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An economical wireless cavity-nest viewer

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ABSTRACT. Inspection of cavity nests and nest boxes is often required during studies of cavity-nesting birds, and fiberscopes and pole-mounted video cameras are sometimes used for such inspection. However, the cost of these systems may be prohibitive for some potential users. We describe a user-built, wireless cavity viewer that can be used to access cavities as high as 15 m and with entrance diameters as small as 2.5 cm. System components include a wireless camera, boom with near-infrared lighting system, hand-held television, and telescoping pole. The unit can be assembled in about one day with commonly available tools, and the total cost was about $850 (US). Our cavity-viewing system was used to monitor the nests of Western Bluebirds (*Sialia mexicana*) and proved to be reliable and effective. During two field seasons, we attempted to check the status of nests 928 times and were able to determine the nesting stage 901 times (97%). For those willing to assemble their own units, our cavity viewer permits safe, direct examination of cavity nests or open nests for investigators with limited budgets.

SINOPSIS. **Aparato inhalambrico de bajo costo para observar nidos en cavidades**

Para examinar nidos en cavidades y cajas de anidamiento, muchas veces es necesario usar instrumentos de fibra óptica y cámaras de videos montadas en postes. Sin embargo, el costo de estos sistemas pudiera ser muy elevado para algunos investigadores potenciales. Describimos un aparato inhalámbrico que puede ser utilizado para examinar cavidades de hasta 15 m de altura y de 2.5 cm de diámetro en su entrada. Entre los componentes del sistema encontramos una cámara inhalámbrica, un sistema de iluminación infrarojo, un monitor de televisión manual y un poste telescópico. El sistema puede ser montado en un dia (si hay las herramientas necesarias) y su costo es de $850 dolares. Nuestro sistema fue utilizado para monitorear nidos de *Sialia mexicana* y provó ser confiable y efectivo. Durante dos temporadas de campo intentamos determinar el estatus de nidos en 928 ocasiones y pudimos determiner la etapa en que se encontraban en 901 (97%) de estas. Para aquellos que estén en la disposición de ensamblar sus propias unidades de monitoreo, nuestro equipo es adecuado y se presta para estudios con presupuesto limitado y le permite al investigador hacer observaciones directas con seguridad.

Key words: cavity nest, nest monitoring, *Sialia mexicana*, video camera, video surveillance

In recent years, investigators have employed a variety of inspection systems to monitor avian nests in tree cavities or nest boxes. For example, Purcell (1996) described the use of an articulated fiberscope to examine cavity nests. The fiberscope permits access through small cavity entrances (9 mm), viewing around bends in convoluted nest chambers, and allows users to move the lens close to the subject of interest for maximum detail (e.g., to determine feather stage). However, to access cavities, investigators may need ladders or climbing gear, and some cavity nests are in snags that present safety issues. Proudfoot (1996) developed a pole-mounted video camera for viewing nests in cavities and nest boxes with entrances as small as 4.5 cm in diameter. This system is used from the ground, saving time, reducing disturbance at nests, and eliminating the possible hazards associated with accessing cavities or nest boxes. Richardson et al. (1999) described a refined pole-mounted video camera to permit viewing of nests in cavities as high as 15 m above ground and with entrance diameters as small as 3 cm. This system was subsequently developed into a commercial product (Sandpiper Technologies, Manteca, California). Because the cost of this commercial product is prohibitive for some investigators, we developed a lower-cost alternative with comparable capabilities.

Our system includes a wireless video camera, lighting system, boom, telescoping pole, and a hand-held television (Fig. 1). The total cost of purchasing all system components was about $850 (US) in 2005. The weight of the total system, including batteries, is about 7.5 kg. Each

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Fig. 1. Complete tree cavity viewing system, including camera boom, telescoping pole, and portable television used to examine contents of cavity nests or nest boxes.

component of our system is described in detail below.

