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Evaluation of moderate and low-powered lasers for dispersing double-crested cormorants from their night roosts

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Abstract: The double-crested cormorant *(Phalacrocorax auritus)* is the primary avian predator on the southern catfish industry, estimated to cause $5 million in damage per year. To date, the most effective strategy for alleviating cormorant depredations in areas of intensive catfish production is coordinated dispersal of cormorant night roosts with pyrotechnics. Many of these night roosts are located in waterfowl refuges or wetland habitat leased for waterfowl hunting. Thus, there is an increasing concern about the effects of cormorant harassment efforts on waterfowl and other wildlife inhabiting these sites in cypress-swamp habitat. To address the need for a roost harassment device that was more species-specific, we evaluated two commercially available low- to moderate-powered lasers in a series of large-pen and field trials for their effectiveness in moving cormorants from test ponds and dispersing cormorants from their night roosts, respectively. In pen trials, laser beams directed at small groups of captive birds produced negligible effects, suggesting that the laser light was not highly aversive. This was consistent with a series of veterinary investigations suggesting no detectable ocular damage to cormorant eyes directly exposed to a selected laser at varying distances down to 1 m. During field trials both lasers, directed at roost trees after sunset, were consistently effective in dispersing cormorants in 1 to 3 evenings of harassment and is comparable to the harassment effort needed with pyrotechnics. Because laser treatment is completely silent and can be directed selectively at cormorants, these devices may be extremely useful for dispersing cormorants in sites where disturbance of other wildlife is a concern. Advantages and disadvantages of lasers relative to pyrotechnics are discussed.

Key words: catfish depredations, double-crested cormorant, low-powered lasers, moderate-powered lasers, ocular hazards, *Phalacrocorax auritus,* roost harassment

Wintering populations of double-crested cormorants *(Phalacrocorax auritus)* in the lower Mississippi Valley increased dramatically during the 1970s and 1980s (Alexander 1977-1990). Since 1990, the wintering cormorant population in this region has more than doubled from approximately 30,000 birds to >60,000 birds (Glahn et al. 2000a). This increase parallels the rapid growth of breeding populations, particularly in the Great Lakes region (Dolbeer 1991, Tyson et al. 1999, Weseloh et al. 1995). Since the early 1990s, Breeding Bird Survey data for cormorants in the Mississippi fly way indicate a mean annual increase of 22% (Sauer et al. 1997) and the number of nesting pairs in the Great Lakes Region has more than doubled from 1991 to 1997 (Tyson et al. 1999).

The corresponding growth of the catfish industry in the lower Mississippi Valley has also contributed to increased wintering populations (Glahn and Stickley 1995) and possibly has increased the over-winter survival of these birds (Glahn et al. 2000&). The economic impact of these cormorant populations on the catfish industry in Mississippi has been under continuous investigation over the past decade (Glahn and Brugger 1995, Glahn et al. 1995, Glahn et al. 2000a, Stickley et al. 1992). Recent estimates from bioenergetic projections suggest that cormorants remove approximately 48 million catfish fingerlings annually, with a replacement cost of approximately $5 million (Glahn et al. 2000a). Depredation losses by wintering cormorants do not appear to be evenly distributed (Glahn et al. 1995) but are associated with the proximity of active night roosts to catfish production areas (Mott et al. 1992). These roosts are located in cypress-swamp habitat (Aderman and Hill 1995), which are distributed throughout the catfish production areas in the delta region of Mississippi and elsewhere.

In response to cormorant depredations on the catfish industry in the delta region of Mississippi (Glahn and Brugger 1995, Glahn and Stickley 1995, Reinhold and Sloan 1999), the U.S. Department of Agriculture, Wildlife Services, in conjunction with catfish farmers, initiated a region-wide cormorant roost dispersal program during the winters of 1993-94 and 1994-95 (Mott et al. 1998). This program requires the simultaneous harassment of all known cormorant roosting sites and involves firing large numbers of pyrotechnics (Screamer-sirens and Bird bangers) during a 1 to 2- h period before sunset for 1 to 3 consecutive evenings (Mott et al. 1998). Because of the success of roost dispersal in temporarily shifting roosting cormorants away from intensely farmed areas (Glahn et al. 2000a, Mott et al. 1998), this program continues to be carried out by catfish farmers in Mississippi and Alabama.

