RADIATION RESEARCH 49, 322–327 (1972)

Mortality of Mallards Exposed to Gamma Radiation

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ABRAHAM, RICHARD L. Mortality of Mallards Exposed to Gamma Radiation. *Radiat. Res.* **49,** 322–327 (1972).

An $LD_{50(30)}$ level of 704 R was calculated for 4-month-old captive mallards. Fifty-five percent of all deaths occurred within the first 16 hours postirradiation. All deaths occurred within 18 days postirradiation. Comparison was made in the rate of dying and the number of deaths between two groups of young game-farm and old wild-caught mallards both given equal high doses of radiation. The percentage of deaths was similar in both groups, but the younger mallards died at a slightly faster rate.

INTRODUCTION

There have been few studies devoted to determining the sensitivity of birds to ionizing radiation. Only two studies have been concerned with fully grown waterfowl. $LD_{50(30)}$ levels of 485 R, 715 R, and 894 R have been determined for green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), and shovelers (*Anas clypeata*) (*1*). The other study on waterfowl reports $LD_{50(30)}$ levels for one-year-old mallards (*Anas platyrhynchos*) of 650 R for x-radiation and 630 R for 60-Co, Gamma radiation (*2*).

This paper reports on the radiation sensitivity of 4-month-old (young) and 40-month-old (old) mallard ducks (*Anas platyrhynchos*). Birds were exposed to whole-body gamma irradiation from a cesium-137 source. The experiments were conducted to provide baseline information for a future study designed to investigate the effects of ionizing radiation on mallard vocal behavior.

METHODS

A flock of 60 mallards 10–14 week-old were obtained from a local game farm. They were acclimated to pen conditions for two weeks at the University of Minnesota's Cedar Creek Natural History Area. Before they were placed in the pens, the birds were banded and randomly divided into 6 groups of 10 birds each(five of each sex). Five of the groups were irradiated, and the sixth was used as a control. Irradiations

consisted of single exposures of 350, 500, 650, 800, and 950 R. The birds were exposed laterally to a 10,000-Ci cesium-137 source in the University of Minnesota Gamma Irradiation Facility. Experimental birds were placed into ten individual 4 × 8 × 10 inch boxes fastened in an arc 34.5 inches from the center of ten cesium pencils in a 5-inch-diameter configuration. All birds of an exposure group were irradiated at the same time. Exposure rate at the center of each box was 51 R/minutes as determined by a Victoreen rate meter. The birds were subjected to one-half of the total exposure from each side. Controls were subjected to "sham" irradiation for the same amount of time as the 950 R group. All groups were weighed, irradiated, and returned to their pens within 5 hours after removal.

A second series of irradiations was started 3 weeks after the young birds were irradiated. A flock of mallards which had been trapped in the wild as juveniles in the fall of 1967 had been held in pens at Cedar Creek since their capture. Twenty of these 40-month-old birds were divided randomly into two equal groups and subjected to the same 800 R and 950 R levels which had proved fatal to most of the young game farm ducks. Two of the 10 birds in the 800 R group died during irradiation. Both were autopsied, but the cause of death could not be determined. Suffocation was the probable cause of death. Thus, the 800 R old bird sample had only 8 birds.

Both groups of ducks were checked daily for 40 days after irradiation. Data were collected on days post irradiation until death, weight at death, posture at death, and survivor weights at end of 40 days. Fourteen of the young birds which died were autopsied at the University of Minnesota Veterinary Diagnostic Laboratories. Sixteen of the birds which survived were killed at the end of 40 days and also autopsied.

RESULTS

The survival data collected after gamma irradiation of the 4-month-old mallards is presented in Fig. 1. None of the control, 350 R, or 500 R birds died. Two died in the 650 R group and 9 died in each of the 800 R and 950 R groups. Eleven of the 20 birds which died succumbed within the first 16 hours after irradiation. No birds died during the second day. Nine other birds died during the 3 weeks following irradiation with the last bird dying on the eighteenth day after irradiation. An exposure-response curve was approximated by linear regression on the percentage data (Fig. 2). This approach was taken because the distribution of sample points and the small sample size did not justify detailed probit analysis.

