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Title

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Permalink

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Journal

Proceedings of the Vertebrate Pest Conference, 28(28)

ISSN

0507-6773

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Publication Date

2018

DOI

10.5070/V42811042

Estimating the Effects of DRC-1339 Treated Egg Baits on Common Ravens Using a Bioenergetics Model

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ABSTRACT: Depredation by common ravens often exceeds stakeholders' levels of acceptance. Common sources of excessive raven damage include loss of young livestock and nest depredation of species of concern, such as desert tortoise, greater sage-grouse, and least tern. USDA/APHIS Wildlife Services applies the avicide DRC-1339 (3-chloro-p-toluidine hydrochloride, CPTH) formulated in an intact-boiled egg bait to reduce such damage under the DRC-1339 Concentrate Livestock, Nest & Fodder Depredations label (EPA No. 56228-29). Although considered extremely effective on corvids, DRC-1339 is a slow acting toxicant and ravens may succumb away from the bait site, preventing the use of carcass recovery as a means to estimate take. To estimate take, Wildlife Services employs a model comprised of a bioenergetics module to predict consumption combined with a toxicological module that predicts mortality based on a probit analysis. This model has recently been revised to improve and standardize take estimates for common raven management activities using the egg baits covered by this label. Common ravens exhibit complex behaviors that impact the amount of bait consumed when offered DRC-1339 egg baits. The approaches to capturing this behavior in the model are presented along with take estimates associated with a range of baiting scenarios.

KEY WORDS: bioenergetics, common raven, *Corvus corax*, CPTH, DRC-1339, model, mortality, nest, predator, probit

Proc. 28th Vertebr. Pest Conf. (D. M. Woods, Ed.)
Published at Univ. of Calif., Davis. 2018. Pp. 231-234.

INTRODUCTION

Common ravens (*Corvus corax*) frequently cause human wildlife conflicts with ranchers and natural resources managers through their foraging behavior. For example, ravens damage and kill young livestock by feeding on their eyes (Larsen and Deitrich 1970), and depredate nests of sensitive bird species such as greater sage-grouse (*Centrocercus urophasianus*; Coates et al. 2008, Taylor et al. 2017), California least tern (*Sternula antillarum*; Butchko 1990), and snowy plover (*Charadrius nivosus*; Burrell and Colwell 2012). Exclusion and habitat management may improve nest success (Dinsmore et al. 2014, Peterson and Colwell 2014), but lethal control measures are often necessary to reduce human conflicts with ravens around specific biological intervals like calving/lambing and incubation (Butchko and Small 1992, Spencer 2002, Peebles and Conover 2016).

A common tool to reduce raven conflict is through the use of compound DRC-1339 (3-chloro-p-toluidine hydrochloride, CPTH), an avicide registered to control nuisance bird species in the United States and only available for use only by trained USDA/APHIS/Wildlife Services personnel or individuals under their direct supervision. The majority of DRC-1339 bait used is applied under the DRC-1339 Bird Control label (EPA Reg. No. 56228-63) for resolving conflicts with several bird species in certain agricultural settings. These applications were formally conducted using the DRC-1339 Feedlot (EPA Reg. No. 56228-10) or DRC-1339 Staging Area (EPA Reg. No. 56228-30) labels. When DRC-1339 is used to reduce livestock depredation or to protect nests, it is applied using the DRC-1339 Concentrate Livestock, Nest & Fodder Depredations label (EPA Reg. No. 56228-29).

WS biologists and specialists report the estimated number of birds taken each time they apply DRC-1339. By design, this avicide is slow acting to keep birds at the bait site, thus promoting bait efficacy. It acts on the kidneys and heart in targeted species, with mortality occurring in 1 to 3 days. Conversely, prolonged time to death complicates estimating mortality (Homan et al. 2001, Kostecke et al. 2001). Historically, bird point counts conducted before and after baiting operations were used to estimate take (Stahl et al. 2016).