However, concern about disturbance of other wildlife, particularly waterfowl, from repeated harassment of cormorants with pyrotechnics has restricted or curtailed this program at waterfowl refuges and other sites leased for waterfowl hunting (Mott et al. 1998). In these locations, increases in cormorant populations to extremely high levels (D. Reinhold, Wildlife Services, personal communication), have negated efforts to move cormorants out of catfish-production areas. Thus, identifying means to selectively disperse cormorants from their night roosts was important to the continued success of the current program to reduce cormorant depredations on catfish.

Although intense light has been recommended for frightening fish-eating birds (Gorenzel et al. 1994), and some preliminary assessments of lasers as bird deterrents have been made (Lustick 1973), there is very little published literature on the effectiveness of lasers as bird frightening devices (Briot 1996). In March 1999, the senior author coordinated a demonstration of the Desman© Laser (model FL R 005, Desman© S.A.R.L, France) (Use of trade names does not necessarily imply endorsement by the U. S. Government) for dispersing cormorants from roost sites in the delta region of Mississippi. This device is specifically marketed for bird dispersal and had been reportedly used to disperse cormorants from their night roosts in Europe (Soucaze-Soudat and Ferri 1997). In the March 1999 demonstration, this laser device was effectively used after sunset to disperse large numbers of roosting cormorants at 2 sites. At the second site an estimated 10,000 cormorants were dispersed from trees by 2 people moving parallel to the roost in a motorized boat and shining the laser beam at the tops of the trees. However, total evacuation of the roost sites, normally requiring repeated nights of harassment with pyrotechnics, was not assessed. Little was also known about how cormorants might habituate to this stimulus or the conditions that might influence its effectiveness. However, attempts to move loafing cormorants during the daylight hours in March 1999 were unsuccessful. Because of human-ocular safety precautions with these devices, it was unclear how laser treatments might negatively impact cormorant vision.

The objectives of this study were to: 1) examine the effects of ambient light, atmospheric conditions, and habituation on the effectiveness of 2 laser devices for repelling captive cormorants; 2) determine the efficacy of the Desman© laser and other selected laser devices in dispersing double-crested cormorants from their night roosts; and 3) examine the possible effects of the Desman© laser for negatively impacting cormorant vision.

Materials and methods

Laser devices evaluated

The Desman© laser (model FL R 005) is a red (632.8 nm) helium-neon laser that is configured to resemble a rifle. It is a class IHB laser with a power of 5 mW (moderate power) and has a beam diameter at the source of 12 mm. For comparison, we also evaluated the Dissuader® laser security device, a compact (flashlight configuration) laser illuminator that is produced as a threat deterrent device for security personnel. Its main function is to produce an intense glare or temporary flash blindness in the adversary. However, it has shown potential as an avian repellent during concurrent studies with other species (B. Blackwell, USDA- National Wildlife Research Center, unpublished data). This device also produces a red (650 nm) beam but is a diode laser. It is categorized as a class II laser (low power) with 68 mW of power and a beam diameter of 76 mm at the source. There was little technical similarity in these devices, but the most conspicuous difference was in beam intensity and beam diameter. The Desman© laser appeared to produce a more intense beam that measured only 2.5 cm at 183 m (200 yards). The Dissuader® produced a less intense beam that measured 58 cm at 183 m (200 yards).

