AN EVALUATION OF FOUR MINERAL FORMULATIONS TO ATTRACT DEER TO CAMERA SURVEY SITES

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ABSTRACT—Estimating local deer populations is an important consideration for deer managers. Shelled corn is commonly used to attract white-tailed deer (*Odocoileus virginianus*) to infrared-triggered camera survey sites. The addition of mineral formulations may increase deer visitation. We evaluated the effect of four mineral formulations on deer visitation at two study areas in Tennessee. Mineral formulations differed in ingredients and amount of sodium (Na) supplied. Type of mineral formulation affected total deer use of baited sites, with a high salt formulation receiving over four times the amount of daily visits (9.86) as other formulations. Depending on the study area, crepuscular and nocturnal time periods accounted for 19–28% and 47–63%, respectively, of daily use by all deer. Average daily visits by bucks to high salt formulation sites (2.10) was also more than four times the amount of other formulations, and peak daily use by bucks across minerals occurred during the crepuscular (28–33%) and nocturnal (51–52%) time periods. Doe use was highest (6.13 visits per day) at high salt formulation sites. Peak daily use by does primarily occurred during the crepuscular (19–28%) and nocturnal (49–66%) time periods. There was relatively little use of mineral sites by fawns and no differences in mineral formulation use were observed. While we do not suggest using minerals alone, where legal, we do recommend a high salt mineral formulation to increase deer attraction to sites baited with corn for the purpose of surveying deer populations.

To effectively manage white-tailed deer (*Odocoileus virginianus*) herds, biologists need estimates of local herd size and the associated sex and age ratios of these herds. Various methods are used to obtain these population estimates (Downing et al., 1965; Roseberry and Woolf, 1991), but a technique using infrared-triggered cameras to photograph deer has produced reliable results (Jacobson et al., 1997). At the highest camera density tested (1/65 ha), Jacobson et al. (1997) captured 100% and 88.2% of marked deer during the first and second years of their study. This camera-station density likely produced a reliable estimate of the study population, with Lincoln-Petersen Index estimates similar to the camera estimates (Jacobson et al., 1997).

