SPACE REQUIREMENT STIPULATIONS FOR CAGED NON-HUMAN PRIMATES IN THE UNITED STATES: A CRITICAL REVIEW

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Cage space requirements for non-human primates in the United States of America are less than those in European countries. Studies in support of the assumption that the US legal minimum cage size provides adequate space have limited value because they only tested cages without structural enhancement. It is not surprising that non-human primates cannot be animated to be more active or to behave in more species-typical manners by only providing them with extra barren space. Explicitly stipulating that all cages have to be equipped with properly installed, elevated structures appropriate to each species and age category would make the US standards more adequate. Such structures would no longer restrict the caged primate to an unnatural, permanent terrestrial lifestyle but would allow the animal to make use of the arboreal, 'safe' dimension to which she/he is biologically adapted. Minimal height requirements will have to be upgraded in the US to accommodate these ethological considerations.

Keywords: *animal welfare, non-human primates, quality of cage space, regulations*

Introduction

Primatologists agree that adequate cage space is a key factor for a monkey's well-being. Bayne (1989) asked 56 investigators of 10 laboratories in the United States what they thought could be done to improve their animals' well-being. The most frequent recommendation was for larger cages (cf National Institutes of Health 1991). This finding is not surprising when considering the fact that cage dimension requirements are less than standard in the United States of America in comparison with European countries (Table 1).

Despite this apparent awareness that non-human primates in the US deserve larger cages than those currently used, there is a strong reluctance to increase cage sizes because of the perceived costs (Bowden 1988; Holden 1988; Line *et al* 1989a, b; 1991; Mason 1989; Woolverton *et al* 1989; Erwin 1991; Wolfle 1991; American Medical Association 1992; Crockett 1993), and because of recent studies which support the status quo by demonstrating that the quantity of cage space is not an important factor in the promotion of primate well-being. The present report reviews these studies and evaluates the usefulness of their methodologies in determining species-adequate cage space standards for non-human primates.

Table 1 **Minimal cage space requirements for the most common laboratory non-human primates in Europe* (European Economic Community Council 1986) and in the USA (National Institutes of Health 1985; United States Department of Agriculture 1991).**

	Floor area (m^2)	Height (m)
Female macaques (5–7kg)	0.70 (Europe) 0.40 (USA)	0.85 (Europe) 0.76 (USA)
Male macaques (10–15kg)	1.10 (Europe) 0.56 (USA)	1.25 (Europe) 0.81 (USA)
Baboons (15–25kg)	1.50 (Europe) 0.74 (USA)	1.25 (Europe) 0.91 (USA)

* Space requirements of some countries, such as Great Britain (Home Office 1989) and Switzerland (Der Schweizerische Bundesrat 1981) exceed the EEC standards.

Activity

Line *et al* (1989a, b; 1990a; 1991) monitored locomotor activity in 10, and 6 adult female rhesus macaques *(Macaca mulatta)* each housed singly for one week at a time in three over-legal size, barren cages ($0.40m^2$x0.81m; $0.57m^2$x0.81m; $0.62m^2$x1.10m). The animals showed no significant changes in activity as a function of cage dimension. The authors inferred from this that changes in the current cage sizes will not improve the animals' well-being in any measurable way (Line *et al* 1989a; 1990a).

It may seem a matter of common sense that non-human primates housed in larger cages would be better off than those housed in smaller ones (Chamove 1989; Chamove & Anderson 1989; Line *et al* 1989a), yet it is hard to imagine that any animal can benefit from space that is not structured. Space is not enough; there must be something in the space (Wilson 1982) to make it useful. Even an over-legal size cage will not make a monkey climb, perch, and explore if there is nothing to climb and perch on, and if there is nothing to be explored. It would be unjustified to classify such a barren cage as unnecessarily large because the occupant fails to be particularly active.

Brent (1992) observed four individually housed chimpanzees *(Pan troglodytes)* in different-sized cages that were not barren but equipped with structuring elements. Under this condition, significantly more activity was noted in larger than in smaller cages. This is congruent with similar findings by Daschbach *et al* (1983) and Kaplan and Lobao (1991), indicating that the well-being of a primate, as measured by his/her activity, is primarily dependent on the *quality* rather than on the quantity of space, since space per se has no stimulatory value.

