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Abstract

*Over-abundant populations of white-tailed deer (*Odocoileus virginianus*) create agricultural and human health and safety issues. The increased economic damage associated with locally overabundant deer populations accentuates the need for efficient techniques to mitigate the losses. Although red lasers can be an efficient tool for reducing damage caused by birds, they are not effective for deer because deer cannot detect wavelengths in the red portion of the spectrum. No research has been conducted to determine if lasers of lower wavelengths could function as frightening devices for deer. We evaluated a green laser (534 nm, 120 mW) and 2 models of blue lasers (473 nm, 5 mW and 15 mW) to determine their efficacy in dispersing deer at night. Deer were no more likely to flee during a green or blue laser encounter than during control encounters. The green and blue lasers we tested did not frighten deer.* (WILDLIFE SOCIETY BULLETIN 34(2):371–374; 2006)

Key words

agriculture, animal damage, frightening devices, integrated pest management, lasers, Odocoileus virginianus, *white-tailed deer, wildlife damage.*

Wildlife damage management involves the integration of a variety of effective methods to prevent or alleviate animal damage. As populations of white-tailed deer (*Odocoileus virginianus*) have increased across North America (VerCauteren 2003), so have the variety and frequency of deer–human conflicts (DeNicola et al. 2000). Deer damage to agricultural crops and ornamental and native vegetation can be severe (Tilghman 1989, Conover 1997). In addition deer also are responsible for causing vehicle collisions (Conover 2002) and transmitting diseases to humans and livestock (Gage et al. 1995, Schmitt et al. 1997).

Both lethal and nonlethal techniques have been used to control deer damage. Lethal control via hunting or shooting can be an effective method to manage deer populations (VerCauteren and Hygnstrom 1998, Woolf and Roseberry 1998, Brown et al. 2000). However, in some settings such as urban or suburban locales, hunting or shooting may not be socially acceptable or practical (DeNicola et al. 2000, VerCauteren and Hygnstrom 2002). Nonlethal control is more widely accepted by the public and nonlethal strategies may be applicable in both rural and urban areas (Green et al. 1997, Dolbeer 1998, Reiter et al. 1999, DeNicola et al. 2000).

Exclusion techniques for deer such as fencing can be effective, but fences can be labor-intensive and materials can be expensive (Craven and Hygnstrom 1994, VerCauteren et al. 2006). Frightening devices are another nonlethal management option, although wildlife often habituates rapidly to auditory and visual stimuli (Bomford and O'Brien 1990, Koehler et al. 1990, Gilsdorf et al. 2003). Traditional frightening devices such as propane exploders and human effigies are usually ineffective for deer (Koehler et al. 1990, Belant et al. 1996, Gilsdorf et al. 2004*a*). Beringer et al. (2003) evaluated a motion-activated frightening device for deer with acoustic and visual stimuli that worked for about 6 weeks. Two other motion-activated devices did not deter white-tailed deer (Belant et al. 1998, Gilsdorf et al. 2004*b*) and a third was ineffective on mule deer (*O. hemionus*) and elk (*Cervus elaphus*; VerCauteren et al. 2005).

A prerequisite in the development of effective, nonlethal devices for controlling deer damage is the testing of new products and applications. An efficient, inexpensive, nonlethal method for controlling deer damage would be applicable in a variety of settings (DeNicola et al. 2000). New products or techniques should be incorporated into integrated deer management programs to maximize the effectiveness of such programs for controlling damage.

Lasers are nonlethal tools that were first used by Lustick (1973) to frighten or haze birds. Most research with lasers on vertebrates has focused on birds, with mixed results. Briot (1999) observed anecdotally that gulls (*Laridae* spp.) avoided laser beams. Glahn et al. (2000) reported red lasers were effective for dispersing double-crested cormorants (*Phalacrocorax auritus*) from night roosts. Similarly, red lasers have been used with some success for dispersing Canada geese from roosting on lakes (Cepek et al. 2001, Sherman and Barras 2004). In pen trials Blackwell et al. (2002) demonstrated strong avoidance of red laser light by Canada geese (*Branta canadensis*), initial avoidance followed by habituation by rock doves (*Columba livia*) and mallards (*Anas platyrhynchos*), and no avoidance by brown-headed cowbirds (*Molothrus ater*), European starlings (*Sturnus vulgaris*), or double-crested cormorants.

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Responses to lasers in these studies appeared to be species- and context-specific. For example, avoidance of lasers may be more pronounced and consistent in natural settings where escape is possible. Lasers appear more effective than several traditional frightening devices for reducing bird damage and are currently being used in a variety of situations. Thus giving us the idea that lasers also may have the potential to frighten deer and reduce deer damage.

