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A RADIO TRANSMITTER FOR MONITORING THE MOVEMENTS OF SMALL PASSERINE BIRDS

by

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ABSTRACT

Radio transmitters weighing 1.7-1.9 g were developed and field tested on house sparrows (*Passer domesticus*) in Colorado. Radio telemetry studies with birds as small as sparrows are uncommon. The radio's design includes a 2-wire antenna (10.2 cm vertical and 7.6 cm horizontal) and a Mallory RM 312-T2, 1.4-V mercury cell. The battery life ranged from 2 to 3 weeks. Stycast #1090 with catalyst #3 served as a lightweight sealant. The maximum ground and air reception distances in agricultural habitat were 5.6 and 30.6 km, respectively; ground reception distances in an urban/university environment were between 0.5 and 1.0 km. The radios (with leg streamers and aluminum leg bands) weighed 7-10% of the 25- to 30-g sparrow's body weight. Radios glued to the base of the tail were more practical than those attached to its leg. Although birds periodically pecked at the radios and experienced some initial flying difficulties, the radios did not seem to affect subsequent flight nor disrupt normal daily activities. Birds with radios appeared to have the same general behavior pattern as birds with leg streamers.

INTRODUCTION

Radio telemetry is a valuable technique for monitoring behavioral activities of birds. Because of the importance of behavioral data to better understanding bird pest problems, and the usefulness of this information in efficacy evaluations, radio telemetry is now often part of many bird pest management operations in the United States (Bray 1973, Besser 1978, Besser et al. 1978). Radios as light as 3-5 g for following red-winged blackbirds (*Agelaius phoeniceus*) and starlings (*Sturnus vulgaris*) (Bray 1973) presently are being used. Similar uses are envisioned for studies of red-billed quelea (*Quelea quelea*), the most important bird pest to cereal crops in Africa, but a limiting factor has been the unavailability of a sufficiently small radio package.

Our paper reports the results of preliminary laboratory tests with red-billed quelea and initial field observations with house sparrows (*Passer domesticus*) evaluating the potential of radio transmitters weighing 1.7-1.9 g in crop protection research involving small passerine species. Information on retention, preferred attachment methods, and reception and tracking distances of the radio transmitters was obtained with red-billed quelea at the

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Denver Wildlife Research Center (DWRC) and in Tanzania and Sudan, Africa. The possibility of behavioral modifications caused by the radios was evaluated in the field with house sparrows at Fort Collins, Colorado.

The influence of radio packages on the behavior of the study animal always is a concern for which there is a general absence of controlled field studies (Haynes and Gray 1979). For this reason, Aucouturier et al. (1979) indicated that radio packages weighing no more than 2% of the animal's body weight were desirable. This concern, however, presents problems for studies of small passerine birds. Except for the 1.7- to 1.8-g radios used by Raim (1978) to follow movements of brown-headed cowbirds (Molothrus ater), a 1.4-g radio used in peregrine falcon (Falco peregrinus) movement studies (Cochran 1975), and the 1.1-g radio pictured by Cochran (1980), such miniature radios are not commonly available or regularly used for birds as small as red-billed quelea and house sparrows. Accordingly, remote location studies of very few other small passerine species have been conducted (see list in Cochran 1980; Bray et al. 1975).