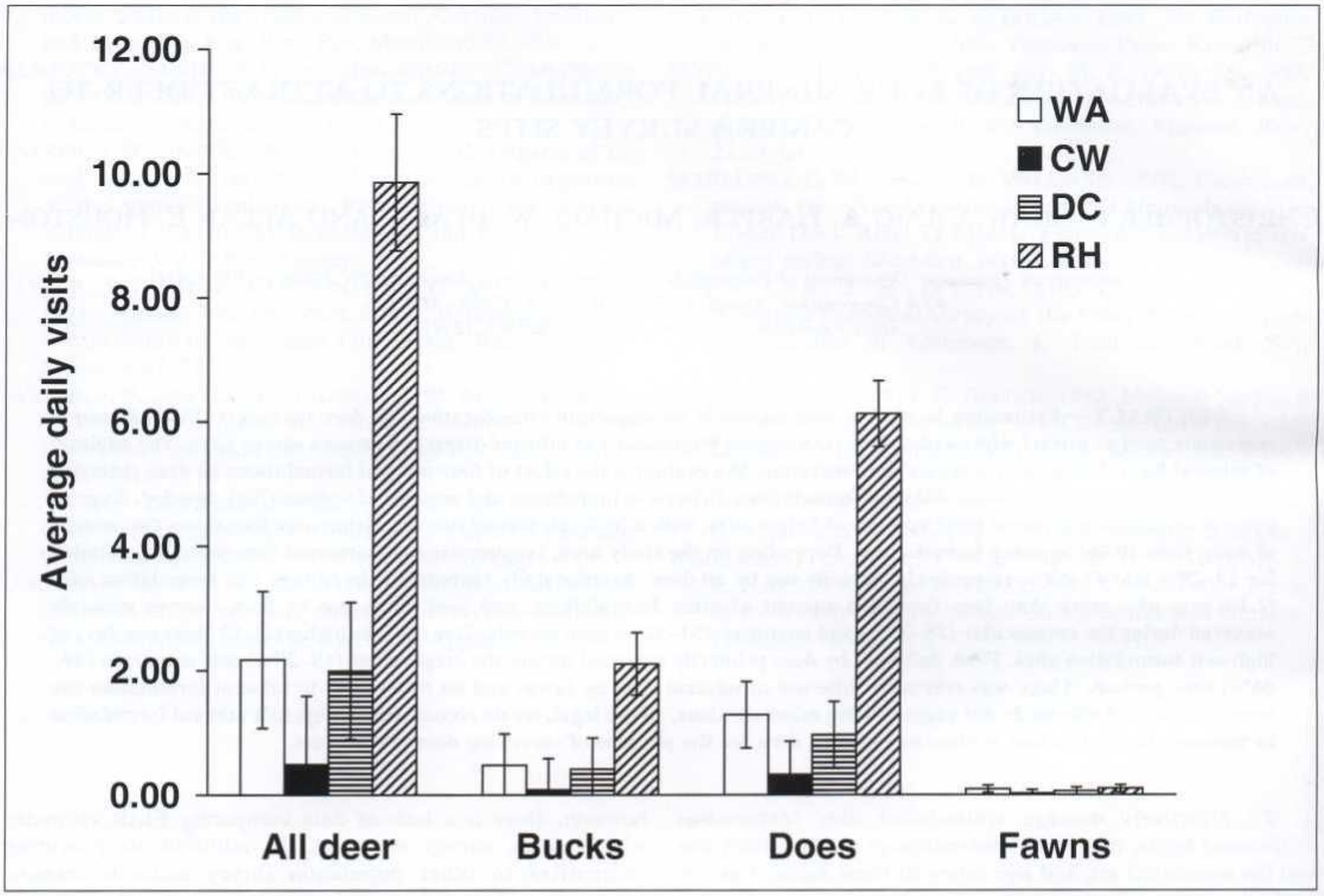
Studies have noted potential biases with the camera survey, including attracting does and bucks to sites not in proportions that represent their presence in the population (Jacobson et al., 1997; Koerth et al., 1997). However, McKinley et al. (2006) found little difference in the recapture rates of bucks and does. Additionally, Jacobson et al. (1997) expressed a need for studies comparing camera survey estimates with other population estimates, as well as using the camera technique in different geographic areas. Koerth et al. (1997) found helicopter counts and camera survey estimates provided similar results in brushland habitats of south Texas. Using unbaited camera sites, Roberts et al. (2006) found camera estimates provided a viable alternative to road survey estimates when road access and/or habitat limited the use of road survey methods. Studies have shown spotlight and Forward-Looking Infrared (FLIR) counts produce similar results (Belant and Seamans, 2000; Drake et al., 2005); however, there is a lack of data comparing FLIR estimates with camera survey estimates. In addition to providing alternatives to other population survey methods, camera surveys provide managers with estimates of sex and age ratios.

Jacobson et al. (1997) also identified a need for information on the camera survey technique with bait types other than shelled corn. Koerth et al. (1997) used a 1:1 mixture of soybeans and corn for baiting their camera sites, while a study in central Texas found deer used corn feeders more than those supplying protein pellets, mineral, and salt (Koerth and Kroll, 2000). Using camera survey sites baited only with corn, McKinley et al. (2006) noted that lower deer recapture rates on one of their study areas could be attributed to alternative food sources (acorns) that had a significant presence on this area. Although corn is an attractive bait for white-tailed deer, salt and other minerals may increase attraction to camera sites baited with corn.

This study was designed to address problems associated with attracting deer to camera survey sites baited with corn. Specifically, our objectives were to: 1) evaluate the attractiveness of four mineral formulations, and 2) determine sex/age use of the four mineral formulations. Secondarily, the use of infrared-triggered cameras allowed us to determine time of use of sites baited with minerals.

METHODS

Study Areas and Design—Our study was conducted over two years on two properties managed under quality deer management (QDM) guidelines in Tennessee. Ames Plantation



Mean white-tailed deer visits per day to mineral stations on Ames Plantation and Rocky River Hunting Clubs, Tennessee, early June–early August, 2004 and 2005. Abbreviations for mineral formulations studied are: WA = Whitetail Addition, CW = Co-op Whitetail Deer Mineral, DC = Deer Cane, and RH = Ranch House Trace Mineralized Salt.

Hunting Club encompasses 18,653 acres in Fayette and Hardeman Counties in the Coastal Plain physiographic province of southwest Tennessee. Rocky River Hunting Club is a 5,200 acre property in Sequatchie, Van Buren, and Warren Counties within the Cumberland Plateau physiographic province in southeast Tennessee.

