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*Effects of aviary and box sizes on body mass and behaviour of domesticated budgerigars (*Melopsittacus undulatus*)*

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Abstract

*Forty-eight budgerigars (*Melopsittacus undulatus*) were pairwise housed in small (80 × 40 × 50 cm) and large (160 × 40 × 50 cm) (length × breadth × height) boxes, as well as in 2.0 × 1.0 × 2.0 m aviaries. All boxes and aviaries had two or three (aviaries) perches and food was offered on the bottom. The body masses of female budgerigars increased significantly when they were housed in boxes instead of aviaries. The size of the box did not influence body mass. The frequency of flying was adjusted to the size of the box as both males and females flew approximately twice as often from perch to perch in a small box than in a large box of double length. Flying behaviour differed significantly between large and small boxes and aviaries. The ratio of invariantly flying from perch to perch to all flying events increased from aviaries < large boxes < small boxes. About 75% of all flying events in small boxes consisted of flying from perch to perch. Females in boxes spent more time on the bottom where the food was placed than females in aviaries. Both the significant body mass gain in female budgerigars, as well as the invariant, stereotypic flying movements, indicated reduced welfare in budgerigars housed in boxes, compared with those in aviaries. Providing a large box did not prevent body mass gain, but did increase the variation in flying patterns. Under long-term housing conditions, boxes could lead to at least two serious welfare problems; obesity and stereotypic behaviour, and should be avoided for budgerigars. Therefore, aviary housing should be chosen wherever possible.*

Keywords: *animal welfare, behaviour, budgerigar, housing, obesity, stereotypy*

Introduction

Budgerigars are one of the most commonly kept pet birds (Isenbügel 1999; Nicol & Pope 1993) and are often used as laboratory animals (Wyndham 1980a). It is recommended that they should be kept pairwise or in groups in aviaries, but little research has been done on their welfare requirements. Nicol and Pope (1993) demonstrated that group-housing, instead of solitary housing, improved the welfare of the budgerigars; however, the space requirements of budgerigars have not been investigated (but see Banz 1982). Banz (1982) demonstrated that budgerigars in cages jumped and flapped their wings instead of flying and they weighed more. After a 7 – 17 month long stay in the cages the budgerigars could not fly and land as well as budgerigars kept in aviaries. Field observations on wild budgerigars in their native Australia revealed that flocks of budgerigars move in flights of a few hundred kilometers (Wyndham 1983). Due to the climate, they are nomadic birds that follow a seasonal food supply. In sedentary periods, budgerigars roost in trees and fly to the ground where they forage or drink (Wyndham 1983). In comparison, captive budgerigars in cages or aviaries can only fly short distances, if at all.

Pet budgerigars are often kept in cages where flights are barely possible (common sizes of cages in Switzerland have a length of 60 – 100 cm; catalogue of the Swiss pet supplier Qualipet 2003). The opportunity to fly around in an apartment may or may not exist and would be offered irregularly in many instances. Breeders commonly keep breeding pairs in boxes (cabinets) with a minimum length of 60 – 80 cm, or groups of budgerigars in aviaries of various sizes. We wanted to find out how the housing conditions (boxes of two sizes and aviaries) affected the behaviour and the body mass of pairs of budgerigars, and to make recommendations on the housing of these birds without compromising their welfare.

Materials and methods

Animals

Budgerigars were obtained from several breeders in Northern Switzerland. Some of these breeders exhibited budgerigars at shows and had large birds with long feathers, while others bred budgerigars exclusively for the pet trade; thus the range of sizes and body masses in our stock was large. The standard of the show budgerigar is for the head to appear large and, when observed from the front, for feathers to cover the eyes. All traits selected for in male show birds were negatively correlated with the frequency of flying from perch to perch in a previous study (Gebhardt-Henrich & Steiger 2005). The birds were kept inside a large room with both natural and artificial illumination. They were fed commercial budgerigar food and slightly germinated

Table1 Experimental set-up of experiment 1. Groups of 8 pairs of budgerigars each were kept pairwise in large or small boxes after a four month stay in an enclosure. Masses of boxes and the enclosure are given in the text.

Group		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
a	ENCLOSURE	LARGE BOX					LARGE BOX				
b		LARGE BOX					SMALL BOX				
c		SMALL BOX					LARGE BOX				
					v	v,m				v	v,m

m indicates that the birds were weighed, v indicates videotaping

budgerigar food seeds supplemented with vitamins. Most pairs had previously been mated and had produced a clutch, but afterwards they had been kept in a large enclosure (5.0 × 2.0 × 2.0 m) (length × breadth × height) in a flock of about 100 budgerigars for approximately 4 months before the start of the experiments. Their ages ranged from 18 months up to 3 years. After the experiments they were returned to the flock in the enclosure.