Non-human primates are characterized by major anatomical and behavioural adaptations to a three-dimensional arboreal environment (Reynolds & Reynolds 1965; Schultz 1969; Rose 1974; Estrada 1989; Martin 1990). This suggests that they have a particular need for *structured vertical space.* Both in the wild and in captivity most species show vertical flight reactions (Jay 1965; Crockett & Wilson 1980; Estrada 1989; Taff & Dolhinow 1989; Burt & Plant 1990; Chopra *et al* 1992; Watson & Shively 1996) and spend a major portion of their time off the ground on trees, cliffs, 'koppes' or artificial structures (Bernstein & Mason 1963; Rosenblum *et al* 1964; Goodall 1965; Simonds 1965; Menzel 1967; Traylor-Holzer & Fritz 1985; Watson 1991; Chopra *et al* 1992). In the wild, the presence of large trees may be the only limitation for the distribution of primates (DeVore & Hall 1965; Simonds 1965; Washburn & Hamburg 1965). In captivity most primates will locate themselves as high as possible rather than on or close to the ground (Williams & Abee 1985; Salzen 1989; Field *et al* 1992; Reinhardt 1992; O'Neill-Wagner 1994; Weed *et al* 1995; Kerl & Rothe 1996; Watson & Shively 1996). European regulations therefore stipulate that perches be installed (Der Schweizerische Bundesrat 1981; European Economic Community Council 1986; Home Office 1989). They make the vertical dimension of the cage accessible for specialized, ie arboreal locomotor patterns (National Institutes of Health 1985; United States Department of Agriculture 1991) such as climbing, leaping, balancing, and for specialized comfort behaviours such as perching, retreating and looking-out (Reinhardt *et al* 1987a; Reinhardt 1989; Watson 1991). European cage height requirements exceed those of the USA mainly because extra space is needed for the proper placement of perches (cf Table 1).

Housing non-human primates in empty cages that are not organized to suit their species-specific needs for arboreal behaviour, is as inappropriate as housing them singly without means to show social behaviour. Fundamental requirements for the expression of 'behavioural needs' (European Economic Community Council 1986; Line 1987; United States Department of Agriculture 1991; Poole 1992; International Primatological Society 1993) are not met in either circumstance. US rules take the animals' needs for the expression of social behaviours adequately into account but fail to address those for the expression of arboreal behaviours (United States Department of Agriculture 1991).

Stress

Crockett *et al* (1993a) assessed urinary cortisol excretion in 10 adult female and 10 adult male long-tailed macaques *(Macaca fascicularis)* housed individually in five different-sized single cages. Floor areas of two cages were 7 per cent and 40 per cent larger than legal size, three cages were 23 per cent, 55 per cent and 77–83 per cent smaller than legal size. There was a tendency for cortisol levels to increase as cage size area decreased, but statistical analysis led to the conclusion that cortisol was unrelated to cage size (Crockett *et al* 1993a). Replication of the study with eight female pig-tailed macaques *(Macaca nemestrina)* yielded the same results (Crockett *et al* 1993b). The authors inferred that the impact of a wide range of different cage sizes on the well-being of the monkeys was small and that the legal minimum cage size did provide adequate space (Crockett & Bowden 1994).

Cortisol is apparently not a good indicator for determining adequate cage space appropriations for non-human primates. The smallest cages examined were so small that they allowed almost no unhindered movements ($0.05m^2$x0.36m, $0.10m^2$x0.43m; cf Crockett & Bowden 1994, Figure 2, right). Yet, being squeezed in these tiny cages, the animals showed no significant cortisol elevation. Increasing the dimensions of such an 'unrealistically small' (Crockett *et al* 1993a) cage intrinsically promotes the well-being of the confined subject by easing the spatial restrictions of its species-characteristic postures and movements. It would be absurd to classify a cage as species-adequate because the occupant fails to show a particular physiological response but does not have enough room to stand upright or turn around. The problems associated with the interpretation of cortisol data in relation to housing changes, have also been encountered when comparing data of single-housed versus compatible pair-housed social primates (Reinhardt *et al* 1991; Schapiro et al 1993; Crockett *et al* 1994). Cortisol levels did not differ within any of these studies, indicating that neither housing condition is a special source of stress. This, however, would not allow the inference that both conditions are species-adequate. Needless to say, single-housing is not adequate for any social species.

The sensivity of caged non-human primates to insufficient quantity of space was drastically demonstrated in a study conducted by Boot *et al* (1985). The authors evaluated reproductive performance in single-caged multigravid long-tailed macaques kept in two different-sized cages. Pregnancy loss was 31 per cent in 67 females housed in sublegal-sized cages ($0.20m^2$x0.60m) versus 8 per cent in 37 females housed in legal-sized cages ($0.49m^2$x1.00m). The difference was significant, suggesting that being forced to live in the very small cages was a distressing experience for the subjects.

