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TECHNICAL NOTE

Digital Versus Film-Based Remote Camera Systems in the Florida Keys

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Abstract
Remote-triggered cameras are an important tool in wildlife research and the increasing availability of digital camera technology can potentially provide researchers with additional options and benefits. We compared the performance and cost of a remote digital camera system (passive infrared) with 2 well-established remote film-based camera systems (1 passive, 1 active) in the Lower Florida Keys. During the approximately month-long study, we found that the digital system provided similar performance and potentially decreased cost compared to the film-based systems when monitoring the endangered Florida Key deer (*Odocoileus virginianus clavium*). Considering the benefits of passive digital camera systems (e.g., large photograph storage capacity, less equipment, easy photograph manipulation), comparable performance by the digital system to film-based systems provides motivation to consider this new and evolving technology in future wildlife research.

Introduction

Remote camera systems have provided wildlife researchers with the ability to monitor wildlife in a variety of settings and have been used to estimate wildlife abundance [1,2,3], research activity patterns [4,5], study nest ecology [6], monitor aquatic or variably wet environments [7], and research wildlife behaviors [8,4]. Despite its widespread acceptance, this technology has several important drawbacks, including expensive equipment, limited operation time due to battery life, disturbance of study animals during required equipment maintenance, and significant time and effort investments to retrieve and review data [9]. Recent developments in digital camera technology have introduced equipment that has unique design and operational characteristics that can potentially address some of these shortcomings.

Traditional remote camera systems have used infrared or motion-sensitive technology coupled with film cameras. Advances in digital camera technology (e.g., improved shutter speed, increased photographic resolution, and increased memory capacity) and declining prices for equipment have provided researchers with an increasing array of options for conducting camera studies [10,11]. This increase in choice has occurred quickly providing little time for researchers to study the benefits and drawbacks of the newest types of equipment.

Researchers have evaluated the performance of different types of non-digital remote camera equipment [12,13], infrared digital cameras [14], web-based digital cameras [9], digital video recorders [15], and various digital camera systems adapted by researchers for wildlife applications [11] but to our knowledge no one has evaluated the effectiveness and cost of new, affordable, and readily available remote digital camera equipment as compared to film-based alternatives.

Wildlife studies have traditionally used 2 types of remote camera systems: 1) active infrared and 2) passive infrared. Swann et al. [13] described active systems as those

that operate in the near infrared band (800 nm - 1000 nm) and send a beam to a separate receiver that acts as a sort of invisible string. When the beam is broken by a passing animal, a signal is sent to the camera to take a picture. Passive systems operate in the thermal infrared band (3000 nm - 10,000 nm) and detect changes in heat energy caused by moving animals [13]. The Cuddeback and TrailMaster passive systems lack a separate infrared emitter; an important consideration when traveling to remote areas, carrying and replacing batteries, and conducting maintenance.
The specific objective of our research was to compare the performance and costs of a new passive remote digital camera system to 2 commonly used and trusted film-based remote camera systems under realistic field conditions. We compared the 1) TrailMaster 1500 Active Infrared Trail Monitor (ITC, TrailMaster, Goodson and Associates, Inc., Lenexa, Kansas, USA), 2) TrailMaster 500 Passive Infrared Trail Monitor (ITC, TrailMaster, Goodson and Associates, Inc., Lenexa, Kansas, USA), and 3) Cuddeback Passive Infrared Digital Scouting Camera (Non Typical, Inc., Park Falls, Wisconsin, USA).

Study area

The Florida Keys are a chain of islands stretching 200 km southwest from the southern coast of Florida. The Upper Keys extend from Key Largo in the north to West Summerland in the south and the Lower Keys range from Big Pine Key to Key West. Big Pine Key (2,522 ha) is the largest island in the Lower Florida Keys [16] and served as the location of our research. This location was desirable because approximately 65% of the entire population of the Florida Key deer (*Odocoileus virginianus clavium*) occurred on just Big Pine Key [17]. The Florida Key deer was an ideal research subject because, although federally endangered, the Key deer is locally abundant on Big Pine Key and inured to human presence. We conducted this research at the northern Key deer box underpass (14 m x 3 m x 3 m) located under United States Highway 1 (US 1) on Big Pine Key, FL (Fig. 1). Previous wildlife research conducted at the site demonstrated high deer use (one of only 2 underpasses that funneled deer under US 1) and good suitability for camera comparisons (e.g. uniform concrete background, no vegetative interference; [18].

