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EVALUATION OF PHOTOGRAPHIC DEVICES TO DETERMINE NESTLING DIET OF THE ENDANGERED RED-COCKADED WOODPECKER

KATHLEEN E. FRANZREB
Southern Forest Research Station
Department of Forest Resources
Clemson University
Clemson, South Carolina 29634-1003 USA

JAMES L. HANULA
Southern Forest Research Station
Forestry Sciences Laboratory
320 Green Street
Athens, Georgia 30602-2044 USA

Abstract.—An efficient, non-invasive protocol to quantify the diet of nestling Red-cockaded Woodpeckers (*Picoides borealis*) was described and evaluated. The method posed no potential hazard to either the adults or young, and afforded nearly constant monitoring of prey brought to nestlings. During four trials with three woodpecker groups in 1992 and 1993, a video camera with a passive infrared sensor, a "lipstick" fiber optics camera, a manual focus camera attached to a spotting scope, and an autofocus camera with an active infrared detector were evaluated. Use of a Nikon F4 camera and flash attachment affixed to a deer stand and interfaced with a Trailmaster sensor unit mounted on the cavity tree enabled identification of approximately 65% of the arthropods in nearly 3000 photographs of adults bringing food to the nestlings. The other setups had serious drawbacks and were deemed unsuitable.

EVALUACIÓN DE DIFERENTES EQUIPOS FOTOGRÁFICOS PARA DETERMINAR LA DIETA DE *PICOIDES BOREALIS*

Sinopsis.—Se describe y evalúa el protocolo de un método no invasivo y eficiente para cuantificar la dieta de pichones de *Picoides borealis*. El método permitió el vigilar casi constantemente las presas traídas a los pichones sin poner en peligro a éstos o a los adultos. Utilizando tres grupos de carpinteros durante el 1992 y 1993, se evaluó el uso potencial de una cámara de video con sensor infrarojo pasivo, una cámara con fibra óptica, una cámara de foco manual unida a un lente de largo alcance (spotting scope) y una cámara de autoenfoque con detector infrarojo. El uso de una cámara Nikon F4, con fuente de luz (flash) y sensor Trailmaster montada en la cavidad del árbol, permitió la identificación del 65% de los artrópodos que servían de presa para los pichones de aproximadamente 3000 fotografías tomadas a adultos. Hubo problemas con los otros montajes lo que los hace inadecuados para este tipo de trabajo.

The Red-cockaded Woodpecker (*Picoides borealis*) is an endangered species the recovery of which depends, in part, on a thorough understanding of the distribution, availability, abundance and diversity of the macroarthropods found within the bark of live pine trees on which it forages (Beal 1911, Harlow and Lennartz 1977, Hooper and Lennartz 1981, Porter and Labisky 1986). Extensive sampling of arthropods in the bird's habitat is underway to determine the potential prey base (Hanula and Franzreb, unpubl. data), but the results of these samples will not disclose what the woodpeckers are actually consuming. One way of relating availability to consumption is to monitor the prey that adults bring to their nestlings. Although adult and nestling diets may differ, provisioning nestlings is a critical, albeit small, part of an adult's annual time budget and an absolute necessity to a species' reproductive success. This nestling diet study is but one component of a much broader research effort that encompasses foraging ecology and dietary requirements.

To determine and monitor the diets of various bird species, investigators have developed a range of approaches including ligatures, emetics, gut and fecal-content analyses, artificial nestlings, visual observations and photography (Calver and Wooler 1982, Kleintjes and Dahlsten 1992, Otvos and Stark 1985, Rosenberg and Cooper 1990, Royama 1970). Most of these methods are not viable for an endangered species because they are invasive and potentially damaging.

