

Effect of beak length on feed intake in pigeons (*Columba livia f. domestica*)

T Savas*, C Konyali, G Das and IY Yurtman

Department of Animal Science, Faculty of Agriculture, Canakkale Onsekiz Mart University, 17020, Canakkale, Turkey

* Contact for correspondence and requests for reprints: tsavas@comu.edu.tr

Abstract

This study was undertaken to investigate the effect of beak length on feed intake with regard to animal welfare. The study involved two treatments groups; short beak pigeons (G-SB; $n = 7$) and normal beak pigeons (G-NB; $n = 7$) and was carried out in two consecutive trials. Daily feed consumption, meal length and behavioural traits such as aggressive pecking, preening, resting and locomotor activity were recorded under different feeding conditions. In Trial I the birds had free access to food material during a single feeding period each day, whereas in Trial II feeding was terminated when a pigeon from any of the groups that stopped eating first, moved towards water. It took a longer time for the pigeons in the G-SB group to consume the same amount of feed. Furthermore, the pigeons in G-SB were affected significantly in Trial II and lost bodyweight more compared to G-NB. Although no significant difference between the groups on frequency of aggressive pecking during feeding was found in Trial I, restricted feeding significantly increased the frequency of aggressive pecking in the G-SB group in Trial II. The results of the present study suggest that short beak, which is a side-effect of artificial selection for aesthetic purposes, can cause serious welfare problems under restricted environmental conditions.

Keywords: animal welfare, feeding behaviour, morphological defect, pigeon breeds, restricted environmental conditions, side-effects of artificial selection

Introduction

Natural selection gives shape to individuals and therefore to populations which results in the most appropriate combination of traits in nature. This combination gives animals the selective advantage they need to survive thereby enhancing their chances of reproductive success, under natural conditions. Domestication has limited the efficiency of natural selection and the effect of artificial selection has become more and more pronounced.

Various production traits have been stretched to their physiological limits due to intensive artificial selection for greater productivity and/or the pursuit of certain aesthetic criteria. This trend has resulted in the occurrence of various side-effects; a fact reported by Rauw *et al* (1998). He noted, without prior knowledge of the underlying physiological processes within which genetic selection acts, that cumulative and permanent genetic improvement through selection was essentially a black box technique which needs to be supported by studies on the biological backgrounds of any selected traits. However, less attention has been given to the more generalised side-effects of selection for increased production efficiency (Bakken *et al* 1998).

Although there have been few studies in this field, the side-effects of artificial selection in particular species have been known for a considerable period of time (Bartels 2003). The selection for increased fecundity has resulted in increased

rates of neonatal mortality in a variety of species (Kallweit & Smidt 1981; Savas *et al* 2000). Dairy cows that have been selected for greater productivity will often only survive long enough to deliver 2 or 3 lactations. Broiler chickens that reach slaughtering age at 40 days have many problems like sudden death and leg deformations. Male and female turkeys are often incapable of natural insemination due to a considerable size difference that precludes natural copulation. Other examples of some of the side-effects of artificial selection include double muscling in meat cattle (Arthur 1995; Juliani 1998; Rauw *et al* 1998; Postler 1999; Eikholt 2001; Rutten *et al* 2002; Wiener *et al* 2002; Egger-Danner & Willam 2003) and the spreading of genes that cause genetic defects in populations such as DUMPS (Uridine Monophosphate Synthase) and WEAVER (Bovine Progressive Degenerative Myeloencephalopathy) syndromes (Hoeschele & Meinert 1990; Kuhn & Shanks 1994).

The undesirable side-effects of artificial selection are also very much in evidence in companion animals where breeding strategies are established to satisfy strict aesthetic guidelines (Bartels 2003). The most well-known examples of this include heart problems in short-leg dog breeds, parturition anomalies in brachycephalic breeds (Hagel 2003; Trautmann 2003) and widespread joint dysplasia. Indeed, a study carried out in Germany, demonstrated that the proportion of dogs with joint dysplasia in

Table 1 Descriptive statistics of certain body measurement in the experimental groups.

