From the Field: A web-based digital camera for monitoring remote wildlife

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Abstract Passive and active infrared camera systems and, more recently, videography have been used in wildlife research to assist in data collection. Traditional camera systems can be expensive and labor-intensive, and are limited in operation time by film length and battery life. Current camera systems are neither computer- nor network-oriented and do not allow for near real-time retrieval and storage of data. We describe a web-based, digital camera system for monitoring wildlife in remote, inaccessible environments. Between February 2002 and December 2003, our web-based camera system collected 486 digital photographs of west Texas wildlife. The key advantage of our camera system is that it allows for unobtrusive monitoring of secretive and often unobservable species in their natural habitat. Because our system is web-based, high-resolution photographs of wildlife can be posted on a web page for viewing, offering a unique teaching tool for grade school and university students who may not have the opportunity to visit these remote, inaccessible areas. Although our camera system was expensive ($12,000 U.S.), it offers a self-sustaining technique for monitoring wildlife in remote regions that allows for easy data retrieval and storage.

Key words camera, remote, self-sustaining, web-based

Infrared-triggered and motion-detecting cameras have been widely used to monitor wildlife (Yasuda and Kawakami 2002), and, more recently, videography has become common (Alexy et al. 2001, King et al. 2001, Yasuda and Kawakami 2002). Remote-triggered photography and video permit researchers to monitor wildlife occurrence (Ng et al. 2004), estimate abundance (Jacobson et al. 1997, Koerth and Kroll 2000), study activity and behavior (Alexy et al. 2001, Main and Richardson 2002), identify nest predators (Hernandez et al. 1997*a*,*b*), and monitor aquatic environments (Lopez and Silvy 1999). Although these methods are widely used, they require expensive equipment (e.g., TrailMaster [Goodson & Associates, Inc., Lenexa, Kans.] or CamTrakker [Camtrakker, Watkinsville, Ga.] cameras, film, and batteries), are limited in operation time by battery life or film and tape length, and require significant time and effort to retrieve and review results (Yasuda and Kawakami 2002). Because of the last 2 deficiencies, considerable human disturbance may be required, resulting in avoidance of camera stations by wary wildlife primarily due to increased human activity rather than the camera station itself (Sequin et al. 2003). Yasuda and Kawakami (2002) also expressed concern that none of the current methods were computer- or network-oriented and did not allow for near real-time observation and easy data retrieval and storage. Traditional camera monitoring techniques for wildlife are neither effi-

cient nor practical in remote, inaccessible environments. Therefore, we designed a web-based wildlife monitoring system that is self-sustaining in remote locations, operates in near real-time, and is web-based for easy data retrieval and storage. Our objectives were to describe a web-based, digital camera system for monitoring wildlife in remote environments. We present the results of a field evaluation of our monitoring system, evaluate the performance of the system, and discuss its advantages and disadvantages.

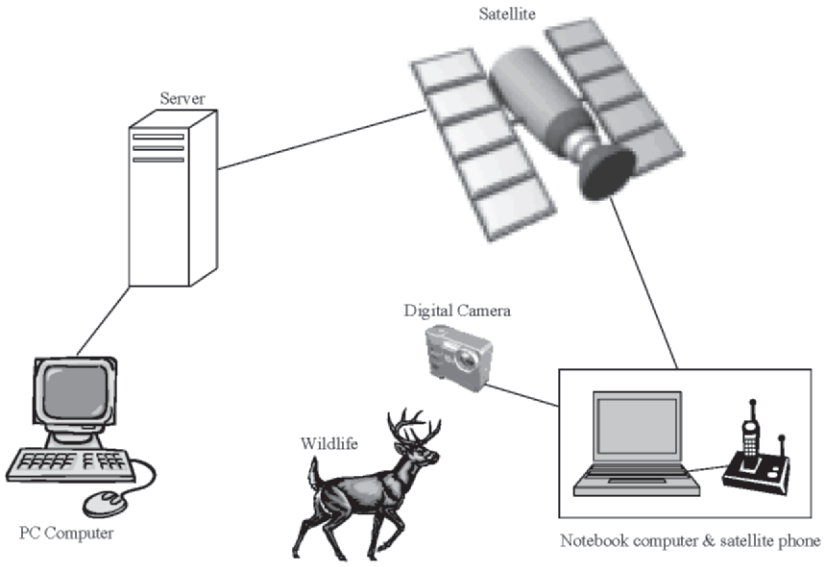

Figure 1. Scheme of web-based camera system. System consists of an infrared-triggered digital camera, notebook computer, satellite phone, server, and PC computer.