Several authors have used movie cameras to monitor food delivered to nestlings (Dahlsten and Cooper 1979, Kleintjes and Dahlsten 1992, Minot 1981). Kleintjes and Dahlsten (1992) studied the diets of Plain Titmouse (*Parus inornatus*) and Chestnut-backed Chickadee (*P. rufescens*) nestlings in California coastal live oak woodlands, comparing a photographic approach to fecal sac and gut analyses. They attached a Minolta super 8 mm movie camera with a Vivitar flash to the backs of artificial nest boxes. The system was activated as the adult passed by photocells at the box entrance. Film images were viewed through a dissecting scope for identification of prey. Combined with insect sampling in the foraging habitat, this system allowed frequent identification of prey to the species level and quantification of prey delivered to the nest. Photography provided a better measure of food brought to the young than concurrent fecal sac or gut analysis. Unfortunately, some of the adults abandoned their nests less than 24 h after installation of the photographic devices.

Others used hand-operated cameras to determine what prey adults brought to nestlings in open-nesting species (Knapton 1980, Meumier and Bedard 1984). Knapton (1980) used a videorecorder equipped with a 230-mm lens to record parent birds bringing food to nestling Clay-colored Sparrows (*Spizella pallida*). As adults perched on a conspicuous branch just before going to the nest, the opportunity for obtaining a high-quality film image was excellent. Later, when the video tapes were processed on closed-circuit television, most of the prey were identifiable at least to the order level. The disadvantage of this approach was that an observer had to be present to photograph the parents because the system did not use a sensor.

As all available photographic approaches were either too intrusive or labor-intensive for studying the feeding of Red-cockaded Woodpecker nestlings, we tested five new photographic methods. Our study provides new insights into the technological aspects of photography as a monitoring device as well as a comparison of different photographic strategies.

METHODS

Trials were conducted during the breeding season (May–July) in 1992 and 1993 at the Savannah River Site, a U.S. Department of Energy facility located near Aiken, South Carolina. Our protocol was to set up the equipment at a nest cavity, then to observe the attendant birds for up to 2 h, the maximum time that adults usually remain away from the nest (R. G. Hooper, pers. comm.). If after that time the parents had not returned to the nest at a frequency consistent with pre-test observations, we removed the camera equipment to allow resumption of feeding. During the course of the study, we evaluated one video camera, one fiber optics camera and two still cameras, operating alone or with various combinations of tripping devices and video cassette recorders (VCRs).

Tech Systems, Inc. of Norcross, Georgia, designed a video camera system consisting of a CCD color video camera (JVC brand) with a 12-mm auto iris lens and a passive infrared sensor which detects the infrared produced by the subject to activate the camera. Encased in a commercially available waterproof housing measuring 12.5 × 17.5 × 51 cm, the unit was mounted on the cavity tree 2 m above the cavity entrance. At the base of the tree were a 12-v deep-cycle marine battery, a timer, and a VCR recorder (Panasonic AG-1050), set to operate from 0600 to 2000 hours EST. Tech Systems, Inc., had programmed the VCR for 30 s of recording followed by 5 min in the "pause" mode (tape on the heads) to decrease the start-up time of the recorder during periods of high feeding activity. The equipment cost approximately $4500 (US) per unit and took 30–45 min to install.

We also tested a "lipstick" fiber optics camera (Toshiba brand), so named because it is about the size of a tube of lipstick. We attached it to a 1.9-cm VCR in the lab and filmed a live-mounted bird that was perched on a small section of tree trunk and that held an insect in its bill. The lipstick camera had a 1:1.6 7.5-mm fixed focus lens and was almost silent when operating. Similar models cost about $2000 each.

The first still camera we tested was a manual focus Nikon N2000 attached to a Questar Field Model spotting scope that featured three power changes (8.5×, 40×, and 65×) per 32-mm eyepiece. The cost of the system was about $3400.

