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A MINIATURE CAMERA SYSTEM FOR EXAMINING PETREL BURROWS

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Abstract.—Studies on burrow-nesting seabirds are hampered by difficulties associated with access to and direct observation of nesting chambers. During a 2-yr study examining the effect of rat predation on Bonin Petrels (*Pterodroma hypoleuca*) on Midway Atoll, we developed a miniature camera system that enabled us to view the contents of burrows, assess the status of the petrels' breeding activity, and search for evidence of rat predation. We successfully entered burrows and examined 65% of all attempts. Nine percent of burrows encountered were either too long or contained sharp turns. The remaining 26% contained rigid roots that prevented passage of the camera head. In addition to being small and inexpensive, the system limited disturbance to birds by using infrared lights and was easy for one person to carry and use efficiently.

SISTEMA DE CÁMARA EN MINIATURA PARA EXAMINAR NIDOS DE *PTERODROMA*

Sinopsis.—El estudio de aves marinas que anidan en cavidades se hace difícil por el limitado acceso que hay para observar la cámara de anidaje. Durante un estudio, que duró dos años, para examinar el efecto de la depredación por parte de ratas, en individuos de *Pterodroma hypoleuca,* se desarrolló un sistema miniaturizado de cámara para examinar las cavidades de anidaje de estas aves. El estudio se llevó a cabo en el Atolón de Midway. El sistema utilizado permitió examinar las cavidades, determinar el estatus del anidamiento del ave y buscar evidencia sobre la depredación por parte de las ratas. Se examinaron el 65% de todas las cavidades utilizadas para intentar anidar. Del 35% restante, un 9% resultaron muy largas o tenían curvaturas muy pronunciadas para ser examinadas y el restante 26% contenía techos rígidos que evitaron el que se pudiera pasar la cámara. Además de ser pequeño y de bajo costo, el sistema desarrollado es fácil de transportar, y redujo el disturbio a las aves al utilizar luz infraroja.

Studying the breeding biology of burrow-nesting seabirds is challenging because access to and direct observation of birds in burrows is often difficult or impossible. Most studies conducted in the past have been limited to nests in short burrows, partially collapsed burrows, or on the surface. Observation chambers have been used to observe breeding birds in their burrows (Dyer and Hill 1991, Grant et al. 1983). This latter technique is complicated and poses the risk of collapsing burrows when the chambers are installed. Instruments such as borescope scopes, endoscopes, and miniature video cameras have also been used to peer into burrows (Cairns 1983, Dyer and Hill 1991). These instruments are expensive, fragile, and require the use of a bright white light (which disturbs the study species and requires a large and bulky power source). In addition, because these scopes are limited in length they cannot be used to study birds that nest in long burrows.

The Bonin Petrel (*Pterodroma hypoleuca*) is a colonial-nesting seabird, abundant in the central Pacific Ocean. In the Northwestern Hawaiian Islands, this petrel builds nests in an enlarged chamber at the end of burrows that can be as long as 3 m, contain turns, and are usually constructed in soft sand (Grant et al. 1983). During a 2-year study examining the effects of rat predation on Bonin Petrel reproductive success, we experimented with different techniques to examine the nesting chambers of these birds. By the end of the study, we developed a miniature camera system that enabled us to view the contents of burrows, assess the status of the petrels' breeding activity, and search for evidence of rat predation.

STUDY AREA AND METHODS

Midway Atoll (28°15′N, 177°20′W) is a low sand and coral atoll located near the northwestern end of the Hawaiian archipelago, approximately 1850 km from Honolulu. The atoll is a nearly circular rim of coral reef, about 8 km in diameter and consists of three islands (Harrison 1990). Sand Island is the largest and only island presently inhabited by humans. It is about 2.9-km long and 1.9-km wide, covering 485 ha. Eastern Island is approximately 1.6 km to the east of Sand Island and is approximately 135 ha. Spit Island is the smallest island in the atoll and is approximately 2.5 ha. All three islands lie close to the southern rim of the atoll.

As many as 1.1 million seabirds comprising 15 species breed on Midway Atoll (Fefer et al. 1984). Midway is the home of the largest breeding colony of Laysan Albatrosses (*Diomedea immutabilis*), White Terns (*Gygis alba*), Black Noddies (*Anous minutus*), Red-tailed Tropicbirds (*Phaethon rubricauda*), and the third largest nesting colony of Bonin Petrels found in the Northwestern Hawaiian Islands.