In the second experiment, in which twenty 40-month-old wild caught mallards were irradiated, five of the 8 birds in the 800 R group and nine of the 10 in the 950 R group died. Although the number of deaths in the 800 and 950 R groups is similar in both the young and older birds, there is a noticeable difference in the rate of deaths, the younger birds succumbing more quickly (Fig. 3).

Table 1 presents data on percentage weight lost or gained post irradiation for the young birds. All those birds which died lost weight. The maximum percent weight

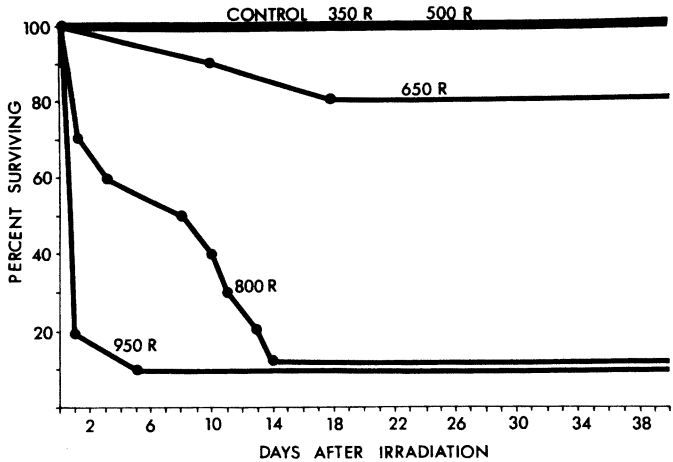

FIG. 1. Percentage of survival after irradiation of 4-month-old mallards. Dots on lines indicate days on which deaths occurred.

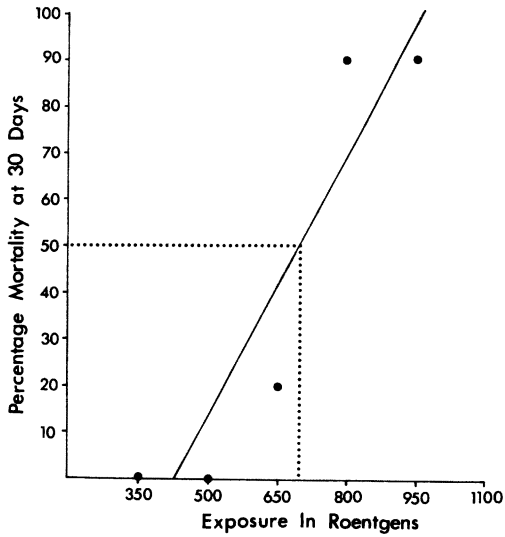

FIG. 2. Computed lethal exposure levels for a 30-day period after irradiation for 4-month-old mallards. Equation of the line is: Percent Mortality = $-79.9 + 0.184$ Exposure.

lost before death was 35%. All birds which lived had gained weight when killed 40 days post irradiation. It is interesting that the two young birds in the 950 R group which survived beyond the first day after irradiation were 25% lighter than the other 8 birds in the group.

Six of the 34 dead young and old birds were found in the water, although there was

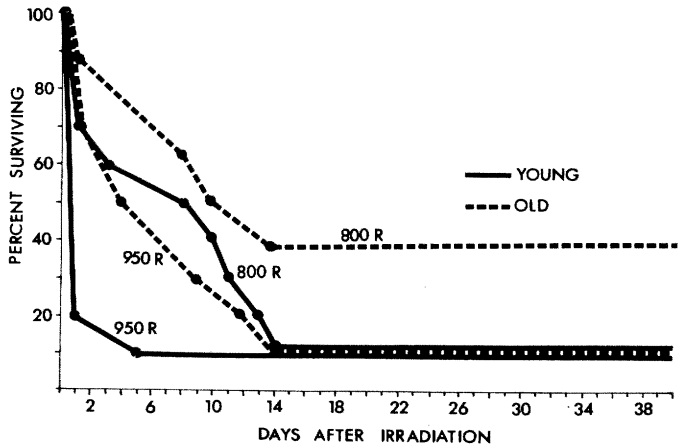

FIG. 3. Percentage survival of two groups of 4-month-old game farm and 40-month-old wild caught mallards exposed to 800 and 950 R. Sample size was 10 birds for each group, except the 800 R old bird group which had only 8 birds. Dots on lines indicate days on which deaths occurred.

an equal amount of water area in the pen. Of the remaining 28 birds which died on land only two were found on their backs. The rest were found resting on their stomachs with their head flopped forward, wings drooped slightly, and their feet tucked under.