MATERIALS AND METHODS

Description of radio transmitters

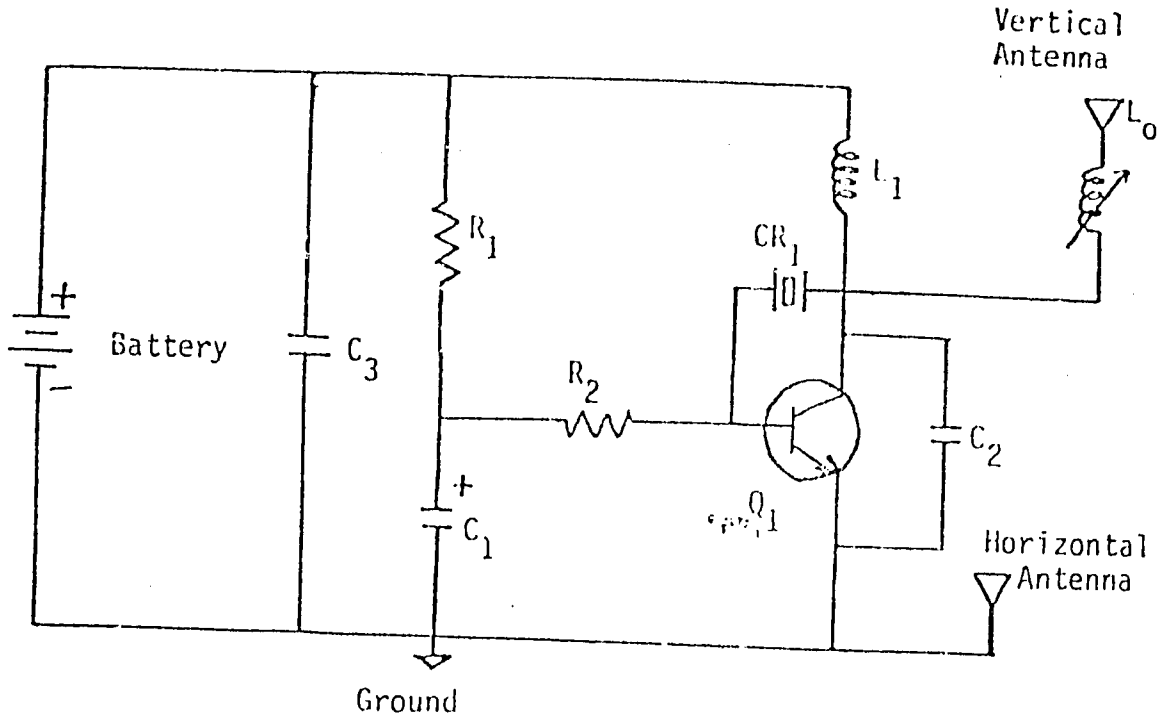
Radio transmitters used in this study were developed at DWRC. A schematic circuit diagram, components, and component values of the transmitter are shown in Figure 1. The transmitter is a single stage crystal controlled Colpitts oscillator. The miniature quartz crystal (Erie Technological Products*), has a fundamental frequency near 27 MHz. L_1 and C_2 were selected to arrive at the desired frequency of 164 MHz; L_0 provides maximum RF output at that frequency. The tuning of this circuit can be modified to other desired frequencies. For tuning ease L_0 is separated from L_1 by 0.16 cm. The number of turns on L_0 is inversely proportional to the antenna length.

The pulse rate and pulse width are determined by R_1, C_1, and R_2. The low series resistance of the crystal and high gain characteristics of Q_1, are the key components needed to produce this low current drain transmitter (Kolz and Corner 1975). This design produces a transmitter with an average pulse width of 40 ms, a pulse rate of 60 pulses/min, a duty cycle of 4%, an average current drain of 60 μ amp, a radiated output power of 0.01 mW, and a working temperature range better than -18°C and 38°C. Finished transmitters, with a 10.2-cm vertical antenna and a 7.6-cm horizontal antenna, weigh 0.7 g without battery, and about 1.7-1.9 g with a 40-mA/h, 1.4-V mercury oxide battery and potting. The potting material is Stycast #1090 (Emerson & Cummings Inc.). Stycast #1090 is about 1/3 the weight of many other epoxies.

Laboratory and cage studies with red-billed quelea

Several preliminary load-lifting and retention studies were conducted in a 1.5 x 3.6 x 2.1-m flight cage at the DWRC laboratory during March and April 1980 using red-billed quelea (weighing 19 to 25 g) which had been in captivity for about 1 year. Similar studies were conducted with wild-trapped adult

* Throughout this paper, reference to trade names does not imply U.S. Government endorsement of commercial products.