Traits (cm)	Mean (\pm SD)	G-SB		Mean (\pm SD)	G-NB	
		Minimum	Maximum		Minimum	Maximum
Beak length	1.05 (\pm 0.054)	1.0	1.1	1.71 (\pm 0.038)	1.7	1.8
Body length	29.91 (\pm 1.501)	27.6	31.6	32.76 (\pm 0.668)	31.5	33.5
Wing length	21.93 (\pm 0.864)	20.5	23.0	23.64 (\pm 0.748)	22.5	25.0
Tail length	12.67 (\pm 0.683)	11.5	13.5	13.30 (\pm 0.461)	12.6	14.0
Tarsus length	2.60 (\pm 0.290)	2.2	3.0	2.23 (\pm 0.213)	2.0	2.5
Middle finger length	2.40 (\pm 0.155)	2.2	2.6	2.47 (\pm 0.076)	2.3	2.5

different breeds varied from 16.1 to 44.2% (Beuing 2000). Examples in other species include crested ducks with cranial anomalies that predispose them to decreased hatching rates in comparison with other breeds (Portmann *et al* 2000) and, white Bengalese finches that display higher than average rates of cataract (Wriedt 2001).

The pigeon was one of the first companion birds to be domesticated and has a special place in the history of human civilization (Haag-Wackernagel 1998). The domestic pigeon differs in many ways from its origin in terms of both its anatomy and physiology. It is these differences that have played a key role in the continued increase in hobby-aimed breeding with a large proportion of the 800 pigeon breeds worldwide subject to such programmes (Vogel *et al* 1998).

There is considerable variation in beak length in pigeons as there is with many other traits. Pigeons bred with extremely short beaks are known to experience difficulties feeding their offspring. Therefore most pigeon breeders tend to keep normal beak pigeon breeds as nursing birds to ensure the survival of squabs from short beak pigeons. Because of the key role the beak plays in food intake, short beak pigeons often struggle to feed themselves. This means pigeons with short beaks cultivated through artificial selection can suffer adversely during direct competition for food and there may be important welfare implications which have been thus far ignored.

This study was carried out to investigate the effect of beak length on feed intake in pigeons and to compare the adaptation to time restricted feeding in short and normal length beaks with respect to certain comfort behaviours.

Materials and methods

Seven short beak, crossbred Baska pigeons (Group G-SB) and seven Flyingtippler pigeons with normal beak length (Group G-NB) were utilised in this study (Table 1). Pigeons in both groups were male and older than six months of age and thereby considered to be mature.

The Baska is a native, hobby-aimed breed which is widely reared in the provinces around Istanbul in Turkey. Typically it has a white head and white wing feathers with variable colouration elsewhere. Although the Baska, in its original form, has a beak of moderate length, many years of cross-breeding with more typically short-beaked breeds has artificially selected for a significantly altered head shape and shorter beak.

The Flyingtippler is bred for competitive endurance flying in many countries. Its small size and large breast create a general body conformation that greatly resembles that of the wild pigeon.

Animals were housed in two group cages in a private pigeon house. The cages were 100 × 160 × 110 cm (length × width × height) and were designed to meet the basic behavioural needs of the pigeons. The ambient temperature and relative humidity were recorded daily and average values were calculated as 9.6 ± 3.9°C and 47.2 ± 5.0% respectively.

According to the traditional feeding system, which is widely used by pigeon breeders, the birds were fed only once per day during the study. A feed mixture containing equal proportions of wheat and triticale grain, mixed on a fresh weight basis was used throughout the study. Pigeons also had free access to grit and fresh water at all times and trough length sufficient to ensure all birds could eat simultaneously.

The study was carried out in two consecutive trials. The effect of beak size on meal length was investigated during Trial I. This trial started after a period of five days acclimatisation to the feeding programme and lasted 15 days in total. Meal length was determined on an individual basis and defined as the period between the time when the first bird took its first peck and the consumption of water. After the allowance of the known amount of feed mixture, feeding period was started and leftover material in foddors was weighed again, then daily feed consumption was calculated on a group basis. The live weights of pigeons in both groups were recorded at the beginning and the end of the trial period. Trial II started after a break of seven days and sought to investigate adaptation to time restricted feeding. The feeding activity was terminated when a pigeon in any group that stopped eating first was seen to move towards water, at which point all the foddors were removed from the cages and feed consumption of the groups was calculated.