During the first few days following irradiation, the droppings of many of the birds appeared lime green, which is usually an indication of sickness in ducks. Fourteen of the dead young birds were autopsied. Gross internal examinations often showed intestinal hemorrhaging and hemorrhaging on mesentary tissues of heart and gizzard. One bird had severe pneumonia. All of the birds autopsied, which died after 10 days, showed pale bone marrow. Bacterial liver cultures from the 14 birds showed *Escherichia coli* present in one of 8 birds which died one day after irradiation and in four of 6 birds which died longer than 5 days after irradiation.

Sixteen of the survivors were killed and autopsied 40 days after irradiation. There were no signs of hemorrhaging, and bone marrow appeared normal. All birds except the lone survivor of the 950 R young group were fat. Hemoglobin values as determined by spectrophometric analysis for survivors and controls 40 days post irradiation are listed in Table 2. There were no apparent differences between the values for the controls and the irradiated birds. All values fell within the 12.9–18.2 range presented for tame mallards by Magath and Higgins (*3*).

CONCLUSIONS

The $LD_{50(30)}$ level of 704 R calculated for 4-month-old mallards is similar to the 630 R $LD_{50(30)}$ level previously determined for 1-year-old mallards (*2*). Both of these values are greater than the 485 R $LD_{50(30)}$ level of the green-winged teal but less than

TABLE I

PERCENTAGE WEIGHT CHANGE IN 4-MONTH-OLD MALLARDS POSTIRRADIATION

Exposure in roentgens	*Days postirradiation until death*	*N*	*Mean percent weight change*	*Standard deviation*
800	1	3	0.0	1.8
950	1	4	−0.4	2.4
950	5	1	−26.8	
800	8	1	−34.9	
650	10	1	−11.0	
800	10	1	−9.3	
800	11	1	−15.6	
800	13	1	−17.1	
800	14	1	−15.1	
650	18	1	−19.1	
350	40[a]	10	+16.5	3.9
500	40[a]	10	+14.9	6.9
650	40[a]	8	+16.1	7.6
800	40[a]	1	+11.2	
950	40[a]	1	+5.4	
Control	40[a]	10	+17.7	6.8

[a] Killed 40 days after irradiation.

TABLE II

HEMOGLOBIN VALUES FOR SURVIVORS AND CONTROLS FOR EXPOSURES SHOWN KILLED 40 DAYS POSTIRRADIATION

Hemoglobin values					
950 R	800 R	650 R	500 R	350 R	*Control*
15.3	13.8	14.3	13.5	15.3	13.5
		16.0	14.3	15.5	15.3
		16.3	16.0	15.5	15.5
		16.5			16.0

the 715 R and 894 R $LD_{50(30)}$ levels of blue-winged teal and shovelers (*1*). All three of these species on the average weigh less than one-half as much as mallards.

Although older mallards initially showed a greater resistance to radiation in the second experiment, a nearly equal number of older birds exposed to the same 800 R and 950 R levels eventually did die. The younger birds were from game-farm stock, whereas the older mallards were caught and held in captivity for 3 years.

There have only been a few experiments concerned with radiation sensitivity of waterfowl, and all of those are not strictly comparable, but the combined results of those and my experiments suggest that weight, sex, age, and length of captivity have

little influence on radiation resistance of the different species. It would appear that such differences are the results of specific variability.

ACKNOWLEDGMENTS

I am grateful to Dr. D. M. Barnes of the Veterinary Diagnostic Laboratories, University of Minnesota, for his help in performing autopsies; to the personnel of the University of Minnesota Gamma Irradiation Facility for their assistance in irradiating the ducks; to Alvar Peterson of the Cedar Creek Natural History Area for his cooperation; and to Dr. Frank McKinney for his helpful comments on the manuscript.

This project was financed by U. S. Atomic Energy Commission Contract AT(11-1)-1332 (COO-1332-62).

RECEIVED: July 22, 1971

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