Battery	1.4 V mercury oxide
Q_1	Transistor, SMT 1157
CR_1	Quartz crystal
R_1	Resistor, 1/8 W, 510 kΩ - 1.2 MΩ
R_2	Resistor, 1/8 W, 10 kΩ - 39 kΩ
C_1	Sprague #182D tantalum capacitor, .47 μF - 4.7 μF
C_2	NPO chip capacitor, 12 pF
C_3	MICP dip capacitor, .01 μF
L_1, L_0	12, 10 turns, respectively, of AWG #36 magnet wire on 3.2 mm diameter coil
Antennas	0.546 mm diameter twist flex triple strand stainless - 10 cm vert. and 7.5 cm horiz. antenna

Fig. 1. Circuit diagram of 1.7- to 1.9-g crystal-controlled 164-MHz radio transmitter with vertical and horizontal antennas.

and juvenile quelea (<3 months old) weighing 15.8-20.2 g in a 2 x 1.5 x 1-m outdoor flight cage during June and July 1980 at Arusha, Tanzania. In all tests radios were attached either to the leg (using aluminum leg bands) or to the base of the rectrices, using Sears[R] electric hot melt glue sticks, of between 2 to 6 birds. Thermogrip[R] hot melt glue previously has been used to attach transmitters to the tail feathers of raptors (Fitzner and Fitzner 1977). Birds carrying tail radios had their tail feathers secured with Super Glue[R] to prevent the feathers from dislodging upon flight. The condition of all birds was monitored daily for up to 3 weeks and the weight of the birds was periodically recorded.

Reception distances and battery life

Maximum ground and air reception distances were obtained for both types of radios in agriculture habitat in Tanzania. For aerial reception, a single yagi antenna mast was vertically mounted between the strut and wing of a Cessna 185-F aircraft. This antenna orientation was not ideal but was necessitated by lack of a proper antenna mast clamp. Tail and leg radios were placed on a 1.5-m wooden fence post, and the reception distances were obtained in line with and parallel to the antenna (in both outbound and inbound directions) at altitudes of 153, 305, 610, 915, 1220, and 1525 m.

Ground reception distances were determined over the rolling terrain of West Kilimanjaro, Tanzania. The radios were placed at ground level, vertically polarized (simulating feeding birds), in and on the edge of thick bush (simulating roosting birds), and monitored from the top of a Land Rover with a hand-held yagi antenna during the afternoon (1400-1600) and early evening (1700-1930).

The battery operating life and frequency stability of the radios were determined under moderate and extreme temperature conditions in Arusha, Tanzania and Khartoum, Sudan, respectively. Pulse rate and frequency were checked every other day for 2-3 weeks in each location.

Field tests with house sparrows

Radios were field tested on house sparrows between 22 January and 14 February 1981 in Fort Collins, Colorado. Sparrows were used because at 25-30 g they are approximately the same weight and size of red-billed quelea and also are agricultural pests in some African countries.

Radios were attached to the legs of 3 birds and to the tails of 2 birds that were known residents in the area; these birds previously had been captured and marked with leg streamers and/or leg bands. Leg streamer retention and wear has been studied for other birds (Guarino 1968, Royall et al. 1974, DeHaven 1975, Bruggers 1980). Leg-mounted radios were attached to the lower leg (tarsometatarsus), using both halves of a longitudinally cut aluminum leg band. Epoxy was applied on the transmitter to form a cradle for the bands. The 2 bands were placed on the bird's leg, a bead of hot melt glue was put in the cradle, and the radio was pressed onto the bands.

The tail-mounted radios were attached at the base of the tail rectrices. The upper tail coverts were first trimmed to allow the radio to be placed directly on the base of the rectrices. The attachment of the rectrices was reinforced with Super Glue[R]. A thin bead of hot melt glue was then applied to the base of the rectrices, the radio was positioned with the ground plane antenna parallel to the rectrices, and pressed into the glue (Fig. 2).