Behavioural observations were recorded during two time periods, 1) pre-feeding (30 min) and, 2) feeding. Observations noted during the pre-feeding period comprised of comfort behaviour such as resting, locomotion and preening and were determined by time-sampling methods at 5 min intervals. Continuous monitoring of aggressive pecking and sexual behaviour were carried out during each observation in both pre-feeding and feeding periods.

Table 2 Mean (\pm SD) of monitored traits in the groups during Trial I.

Parameters	G-SB Mean (\pm SD)	G-NB Mean (\pm SD)
Initial live weight (g)	273.6 (\pm 31.01)	308.6 (\pm 16.02)
Final live weight (g)	277.0 (\pm 27.78)	305.6 (\pm 16.50)
Average feed consumption (g day ⁻¹)	22.4 (\pm 3.47)	21.1 (\pm 4.28)
Meal length (min)	15.9 (\pm 8.89)	5.6 (\pm 2.05)
Aggressive pecking (frequency min ⁻¹)	0.4 (\pm 0.41)	0.1 (\pm 0.38)

Table 3 Least square means (+ SE) of meal length and aggressive pecking frequencies in the groups during Trial I.

Parameters	G-SB	G-NB	P \leq
Meal length (log ₁₀ [min+1])	1.15 (0.057)	0.73 (0.057)	0.001
Aggressive pecking ($\sqrt{[\text{freq}/\text{min}] + 1}$)	1.17 (0.048)	1.05 (0.048)	0.125

Table 4 Mean (\pm SD) of monitored traits in the groups during Trial II.

Parameters	G-SB Mean (\pm SD)	G-NB Mean (\pm SD)
Initial live weight (g)	285.6 (\pm 21.85)	312.3 (\pm 14.40)
Final live weight (g)	263.9 (\pm 21.88)	300.4 (\pm 11.97)
Live weight change(g)	18.6 (\pm 9.96)	8.8 (\pm 4.20)
Live weight change (%)	6.7 (\pm 4.22)	2.8 (\pm 1.26)
Average feed consumption (g day ⁻¹)	14.2 (\pm 1.13)	19.5 (\pm 1.23)
Meal length (min)	-	4.0 (\pm 0.60)
Aggressive pecking (frequency min ⁻¹)	0.9 (\pm 1.09)	0.2 (\pm 0.68)

Table 5 Least square means (+ SE) of meal length and aggressive pecking frequencies in the groups during Trial II.

Parameters	G-SB	G-NB	P \leq
Live weight loss (%)	7.63 (1.353)	2.81 (1.351)	0.001
Aggressive pecking ($\sqrt{[\text{freq}/\text{min}] + 1}$)	1.32 (0.069)	1.06 (0.068)	0.022

In order to get a precondition of analysis of variance, aggressive pecking and sexual behaviour frequencies were put into logarithmic or square root transformations. Statistical analyses of live weight changes, meal length and aggressive pecking observed during the feeding period were done using a repeated measurements design of analysis of variance for which the groups (short and normal beak) and the numbers of observation days were fixed effects in the statistical model for both trials. Aggressive pecking and sexual behaviours observed during the pre-feeding period were also analysed by performing a repeated measurement designed linear model, in which groups, observation days and trials (I and II) were fixed effects and the interaction effect of the group and the trial were also included in the model. The interaction effect of the group and the trial was found to be significant and therefore Table 6 consists of last square means of interaction groups.

