Technical Wildlife Session

Comparison of the Camera Estimate to Program CAPTURE to Estimate Antlered White-tailed Deer Populations

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Abstract: We used infrared-triggered cameras to estimate white-tailed deer population size. The camera estimate simplifies analysis of photographs obtained from these cameras and provides an estimate similar to that generated using the models with program CAPTURE. Four surveys of an enclosed property in northeastern Mississippi generated counts of 16, 31, 40, and 14 antlered white-tailed deer using the camera estimate at different camera densities and at different time periods. Indentifying individuals by antler characteristics and analyzing the data using program CAPTURE estimated the population of bucks for the same 4 surveys of the same property to be 13 (95% CI = 12–27), 30 (95% CI = 20–169), 22 (95% CI = 21–41), and 11 (95% CI = 8–27) respectively. All camera estimates fell within the 95% confidence interval for program CAPTURE when models correcting for heterogeneity of capture and bias due to time and behavior were employed. Results indicated that the camera estimate is useful for estimation of antlered white-tailed deer populations where Lincoln-Petersen models are appropriate and possibly for more complex sampling situations if photographs capture a large percentage of the population.

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Technological improvements in data collection are providing wildlife managers with systems that are inexpensive, accurate, and reliable. Data provided by remote, infrared-triggered cameras have similar accuracy to time-area counts, spotlight, drive, strip, or aerial surveys but are inexpensive by comparison (Jacobson et al. 1997).

Cameras triggered automatically by the presence or behavior of an animal have a long history. However, early versions had limited usefulness and were plagued with problems (Carthew and Slater 1991, Kucera and Barrett 1993, Rice 1995). Current models have been improved. Information on animal presence or abundance has been collected with remote cameras successfully on numerous occasions for several mammalian species (Savidge and Seibert 1988, Bull et al. 1992, Garshelis et al. 1993, Laurance and Grant 1994, Mace et al. 1994, Major and Gowing 1994, Karanth 1995, Rice 1995, Zielinski and Kucera 1995, Bowman et al. 1996, Jacobson et al. 1997, Vanderhoof 1997).

Several studies have determined population estimates from photographic capture-recaptures (Mace et al. 1994, Karanth 1995, Bowman et al. 1996, Jacobson et al. 1997). Karanth (1995) and Bowman et al. (1996) used the program CAPTURE to obtain estimates from individually marked animals. Jacobson et al. (1997) developed a method termed the "camera estimate" to obtain similar information. This estimate, based on a Lincoln-Petersen model, uses total occurrences of animals in the photographs. Separating deer into 3 categories based on antlerless, spike-antlered, and branched-antlered animals, the estimate uses observation of detail and simple math to provide a population estimate (Jacobson et al. 1997). The objective of our study was to determine if the method proposed by Jacobson et al. (1997) provided population estimates similar to those generated by the accepted but more complex program CAPTURE (Nichols 1992).

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Methods

The study was conducted from September 1996 to February 1997 on a 265-ha hunting camp located in the Upper Coastal Plain of Mississippi near Crooksville, Noxubee County. The property was completely enclosed by a 3-m high net wire fence that prevented deer from entering or leaving the area. The property consisted of an upland pine-hardwood vegetative association with cherrybark oak (*Quercus pagodaefolia*), water oak (*Q. nigra*), and loblolly pine (*Pinus taeda*) as dominant species. Agricultural food plots of oat/wheat mix (*Avena sativa / Triticum aestivum*), ryegrass (*Lolium spp.*), Pensacola bahia grass (*Paspalum notatum*), arrowleaf clover (*Trifolium versiculosm*), osceola clover (*T. ripens*), and crimson clover (*T. incanatum*) were planted throughout the enclosure.

Four separate surveys using photographic traps were conducted to estimate the white-tailed deer population on the Walker property. Surveys were conducted 3–10 September 1996, 11–18 September 1996, 10–17 January 1997, and 4–11 February 1997. Trailmaster TM-500 passive and TM-1500 active infrared monitoring stations (Goodson and Associates, Lenexa, Kans.) were established within the fenced area. Sensitivity for the passive monitors was set to record an event when 4 beams were broken within 3 seconds ($P = 4$, $Pt = 3$). Sensitivity for the active units was set to record an event when an animal stood within the beam for 0.75 seconds ($P = 15$). Camera delay was set at 4 minutes ($Cd = 4.0$) for all units. All monitors were set to photograph on a continuous 24-hour interval.

A grid of 16.2-ha squares was placed over a map of the property. The property was then sectioned into 14 equal blocks. Cameras were placed in each block at densities of 1 / 16.2 ha or 1 / 32.4 ha depending upon the survey. Approximately 20 kg of cracked corn bait was maintained at each camera site. Kodak ISO 200 speed, 24-exposure film was loaded into each of the Olympus Infinity Twin (Olympus Optical Co., Ltd., Tokyo, Japan) automatic cameras. The first picture in each roll was of the researcher holding up a marker with the station number to ensure proper identification of the film once developed. Detailed descriptions of camera setup and use are provided in Kucera and Barrett (1993) and Zielinski and Kucera (1995). Units were checked every 3 days.

