Allometric comparison of recommendations of minimum floor areas for laboratory animals.

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Summary:
The recommendations for minimum floor area given in the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific purposes (1986) as well as in the Publication on the Planning and Structure of Animal Facilities for Institutes Performing Animal Experiments of the Society for Laboratory Animal Science (GV-SOLAS 1989) are plotted in a double logarithmic system in order to get an allometric function of recommended floor area to body weight. Both recommendations correspond very well with the so called metabolic body weight seen at the allometric exponent of 0.73 and 0.70 respectively. Thus the recommendations in general attribute the floor space according to the metabolic body weight on the animal. Nevertheless knowing this general rule, some species are recommended less space than others when compared on this allometric measure, thus it must be questioned why for example rabbits, chicken and pigs are recommended less space than other species. The general allometric measure seems at least to be a good scale for the comparison of recommended floor space and for the discussion of species specific needs for more or less space.
Key words: floor area, allometry, laboratory animals

Introduction:

All currently used recommendations for the minimum floor area for housing laboratory animals are based on body weight. According to the weight of the animals, a minimum floor area is recommended in the Explanatory Report of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific purposes (1986), as well as in the Publication on the Planning and Structure of Animal Facilities for Institutes Performing Animal Experiments of the Society for Laboratory Animal Science (GV-SOLAS 1989). Most of these recommendations derived from empirical experiences ("in use" practices) and are under permanent discussion, for example recently at an International Workshop held at the Bundesgesundheitsamt in Berlin in May 1993 on "The Accommodation of Laboratory Animals in Accordance with Animal Welfare requirements" (O'Donoghue 1993). The question to be answered by the presented analysis is not, what will be the right size of floor area for a laboratory animal, but, which general rule may be applied across all possible warm blooded vertebrate animal species to get an average idea of their need for minimum floor area in respect to their animal welfare.

Material and Methods:

The given recommended minimum floor areas were plotted against body weight in a double logarithmic scale for the European recommendation (Figure 1) as well as for the recommendation of GV-SOLAS (Figure 2). The data used for both calculations are given in detail in the tables of both recommendations. According to the formula of Huxley (1932) an allometric function was calculated such as:

- floor area (cm2) = a x body weight^{b} (g)
- The coefficient of correlation (r) and the significance of this correlation (p)

was calculated. This kind of allometric function is used in comparative physiology to find a functional relationship between different physiological traits, especially between body weight and physiological functions such as energy metabolism (Kleiber 1932), heat production (Rubner 1883) and many other different body functions and structures (Schmidt-Nielsen 1984) and is also suitable for the comparison within as well as between different laboratory animal species (Hackbarth 1991). Therefore the data given in the recommendations were transformed into a double logarithmic system, thus the allometric function could be calculated by a simple regression such as:

- log floor area = log a + b x log body weight.
- The resulting allometric functions are plotted (Figure 1, Figure 2) compared and discussed in respect to animal welfare requirements.

