Bait Preference and Banding Cost Analysis for Mourning Doves in the Chenier Plain of Southwest Louisiana

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Abstract: The mourning dove (*Zenaida macroura;* hereafter dove) is among the most iconic symbols for hunting in the southeastern United States. Conservation and management of this species is a priority for many state wildlife management agencies. Annual banding efforts are one of the main methods used to measure survival and recovery rates, which aid in harvest management recommendations. We examined a number of dove captures using five different bait types over a two-year period in southwestern Louisiana and performed a banding cost analysis. We found milo to be the most efficient bait for banding new doves and total captures (newly banded doves and all recaptures combined), followed by browntop millet. Similarly, milo was least expensive bait per volume, most economical per capture, and yielded the most captures, with a cost of US$1.09 for each new band deployed and $0.25 per capture. Conversely, browntop millet ranked second in the number of new birds banded and total captures but was also the second most expensive bait. We recommend agencies in the southeastern United States consider both bait preference and cost when operating a dove banding program to ensure banding programs run efficiently and research funds are allocated appropriately to achieve the desired number of captures.

Key words: banding, migratory game bird, trapping, bait preference, grains

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The mourning dove (*Zenaida macroura*; hereafter dove) is an important webless migratory game bird with more than 11.5 million individuals harvested annually throughout the United States (U.S. Department of Interior et al. 2016). Each year, approximately 709,000 dove hunters spend more than 2 million hunter days afield and spend an estimated US$86.9 billion on hunting related items, generating an estimated $11.8 billion in tax revenues (U.S. Department of Interior et al. 2016). To inform annual dove harvest management decisions and conserve populations for long-term hunting opportunities, a national strategic harvest management plan was implemented in 2003 (U.S. Fish and Wildlife Service 2005). The plan established monitoring programs to further define population vital rates linked to survival and reproduction (Miller 2009). Historically, dove populations were monitored with Call Count Surveys, an annual roadside index for dove abundance (Otis et al. 2008, Miller 2009). The current national dove banding program involves landscape level, multi-state banding efforts aimed at improving our understanding of dove population biology and estimating the effect of harvest on dove populations (Seamans 2018).

Techniques associated with trapping efforts and factors influencing trap success have been documented throughout the southern United States over the last 50+ years in many states such as Oklahoma (Dyer 1973, Lewis and Morrison 1973), Missouri (Henry et al. 1976, Schulz et al. 1995), Alabama (Hayslette and Mirarchi 2002), and Florida (Beckwith 1959). However, bait preferences by mourning doves can vary geographically and there remains limited information for dove banding efforts in Louisiana, including the effectiveness of different bait types for live-capture. Research on factors influencing dove trapping success coupled with cost analysis is needed to efficiently and effectively accomplish the goals of operating a banding program, especially given personnel and budgetary constraints. Therefore, the goal of this study was to compare dove captures by bait type and determine the most economically efficient bait type to use when trapping doves in southwestern Louisiana. We hypothesized that there would be significant differences in dove capture rates among bait types, and doves would be captured most often in traps baited with browntop millet. We based this hypothesis on anecdotal observations from the correspond-

