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Inter-Species Interactions: Effects of Spatial Proximity of Breeding Burrowing Owls (*Athene cunicularia*) and Mountain Plovers (*Charadrius montanus*) on Mountain Plover Nest Success

Abstract

Predator-prey interactions are complex and direct interactions between predator-prey pairs are difficult to distinguish due to direct and indirect effects of additional predator-prey interactions. While most studies evaluating the impact of predators on prey concentrate on consumption (mortality of prey caused by a predator), there are a variety of interactions that take place between predators and prey that may not result in mortality. These in direct impacts of predation have been found to influence micro- and macro-habitat use, time allocation patterns, species distribution, population growth, and species interactions and can be just as strong or stronger than consumptive effects.

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Inter-species Interactions: Effects of Spatial Proximity of
Breeding Burrowing Owls (*Athene cunicularia*) and Mountain
Plovers (*Charadrius montanus*) on Mountain Plover Nest
Success

by

Lindsey Messinger

Capstone Project

Presented to Department of Geography

Division of Natural Sciences and Mathematics, University of Denver

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Advisor: ~~D-M~~r. Steve Hick

Denver, Colorado

October 22, 2012

ABSTRACT

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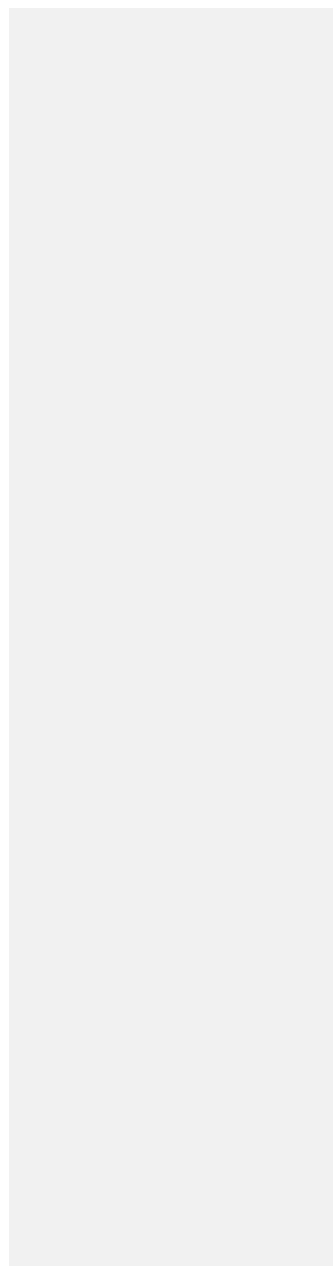


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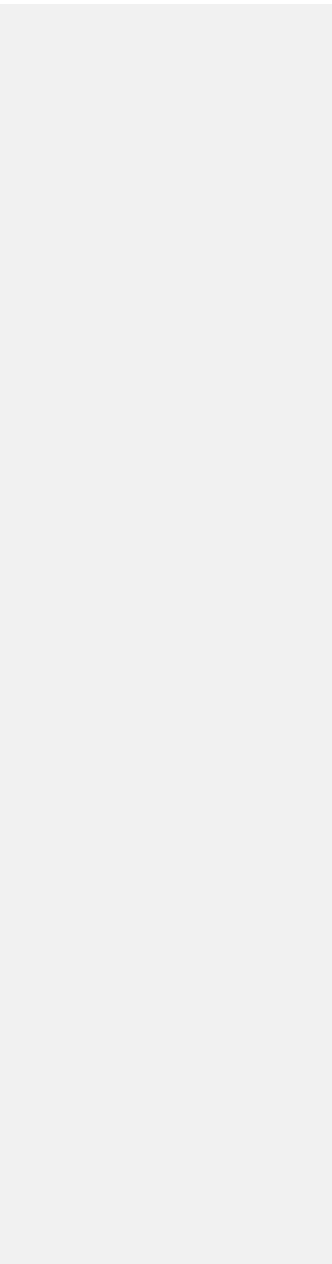
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INTRODUCTION