The camera is a small, black-and-white wireless model (ST-100A; distributed by Securetek, Ft. Lauderdale, Florida). Retailers of this camera can be found by searching the World Wide Web for "ST-100A wireless camera." We chose this camera because of its small size, lens orientation (perpendicular to longitudinal axis to fit in the smallest possible cavity while viewing downward), and its wireless transmission. This black-and-white model costs about \$200–\$250 (US). The camera broadcasts at a frequency of 434 MHz, and is approximately 2.5 × 1.3 × 1.3 cm, exclusive of antenna and battery wires. The image sensor uses low power consumption complementary metal oxide semiconductor (CMOS) technology, with 380 lines of resolution and light sensitivity to 0.7 Lux. The camera can focus on objects as close as 4 cm from the lens, and its field-of-view is approximately equal to its distance from the subject. For example, when the camera is 20 cm from the subject, the field of view is about 20-cm wide. A 9-volt battery powers the camera for up to 10 h of continuous use. The camera can fit through a 2.5-cm diameter cavity entrance.

The boom houses the camera and lighting system and connects them to the telescoping pole (Fig. 2). The boom is a steel rod (6.35 mm diameter and 60 cm long) with a shelf formed by flattening 8 cm at one end to a thickness of about 1.2 mm with a hammer. This produces a shelf about 1.5 cm wide. The end of the 8-cm shelf (about 1.5 cm) is bent up at a 90-degree angle to protect the camera from bumping against the tree during use. Holes are then drilled in the shelf to permit attachment of the camera and lighting system. A hole, about 7 mm in diameter, for the camera lens should be placed as close to the end of the flattened shelf as the camera body permits for greatest effectiveness in shallow cavities. Then, six 5-mm holes for the light emitting diodes (LEDs) are drilled in the remaining space on the shelf. Six near-infrared (940 nm) LEDs (Model 276-143; Radio Shack, Fort Worth, Texas) and a 68 Ohm, 0.125 watt current-limiting resistor are used for the lighting system. We used near-infrared LEDs to minimize, if not eliminate, perception of the lighting by the subject birds. Based on spectral absorption work with many avian species (Hart 2001), the use of near infrared LEDs seemed to be a reasonable approach. The black-and-white

Fig. 2. Boom prepared with shelf and holes, camera and LEDs secured with hot glue.

camera we used is sensitive to the light created by the near-infrared LEDs and shifts it into the visible range. Although these LEDs illuminated subjects over 1-m away in total darkness, eggs or nestlings viewed at that distance may be difficult to identify because they occupy only a small part of the television monitor. The LEDs and current-limiting resistor are wired in series and powered by one 9-volt battery. Hot glue is used to secure the LEDs and camera to the boom shelf and insulate the LED and resistor leads, preventing short circuits. A 60-cm extension wire is soldered to the antenna for improved signal transmission. The wires from the camera and LEDs, including the antenna, are attached to the boom with electrical tape to a point about 35 cm from the camera (Fig. 1). The camera and LEDs are protected and further secured to the boom with heat-shrink tubing (e.g., HST-999, Gardner Bender, Milwaukee, Wisconsin). Holes are cut in the heat shrink tubing for the camera lens and LEDs. At the opposite end of the boom from the camera is a battery case that holds two 9-volt batteries, one for the camera and one for the lighting system. The battery case is a small, resealable food container (118 mL, Rubbermaid, Fairlawn, Ohio). A switch (e.g., Model 275–407; Radio Shack, Fort Worth, Texas) is added to the battery pack to allow convenient camera and light activation. The camera-boom assembly weighs 325 g with batteries.

The boom assembly is attached to the telescoping pole with a small clamp made with two pieces of 6.35-mm thick aluminum cut to dimensions of 3 cm by 5 cm. A 7.93-mm diameter hole is drilled through both pieces about 1.5 cm from the 3-cm wide edge to accommodate a mounting screw (Fig. 3A). Then, a piece of chipboard (e.g., cereal box) is placed between the two pieces, they are clamped together, and a 6.35-mm diameter hole is drilled about 1 cm from the opposite 3-cm wide edge along the chipboard (Fig. 3B). The chipboard reduces the size of the finished hole and insures a tight clamping action on the boom. It is discarded after drilling. A 7.93 × 3.81 cm, 1.41 mm pitch (5/16″ × 1.5″ 18 pitch) thumb screw with a corresponding nut secure the clamp to the pole head (Fig. 4).