A photographic trap session consisted of 7 days. Stations were placed within the blocks, in areas of known deer activity as recommended by the landowner and experienced hunters familiar with the activity patterns of deer in the area. Stations were placed to maximize separation and were assumed to be equally attractive. Surveys began at 1200 hours on day 1 of the survey. Removal of the stations occurred after 1200 hours of day 8. Photographs without contents readily identifiable as 1 of Jacobson et al.'s (1997) 3 camera estimate categories (e.g., nothing in photo, picture blurry) were discarded. White-tailed deer occurrences in the photographs of each survey were separated into the 3 categories and totaled. These data were used to generate population estimates.

Antlered bucks can be individually distinguished in photographs by antler configuration, number of points, relative length of points, angle and projection of points, pelage characteristics, and overall body traits (Jacobson et al. 1997). In our study, bucks were considered captured on the first picture taken and subsequent photographs were counted as single recapture for use in program CAPTURE. Only 1 recapture per 24-hour period per individual was actually recorded (Mace et al. 1994, Karanth 1995). Multiple photographs of the same individual within a single day were recorded as a single recapture. For the camera estimate, number of does was determined by ratios to branch-antlered bucks as given by Jacobson et al. (1997). However, only number of antlered bucks could be determined with program CAPTURE. Therefore, we limited comparison between the 2 techniques to estimates of antlered deer. The results of the estimate for the total buck population in each survey for both techniques were compared by evaluating if the camera estimate predicted the total number of bucks within the 95% confidence interval generated by program CAPTURE.

The following equations constitute the camera estimate for bucks (Jacobson et al. 1997):

$$P_s = N_{sa}/N_{ba}$$

Where: P_s = ratio of spike: branch antlered bucks
N_{sa} = total number of spike-antlered deer occurrences in photographs
N_{ba} = total number of branch-antlered deer occurrences in photographs

$$E_b = (B \times P_s) + B$$

Where: E_b = estimated total buck population
B = number of individually identified branch-antlered bucks

Interactive software 2CAPTURE (Rexstad and Burnham 1991) was used to enter data for analysis by program CAPTURE. The 2CAPTURE interface permitted easier data entry with analysis still being conducted under the CAPTURE format.

Results

We placed 35 camera stations on the property during the surveys. These stations each generated between 6 and 20 individually identifiable bucks (Table 1). From 355 photographs, 72 pictures were discarded as unusable. Number of antlered deer photographed varied considerably relative to each census period (Table 1). All 4 of the camera estimates fell within the 95% confidence interval generated by program CAPTURE (Table 2). Program CAPTURE suggested 2 models for survey 1, model M_o (criteria = 0.97) and model M_h (criteria = 1.00). The estimates for survey 2 and 3 were based on a model that corrected for bias in time and behavior (M_{tb}). Program CAPTURE corrected for bias due to heterogeneity of capture (M_h) for survey 4 (Otis et al. 1978, Rexstad and Burnham 1991).

A mean of 14 individuals were identified per census, with a mean recapture percentage of 30.4 Average estimates of antlered bucks were 25 derived from the camera estimate and 18 derived from program CAPTURE.

Discussion

Assumptions for a Lincoln-Petersen closed population estimator include demographic closure (Seber 1973, Otis et al. 1978). This assumption was met due to the short sampling sessions. Geographic closure was accomplished by the existing 3-m high deer proof fence. Animals were assumed to have retained their marks (identifying antler, pelage, and body traits) for the duration of the study. Deer not identifiable to 1 of the categories were not used. Using antler condition as a mark and discarding animal occurrences that were not discernible satisfied the conditions of mark retention (Arnason et al. 1991).

Placement into 1 of the 3 camera estimate categories based on antler condition was the only mark used for separation and loss or absence of an antler still placed the

Table 1. Survey dates, camera densities, and number of individual white-tailed bucks identified for use with program CAPTURE from Walker Property, Noxubee County, Mississippi, in 1996–1997.

Survey	Dates	Camera density	*N* Individuals Identified	Total photographs Spike-antlered	Total photographs Branch-antlered	Individuals recaptured
1	3–10 Sep 1996	1/32.4 ha	11	26	63	6
2	11–18 Sep 1996	1/32.4 ha	20	20	37	5
3	10–17 Jan 1997	1/16.2 ha	20	22	22	5
4	4–11 Feb 1997	1/32.4 ha	6	9	7	1

Table 2. Estimate of adult white-tailed buck population on Walker property in northeastern Mississippi using camera estimate proposed by Jacobson et al. (1997) and program CAPTURE.