Experiment 1

Twenty-four pairs of budgerigars were randomly assigned to three groups of eight pairs each: one group was housed in long boxes (160 × 40 × 50 cm) (length × breadth × height) during ten weeks, one group was initially housed in the long boxes, but the boxes were shortened after five weeks to 80 × 40 × 50 cm (length × breadth × height), and the third group stayed in the short boxes for the first five weeks which were then enlarged to long boxes (Table 1). Each box was occupied by one pair. There were two perches in each box which were 134 cm apart in the long box and 51 cm apart in the short box. Birds were weighed to the nearest 0.01 g three times: when they were placed in the boxes, three weeks later when some box sizes were altered, and at the end of the experiment (Table 1). Due to large individual variation a cross-over study where box sizes were altered could increase the power of the experiment.

Experiment 2

After the end of experiment 1 the pairs were randomly assigned to two groups of 12 pairs each, but all former groups were equally represented in the new groups. From one group six pairs (again equally representing the groups of experiment 1) were pairwise housed in large boxes and six pairs were pairwise housed in aviaries (2.0 × 1.0 × 2.0 m) (length × breadth × height). The aviaries were equipped with three perches: two perches were 140 cm apart with one lower (10 cm) perch in the middle with a distance of 70 cm to each perch. Birds stayed in their housing system during the three weeks before they were videotaped. The birds were weighed when they were placed in the boxes or aviaries and again after videotaping. These birds were then returned to the enclosure with other budgerigars. Due to space limitations, this procedure was repeated sequentially for the remaining twelve pairs. Again birds were weighed at placement and after videotaping. At the end of experiment 2, the twelve pairs that had been returned to the enclosure were also weighed.

Videotaping

Cameras and additional lamps were set up on the day prior to videotaping. Each day, two to three boxes (experiment 1), or one box and one aviary (experiment 2), were videotaped. Small boxes were videotaped with one camera, large boxes and aviaries were videotaped with two cameras placed side by side (the distance between the cameras was about 1.0 m). The behaviour of the budgerigars was recorded on videotape and analysed using the software Observer®, VideoPro 3 (Noldus Information Technology). Birds were videotaped from 0830h until 0935h and then each half hour for 5 min until 1605h. The following behavioural activities: preening, reciprocal preening, feeding, reciprocal feeding (ie allofeeding), manipulating an object, and foraging on the bottom all scored as states. Meanwhile the following: several forms of flying, climbing at the bars of the cage, walking on the bottom, bill thrust, head-bobbing, sidling (moving on the perch at least once forward and back), jumping without using the wings, copulating, lifting wings, rubbing head or beak against perch or wire, nudging, and stretching one wing scored as events. The frequency and duration were measured for all states while for events only the frequency was determined. The definitions of the behavioural elements follow Brockway (1963, 1964). Additionally, it was scored whether the bird was on the bottom or above the bottom of the box or aviary. Various elements of flying were distinguished: flying from perch to perch (and distance in aviaries), from the perch down to the bottom or up, from the perch to the feeding table or back, turning in flight and returning to the same perch, hovering like a humming-bird without moving, crashing or missing the perch, and flying a stereotypic pattern ie the same pattern repeatedly.

Flight speed was measured in small and large boxes. The birds were videotaped, and frame-by-frame analyses determined the exact time when the bird left one perch and when it reached the opposite perch (Observer Software by Noldus).

Statistical Analyses

Statistical analyses were done using SAS® programs (SAS Institute). Data and residuals were checked for normality

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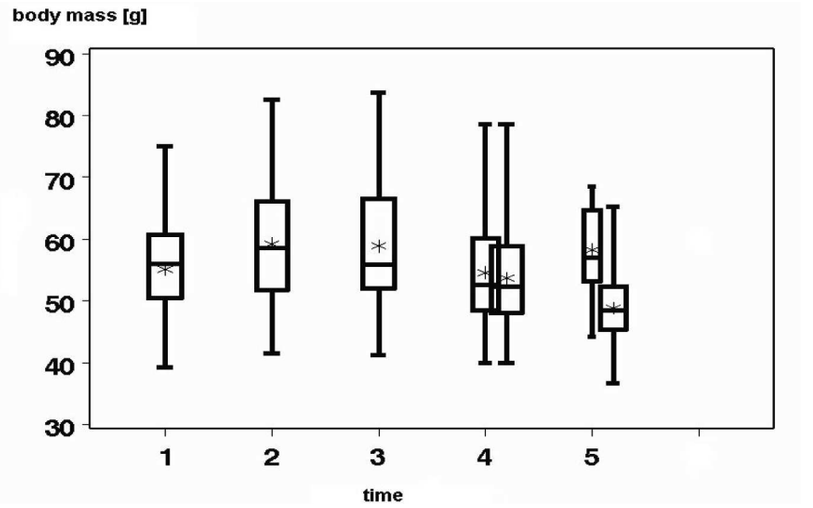
Figure 1

