SOME EFFECTS OF NEUTRON-GAMMA RADIATION ON LATE SUMMER BIRD POPULATIONS

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IN 1960 the late summer bird populations of a small valley 50 miles north of Atlanta, Georgia, were exposed to high level neutron-gamma radiation which was released from a 10 megawatt, air-shielded nuclear reactor at Air Force Plant 67. The reactor operated for five days in each of three consecutive weeks and was shut down on weekends. The purpose of this study is to compare the changes in numbers of birds living in the radiated valley with those in a similar non-radiated area.

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METHODS

Birds were censused on the two study areas, each about 3,000 feet (900 m) in diameter, from 26 July to 30 August 1960. Both the irradiated and control areas contained a stand of old field vegetation of forbs and grasses with a few woody shrubs; both were surrounded by ridges which supported mixed deciduous and pine forests. Censuses were made before, during, and after the reactor operations. Each census, consisting of two counts taken on consecutive days, began at about 0600 hours and lasted about two hours. Numbers given represent the average of each two counts. The census route circled the study area and was about 1,000 feet from its center. I think that the majority of the singing birds within a circle 3,000 feet in diameter was counted. A preliminary census was made in the radiated area five days before the reactor began operation. All successive censuses were made at weekly intervals, the first beginning two days before the reactor started to irradiate the valley. The radiated area was censused on Saturdays and Sundays, when the reactor was inactive, and the non-radiated area was censused on Mondays and Tuesdays.

The locations of all birds seen or heard were mapped and numbered. Singing birds were assumed to be resident in a breeding territory despite the lateness of the season. Single birds that were seen but did not sing were assumed to be in non-breeding or post-breeding condition unless they were in a previously delimited territory.

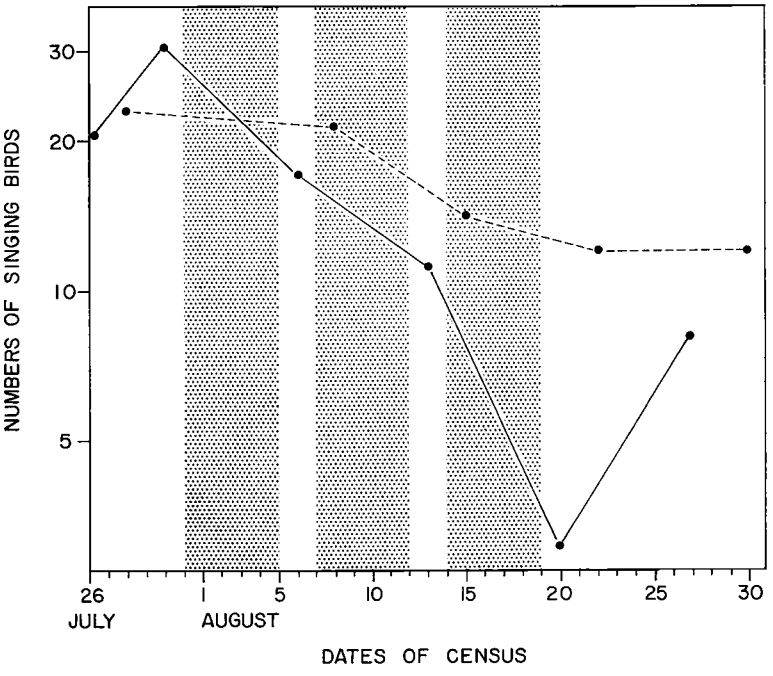

Figure 1. Total numbers of singing Eastern Wood Pewees, Carolina Wrens, White-eyed Vireos, Indigo Buntings, Yellowthroats, Red-eyed Vireos, and Bobwhites that exhibited well defined territories in both irradiated (solid line) and control (broken line) study areas. Stippled areas indicate periods when the reactor was in operation.

Most of the birds observed were within 1,500 feet of the reactor. Doses received by individual singing birds were estimated on the basis of the distance from the center of their territory to the reactor, the time that the territory was occupied, and the dosage rates as determined by Cowan and Platt (1963) for the various distances. Dosages are expressed in rads (absorbed dose of 100 ergs of energy per gram of tissue). With respect to the effects on living organisms, a rad is nearly equivalent to a roentgen (r).