Predator-prey interactions are complex and direct interactions between predator-prey pairs are difficult to distinguish due to direct and indirect effects of additional predator-prey interactions. While most studies evaluating the impact of predators on prey concentrate on consumption (mortality of prey caused by a predator), there are a variety of interactions that take place between predators and prey that may not result in mortality. These indirect impacts of predation have been found to influence micro- and macro-habitat use, time allocation patterns, species distribution, population growth, and species interactions (Sih 1987, reviewed by Lima & Dill 1990, Lima 1998, Frid & Dill 2002, Cresswell 2008, Laundré et al. 2010) and can be just as strong or stronger than consumptive effects (Schmitz et al. 1997, Preisser et al. 2005, Creel & Christianson 2008, Zanette et al. 2011). The spatial proximity between predators and prey is important in predicting predator-prey encounter rates as well as the strength of the interaction between the species and changes in habitat use and daily habitats due to the predator-prey interaction. *A priori* predictions concerning proximity to predators may include both positive and negative effects on prey when predators are nearby. One may predict positive effects on a prey individual in cases where a nearby predator acts as a deterrent to or predator of other potential predators in the area. Alternatively, negative effects may result

when a nearby predator triggers anti-predator responses in a prey individual, altering the behavior of the prey individual in a way that increases the individual's risk to predation by other predators in the area (predator may cause prey individual to become more vigilant, forgoing opportunities to forage, resulting in reduced body condition and physical ability to flee approaching predators). Prey species make choices about the habitats they occupy in order to forage, seek shelter, and breed. Prey are conditioned to make choices that enhance their fitness, thus understanding the direct as well as the indirect effects of proximity of a prey individual to a potential predator may provide important insight on prey habitat choice, implications of specific choices (positive or negative), and the nature of interactions between specific potential predators.

In avian systems, adults invest considerable time and energy in reproduction. Nest site selection and nesting success is an important component of reproduction and in turn, population dynamics. Nesting success is defined as the probability that a nest survives from initiation (nest building) to completion (hatching in precocial species and fledging in altricial species) and results in at least one offspring leaving the nest (Dinsmore & Dinsmore 2007). Direct predation of nesting adults or depredation of initiated nests by predators is a primary component of nest success or failure in many avian species. Thus, habitat choices, including nest site selection, and their effects on nesting success are important in evaluating

avian reproductive success and likely have important impacts on avian populations.

Documented declines in populations of many North American grassland bird species are cause for conservation concern. Fragmentation and conversion of native prairie to developed landscapes as well as changes to native grazers and grazing practices; drainage of wetlands; and an increase in woody, and often times invasive, plant species, are all human-induced changes that have occurred on North American grasslands and are believed to impact native grassland bird species (Knopf 1994).

The Mountain Plover (*Charadrius montanus*) is just one of a number of endemic North American grassland birds experiencing a declining population trend during the later half of the 20th century (Knopf 1994, Knopf and Wunder 2006). Breeding bird survey data shows that between 1966 and 2009, the Mountain Plover population experienced a 2.6% annual decline (Sauer et al. 2011). The Mountain Plover has elevated conservation status in 13 US states and 2 Canadian Provinces (Andres & Stone 2009, NatureServe 2011) and has been proposed for listing as a federally threatened species with the US Fish and Wildlife Service (USFWS), each of these proposals resulting in withdrawal (USFWS 1999, USFWS 2003, USFWS 2010, USFWS 2011).

Another grassland bird species experiencing population declines is the Burrowing Owl (*Athene cunicularia*) (Dechant et al. 2003a). Breeding bird survey data shows that between 1966 and 2009, the Burrowing Owl population experienced a 0.9% annual decline (Sauer et al. 2011). While the Burrowing Owl has no federal special status in the United States, it has elevated conservation status in 10 US states and is federally listed as threatened in Mexico and endangered in Canada (Klute et al. 2003). Burrowing Owls are intensely dependent on communities of burrowing mammals, in particular the black-tailed prairie dog (*Cynomys ludovicianus* - hereafter referred to as prairie dog), for nesting and brood rearing (Dechant et al. 2003a). The Mountain Plover also uses areas occupied by prairie dogs for nesting and brood rearing (Dechant et al. 2003b). Because grasslands occupied by prairie dogs are used by both Burrowing Owls and Mountain Plovers, these species often use the same prairie dog colonies for breeding, nesting, and brood rearing.