A numbered, orange Saflag[R] streamer, 1 cm wide and 3 cm long was attached to the leg of the sparrow using a 1A 3.18-mm internal diameter USFWS bird band. The numbered streamers allowed rapid field identification of individual radio-equipped birds in groups. The radio (with extra potting), leg band, and streamer weighed 2.0-2.25 g or 7-10% of the sparrow's body weight, proportionally similar to the 1.7-1.9 g radio to the quelea's body weight. In addition to the 5 birds with radios and streamers, 74 other house sparrows were captured and tagged with streamers. Instrumented birds were tracked several times daily for 3 weeks using LA-12 receivers (built by AVM Corp.*) and hand-held yagi antennas. Their daily movements and behavior patterns were then compared with those of sparrows carrying streamers. One radio-equipped bird also was captured after the battery had discharged. After removing the radio, the bird was released and observed in 5 occasions for the next 30 days.

RESULTS AND DISCUSSION

Laboratory and cage studies

Radios weighing 8-9% of the body weight were the maximum red-billed quelea could effectively carry; most individuals required an adjustment period of about 1 day. The tail attachment was preferable to the leg attachment. With the weight more evenly distributed, the bird was better able to maintain balance in flight and land more easily; birds with leg transmitters flew off balance and with 1 leg extended. Although a few red-billed quelea lost their tail (and radio) in the flight cages (in the process of handling or contact with the cage), several of the birds with leg radios developed swollen, infected, and even broken legs.

Quelea with radios attached to their tails also tended to maintain or put on body weight comparable to birds without radios (Table 1). The weight of 1 house sparrow that was recaptured and weighed when the radio battery had discharged was nearly identical (26.8 g) to when the radio was attached (26.9 g) and comparable to the weight of other sparrows of the same sex in the area (24.6-32.2 g; n = 9).

Battery life and transmitter stability

The battery life of 5 radio transmitters exposed to the moderate temperatures in Arusha, Tanzania [max. avg temp = 22.1°C (range 19.8-25.0); min. avg temp = 12.6°C (range 8.5-15.1)], and the extreme heat of Khartoum, Sudan [max. avg temp = 37.1°C (range 29.7-40.2); min. avg temp = 25.6°C (range 21.8-29.0)], was between 2.5 and 3.5 weeks. In both locations the pulse rates of all radios remained relatively stable when checked at the same time each day, but the fine-tune frequency setting shifted slightly. When placed in bright sunlight, the frequency also tended to drop; when temperature