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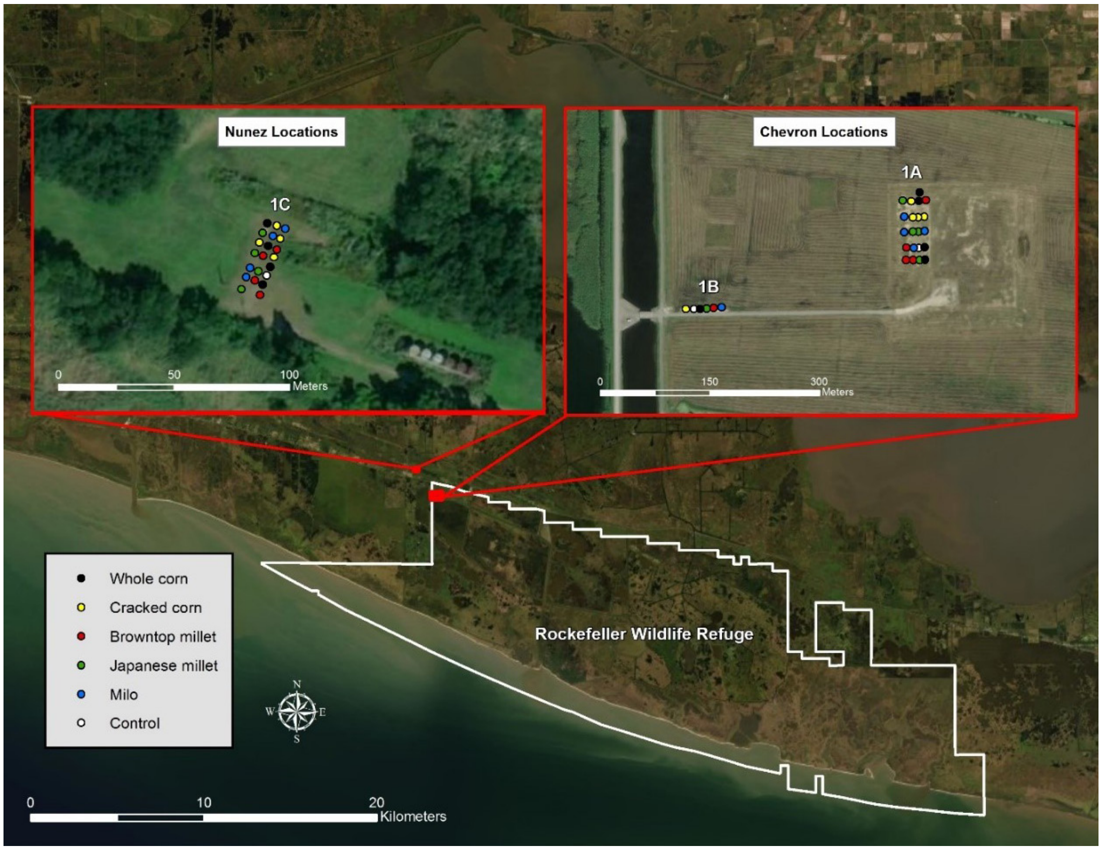

Figure 1. Trapping locations with bait types used in a study to assess bait effectiveness for banding new mourning doves (*Zenaida macroura*) and total number of captures at Rockefeller Wildlife Refuge and Nunez Woods, Cameron Parish, Louisiana, 2017 and 2018. Control trapping points were excluded from analyses due to lack of replication.

ing author during previous dove trapping operations throughout the southern United States, and because browntop millet is often planted in dove fields in the south (Duguay et al. 2017).

Study Area

Trapping efforts were conducted on Rockefeller Wildlife Refuge or directly adjacent to the Refuge at Nunez Woods (Figure 1). Rockefeller Wildlife Refuge lies within the southeastern portion of the Chenier Plain Region of southwestern Louisiana in Cameron and Vermilion Parishes (between approximately 92º54' E and 92º30' E). The Chenier Plain, located near the southwestern corner of Louisiana's Acadiana triangle, is readily identifiable by its unique cheniers. Cheniers are narrow strips of forested habitat that formed from sedimentation by historic fluctuation in the Mississippi River delta and are primarily characterized by live oak (*Quercus virginiana*) and hackberry (*Celtus laevigata*). These remnants of the Gulf's former shorelines and the freshwater marshes that surround them make up the Chenier Plain (Crowell 2015). Rockefeller Wildlife Refuge borders the Gulf of Mexico for 42.6 km and extends inland toward the Grand Chenier ridge, an isolated beach ridge located ~9.7 km from the Gulf of Mexico. Rockefeller Wildlife Refuge is managed by the Louisiana Department of Wildlife and Fisheries agency's Coastal and Non-Game Resources Division. When it was deeded to the state in 1914, Rockefeller Wildlife Refuge encompassed approximately 34,802 ha, but the property has since lost approximately 5666 ha (16.6% ha loss) due to shoreline/beach erosion and currently stands near 29,136 ha.