Boxplots of body masses of budgerigars during the experiment. The boxes include 75% of the data points, the horizontal line is the median. The stars show the arithmetic means and the vertical lines depict the ranges. Time 1: at the end of a stay of at least 10 weeks in the enclosure. Time 2: birds had been in 80 or 160 cm long boxes for 5 weeks. Time 3: birds had been in 80 or 160 cm long boxes for 10 weeks. Time 4 (left boxplot): ¾ of the pairs had been in 160 cm long boxes for 4 wks after time 2, (right boxplot): ¼ of the pairs had been in aviaries after time 2. Time 5 (left boxplot): ¼ of the pairs had been in 160 cm long boxes for another 4 weeks after time 4, (right boxplot): ¾ of the pairs had been in aviaries or the enclosure with other budgerigars. The width of the box denotes the sample size.



and, if appropriate, transformations or non-parametric tests were used (as mentioned later). Cross-over studies like experiment 1 needed to be analysed by taking probable period and carry-over effects into account (see Díaz-Uriarte 2001, 2002). Data from experiment 1 were analysed by repeated measures analyses. The flying speed in large and small boxes was analysed by a mixed model (Proc Mixed in SAS) with bird as a repeated factor.

The experiments and the husbandry of budgerigars were evaluated and approved by the Cantonal Office of Agriculture and Nature and licensed under No. 86/01.

Results

Body mass

Body masses increased after the budgerigars were pairwise placed into boxes but decreased after they were placed into aviaries or the enclosure with the flock (Repeated Measure ANOVA, time × sex: $F_{4,68} = 3.02$, $P = 0.02$, time × housing: $F_{4,68} = 3.15$, $P = 0.03$) (Figure 1).

The initial increase after the birds were placed into boxes was greater for females than for males (Repeated Measure ANOVA, $F_{2,80} = 4.14$, $P = 0.02$). The increase in female body mass did not differ whether they were placed into large or small boxes (Table 2).

The size changes of the boxes significantly influenced the changes in body mass; females who were placed into small boxes first and large boxes later gained significantly less mass than those placed into large boxes for ten weeks (Tukey's Studentized Range Test, critical value: 3.56, n = 24, $P < 0.05$) (Table 2). In part 2 of the experiment, birds kept in boxes were significantly heavier than birds in small aviaries or the enclosure with the other birds (box/aviary, enclosure: $F_{2,10} = 9.76$, $P = 0.0045$, sex: $F_{1,10} = 7.71$, $P = 0.02$, interaction: $F_{2,10} = 4.24$, $P = 0.046$) (Figure 1). In a Duncan's multiple range test only the difference between boxes and aviaries/enclosure were significant, not the difference between aviaries and the enclosure with the flock of budgerigars (df = 10, error mean square = 29.2, $P = 0.05$).

Behaviour

The most frequent activity in boxes was flying from perch to perch. Males did this significantly more frequently than females and both sexes did it more frequently in small boxes than in large boxes. Prior to the change in box size: sex: $F_{1,23} = 15.00$, $P = 0.0008$, pair (nested in box size): $F_{22,23} = 3.81$, $P = 0.0011$, box size: $F_{1,23} = 6.11$, $P = 0.02$. (Data values were log-transformed) (Figure 2).

When all types of flying (including flying to the bottom, flying up, flying to the cage bars, turning during flying, hovering) were added, only the difference between the sexes remained significant. Flying from perch to perch represented about 75% of all flying events in small and about 50% in large boxes (median test statistic for both sexes = 11, $P = 0.05$). This means when a budgerigar flew in a small box, it most likely flew from perch to perch. In the large box, it frequently flew a different route than from perch to perch.