Study area

We conducted the field evaluation of the web-based digital camera monitoring system within the Chihuahuan Desert at Elephant Mountain Wildlife Management Area (EMWMA), located approximately 42 km south of Alpine, Texas on State Highway 118 in Brewster County. The management area was approximately 9,330 ha and ranged in elevation between 1,256–1,898 m above sea level. Elephant Mountain is of igneous origin and contains rugged, often inaccessible, mountainous terrain. Mean annual rainfall at the management area was 36.3 cm, with peak rainfall occurring between June and September. Numerous permanent water sources were distributed around the management area in natural and man-made forms such as metal storage tanks, earthen dams, slick rock and conventional guzzlers, and natural springs. Temperatures at the management area ranged from –1.7ºC (average daily minimum) in January to 32.2ºC (average daily maximum) in June (Brewer 2001).

Common fauna present at EMWMA included desert bighorn sheep (*Ovis canadensis*) desert mule deer (*Odocoileus hemionus crooki*), collared peccary (*Pecari tajacu*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), ringtail (*Bassariscus astutus*), mountain lion (*Puma concolor*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*; Locke 2003). Flora present at EMWMA was consistent with Chihuahuan Desert vegetation (Powell 1998).

Methods

We established our web-camera system near a permanent watering hole on Elephant Mountain WMA. The web-camera system (Figure 1) consisted of a Kodak DC260 digital zoom camera (Eastman Kodak Company, Rochester, NY), enclosed in an outdoor security case for protection against the weather (i.e., rain, sun, dust). The camera was activated via motion and heat of wildlife visiting the water hole, and "scheduled shots" were taken twice daily (1200 and 1600 hours) to ensure the system was working properly. Thumbnail pictures, initially stored in the digital camera, were downloaded to a Dell Inspiron 5150 notebook computer (1.00 GHz Pentium 3 Processor, 20 GB of memory; Dell Inc., Round Rock, Tex.) stored in a weather-proof metal container at the site. Twice a day the notebook computer turned on a GlobalStar satellite phone (GlobalStar, Milpitas, Calif.), also stored in the metal container, which downloaded the thumbnail pictures to a server in Dallas, Texas. Thumbnail pictures were stamped with a unique identification number consisting of the date and time, and reviewed for wildlife. High-resolution photos of wildlife or other interesting pictures were requested for further evaluation via the server based on the unique identification number. High-resolution pictures were then posted on the Texas Bighorn Society's webpage (http://texasbighornsociety.org/index.htm) for public viewing.

We mounted a weather station at the camera site and recorded temperature, rainfall, barometric pressure, relative humidity, and wind speed and direction twice a day. These data were downloaded to the server in a manner similar to that used for the digital photographs. The entire camera and weather station system were self-sufficient, running on 2 deep-cycle 12V marine batteries. The batteries were continually recharged via a solar panel.

Results and discussion

Between February 2002 and December 2003, the web-based camera collected 486 digital photographs of west Texas wildlife (Figure 2). We documented photographs of desert bighorn sheep, desert mule deer, collared peccary, gray fox, coyote, mountain lion, roadrunner (*Geococcyx californianus*), and scaled quail (*Callipepla squamata*). The camera collected 205 "scheduled shots" which ensured the system was working properly without human intrusion. Approximately 79 photographs contained no animals or were completely black, with no photograph denoting a malfunction of some type (e.g., camera misfire, computer glitch, download malfunction). Pictures with no animals probably were caused by grass or shrub movement due to wind, indicating the high sensitivity of the system, although it was possible that animals present may not been detected in the photograph (e.g., camouflaged, small, moved outside of frame prior to photo).

The key advantage of our system was that it allowed us to unobtrusively monitor wildlife at a remote, inaccessible site. Data from the site were collected in near real-time, and our system allowed for easy retrieval and storage of data. Yasuda and Kawakami (2002) acknowledged power supply as the biggest obstacle for field applications and suggested using a generator or high-capacity battery.