Locomotion, resting and preening behaviours were observed by the time sampling method, expressed as binary data and put into a Generalized Estimating Equations (GEE) logistic regression model, including a repeated measure-

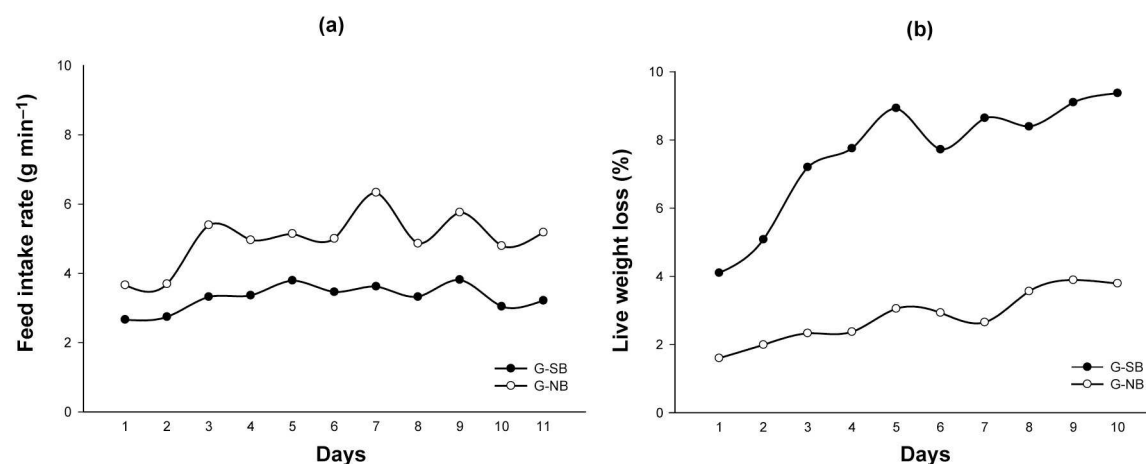
ment design for the two trials. Fixed effects used in the model were groups and observation days. Odds ratios, regression coefficients, and standard error values of regression coefficients were used in the evaluation of the effects. Odds ratio was defined as the ratio of observation to non-observation of behaviour and calculated from the equation: $\Psi = e^b$, where Ψ is the odds ratio, b the regression coefficient, and e the exponential constant. All the statistical analyses were done by statistical package program (SAS Institute Inc 1996).

Results

Trial I

The pigeons in both groups had *ad libitum* access to feed during Trial I. Under this feeding regime, small differences were found between the groups in terms of the average live weight at the start of the trial period compared to the weight at the end. (Table 2). The average daily feed intake of the G-SB group (22.4 g) was found to be higher than that of the G-NB group (21.1 g).

Figure 1



Average feed intake rate (a) and relative live weight changes (b) in the groups during Trial II.

Although the daily feed intake for the groups was very similar during the two week trial period, meal length in the G-NB group was found to be considerably shorter than in the G-SB group; the differences between the transformed values of the meal length of the groups were significant ($P < 0.001$). The rate of feed intake was also calculated as 1.40 g min^{-1} for the G-SB group compared to 3.76 g min^{-1} for the G-NB group. The pigeons in the G-SB group showed more aggressive pecking frequency (Table 3), however the differences between the groups were not significant ($P = 0.125$).

Trial II

A pigeon in the G-SB group who lost 28% of its body weight between the start of the trial and day 5 was removed from Trial II. Live weight losses in the G-SB group reached 10% of start weight by the end of the trial as a direct consequence of the treatment. The trial was terminated on day 11 as a direct result of the excessive level of weight loss that was considered detrimental to the health and welfare of the pigeons.

Daily meal length was calculated for the pigeons in the G-NB group and the average was found to be 4 min (Table 4). Comparing these results with Trial I, in which the pigeons' average daily feed intakes were 22.4 g and 21.1 g for the G-SB and G-NB groups respectively, restriction in meal length resulted in a considerably reduced feed intake (36%) in the G-SB group. The feed intake rates, described as the ratio of daily feed intake (g) to meal length (min), were calculated as 3.55 g min^{-1} for the G-SB group and 4.87 g min^{-1} for the G-NB groups. The changes in the calculated daily feed intake rates for the groups are given in Figure 1(a).

