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Thick-billed Longspur (*Rhynchophanes mccownii*) reproduction shows minimal short-term response to conservation-based program

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ABSTRACT—The Thick-billed Longspur (*Rhynchophanes mccownii*) is a bird species of conservation concern that relies on shortgrass prairies and steppes of western North America. These habitats have been greatly altered from expansive and diverse ecosystems into small patches of homogeneous pastures interspersed with agricultural lands, yet little information exists on how land use affects Thick-billed Longspur demography. This study evaluates the benefits of an incentivized private land conservation-based program (CBP) on Thick-billed Longspur reproduction. We compared Thick-billed Longspur nest success and density on data collected on pastures enrolled in CBP with pastures not enrolled. CBP pastures experienced a rest–rotation specified grazing regime, while there were no requirements for the pastures outside the program. We use a time-to-event state-space superpopulation model that accounts for the availability of nests when estimating detection. We detected and monitored 74 Thick-billed Longspur nests over 2 breeding seasons, including 28 nests in CBP pastures. Our results suggest similar estimates of nest success and nest density between nests in CBP pastures and nests in pastures not participating in the conservation program. Our estimates of nest success and nest density advance our understanding of the influence of an incentivized conservation program on songbirds and give insight into 2 metrics of Thick-billed Longspur reproduction. *Received 30 June 2021. Accepted 26 February 2022.*

Key words: livestock, McCown's Longspur, nest density, nest success, prescribed grazing, reproduction, songbird.

La reproducción del escribano *Rhynchophanes mccownii* muestra una respuesta mínima de corto plazo a un programa de conservación

RESUMEN (Spanish)—El escribano *Rhynchophanes mccownii* es una especie con estatus de conservación preocupante que depende de praderas bajas y estepas del occidente de Norteamérica. Estos hábitats han sido grandemente alterados de ser ecosistemas dominantes y diversos a pequeños parches de pasturas homogéneas mezcladas con tierras agrícolas. Sin embargo, existe poca información de cómo el uso del suelo afecta la demografía de estos escribanos. Este estudio evalúa los beneficios de un programa que incentiva la conservación de tierras privadas (CBP) en la reproducción del escribano. Comparamos el éxito de anidación y densidad según datos colectados en pasturas que se inscribieron en un CBP con aquellas de pasturas que no formaban parte del programa. Las pasturas en el CBP experimentaron un régimen específico de pastoreo de descanso-rotación, mientras que no hubo requisitos para las pasturas que no formaban parte del programa. Usamos un modelo de superpoblación de estado-espacio que cuantifica la disponibilidad de nidos mientras estima su detección. Detectamos y monitoreamos 74 nidos de escribano a lo largo de 2 temporadas reproductivas, incluyendo 28 nidos en pasturas en el CBP. Nuestros resultados sugieren estimaciones similares de éxito de anidación y densidad de nidos entre nidos de pasturas en el CBP y los nidos en pasturas que no participaban en el programa de conservación. Nuestras estimaciones de éxito de anidación y densidad de nidos avanzan nuestro entendimiento de la influencia de un programa de conservación de pájaros con incentivos y da una visión en 2 métricas de reproducción del escribano.

Palabras clave: aves canoras, densidad de nidos, escribano, éxito de anidación, ganado, pastoreo prescrito, reproducción.

Thick-billed Longspur (*Rhynchophanes mccownii*), formerly McCown's Longspur, is a songbird found in the shortgrass prairies and steppes of North America. Since European settlement, ~99% of grasslands in North America have been converted to other land uses, primarily to produce domestic livestock and crops (Knopf 1994, Burel et al. 1998, Rosenberg et al. 2019). Concurrent with the declines in the grasslands of North

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America, Thick-billed Longspur populations have substantially declined, noted as early as the 1900s (With 2020). Thick-billed Longspurs are grassland specialists (Mengel 1970, Vickery et al. 1999) and sensitive to land uses that might modify their habitat (With 2020). Thus, many organizations consider it a species of conservation concern, including state wildlife agencies (i.e., Colorado, Wyoming, and Montana) and federal agencies (i.e., U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management; Augustine and Baker 2013).