Four 150-acre forested sites were identified during May 2004 at each study area. Near the center of each site, four mineral stations were established in a pattern 50 yards square, with a different mineral randomly chosen for a corner of the square. At each mineral station, a "camera tree" was identified and the appropriate mineral was placed 15 feet away. Any obstructing vegetation and debris were cleared from the area and a granular mineral mix was spread onto the ground according to the instructions per mineral mixture. A sign used to identify the mineral and site location was placed 30 feet away from the tree as a boundary marker for "in" deer. In early June 2004, infrared-triggered cameras (Non-Typical DeerCams) were placed at each camera station to monitor deer use of the various mineral formulations until early August 2004.

This time period was used to ensure adequate deer visitation to sites, as research has shown mineral lick use is seasonal (Weeks and Kirkpatrick, 1976). Deer visitations to natural mineral licks in Indiana peaked in spring and declined throughout the summer and fall, with no activity observed during January, February, and March (Weeks and Kirkpatrick, 1976). Early June–early August also was chosen because this is the time period leading into late summer, when deer populations are surveyed, as bucks and fawns are most easily identified and just prior to oak mast becoming available. Before cameras were put out again in June 2005, stations were refreshed with appropriate mineral formulations. During both years, mineral sites were monitored a total of 59 days.

Mineral Formulations Tested—We selected four mineral formulations for comparison: Co-op Whitetail Deer Mineral (Tennessee Farmers Cooperative), Whitetail Addiction (Biologic), Ranch House Trace Mineralized Salt (United Salt Corporation), and Deer Cane (Evolved Habitats). While we did not have the means or inclination to compare all mineral formulations available, we chose four formulations that were diverse in composition (Table 1). Ingredients in Co-op Whitetail Deer Mineral were: dicalcium phosphate, sodium chloride (salt), calcium carbonate, molasses products, sodium selenite, mineral oil, natural and/or artificial flavors, magne-

TABLE 1. Ingredients of mineral formulations tested on Ames Plantation and Rocky River Hunting Clubs, Tennessee during early June–early August, 2004 and 2005.

Whitetail Addiction	Co-op Whitetail Deer Mineral	Deer Cane	Ranch House Trace Mineralized Salt
sodium carbonate	dicalcium phosphate	sodium carbonate	sodium chloride
calcium stearate	sodium chloride	sodium bicarbonate	calcium sulfate
monosodium glutamate	calcium carbonate	calcium stearate	iron oxide
natural and artificial sweeteners	molasses products	monosodium glutamate	manganous oxide
	sodium selenite	natural and artificial sweeteners	zinc oxide
	mineral oil		ferrous carbonate
	natural and/or artificial flavors		calcium carbonate
	magnesium oxide		copper oxide
	manganous oxide		calcium iodate
	manganese sulfate		cobalt carbonate
	zinc oxide		sodium selenite
	zinc sulfate		molasses products
	ferrous sulfate		natural and artificial flavors
	copper sulfate		
	ethylenediamine dihydriodide		
	calcium iodate		
	cobalt carbonate		
	vitamin A acetate		
	vitamin D-3 supplement		
	vitamin E supplement		

sium oxide, manganous oxide, manganese sulfate, zinc oxide, zinc sulfate, ferrous sulfate, copper sulfate, ethylenediamine dihydriodide, calcium iodate, cobalt carbonate, vitamin A acetate, vitamin D-3 supplement, and vitamin E supplement. Whitetail Addiction contained sodium carbonate, calcium stearate, monosodium glutamate, and natural and artificial sweeteners. Deer Cane had similar ingredients listed, but sodium bicarbonate also was listed with amounts between levels of sodium carbonate and calcium stearate. Ranch House Trace Mineralized Salt listed sodium chloride (salt), calcium sulfate, iron oxide, manganous oxide, zinc oxide, ferrous carbonate, calcium carbonate, copper oxide, calcium iodate, cobalt carbonate, sodium selenite, and molasses products, with natural and artificial flavors added.

Photograph Evaluation and Statistical Analysis—A visit occurred when deer were photographed between the camera and the identification sign. Deer were placed into four categories: buck, doe, fawn, or unknown adult deer. These four categories were combined for analysis of preference by all deer, while bucks, does, and fawns were analyzed separately to determine possible sex/age preferences. Additionally, the time stamps on photographs allowed deer visits to be placed into 24 time classes, depending on the hour. Time class 0 was defined as midnight until 12:59 AM, while time class 23 was defined as 11:00 PM until 11:59 PM. Time classes without any observed visits were assigned a zero value to account for all time classes measured during the study. Visits were averaged across time classes into three time periods, producing visits/hour for analysis. Crepuscular was defined as time classes 5, 6, 19, and 20, because these time classes contained the official sunrise and sunset times for both study areas across both months and during both years. Nocturnal was defined as time classes 21, 22, 23, 0, 1, 2, 3, and 4, while diurnal was defined as time classes 7 through 18.