We focused trapping and banding efforts at two locations approximately 2.5 km apart, Chevron and Nunez (Figure 1). The Chevron site was formally an oil pad that was abandoned in 2014. The site was predominantly bare ground with a few sparse weeds and minimal amounts of loose gravel/grit. The surrounding habitat consisted of pastureland with plant communities dominated by longtom (*Paspalum lividum*). Our Nunez site was directly north of the Rockefeller Wildlife Refuge boundary and had bare ground with a few sparse weeds and minimal amounts of loose gravel/grit within the trapping locations, similar to the Chevron site. The areas adjacent to our study sites primarily consisted of live oak and hackberry trees and bahiagrass (*Paspalum notatum*) and Johnson grass (*Sorghum halepense*). There were no row-crop agricultural dominated landscapes within ~50 km of either trapping site.

Methods

Field Techniques

We trapped and banded doves June–August 2017 and 2018 during normal banding operations (Seamans 2018). However, due to various logistical constraints, we allocated more time to trapping in 2018 (total survey length: 6 June to 9 August) than in 2017 (12 July to 2 August). We selected trapping locations in areas where high concentrations of doves were documented (Keeler and Winston 1951), which allowed for multiple "runs" or checks of the traps daily. We cleared all trapping locations of vegetation via lawnmower, weed eater, and herbicide prior to the trapping season. Trapping locations remained the same for the 2017 and 2018 seasons with no variation within sites.

We used a similar version of the Kniffin modified funnel traps for dove trapping efforts (Reeves et al. 1968, Dyer 1973). We placed 26 traps at the Chevron site equally spaced between each other at 18 m by 18 m, and 21 traps at the Nunez site equally spaced between each other at 5 m by 5 m (Figure 1). At our Chevron and Nunez sites we baited five and four traps, respectively, with 226.8 g of one of the following bait types: 1) browntop millet (*Urochloa ramosa*), 2) cracked corn (*Zea mays*), 3) Japanese millet (*Echinochloa esculenta*), 4) milo (*Sorghum bicolor*), and 5) whole kernel corn. To reduce the effect of environmental variables on attractiveness of any kind of bait, we randomly selected a bait type for each trap using a random number generator (Lewis and Morrison 1973) and maintained the trap-bait pairing both years. We meticulously maintained 228.8 g of bait per trap and replenished bait after each banding effort to maintain bait availability consistency. We placed the bait on the ground in the interior center of the trap. We baited traps before dawn and checked each trap every 2–3 hours to avoid any heat related mortality but continued to band throughout the entire day and into the evening as long as no heat related mortality or stress occurred (Keeler and Winston 1951). We did not operate traps during rain or lightning weather conditions to ensure the safety of birds and staff. We trapped Monday–Thursday and left traps open Friday–Sunday. We removed all bait following our final trapping effort of each week to prevent any sprouting or spoiling and replenished it at the beginning of the next trapping event.

During each trap check we removed captured doves and placed them in a catch crate to allow for quick processing. Birds were banded and released in the center of either the Chevron or Nunez trapping site, depending on where they were captured. For each dove captured, we recorded date, weather, location, age [hatch year (HY) or after hatch year (AHY)], sex of AHY birds (the sex of HY birds is unidentifiable in field settings), and bait for each newly banded and recaptured bird. We assigned age based on presence or absence of buffy-tipped wing coverts (Pearson and Moore 1940) and progression of primary molt (Swank 1955, Wight et al. 1956, Allen 1963, Sadler et al. 1970, Haas and Amend 1976). We classified sex according to plumage color of the nape, crown, and breast (Ridgway 1915, Friedman and Ridgeway 1950, Petrides 1950, Reeves et al. 1968, U.S. Fish and Wildlife Service and Canadian Wildlife Service 1977, Cannell 1984). We also used whiteness on the tips of the outer three rectrices and eye ring color to assist with the designation of sex (Mirarchi 1993). We banded all doves with a standard USGS aluminum leg band size 3A and handled all birds following handling guidelines (Gaunt et al. 1997) to minimize risk of injury.

Table 1. Output of candidate models of hypothesized bait type effectiveness for banding new mourning doves (*Zenaida macroura*) and total number of captures at Rockefeller Wildlife Refuge and Nunez Woods, Cameron Parish, Louisiana, 2017 and 2018. Included for each model are the model variables, number of parameters (K), Akaike's Information Criterion (AIC), difference in AIC between a given model compared to the model with lowest AIC (ΔAIC), Akaike weights (w_i), and log- likelihood [log(L)].