RESULTS

A total of 50 species was observed during the study; 34 of these were observed in both the irradiated and non-irradiated study areas. Individuals of 7 of the 34 species exhibited well defined territories and could be censused easily by their vocalizations. In the irradiated area all of these individuals were located within 1,500 feet of the reactor. The numbers of singing birds for both areas are shown in Figure 1. These territorial birds declined at a greater rate in the irradiated area than in the control area.

TABLE 1

NUMBERS OF SINGING INDIVIDUALS PRESENT IN BOTH THE IRRADIATED AND CONTROL AREAS AT GIVEN TIMES

Species	*Dates for control area*[1]					*Dates for irradiated area*[1]					
	July	*August*				*July*		*August*			
	28	*8*	*15*	*22*	*29*	*26*	*30*	*6*	*13*	*20*	*27*
Eastern Wood Pewee	6	5	4	4	2	8	10	7	6	2	3
Carolina Wren	0	2	1	2	2	1	3	1	0	0	2
White-eyed Vireo	4	3	2	2	2	2	2	2	2	0	2
Indigo Bunting	5	4	3	1	1	2	4	3	0	0	0
Yellowthroat	4	3	1	1	2	2	2	0	0	0	0
Red-eyed Vireo	2	3	3	1	2	4	6	3	3	1	1
Bobwhite	2	1	0	1	1	1	4	1	0	0	0
Totals	23	21	14	12	12	20	31	17	11	3	8

[1] Values represent an average of the numbers of birds observed on two consecutive days. Dates given are the first day of each census.

The singing Indigo Buntings (*Passerina cyanea*), Yellowthroats (*Geothlypis trichas*), and Bobwhites (*Colinus virginianus*) disappeared after the first week of irradiation. In the control area these species decreased in numbers but did not disappear (see Table 1). Several Carolina Wrens (*Thryothorus ludovicianus*), Eastern Wood Pewees (*Contopus virens*), White-eyed Vireos (*Vireo griseus*), and Red-eyed Vireos (*Vireo olivaceus*) also disappeared from the irradiated area. The estimated range of doses received by the disappearing birds is presented in Table 2.

In contrast, the numbers of non-singing individuals which were not occupying territories declined slightly in both areas, but no difference was detectable between irradiated and control areas (Figure 2).

DISCUSSION

The calculated actual dose received by individual birds is approximate for the following reasons. (1) Movements of an individual in its territory are known only from the records of the weekly censuses. Therefore, the territorial center plotted from the map data may not be accurate. However, even if the real center could be determined, it would probably not represent the bird's average position in terms of time. (2) The total time that an individual occupied a particular territory could not be accurately determined. If a bird appeared in two censuses, but was absent during the third, it resided in the study area for at least seven days, and may have been present for six additional days. Thus, both minimum and maximum possible doses are given in Table 2. (3) Shielding of the habitat probably differs between species of birds, as it did for species of small mammals at the reactor site (Schnell, 1963). For example, the Indigo Buntings were

TABLE 2

ESTIMATED DOSAGES OF RADIATION RECEIVED BY BIRDS THAT DISAPPEARED FROM THE IRRADIATED AREA

Species	*Individuals*	*Minimum*		*Maximum*	
		Total dose[1] *received (in rads)*	*Days of exposure*	*Total dose*[1] *received (in rads)*	*Days of exposure*
Indigo Bunting	1	700	5	2,300	14
	2	875	5	2,775	14
	3	0	–	500	5
	4	600	5	2,200	14
Yellowthroat	1	0	–	2,600	5
	2	0	–	20,000	5
Bobwhite	1	0	–	650	5
	2	100	5	310	14
	3	0	–	860	5
	4	0	–	350	5
Carolina Wren	2	0	–	1,150	5
	3	700	5	3,000	14
	4	0	–	1,150	5
Eastern Wood Pewee	1	1,200	5	3,700	14
	2	420	5	1,260	14
	4	1,140	14	1,740	21
	5	0	–	2,600	5
	7	0	–	700	5
	8	1,360	14	2,060	21
	9	2,760	14	4,260	21
	10	1,150	5	5,600	14
White-eyed Vireo	1	5,950	14	8,970	21
	2	17,900	14	27,700	21
Red-eyed Vireo	1	4,050	14	6,150	21
	2	0	–	3,300	5
	3	350	5	1,140	14
	5	0	–	710	5
	6	1,400	5	4,500	14
	7	700	5	2,300	14

[1] A zero indicates that the bird was heard singing only before the area was irradiated and not in the later censuses.

