AVOIDANCE REACTION OF ANIMALS TO RADIATION FIELDS

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Experiments on mice, rats, guinea pigs, dogs, and monkeys have shown that animals can accurately locate sources of β- and γ-rays and drink much less water from an irradiated than from an unirradiated basin. Marked fluctuations in radiosensitivity are found (experiments on guinea pigs).

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Investigations of the action of radiation as a stimulus have recently attracted increasing attention. Interesting results have been obtained by the study of reflex defensive responses of invertebrates [5, 8, 11, 15, 16] and of conditioned-reflex responses of vertebrates, inwhich radiation may play the role of unconditioned or conditioned stimulus [1-4, 6, 7, 9-10, 12-14, 17].

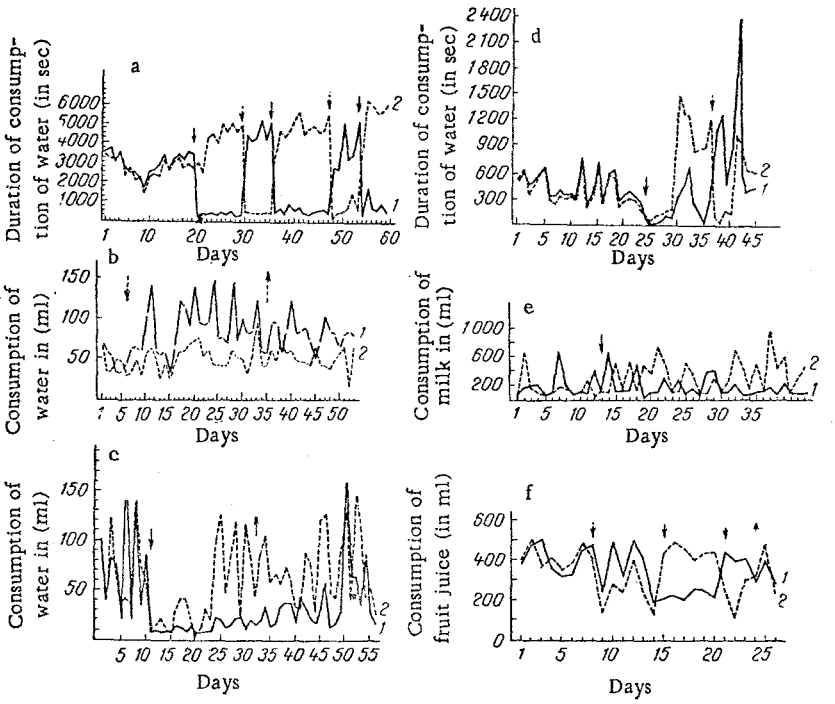

Fig. 1. Avoidance by different animals of drinking water from irradiated basin: 1) right basin; 2) left basin. Arrows denote times of switching radiation sources on or off in neighborhood of right (continuous arrow) and left (broken arrow) basin. a) Mice, whole-body irradiation (five changes of radiation sources); b) whole-body irradiation (experiments on rats); c) whole-body irradiation (experiments on guinea pigs); d) irradiation mainly of head (experiments on mice); e) irradiation of head (experiments on dogs); f) irradiation of head (experiments on monkey).

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TABLE 1. Species of Animals and Investigated Dose Rates of Radiation (in mR/sec)

Animals	Type of radiation	Whole-body irradiation		Local irradiation dose rate
		Range of dose rates studied	Threshold dose rate	
Drosophila	β-rays P^{32}	5.0-170.0	20.0	
Carp	γ-rays Co^{60}; Cs^{137}	41.3		
Mice	Ditto	1.3-3.4	2.0	350-450
Rats	Ditto	12.0-13.6	13.2	
Guinea Pigs	Ditto	0.1-13.6	1.1	
Dogs	Ditto			5
Monkey	Ditto			8-9

We have studied the character of behavior of seven species of animals, at different levels of phylogentic development, in weak radiation fields: Drosophila [8], fishes [6], mice, rats, guinea pigs, dogs, and monkeys [1, 2, 7]. In this report we describe data relating to specific and individual differences in the avoidance reaction to radiation fields and the effect of various experimental conditions on the onset of these responses.

EXPERIMENTAL METHOD AND RESULTS

The experimental conditions and method of investigation were described in previous papers [1, 6-8]. Experiments were performed on 25 carp, 180 mice, 70 rats, 60 guinea pigs, 2 dogs, and a monkey.

All the animals used located very precisely the cource of radiation and avoided being in its zone of action. The flies largely stopped their oviposition in the zone of β-radiation, while the fishes and mammals developed a clear response of avoiding taking food or water from bowls or basins lying in a zone of γ-rays. Significance of the differences in the amount of fluid taken from the irradiated and control basins was assessed by the sign test [18].