During the first year of our study, we used a Lenox Instrument FF896DR flexible borescope (approximately 2-m long) to examine burrow contents. The scope was not weather proof and thus needed to be protected from rain and sand. We placed the head of the scope in a small glass vile and the remainder of the scope in a garden hose. The borescope scope used a white light and was powered by a portable battery that weighed approximately 1.8 kg. The scope had the capability to turn left and right or up and down. However, after examining a number of burrows, we soon found that we needed a stronger turning capability to examine burrows with sharp turns. Motorcycle cables were anchored to the sides of the head to provide greater turning ability. When using this instrument during the day, we covered our heads and the eyepiece with a towel because the bright sunlight made it difficult to look through the single eyepiece. After 2 mo of use, the borescope was no longer operable.

To overcome this problem, we purchased a small home security system that consisted of a closed-circuit miniature camera system with infrared sensors linked to a small monitor for viewing. To protect the system from weather and outdoor use, we housed the rectangularly shaped camera (8.3 cm × 6.4 cm) in a plexiglass box. Wires connecting the camera to the monitor were housed in rubber tubing. We taped motorcycle cables to the camera case to provide turning capability and used a towel to cover our heads and the monitor screen to reduce glare caused by sunlight. We adapted the camera to run off a small, portable, and rechargeable 12-v battery. The monitor and battery was housed in a small cooler for transportation. We used this camera and monitor system to examine burrow contents for the rest of the petrels' breeding season.

Still in search of an efficient technique to examine petrel burrows, in 1994 we constructed a miniature camera system similar to a system used to study petrels in New Zealand. This system was composed of a miniature Charge Couple Device (CCD) camera (WATEC model WAT-902) linked to the small monitor from the home security system we used in the previous year. We attached a Computar H3616FI manual C-mount lens (3.5-mm focal length, f1.6) to the camera and used six infrared light emitting diodes (LED, Philips ECG 3017) as a light source. Figure 1 details the electrical connections for the entire unit. A plexiglass cylinder (6 cm in diameter) housed the entire camera/LED unit for protection from water and sand. Two silica gel packets were placed in the plexiglass cylinder with the camera/LED unit to absorb condensation. The same packets and LEDs lasted for the entire study period (6 mo). A small sled, carved out of a rubber float, was taped to the bottom of the camera head to prevent the blunt edge of the cylinder from pushing sand in front of the camera as it was pushed into the burrow allowing the camera to slide into the burrows easily. The camera/LED unit was then connected to a vacuum hose that protected all the essential wires leading from the unit to the monitor. The monitor and control box were placed in a plastic carrying container about 39.0-cm long × 26.5-cm wide × 26.8-cm high. One side of this container consisted of a plexiglass panel to allow viewing of the monitor without opening the container unit. A black rubber snorkel mask with the glass face removed was attached with marine silicone rubber to the plexiglass. Black poster board covered the inside surface of the plexiglass extending outside of the perimeter of the mask. This allowed the observer to place his/her face up against the mask, blocking out sunlight that would cause glare on the monitor screen (Fig. 2). This miniature camera system was powered by a small, portable rechargeable 12-v battery; the entire unit weighed approximately 6.8 kg.

In 1997, we modified this same camera system to reduce the size and weight. We replaced the TV monitor with a Sony FDM-402A B/W monitor. This monitor was smaller and lighter, therefore, we were able to carry the entire unit in a small tool box (40.5-cm long × 20.3-cm wide × 18.5-cm high). The remaining part of the system was not changed. The carrying case, containing the monitor, battery, and control box weighed approximately 5.3 kg.

