J. Field Ornithol. 74(2):193–196, 2003

A non-intrusive method for measuring movements and seed dispersal in cassowaries

Andrew L. Mack[1] and Gretchen Druliner[2]

Wildlife Conservation Society, P.O. Box 277, Goroka, EHP, Papua New Guinea

Received 8 April 2002; accepted 11 October 2002

ABSTRACT. We describe a method for measuring gut passage time and seed dispersal distance for a large terrestrial frugivore. We attached temperature data loggers to radio transmitters in baits that were ingested by free-ranging cassowaries. The resulting data yielded information on how fast the unit passed through the gut (3–4 h) and how far they were moved (240–325 m), an analog for dispersed seeds. Additionally, the data loggers revealed that cassowaries reingest fecal matter, the first observation of coprophagy in wild cassowaries.

SINOPSIS. **Un método no invasivo para medir movimiento y dispersión de semillas en casuarios**
Describimos un método para medir el tiempo que toma en pasar alimento a través del tracto digestivo de casuarios y la distancia de la dispersión de semilla. Unimos a un radiotransmisor un "recogedor" de temperatura que fue mezclado con comida para que fuera ingerido por los casuarios. El aparato tomó de tres a cuatro horas para moverse a través del tracto digestivo y fue transportado de 240 a 325 metros, lo que es un análogo a la dispersión de semillas. El recogedor de datos de temperatura reveló, además, que los casuarios ingieren heces fecales lo que es la primera observación de coprofagia en estas aves.

Key words: Casuariidae, gut passage, Papua New Guinea, telemetry

Large animals in low population density are often conservation concerns and difficult to study (Ehrenfeld 1970; Gaston and Blackburn 1995), and biologists must be particularly vigilant when capturing and handling threatened species (Withey et al. 2001). For decades, radiotelemetry has been used where direct observation of a species is difficult (Kenward 2001). Telemetry can now reveal more than simply movements (Gauthier-Clerc and Le Maho 2001); it can, for example, monitor body temperature (Brigham et al. 2000) or activity (Hassall et al. 2001). Satellite telemetry monitors tagged animals with less disturbance and field labor (e.g., Martell et al. 2001), but often movements under a few hundred meters are indiscernible (Blouin et al. 1999; Britten et al. 1999).

Studying seed dispersal is especially difficult because one must determine both where seeds are consumed and subsequently voided. Measures of seed dispersal often combine telemetry with gut passage rates measured in captive birds (Sun et al. 1997; Holbrook and Smith 2000; Westcott and Graham 2000). But this method has limitations: gut passage rate might differ in wild individuals, observers could affect animal movements, and no data on deposition site are produced. Some investigators have tracked seed movement by placing thread spools in the seeds moved by seed-caching terrestrial dispersers (Hallwachs 1986; Theimer 2001), tagged seeds and retrieved tags from dung (Mack 1995), or put microtaggants on fruits and recovered the taggants from dung (Levey and Sargent 2000). Such methods enable precise data on dispersal distance and seed deposition site.

Dwarf Cassowaries (*Casuarius bennetti*) are exceptionally difficult to study because they occur at low population density and are extremely secretive. Capturing adult cassowaries is difficult and risks injury both to the birds and the researchers. Cassowaries are prolific dispersers of seeds, but tagging seeds in fresh fruits and relocating tagged seeds is extremely labor-intensive (Mack 1995).

Here we describe a method for studying seed dispersal and movement that has circumvented some of these problems and that could be modified for successful application in other systems.

METHODS

Study site. This study was done at the Crater Mountain Biological Research Station

[1] Corresponding author. Email: amack@wcs.org

[2] Current address: The Peregrine Fund, 5666 West Flying Hawk Lane, Boise, Idaho 83709 USA.

(CMBRS), Papua New Guinea (145°05′34.5″E, 6°43′26.2″S) between September 2000 and November 2001. Dwarf Cassowaries (20–30 kg) are common in the study area and consume a great variety of fruit (Wright 1998). The study area is rugged and the flora is diverse (Wright et al. 1997).