Survey	Spike: Branch Ratio (P_s)	Total Buck Estimate (E_b)	# Bucks estimated from CAPTURE	Standard Error	95% C.I.	Model[a]
1	0.4	16	13	3	12 to 27	M_h
			14	3	12 to 26	M_o
2	0.5	31	30	24	20 to 169	M_{tb}
3	1.0	40	22	4	21 to 41	M_{tb}
4	1.3	14	11	4	8 to 27	M_h

a. Model descriptions and explanations are in Otis et al. (1978)

animal into 1 of the categories. The probability of antler loss due to damage or shed was negligible. Most damage to antlers occurs in the velvet phase, not after mineralization. Mean antler shed in Mississippi occurs in late March and the last census survey occurred in mid-February.

A possible bias for both the camera estimate and program CAPTURE exists with the assumption of all marks being reported at recovery. In addition, identification of animals as individuals is subjective. The different surroundings captured in the photographs could have also caused mistakes in identification. This would constitute a lost mark and the animal would have been treated as a new individual, inflating the estimate. Experience with identifying white-tailed deer will likely decrease bias but cannot eliminate it (Jacobson et al. 1997). If experienced researchers are used to identify deer in photographs, we believe this potential error will be minimized.

The assumption of marking having no effect on recapture was believed to have been met. Negative association with the method of capture was a concern (Mace et al. 1994). Initial photographs of certain animals showed individuals fleeing from the station, possibly frightened by the camera's flash. Photographic recapture of these same individuals suggested that habituation to the camera had occurred, however.

The final assumption was that animals had the same probability of being photographed. Animals having identical capture rates is unrealistic (Otis et al. 1978), but unequal sightability that affects all animals equally will not bias the estimator (Arnason et al. 1991). Animals from stable social associations no longer have independent sighting probabilities (Neal et al. 1993). However, bias will not be introduced unless group size or other social attributes affect sightability (Arnason et al. 1991).

Variation in environmental conditions during any survey is expected. Variation in behavior occurs if animals become trap-happy due to consumption of the bait, or trap-shy based on aversive stimuli before and between samples. Program CAPTURE suggested models based on heterogeneity of capture (M_h) for surveys 1 and 4 and variation in time and behavior (M_{tb}) for surveys 2 and 3. The bias in either model will be within a tolerable range if trapping occasions exceeded 5 and if a negligible portion of the population was left untrapped (Otis et al. 1978).

All surveys had 7 trap occasions. Camera placement allowed for the possibility of multiple stations to be discovered by an individual deer. Home range estimates of individual bucks in Mississippi range from 220 to 1,513 ha with home range size decreasing at high deer density (Jacobson 1983, Morgan 1995). This information indicates that 6–14 stations / buck were available to study individuals. This degree of coverage should have censured nearly all the animals on the property. With the prescribed trapping occasions and high degree of camera coverage, bias corrected by the software should have fallen within the tolerable range described by Otis et al. (1978). Thus, bias inherent in the camera estimate fell into an acceptable range because camera estimates were within the confidence interval generated by program CAPTURE. The linear additive model states that every value within a confidence interval is acceptable as a candidate for the mean (Steel and Torrie 1980). The camera estimate provided a value that fell into the confidence interval generated by program CAPTURE for all 4 surveys. Therefore, one estimate is as valid as the other.

Future research implementing photographic identification of deer should include variables such as modifying the duration of trap sessions and prebaiting sites. Lengthening the trap sessions, possibly to 14 days, should increase the probability of photographing a larger percentage of the animals present. Prebaiting may provide a greater opportunity for deer to find and use bait sites, thereby increasing the number of animals photographed and the proportion of the population captured. Otis et al. (1978) recommended 5 trapping occasions and leaving a negligible portion of the population untrapped as ways to reduce estimate bias. Based on these recommendations, our modifications of the technique may reduce bias in the camera estimate.

Possible seasonal differences should also be investigated in future research. Seasonal differences in capture probabilities may result from the availability of alternate food sources. Bait may not be as attractive to white-tailed deer when preferred natural foodstuffs are abundant. Seasonal behavior also may affect how readily an animal approaches a monitor station. Results of this study suggest that conducting capture sessions in mid-September to late January is best for bucks, while late January to early February may be optimal for antlerless deer.

Management Implications

The camera estimate proposed by Jacobson et al. (1997) provides wildlife managers with a technique for easy and accurate estimation of buck numbers, and possibly entire white-tailed deer populations, using pictures generated from remote cameras. Remote cameras are inexpensive to operate and provide data that are easy to understand. The photographs are an improvement over traditional methods because they can provide qualitative and quantitative information. The quantitative data is useful for demographic estimates, but the qualitative information on body condition, antler development, and overall appearance of the animals is also important to a wildlife manager. Traditional methods require more difficult and costly measures to obtain the same information. Further research is necessary to determine if bias in capture probabilities exist between sex and age classes. Results of future research may indicate whether the camera estimate is appropriate for estimation of entire white-tailed populations, not only antlered males.

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