Information on the effects of land use on reproductive demographic rates of Thick-billed Longspurs will benefit conservation efforts. The species is a short-lived songbird; thus, reproduction influences populations more than adult survival (Clark and Martin 2007). Nest success, the proportion of clutches from which 1 or more offspring fledge (Armstrong et al. 2002), is often used to determine overall reproductive success. It is influential to population size and easy to determine compared to other demographics (Johnson 2007). However, additional components of reproduction influence populations, such as nest density (Van Horne 1983, Thompson et al. 2001).

Domestic livestock grazing is the primary land use in the grasslands of North America (Vitousek et al. 1986, Herrero and Thornton 2013). It can modify vegetation composition, structure, and productivity (Ryder 1980, Milchunas and Lauenroth 1993, Fuhlendorf and Smeins 1997), affecting songbird habitat and populations (Coppedge et al. 2006). For instance, adult density (Golding and Dreitz 2017, Davis et al. 2020) and reproduction (With 1994, Skagen et al. 2018) of Thick-billed Longspurs are affected by grazing regime and intensity. The use of livestock grazing as a management tool has been suggested for songbird conservation and could be beneficial for Thick-billed Longspurs (Lipsey et al. 2015, Golding and Dreitz 2017, Davis et al. 2020). Natural resource organizations have initiated exploration of livestock grazing as a conservation tool through incentive programs, such as within the Sage Grouse Initiative (SGI). Few studies explore the relationship between Thick-billed Longspur demography and livestock grazing (With 2020). Thus, the potential effects of livestock grazing as a conservation tool on Thick-billed Longspur populations is unknown.

Here, we explore the effects on Thick-billed Longspur reproduction of a conservation-based program (CBP) that uses a prescribed grazing regime. Our work is part of an ongoing, multi-species study investigating the benefits of the conservation program on the periphery sagebrush-steppe ecosystem in the northern Great Plains region of North America. The vegetation structure and composition are unlike other Thick-billed Longspur reproduction studies (e.g., Greer and Anderson 1989, With 1994, Skagen et al. 2018), having a high density of shrubs interspersed with areas dominated by grasses. We capitalize on a high density of adult Thick-billed Longspurs during the breeding season (Golding and Dreitz 2017) compared to other studies (e.g., Finzel 1964, Giezentanner and Ryder 1969, Wiens 1971, Porter and Ryder 1974, Martin and Forsyth 2003, Augustine and Derner 2015, Davis et al. 2020). We compare estimates of nest success and nest density of Thick-billed Longspurs within pastures enrolled in the CBP targeted on private land and to pastures not enrolled in CBP.

Methods

Nest data

We randomly placed 94 plots of 500×500 m on 89,000 km^2 of area dominated by sagebrush shrubs (*Artemisia tridentata* ssp. *wyomingensis*) and grasses (i.e., needle-and-thread grass [*Hesperostipa comata*] and western wheatgrass [*Pascopyrum smithii*]) on private and public managed lands near Roundup, Montana (46.4452°N, 108.5418°W, 980 m elevation; Golding and Dreitz 2017). In 2013, all plots were opportunistically searched for nests and systematic nest searching was conducted as time allowed throughout the breeding season (i.e., May–Jul; Table 1). In 2014, a subset (i.e., 80) of those 94 plots was nest-searched similar to 2013 (Table 1). Opportunistic nest searching involved observers looking for nests while in the plot for any other reason besides nest searching (i.e., other studies, nest monitoring). Systematic surveys required 2 observers dragging a 10 m chain between them centered on an established transect line (Winter et al. 2003). Transect lines were spaced 100 m apart and spread evenly throughout the plot following Reintsma et al. (2019). Nest searches did not take place during precipitation or temperature extremes (e.g., below freezing).

Table 1. The time-to-event model (TTE) estimates of Thick-billed Longspur nest success and nest density (i.e., number of nests per square kilometer) in pastures enrolled in the conservation-based program (CBP) compared to pastures not participating in the conservation program near Roundup, Montana. The number of plots searched, the number of systematic nest searches, and the number of nests found by year and CBP participation are also included.