Overview. An ingestible data logger and transmitter (IDLT) packet was made by epoxy-bonding a temperature data logger to a two-stage transmitter. The IDLT was then placed in a bait at a fruiting tree where free-ranging cassowaries foraged. If baits were removed we searched for the IDLT with a standard wildlife telemetry receiver and directional antenna. When located, the distance and bearing of the movement were directly measured with compass and tape measure. The temperature data were downloaded and the IDLT cleaned and redeployed.

Wild rats caught with snap traps were used for bait. Part of the rat's body was removed and the IDLT implanted in the cavity. The whip antenna protruded from the anus and was tied to the tail with thread. Feeding trials with captive birds revealed cassowaries swallow baited rats whole with no ill-effects. Rats were chosen for bait because they are readily consumed by cassowaries (Wright 1998).

Technical details. We used TidBit® temperature loggers (Onset Industries). This data logger is small (14 g), robust, and programmable to take a temperature reading (±0.2°C) as frequently as desired for 32,520 readings that are stored until downloaded. The logger is launched and downloaded via a sealed optical coupling. We set the logger to record the temperature every three minutes.

We tried two models of transmitter. The first model was designed for implantation in the body of a medium-sized vertebrate. The second was a two-stage transmitter commonly used with small to medium-sized mammals with a 9-cm flexible whip antenna.

RESULTS

We deployed IDLTs 26 times, of which ten (38%) were ingested and three of which were recovered in cassowary droppings. Only one other large, rare and partially arboreal vertebrate, the Mangrove Monitor (*Varanus indicus*), at CMBRS could conceivably ingest dead rats.

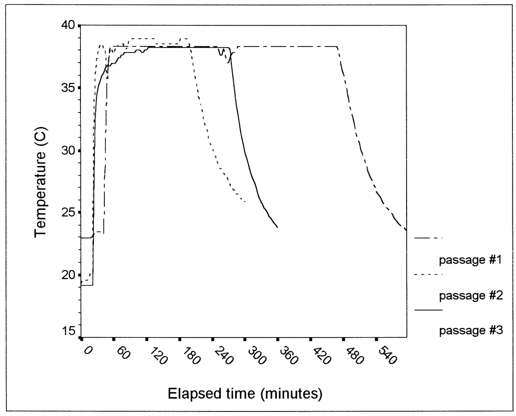

Fig. 1. Transit times of three separate gut passage events. Time of initial ingestion for #2 and #3 was in the early morning and the IDLT was voided midday. Passage #1 was ingested about 14:00, and the IDLT was voided near dusk when the bird was probably bedded down. The IDLT was quickly re-ingested (note drop in temperature) then passed through the gut a second time and was voided near midnight. The fluctuations in temperature shortly after ingestion in passage #2 probably reflect changes during feeding as ambient food was swallowed and absorbed energy from the gut and gut contents.

When small mammals moved baits, we easily recovered IDLTs close to their original position. Thus the seven IDLTs that were taken and not recovered were most likely taken by cassowaries, but removal by monitor cannot be entirely ruled out. Loss was probably due to transmitter failure (see below).

Three recovered IDLTs were moved 240, 325 and 290 m in 213, 189, and 249 min, respectively (Fig. 1). One IDLT was reingested by the cassowary after excretion and transitted the gut a second time in 192 min (Fig. 1).

DISCUSSION

This method could be used with frugivores that swallow large fruits or fruit pieces whole (e.g., trumpeters, hornbills, toucans) and possibly large mammals (e.g., tapirs) if the IDLT is rugged enough.

Making the IDLT, launching the logger, and implanting it in a bait took only a few minutes. Finding IDLTs is easier than locating a radio-collared animal because the IDLTs are static; an area only needs to be searched once. Seed dispersal distances by cassowaries have been measured using tagged seeds (Mack 1995), but were labor-intensive and yielded no data on time. One IDLT was recovered in less than five hours, but in the other two successful relocations up to seven days of fieldwork were required. We attribute this extra effort to the rugged terrain and the poor-quality transmitters used (see below). Locating an IDLT requires little formal training; we employed illiterate local hunters to search. Many IDLTs using the same frequency could be deployed and searched for simultaneously.

The cost is relatively minor. One assistant can perform the fieldwork using one receiver and antenna. The IDLTs cost $215 (U.S.) each, but that price could be reduced by constructing one's own or buying in bulk. A smaller packet could be made that is driven by a single, smaller battery (ours had two); an inexpensive unit could be produced that weighs less than 35 g.

