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A portable system for continuous monitoring of bird nests using digital video recorders

Andrew J. Pierce[1] and Korakoch Pobprasert

King Mongkut's University of Technology Thonburi, School of Bioresources and Technology, 83 Moo 8 Thakham, Bang Khun Tien, Bangkok 10150, Thailand

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ABSTRACT. A variety of photographic methods have been described for monitoring nest predation. All have limitations for studying active nests in remote situations, such as size, expense, volume of data recorded, and types of trigger mechanisms. We developed a digital video surveillance system using infrared cameras to monitor predation at bird nests. The main advantage of this system over other video recorders is the small size of the recorder that can run continuously at 29 frames/s for more than 3 days. The recorder's built-in monitor makes it more transportable and allows for easy setup. Digital data is compact, can be reviewed quickly, and requires less physical storage space than videotapes. We recorded nest predation by mammals, birds, and snakes as well as egg and nestling losses not caused by predation. System failure rates were low and the total cost was comparable to ($700 US) video cassette recorders that are often used to monitor nests.

SINOPSIS. **Sistema portátil para monitoreo continuo de nidos de aves utilizando grabadoras digitales de video**

Se han descrito una gran variedad de métodos fotográficos para monitorear la depredación de nidos. Todos los métodos tienen limitaciones para estudiar nidos activos a distancia, como su tamaño, costo, volumen de los datos grabados y mecanismos para activar el equipo. Desarrollamos un sistema digital de vigilancia, utilizando cámaras infrarrojas para monitorear la depredación de nidos. La ventaja principal de este equipo sobre otros similares es el tamaño de la grabadora, la cual puede funcionar continuamente a 29 cuadros/s por más de tres días. El monitor integrado a la cámara hace que el equipo que sea más fácil de transportar y permite que se pueda montar con facilidad. Los datos digitales son compactos, se pueden revisar rápidamente, y requieren menos espacio de almacenaje que las cintas de video convencionales. Grabamos depredación de nidos por mamíferos, aves y culebras al igual que la pérdida de huevos y pichones por otras causas. La tasa de malfuncionamiento fue baja y el costo del equipo ($700 US) es comparable a otros equipos de videograbación a cassette que se utilizan frecuentemente para monitorear nidos.

Key words: digital video recorder, monitoring, nest, predation, video surveillance

Nest predation plays an important role in shaping the life history traits of birds (Martin 1995, Fontaine and Martin 2006) and, therefore, identifying reasons for nest failure is important for understanding nesting strategies. Determining the causes of nest predation, however, is problematic because observations of predation events are rare (Robinson and Robinson 2001) and inferring the reasons for nest failure from nest remains is difficult (Larviere 1999, Williams and Wood 2002, Staller et al. 2005). Recognizing this difficulty, investigators have developed a variety of camera and video recorder systems to identify predators as well as monitor other activities at bird nests. Time lapse videorecording (five frames/s) with near-infrared cameras has been used effectively in several instances (Staller 2001, Hancock et al. 2002, Thornton 2003, Sabine et al. 2005 and Staller et al. 2005). Although these systems produce good quality footage with minimal disturbance, they have several inherent problems. One is the potentially large number of videotapes generated and the time required to review them (Sykes et al. 1995, J. P. Carroll, pers. comm.). In addition, video systems may be bulky and difficult to transport by hand, require a monitor to aid setting the cameras, and use tapes that must be changed daily. Systems using cameras or videos with motion sensors have been used and, although they use less energy and produce fewer images and videos, there may be a start-up delay after the sensor is tripped causing the loss of data (Franzreb and Hanula 1995, Purcell and Verner 1999, Staller 2001). Another problem with most commercially available systems for surveillance

[1]Corresponding author. Email: andrew@pdti.kmutt.ac.th

work is the prohibitive cost (Sykes et al. 1995, Thompson et al. 1999, Lewis et al. 2004).

In 2006, we initiated a project to study the causes of nest failure in a seasonally wet forest at Khao Yai National Park Thailand, Nakhon Nayok Province (14° 26′ N, 101° 22′ E). We needed an affordable camera system that could be transported on foot several kilometers to a research site and would withstand tropical monsoon conditions. The system needed to run continuously, be easily operated, and require low maintenance. We were able to design a complete digital video surveillance system that could be transported by one person and run continuously for up to 86 h at a cost of less than $700 (US) per unit.