To elevate the camera and boom to cavities, we used a Hastings HV-240 12-m telescoping fiberglass pole (Hastings Fiberglass, Hastings, Michigan). This sturdy pole (total weight = 6.8 kg) can be disassembled, permitting users to carry only the sections needed to reach the highest nest. Telescoping poles as long as 15 m are available (e.g., CMR 50, Crain Enterprises, Mound City, Illinois), but the 15-m pole has a different mounting thread than the Hastings pole and requires a different thumb screw.

A hand-held battery-operated television receives the signal from the wireless camera. We

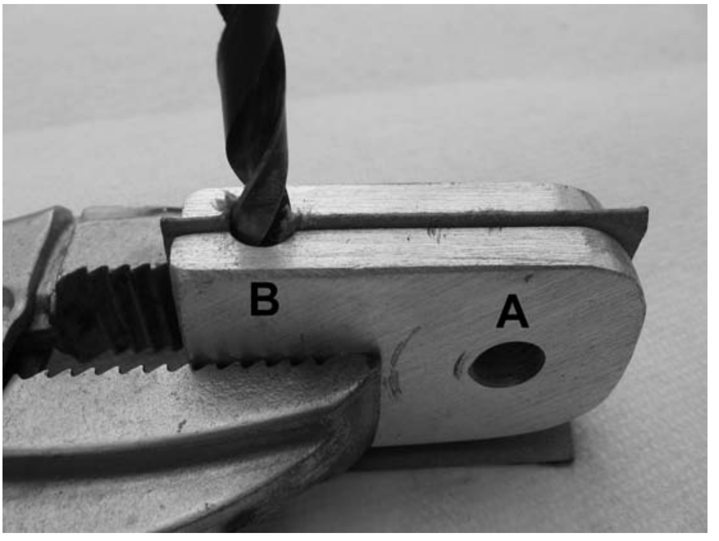

Fig. 3. Boom clamp assembly showing location of holes. (A) 7.93 mm hole, (B) Drilling a 6.35-mm hole with chipboard spacer.

used a 7.6-cm LCD Pocket Color television (Catalog number 16-3012; Radio Shack, Fort Worth, Texas) that cost about $120 (US; Fig. 5). This television weighs 310 g and uses four AA batteries that permit about 3 h of continuous viewing. Using a hand-held television instead of a separate monitor and receiver reduces the cost, weight, power demand, and complexity of the system.

The 434-MHz signal from the camera corresponds to cable television channel 59 in the United States. This does not fall into the normal range of broadcast television frequencies, falling between VHF channel 13 and UHF channel 14.

Fig. 4. Completed clamp assembly mounting the camera boom to the telescoping pole.