Cassowaries and seed dispersal. Seed dispersal distance has significant implications for gene flow (Williams and Guries 1994; Schnabel et al. 1998) and colonization ability (Willson 1993). In this pilot study we demonstrated that dispersal distance can be precisely measured using IDLTs without relying on estimates of dispersal distance (Sun et al. 1997; Holbrook and Smith 2000; Westcott and Graham 2000). The dispersal distances revealed by IDLTs were close to distances ($\bar{x}$ = 388 m, SD = 196.8) found using tagged seeds (Mack 1995).

Coprophagy is little known in birds (Soave and Brand 1991) other than passerines that ingest their chicks' feces; this study is the first confirmation of coprophagy in wild cassowaries (Fig. 1) although it has been observed in captives (A. Mack, pers. obs.). Coprophagy could have significant implications, aiding uptake of proteins among lagomorphs and leporids (Takahashi and Sakaguchi 1998; Hirakawa 2001). Gut treatment is gentle in cassowaries, and even soft fruits pass virtually intact (Wright 1998). Reingestion could assist nutrient uptake by doubling transit time (Levey and Del Rio 2001). Significant absorption occurs in the rectum of some frugivores, so coprophagy could be advantageous if absorption is not complete (Levey and Duke 1992), especially for nutritious items like high-protein carrion. If coprophagy occurred during the overnight bivouac, as did the observed event, any items reingested would not displace intake of fresh fruit.

Problems encountered. The main problem came from transmitter failures. The implantable transmitters had a range of less than 100 m when new. The model with the whip antenna failed from the beginning. Of 10 purchased, three failed before deployment. With a known 30% failure rate, it is likely the IDLTs that could not be located were due to technical failures. We believe a robust transmitter from a reliable manufacturer with a short, flexible whip antenna will work well.

Occasionally rodents would move the bait and IDLT. Movement by taxa other than cassowaries was apparent because IDLTs were not found in cassowary feces, were moved short distances (<20 m), were gnawed (not swallowed), and the data logger showed no temperature profile for gut passage. Once an IDLT was secondarily dispersed three meters from a cassowary dropping. The temperature log indicated that the IDLT had been swallowed by a cassowary (mammals have lower body temperatures). A camera trap could be useful to confirm the species or individual that takes the IDLT bait. We believe this method is viable and could be useful to a wide range of taxa with modest modifications to the IDLT.

ACKNOWLEDGMENTS

Financial support was provided by the Eppley Foundation and Disney Corporation. We thank A. Chatfield, M. Chatfield, Q. Latif, and I. Samuels for field assistance. D. Levey and N. Wheelwright made helpful comments on the manuscript. Many Pawaiian landowners assisted during this study and kindly hosted us on their land. We thank the PNG Office of Environment and Conservation for allowing us to undertake this study.

LITERATURE CITED

Blouin, F., J. F. Giroux, J. Ferron, G. Gauthier, and G. J. Doucet. 1999. The use of satellite telemetry to track Greater Snow Geese. Journal of Field Ornithology 70: 187–199.

Brigham, R. H., G. Kortner, T. A. Maddocks, and F. Geiser. 2000. Seasonal use of torpor by free-ranging Australian Owlet-Nightjars (*Aegotheles cristatus*). Physiological and Biochemical Zoology 73: 613–620.

Britten, M., P. Kennedy, and S. Ambrose. 1999. Performance and accuracy evaluation of small satellite transmitters. Journal of Wildlife Management 63: 1349–1358.

Ehrenfeld, D. 1970. Biological conservation. Columbia University Press, New York.

GASTON, K. J., AND T. M. BLACKBURN. 1995. Birds, body-size and the threat of extinction. Philosophical Transactions of the Royal Society of London 347: 205–212.

GAUTHIER-CLERC, M., AND Y. LE MAHO. 2001. Beyond bird marking with rings. Ardea 89: 221–230.

HALLWACHS, W. 1986. Agoutis (*Dasyprocta punctata*): the inheritors of Guapinol (*Hymenaea courbaril*: Leguminosae). In: Frugivores and seed dispersal (A. Estrada, and T. H. Fleming, eds.), pp. 285–304. Junk Publishers, Dordrecht, Netherlands.

