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GENERAL BIOLOGY

# Radioresistance As a Method for Evaluating Specific Independence of Closely Related Forms by the Example of Hamsters of the *Phodopus* Genus (Rodentia, Cricetinae)

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Currently, there is no clear knowledge or consensus among researchers regarding the determination of specific independence of the dwarf and Campbell hamsters. These forms have some morphological differences that are considered to be species-specific. Some authors suggest that they are independent species [1–3]; others consider the dwarf hamster and the Campbell hamster to be a nominal form and its subspecies, respectively [4, 5]. According to N.N. Vorontsov *et al.*, "the existence of differentiation between allopatric and geographically separated populations of *Phodopus s. sungorus* and *Phodopus s. campbelli* is indicative of significant divergence. It is more correct to consider these two genetically isolated species to have originated allopatrically *in status nascendi*, namely, *Ph. sungorus* Pall. and *Ph. campbelli* Th., which belong to the *Phodopus sungorus* superspecies."

It is known that radioresistance is a fundamental genetically determined specific characteristic. This was also shown in our previous study on the contribution of genetic and environmental components to the formation of radiosensitivity [7]. We suggest that ionizing radiation is a convenient tool for studying specific distances between hamsters based on their radiobiological characteristics.

The goal of this study was to compare the radioresistance of hairy-legged hamsters belonging to the *Phodopus* genus: the dwarf hamster (*Ph. sungorus* Pallas, 1970), Roborovskii hamster (*Ph. roborovskii* Satunin, 1903), and Campbell hamster (*Ph. campbelli* Thomas, 1905). We sought to determine the specific distances using radiobiological criteria (the mean half-lethal dose (LD50/30) that characterizes the survival of the 50% of irradiated population, the mean life span at equal received doses, and the dynamics of body weight).

The experiments were performed on 4- to 5-month-old animals from a laboratory colony, whose founders were obtained from the Severtsov Institute of Ecology and Evolution (Moscow, Russia). The animals received various doses of γ-radiation, dates of death and body weights were registered other a 30 day period.

Figure 1 illustrates the dependence of the mortality rate of the irradiated hamsters on the radiation dose. Each point on the curves is the mean of experiments performed on seven to nine animals. The LD50/30 values (calculated using probit analysis) increased in the order Roborovskii hamster, Campbell hamster, dwarf hamster (the differences were statistically significant, see table).

Judging by all radiobiological characteristics presented in the table, the Roborovskii hamster and the Campbell hamster are more similar to each other than either of these two species is to the dwarf hamster. Similar trends were observed in the body weight dynamics of irradiated animals over a period of a month (Fig. 2). The age differences in the postirradiation body weight dynamics of the dwarf hamster were more pronounced than the interspecific differences: the body weight of two-year-old animals had not been restored by the end

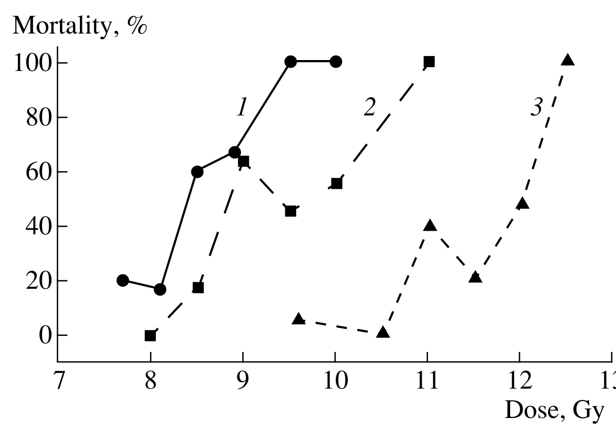


**Fig. 1.** Mortality of hamsters of the *Phodopus* genus after acute total γ-irradiation at various doses (% of individuals that died within 30 days): (*1*) *Ph. roborovskii*; (*2*) *Ph. campbelli*; (*3*) *Ph. sungorus*.

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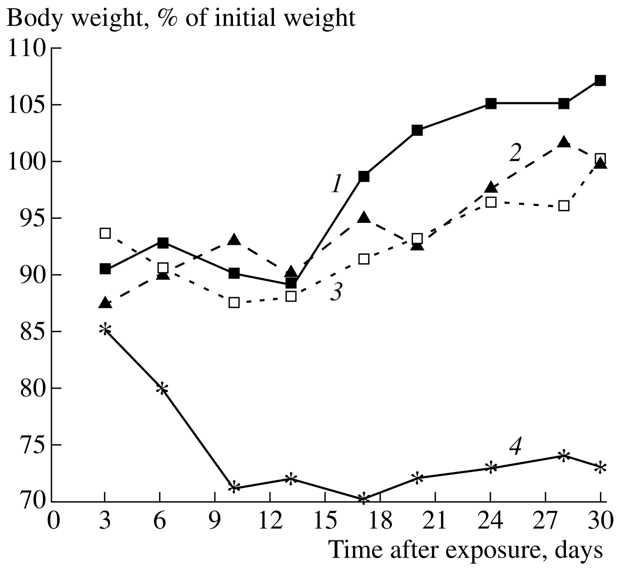


**Fig. 2.** Dynamics of body weight of hamsters of the *Phodopus* genus irradiated with LD50/30: (*1*) *Ph. sungorus* (four-month-old); (*2*) *Ph. roborovskii*; (*3*) *Ph. campbelli*; (*4*) *Ph. sungorus* (two-year-old). The mean values for the groups of surviving animals of each species are shown.