Analysis	Model	K	AIC	ΔAIC	w_i	log(L)
New bands	Bait	6	445.9	0.0	0.73	–216.9
	Bait and site	7	447.5	1.6	0.27	–216.8
	Null	2	465.5	19.6	0.00	–230.7
	Site	3	467.1	21.2	0.00	–230.6
All captures	Bait	6	824.2	0.0	0.65	–406.1
	Bait and site	7	825.1	0.9	0.35	–405.6
	Null	2	955.0	130.8	0.00	–475.5
	Site	3	955.9	131.7	0.00	–474.9

Data Analysis

Banding Analysis—We summed the number of new bands and total number of captures (i.e., new bands and all recaptures combined) by bait type for each site and used those values as our response variables for two analyses to assess bait type effectiveness for capturing doves. First, we modeled the number of new bands deployed by site to evaluate bait types that would be representative of a typical banding study, and second, the total number of captures for each bait type, which would be more relevant to a mark-recapture study. For each analysis, we built four Poisson generalized linear mixed effects models to evaluate band number differences between bait types and sites (Table 1). We used year as the random effect in all models to account for environmental variation that may have affected naturally available foods and more captures in 2018 due to the greater survey length. Because we hypothesized the most captures would occur with browntop millet, we set that bait type as our reference category for analyses. We did not conduct an analysis on bait preference between sexes nor age per se because of our male-biased data and behavioral effects from trap happy birds. However, because such differences may be of interest for future studies, we investigated proportions of age and sex by bait type. We conducted our analyses in R (R Core Team 2018) with the lme4 version 1.1–21 package (Bates et al. 2015) and conducted a Tukey post-hoc test to evaluate pairwise comparisons from our bait models using the multicomp package (Hothorn et al. 2008). We assessed significance at $\alpha = 0.05$ for both analyses.

Cost Analysis—We conducted a cost analysis to determine the price per newly banded dove and the price per dove capture (i.e., total number of captures), among bait types. We calculated cost as the total price for each bait type divided by either the number of new bands deployed or the total number of captures. We did not include employee salaries because of differences between agencies and among employees, nor equipment costs, as our primary objective was to only investigate cost differences among bait types and captures.

Results

Among bait types, we deployed 240 new bands on mourning doves during the 2017 ($n = 103$) and 2018 ($n = 137$) seasons. Captures were male biased in both years. In 2017, we captured 30 females, 78 males, and one unidentified sex as AHY, and 34 HY birds. In 2018, we captured 33 females and 135 males as AHY birds, and 56 HY birds. Including recaptures, we had 791 total captures (2017 = 221, 2018 = 570) comprised of 311 individuals, with 71 of these individuals banded prior to this study. The number of individuals captured in an individual trap during a single banding effort ranged from 0–30, with the greatest number of captures occurring in traps baited with milo. On average, individuals were each captured 2.5 times. Of all individuals, 184 were only captured once, 21 were captured 2 and 3 times, and the remaining ranged from 4 to 30 times. We documented 19 and 25 individuals being captured at both Chevron and Nunez in 2017 and 2018, respectively.

For both analyses, the model including bait as the only fixed effect had the lowest AIC value, although it was only one-two AIC units apart from our bait + site model in both analysis (Table 1). Of the latter model, the number of doves banded and total captures was not different at Nunez compared to our Chevron site (Table 2). We had hypothesized browntop millet would be our most effective bait type, and we banded more new doves and had more total captures with that bait than all other bait types, except milo (Tables 2–4). Milo was our most effective bait type for banding new doves and for total number of captures, followed by browntop millet and Japanese millet, with the fewest captures using corn (Tables 2–4). We found four significant differences in bait types when banding

Table 2. Variable estimates, standard errors (SE), and lower (LCI) and upper (UCI) 95% confidence intervals from our analyses of bait type effectiveness for banding new mourning doves (*Zenaida macroura*) and total number of captures at Rockefeller Wildlife Refuge and Nunez Woods, Cameron Parish, Louisiana, 2017 and 2018. Browntop millet (*Urochloa ramosa*) was used as the reference category. CC = cracked corn (*Zea mays*), WC = whole corn, JM = Japanese millet (*Echinochloa esculenta*), MI = milo (*Sorghum bicolor*).

