COO-1156-32

RECEIVED BY DTIE FEB 18 1970

Radiation $LD50_{(30)}$ of Pikas (Ochotona princeps) in the Natural Environment and in Captivity[1]

O. D. Markham and F. W. Whicker
Department of Radiology and Radiation Biology
Colorado State University
Fort Collins 80521

[1] This work was conducted under Contract AT(11-1)-1156 between the U. S. Atomic Energy Commission and Colorado State University.

DISCLAIMER

ABSTRACT

Estimates of the $LD50_{(30)}$ from ^{60}Co radiation were made for a group of pikas (Ochotona princeps) held in captivity and for another group observed in the natural environment near the summit of Mount Evans, Colorado. The $LD50_{(30)}$ estimate was 560 r (438-717 r; 95% confidence limits) for captive animals and 380 r (250-578 r) for pikas at Mount Evans. Mean survival time for irradiated pikas was 9 to 13 days in captivity and 5 to 7 days in the natural environment. Results are discussed in relation to artificial stresses resulting from captivity and natural stresses such as intraspecific competition and predation.

Key Words: $LD50_{(30)}$, pikas, synergisms.

INTRODUCTION

Although several studies have been made on the radiosensitivity of wild mammals, most of the experiments have been conducted with captive animals. Information obtained from laboratory studies may not be applicable to a species in its natural environment because captivity exposes the animal to new stresses while protecting it from natural ones. These stresses may form synergisms with radiation and significantly alter the results. This report describes an effort to compare the radiosensitivity of pikas (Ochotona princeps) in a captive colony near Fort Collins, Colorado to pikas in their natural habitat at Mount Evans, Colorado.

Pikas at Mount Evans inhabit rocky areas in the alpine tundra at elevations from 3450 to 4340 m. At these elevations, animals are subjected to relatively severe weather conditions. Adaptations of animals to permit survival in relatively harsh environments may influence radiosensitivity.

ACKNOWLEDGMENTS

We wish to thank A. W. Alldredge for his able assistance throughout the study, and W. C. Dewey and R. J. Garner for reviewing the manuscript.

MATERIALS AND METHODS

Pikas were live trapped at elevations between 3960 and 4175 m on Mount Evans by placing #1 Havahart traps baited with pika hay near their dens and hay piles. The animals were transferred from the traps to 4 x 8 x 4 inch (10 x 20 x 10 cm) ventilated plyboard boxes supplied with their natural feed. Transfer was accomplished without handling the animals. Pikas were transported at the end of each trapping day to Fort Collins and either released in the captive colony or irradiated and returned to Mount Evans early the following day. Transit time between Fort Collins and Mount Evans was two to three hours. Pikas returned to Mount Evans remained in the transportation boxes approximately 14 hours.

All animals received whole-body irradiation while confined in the transportation boxes. Doses ranging from 200 to 1000 r were delivered at 50 r/min from a 4430 curie ^{60}Co source. The control groups were subjected to the same procedures as the other randomly selected groups including sham irradiation. No attempt was made to group pikas by sex but only mature-sized animals were irradiated.

NATURAL ENVIRONMENT STUDY

The pikas were trapped and irradiated within a 13-day period in August, 1968. Several dose levels, depending upon the numbers of pikas trapped, were administered each day and each dose level was given at intervals throughout the period.

Prior to release, each pika was tagged with a numbered fingerling monel ear tag. The opposite ear was color coded by attaching 3/8 and 5/8 inch (9.5 and 16.0 mm) diameter colored celluloid washers to each side of the ear with a semitubular rivet. The larger washers could, under ideal conditions, be distinguished as far away as 70 m but usually the observer had to be within 30 m to observe the washers on both sides of the ear. Each pika was then released at the location of its capture. A colored flag attached to a wire probe and the ear tag number painted on a rock near the flag marked each release site.

The trapping area of approximately 9 acres (415 by 90 m) and adjacent areas were normally observed with binoculars and spotting scopes for 2 to 8 hours daily during the 30 day post irradiation period. If a color coded pika was observed in the same area for several days and then was not seen during the remainder of the study, the animal was assumed dead.