An on-going research investigation on the cause-specific mortality of Mountain Plover chicks conducted by the Colorado Division of Wildlife (CDOW) in Eastern Colorado documented 12 occurrences of Burrowing Owl predation on Mountain Plover chicks (unpublished data, Dreitz 2011). Mountain Plover remains have also been discovered in Burrowing Owl pellets in other areas of the state (Conrey 2010). These observations establish that the Burrowing Owl and Mountain Plover interact as predator and prey.

However, research in Eastern Colorado also revealed that Mountain Plover chick survival was highest in habitats occupied by prairie dogs, the same habitat where a vast majority of Burrowing Owl nests are found. Due to these seemingly contradictory pieces of evidence (there is a potential for both positive and negative relationships between Burrowing Owls and Mountain Plovers) and the sympatric inhabitation of grasslands by Burrowing Owls and Mountain Plovers, understanding how Burrowing Owls and Mountain Plovers interact will allow land managers to make better-informed management decisions involving these species.

Our primary goal was to better understand the inter-species interaction between Mountain Plovers and Burrowing Owls and to determine if the proximity between breeding individuals of the two species influenced Mountain Plover nesting success. We completed a preliminary investigation in an area of eastern Colorado where the two species breed sympatrically.

DESIGN AND IMPLEMENTATION

Study Area

The study area spans approximately 600 km² and is located in the southern portion of Lincoln County, Colorado (figure 1). The study area lands are privately-owned and are classified as one of three habitat types: shortgrass prairie unoccupied by prairie dogs (grassland), shortgrass

prairie occupied by prairie dogs (prairie dog), and agricultural fields (crop). Shortgrass prairie vegetation in both prairie dog and grassland habitats is dominated by buffalograss (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*). Agricultural fields include both fallowed and actively farmed lands. Agriculture in this area is limited to non-irrigated, dry land crops. Small grain agriculture dominates in this area with winter wheat as the primary crop. Row crops are planted sparingly and include milo, sunflower, and corn.

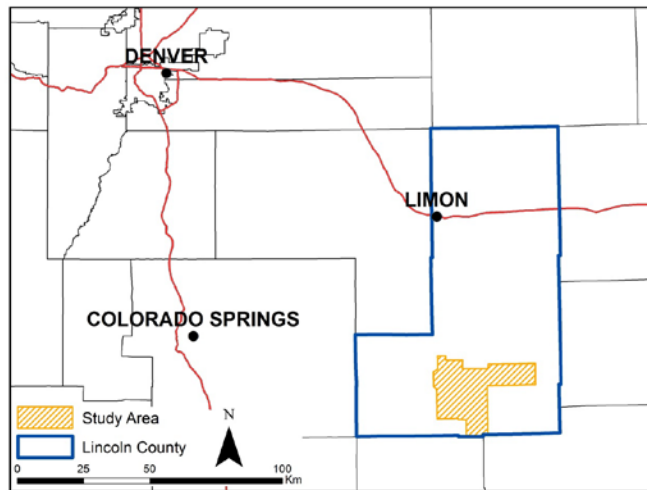


Figure 1. Study area (orange hashed area) in south-central Lincoln County, Colorado, southeastern Colorado. Study area is approximately 600 km², and is composed of privately-owned grass and agricultural lands.