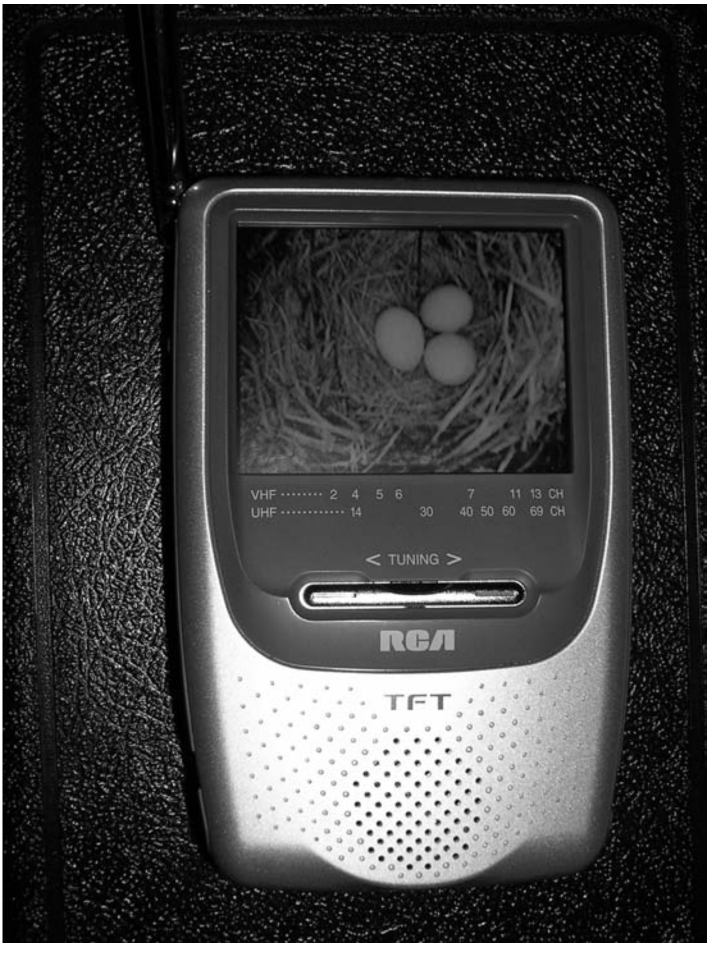

Fig. 5. Handheld, battery-operated television with image of nest contents transmitted from the cavity camera.

However, some broadcast television receivers, including the one we describe, can receive this frequency. If a different handheld television is selected, test it for compatibility with the camera before purchasing.

Assembly of our nest-cavity viewer requires a moderate skill level and commonly-available tools (e.g., drill, hacksaw, vice, soldering iron, and hot glue gun). Assembly requires about one day. More information about parts and assembly is available on the web site www.rmrs.nau.edu/cavityviewer/.

Based on need and availability, investigators may use different components than we did. However, the critical components (camera, lighting, receiver, and monitor) require interoperability. Miniature wireless video cameras are available in either color or black-and-white and usually transmit at one of three frequency ranges (434 MHz, 2.4 GHz, or 900 MHz). Black-and-white cameras cost less and require less light. Near-infrared LEDs may be used as a light source with some black-and-white cameras. A color camera may be useful for observing characteristics important in ageing nestlings. However, color cameras require more light, and light in the visible range. A color version of the camera we used (ST-100AC) is available. Cameras broadcasting at 434 MHz are convenient because a portable television can be used as both receiver and monitor (but check to insure compatibility due to the nonstandard frequency). Although 900 MHz and 2.4 GHz wireless cameras typically require a separate receiver and monitor to view the image, some combination receiver/monitor units are available (e.g., MDVR-10; Supercircuits, Liberty Hill, Texas).

We used our cavity-nest viewer to monitor the nests of Western Bluebirds (*Sialia mexicana*) in natural cavities from May–August 2005 and 2006 in northern Arizona. During our study, 171 cavity nests were located, and our nest viewer could not be used at 16 (9%) nests because cavities were too high or narrow. For these nests, we observed the behavior of adults and young to determine the nesting stage. Such observations lasted up to 30 min, and multiple visits were sometimes required. With the cavity-nest viewer, we typically needed about 7 min to check a nest and, therefore, were able to determine the status of more nests each day than would have been possible by conventional monitoring methods.

Once a nest was discovered and we determined that the camera system would reach and fit into that nest, each subsequent visit to that nest was considered a monitoring attempt. During our two field seasons, we attempted to check the status of nests 928 times and were able to determine the nesting stage 901 times (97%). Failed attempts were due to poor video clarity. This problem was remedied by adding a longer antenna wire to the camera. In many cases, we were able to age nestlings by inspecting feather development and whether or not eyes were open. Counting nestlings became more difficult as nestlings grew larger and, as a result, we were unable to confidently determine the number of nestlings present during 78 nest visits (8%).

The cavity-nest viewer we describe here improves on past efforts by reducing the cost of pole-mounted cavity-nest inspection systems for those willing to assemble their own units. This viewer could also be used to examine open-cup nests. Limitations include a maximum 15 m height and minimum 2.5 cm entrance diameter for cavities or nest boxes. Unlike a fiberscope, our system cannot be used when the nest cup is not visible via a straight line from the cavity entrance. However, our system permits safe, direct examination of cavity nests or open nests for researchers with limited budgets.

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