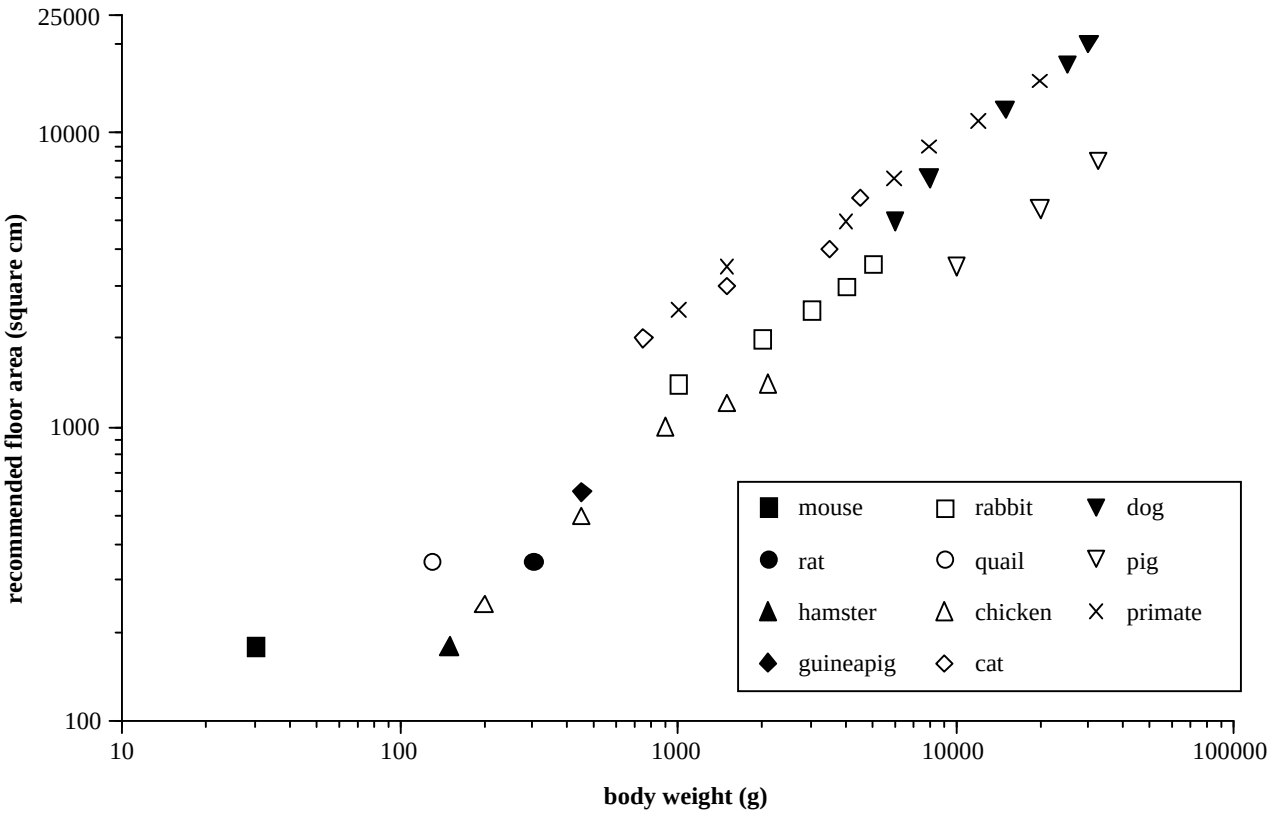
Results:

The data of the Explanatory Report of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific purposes resulted in an allometric function of:

- floor area (cm2) = 8,85 x body weight^{0,73} (g)

r = 0.947 p < 0.01

- A detailed plot of these data on a double logarithmic scale is given in figure 1:

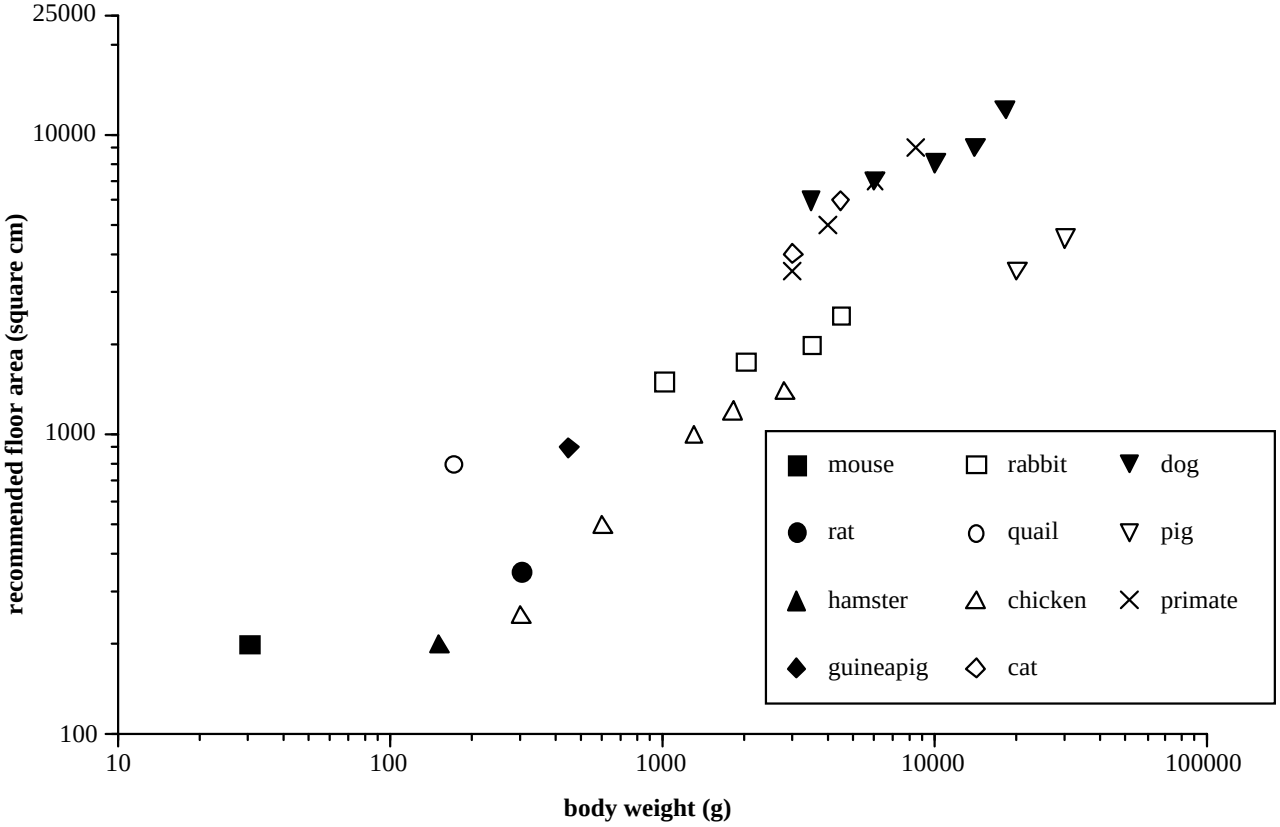


The data of the Publication on the Planning and Structure of Animal Facilities for Institutes Performing Animal Experiments of the Society for Laboratory Animal Science (GV-SOLAS) resulted in:

floor area (cm2) = 9,89 x body weight^{0,70} (g)

r = 0.919 p < 0.01

A detailed plot of these data on a double logarithmic scale is given in Figure 2:



Discussion:

The first impression of the analysis of the recommended floor area is surprising as the resulting allometric functions fit very well with what was found for energy metabolism related variables (Schmidt-Nielsen 1984). Thus the empirical recommended floor area for laboratory animals corresponds closely with their metabolic body weight, which would be body weight0,75, as suggested by Kleiber (1932) and found by many authors for several biological variables (Hemmingsen 1960, McMahon and Bonner 1983, Calder 1984, Prothero 1984, Hackbarth et al. 1982). The empirical application of "in use practices" at least seems to follow more or less by chance the logical concept of allometry. And for an overall estimation of the necessary floor area for a laboratory animal, the metabolic body weight seems to be a good measure, as the space needs to increase with higher metabolism. Thus it seems to be reasonable to attribute the minimum floor area for laboratory animals according to their metabolism. Moreover by this measure we can start to compare the recommendations for the different species on a comparable scale, although this estimation may be an approximation for very small and very large animals. The Explanatory Report of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific purposes recommends on this scale a larger floor area for mice than for hamsters or rats. Also quails are recommended more space in comparison to chickens. Cats, dogs and non human primates are recommended about the same space, while rabbits and especially pigs are recommended much less space. Within a species the recommendations follow the allometric rule according to the metabolism, thus

they are having the same slope but seem to be shifted above or under the general interspecies line. Comparison of different species can now be made in relation to this overall allometric function. Species specific needs can at least be discussed on this scale. Of course it is questionable if the metabolic body weight is the one and only correct measure for the need of floor area, especially in regard to growing organisms, as it is known that growing animals in particular have a higher need for space than adult animals of the same species. The GV-SOLAS recommendations attribute relatively more space to growing animals (rabbits and dogs) than to the adult animals of the same species, which can be seen by the different slopes of their intra species regression lines in comparison to the interspecies regression. But in all other respects the comparison of the European recommendations with the recommendations of GV-SOLAS shows a good agreement. Mice and guinea pigs get much more space than rats and hamsters. While non human primates, cats and dogs get about the same space, pigs are recommended much less space in comparison to these species.
As mentioned these space recommendations based on allometric. i.e. metabolic body weight can only be a first and approximate step for the comparison of recommended floor areas. It does not take into account the age nor special needs of the different species. It also reflects only the floor space but not the spatial extension of a cage, especially for those animals which are able to use their space in three dimensions. Enrichment and social structure are also not considered. Nevertheless this allometric approach enables the opportunity to compare the given or future regulations on a more objective scale than ever before, as until now there is nothing more than "in use practices". On this allometric scale species and age specific needs can be discussed and it will be a good measure for a very first recommendation for species which are not common in the laboratory.

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