Data Collection & Methods

Nest Location

We conducted Burrowing Owl and Mountain Plover nest searches simultaneously beginning 15 April and ending 15 July 2011. We walked or drove (using all-terrain vehicles) transects across study sites, visually locating and observing breeding adults with the aid of binoculars, subsequently allowing us to locate initiated nests. All documented Mountain Plover nests contained at least one egg. We inferred the presence of Burrowing Owl nests through the presence of adults at the burrow as well as the presence of scat (usually small pieces of cattle manure) lining the entrance and directly surrounding the burrow as well as the presence of insect and other prey item remains in and around the burrow entrance (Conrey 2010). We employed the use of an infrared video probe to confirm the presence of nesting Burrowing Owls at some burrows and recorded the locations of both Burrowing Owl and Mountain Plover nests using GPS devices.

Comment [SRH1]: Distance and/or spacing?

Nest Monitoring

We monitored Mountain Plover nests at uneven intervals (approaching the nest as infrequently as possible while still being able to determine nest fate) over the course of the entire nesting period until either the nest was determined failed (zero eggs from the nest hatched and the nest was either depredated during incubation or abandoned) or successful (at least one egg

from the nest hatched). We documented suspected cause of failure for all unsuccessful nests.

Nest Proximity

At the conclusion of the nesting season, GPS coordinates of both Mountain Plover and Burrowing Owl nests were converted into a shapefile for analysis in ESRI's ArcMap. The linear distance between each Mountain Plover nest and the nearest documented Burrowing Owl nest was calculated using the "Near" tool in ESRI's ArcMap software program. Breeding adult Burrowing Owls and Mountain Plovers have the ability to fly and are not constrained by habitat features (changes in habitat type, composition, or terrain) or anthropogenic boundaries or structures (roads, fence lines, ownership). As such, the Euclidean distance (shortest distance between two points) was determined as the appropriate linear measurement for the "near" analysis.

Comment [SRH2]: How many nests are we talking about?

Is it risky to put a map in paper that shows nest distribution in the study area.

Statistical Analysis & Covariates

In order to explain variation in Mountain Plover nest survival, we constructed a model set (table 1) in Program MARK which scored models using Akaike's information criterion scores corrected for small sample size (AIC_c) and ranked them accordingly (AIC_cw). Models included in the candidate model set were based on *A Priori* hypothesis (outlined below) about possible effects of nesting Burrowing Owl proximity on Mountain Plover nest survival.

Comment [SRH3]: These needs a footnote or some description for me at least.

Four covariates were used in the creation of candidate models to explain variation in Mountain Plover nest survival (habitat type, distance (m) to from Mountain Plover nest to nearest burrowing owl nest, distance from Mountain Plover nest to nearest Burrowing Owl nest (m^2), and distance from Mountain Plover nest to nearest Burrowing Owl nest (m^3).

Mountain Plover Nesting Habitat Type

Mountain Plover nests were grouped by nesting habitat. Previous research has found that Mountain Plovers are more abundant in prairie dog habitat during the breeding season and that chick survival on prairie dog habitat is higher than that in grassland or crop habitats (Dreitz *et al.* 2006, Dreitz 2009). In other areas of Colorado and in breeding habitats outside of Colorado, Mountain Plovers almost exclusively nest in prairie dog habitat (Dinsmore *et al.* 2005). We hypothesize that nesting habitat will positively influence Mountain Plover nest survival due to the strong preference of this habitat by breeding adults and higher chick survival observed in this habitat type (Dreitz 2009).

Mountain Plover-Burrowing Owl Nesting Distance/Proximity

Three measures of nesting proximity were included in our models. We used the distance in meters to test for a linear relationship between Burrowing Owl and Mountain Plover nesting proximity and Mountain Plover nest survival. We also included the distance in m^2 and m^3 in order to test for non-linear relationships. *A priori*, our prediction was that Mountain Plovers

nesting in close proximity to Burrowing Owls would experience lower nest survival due to behavioral changes that result when in close proximity to a predator (increased vigilance, decreased foraging efficiency, longer incubation absences during longer feeding sessions).