Methods

Camera System Setup

We positioned all 3 camera systems in the center of the underpass with the cameras facing the same direction (perpendicular to underpass entrances). We positioned the camera systems adjacent to one another (approximately 30 cm apart) from right to left, TrailMaster 1500, TrailMaster 500, and Cuddeback Digital Trail Monitor respectively. Camera systems could not be unintentionally activated by normal operation of adjacent cameras (i.e., flash activation, tripping of infrared beam; personal observations). We set all systems to manufacturer recommended settings for deer, deer-sized animals, or general settings appropriate for these species (described in detail below). All systems recorded the date and time of camera activation on the associated photograph. We set all camera stations to take pictures throughout the day (0001 - 2400 hours) with a camera delay of 2 minutes between photographs.

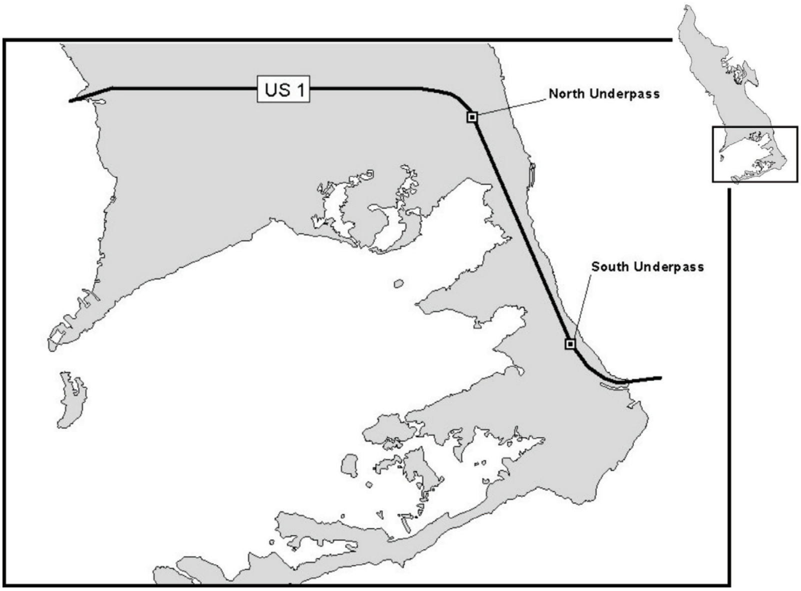

Fig. 1. Florida Key deer underpasses on United States Highway 1 (US 1), Big Pine Key, Florida, 2005.

TrailMaster 1500 Active Infrared Trail Monitor

We placed TrailMaster 1500 Active Infrared Trail Monitors (TM1500; ITC, TrailMaster, Goodson and Associates, Inc., Lenexa, Kansas, USA) in the center of the underpass to monitor movements of Florida Key deer. We set camera stations to take pictures throughout the day (0001 - 2400 hours) with a camera delay of 2 minutes. We set sensitivity to the default level (5 on a 1 - 30 scale with 30 the least sensitive). For security purposes we locked the entire system into 2 locked 0.30 caliber metal ammunition cans (no cost) with holes cut for the camera and the infrared beam. We attached these cans via welded rebar to cinderblock substrates cemented into the ground on either side of the underpass (north = camera and receiver, south = infrared emitter). The camera and infrared beam were approximately 60 - 75 cm from above the ground. The system required 8 C batteries and 2 AA batteries.