VerCauteren et al. (2003) reported that red lasers (630–650 nm) were ineffective at frightening deer because they may not be able perceive the red laser light. In a subsequent literature review on the visual abilities of deer, VerCauteren and Pipas (2003) reported that the eyes of deer are characterized by 3 classes of photopigments: a short-wavelength-sensitive cone mechanism, a middle-wavelength-sensitive cone mechanism, and a short-wavelength-sensitive rod pigment. They can see colors of lower wavelengths (450–537 nm) and have a large degree of visual sensitivity in light and darkness (VerCauteren and Pipas 2003). At night and during crepuscular periods, when deer are more active and most likely to be causing damage, rods serve the primary discriminatory role in color vision. Under these light conditions, deer see color in the blue to blue-green range (Jacobs et al. 1994, Yokoyama and Radlwimmer 1998, VerCauteren and Pipas 2003), with a peak sensitivity of 497 nm (Jacobs et al. 1994). Therefore, white-tailed deer should be able to perceive green and blue laser light and lasers, generating potential for these tools to be effective frightening devices. Where effective, lasers have advantages over other frightening devices because they are not as disturbing to humans as acoustic devices (e.g., propane exploders). Thus, they have the potential to selectively target specific individuals or groups of deer. Our objective was to determine the efficacy of green and blue laser light for dispersing deer from agricultural fields and meadows at night.

Study Area and Methods

To make the current study directly comparable to previous evaluations with red lasers, we followed the methods of VerCauteren et al. (2003). The study was conducted in a 200-km^2 area encompassing DeSoto and Boyer Chute National Wildlife Refuges in eastern Nebraska and western Iowa, USA. Deer in the area were hunted during the autumn and typically avoided close association with humans. We used 114 fields planted to agricultural crops (alfalfa, soybeans, wheat) or native grasses throughout the study.

We evaluated a green laser (534 nm, 120 mW) and 2 models of blue laser (473 nm, 5 mW and 473 nm, 15 mW). All were diode-pumped solid-state lasers. The green laser (SeaTech, Lebanon Junction, Kentucky) was a prototype developed for this study. It was powered by 3 AAA batteries (4.5V DC) and emitted a beam that was 64 cm in diameter at a distance of 100 m. The 5-mW blue laser (Power Technology, Little Rock, Arkansas) and 15-mW blue lasers (Melles Griot Laser and Electronics Group, Carlsbad, California) were designed for industrial applications and required a 120-V AC input power supply that was converted to 5-V DC by a portable inverter (Rally Manufacturing, Miami, Florida). The 5-mW and 15-mW blue lasers emitted beams that were 41 cm and 13 cm, respectively, at a distance of 100 m.

Experimental Design

We tested each laser independently on 4 consecutive nights, from $\geq$30 min after sunset to $\geq$30 min before sunrise. We tested the green laser from 30 July–3 August 2002, the 5-mW blue laser from 28 July–1 August 2004, and the 15-mW blue laser from 17 August–21 August 2004. We randomly assigned each field as treatment (using laser) or control and retained this designation throughout the study. One observer drove and operated the laser while another located deer and recorded data. Time spent in the field each night was dictated by the number of deer encounters. We defined an encounter as a sighting of $\geq$1 deer lasting long enough that observers could document its reaction to a laser and the presence of the vehicle and observers or just the vehicle and observers in the case of controls. We defined a flight response as when $\geq$1 deer fled from the field in which it was initially observed and was out of the observer's sight by the conclusion of the encounter.

We initially detected deer with a 2-million-candlepower, hand-held spotlight (Koehler-Bright Star, Wilkes-Barre, Pennsylvania). We illuminated fields with this visible light and extinguished it after locating deer. We determined distance to the deer from the vehicle with a laser rangefinder (Yardage Pro, Bushnell Sports Optics Worldwide, Overland Park, Kansas). To minimize potential for the deer's eyes to adjust to the spotlight, we illuminated the area for <3 seconds and did not shine the spotlight directly at deer. Once deer were located, we used night-vision binoculars (United States Army) to observe subsequent behaviors. We used spotlights to find deer in fields because night vision did not provide adequate resolution to easily and quickly discriminate deer >70 m away, and for practical applications, spotlights provided a cost-effective means to locate deer, whereas night-vision equipment costs >$1,000.

Control encounters entailed observing deer with night-vision binoculars for 2 min. At the conclusion of the encounter, we used the spotlight to ascertain whether deer had fled from sight. If they had not, we used the laser rangefinder to determine their current distance from the vehicle. Treatment encounters were identical to control encounters with the only difference being that observers applied the laser treatment for 2 min. The lasers were first directed at vegetation close to and in front of deer and moved vigorously in a zig-zag manner. If this did not prompt a flight response within 15 seconds, we moved the laser beam in the same manner across the bodies and heads of deer.