CAPTIVE COLONY STUDY

Pikas trapped in July and August, 1968 were placed in the captive colony and were irradiated in October. In earlier work we were not successful in keeping pikas alive in captivity with normal indoor laboratory facilities. As a result, several special provisions were made for the animals by modifying some ideas described by Severaid (1955) (Fig. 1). For example, the pikas had to be individually

confined to avoid the fighting and subsequent mortality that would otherwise result. Underground dens provided security and also a cool retreat for the animals during the summer days. (During the period of July 17 - August 4, maximum den temperatures averaged 13°C less than maximum ambient air temperatures at ground level in the shade.) Water and commercial rabbit feed were provided ad libitum. Dandelions (Taraxacum sp.) were fed daily until October when lettuce was gradually substituted for the dandelions. Food and water consumption was noted each day and when intake dropped the den was opened and the animal's status determined.

RESULTS

A summary of the survival data is shown in Table 1. Figure 2 shows probability plots for the acute dose-mortality data. The $LD50_{(30)}$ value for pikas in the natural environment was estimated to be 380 r (250 to 578 r 95% confidence limits; method of Litchfield and Wilcoxon, 1949). The $LD50_{(30)}$ for pikas in captivity was 560 r (438-717 r). Corrections for survival in the control groups were applied to the data prior to the LD50 calculations. The average survival time of irradiated pikas that died within 30 days at Mount Evans was 5 to 7 days, whereas corresponding captive pikas lived 9 to 13 days.

Seven of the pikas that were returned to the natural environment after treatment were not observed again after the date of their release.

These animals were not included in the $LD50_{(30)}$ determination since their immediate fate was unknown. These pikas may have died immediately as a result of being in the transportation box overnight (three deaths did occur in transit) or the ear tagging procedure may have been sufficient to cause death as pikas are vulnerable to shock disease (Severaid, 1955). Some of the unobserved animals may not have had an established territory or were unable to reclaim their territory and left the area. All of the remaining pikas appeared to defend the same territories that they had held prior to their capture, although some of these territories had to be reclaimed since other pikas had moved in during the absence of the experimental animals.

The first indication of the disappearance of a tagged individual was often the presence of an untagged pika at the den where the tagged individual previously had been active. The only fatality actually observed at Mount Evans was an animal from the 600-r group. Only one control disappeared in the natural environment during the 30-day post-irradiation period and one control died in the captive colony.

DISCUSSION

Both experiments suggest that the pika is relatively sensitive to ionizing radiation in comparison to other wild mammals (Chang et al., 1964; Golley et al., 1965; Gambino and Lindberg, 1964; Provost et al., 1965) and similar in sensitivity to laboratory mice (Roderick, 1963).

This result suggests that the pika's adaptation to an alpine environment does not appear to confer any special degree of resistance to radiation. The possibility exists however, that the apparent radiosensitivity of the pikas could have resulted from natural and artificial stresses interacting with the irradiation treatment.

The apparent difference in $LD50_{(30)}$ values for pikas in captivity versus those in the natural environment cannot be tacitly assumed as real because the experiment was not replicated. Nevertheless, a probable difference seems to be indicated and further study may be warranted.

The nature and degree of stress imposed upon the captive pikas by the change in climate and surroundings is not known, except for the fact that 89% of the controls survived the 30-day study period. Other workers have reported that higher temperatures for example, appear to be detrimental to captive pikas (Severaid, 1955; Dice, 1927).

Synergisms between radiation and social stress may have contributed to the apparent differences in radiosensitivity between the two environments. Pikas in the natural environment aggressively defend their territories, but pikas in captivity had to be caged individually because of this social behavior. Hahn and Howland (1963) demonstrated that singly caged female albino rats were more apt to survive a dose of 500 r than rats which were housed in multiples.