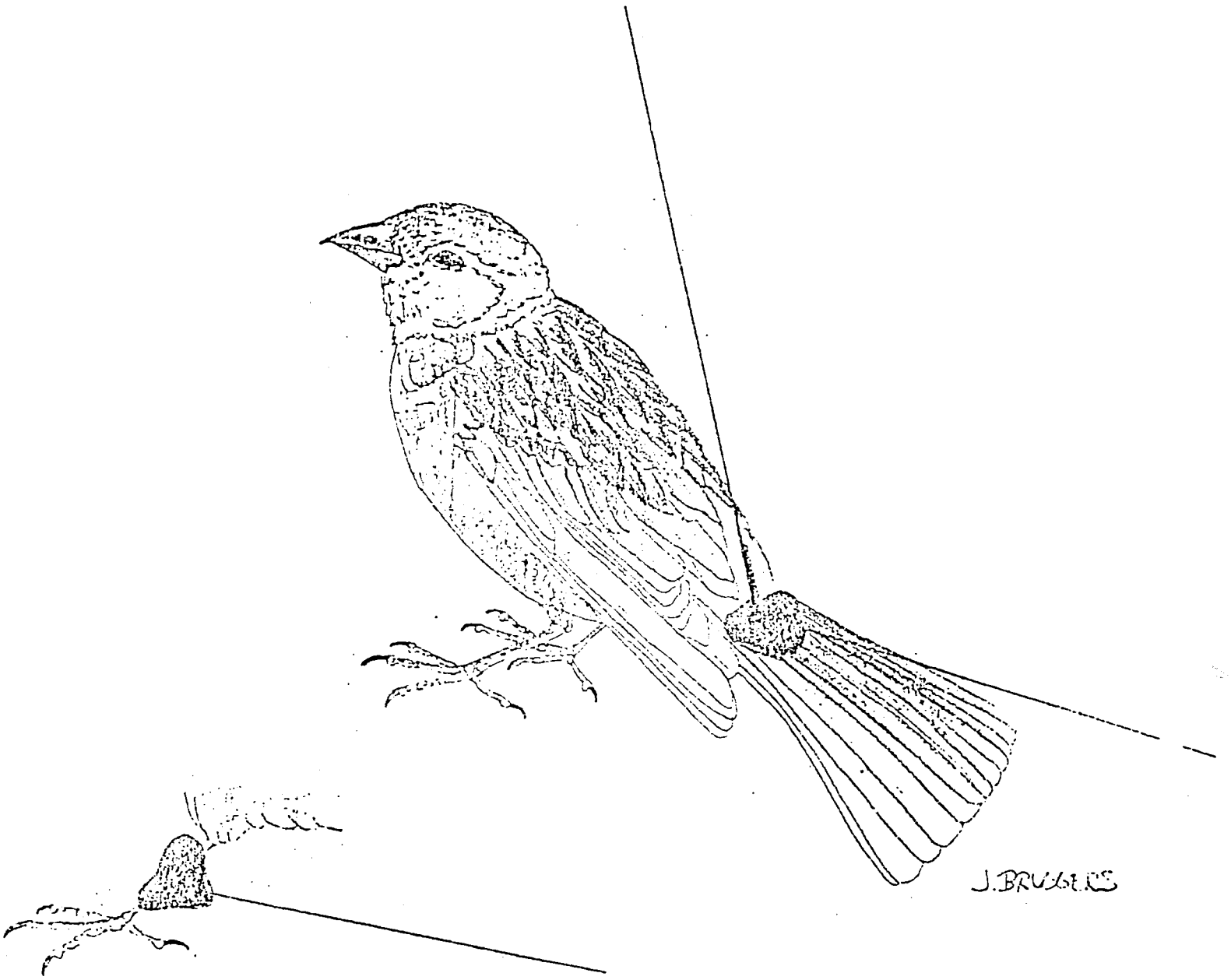


Fig. 2. House Sparrow (*Passer domesticus*) showing 1.8-g radio transmitters glued to the base of the tail and attached by bands to the leg. Illustration is actual size.

Table 1. Retention and weight change of red-billed quelea equipped with surrogate radio transmitters in an outdoor flight cage, Arusha, Tanzania, June- July 1980. Sample sizes are indicated in parentheses.

Attachment method	Avg wt (g) of radio	Avg wt (g) of birds Day 1	Day 7	Day 18	Comments*
Leg					
Adults	2.07	18.6 (5)	17.9 (3)	20.9 (1)	4 escaped, 1 died (broken leg)
Juveniles	2.10	18.1 (3)	16.4 (3)	16.5 (1)	1 escaped, 1 died
Total avg	2.08	18.4 (8)	17.0 (6)	18.7 (2)	
Tail					
Adults	2.03	17.7 (3)	18.2 (3)	19.7 (1)	tails of 2 birds dislodged**
Juveniles	2.03	18.4 (4)	19.8 (4)	22.9 (2)	1 died, 1 escaped
Total avg	2.03	18.1 (7)	19.1 (7)	21.8 (3)	
Reference					
Juveniles	no radio	17.3 (5)	18.8 (5)	20.3 (5)	all healthy

* Weights of dead birds or birds losing radios are not included in averages.
** Radio removed when tails dislodged during weighing.

decreased, it rose slightly. The same pattern was noted for radios on red-winged blackbirds in North Dakota (Knittle pers. comm.).

Reception and tracking distances

In agricultural habitat near Arusha and West Kilimanjaro, Tanzania, maximum ground and air reception distances for radios with both vertical and horizontal antennas were 5.6 and 30.6 km, respectively. The reception distances of leg- attached radios (which did not have horizontal antennas) were usually at least 50% less with a maximum distance of 12 km obtained. We found that the 7.6-cm horizontal antenna increased the radiated power by a factor of about four compared to the single vertical antenna. Longer aerial reception distances were obtained during inbound than during outbound flights for both types of radios. The tail, wing, and struts of the aircraft apparently interfered with reception during outbound flights, because the signal could be improved by circling. A loss of signal occurred off the wing tips (the ends of yagi antenna elements), which would be expected considering the non-conventional attachment method. Between altitudes of 305 to 1525 m, excellent reception of 22 to 31 km was attained with the tail radios. Reception was impaired when the aircraft was in the clouds.