Data recorded for each encounter included: field number, treatment (laser or control), number of deer per group, initiation and termination times of the encounter, geographic location (UTM coordinates of vehicle), distance and compass bearing from vehicle to deer at initiation and termination (if still visible) of the encounter, deer behavior during the encounter (fleeing or other [bedded, walking, feeding]), and vegetation type (alfalfa, wheat, soybeans, or grass) that deer were located in at the initiation and termination of the encounter. We recorded data on preconfigured forms and noted general weather conditions each night. We determined UTM coordinates with a hand-held global positioning system unit (GPS III, Garmin International, Olathe, Kansas). All procedures were approved by the United States Department of Agriculture/Animal and Plant Health Inspection Service/Wildlife

Table 1. Percentage of deer, by group size, that fled during laser treatment and control encounters, eastern Nebr. and western Ia., USA, 2002–2004.

Deer group size	Green laser	5-mW blue laser	15-mW blue laser
1 (Control)	0/28 = 0%	3/36 = 8.3%	0/48 = 0%
1 (Treatment)	1/49 = 2.0%	5/48 = 10.4%	0/56 = 0%
2–3 (Control)	2/49 = 4.1%	1/23 = 4.3%	2/28 = 7.1%
2–3 (Treatment)	1/37 = 2.7%	6/43 = 14.0%	0/34 = 0%
≥4 (Control)	0/17 = 0%	2/19 = 10.5%	0/10 = 0%
≥4 (Treatment)	0/9 = 0%	0/18 = 0%	0/13 = 0%
Combined (Control)	2/94 = 2.1%	6/78 = 7.7%	2/86 = 2.3%
Combined (Treatment)	2/95 = 2.1%	11/109 = 10.1%	0/103 = 0%

Services/National Wildlife Research Center's Institutional Animal Care and Use Committee.

We summarized frequency data with cross-tabulation tables. Due to ineffectiveness of lasers in eliciting flight responses, sample sizes were small, which limited correlation tests to one comparison: flight response versus treatment (SAS Institute Inc. 2003). We classed group size into 3 categories: 1, 2–3, or ≥4 deer. Group size versus flight response was examined descriptively by treatment within laser evaluation. When flight response data were adequate, we also calculated mean distance from vehicle to deer by treatment.

Results

Flight responses did not differ between any of the 3 laser treatments and their corresponding controls (Table 1). No association occurred for any of the lasers between flight response and laser treatment, Pearson correlation coefficients equaled −0.0008, 0.0355, and −0.1134 for the green, 5-mW blue, and 15-mW blue lasers, respectively. Independent of group size, deer in treatment encounters with any of the 3 lasers were no more likely to flee than those in control encounters. We observed little difference in flight response to the 3 laser treatments and their corresponding controls relative to group size (Table 1). The lack of frightening response during treatment and control encounters precluded analyses of distance from vehicle to deer for all but the 5-mW blue laser. The mean initial distance to deer that fled the 5-mW blue laser was 70.4 m (SE = 11.2, $n = 11$), no different than the 72.5 m (SE = 18.3, $n = 6$) documented during control encounters.

Discussion and Management Implications

Deer did not respond to green or blue lasers. We recorded 307 encounters with the green laser, 5-mW blue laser, and 15-mW blue laser, in which we observed 13 flight responses (4.2%). In 258 control encounters we observed 10 such responses (3.9%). The closer we were to the deer, the brighter the laser would shine on and around them, though even when <50 m away deer only fled 7% (6 of 92 encounters) of the time. It was obvious, however, that deer could perceive the light emitted from the lasers. We observed deer watching the spot of light as we directed it on vegetation nearby and on their bodies; deer appeared to be more curious than frightened. We conclude that laser light has little to no potential as a nonlethal management option for reducing deer damage.

We found no relationship between deer group size and response to laser light. LaGory (1987) noted that larger groups (≥3) of deer in forested habitat were more likely to flee than were smaller groups. LaGory also indicated that white-tailed deer were less likely to flee with increasing distance from the observer, especially beyond distances of 100 m. In our study 39% (9 of 23) of deer that fled were >100 m from the vehicle. LaGory's study differed from ours in that it was conducted during the day with no disturbances (lasers, lights, vehicles) other than the observer. We do not believe that deer in our study area were habituated to spotlighting because, in the 13 years we have been studying deer in the area, we have not seen others spotlighting and our own spotlighting activity was limited.

Lasers have been shown to be effective on birds (Glahn et al. 2000, Blackwell et al. 2002) and we demonstrated their ineffectiveness on deer, even when deer can perceive the laser light. The differential effectiveness of lasers may be due to species-specific differences in threat perception and avoidance behavior. Lasers should continue to be evaluated across taxonomic groups as potential frightening devices for species that cause human–wildlife conflicts.

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