Predation could have also been responsible for the lower $LD50_{(30)}$ in the natural environment. Animals suffering from radiation sickness in the laboratory may recover whereas corresponding pikas in the natural environment may become easy prey for the long-tailed weasels (Mustela frenata) and martens (Martes americana) which were repeatedly observed on the Mount Evans study area. One pika which received 600 r may have been saved from such a fate by the observers' presence. This animal was so weak that it did not react to the observers' approach until it was touched. A weasel was approximately 40 m from the animal at this time.

The observation that irradiated pikas in the captive colony appeared to survive for longer periods of time than animals in the natural environment may be of significance. Reduced activity prior to death would have decreased the probability of a pika being observed in the natural environment. However, a synergism between radiation and social competition may have been responsible for the apparent reduction in survival time at Mount Evans. Predators may have also contributed to reduced survival times.

REFERENCES

Chang, M. C., D. M. Hunt and C. Turbyfill. 1964. High resistance of mongolian gerbils to irradiation. Nature, 203:536-537.

Dice, L. R. 1927. The Colorado pika in captivity. J. Mammal., 8:228-231.

Gambino, J. J. and R. G. Lindberg. 1964. Response of the pocket mouse to ionizing radiation. Radiat. Res., 22:586-597.

Golley, F. B., J. B. Gentry, E. F. Menhinick and J. L. Carmon. 1965. Response of wild rodents to acute gamma radiation. Ibid., 24:350-356.

Hahn, E. W. and T. W. Howland. 1963. Modification of irradiation response of female rats by population density. Ibid., 19:676-681.

Litchfield, J. T. Jr. and F. Wilcoxon. 1949. A simplified method of evaluating dose-effect experiments. J. Pharmacol. Exp. Ther., 96:99-108.

Provost, E. E., M. R. Pelton and F. E. Kellogg. 1965. The effects of acute gamma irradiation on survival in feral rodents, p. 35-39. In: G. A. Sacher (ed.), Radiation Effects on Natural Populations - A Colloquium held in Philadelphia, May 23, 1965. Issued by Argonne Nat. Laboratory, Argonne, Ill.

Roderick, T. H. 1963. The response of twenty-seven inbred strains of mice to daily doses of whole-body X-irradiation. Radiat. Res., 20:631-639.

Severaid, J. H. 1955. The natural history of the pikas (Mammalian genus Ochotona). Ph.D. thesis. Univ. of California, Berkeley. 820 p.

Table 1. Summary of survival data for irradiated pikas

Dose (R)	No. in treatment group	Fraction observed after 30 days (F)		Survival time for mortalities (days post irradiation) Average	Range
Pikas in natural environment					
0	10	8/9*	(.89)	8	(8)
300	7**	3/5	(.60)	7	(4-10)
600	7	1/6	(.17)	6	(3-8)
900	6	0/4	(.00)	5	(3-8)
1200	4	0/2	(.00)	5	(3-7)
Pikas in captivity					
0	9	8/9	(.89)	24	(24)
200	9	9/9	(1.00)	-	
400	9	6/9	(.67)	13	(10-16)
600	7	3/7	(.43)	11	(9-17)
800	7	1/7	(.14)	9	(7-9)
1000	7	0/7	(.00)	9	(6-9)

* The denominator is the number observed after initial release-used in determination of (F).