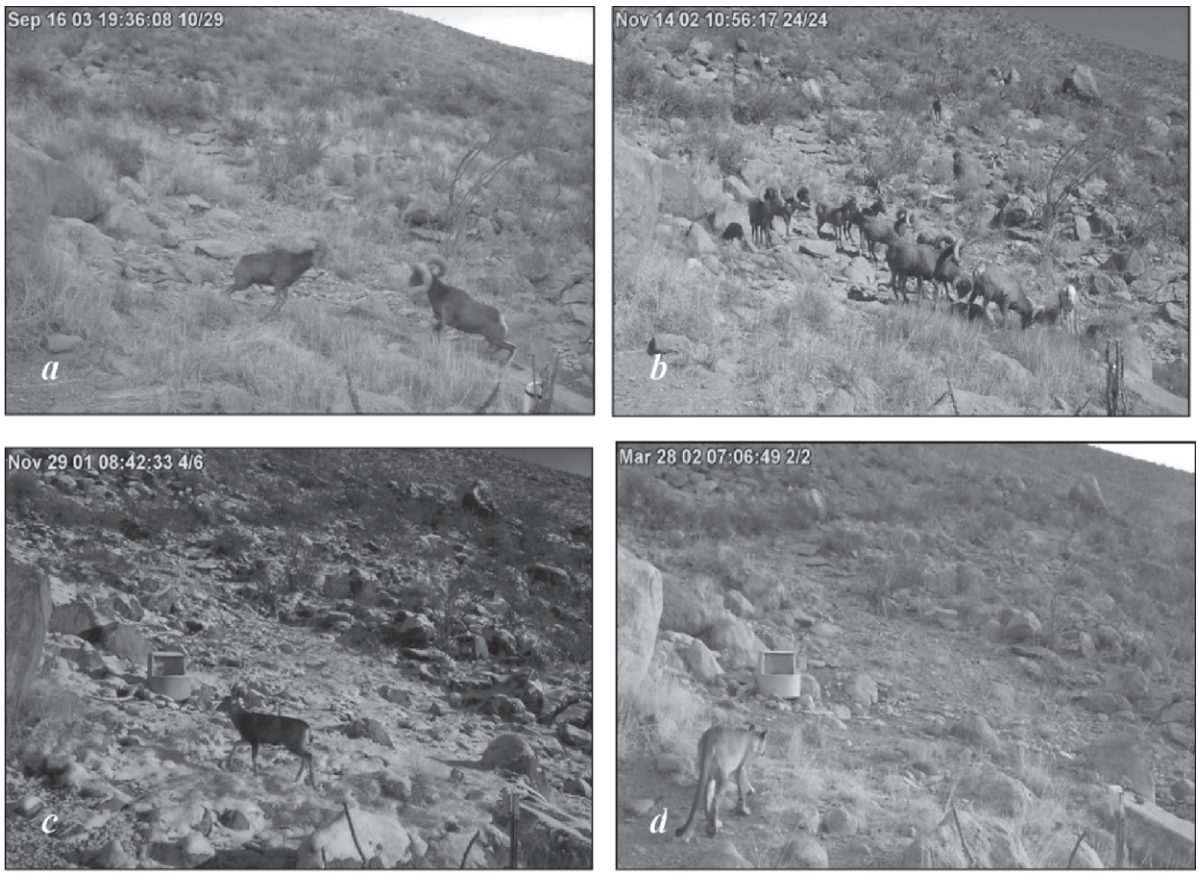

Figure 2. Photographs taken by the web-based digital camera between February 2002 and December 2003 at Elephant Mountain Wildlife Management Area, Texas. Pictures of (a) 2 desert bighorn rams (*Ovis canadensis*) fighting, (b) a group of bachelor rams, (c) desert mule deer (*Odocoileus hemionus crooki*), and (d) a mountain lion (*Puma concolor*) were taken and posted on the Texas Bighorn Society web page (http://texasbighornsociety.org/index.htm).

Our system overcame this obstacle by using 2 deep-cycle marine batteries that were continuously recharged via solar panels, making them essentially self-sufficient.

Because our system was web-based, posting the high-resolution photographs on a website allowed the public an opportunity to view elusive, secretive, and often unobservable species of wildlife in their natural habitat. The photographs have significant potential as a classroom teaching tool in urban and rural grade schools and universities. Leopold (1949) was among the first to warn of the dangers of not owning a farm and not recognizing where breakfast and heat come from. Since then there has been a growing disconnect between younger generations and "wild things." Photographs and websites, although not a replacement for real outdoor experience, may help bridge the gap and educate students about wildlife, ecology, and principles of conservation.

A disadvantage of our system was the cost. The entire system cost approximately $12,000 (U.S.) in 2001. With advances in technology, cost of components may decline with time. Nevertheless, most rigorous research would require multiple camera systems, which would increase overall costs. However, we recommend our web-based camera system because it offers a self-sustaining technique for monitoring wildlife in remote regions that allows for easy data retrieval and storage, thus overcoming obstacles associated with other wildlife monitoring techniques.

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