Effective ground signal range was limited by line of sight. In areas of topographical relief, the signal was lost behind hills. Signals from radios placed at 2-m heights in bushes (comparable to roosting birds) were strong

for 0.4-0.6 km; signals were received only 0.2-0.3 km for radios placed on the ground in 0.5-m grass. Reception was better during the early evening (5.6 km) than during the day (1.6-2.8 km). Ground tracking distance for all radios in the urban/university environment of Fort Collins was limited to between 0.5 and 1.0 km because of interference.

Behavior observations with house sparrows

Both leg and tail attachment methods initially inhibited the flying ability of the birds. Most individuals at first seemed reluctant to fly and hopped on the ground or in bushes for about 10 min before making short flights. They experienced some difficulty gaining altitude and flew with their tail drooping or leg extended under the weight of the radio. However, all birds, and particularly those with tail-attached radios, adjusted to the weight of the package and flew as well as birds without radios within 1 day. Some birds occasionally pecked at the leg radios, the antennas, or the streamers. None of the birds with radios died. Overall, the tail attachment package performed better and seemed more practical for house sparrows and red-billed quelea than the leg attachment package. However, the leg attachment method has worked very well on 50- to 70-g red-winged blackbirds (Knittle pers. comm.) and it may be more applicable to larger passerines.

Birds with radios appeared to exhibit the same general movements and habits as birds with streamers or with leg bands during the time of the year this study was conducted. Radio-equipped birds fed regularly at several bird feeders as far as 0.5 km from their trapping site and remained in flocks of 20-30 individuals, many of which had neither streamers nor radios. Four of 5 instrumented birds maintained their roost site throughout the study. One radio-equipped bird changed its roost site when its roost tree was pruned. The bird from which the radio was removed continued to feed and roost in the same locations for 30 days. Birds with leg streamers also tended to retain premarking roosting patterns; 6 birds tagged in a roost site were regularly seen or recaptured there. Several other birds left this roost, presumably disturbed by our trapping efforts.

Birds with radios were tracked an average maximum distance of 529 m from their capture site; birds with only streamers were seen an average maximum distance of 218 m from their marking site. The distances radio-equipped birds moved were greater but undoubtedly biased due to the difficulty of locating birds with streamers. However, maximum foraging distances were equivalent for birds with radios and birds with streamers. Radio-equipped birds were tracked as far as 840 m from their capture site and foraged in an area of 0.5 km^2; birds with streamers were tracked as far as 850 m and foraged in an area of 0.6 km^2 (Fig. 3). Bray et al. (1975), Raim (1978), whose radios weighed 3-5% of the body weight of cowbirds, and Cochran et al. (1967) whose radios weighed 8% of the body weight of Hylocichla thrushes, also believed that radios did not adversely affect the movement distances or certain activities of starlings, cowbirds, or thrushes, respectively. Likewise, Graber and Wunderle (1966) instrumented a 30-g house sparrow with a 4.7-g radio and concluded that the sparrow "could fly well, climb, and maneuver sharply without obvious difficulty."