** One pika died in trap following accidental recapture after irradiation.

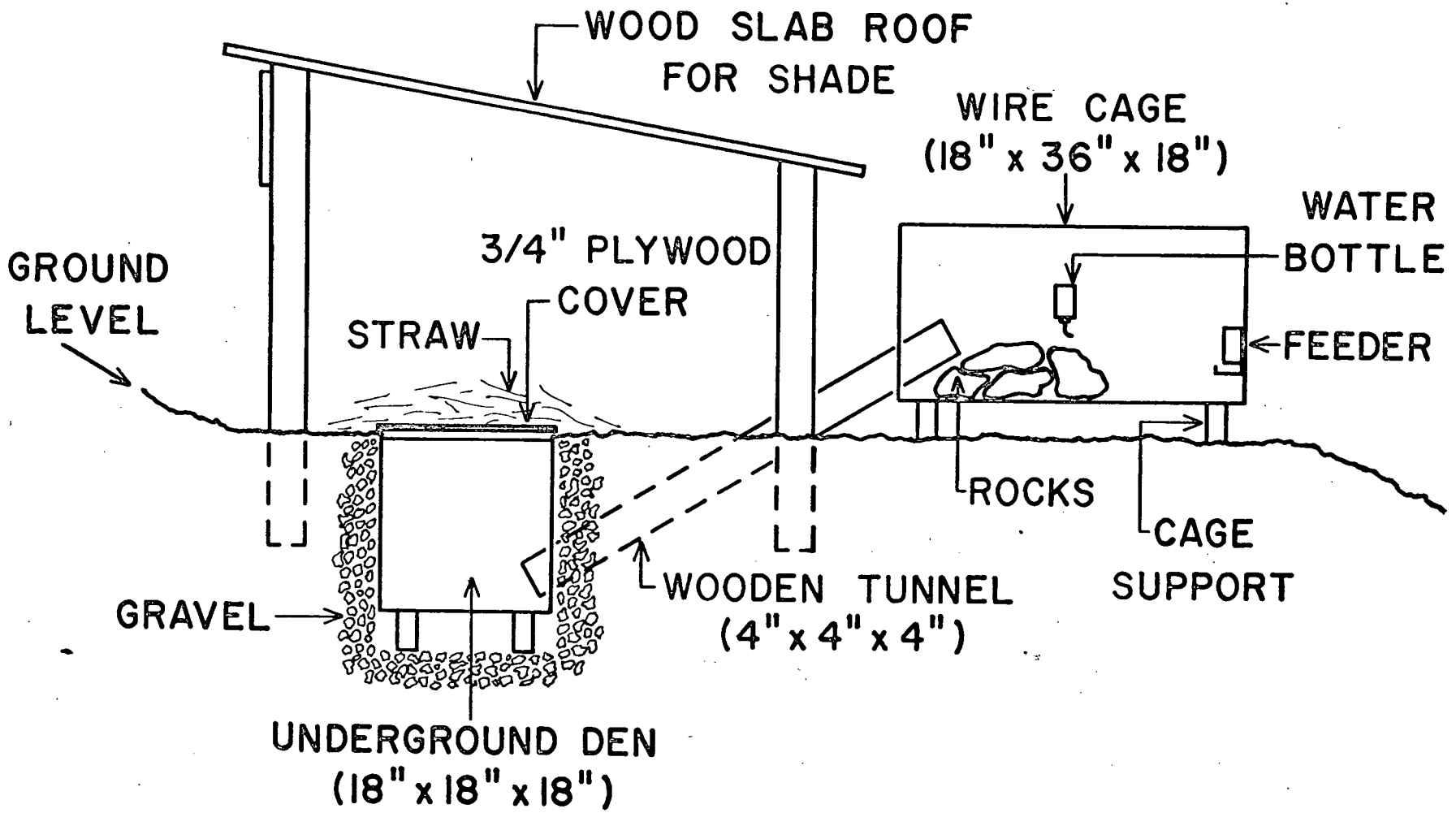
WOOD SLAB ROOF
FOR SHADE
WIRE CAGE
(18" x 36" x 18")
WATER
BOTTLE
FEEDER
GROUND
LEVEL
3/4" PLYWOOD
COVER
STRAW
ROCKS
CAGE
SUPPORT
WOODEN TUNNEL
(4" x 4" x 4")
GRAVEL
UNDERGROUND DEN
(18" x 18" x 18")

Fig. 1. Schematic diagram of the facilities used for holding pikas in captivity.