Statistically significant data obtained in experiments on mammals of different species are given in Fig. 1. Before the source of radiation was introduced into the experiment the animals used both basins equally. Introducing the γ-ray source into the neighborhood of one basin led to a significant decrease (by 3-10 times) in consumption of water from it. Moving the source into the neighborhood of the other basin immediately reversed the relationship between consumption of liquid. Its removal from the experimental situation led to equalization of water consumption from the two basins. The avoidance reaction appeared both in response to whole-body irradiation (mice, rats, guinea pigs) and to irradiation concentrated mainly on the head (mice, dogs, monkey) or abdomen (mice).

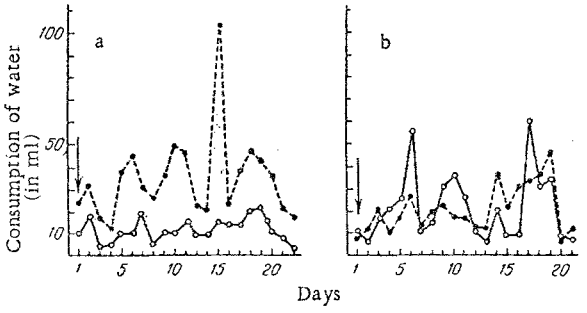

Fig. 2. Avoidance of drinking water from irradiated basin by guinea pigs with high (a) and low (b) radiosensitivity. Arrow denotes moment of introduction of source into neighborhood of right basin. Remainder of legend as in Fig. 1.

It may thus be concluded that all species of animals exhibit the avoidance reaction, i.e., that it is a general rule in biology.

By varying the activity and location of the radiation sources, the dose rates of radiation could be modified. Dose rates evoking an avoidance reaction of the irradiated zone in the animals are shown in Table 1. Comparison of the threshold dose rates to which the animals of different species reacted when a group of them received whole-body irradiation in the experimental chamber shows that they differed in their radiosensitivity.

Depending on the duration of preliminary habituation of the animals to the experimental situation, the effect of avoidance of the irradiated zone varied. A clear

response appeared when the animals had been placed in the experimental chamber 10-20 days before introduction of the source. If the period of habituation to the experimental situation was increased to 36-45 days, the reaction of avoiding the irradiated basin did not appear until 10-14 days after introduction of the source. If the source remained in the neighborhood of the same basin for a long time (25-40 days), the animals avoided using it for an even longer period (up to 20-75 days) after discontinuing irradiation from this source.

The method used enabled individual differences in the avoidance reaction of the animals to radiation fields to be determined. In a series of experiments after precise results had been obtained with a group of animals kept together in the experimental chamber, the animals were introduced one at a time (mouse or guinea pig). Significant individual differences were observed in the behavior of the animals: in some the reaction of avoiding the zone of radiation was very clearly marked, while in others it was almost absent. By means of thermoluminescent dosimeters the total dose received by each animal (30 guinea pigs) during the period of the experiment (40 days) was determined. These doses varied considerably (by 2-16 times), ranging from 8.4 to 130 R for different individuals. We assumed that animals receiving smaller total doses possessed higher radiosensitivity, and vice versa. In accordance with the results described, the animals were divided conventionally into three groups. The group of animals with high radiosensitivity included 9 guinea pigs receiving doses from 8.4 to 22.3 R, 11 guinea pigs were moderately radiosensitive (total doses from 27 to 58 R), and 7 guinea pigs showed low radiosensitivity (total doses from 67 to 130 R). Groups of animals possessing similar sensitivity were replaced in the experimental chamber for observation to be continued. The results of this experiment are given in Fig. 2. They show that the reaction of perception of radiation was most marked in the animals with high radiosensitivity and least marked in animals with low radiosensitivity.

The results of control experiments performed to rule out the possible effect of various factors accompanying irradiation on the animals showed that the avoidance reaction of the animals to radiation fields is independent of radiophosphene, of changes in the taste of the water, and of acoustic stimulation accompanying introduction of the sources into the experiment.

Analysis of the character of the animals' behavior in the zone of radiation shows that the radiation source in these experiments played the role of an inadequate unconditioned stimulus, and avoidance of the radiation fields by the animals was a defensive reaction to the unconditioned radiation stimulus. The appearance of the reaction of avoiding the radiation field may be explained in terms of the theory of external inhibition. During preliminary habituation to the experimental situation (before introduction of the sources) for an optimal period (10-20 days), a stable conditioned reflex to both basins and to the experimental situation was formed. Under the influence of the radiation source placed in the neighborhood of one basin, the conditioned connection previously formed to this basin was inhibited, as shown by the reduced consumption of water from it and the increased consumption of fluid from the control basin lying in a protected zone. After prolonged (36-45 days) habituation of the animals to the experimental conditions, when the avoidance reaction appeared after a longer interval, the presence of automatized conditioned-reflex reactions may be postulated, which are much more difficult to inhibit if allowance is made for the weakness of the unconditioned radiation stimulus. Persistence of the avoidance reaction for a considerable period of time after removal of the source from the experimental situation may evidently be regarded as a manifestation of the formation of a negative conditioned reflex to the radiation stimulus. It may thus be assumed that radiation acts, on the one hand, through inhibition of positive conditioned connections, and on the other hand, by the formation of a negative conditioned reflex.

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