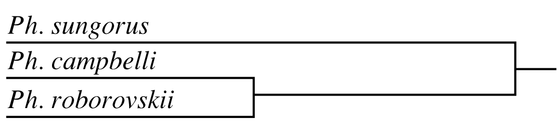


**Fig. 3.** Results of cluster analysis of interspecific differences of the hamsters by six radiobiological characteristics.

of the month. Therefore, animals of the same age should be used in studies of interspecific variability of the radiobiological response. The results of cluster analysis by the method of medium relationship (UPGMA) by six characteristics (% of viability, LD50/30, the mean life span, and body weight on days 11, 21, and 30 after irradiation) also indicate that the Campbell and Roborovskii hamsters fall within one cluster, whereas the dwarf hamster is far from this pair (Fig. 3).

There exists a hypothesis on the landscape determination of radioresistance [8]. According to this hypothesis, animals that inhabit arid areas are more resistant to radiation. However, among the species analyzed, the Roborovskii, which that is mostly adapted to arid conditions, has the lowest LD50/30 value. Individuals of this species have a more efficient mechanism for conserving water in the kidneys and a high thermoresistance. The latter is achieved through the high level of skin–lung water release characteristic of small mammals living in arid regions [9].

The Campbell hamster inhabits arid steppe regions. It is similar to the Roborovskii hamster in its way of life and type of feeding. However, in the area of sympathy of these two xerophilic forms, the Campbell hamster depends to a greater extent on the sources of free moisture, which may play the role of a limiting factor [10]. The Campbell hamster holds an intermediate position by its radioresistance: it significantly differs from the Roborovskii hamster by the criteria used; however, they fall within the same cluster as a result of a combination of radiobiological parameters. Probably, the higher level of metabolic activity of the Roborovskii hamster compared to the Campbell hamster [11] is a reason for the lower radioresistance of the former. This is consistent with the main radiobiological regularities.

The area of the dwarf hamster is isolated and confined to grassy and forest steppes. This provides better access to and diversity of green feed in the diet of the animals. However, they have a more developed kidney concentrating mechanism compared to the Campbell hamsters and therefore are better adapted to water deficit [10]. This indicates that they retain all developed physiological abilities to actively resist dehydration.

During the last decade, many papers concerning various ecological and physiological characteristics of the dwarf and Campbell hamsters have been published. Significant behavioral differences and different levels of aggression [3], peculiarities of spatial distribution and thermoregulation [12], and specific differences in the postnatal ontogenesis [13] of these species have been described. Published data and the results of our radiobiological study are indicative of specific discreteness of these forms. It is difficult to determine the reasons for the higher radioresistance of the dwarf hamster. However, it seems quite reasonable that it may be associated with the higher ecological plasticity of this species, euryphagia, and a complex of physiological adaptations. Analysis of karyotypes of the dwarf and Roborovskii hamsters [5] revealed the existence of a common precursor. After divergence, a larger portion of the chromosomal set was retained in the karyotype of the Roborovskii hamster.

Interspecific differences between hairy legged hamsters with respect to their radiobiological characteristics

| Species | Number of dead/irradiated animals | Survival, % | LD50/30, Gy | Var. coefficient, % | Mean life span, days |
|---|---|---|---|---|---|
| *Ph. roborovskii* | 5/11 | 45.4 | 8.9 ± 0.4 | 28 | 5.0 ± 0.4 |
| *Ph. campbelli* | 5/12 | 42.0 | 9.6 ± 0.3 | 23 | 7.5 ± 1.0 |
| *Ph. sungorus* | 9/16 | 56.2 | 11.9 ± 0.3 | 19 | 9.0 ± 0.5 |

The karyotype of the dwarf hamster is more complex. There is possibly a correlation between the interspecific differentiation of some functional systems (those associated with ecological adaptations, such as resistance to dehydration, euryphagia, etc. and those determining radioresistance). Probably, a broad range and ambiguity of physiological responses and resistance parameters of animals inhabiting arid areas [14] are also manifested in the case of an integral characteristic such as radioresistance.

Therefore, judging by the complex of radiobiological parameters, the Roborovskii hamster is more sensitive to ionizing irradiation that the Campbell hamster. The dwarf hamster significantly differs from these species by a higher radioresistance. This points to the specific independence of the Campbell and dwarf hamsters. Certainly, the use of radioresistance as the only method to solve systematic problems is not sufficient. However, in some cases, its application in of complex of other methods is quite reasonable.

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