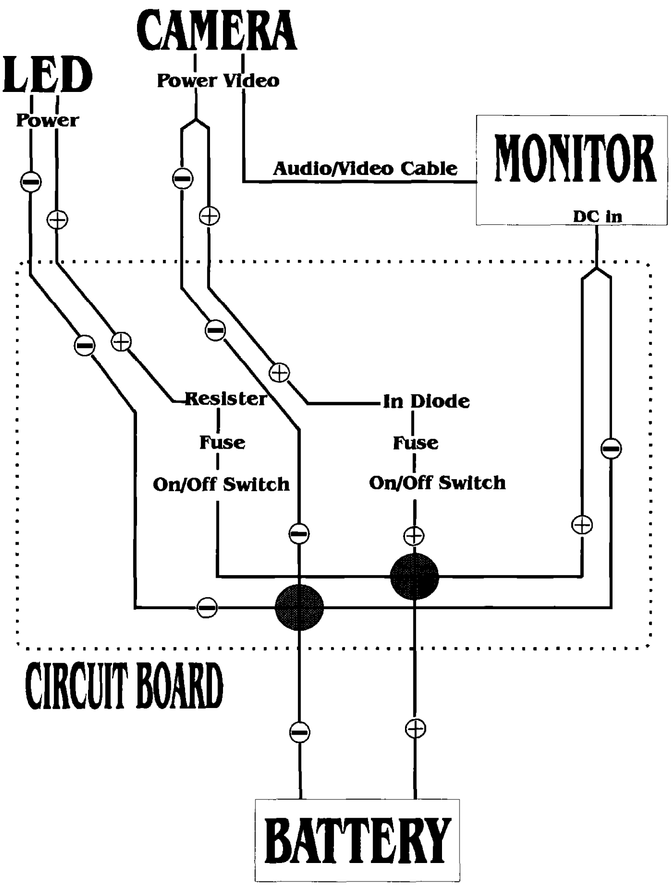

FIGURE 1. Schematic diagram illustrating electrical connections for camera system.

RESULTS AND DISCUSSION

The small narrow head of the borescope scope allowed us to enter about 90% of all examined burrows. However, viewing burrow contents was not easy because of the single eyepiece and wide angle lens. For all burrows longer than 0.5 m, we needed a third arm to push the head of the scope down into the burrow. Two hands were already occupied with holding the eyepiece and pulling the cables for turns. Thus, it required two people and 15–20 min to examine one burrow. The scope proved to be too delicate an instrument for this kind of use. The fiber bundles frayed (most likely caused by the frequent turning), causing the image to gradually black out. The scope was no longer operable after less than 2 mo of use.

The miniature security camera used in the latter part of the 1993 breeding season resulted in better identification of burrow contents. It was

FIGURE 2. Author using camera to view contents of Bonin Petrel burrow on Sand Island, Midway Atoll.

much easier to view the monitor screen, which was set on the ground, while pushing the camera into the burrow with one hand (thus eliminating the need for a second person). However, this was a larger unit in size and weight. The larger rectangular shaped camera body made it difficult to fit into all of the burrows originally monitored with the smaller borescope. Some petrel burrows were narrow and contained roots that blocked passage. We were able to monitor only 131 of the 144 burrows originally selected.

The miniature camera system used in 1994 was streamlined in shape and therefore, easy to maneuver into petrel burrows. The head of the camera unit was about 6 cm in diameter. Therefore, it fit into 65% of all burrows encountered. The only burrows that it could not fit into were burrows that were horizontally narrow, contained sharp turns, or filled with rigid tree roots. The illumination from the LEDs in this camera system was much brighter than the home security camera used in 1993. We could see much more of the burrow and its contents. We were able to identify items as small as bugs crawling on an abandoned egg. We found that twisting the vacuum hose back and forth while pushing forward, allowed us to slide the camera head into the burrow without pushing sand up. In addition, rotating the vacuum hose to the left or right allowed us to turn the camera head to follow the direction of the burrows, eliminating the need for attachment of motorcycle cables. We were able to determine that we located the nesting chamber or end of burrow with this camera system much easier than with the previous systems. In examining 165 burrows, we could not locate the nest chamber or burrow end in 15 burrows, either because the burrow was longer than the length of the camera system or because of a sharp turn.

A fully charged battery in the 1994 system could be used for approximately 7–8 h. The modified camera system used in 1997 was compact and light. This lighter version increased our efficiency in monitoring burrows.

For all three systems, petrels reacted by pecking continuously at the head of the scope, running to the back of the burrow, or simply staring at it. It was a much more common reaction for the petrel to peck at the scope when we were using the borescope with the white light. When using the infrared systems, we observed a decreased frequency of aggressive attacks on the camera. Complete study results using this camera system are detailed by Seto and Conant (1996).

Overall, this system was easy for one person to carry to the study site and examine the study burrows efficiently. The entire system cost approximately US $900.00 to construct. It is an inexpensive alternative to borescopes (fiber optic scopes) that are not suitable for long-term use in the field. This miniature camera system is an example of what biologists with limited budgets can construct to study burrow-nesting species. There are a variety of miniature cameras, infrared light sources, small monitors (watchman TV), and rechargeable power sources available for biologists to assemble into small portable units for use in a field. This growing technology is allowing biologists to explore a field that has been limited in the past.

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