To determine the most effective bait for attracting deer (bucks, does, fawns, and all combined) throughout time periods, we used a mixed model repeated measures analysis of variance (ANOVA) with mineral formulation, time periods, and property as fixed effects. Random effects were year and replication. A log transformation was necessary for all variables to meet normality and equal variance assumptions of the model. When the interaction term was significant ($P < 0.050$), we conducted Tukey's studentized range test on the interaction means to separate significant differences among means.

RESULTS

Most photographs were clear enough to allow sex and age (adult or fawn) determination of deer, but the clarity of some pictures prevented accurate classification of all deer. A total of 1,509 photographs were recorded during the study. This captured a total of 1,604 deer, allowing identification of 1,325 deer by sex/age.

For all deer combined, mineral ($F_{3,42} = 15.34$, $P < 0.001$) and time period ($F_{2,78} = 12.29$, $P < 0.001$) effects were significant. The interaction effect of property by time period ($F_{2,78} = 7.38$, $P < 0.002$) also was significant for all deer. Ranch House Trace Mineralized Salt sites received greater ($P < 0.05$) use than all other mineral formulations (Table 2). Visits to Rocky River sites during the crepuscular time period were greater ($P < 0.05$) than visits during the diurnal time period (Table 3). At Ames Plantation, more visits occurred during the nocturnal period than during the crepuscular or diurnal periods (Table 4).

TABLE 2. Mean (± *SE*)[a] number of white-tailed deer visits per day to mineral stations by formulation type on Ames Plantation and Rocky River Hunting Clubs, Tennessee during early June–early August, 2004 and 2005.

Formulation type	All deer	Bucks	Does	Fawns
Whitetail Addiction	2.17 (1.10)b	0.48 (0.50)b	1.29 (0.53)b	0.09 (0.06)a
Co-op Whitetail Deer Mineral	0.49 (1.10)b	0.08 (0.50)b	0.33 (0.53)b	0.02 (0.06)a
Deer Cane	1.99 (1.10)b	0.41 (0.50)b	0.97 (0.53)b	0.06 (0.06)a
Ranch House Trace Mineralized Salt	9.86 (1.10)a	2.10 (0.50)a	6.13 (0.53)a	0.10 (0.06)a

[a] Within a column, means with different letters are different at $P < 0.05$.

A significant effect of mineral ($F_{3,42} = 7.14$, $P < 0.001$) and time period ($F_{2,78} = 6.01$, $P < 0.004$) on buck visits was detected. There was no significant property by time period interaction for bucks. Ranch House Trace Mineralized Salt sites received greater ($P < 0.05$) buck use than the other formulations (Table 2). Overall, crepuscular and nocturnal time periods received greater ($P < 0.05$) buck use than the diurnal time period.

Mineral ($F_{3,42} = 20.13$, $P < 0.001$) and time period ($F_{2,79} = 13.17$, $P < 0.001$) effects were significant for does. The interaction effect of property by time period ($F_{2,79} = 4.83$, $P < 0.011$) also was significant for does. Does visited Ranch House Trace Mineralized Salt sites more ($P < 0.05$) than other mineral formulation sites (Table 2). Visits to sites at Rocky River during the crepuscular time period were greater ($P < 0.05$) than visits during the diurnal time period (Table 3). Doe visits to sites at Ames Plantation during the nocturnal time period were greater ($P < 0.05$) than visits during the crepuscular and diurnal time periods (Table 4).

Fawns visited all sites less than bucks and does (Table 2). Only time period ($F_{2,66} = 6.52$, $P < 0.003$) effects were significant for fawns. Diurnal use for fawns was higher than crepuscular and nocturnal time periods ($P < 0.05$).

DISCUSSION

Sodium (Na) is the mineral most sought by white-tailed deer when using mineral licks (Weeks, 1978; Kennedy et al., 1995). This desire for sodium may be attributed to spring and summer diets high in water and potassium, resulting in sodium deficiencies (Weeks and Kirkpatrick, 1976). However, Atwood and Weeks (2002) found no relationship between sodium content and the number, sex or age of visitors. Atwood and Weeks (2003) compared use of natural seeps, artificial salt (granular NaCl) licks, and artificial mineral (Mineral King mineral mixture) licks. Males and females preferred artificial salt licks in the summer, while females preferred artificial mineral licks in the spring (Atwood and Weeks, 2003).