Johnston et al. (2007) developed an alternative approach for estimating take using probabilistic modeling. This approach was later combined with a bioenergetics component that estimates the caloric requirement of a bird to maintain its core body temperature during heat and mass transfer with the environment (Campbell 1977, Campbell and Norman 1998). The bioenergetics model produces lower estimates of take than linear regression models, reflecting differences in the way that the models capture feeding behavior (Homan et al. 2011, Homan et al. 2013). This bioenergetic, dose-response model was developed to predict take under the Feedlot label for European starlings (*Sturnus vulgaris*) using discrete bait pellets (Homan et al. 2005). Further development expanded the species covered, bait choices, and states covered to create a Wildlife Services Unified Take Model for the Feedlot and Staging Area labels. Stahl et al. (2008) used the bioenergetics approach to evaluate the efficacy of egg baits for raven control under the Livestock, Nest, & Fodder label. The Unified Take Model is flexible and can be refined to further improve take estimates and incorporate new scenarios. This paper describes improvements made to the Unified Take Model to improve take estimates for egg baiting operations that target ravens.

METHODS

We modified the USDA/APHIS/WS DRC-1339 Unified Take Model (Stahl et al. 2016) to estimate raven take using egg baits under the Compound DRC-1339 Concentrate - Livestock, Nest & Fodder Depredations label EPA Reg. No. 56228-29. Per label instructions, we simulated deployment of 18 eggs at the management site, each containing 1 ml of 2% DRC-1339 solution in the yolk of each boiled egg. Eggs were assumed to weigh approximately 50g each in the parameterization of the model. If egg baits are recovered after a baiting operation, these values are input into the model and removed from available bait. In our simulated exercise, no egg baits were recovered.

The model uses a bioenergetics approach (Campbell 1977, Campbell and Norman 1998) to estimate the caloric requirement for an individual raven over a 24-hr period needed to maintain a core body temperature given the net energy exchange between the body of the raven and its environment. Details for the calculations implemented in this estimate are found in Homan et al. (2011). The core body temperature for ravens used in the model is 39.5 °C (Wetmore 1921). The model generates a random population of ravens based on the amount of bait available and where the body mass of each raven is normally distributed in the range of 1240 g ± 140 g (mean ± 1 sd).

Ravens feed at the bait site until all the bait is consumed, with each bird consuming a mass of bait based on a randomly generated mass fraction of its caloric requirement need, capped at a maximum of portions of 1 or 2 eggs. Thus, a single raven may not consume all of an egg and another raven may consume the remainder. This feeding behavior was based on a pen study conducted by

Knittle and Gaddis (1992). Mortality is estimated for each raven using the probit method presented in Johnston et al. (2007) and the probability of mortality resulting from the amount of DRC-1339 consumed is estimated using an LD₅₀ = 13 mg/kg (Eisemann et al. 2003). This approach allows the model to simulate a bird population larger than the number of eggs applied at a bait site. In addition, some of these ravens may not ingest sufficient DRC-1339 to result in mortality. The model allows the user to indicate whether ravens were observed caching eggs during the pre-baiting. If so, a raven could cache up to three eggs based on the behavior of ravens reported by Heinrich & Pepper (1998). These were removed from the available bait at the site and not used to estimate mortality in the 24-hr period.

The model runs as a VBA macro in an Excel spreadsheet. Inputs required to make an estimate of the daily caloric requirement for the ravens during the baiting are: the state where the baiting occurred, the month of the baiting, the daily maximum and minimum temperatures for a 24-hr period during the baiting, the average wind speed over a 24-hr period, the average percent cloud cover, and type of cloud present. The number of treated eggs applied at a bait site and the number of eggs recovered at the end of the baiting period are required to make an estimate of mortality. User prompts generated as the macro runs allow for the site-specific input of these parameters.