When pairs of budgerigars in boxes were compared with pairs of budgerigars in 2 m long aviaries, those in boxes flew significantly more frequently from perch to perch than those in aviaries ($F_{1,20} = 70.54$, $P < 0.0001$). Again, males flew significantly more frequently than females ($F_{1,20} = 17.83$, $P = 0.0004$). The same was observed when all forms of flying were analysed; the frequency was higher in boxes and males flew more frequently than females ([box/aviary]: $F_{1,21} = 16.21$, $P = 0.0006$, sex: $F_{1,21} = 32.34$, $P < 0.0001$, pair[box/aviary]: ns, values were log-transformed). As in the first part of the experiment, the ratio of flying events perch to perch to all kinds of flying events was about 50% in the large boxes. In the aviaries, this

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Table 2 Body masses (g) of female budgerigars under different housing conditions. Group A stayed in 160 cm long boxes for 10 weeks, group B was in 160 cm long boxes for 5 weeks, then their boxes were shortened to 80 cm, group C was in 80 cm long boxes for 5 weeks, then their boxes were elongated to 160 cm. Difference 1 was calculated as the body mass at 5 weeks minus the initial body mass in the enclosure. Difference was calculated as the body mass at 10 weeks minus the initial body mass in the enclosure. Different letters indicate significant differences in Tukey's Studentized Range Test.

	Group A	Group B	Group C	*F*	*P*
Enclosure	59.32 ± 7.87	57.48 ± 8.30	59.30 ± 4.36	0.18	ns
5 weeks	66.84 ± 9.35	63.42 ± 10.14	64.70 ± 7.15	0.31	ns
10 weeks	69.75 ± 9.31	63.18 ± 10.14	61.45 ± 5.88	2.05	ns
Difference 1	7.5 ± 4.87	5.95 ± 6.94	5.4 ± 5.14	0.29	ns
Difference	10.42 ± 4.39[a]	5.70 ± 7.74[a,b]	2.15 ± 4.20[b]	4.28	0.03

percentage was significantly lower (about 10%) and this difference applied to both males and females (box/aviary: $F_{1,19} = 45.74$, $P < 0.0001$, sex and pair: ns, percentages were $2 \times \sqrt{}$arcsin transformed) (Figure 3).

In the aviaries, flying from perch to perch was not the most common way of flying.

The bottom where the food was placed was about 1.5 m below the perches in the aviaries, but only 30 cm below the perches in the boxes. Switching between the food and the perch and thus flying vertically was more frequent in males and more frequent in boxes. (Sex: $F_{1,20} = 16.50$, $P = 0.0006$, box/aviary: $F_{1,2} = 32.19$, $P < 0.0001$, the frequency of switches was log-transformed). When the sexes were analysed separately, the difference in the number of switches was significantly different in boxes and aviaries in males and females (females: $F_{1,2} = 16.82$, $P = 0.0006$, males: $F_{1,20} = 24.59$, $P < 0.0001$). Females, but not males, spent significantly more time above the bottom in aviaries than in boxes (median one-way analysis: $\div 2 = 4.34$, $P = 0.037$). The duration and frequency of feeding did not differ significantly between the sexes.

Budgerigars in large boxes flew 160 cm s^{-1},budgerigars in small boxes flew 101 cm s^{-1}. This difference in velocity was highly significant ($F_{1,8} = 508.48$, $P < 0.0001$).

Discussion

The body mass and flying behaviour of budgerigars were significantly influenced by the type of housing and these effects could have implications for the welfare of these birds. Obesity is a common problem in captive birds and is associated with detrimental health effects and a shortened lifespan (Wedel 1999). Fattening in (migratory) birds shows metabolic and hormonal similarities to the obesity syndrome in humans (Bairlein 2002). In our study budgerigars, especially females, gained body mass when housed in boxes. Lipid contents of wild budgerigars do not differ among the sexes, but caged adults have significantly more lipids than free-flying budgerigars (Wyndham 1980c). In the wild, breeding is triggered by the availability of breeding holes and a sufficient food supply (Wyndham 1983). Egg-laying, incubation, and the care of young expend much energy. In captivity, *ad libitum* feeding occurs also outside the breeding period. Despite 200 years of domestication, female budgerigars do not seem to be adapted to *ad libitum* feeding and consume more food than the optimal amount. This is due in part to (sometimes forceful) allofeeding by the male (Schnegg *et al* 2006). In our study, housing in boxes led to a significant body mass gain in females which might impair their welfare if this type of housing is used for longer periods. Males did not significantly gain body mass, which might be due to their greater flying activity or a smaller food intake.