HASSALL, M., S. LANE, M. STOCK, S. PERCIVAL, AND B. POHL. 2001. Monitoring feeding behaviour of Brent Geese *Branta bernicla* using position-sensitive radio transmitters. Wildlife Biology 7: 77–86.

HIRAKAWA, H. 2001. Coprophagy in leporids and other mammalian herbivores. Mammal Review 31: 61–80.

HOLBROOK, K., AND T. SMITH. 2000. Seed dispersal and movement patterns in two species of *Ceratogymna* hornbills in a West African tropical lowland forest. Oecologia 125: 249–257.

KENWARD, R. 2001. Historical and practical perspectives. In: Radio tracking animal populations (J. Millspaugh, and J. Marzluff, eds.), pp. 3–12. Academic Press, San Diego, CA.

LEVEY, D. J., AND G. E. DUKE. 1992. How do frugivores process fruit—gastrointestinal transit and glucose-absorption in Cedar Waxwings (*Bombycilla cedrorum*). Auk 109: 722–730.

———, AND S. SARGENT. 2000. A simple method for tracking vertebrate-dispersed seeds. Ecology 81: 267–274.

———, AND C. M. DEL RIO. 2001. It takes guts (and more) to eat fruit: lessons from avian nutritional ecology. Auk 118: 819–831.

MACK, A. L. 1995. Distance and non-randomness of seed dispersal by the Dwarf Cassowary *Casuarius bennetti*. Ecography 18: 286–295.

MARTELL, M. S., C. J. HENNY, P. E. NYE, AND M. J. SOLENSKY. 2001. Fall migration routes, timing, and wintering sites of North American Ospreys as determined by satellite telemetry. Condor 103: 715–724.

MURRAY, K. G. 1988. Avian seed dispersal of three neotropical gap-dependent plants. Ecological Monographs 58: 271–298.

SCHNABEL, A., J. D. NASON, AND J. L. HAMRICK. 1998. Understanding the population genetic structure of *Gleditsia triacanthos* L.: seed dispersal and variation in female reproductive success. Molecular Ecology 7: 819–832.

SOAVE, O., AND C. D. BRAND. 1991. Coprophagy in animals—a review. Cornell Veterinarian 81: 357–364.

SUN, C., A. R. IVES, H. KRAEUTER, AND T. C. MOERMOND. 1997. Effectiveness of three turacos as seed dispersers in a tropical montane forest. Oecologia 112: 94–103.

TAKAHASHI, T., AND E. SAKAGUCHI. 1998. Behaviors and nutritional importance of coprophagy in captive adult and young nutrias (*Myocastor coypus*). Journal of Comparative Physiology B 168: 281–288.

THEIMER, T. C. 2001. Seed scatterhoarding by white-tailed rats: consequences for seedling recruitment by an Australian rain forest tree. Journal of Tropical Ecology 17: 177–189.

WESTCOTT, D. A., AND D. L. GRAHAM. 2000. Patterns of movement and seed dispersal of a tropical frugivore. Oecologia 122: 249–257.

WILLIAMS, C. F., AND R. P. GURIES. 1994. Genetic consequences of seed dispersal in three sympatric forest herbs. I. Hierarchal population-genetic structure. Evolution 48: 791–805.

WILLSON, M. F. 1993. Dispersal mode, seed shadows, and colonization patterns. Vegetatio 107/108: 261–280.

WITHEY, J., T. BLOXTON, AND J. MARZLUFF. 2001. Effects of tagging and location error in wildlife radiotelemetry studies. In: Radio tracking and animal populations (J. Millspaugh, and J. M. Marzluff, eds.), pp. 43–75. Academic Press, San Diego, CA.

WRIGHT, D. D. 1998. Fruit choice by the Dwarf Cassowary, *Casuarius bennetti*, over a three year period in Papua New Guinea. Ph.D. dissertation. University of Miami, Coral Gables, FL.

———, J. H. JESSEN, P. B. BURKE, AND H. G. S. GARZA. 1997. Tree and liana enumeration and diversity on a one-hectare plot in Papua New Guinea. Biotropica 29: 250–260.