METHODS

Our monitoring system included an infrared camera, a mini-microphone (optional), and a digital video recorder (DVR). The DVR has a docking pod for connection to an external power source. We used 12-volt deep-cycle batteries (35 Amp/5 h; 3K Thai Battery Storage Co. Ltd.; Fig. 1). The DVR (Archos model AV500; 7.6 × 12.4 × 1.8 cm; about $400) with 30 Gigabytes (GB) hard disk drive (100 GB models are now available) has a 10-cm liquid crystal display (LCD) screen and produces digital files in MPEG-4 format (AVI) at 29 frames/s. The DVR can record file sizes of 512 × 384 (called "Optimal") or 640 × 480 (VGA) and at bit rates of 500–2500 kbits/s. We set the DVR to record at the smallest file size and at the lowest bit rate that allows recording of up to 86 h.

We used waterproof Fujiko cameras (65 × 65 × 85 mm) and added a small plastic shield to protect the lens from rain. Cameras had either a 4- or 6-mm lens and 12 near-infrared light-emitting diodes so nests could be monitored at night. The diodes appear as small red dots at night or in dim light, but do not affect nesting behavior or predators (Delaney et al. 1998, Thornton 2003, Sabine et al. 2005, Staller et al. 2005) and no visible light shines on the nest. We also attached a mini-microphone (6 × 6 × 25 mm) covered with plastic wrap (for waterproofing) outside the camera housing and connected it to the DVR via the same cable as the camera. The camera has a universal screw mounting to which we attached a pivot head camera mount that was then slotted into a bamboo pole (16 × 16 × 530 mm) and connected to the video recorder and battery with a

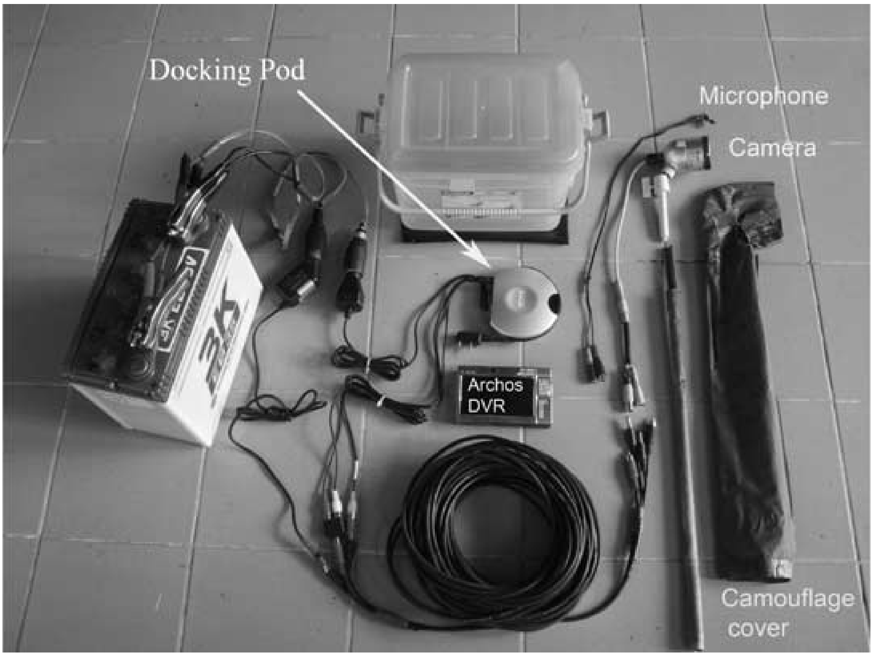

Fig. 1. Individual components of the video surveillance system.

Fig. 2. Field installation of digital video surveillance system covered by camouflaged waterproof material. Plastic box contains video recorder, adaptor and cigarette lighter connectors to connect to the deep cycle batteries.

30-m cable (Fig. 1). A sleeve made from green camouflaged plastic covered the camera and this was tied to a sapling or tree trunk so the camera was 2.5–5.0 m from the nest (Fig. 2). We positioned the camera to get the clearest view of the nest without altering nest concealment and as low as possible to be inconspicuous and avoid creating a potential perch site for a predator.

Current consumption of the camera and infrared diodes was about 180 mA/h and 170 mA/h, respectively. The DVR consumed about 250 mA/h, making total current consumption ca. 430 – 600 mA/h depending on the time of day and weather conditions (the infrared lights turn on automatically at low light levels). Although the system could run for more than 3 days on a single 12 V battery, we used two batteries in series to power the system for at least 1 week to make best use of our limited transport and labor. We placed the DVR and adaptor in a small plastic box that, along with the batteries, was covered by a camouflaged waterproof sheet 25–30 m from the camera in a position where both could be adjusted without disturbing the nest (Fig. 3). The DVR generates a small amount of heat so the box did not need to be completely airtight.