well exposed because they perched in the tops of trees and on the ends of branches. In contrast, the White-eyed Vireos were shielded since they spent much time close to the ground investigating cavities along a river bank which was not in a direct line of sight with the reactor. The supposed relative degree of shielding of the singing birds is, in increasing order, Indigo Buntings, Yellowthroats, Eastern Wood Pewees, Red-eyed Vireos, Bobwhites, Carolina Wrens, and White-eyed Vireos. Detailed behavioral studies or dosimeters attached to the individual birds would be necessary to substantiate these suppositions. (4) Radiation sickness may cause a decrease in singing activity; if so, the absence of singing would not necessarily

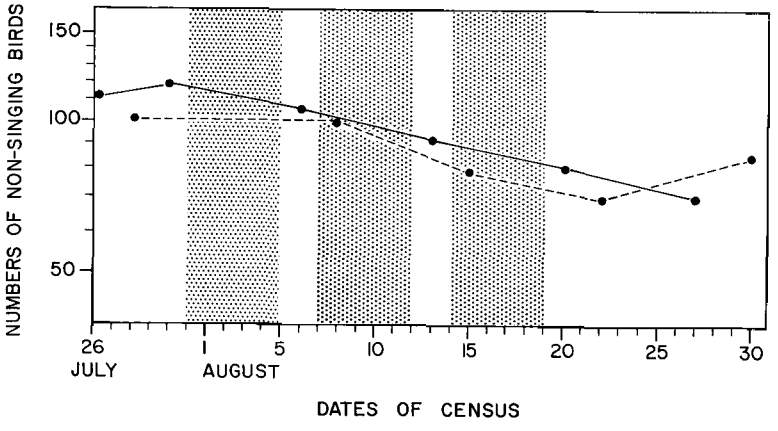

Figure 2. Total numbers of non-singing and non-territorial individuals in the irradiated (solid line) and control (broken line) areas. Stippled areas indicate periods when the reactor was in operation.

mean that the birds had disappeared. Thus, if the birds were still present, the actual exposure time would be higher than that estimated.

In late summer, a decline in singing and territoriality would be expected; this was observed on the control area. However, the difference in the slopes of the curves seen in Figure 1 suggests a definite effect of radiation on the resident populations in the irradiated area. Undoubtedly some of the exposed singing birds were affected although no dead or sick birds were observed. It is likely that the movements of non-territorial birds that occur in late summer prevented large-scale deaths. Most birds probably did not remain near the reactor long enough to obtain a severe dose.

The first and last censuses of the irradiated area require special comment. The irradiated area was sampled first, and the low count may reflect my unfamiliarity with the census area and the birds found there. The increase in numbers indicated by the last census, one week after the last reactor operation, may have been caused by immigration of wandering birds into the recently vacated territories. This type of replacement has been reported by Stewart and Aldrich (1951) and by Hensley and Cope (1951). In the latter study the authors stated that the newcomers established territories in the same areas as their predecessors. It is not clear, however, why the replacement in the present study did not occur until a week after the reactor terminated operation; probably the lateness of the season was a factor. An alternative explanation would be that the birds stopped singing because of radiation sickness but recovered before the last census.

The lethal dose necessary to kill 50 per cent of the population within 30 days ($LD_{50/30}$) for wild birds is poorly known. Willard (1963) reported the LD_{50} for nestling Eastern Bluebirds (*Sialia sialis*) to be about 2,500 roentgens for a 16-day period. Stearner and Tyler (1962) reported that of four species of domesticated or semi-domesticated birds the pigeon (*Columba livia*) is most resistant. They found that the $LD_{50/30}$ with a protracted exposure of 480 to 1,440 minutes was 3,159 r for pigeons; 2,297 r for parakeets; 1,630 r for chicks; and 1,015 r for canaries. Of the 29 birds that disappeared from the irradiated area in the present study, 22 could have received over 1,015 rads and of these 9 could have received over 3,159 rads (see Table 2). The doses were delivered over a period ranging from five days to three weeks. This long exposure time means that the lethal dose for 50 per cent of the population may be slightly higher than those reported for other situations.

Apparently, radiation affected the territorial birds adversely, but since no dead birds were found it could not be determined whether the disappearances were due to radiation mortality, reduction of the singing urge due to radiation sickness, or emigration as a result of radiation flux. To clarify some of the questions raised here, future investigators might use a mist net program to equip the birds with glass rod dosimeters and make periodic checks on weight changes and general condition during the period of study.

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