Captive cormorant trials

In December 1999, 2 groups of 5 wild-trapped cormorants each were assigned to either a 0.1- ha or a 0.2-ha enclosed area in a large 0.4-ha flight pen. Each area contained a 0.04-ha pond stocked with catfish fingerlings to serve as a food supply. Each pond was also equipped with a servicing pier where cormorants loafed. After a week of acclimation in the flight cage, we conducted 7 days of trials with the Desman© laser followed by 5 days of trials with the Dissuader® laser. With the Desman© laser, we started each daily trial 2 h before sunset and continued the trial 20 minutes after sunset. With the Dissuader® laser we started each daily trial at sunset and continued the trial to 40 minutes after sunset. We recorded the ambient light and atmospheric conditions (cloud cover, precipitation etc.) at 20-minute intervals. We then pointed the laser beam sequentially at each individual for 5 to 30 seconds in both test groups from a 4-m high enclosed tower, approximately 10 to 15 m away. Each time we focused the laser on an individual bird we recorded the length of time the laser was on to get a response, and the response, if any, of a focal animal and remaining birds. Responses of focal birds and flocks were categorized as flying, rapid swimming, slow swimming, diving, walking and no response. No response was defined as the lack of movement or movement of less than 5 m in any direction.

Cormorant field trials

From January through March 2000, we conducted 6 field trials with the Desman© laser and 5 field trials with the Dissuader® laser at cormorant roosts in the delta region of Mississippi and western Alabama (Table 1). Roost sites with at least 1,000 birds were selected by USDA-Wildlife Services personnel in these areas. Similar to pyrotechnic harassment (Mott et al. 1998), laser harassment of these roosts were conducted for up to 3 consecutive evenings. Starting 2 hours before sunset of the first evening we counted and recorded all cormorants entering the roost site. Just before sunset we entered the roost by foot or by boat until we had an unobstructed view of birds in trees at a distance of 100 to 1000 m. Between sunset and up to 1 h after sunset, we moved the laser beam across the tree-tops where the cormorants were located, moving our position as needed to cover the entire roosting area. We assessed the effectiveness of the treatment immediately after treatment by attempting to count the birds still remaining in the roost after dark. To obtain a better assessment of the treatment, we returned to the roost both the following morning and evening and counted birds leaving and entering the roost, respectively, using procedures described by Glahn et al. (1996). We continued laser harassment for up to 2 more consecutive nights when subsequent evening counts exceeded 10% of pretreatment levels.

Ocular hazard assessment

The assessment of ocular hazards to cormorants involved the Desman©laser only because its higher hazard class rating (IIIB) presented a higher potential for eye injury. Five individually-identified captive cormorants, not previously exposed to lasers, were used for these assessments. Prior to laser exposure, pre-existing ocular conditions of all cormorants were assessed through examination by a veterinary ophthalmologist and electroretinagram (ERG). The ERG records electrical potentials of the retina and is used to test for impairment of retinal function that may not be apparent from visual examination (Dceda 1993, Rojas et al. 1999). The ERG required that cormorants be anaesthetized using Telazol® injected intramuscularly with a dosage that varied from 2.8 mg/kg to 20 mg/kg. Variation in Telazol® dosage was dictated by the narrow tolerance range of cormorants to this sedative. The dosage recommended for similar-sized waterfowl (20 mg/kg, Schobert 1987)) caused mortality from respiratory failure, while doses ranging from 2.5 to 5 mg/kg produced either very light sedation or excessively heavy sedation, sometimes requiring a respiratory stimulant for recovery.

Table 1. Trial site code (TRIAL SITE), dated started (DATE), cormorants counted before treatment (DCCO COUNTED), number of days harassed (DAYS HARASSED) and (MINUTED HARASSED) of laser treatments, and percent reduction of cormorant populations immediately after harassment with the Desman® (Model FL R 005) laser (DESMAN) and the Dissuader® laser (DISSUADER) at double-crested cormorant roosts in the delta region of Mississippi and western Alabama during January through March 2000.