Behavioural disorders

Crockett and Bowden (1994) examined the effect of cage space on the expression of behavioural disorders. The above long-tailed and pig-tailed macaques were videotaped in a familiar environment (Crockett *et al* 1993a) when being single-housed for two weeks, each in five different-sized barren cages (largest cage: $0.61m^2$x0.84m; smallest cage: $0.05m^2$x0.36m). Smaller cages failed to trigger an increase in abnormal behaviours. These findings are in line with those of Bayne and McCully (1989) and Line *et al* (1989a; 1990a; 1991): six and ten adult single-housed rhesus macaques were tested in small and moderately enlarged barren cages ($0.40m^2$ versus $0.57m^2$ versus $0.63m^2$). No reduction in stereotypical behaviours was seen in the larger cages. It was concluded that increasing cage size does not lead to improvements in well-being (Crockett & Bowden 1994).

It would be surprising if intelligent animals such as primates could be cured from ingrained behavioural disorders by simply being provided with more empty space. Even a manyfold enlargement of unstructured cage space will not change this circumstance (Goosen 1988). The situation is different when increased space also implies more complexity. Leu *et al* (1993), for example, noted a significant decrease in stereotypical activities in 20 single-housed long-tailed macaques transferred daily from barren home-cages to large multi-compartmentalized cages. Exploring the various compartments of the larger cage probably distracted the animals sufficiently to override the urge for stereotyped movements.

The predominant importance of the *quality* rather than quantity of cage space for the behavioural health of non-human primates is underscored by the fact that 'pathologic behaviour' (Brent *et al* 1989), especially stereotypies, is ameliorated or even eradicated when no extra space is provided, but suitable stimuli added to counteract 'boredom' (Whitney & Wickings 1987; Vandenbergh 1989; Wemelsfelder 1994) in a hitherto barren cage environment (Reinhardt *et al* 1987b; Goosen 1988; Brent *et al* 1989; Line *et al* 1989c, 1990b; Meunier *et al* 1989; Weld *et al* 1989; Weld & Erwin 1990; Bayne *et al* 1991; Lam *et al* 1991; Bayne *et al* 1992a, b; Nadler *et al* 1992; Perkins *et al* 1992; Eaton *et al* 1993; Phillippi-Falkenstein 1993; Shimoji *et al* 1993; Boinski *et al* 1994; Brent & Long 1995).

While behavioural disorders are not significantly affected by the actual cage size, sporadic disorders may be triggered in an animal when the cage becomes too small for normal 'distancing responses' (Hediger 1955) during an alarming situation. The confined subject is quasi cornered in such a circumstance and experiences higher tension (Berkson *et al* 1963) than in a large cage with adequate options for flight. Draper and Bernstein (1963) noticed that rhesus macaques resort to stereotyped activities in an unfamiliar, potentially alarming environment when being confined in small cages ($0.64m^2x0.80m$) but not when being confined in much larger cages ($3.84m^2x1.60m$) with enough space for escape. The authors hypothesized that the stereotyped movements served the subjects as substitute actions for inhibited flight responses to the fear-inducing, unfamiliar environment. This inference is in line with the commonly made observation that caged primates afflicted with gross behavioural pathologies such as self-biting or self-clasping, predictably display these reactions when being approached or looked at by a fear-provoking person (Reinhardt 1995, Slides 34–36; cf Berkson 1968; Fittinghoff *et al* 1974; Fritz *et al* 1992).

Discussion

Assessing the *quantity* of cage space on the well-being of primates has limited value because the usefulness of space depends on its *quality* rather than on its quantity (cf Erwin & Deni 1979; Wilson 1982; Whitney & Wickings 1987; Chamove 1989; Line *et al* 1989b; Anderson & Visalberghi 1990; Schapiro *et al* 1991; Rümpler 1992; International Primatological Society 1993; Leu *et al* 1993; Benn 1995). Having no stimulatory value, space alone does not enhance an animal's environment.

There is professional agreement that adequate cage size is best determined by behaviour-based criteria. These criteria set the standards for the *quality* of the cage volume, which in turn determines the quantity of space that is required to meet basic behavioural needs of the caged subject. The cage should not only provide enough room for normal posture, postural changes and movements on the ground (cf National Institutes of Health 1985; United States Department of Agriculture 1991), but its space must be sufficiently usable and complex to allow for species-specific locomotor and posture characteristics *above* the ground (International Primatological Society 1993). Vertical climbing surfaces and perches are therefore recommended (International Primatological Society 1993) as a means of making the space of the cage usable for the expression of arboreal behaviours. Furthermore, cages should be designed in such a way that the confined subject can show natural vertical flight responses (International Primatological Society 1993).