Analysis	Bait type[a]	Estimate	SE	LCI	UCI	P-value
New bands	Intercept	1.19	0.15	0.88	1.50	< 0.01*
	CC	–0.68	0.22	–1.12	–0.23	< 0.01*
	JM	–0.17	0.19	–0.55	0.22	0.40
	MI	0.19	0.18	–0.16	0.54	0.30
	WC	–0.68	0.22	–1.12	–0.23	< 0.01*
	Site: Nunez	–0.08	0.13	–0.34	0.18	0.55
All captures	Intercept	2.18	0.32	1.54	2.81	< 0.01*
	CC	–0.52	0.12	–0.77	–0.27	< 0.01*
	JM	–0.34	0.12	–0.57	–0.10	< 0.01*
	MI	0.45	0.10	0.26	0.64	< 0.01*
	WC	–0.73	0.13	–0.99	–0.46	< 0.01*
	Site: Nunez	–0.08	0.07	–0.22	0.07	0.30

* indicates significance at α = 0.05.

Table 3. Pairwise comparisons of bait types used to evaluate bait effectiveness for banding new mourning doves (*Zenaida macroura*) and total captures at Rockefeller Wildlife Refuge and Nunez Woods, Cameron Parish, Louisiana, 2017 and 2018. Bait 2 is set to zero for pairwise comparisons. CC = cracked corn (*Zea mays*), WC = whole corn, BTM = browntop millet (*Urochloa ramosa*), JM = Japanese millet (*Echinochloa esculenta*), MI = milo (*Sorghum bicolor*).

Analysis	Bait 1	Bait 2	Estimate	SE	LCI	UCI	*P*-value
New bands	CC	BTM	–0.68	0.22	–1.29	–0.07	0.02*
	JM	BTM	–0.17	0.19	–0.69	0.36	0.91
	MI	BTM	0.19	0.18	–0.29	0.66	0.83
	WC	BTM	–0.68	0.22	–1.29	–0.07	0.02*
	JM	CC	0.51	0.23	–0.12	1.14	0.17
	MI	CC	0.86	0.22	0.27	1.45	< 0.01*
	WC	CC	0.00	0.26	–0.70	0.70	1.00
	MI	JM	0.35	0.18	–0.15	0.85	0.31
	WC	JM	–0.51	0.23	–1.14	0.12	0.17
	WC	MI	–0.86	0.22	–1.45	–0.27	< 0.01*
All captures	CC	BTM	–0.52	0.12	–0.86	–0.18	< 0.01*
	JM	BTM	–0.34	0.12	–0.66	–0.01	0.04*
	MI	BTM	0.45	0.10	0.19	0.72	< 0.01*
	WC	BTM	–0.73	0.13	–1.09	–0.37	< 0.01*
	JM	CC	0.19	0.13	–0.18	0.55	0.62
	MI	CC	0.97	0.12	0.66	1.29	< 0.01*
	WC	CC	–0.21	0.15	–0.61	0.20	0.62
	MI	JM	0.79	0.11	0.49	1.08	< 0.01*
	WC	JM	–0.39	0.14	–0.78	–0.01	0.04*
	WC	MI	–1.18	0.13	–1.52	–0.84	< 0.01*

* indicates significance at α = 0.05.

new doves, all with cracked or whole corn as being less effective. However, when considering all captures, 8 of 10 pairwise comparisons yielded significant differences, mostly from the effectiveness of milo and browntop millet and few captures using corn (Table 3).

Overall, bait preference by HY birds was similar across bait types, where the proportion of HY birds receiving new bands ranged from 27.1% (browntop millet) to 30.0% (cracked corn) of the new bands deployed, except for milo which was 40.8%. For all captures, HY birds comprised of 13.8% (milo) to 15.1% (browntop millet) of all captures, except for Japanese millet which yielded 21.1% of the captures. Bait preference by sex had greater variability, with newly banded females ranging from 14.3% (milo) to 30.6% (Japanese millet) of all AHY birds, except for cracked corn which yielded 52.4% of the individuals. For all captures, proportions of females were more similar, with a range of 15.3% (milo) to 32.2% (cracked corn).

