to hold this species were examined and four adults incubating eggs were banded. On the following day, these four burrows were again examined and four unbanded adults were present.

In 1972, G. Friedrichsen, my wife, and I banded 10 adults all incubating eggs in 10 burrows. One of the birds banded in 1970 was recaptured within 3 m of its 1970 location.

Castle Island is located 4.0 km (2.5 miles) NW of Crescent City and 0.8 km (0.5 miles) offshore. The island measures 2.76 ha (6.82 acres) and is occupied by 12 species of sea birds during the breeding season. The major vegetation of the island is *Elymus mollis*, *Lasthenia minor*, and *Poa annua*. All the Rhinoceros Auklet burrows were found in the area with *Lasthenia-Poa* cover, no more than 2–3 cm high. Most of the burrows were 2–3 m long and 10–30 cm below the surface. Because of the shallow nature of the burrows, walking on the island is difficult.

Based on the numbers of suitable burrows present, I would estimate the breeding population of Rhinoceros Auklets on Castle Island to be 50–75 pairs.

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REMOTE SENSING OF BODY TEMPERATURE IN A CAPTIVE 25-G BIRD

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INTRODUCTION

Much attention has recently been focused on the application of remote sensing to studies of the physiology and behavior of unrestrained animals under field and laboratory conditions (Boyd and Sladen 1971; Goodman 1971; Davis 1970; Gates 1968; Zigmond et al. 1970; Essler and Folk 1961). The inherent errors in "grab and jab" and implanted thermocouple techniques of body temperature measurements are avoided by transmitting the temperature by telemetry. In a study on the cold-temperature physiology of White-crowned Sparrows (*Zonotrichia leucophrys gambelii*) held in captivity, a simple method of telemetry of body temperature was developed (Southwick 1971). This telemetry system herein described is uncomplicated and can be constructed in most laboratories without special knowledge or tools.

MATERIALS AND METHODS

Instrumental characteristics. A small temperature transmitter was developed for surgical implantation in the intraperitoneal cavity of the White-crowned Sparrow. It consisted of a small oscillating circuit, utilizing a temperature-sensitive resistor as the sensing element. A change in temperature altered the resistance so that the frequency of oscillation increased with increasing temperature. The electrical design was similar to that described by Mackay (1970) and used by Coulombe (1970) and Osgood (1970). The completed unit weighed about 0.86 g or less than 3.5% of the body weight of the bird. It was nearly spherical with a diameter of 6–8 mm. The 25-g bird showed no visible effect from the implanted transmitter and could not be distinguished from birds without the unit. A schematic diagram of the transmitter is shown in figure 1.

A receiver was constructed to integrate the output signal over time via a "one-shot" (mono-stable multivibrator), resulting in a variable potential proportional to the transmitted frequency, which was read directly on a meter or a strip-chart recorder.

The readability of the meter or graphic display, combined with the nonamplifying receiver circuit employed, resulted in body temperature readings reliable to 0.1° C. Each transmitter was calibrated in a saline bath over the range of temperature expected to be encountered in the test animal (usually 35–45° C). Only those units that held calibration over a 3-day trial period were used in experimental animals. The transmitter's range was limited to about 1 m.

The continuous graphic output indicated not only telemetered body temperature but also provided a rough index of locomotor activity. As the bird moved about, the coil position of the implanted transmitter changed relative to the stationary receiving antenna, resulting in brief periods of weaker signals.

Techniques of surgical implantation. Animals to be used for body-temperature measurements were lightly anesthetized with ether. Following procedures similar to a laporotomy, a 1-cm incision was cut with scissors through the skin and muscle layer parallel and just posterior to the rib cage (at left lateral apterum). The transmitter was cleaned with alcohol and rinsed with saline before implantation. The transmitter was placed in the abdominal cavity between the liver and stomach, thus lying a little to the left of midline. The position of the transmitter was later