For demonstrative purposes, we ran multiple simulations to demonstrate possible results from management activities to protect greater sage-grouse nests from common ravens near Denio, Humboldt County, Nevada. We used 2 weather scenarios including clear sky with light wind, and stratus clouds with 60% coverage and light winds. We ran simulations in April, May, and June and our scenarios included egg caching and no egg caching.

RESULTS

Minimum and maximum daily temperatures increased through the spring and monthly means ranged from 32-81°F (Table 1). When caching was selected, a large proportion of eggs were cached in each month and under both weather scenarios, although more eggs were generally cached with cloud cover (Table 2). Egg caching affected the number of egg baits available for consumption and resulted in less raven mortality under all scenarios (Table 3). Over a 3-month period at the same location, simulations resulted in the estimated take of 1-15 ravens when deploying 18 treated egg baits (Table 3).

Table 1. Mean daily minimum and maximum temperatures by month near Denio, Humboldt County, Nevada.

Month	Min Temp (°F)	Max Temp (°F)
April	32	62
May	39	71
June	46	81

Table 2. Number of eggs cached in model simulations near Denio, Humboldt County, Nevada.

Month	Clear Sky	Cloudy Sky
April	13	14
May	14	14
June	11	14

Table 3. Estimated number of birds taken with and without egg caching under 2 weather scenarios near Denio, Humboldt County, Nevada.

Month	Estimated Number of Raven Mortalities			
	Without Caching		With Caching	
	Clear Sky	Cloudy Sky	Clear Sky	Cloudy Sky
April	10	10	6	4
May	11	15	2	5
June	9	11	3	1

DISCUSSION

The site we chose for our demonstration is an important site for sage-grouse nesting in Nevada and the timeframe reflects a range of when baiting operations may occur. However, the model can be executed for the application of egg bait to control ravens in 34 states throughout their range and under a range of environmental conditions. Caching was incorporated in the model to reflect the propensity of ravens to remove egg baits from the bait site. The differences in take demonstrate the impact of allowing birds to cache eggs in a baiting scenario. This behavior must be determined by the applicator during pre-baiting. The model does not assume that cached eggs are consumed but it does assume the raven commonly consumes part of one or two eggs. The outcome of this ingestion is determined and generally results in mortality. Post-cache egg fate is not known at this time but will be updated pending additional research. Studies are currently underway to evaluate egg bait stability under simulated field conditions. This study will help us understand if and how the toxicant breaks down within the egg, and how long a cached egg is lethal. The model will be updated once these studies are completed.

Stahl et al. (2008) demonstrated that across a number of baiting scenarios encompassing a broad range of weather at different locations, a raven requires approximately whole boiled eggs to meet its caloric requirement for a 24-hr period. However, Knittle and Gaddis (1992) found that ravens stop feeding soon after ingesting CPTH treated egg baits. Therefore, the current version of the model restricts consumption for any given raven to a maximum of two eggs in a 24-hr period, but allows for a raven to cache additional eggs (1-3) consistent with a bioenergetics requirement for four eggs.

The current unified take model provides a uniform method for estimating take following a baiting operation and is a program standard for Wildlife Services. It represents current understanding of the feeding behavior for ravens and other target birds, and the behavior of the multiple bait types in the field. The current model meets the needs of many users in the various applications of CPTH treated egg baits under the depredation label. There are current plans to update the model to reflect loss of the Feedlot (EPA Reg. No. 56228-10) and Staging Area (EPA Reg. No. 56228-30) labels, and the addition of the latest Bird Control label (EPA Reg. No. 56228-29).

The unified take model is a living product and will be updated to reflect all changes in knowledge pertaining to raven feeding or bait stability in the field. We also will continue to update the model with similar applications for bait type-species combinations that are currently unavailable, such as using treated meat to manage ravens under the DRC-1339 Concentrate Livestock, Nest & Fodder Depredations label (EPA Reg. No. 56228-63).

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