Enrolled in CBP	Year	Plots searched	Systematic nest searches	Nests found	Nest success	Nest density
Yes	2013	43	24	18	30% (29–32%)	6 (6–6)
	2014	27	25	12	34% (32–35%)	6 (5–6)
No	2013	51	48	13	25% (15–50%)	5 (3–12)
	2014	53	53	31	27% (19–33%)	8 (7–12)

Upon nest discovery, observers took a GPS point above the nest, photographed the offspring (i.e., eggs and nestlings), and discreetly placed flagging ~5 m away from the nest in the 4 cardinal directions. Nests were monitored approximately every 3 d until inactive. Thick-billed Longspurs incubate for ~12 d, and the nestling stage (i.e., from hatch date to leaving the nest) is ~10 d (Mickey 1943, With 2020). When nestlings were present, we determined their age based on nestling growth patterns found in prior studies, such as eye opening by day 3, egg tooth absence by day 5, and pin feathers beginning to unsheathe at day 6 (Mickey 1943, Jongsomjit et al. 2007). We assigned the date of clutch completion as a date between 2 visits where the clutch reached the maximum number of eggs or 12 d before the hatch date as predicted by aging nestlings. If we never observed a nest during clutch completion or the nestling stage, we assigned a clutch completion date on the day initially located. For example, if we located a nest that had already had a full clutch (i.e., 4 eggs) and we found the nest empty on the next monitoring visit then we recorded the clutch completion date as the day the nest was found. Nest fate was either (1) successful if we observed signs of at least 1 offspring leaving the nest (e.g., fledgling or adult activity near the nest, fecal matter on the edges of the nest), or (2) failed if there was evidence of failure (e.g., carcasses present, nest destroyed) or the necessary time had not passed to allow the offspring to fledge.

Covariates

The CBP is part of the USDA Natural Resources Conservation Service (NRCS) Sage Grouse Initiative established in 2010 and implemented beginning in 2011. Private landowners enrolled specific pastures into the program that over ~3 year period implemented a prescribed grazing regime developed as a conservation tool to improve rangelands for wildlife and domestic livestock. These grazing regimes require that pastures in the program (1) use ≤50% of the current year's key forage species growth for grazing, (2) shift grazing ≥20 d each year, (3) have an established plan for unexpected circumstances (e.g., fire, drought), and (4) implement grazing ≤45 d (Hormay 1970, Golding and Dreitz 2017, Smith et al. 2018). We established sampling plots in our pastures enrolled in the CBP and pastures not participating in the CBP (Table 1). Pastures were only considered to be enrolled in the CBP within the ~3 year grazing implementation period, which could change over the duration of the study. Non-enrolled pastures experienced a wide variety of other grazing regimes, including season-long grazing (i.e., continuous grazing of the same pasture for the same period every year; Holechek et al. 1998, Briske et al. 2008, Golding and Dreitz 2017). We considered the effect of year in addition to the effect of the CBP.

Analyses

We used the *nestAbund2* package (Hines 2014) in program R (R Core Team 2019) to estimate daily nest survival and nest abundance with the time-to-event (TTE) model developed by Péron et al. (2014). The TTE model uses the age of the nest at detection to account for both availability and detection in nest success and nest abundance. The *nestAbund2* package allows easy access to the