TrailMaster 500 Passive Infrared Trail Monitor

We placed a TrailMaster 500 Passive Infrared Trail Monitor (TM 500; ITC, TrailMaster, Goodson and Associates, Inc., Lenexa, Kansas, USA) in the center of the northern part of the underpass 30 cm to the left of the TrailMaster 1500. We set the sensor at the recommended height (chest height of study animals, ≈ 50 - 62.5 cm for Key deer) and we used the default sensitivity settings (1 on a 1 - 5 scale with 5 the least sensitive). The system was set to take pictures throughout the day (0100 - 2400 hours) with a camera delay of 2 minutes. For security purposes, we placed the sensor and camera units into a locked 0.30 caliber metal ammunition can (camera directly above the sensor; no cost for cans) with specially cut holes for the sensor and camera lens. We mounted these on a 1-m tall piece of 10 cm x 10 cm pressure treated lumber set into a 136 kg block of cement. The system required 4 C batteries and 2 AA batteries.

Cuddeback Passive Infrared Digital Trail Monitor

We placed a Cuddeback Passive Infrared Digital Scouting Camera (CB; Non Typical, Inc., Park Falls, Wisconsin, USA) approximately 30 cm to the right of the TrailMaster 1500 trail monitor. The 2005 version of the Cuddeback had an integrated 3.0 megapixel digital camera creating images of approximately 0.5 megabytes (MB) each. We used a 512 MB memory card with a capacity of >1000 photographs. We set the camera on high sensitivity and housed the unit in a locked metal "bear box" provided separately by the manufacturer (≈$35.00). We mounted this box at a height of 1.2 m (within manufacturer's height recommendation) on a 10 cm x 10 cm pressure-treated piece of lumber set into a 136 kg block of cement. The Cuddeback required 4 D batteries.

Camera Comparison

We operated all camera systems simultaneously for a total of 33 days (Underpass, 7 November - 9 December 2005). During initial setup we recorded date, roll number, and camera ID. We wrote this information on 22 cm x 28 cm sheets and test-fired each system by exposing the appropriate data sheet. We visited the cameras every other day for the duration of the study. We used Winn Dixie brand 200-speed 24-exposure color film (Winn Dixie Stores Inc., Jacksonville, FL, USA) for both TrailMaster cameras. During each visit we checked the film cameras for film use and availability, updated the data sheets with check-date and new roll number if necessary, and replaced film if ≥17 photographs had been taken to ensure constant film availability. We test fired all camera systems with updated data sheets to ensure continued proper function. All exposed film was developed by Wal-Mart (Wal-Mart Stores, Inc., Bentonville, AR, USA). We compared cost of operation, photograph number, and quality of photographs among the camera systems.

Data Analysis

We used logistic regression to compare the number of deer images [good pictures] and the number of photos with no subjects [misfires] between camera systems in the underpass [19,20]. Then we compared the number of unidentifiable photographs between systems (i.e., deer with identifying characteristics for sex and age cut out of the photograph) again using logistic regression. Finally, we compared the costs for purchase and operation of each camera system.

Results

Photographs

Over the course of 33 days we collected 533 photographs. The type of camera system had a significant impact on the presence of misfires (TM 1500 = 136 good pictures:87 misfires, TM 500 = 113 good pictures:24 misfires, CB = 145 good pictures:28 misfires [Likelihood Ratio = 33.146, df = 2, $P < 0.001$; Pearson $X^2 = 33.346$, df = 2, $P < 0.001$]). The obvious difference between systems was the 87 misfires of the TM 1500. The type of camera system had no significant impact on the presence of unidentifiable pictures of deer (Likelihood Ratio = 0.877, df = 2, $P = 0.645$; Pearson $X^2 = 0.876$, df = 2, *P* = 0.645). Each system had a low percentage of unidentifiable deer photographs (TM 1500 = 14 unidentifiable deer [10.3%], TM 500 = 10 unidentifiable deer [8.8%], CB = 18 unidentifiable deer [12.4%]).

Table 1. Deer image-capture effectiveness for each camera system (TrailMaster 1500 = TM 1500, TrailMaster 500 = TM 500, Cuddeback = CB), Big Pine Key, Florida, 2005.