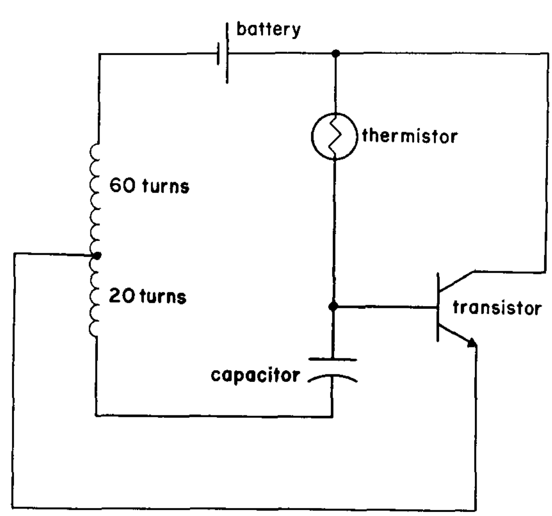

FIGURE 1. Schematic diagram of the implantable temperature transmitter. Various components were tried in the circuit. Those parts listed were found to be most reliable and easily obtained: wire—40-gauge copper magnet wire (frequency depends on number of turns in coil); battery—1.4 volt (Mallory 212); thermistor—1000 kohm (Fenwal GABIJI); transistor—NPN (GE D26Er); capacitor—0.68 to 0.1 μF tantalum (Allied 162D); encapsulated in Silastic®.

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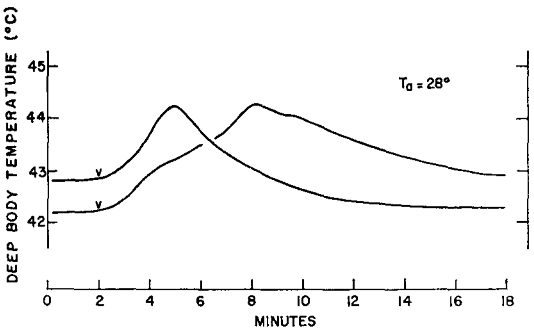

FIGURE 2. Fluctuation in telemetered intraperitoneal temperatures of two birds resulting from minor disturbance. The arrowheads indicate the time of silent approach to within 2 m of the caged birds (followed by immediate departure).

confirmed by X-ray photographs. Post-operative temperature was recorded and the bird was placed in a cage for recovery at room temperature. Most post-operative animals immediately hopped about and even attempted to fly within minutes after surgery. The birds were then allowed 5–7 days of adjustment in an outdoor aviary before experimental temperature measurements were attempted. Virtually every animal survived the surgery. Immediately after completion of an experimental series, the transmitters were removed and retested to verify calibration.

SAMPLE DATA AND RESULTS

Simultaneous recording of cloacal temperatures and telemetered intraperitoneal (i.p.) temperatures indicated that abdominal temperatures were higher by a mean of 0.97° C ($N = 17$, range -0.3 to +3.0). Coulombe (1970) found a mean difference of 0.4° C in Burrowing Owls (*Speotyto cunicularia*). Table 1 shows variation between cloacal and telemetered i.p. temperatures in animals acclimated to 28° C for 12 weeks under changing summer or winter daylengths. The daylengths were altered to correspond with the changing natural daylengths (including dawn and dusk) prior to the dates indicated. Although the data are few, the summer warm-acclimated animals showed a lower i.p.-cloacal difference and a somewhat smaller variation (but $P > 0.05$). The remote sensing also revealed that a very slight disturbance (such as silently approaching a caged bird to within 2 m and then leaving) caused a transient rise of 2–3° C in telemetered deep body temperature which lasted 10 or more min before returning to normal (fig. 2). There was no gross activity by the animals during this time. Such a change in body temperature without activity may have resulted from increased muscle tonus. Further investigation is necessary into this event.

The variability in deep body temperatures through a February day was examined using this tool. The test birds were shaded from direct rays of the sun and the cold night sky, and exposed to a maximum midday temperature (black-body temperature) of about 0.5° C and a minimum night-time temperature of -4.8° C. The birds were hyperactive just before sunrise and at sunset according to the activity trace. These activity periods correspond with maximal feeding, as noted by Morton (1967). The telemetered core temperatures were high at these times, showing

TABLE 1. A sample of simultaneous measurements of temperature via telemetry and cloacal probe in *Zonotrichia leucophrys gambelii.*

Season	Summer (15 July)		Winter (15 February)	
Method of measurement:	Telemetered intra-peritoneal	Cloacal	Telemetered intra-peritoneal	Cloacal
Temperatures: (°C)	42.7	43.0	40.8	39.2
	42.8	43.0	42.1	40.1
	41.7	39.8	47.7	44.1
	42.9	41.8	40.5	40.1
	43.3	41.4	44.6	41.6
$T_{i.p.} - T_{cloacal}$ Mean ± SE	0.68 ± 0.41		1.52 ± 0.47	

peaks near 43° C 0–30 min before sunrise and again 30 min after sunset. Generally, the birds had body temperatures that were about 2° higher during the day (43° C) than at night (41° C). In all cases, body temperature began a transient rise before dawn and before any indication of activity. The body temperature did not begin to fall until after sunset, although it did decline before cessation of activity. Similar daily changes in telemetered body temperature have been shown by Southwick (1971) in cold- and warm-acclimated birds in both summer and winter. Baldwin and Kendeigh (1932) and Hudson and Kimzey (1966) have also found such temperature-activity correlations in other species using non-telemetric methods.