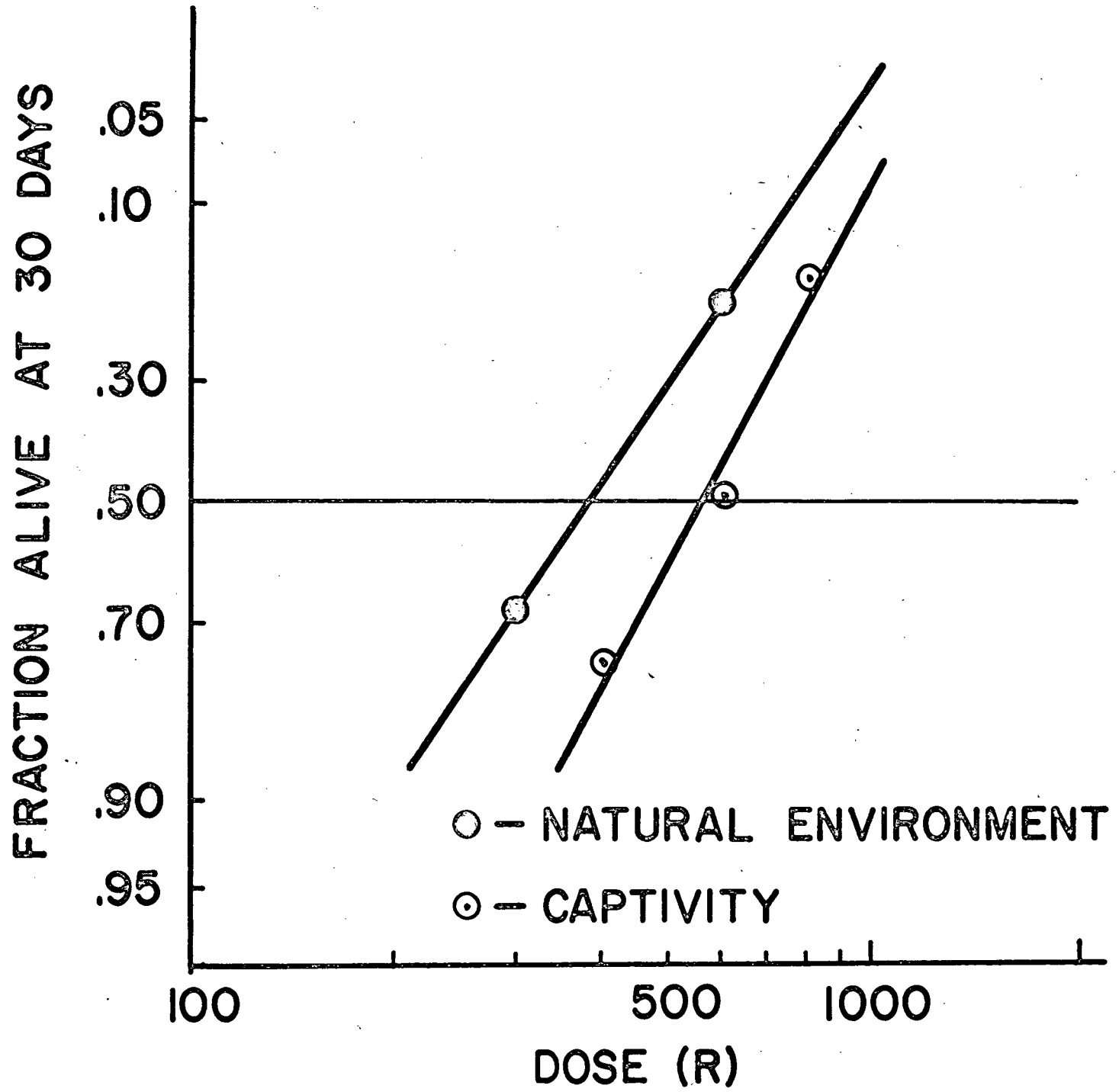
FRACTION ALIVE AT 30 DAYS
.05
.10
.30
.50
.70
.90
.95
100
500
1000
DOSE (R)
○ – NATURAL ENVIRONMENT
⊙ – CAPTIVITY

Fig. 2. Thirty-day survivorship of pikas exposed to acute doses of ^{60}Co gamma radiation and observed in two environments. Surviving fractions corrected for 89% survival of the controls. Abscissa, log scale; Ordinate, probability scale.