Desman						Dissuader					
Trial site	Date	DCCO counted	Days harassed	Minutes harassed	Percent reduction	Trial site	Date	DCCO counted	Days harassed	Minutes harassed	Percent reduction
ML	1/4/00	10,000	1	16	100	TC	1/18/00	19,500	2	81	99
MB	1/10/00	6,500	1	55	100	EL	1/25/00	2,500	1	22	100
HS	2/1/00	3,700	3	131	98	LC	2/22/00	4,300	2	62	97
LW	2/16/00	34,000	2	80	100	HS	3/9/00	4,500	2	36	94
CW	2/23/00	3,100	3	113	94	CW	3/28/00	3,500	2	30	100
TC	2/29/00	5,400	3	44	100	--	-	--	--	-	—

On the same evening (after sunset) following pre-treatment examinations, 3 cormorants were hand-held and their eyes directly exposed to the Desman© laser beam at distances of 1 in, 13 m, and 33 m, respectively. Exposure distances were chosen based on the nominal ocular risk distance (NORD) for Desman© laser to humans at 12.73 m assuming a palpebral (blink) reflex of 0.25 sec (Soucaze-Soudat and Ferri 1997). Because photochemical lesions may not appear for 24 to 48 h after laser exposure (OSHA 1991), 2 post-treatment ophthalmic exams were performed at 24-h intervals, followed by a post-treatment ERG, 72 h after exposure. Following post-treatment ERG's, all cormorants were euthanized with carbon dioxide. A histological examination was then performed by a veterinary pathologist on tissue sections from both eyes of treated and control cormorants. To reduce bias in these examinations, veterinarians were not informed of specific treatments applied to these birds.

All animal care and use for this study (QA-730) was approved by the Institutional Animal Care and Use Committee of the National Wildlife Research Center.

Results

Despite completing 228 captive focal-bird trials with the Desman© laser at recommended light levels below 1200 lux, only 7 focal-animal responses were recorded sporadically over time. At similar light levels after sunset, only one focal-bird response was noted with the Dissuader® laser after 105 trials. The lack of consistent response of cormorants to either laser precluded any assessment of factors contributing to their effectiveness or habituation to these devices.

During field trials, both lasers were consistently effective in reducing cormorant populations by at least 90% after 1 to 3 evenings of harassment (Table 1). There was no difference (t = 0.818, P = 0.440) between the type of lasers used with respect to the number of days of harassment needed to achieve this reduction (Table 1). Actual minutes of harassment needed varied considerably (Table 1), but did not differ {t = 1.293, P = 0.232) between lasers. In most (73%) trials, we estimated that all birds had left the roost during the first evening of harassment, but in all cases a varying percentage (up to 59%) of the roosting population was counted in the roost the following morning. Despite both lasers being used in separate trials about 1 month apart at each of 3 roost sites (Table 1), there was no conspicuous habituation to the laser beams. Although in some cases significant numbers (> 1,000) of cormorants were observed to return to laser harassed roost sites within 1 week after harassment, in other cases cormorants were never observed to return to harassed roosts during 9 weeks of post-treatment monitoring with aerial surveys (G. Ellis, unpublished data).

Pretreatment ophthalmic exams revealed some minor pre-existing conditions in 2 of the 3 birds subsequently exposed to laser treatments, but identical examinations 24-h and 48-h post-treatment revealed no ocular changes in these birds following laser exposure (Table 2). Similarly, comparison of pretreatment baseline ERG's with those 72 h after laser exposure showed no change in retinal function (Table 2). Two of the 5 captive cormorants that died from handling stress and respiratory depression following injection of Telazol® at 20 mg/kg were used as an untreated control group for histopathology studies. This study revealed no retinal degeneration or necrosis. Detached retinas, congested chorids and subscapular globules in the lens were equally distributed between treated and control birds and appeared to be post-mortem artifacts (Table 3). Unique to the bird exposed to the laser at 1 m was the presence of mild mononuclear cell infiltrates (MONO CELLS) in the iris (Table 3). However, based on the pathology report these cells were indicative of a chronic or pre-existing condition not related to laser treatments.