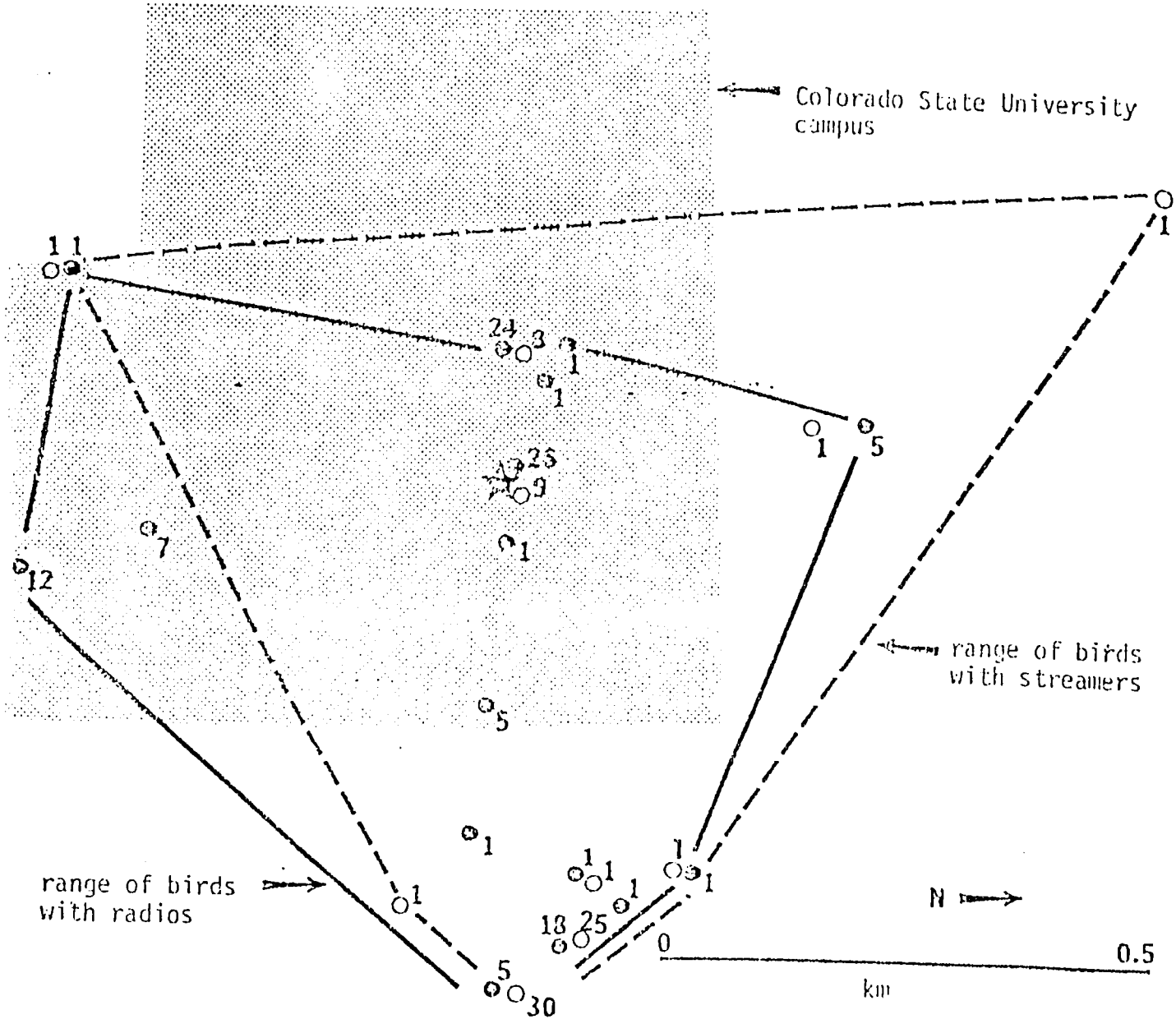


Fig. 3. Location and sighting frequency of house sparrows marked with leg streamers (O) or radio transmitters (⊙) between 22 January and 14 February 1981 in Fort Collins, Colorado. ☆ indicates the capture and marking location.

CONCLUSIONS

As with all telemetry studies to date, the impact of the transmitter package on the movement patterns of the animal studied is difficult to assess. Birds as small as sparrows and red-billed quelea present special problems because the weight of the transmitter package represents such a high proportion of their body weight. The use of these radios ultimately depends on the objectives of the study. For example, this high weight proportion may be acceptable for short-term studies describing the local, daily movements of certain species, but inappropriate for reproductive behavioral studies of the same species. Our preliminary study indicates that house sparrows apparently were able to accept and adjust well to these transmitter packages without any major behavioral modification. Although longer, more detailed behavioral studies would be desirable, our present laboratory and field results are particularly encouraging regarding the use of these radios for field studies of small passerine birds. Undoubtedly, each species will need to be evaluated individually.

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