Data Format – Program MARK input file

Data was formatted for nest survival analysis in Program MARK. The minimum data necessary for nest survival analysis in Program MARK (the day the nest was found, the day the nest was last checked alive, the day of the last nest check, the nest fate, and the number of nests with this encounter history) as well as data for our three distance covariates was included in the data input file for each Mountain Plover nests located in the study area during the 2011 nesting season where nest fate could be determined (n= 101). For the purpose of this analysis, nests included in the input file were divided into three groups according to habitat type (group 1= prairie dog, n= 29, group 2= grassland, n= 42, group 3= crop, n= 30) as demonstrated below:

```
Nest Survival group=1
/*002-11*/ 17 40 40 0 1 217 46905 10158440;

Nest Survival group=2
/*009-11*/ 27 43 43 0 1 1468 2154351 3162093503;

Nest Survival group=3
/*026-11*/ 61 61 74 1 1 2152 4629984 9962521124;
```

RESULTS

Habitat type was the strongest predictor of Mountain Plover nest survival from our candidate set of models (table 1 & figure 1, $AIC_c = 273.3657$, $dAIC_c = 0.0000$, $AIC_{cW} = 0.37261$, $k = 3$). Habitat type alone explains 37% of the variation in Mountain Plover nest survival. Although not a strong effect, the distance in meters between Mountain Plover nests and the nearest Burrowing Owl nest combined with habitat type did predict about 14% of the variation in Mountain Plover nest survival ($AIC_c = 275.3589$, $dAIC_c = 1.9932$, $AIC_{cW} = 0.13754$, $k = 4$). Mountain Plover nests close to Burrowing Owl nests had higher survival than those farther away. The model with distance from Mountain Plover nests to the nearest Burrowing Owl nest in meters was the 3rd ranked model, explaining 12% of the variation in survival ($AIC_c = 275.5524$, $dAIC_c = 2.1867$, $AIC_{cW} = 0.12486$, $k = 2$). Models considering the effects of nesting distance as a non-linear function were ranked similar to the null model.

Table 1. Model selection set investigating influence of Burrowing Owl (*Athene cunicularia*) nest proximity on Mountain Plover (*Charadrius montanus*) nest survival near Karval, Colorado. Bold type represents top models based on Akaike's information criterion scores corrected for small sample size (AIC_c), difference between top model and candidate model ($dAIC_c$), and model weight (AIC_{cW}).

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Model	AIC _c	dAIC _c	AIC _{c w}	k
Habitat	273.3657	0.0000	0.37261	3
Habitat x BUOW dis	275.3589	1.9932	0.13754	4
BUOW dis	275.5524	2.1867	0.12486	2
BUOW dis x BUOW dis ²	275.5791	2.2134	0.12320	3
Null	276.2527	2.8870	0.08797	1
BUOW dis x BUOW dis ² x BUOW dis ³	276.4231	3.0574	0.08079	4
Habitat x BUOW dis x BUOW dis ²	277.3608	3.9951	0.05055	5
Habitat x BUOW dis x BUOW dis ² x BUOW dis ³	278.9831	5.6174	0.02246	6

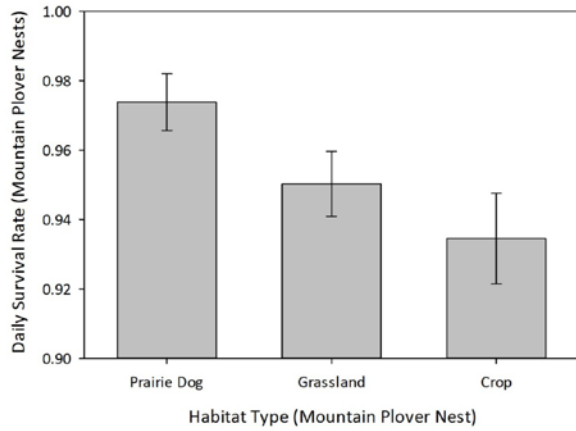


Figure 2. Daily Mountain Plover nest survival by habitat type. Daily nest survival is highest for nests in prairie dog habitat.