Milo was the least expensive bait type used to capture doves when considering only new captures ($1.09 per dove; Table 4). Japanese millet was the most expensive bait type and was 5.75 times more expensive per dove than milo when considering new captures (Table 4). When considering all captures (i.e., newly banded individuals and all recaptures), milo ($0.25) and Japanese millet ($2.78) were the least and most expensive bait types, respectively (Table 4).

Table 4. Bait type, price ($USD) per 18.14 kg bag, number of bags purchased, total bait price (nine bags each), number of new bands deployed and total captures (in parentheses), and price per new band and per capture of mourning doves (*Zenaida macroura*) at Rockefeller Wildlife Refuge and Nunez Woods, in Cameron Parish Louisiana, summers 2017 and 2018.

Bait type	Price per bag	Price of bait	New bands (total captures)	Price per new band	Price per capture
Browntop millet	$32.00	$288.00	59 (179)	$4.88	$1.67
Cracked corn	$9.95	$89.55	30 (102)	$2.99	$0.88
Japanese millet	$38.00	$342.00	50 (123)	$6.84	$2.78
Milo	$8.50	$76.50	70 (311)	$1.09	$0.25
Whole corn	$8.95	$80.55	31 (83)	$2.60	$0.97

Discussion

Our results indicated that milo was the most effective bait for capturing doves in our study area, and overall, most cost effective. Our results, however, may have limitations to our study area, as bait availability may differ among geographic regions. For example, we limited our choices to common bait types available at local grain providers within 161 km of the study site. Similarly, our study sites were not independent due to 1) the narrow distance between them that allowed crossover from individuals, and 2) the small difference in spacing between trapping plots. We believe the effects of these differences were minimal, however, and the former may have actually benefited our study by increasing the number doves in our local population to be banded.

While direct comparison to other studies is confounded by bait types used, this study does expand on the current body of literature of bait effectiveness. Lewis and Morrison (1973) found mourning doves preferred white proso millet (*Panicum miliaceum*) followed by milo, while LeBlanc and Otis (1998) determined that mourning doves in a caged experiment preferred browntop millet over grain and native seeds. Futch (2014) found browntop millet and pigweed (*Amaranthus* spp.) to be the top ranking seeds, based on mass in mourning dove crops from birds harvested in northeast Louisiana during the first year of his study, while corn and goatweed (*Croton* spp.) were the most abundant seeds during the second year of his study. Davison and Sullivan (1963) developed a list of 64 choice foods out of more than 200 offered to wild mourning doves in the Southeast, which included milo, browntop and Japanese millet.

Given that mourning doves preferentially feed on a wide variety of seeds, an important consideration in wildlife management and research projects includes the associated cost (e.g., Davison and Sullivan 1963, Lewis and Morrison 1973, Reed et al. 1982, Oneto et al. 2010, Riley and Litzgus 2013, Futch 2014). We found milo, at a cost of $1.09 per new dove captured and $0.25 per total dove capture to be the most cost-effective bait in our study, followed by whole corn, cracked corn, browntop millet, and Japanese millet, respectively. Our results suggest that although a variety of baits may be effective in capturing doves, baits anecdotally thought to be the best at attracting doves (i.e., browntop millet) may not be the most economical to use. Similarly, baits like whole and cracked corn that are overall inexpensive to purchase may be less preferable for research due to the paucity of captures, which may increase indirect costs (e.g., salary and transportation) when attempting to achieve desired sample sizes. Conversely, if increasing female captures is a goal, the proportion of new females banded and total number of captures of females in our study suggests that cracked corn may be preferable.

In the course of their work, agency personnel in the southeastern United States routinely consider both bait preference and cost when operating a dove banding program. Although milo did not significantly differ from browntop or Japanese millet when considering capture probability and total captures in our study, we recommend biologists in southwestern Louisiana and other areas with similar habitat conditions trap doves with milo, as we found it to be the most cost-effective bait type.

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