When set to record, the DVR records continuously, but splits recordings into files of 2 GB (about 6 h at 500 kb/s). These are relatively large and make analysis more difficult. We found it better to use the DVR's built-in recording scheduler to create smaller, more manageable files. A 2-h file, for example, makes about a 670 mb file, and fits on a standard video compact disc. However, we found it more efficient for storage and reviewing to put the data on DVDs because all activity from dawn until dusk (at our latitude) fit on one disc. If the DVR is left for the maximum period of 86 h, files need to be scheduled for 3–5 h because only 20 advance recording periods (files) can be scheduled at any one time. Up to 20 additional files can be scheduled at anytime without downloading already stored files, allowing models with larger hard disks to be left for several more days before downloading data. A 100 GB hard disk, for example, could store about 286 h of data, but would need to be rescheduled at least every 3 days.

The digital movie files can be played back with many kinds of media software. We used "DivX player" (see www.divx.com for detail), a program that allows viewing of movie files up to 32 times

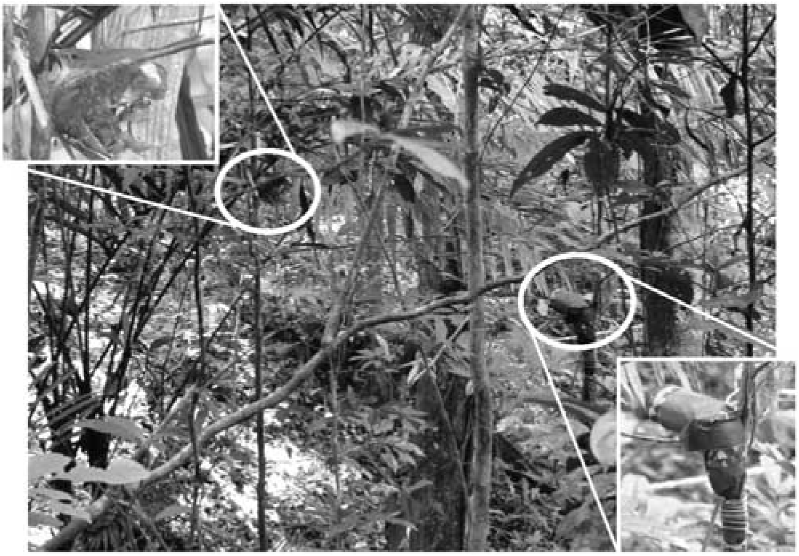

Fig. 3. Field placement of camera at a Puff-throated Bulbul (*Alophoixus pallidus*) nest.

normal speed and reduces the time required for analyses of video recordings. We changed the DVR, or downloaded data to a laptop, every 3 days and replaced the two batteries once per week.

To test the equipment, we used two camera systems to monitor nests from February–August 2006. We placed cameras at a variety of nests, ranging from ground level to 5 m above ground. Nests were monitored as part of a wider study on the nesting ecology of understory birds and the same protocol for checking nests was used at nests with and without cameras (Martin and Geupel 1993). We placed cameras at 32 nests of eight different species. To assess the effects of cameras, we compared failure rates with an additional 142 nests of the same species (Table 1).

RESULTS

Initially, we found that one person could setup the monitoring system in about 20–30 min. However, with two people (one watching the LCD monitor of the DVR and the other positioning the camera), only a few minutes

Table 1. A comparison of daily nest failure rates at nests with and without cameras.

	Nests monitored with cameras				Nests monitored without cameras			
Species[1]	Nests	Days	Nests predated	% daily failure rate	Nests	Days	Nests predated	% daily failure rate
RHT	4	27	4	14.8	11	142	7	4.9
EPT	3	48	2	4.2	0	0	0	–
PBU	13	93	6	6.5	79	634	60	9.5
ABB	4	25	4	16.0	41	531	28	5.3
WSB	3	19	3	15.8	8	60	4	6.7
WFO	1	11	0	0	3	32	1	3.1
HFY	2	9	1	11.1	13	119	6	5.0
MON	2	17	1	5.9	14	235	2	0.9

[1]RHT = Red-headed Trogon (*Harpactes erythrocephalus*); EPT = Eared Pitta (*Pitta phayrei*); PBU = Puff-throated Bulbul (*Alophoixus pallidus*); ABB = Abbott's Babbler (*Malacocincla abbotti*); WSB = White-browed Scimitar-babbler (*Pomatorhinus schisticeps*); WFO = White-crowned Forktail (*Enicurus leschenaulti*); HFY = Hill Blue Flycatcher (*Cyornis banyumas*); and MON = Black-naped Monarch (*Hypothymis azurea*).

was spent near the nest and setup time was less than 20 min. Subsequent changing of batteries and DVRs was accomplished without disturbing nests. With two batteries, they could be changed without loss of camera signal and when changing the DVR, less than 15 s of signal was lost.