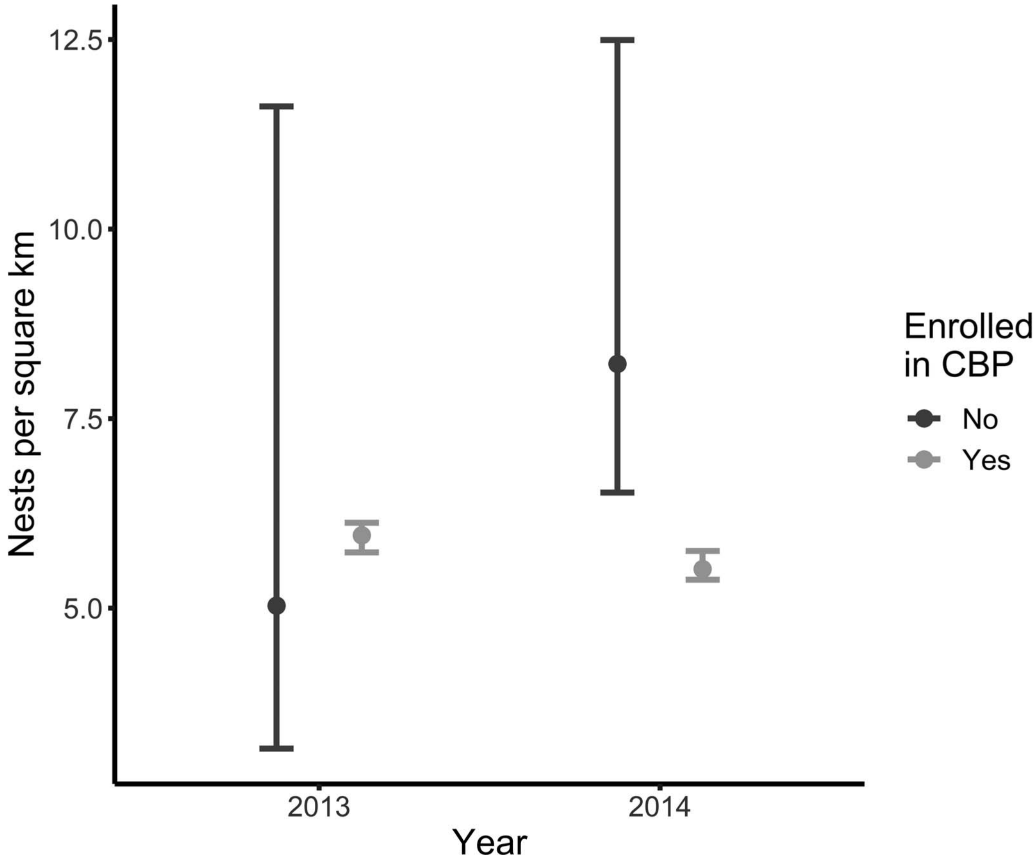

Figure 1. The time-to-event model estimates of nest density for Thick-billed Longspur nests in pastures enrolled in conservation-based program (CBP) near Roundup, Montana, compared to Thick-billed Longspur nests in pastures not participating in the CBP.

TTE model and supports the use of site, nesting stage, 1 binary variable, and 1 continuous variable to be used as additive covariates on detection and/or survival. The suite of models we could run included year as a substitute for site, nesting stage, CBP inclusion as a binary covariate, and 1 continuous covariate. We ran and compared models based on visual fit, AIC, and negative log-likelihood values. We removed models from consideration if they did not converge (i.e., produced estimates of infinity).

Using the outputs from our final model we derived overall nest survival and nest density. We used daily nest survival to calculate overall nest survival by multiplying the rate for every day of the total period required for incubation and brooding (i.e., $[\text{daily nest survival}]^{22}$). We converted the estimated nest abundance into nest density by dividing the estimated abundance by the number of meters in the area sampled in km^2 for that year and participation in CBP.

Results

We found 74 Thick-billed Longspur nests in 2013 and 2014 (Table 1). Over one-third of the nests were located in CBP pastures (38.89%, $n = 28$). The number of nests we found limited the models that converged successfully to only those with year and the binary CBP variable as covariates. Our final model allowed both nest success and detection to vary by year and CBP participation.

In 2014, the TTE model estimate for nest density in CBP pastures was statistically lower than the nest density estimate for non-program pastures, as shown by the lack of overlap in the