DISCUSSION

Understanding inter-species relationships is important in guiding management decisions involving the conservation and continued persistence of species. When these relationships involve species of concern that exhibit a predator-prey relationship, understanding these relationships is even more critical. The results of our investigation indicate that there is likely an interaction between Mountain Plovers and Burrowing Owls and that Mountain Plovers nesting closer to Burrowing Owls may have slightly increased nest survival. Our results clearly demonstrate that the nesting habitat of

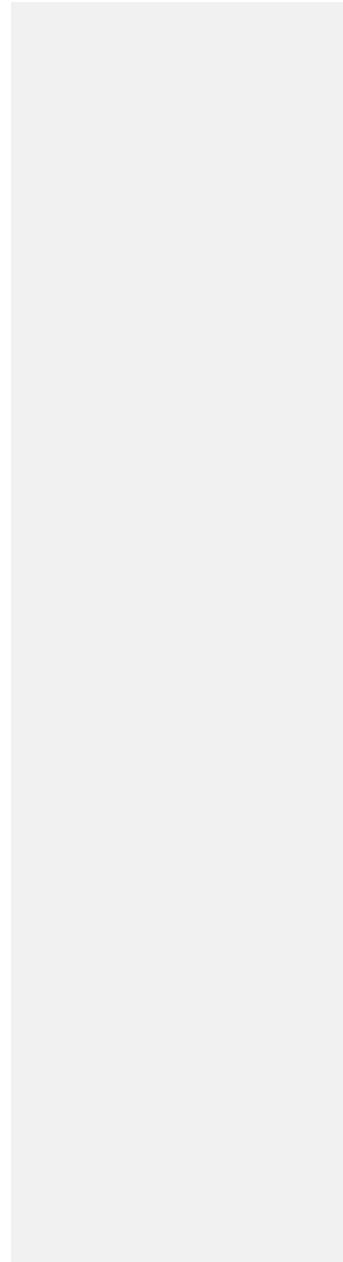
Mountain Plovers is a strong predictor of Mountain Plover nest survival. The daily survival rate of Mountain Plover nests in prairie dog habitat was 0.9738675. Over the 29-day incubation period, nests in prairie dog habitat have a 46% probability of survival (0.9738675^{29}). In comparison, nests in grassland and crop habitats have daily survival rates of 0.950349 and 0.9345283 respectively and a 23% and 14% probability of survival over the 29 day incubation period. Although daily survival rates vary only slightly (0.97-0.93), when extrapolated over the duration of the incubation period, drastically different survival probabilities exists over habitat types (46% - 14%).

While our results did not indicate a strong effect of Burrowing Owl and Mountain Plover nesting distance on Mountain Plover nest survival, I believe that a slight positive relationship exists between these species. Small sample sizes ($n < 45$ in each habitat type) of Mountain Plover nests as well as a wide-range of nesting distance with little replication (32-1400m) may have influenced the effect of nesting distance on Mountain Plover nest survival. Furthermore, because Burrowing Owl nests occur almost exclusively in prairie dog habitat, separating the effects of Burrowing-Owl Mountain Plover nesting distance and Mountain Plover nesting habitat is difficult. Additionally, there are other variables that are known to influence Mountain Plover nest survival that have not been considered in this model set including sex of tending adult, nest age, and daily precipitation (Dinsmore *et al.* 2002).

AREAS FOR FURTHER RESEARCH

I recommend increasing the sample size (possibly by considering multiple seasons of data) of Mountain Plover nests in each habitat type where the distance between nesting Mountain Plovers and Burrowing Owls is known. Larger sample sizes will allow for the inclusion of other important variables influencing Mountain Plover nest survival including sex of the tending adult, nest age, and daily precipitation. A model set that includes these variables will better predict and weigh the different factors influencing Mountain Plover nest survival. In order to separate the effects of habitat type and nesting distance, comparing Mountain Plover nest survival in prairie dog habitats with nesting Burrowing Owls and nest survival in prairie dog habitat without nesting Burrowing Owls might paint a clearer picture of the separate effects of habitat type and Burrowing Owl nesting distance.

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