Deer use of mineral formulations tested in our study suggests the compound supplying the sodium influences deer use of mineral sites as well. Ranch House Trace Mineralized Salt contained the second highest amount of sodium (35–37%), but this formulation also contained the most sodium chloride (88–93%). This formulation received the highest use by deer (Table 2). The two mineral formulations (Whitetail Addiction and Deer Cane) receiving similar deer use contained the highest percentage of sodium with a range of 40–45%, but Deer Cane also contained sodium bicarbonate. Although these formulations contain the highest percentage of sodium, estimated use of these sites was between estimates for formulations receiving the highest and lowest use (Table 2). Co-op Whitetail Deer Mineral contained 26–31% sodium chloride and the least amount of sodium (10–12%). Although this formulation contained sodium chloride, dicalcium phosphate is the primary ingredient. The addition of dicalcium phosphate to this formulation may have affected its attractiveness to deer.

Trends of daily deer use of mineral sites in our study were characteristic of activity patterns of white-tailed deer. Typically, site use was greatest during the crepuscular and nocturnal time periods. An exception was use by fawns, as they visited the sites most during the diurnal time period. Fawn use was low relative to buck and doe use, with several visits occurring in conjunction with does. Weeks and Kirkpatrick (1976) stated no spotted fawns were seen at licks in their study, and they also noted salt drive was common to all sex-age classes except nursing fawns. Fawns observed in our study were still spotted and their visitation to sites was likely incidental to their dam's visits.

TABLE 3. Mean (± *SE*)[a] number of white-tailed deer visits per 24 h time period to mineral stations by time period on Rocky River Hunting Club, Tennessee during early June–early August, 2004 and 2005.

Time period[b]	All deer	Bucks	Does	Fawns
Crepuscular	1.80 (0.64)a	0.36 (0.16)a	1.11 (0.18)a	-
Diurnal	1.58 (1.93)b	0.18 (0.48)b	0.96 (0.55)b	0.06 (0.06)
Nocturnal	2.96 (1.29)ab	0.56 (0.32)a	1.97 (0.36)ab	-

[a] Within a column, means with different letters are different on an hourly basis at $P < 0.05$.

[b] Time periods vary in the amount of hour classes (0–23) contained in them (crepuscular = 4, diurnal = 12, and nocturnal = 8).

TABLE 4. Mean (± *SE*)[a] number of white-tailed deer visits per 24 h time period to mineral stations by time period on Ames Plantation Hunting Club, Tennessee during early June–early August, 2004 and 2005.

Time period[b]	All deer	Bucks	Does	Fawns
Crepuscular	1.14 (0.64)b	0.39 (0.16)a	0.64 (0.18)b	0.04 (0.02)ab
Diurnal	1.10 (1.93)b	0.28 (0.48)a	0.52 (0.55)b	0.19 (0.06)a
Nocturnal	3.88 (1.29)a	0.72 (0.32)a	2.25 (0.36)a	0.03 (0.04)b

[a] Within a column, means with different letters are different on an hourly basis at $P < 0.05$.

[b] Time periods vary in the amount of hour classes (0–23) contained in them (crepuscular = 4, diurnal = 12, and nocturnal = 8).

Our study was designed to address problems with attracting deer to camera sites. We want to stress that we were interested in identifying mineral formulations that increased deer attraction to bait sites for surveying populations and not promoting mineral formulations for improved herd health or antler growth. Schultz (1990) found no differences in growth rate, body size, and antler quality of captive and wild deer populations with mineral supplementation. Furthermore, it is not clear what minerals may be needed to improve deer and antler quality (Weeks, 1995).

One brand of mineral formulation considered for inclusion in this study claimed to improve deer herd genetics, while another formulation warned of approaching sites baited with the formulation due to possible aggressive deer behavior. Claims such as these may give unrealistic expectations to managers and the public. However, choosing the correct type of mineral formulation will help increase the number of visits (sample size) to bait sites when surveying deer populations.

Our results suggest mineral formulations with a high salt content can be used to increase deer visitation to bait sites. It is also important to consider palatability of other minerals present in the formulation. Furthermore, mineral use is highly seasonal (Weeks and Kirkpatrick, 1976). A property surveyed in late summer will likely receive more benefit from the application of mineral formulations to bait sites than a property surveyed in the winter. To ensure adequate attraction of deer during survey periods, we suggest minerals should only be used to complement (not replace) corn at bait sites.

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