Discussion

The lack of predictable overt response to laser light in captive trials is not clearly understood, but suggests that the laser light used in this study is not a highly aversive agent. However, sensitivity to fright-producing stimuli may be altered by confinement. Although optimal light conditions for laser effectiveness could not be ascertained, previous trials in March 1999 suggested the need for low-light levels to disperse cormorants. This is consistent with laser trials on birds in Europe (Briot 1996) and manufacturer's recommendations to use the Desman© laser at light levels below 1200 lux (typically near sunrise and sunset). Under these light conditions, cormorants in the field utilized group avoidance behavior to laser light that presented a novel, highly visible stimuli approaching them. Because groups of cormorants moved as the laser light approached them, relatively few birds were contacted with the laser light. In fact, movement of the laser light through the tree branches appeared more likely to elicit avoidance than focusing the light on individual cormorants.

Although in most cases during field trials it appeared that the entire roost was evacuated during the first evening of laser harassment, consistently higher counts of birds leaving the roost the following morning suggested that birds returned to the roost later that night. However, on 3 occasions during the evening following the first laser harassment, all roosting cormorants left the site before sunset before any further laser harassment was deployed. Consistent with previous cormorant dispersal studies using pyrotechnics (Hess 1994, Mott et al. 1992, Mott et al. 1998, Glahn, In press), cormorants were effectively dispersed after 1 to 3 evenings of laser harassment, but returned within 1 week. Thus, laser harassment appeared equally effective as pyrotechnics for cormorant roost dispersal. Both commercially available laser devices also appeared to be equally effective as a cormorant roost dispersal tool, despite the Dissuader® laser not being designed for this purpose.

Because laser treatments are completely silent and can be directed only at cormorants, they have advantages over pyrotechnic treatments where disturbance of other wildlife is a concern. Another logistic advantage of laser devices to dispersal operations may be their long effective range. We dispersed cormorants from up to 1000 m away, and the manufacturer reports the effective range of the Desman© laser to be 2.5 km. However, the effective range of these devices is largely determined by the amount of obstructions such as trees between the birds and the device. The only disadvantage of lasers for cormorant roost dispersal is their cost. The Desman© laser is distributed in the United States by Reed -Joseph International, Greenville, MS at a cost of $7,500.

Table 2. Results of pretreatment and two blind post-treatment ocular examinations and observed changes in eletroretinagrams (ERG) of 3 double-crested cormorants before and after direct exposure to the Desman® laser at varying distances, March 2000.

Bird #/eye	Exposure distance	Ocular examination (pretreatment)	Ocular examination (24 h post-treatment)	Ocular examination (48 h post-treatment)	ERG changes (72 h post-treatment)
3/Right	33 m	Normal	Normal	Normal	No change
3/Left	33 m	Normal	Normal	Normal	No change
4/Right	13m	Cataract	No change	Normal	No change
4/Left	13m	Normal	Normal	Normal	No change
5/Right	1 m	Corneal ulcer	Mild scarring	Normal	No change
5/Left	1 m	Corneal ulcer	Mild scarring	Normal	No change

Table 3. Summary of blind histopathology findings for double-crested cormorants (DCCO) either untreated (CONTROL) or having direct eye exposure to the Desman® laser at varying exposure distances. One slide of selected eye tissues was prepared for each eye of the DCCO, NSL = no significant lesions, Mono cells = mononuclear cell infiltrates that were from pre-existing chronic conditions.