SUMMARY

Small size transmitters (6–8 mm diameter) sensitive to temperature were surgically implanted in White-crowned Sparrows. They provided for remote recording of body temperature and indicated locomotor activity. Continuous measurements revealed transient fluctuations in body temperature resulting from minor disturbance. Cloacal temperature was usually lower than telemetered body temperature. The daily cycle of telemetered body temperature is correlated only indirectly to gross activity. Although the range is only about 1 m, and the transmitter's useful life is about one month, the low cost and simplicity of construction makes the unit attractive for studies in physiological ecology. The instrumental characteristics, technique of surgical implantation, and some examples of experimental data from the transmitters are given.

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BEHAVIOR AND ACTIVITY CYCLES OF GAMBEL'S QUAIL AND RAPTORIAL BIRDS AT A SONORAN DESERT WATERHOLE

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A field study designed to observe the behavior and activity cycles of animals attendant at a Sonoran Desert waterhole was conducted during January 1969. The rationale for the choice of waterholes as study areas is discussed elsewhere (Beck and Tuttle 1972). The activity of a winter flock of Gambel's Quail (*Lophortyx gambelii*) and of raptorial birds was monitored. Among the raptors seen in the waterhole area, those positively identified were Marsh Hawks (*Circus cyaneus*), Sparrow Hawks (*Falco sparverius*), Red-tailed Hawks (*Buteo jamaicensis*), Harris' Hawks (*Parabutea unicinctus*), and Bald Eagles (*Haliaeetus leucocephalus*). The daily cycle of quail presence at the waterhole differed systematically from that of raptors and it appears that the presence of raptors at the waterhole was associated with the absence of quail.

METHODS

The observations were made at Jose Juan Tank in the Cabeza Prieta Game Range, southern Arizona (about 32° 5′ N, 113° 6′ W). Jose Juan is the only perennial source of standing water within 8 km in the Game Range although small temporary accumulations of rain may occur. Additionally, there are drinking troughs provided for cattle about 1.5 km away in the fenced Organ Pipe Cactus National Monument. The tank is roughly rectangular in shape, measuring, at the top of the banks, about 73 m on the N-S axis and about 56 m on the E-W axis. The tank has been artificially deepened and an earthen dike has been erected on the north end. Water accumulates from rainfall run-off. The tank was only partially filled at the time of the study, leaving a surrounding apron about 10 m wide sloping gently upward from the water to the top of the banks.

Jose Juan Tank is ringed by honey mesquite trees (*Prosopis juliflora*) which grow on top of the banks. Microphyll flatland desert, populated primarily by creosote bush (*Larrea tridentata*), surrounds the tank for at least 3 km in all directions.

The observations were made from a blind built on top and at the mid-point of the west bank about 10 m from the water's edge. Usually three, but never less than two, observers began work at about 06:00 and ended about 18:30. The study encompassed 258 hr and 45 min of observation on 21 days (30 December 1968–5 January 1969, 13–25 January 1969, and 29 January 1969).

Average daily shade temperature in the blind ranged from 41.8° F (5.4° C) before sunrise to 65.5° F (18.6° C) at about 14:30. The lowest temperature recorded during the study was 28° F (–2.2° C) and the highest, 76° F (24.4° C). Light to moderate rainfall was recorded on 13, 14, 17, and 21 January; no measurement was made at the site but 0.7 inches (1.78 cm) of rain fell during the study period at the headquarters of the Organ Pipe Cactus National Monument, about 32 km away. During the study, sunrise occurred, on the average, at 07:45 and sunset, at 17:45. There was sufficient light for detailed observation from about 06:55 to about 18:30.

Movement to and from the blind was as limited as possible and was always to the rear (west) of the blind so as to interfere minimally with faunal activity. When a vehicle was present during the day, it was parked inconspicuously some distance from the waterhole. The group camped about 10 km away and other people were observed near the study area only twice.

Binoculars (7 × 35, 8 × 40), pens, notebooks,

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