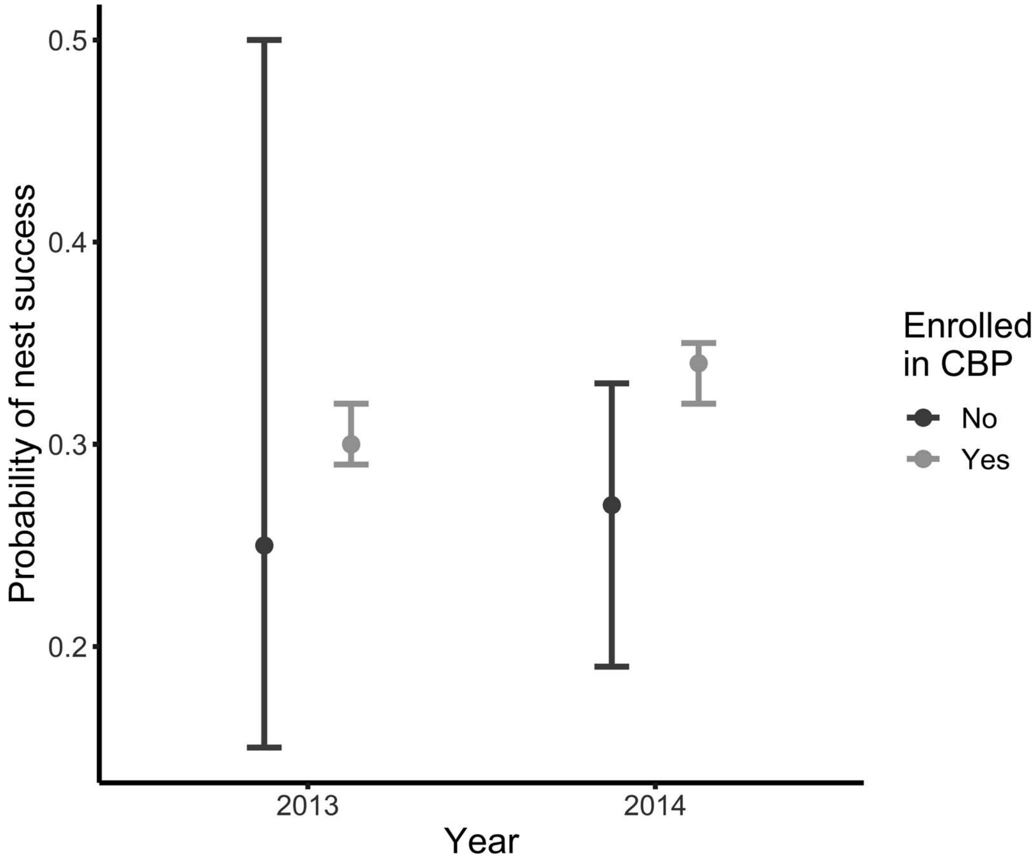

Figure 2. The time-to-event model estimates and 95% confidence intervals for nest success for Thick-billed Longspur nests in pastures enrolled in the conservation-based program (CBP) near Roundup, Montana, compared to Thick-billed Longspur nests in pastures not participating in the CBP.

95% confidence intervals (Table 1, Fig. 1). Otherwise, there are no statistically significant patterns observed in nest success and nest density between pastures enrolled and not enrolled in the CBP because point estimates for nest success and nest density are within the 95% confidence intervals (Table 1, Fig. 1 and 2).

Discussion

This study suggests that nest success and nest density for Thick-billed Longspurs did not differ between the CBP and non-program pastures. The small difference found between nest density in pastures in the CBP to non-program pastures in 2014 is statistically significant (Table 1, Fig. 1), but the difference is relatively small, likely not biologically important, and potentially due to the small sample size. Our general findings are consistent with other studies showing that other factors are likely more influential to avian reproduction than the short-term effects of livestock grazing in similarly arid habitats (Lipsey et al. 2015, Smith et al. 2018). Specifically, Thick-billed Longspur reproduction is influenced by timing of nest initiation (Felske 1971), land and soil classification (Lipsey and Naugle 2017), and vegetation structure (e.g., shrub proximity to nest [With 1994], biomass [Pulliam et al. 2020], grass height [Knopf 1994, Skagen et al. 2018], vegetation density or area [Mahoney and Chalfoun 2016]).

It is also possible that there was not enough variation between the CBP and non-program pastures to alter Thick-billed Longspur habitat in a manner that would be detectable (Table 1; Smith et al. 2018). We have limited information on what grazing took place in our study because landowners with CBP pastures only needed to show pastures were complicit with the program, while pastures outside of the program were not required to share any information. Thus, we took a broad approach to understand if CBP was beneficial. However, there are many management aspects of grazing capable of habitat manipulation, including grazing intensity, frequency, timing, duration, rest, and livestock type that may alter the effect of grazing on the landscape (Heady 1974). Private landowners manage their pastures for sustainability focusing on continued livestock production for future generations. The CBP goal is also sustainability, and the program implements a grazing regime supporting that goal. Thus, contrasts in livestock grazing and vegetative responses to livestock grazing between pastures enrolled in CBP and non-program pastures may not have been extreme enough to detect differences.