The second still camera we tested was an autofocus camera (Nikon F4) with a MF-24 multicontrol back that held 250-exposure Ektachrome 200 film and imprinted the time and date of exposure on each frame. The Nikon was the only camera that we could find that had both the multicontrol back and date/time imprinting features. The camera had a Sigma 500-mm/f7.2 APO lens and a Nikon SB-25 autofocus flash to supplement natural light, and was attached to a Trailmaster 1500 active infrared detector. The sending unit of the Trailmaster detector, a 1.3-cm cube, was affixed 1–2 m above the cavity entrance; the receiving unit was attached to the base of the tree and connected to the camera by a cable. Each time a bird interrupted the Trailmaster infrared beam, the camera shot one frame of film. An auxiliary battery pack provided additional power to increase the number of flashes between battery changes. Protected by a watertight 15 × 38 × 43 cm fiberglass electrical box, the camera sat on a 4-m tall Warren and Sweat Co. tripod-style deer stand. The stands were placed near the nest tree before the breeding season; as the birds became accustomed to them, they were gradually moved to within 3–5 m of the cavity. Film canisters were replaced every other day. The total cost of each system was approximately $6400.

RESULTS AND DISCUSSION

In 1992, we subjected three groups of birds to the video camera system. The first group readily accepted the unit and returned to their normal rates of provisioning the nestlings within 15 min. The second and third groups did not accept the device during the 2-h testing period, so we removed the equipment. We then constructed a smaller housing, camouflaged its appearance with bark and re-introduced it 5 d later to the third group. The birds accepted the new housing, and we left the camera in place for 2 d to complete the test.

A major problem with the video camera was the delay in start-up after the sensor was tripped by a bird. The camera captured less than a third of the visits and many of the recordings failed to capture the delivery of food to the young. Part of the problem was that the passive infrared tripping device was not sensitive enough to detect a small bird. After testing two passive infrared detectors at their most sensitive settings, we switched to a video image detector, which compared the camera images frame to frame and tripped the recording device when a change in the image occurred. The new detector worked well, but the slow start-up of the VCR prevented regular recording of food before it was passed to the nestlings. We also encountered false trips of the camera when no bird was present. These occurred primarily on partly cloudy days when the light and shadow intensity varied frequently, resulting in detected images. These false trips were fortuitous, however, because most of our recordings of birds carrying prey occurred when the recorder already had been activated. We soon had enough recordings to determine that image quality and the position of our camera were inadequate for prey identification. On the basis of discussions with a professional video photographer, we decided that the cost of upgrading to commercial video cameras was prohibitive for our purposes (about $20,000 per camera).

Limited tests with the lipstick camera in the laboratory showed that the camera's fixed iris was a major limitation (e.g., when set for midday light intensities, the camera functioned poorly in low light conditions). Although a camera with an auto-iris lens would have resolved this problem, such a unit would have cost about $30,000 and would have been considerably larger than the lipstick version we tested, negating the advantage of a small camera that could be positioned close to the cavity entrance. The even-more expensive auto-iris lipstick camera was beyond our financial means, especially in light of our need to monitor 4–5 nest cavities simultaneously.

Preliminary tests using the Nikon N2000 and Questar spotting scope to photograph insects pinned to a section of tree trunk indicated that performance was poor in low lighting. Without a flash unit, we were un-