There were no significant differences in the amount of body mass gain in the two sizes of boxes although changing the size of box diminished the body mass gain. Perhaps altering the size of the box was stressful for the birds so they consumed less food. This was not supported, however, by the measurements of cortisol metabolites in our birds' faeces (Keller *et al* 2005). Birds compensated for the smaller distance between the perches by flying more frequently. Frequency of flying could not have been the reason for the lower body mass in small aviaries, though, because flying was less frequent in aviaries. In boxes, birds spent more time at the bottom where the food was located than in the aviaries. Budgerigars naturally feed on the ground in the wild (Wyndham 1980a,b). Perhaps the food consumption was higher in the boxes and flying vertically in the aviaries more energy-consuming. Vertical flights in aviaries were much more frequent in males. Males flew more frequently under all housing conditions, maybe because flying is part of male mating behaviour (see Gebhardt-Henrich & Steiger 2005).

Repetitive flying from perch to perch represents a stereotypic movement (Garner *et al* 2003). Stereotypies have been associated with inferior housing conditions and reduced welfare (Mason 1991a,b). Caged blue tits (*Parus caeruleus*) and marsh tits (*Parus palustris*) that showed stereotypic movements had altered brain function (Garner *et al* 2003). The short duration of a couple of weeks might not suffice for the development of stereotypies, but the high percentage of flying from perch to perch in small boxes compared with larger boxes and aviaries rates the housing in aviaries superior to the housing in boxes and large boxes superior to small boxes. In our study, long-term effects were not addressed. Even after housing budgerigars in very small cages for 9 months, all birds regained their flying abilities

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after being in an aviary for a couple of days (Banz 1982). Not surprisingly, flying speed was significantly reduced in small boxes. The slowing effects of take-off and landing must have reduced the average speed.

Animal welfare implications and suggestions for the housing of budgerigars

Both the body mass gain and the predominance of stereotypic flying movements from perch to perch imply that the welfare of budgerigars housed in boxes of both sizes was impaired. This study showed that these problems might be diminished by housing budgerigars in aviaries. Future investigations could explore whether or not enrichment with periodically replaced fresh branches and the keeping of more than one pair would further prevent stereotypic behaviour.

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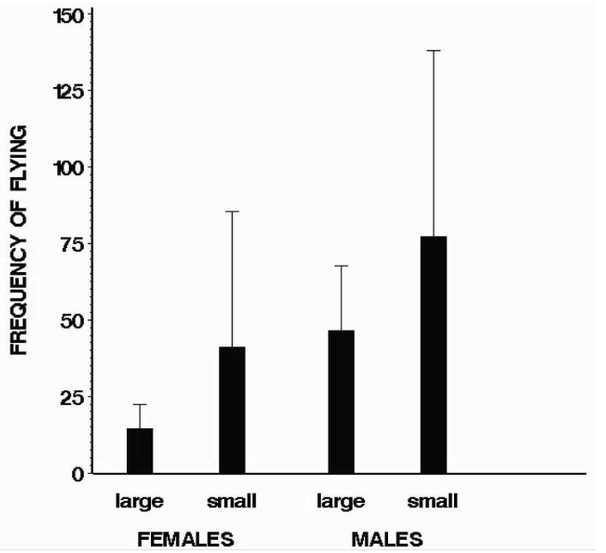
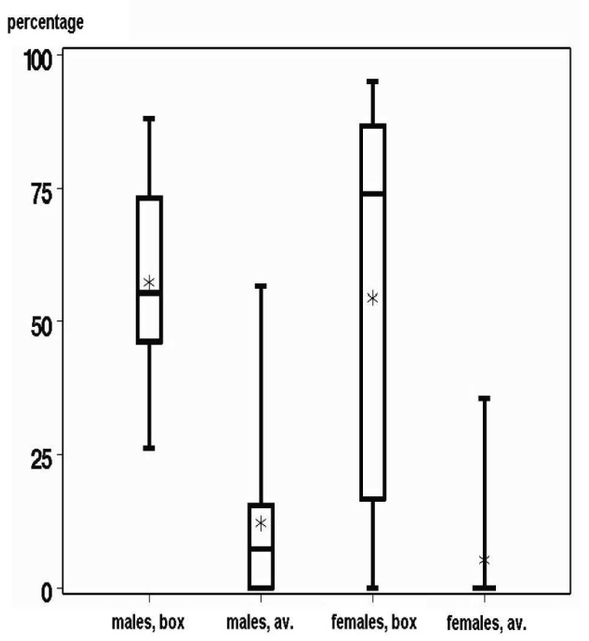
Figure 2



Mean number of flights from perch to perch in small and large boxes. Error bars denote the standard deviation.

Figure 3



The percentage of flights that were from perch to perch of male and female budgerigars in experiment 2. Box: pairs were kept in 160 cm long boxes. Av: pairs were kept in 2 m long aviaries. For details of the boxplots see Figure 1.

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