In addition, CBP began implementation in 2011 and our study was over a 2-year period (i.e., 2013–2014), which may not be long enough for the effects of grazing to modify pastures based on a program-level assessment. Long-term grazing patterns can change those aspects of Thick-billed Longspur habitat more influential to reproduction like composition and productivity (Ryder 1980, Milchunas and Lauenroth 1993, Fuhlendorf and Smeins 1997). The time required to create those changes on the landscape on a purely ecological (i.e., not evolutionary) scale could be as much as 100 years (Oesterheld and Semmartin 2011). Even in cases where extreme differences in grazing were present, it can be difficult to see multiple effects of grazing in the short term (e.g., Kitti et al. 2008). Thus, the short-term nature of this study, and similar studies, may not provide the temporal duration to understand the effects of livestock grazing on wildlife in general (Pelton and Van Manen 1996, Schieltz and Rubenstein 2016).

We used TTE because it is infeasible to locate every nest in this study, thus the need to account for imperfect detection in our estimates. The TTE model also allowed us to account for bias when locating nests by incorporating nest availability within the estimator. The TTE model is a convenient and reliable way to estimate nest success and nest density for songbird species like the Thick-billed Longspur using one data stream while accounting for nest detection and availability (Reintsma et al. 2019).

However, the TTE model combined with small sample sizes used in this study may also have influenced our results. The TTE model uses many parameters to determine nest detection and survival, especially when covariates are introduced. We believe our sample size of nests restricted use of covariates beyond the binary CBP variable. We attempted to incorporate other covariates such as nesting stage and environmental variables into our model suite, but the TTE model did not converge to produce realistic nest success and nest density estimates. The relatively small 95% confidence intervals for nest success and density model estimates are also one potential effect of those small sample sizes caused by minimal variation among the limited number of nests found.

Our study found nest success rates similar to other studies despite our study area being primarily composed of sagebrush steppe habitat. Previous accounts of apparent nest success rates, which tend to be higher than estimates accounting for detection (Armstrong et al. 2002), ranged from 43% to 81% in Colorado, Wyoming, and Saskatchewan (Felske 1971; Strong 1971; Maher 1973; Greer and Anderson 1989; With 1994, 2020). Nest success estimates of Thick-billed Longspurs from other studies that incorporate sources of variation (i.e., covariates) are comparable to our TTE model estimates. For example, Conrey et al. (2016) reported nest success of 20% (SE = 0.027) for Thick-billed Longspur based on daily nest survival estimates. Mahoney and Chalfoun (2016) also found daily nest survival of 96% (SE = 0.009), which translates to an overall survival rate of 42% using 22 d as total length of incubation and nestling stages. Our estimates of nest success using the TTE model (Table 1) fall within the range of these studies.

Our study is the first to explore the influence of a conservation program on the reproduction of Thick-billed Longspurs. This study provides evidence that the CBP did not have a strong short-term, direct effect on Thick-billed Longspur reproduction when compared to non-program grazing. The CBP targets Greater Sage-Grouse (*Centrocercus urophasianus*) habitat, but conservation activities like CBP may benefit Thick-billed Longspurs where they coexist with sage-grouse. Other benefits of the CBP, such as decreasing habitat loss, directly benefit Thick-billed Longspurs. We suggest further investigations on the effect of the CBP as a conservation tool on Thick-billed Longspur demography.

A controlled experimental study would provide more definite conclusions on the use of livestock grazing as a conservation tool. For example, a factorial paired study design that uses diverse grazing intensity, duration, and frequency levels over a long temporal period would be ideal. However, such experimental grazing studies are often not realistic, and stringent grazing requirements may not be ideal for engaging private landowners in participating in conservation programs. We encourage future studies to further evaluate livestock grazing, as part or not part of a conservation program, accounting for environmental variables potentially conflating the influence of grazing and variation in grazing management.

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