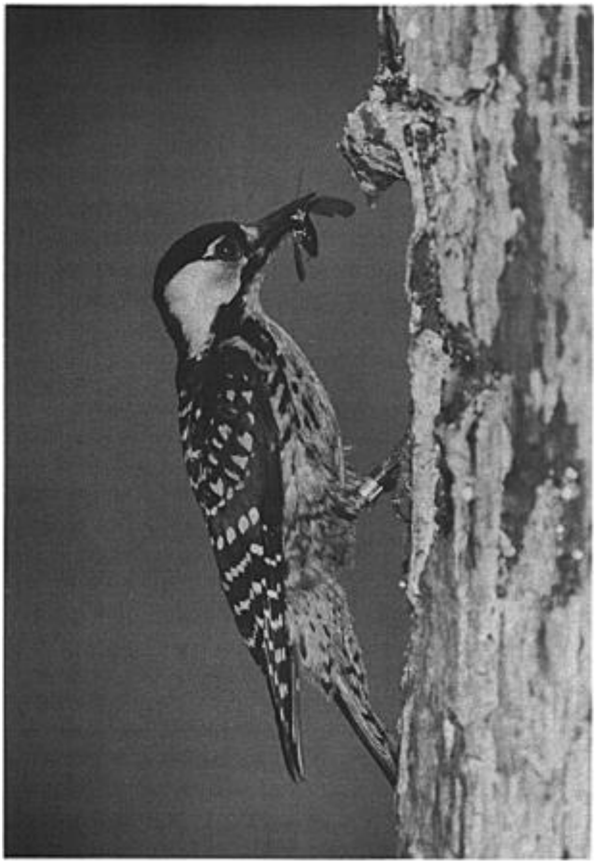

FIGURE 1. Photograph of Red-cockaded Woodpecker poised at nest cavity entrance with food for nestlings, taken with a Nikon F4 camera, flash, and Trailmaster sensor.

able to get consistent proper exposure of the film, making identification of the insects difficult.

In 1993, we tested the Nikon F4 camera with Ektachrome 200 film, flash, and Trailmaster sensor. Our initial concern was whether the sensor and flash might keep the birds from entering the nest cavity. After inspecting the newly installed Trailmaster unit, however, they quickly adjusted and seemed to ignore it. Adults appeared unconcerned to see us climbing the deer stands daily, and they frequently returned to the nest cavity while the cameras were being serviced. This system worked well (Fig. 1) and we were able to identify approximately 65% of the arthropods in the nearly 3000 photographs we took in 1993 (Hanula and Franzreb, unpubl. data). Our ability to determine what prey were held by the birds was affected by several factors including sharp focus, camera to subject distance, size of the prey, type of prey and camera angle. Sharp focus was critical for prey identification but was primarily a function of the operator. The autofocus feature of the camera was not fast enough to photograph the birds before they entered the cavity so we used the manual focus setting. The camera to subject distance was determined by the cavity location on the tree bole. As the distance increased, it was more difficult to identify prey, particularly small prey items such a spiders, beetles or roach egg capsules (oothecae), whereas larger items such as wood-borer and moth larvae or roaches were still recognizable at the longer distances (10–12 m). By choosing a longer focal length lens, this difficulty may be mitigated; however, the cost would increase and the light gathering ability of the lens may be compromised, thus possibly reducing image quality depending on the lens selected. The size and type of prey also influenced whether they could be identified. For example, roaches, centipedes, caterpillars, wood-borer larvae, and long-horned grasshoppers were easily recognized. Conversely, beetle adults were generally difficult to identify even at the closest camera to subject distances. A critical factor in prey recognition was a reference collection developed from sampling in the primary foraging habitat of the Red-cockaded Woodpecker. Camera angle also was a function of the cavity location to some degree. The best photographs were taken when the camera was positioned to the side and slightly lower than the cavity so that a profile of the bird was taken. This position often allowed us to see both ends of a prey item that was grasped in the middle, which facilitated identification.

Photographic systems can provide a wealth of information about provisioning rates, intersexual differences in parental care, amount of prey delivered to the nest per visit, preferences for prey at specific times of the nesting cycle or in different years and selective feeding of nestlings (preference to feed certain young).

Along with acceptance by adult woodpeckers, the critical factors in selecting suitable equipment packages were response time, shutter tripping ability and speed, film or tape advance and capacity, image resolution and cost.

Several additional basic criteria come into play when selecting photographic equipment for prey-use studies. These include comparisons of size, camera-placement and light-intensity requirements. For our purpose the most expensive alternative, the autofocus still camera, was also the most effective. The other systems we tested, however, might be acceptable for work with other species.

Regardless of the type selected, the high cost and portability of most equipment makes security a factor that usually requires consideration. Fortunately, the Savannah River Site is a fenced facility with restricted public access, thus affording reasonably good security against theft of the equipment in our study.

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