	Good Pictures	Misfires	Unidentifiable Deer (% of Good Pictures)
TM 1500	136	87	14 (10.3%)
TM 500	113	24	10 (8.8%)
CB	145	28	18 (12.4%)

Costs

System purchase costs were reasonably similar; however, due to the lack of film purchase and development costs, the Cuddeback system cost of operation ($0) over the course of the study was less than the TM 1500 ($98.34) and TM 500 ($98.34, Table 1). The lack of Cuddeback operational costs was due to the short study time and the subsequent grouping of battery costs into a startup costs category. The Cuddeback system requires electronic viewing and storage media which greatly increases potential startup costs if such equipment must be purchased (e.g., computer, handheld digital camera). Due to the short timeframe for this study, battery life and costs could not be evaluated beyond initial purchase costs. As such, costs for batteries were grouped into startup costs for each camera system (TM 1500 = $566.33, TM 500 = $488.54, CB = $485.79; Table 1). We chose to omit the estimated costs associated with ammunition cans due to the higher likelihood of researchers purchasing the readily available Cuddeback security box versus purchasing ammunition cans or other security devices for TrailMasters. Also due to short study length, we limited operational costs to expenditures during the month-long study.

Table 2. Costs of each camera system (TrailMaster 1500 = TM 1500, TrailMaster 500 = TM 500, Cuddeback = CB), Big Pine Key, Florida, 2005.

	Startup Costs ($US)					Operational Costs ($US)			
	System Cost*	Batteries	Memory Card	Other‡	Total	Film	Film Develop	Total	Grand Total†
TM 1500	550	16.33	-	100.00	666.33	59.07	39.27	98.34	$764.67
TM 500	470	13.54	-	100.00	483.54	53.70	35.70	89.40	$573.08
CB	399	6.79	43.00	137.00	585.79	-	-	-	$585.08

*Based on 2007 estimates.
‡Cost of concrete, wood, and camera system containers.
†Startup costs + operational costs.

Discussion

The Cuddeback digital camera system demonstrated similar performance to the established TrailMaster systems. More importantly, our study demonstrated the potential for remote digital cameras in wildlife research. Comparable performance between digital and film systems gives researchers more options for conducting research. Passive digital systems have less equipment and weight, fewer batteries to carry and change, easier photograph movement and storage, and lower operational costs than the other systems tested. Additionally, digital systems have the potential to store hundreds of pictures without exhausting storage or battery life. This decreases the need to visit field equipment, thereby lowering disturbance and visitation costs (e.g., man-hours, fuel costs). Though we did not quantify the costs associated with checking camera systems (e.g. man-hours, fuel costs), the digital system required only occasional checking due to high digital photograph storage capability. The film-based systems required relatively frequent checking to ensure that film had not been exhausted. Finally, with the increased clarity of digital technology, images are easily analyzed and identified.

However, this study is far from comprehensive. The consistent durability and output of film-based systems has been repeatedly demonstrated elsewhere [2,13]; but, due to the short duration of our study, direct analyses of durability and battery life of the digital system could not be tested. Other studies using Cuddeback Digital Scouting Cameras (1.5 MB and 3.0 MB models) found consistently high battery life (>2 months) and durability [21]. Despite these positives, digital camera systems have higher potential startup costs related to computer and download equipment. They also have yet to undergo the years of testing related to film camera technology, especially in the harsh conditions found in some study areas. Additionally, results of remote camera research are critically linked to operation skill and experience [13]. Our findings and those of all research involving remote camera systems can be greatly impacted by these considerations. While we attempted to reduce the impact of the researchers in our study by placing the camera systems in a relatively controlled environment, these considerations cannot be completely eliminated and further studies are needed.

Digital remote camera systems are appropriate for use in a variety of settings, especially research conducted in remote areas that are difficult to access, studies that expect a great deal of wildlife traffic, or studies with limited budgets for film purchase and development. While further research is suggested, we believe that digital remote systems expand on the capabilities of traditional film-based systems and will progress further as technology improves.

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