We recorded 249 days of nesting activity on video at 32 nests of eight species (Table 1). Partial or complete predation occurred at 21 nests, and predators were birds, snakes, macaques, and other mammals (Figs. 4 and 5). Most predation incidents occurred during the day, except for all snakes, a rat (probably *Maxomys surifer*, Fig. 4), and a common palm civet (*Paradoxurus hermaphroditus*). At one nest, we were unable to identify the reason for a loss of a nestling during inclement weather. Two separate predation events by different predators occurred at three nests and, at four nests, egg or nestling losses did not involve predators. We also recorded instances of nest defense, and removal of damaged eggs, dead nestlings, and fecal sacs by adults. No nests with cameras were abandoned, but it was difficult to assess the effects of cameras on predation due to the small number of nests studied. For the largest sample, Puff-throated Bulbul (*Alophoixus pallidus*), the daily failure rate of nests with cameras was 6.5% compared to 9.5% for nests without cameras (Table 1). The effects of cameras on predation are made more complicated by nonpredation failures that we know occurred at one nest with a camera due to structural damage, but would have been impossible to determine without a camera. Many other studies have demonstrated that cameras using infrared diodes have no significant effect on nest outcomes (Leimgruber et al. 1994, King et al. 2001, Staller et al. 2005). Furthermore, we recorded instances of mammals, including deer and rodents, passing by cameras, at day and night, that did not appear to change their behavior.

Fig. 5. Video still of a Crested Goshawk (*Accipiter trivirgatus*) taking the nestlings of a Red-headed Trogon (*Harpactes erythrocephalus*).

Fig. 4. Video still of a rat (probably *Maxomys surifer*) taking the nestlings of a Red-headed Trogon at night.

DISCUSSION

We found continuous recording on a DVR suited our requirements satisfactorily. The file quality was sufficient to record all the causes of egg or nestling loss except one and data were stored compactly on DVDs. Another advantage of digital recordings over videotapes is that by using "Movie maker" or similar software it is easy to make short clips of interesting events.

The Archos DVR allows only 20 advance files to be scheduled, so careful planning is needed to insure the DVR does not become full before a change/download is undertaken. This handheld DVR does not have a time-date generator like conventional time lapse video home systems (VHS) recorders. However, with appropriate settings of the advance scheduler, it is possible to record the time and date when each file started and determine the timing of any event on any file.

Several events were filmed that highlighted the advantages of continuous recording over other systems. Some predation events that occurred at night, such as when a snake took a nestling during a storm and most of the nonpredation losses, would not have been recorded by systems that use a trip mechanism to start the cameras. Further, we found two instances where a known predator visited a nest but did not take any nestlings that, without continuous surveillance, would likely have been difficult to interpret.

Apart from some larger invertebrates, such as spiders and earthworms, we could rarely identify prey items. This would require cameras to be placed closer to the nest and a higher lens magnification. Setting the DVR to record at a higher resolution and bit rate had little effect on the quality of the images produced, but had the disadvantage of producing larger files that would require the DVR to be downloaded more frequently.

We did have some minor problems, especially during the early stages, and lost some data as a result. Video quality was often reduced at night when humidity was high and during inclement weather. Although the equipment functioned even during storms, one nestling disappeared for unknown reasons during heavy rain. However, it seems unlikely that any system would work much better during such adverse weather. Other investigators have also reported difficulty in identifying predators and the loss of data due to weather with VHS-based systems (Staller 2001, Thornton 2003, Sabine et al. 2005, Staller et al. 2005).

Other minor problems we encountered were mainly concerned with connections at the camera (rather than the DVR) that were adversely affected by the humid conditions of a tropical forest. However, by replacing all cables with the best available, and resoldering all connections, we reduced failures to a minimum. Other investigators have also reported all of these problems using analog video systems (Staller et al. 2005).

Despite these limitations, we found that this method of digital surveillance has considerable advantages over video cassette recorder systems in current use especially its portability and ease of data storage and analysis. At less than $700 (US) per unit, we believe that this system can make significant contributions to the study of nesting birds and could easily be adapted for surveillance of other wildlife.

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