= *O. petrowi*)
† *O. sygmoidea* (= *O. petrowi*)
‡ *O. matogrosensis* (= *O. petrowi*)

Table 1. List of Oxyspirura petrowi published reports in Passeriformes and Galliformes as of 2014 (reprinted from Bruno 2014).

FINDINGS FROM THE SUSTAINABLE QUAIL HARVEST PROJECT

East Foundation currently manages a large-scale northern bobwhite harvest project to directly evaluate the sustainability of the commonly recommended 20% annual harvest rate. Through this program, we worked with lease hunters to collect a large (n=743) sample of hunter-harvested bobwhites from four hunting seasons (November–February) 2019 and 2021–2023. Hunters and technicians present on hunts collected the head and a wing from a subset of all harvested individuals and placed samples on ice as soon as possible. Upon completion of the hunt, samples were frozen until necropsy. Samples were collected from Buena Vista Ranch (n=394) in Jim Hogg County, Ranchito Ranch (n=166) in Jim Hogg County, and Santa Rosa Ranch (n=183) in Kennedy County. Since age is an essential determinant of *O. petrowi* prevalence, the sample included 57%(n=426) adult and 43%(n=317) juvenile bobwhites. Necropsies of all known tissue sites were conducted on each individual under a stereomicroscope. No eyeworms were detected – *Oxyspirura petrowi* was absent from all 743 samples collected (Table 2 for summary of results).

Year	n	Juvenile	Adult	Male	Female	*Oxyspirura petrowi*
2019	193	141	52	91	102	0
2021	166	136	30	89	77	0
2022	98	40	58	68	30	0
2023	286	0	286	190	96	0

Table 2. The total sample (n=743) of hunter-harvested northern bobwhites by year (2019, 2021–2023), age (Juvenile or Adult), and sex (Male or Female). No eyeworms (*Oxyspirura petrowi*) were found in the sample across Jim Hogg, Brooks, and Kennedy counties, Texas.

CONCLUSIONS

Our additional study adds a much larger sample to the few studies (Olsen et al. 2016, Shea et al. 2020) conducted in the South Texas Plains with intensive necropsies for *O. petrowi* presence. While Olsen et al. (2016) and Shea et al. (2020) observed low but detectable prevalence (6% across those studies), we did not detect *O. petrowi* over the four years, even though harvest method (hunter-shot) and time of year (October–February) were similar to the other studies.

The low (2.7%) prevalence and intensity of infection over these three studies spanning a 10-year period show little cause for concern for *O. petrowi* morbidity in bobwhites from the South Texas Plains, especially as a driver of population dynamics. Treatment for these helminths is likely unnecessary in this region, and bobwhite populations are unlikely to respond to such treatment. Bobwhite populations in this area of South Texas are more likely regulated by fluctuations in breeding season precipitation (Tri et al. 2013) and habitat loss (Hernández et al. 2013). Management strategies that address habitat improvement or maintenance, and those that may increase resilience to drought conditions, are more likely to yield benefit to quail populations in South Texas. Some related bulletins and research reports from East Foundation and its partners can be found on our website, eastfoundation.net. Given the regional importance of bobwhites and continued interest in potential impact of *O. petrowi*, we will continue to monitor a sub-sample of hunter-harvested bobwhites within our quail research program to identify any change in worm burdens.

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