DCCO #/slide	Exposure distance (m)	Cornea	Iris	Choroid	Sclera	Retina	Lens
1/1	Control	Central ulcer	NSL	Congested	NSL	Detached	Epithelium detached
1/2	Control	NSL	NSL	Congested	NSL	Detached	Missing
2/1	Control	NSL	NSL	Congested	NSL	Detached	Subscapular globules
2/2	Control	Central ulcer	NSL	Congested	NSL	Detached	Subscapular globules
3/1	33	NSL	NSL	Congested	NSL	Detached	Subscapular globules
3/2	33	NSL	NSL	Congested	NSL	Detached	Mostly missing
4/1	13	NSL	NSL	Congested	NSL	Detached	Subscapular globules
4/2	13	NSL	NSL	Congested	NSL	Detached	Subscapular globules
5/1	1	Missing	Mono cells	Congested	NSL	Detached	Subscapular globules
5/2	1	NSL	Mono cells	Congested	NSL	Detached	NSL

The Laser Dissuader® is manufactured and distributed by SEA Technologies, Albuquerque, NM at a cost of $5,600. Although the cost of using pyrotechnics to disperse cormorant roosts can be highly variable, Glahn (in press) reported the average cost of pyrotechnics for dispersing a cormorant roost to be approximately $150. Thus, laser devices would probably pay for themselves after 40 to 50 successful dispersals.

The potential hazards of these lasers, particularly ocular, for humans is defined by their hazard classification of II and IIIB (OSHA 1991), by the manufacturer of the Desman© laser (Soudat-Soucaze and Ferri 1997) and by independent testing of the Laser Dissuader® (Dennis et al. 1999). From review of these documents by other researchers, ocular hazards appear to result only from intentional staring at the laser light close to the diffuser, but the probability of injury increases with proximity to the diffuser and is greater for a class IIIB laser than a class H (B. Blackwell, USDA- National Wildlife Research Center, personal communication). Thus, as a general safety precaution the Desman© manufacturer recommends that the laser not be pointed at people within the nominal ocular hazard distance (NORD) of 13 m (Soudat-Soucaze and Ferri 1997).

Although potential ocular hazards from lasers are well defined for humans, little is known about the hazards of these devices to cormorants. Early experiments on the effects of lasers on birds showed that some birds were less sensitive to laser light than others given species-specific physiological mechanisms to defuse intense light (Lustick 1973). Thus, human standards of laser hazards may not necessarily apply to birds. This might explain why we were unable to detect any evidence of ocular damage to cormorants exposed to the more intense Desman© laser at distances down to 1 m. Although our sample size is small (n = 3), because all exposure distances were less than those expected during field use of this laser, we conclude that use of this device is unlikely to cause measurable damage to the eyes of double-crested cormorants. This conclusion is consistent with the lack of aberrant behavior observed with cormorants exposed to laser treatments in both captive and field trials. If there are effects to cormorant eyes, it is more likely temporary "flash blindness" that forms the functional use of the Laser Dissuader®. This effect is comparable to the human response to photographic strobe lights, but causes no measurable damage. However, due to group avoidance behavior of cormorants to approaching lasers, very few birds would likely experience this effect.

Management implications

Two commercially available low- to moderately-powered lasers appeared consistently effective for dispersing double-crested cormorants from their night roosts and did not present detectable ocular hazards to these birds. However, these laser devices do present some minimal human safety concerns, and precautions for safe use should be followed. Although laser treatments appeared equally effective as pyrotechnics, because of their present costs, they are not likely to replace pyrotechnics as roost dispersal tools. Because they are silent and can be selectively directed only at cormorants, laser devices can be effectively used as a non-lethal, species-specific dispersal tool, where disturbance of people and other wildlife is a concern. Another advantage of these devices is their effective range that would increase the efficiency of cormorant dispersal operations. Like other frightening devices, cormorants may eventually habituate to these laser devices after repeated use. However, we found no evidence of habituation to these devices after repeated harassment of the same roost sites during our field trials.

Although their mode of action is not clear, lasers were not highly aversive in captive trials, but in field trials appeared to present a novel avoidance-provoking stimulus that might be reinforced with temporary flash blindness. Low- to moderately-powered lasers might have utility for dispersing birds in other situations, but the presumed low-light requirement for effectiveness may limit their utility to night roosting or crepuscular damage situations.

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