Cage space requirement stipulations in the USA are not congruent with these professional standards because they only partially define the *quality* of the minimum cage space they prescribe. The rules define the social but not the arboreal quality of the minimum cage space. Taking the social life-style of non-human primates into account, compatible companionship must be provided and the floor area of the cage increased accordingly (United States Department of Agriculture 1991). The arboreal life-style of non-human primates, however, is not taken into account. No provision is made that adequate space *and* structure be provided to make the vertical dimension of the cage accessible, and suitable for the expression of species-typical arboreal activities and postures and species-typical vertical flight responses. This circumstance contradicts the USA guidelines stipulating that the environment in which an animal is held should be appropriate to the species and its life history (National Institutes of Health 1985). A legal-sized cage will not be appropriate to any non-human primate if it is empty, without means to actively use the vertical space in species-characteristic ways. When an elevated structure such as a perch is available, non-human primates will spend up to 90 per cent of their time above the ground exhibiting species-typical arboreal postures and activities (Reinhardt & Smith 1988; Reinhardt 1989, 1990; Schmidt *et al* 1989; Watson 1991).

Explicitly stipulating that all cages have to be equipped with elevated structures appropriate to each species and age category, would make the US cage space stipulations more adequate. They would be a safeguard against animals being restricted to an unnatural, permanent terrestrial lifestyle. Elevated structures are too important to be merely listed among other *options* for environmental enrichment (United States Department of Agriculture 1991). Multiple spatial and behavioural benefits derived from elevated structures suggest that they promote the caged primate's state of well-being: they increase the usable cage volume, provide means for species-typical arboreal behaviours (cf Figure 1) and offer dry places during routine cage-cleaning procedures and 'safe' locations to retreat during fear-inducing situations (O'Neill 1987; Reinhardt & Smith 1988; Reinhardt 1990; Watson 1991; Reinhardt *et al* 1992).

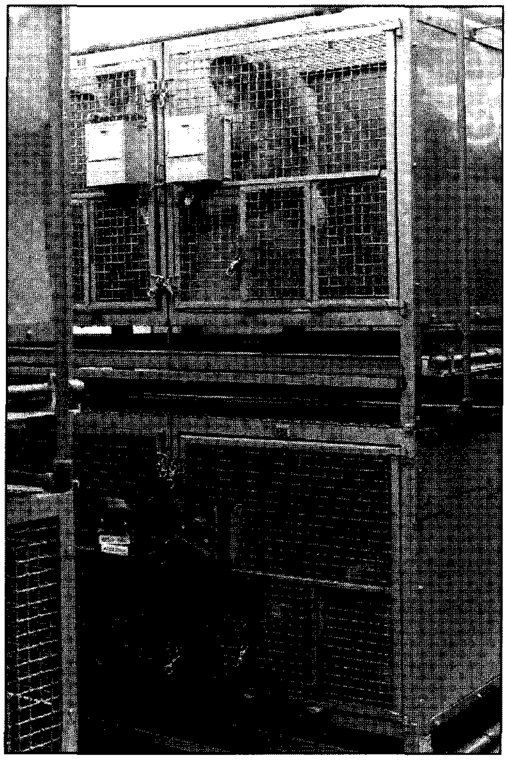

Figure 1 US legal-sized cages (here a $0.53m^2$x0.77m cage for adult rhesus macaques) do not provide sufficient height to permit the installation of an elevated structure (here PVC perches), in such a way that it blocks neither space *below* nor *above* it for the expression of species-characteristic terrestrial and arboreal postures and activities.

Sitting in an elevated position fosters a monkey's feeling of security by having better visual control over the environment (cf Figure 1; Estrada 1989; Reinhardt 1989; Woodbeck & Reinhardt 1991). Monkeys in barren cages can often be found clinging to the cage wall (Shimoji *et al* 1993), probably in an attempt to attain the arboreal dimension. Clearly, the provision of a comfortable perch or shelf is preferable to having to struggle to hold on to the perpendicular wall of the cage. 'Structural enhancement' (Schapiro *et al* 1991) is particularly important for animals that are confined in dark lower-row cages, and hence forced to continuously live close to the ground. These animals have a definitive disadvantage in comparison with those living in bright upper-row cages (cf Figure 1) and they consequently make more use of elevated structures, such as perches (Reinhardt 1989; Woodbeck & Reinhardt 1991; Shimoji *et al* 1993).

In order to guarantee minimum quality standards of vertical cage space for non-human primates, height requirements will have to be upgraded in the US (Figure 1) to allow adequate installation of elevated structures, such as perches, shelves, ledges or swings. Ideally the cage should extend from floor to ceiling of the room thus taking maximum advantage of the space and light available, allowing the installation of several elevated structures at different levels, and making it possible for the occupant(s) to retreat above human eye level in the event of alarm (International Primatological Society 1993).

Animal welfare implications

Legal cage space requirements for non-human primates are not adequate unless they stipulate that sufficient height be provided to accommodate properly placed elevated structures. The provision of such structures promotes the caged subject's well-being by fostering the expression of his/her biological adaptation to a three-dimensional arboreal environment.

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