The live weight of the pigeons in both groups decreased as a result of restrictions to the daily meal length and the total live weight losses of G-SB pigeons were greater than those of the G-NB (6.7% compared to 2.8%). As Figure 1(b) illustrates, the level of relative live weight losses in the G-NB group showed greater uniformity compared to G-SB, espe-

cially among early consecutive days of the trial. However, the pigeons in the G-SB group were more seriously affected by the treatment, and the differences in the relative live weight losses between the groups were found to be significant ($P < 0.001$).

Aggressive pecking frequency in the groups was also affected by the treatment (Table 5). The pigeons in the G-SB group showed more aggressive pecking behaviour than those in the G-NB group ($P = 0.022$). The results of the statistical analyses on behavioural observations recorded during the pre-feeding periods of each trial steps of the study are summarised in Table 6 and Table 7. The statistical analyses showed that there were no significant effects of beak type ($P = 0.621$) or trials ($P = 0.628$) on aggressive pecking frequency in the groups. However, an interaction effect was seen for this behavioural parameter ($P = 0.004$). Sexual behaviours in the groups did not appear to be affected by beak type ($P = 0.472$), although the effects of treatment ($P = 0.005$), and the interaction between the main effects ($P = 0.004$) on this type of behavioural trait were found to be statistically significant. Thus, only the means of the interaction effect for each behavioural trait are presented in Table 6.

Preening was 48% ($\Psi = 1.48$) higher in the short beak group than in the control group in the first trial ($P = 0.001$) while this difference disappeared in the second trial ($P = 0.396$).

Short beak pigeons displayed 80% ($\Psi = 1.80$) more resting behaviour than the normal beak pigeons in the first trial ($P < 0.001$), but the reverse was seen to be true for Trial II. During this trial, the pigeons from the G-SB group showed 27% ($\Psi = 0.73$) less resting behaviour frequency than the G-NB group ($P = 0.021$). Locomotion frequency was very similar for the groups in the first trial ($P = 0.850$). Locomotion was observed 28% ($\Psi = 0.72$) less in the short beak group than in the control group ($P = 0.160$) although the difference was not significant.

Table 6 Least square means (+ SE) of aggressive pecking frequencies and sexual behaviour in the groups observed prior to the feeding period with respect to the interaction effect between beak type and feeding type.

Traits	G-SB		G-NB	
	Trial I	Trial II	Trial I	Trial II
Aggressive pecking ($\sqrt{[\text{freq}/\text{min}] + 1}$)	1.24 (0.113) ^{ab}	1.16 (0.114) ^{ab}	1.06 (0.113) ^a	1.17 (0.114) ^b
Sexual behaviours ($\sqrt{[\text{freq}/\text{min}] + 1}$)	1.18 (0.106) ^{ab}	1.18 (0.107) ^{ab}	1.19 (0.106) ^a	1.39 (0.107) ^b

Significant differences: ^{ab} $P < 0.05$.

Table 7 Estimates (b), standard errors (SE) and odds values (Ψ) of some behavioural traits observed in the pre-feeding period during Trial I and Trial II⁽¹⁾.

Behaviours	Trial I				Trial II			
	b	SE	Ψ	$P \leq$	b	SE	Ψ	$P \leq$
Preening	0.39	0.120	1.48	0.001	0.12	0.142	1.12	0.396
Resting	0.59	0.121	1.80	0.001	-0.31	0.133	0.73	0.021
Locomotion	0.04	0.187	1.04	0.851	-0.34	0.239	0.72	0.157

⁽¹⁾ Odds ratio values (Ψ) of the normal beak group (G-NB) were 1.00.

Discussion

Morphological traits are a key component of the adaptive capabilities of an individual. Leaving aside the issue of welfare adaptations of wild populations, welfare remains the responsibility of man, who tends to control the production processes that underpin breeding conditions. Therefore, human-oriented preferences either for production or recreational purposes have become the dominant force in shaping breeding and environmental conditions. This has led to a growing number of discussions on animal welfare (Das *et al* 2004). In this study, the welfare implications of having a short beak, developed purely as breeder preference, was investigated under different feeding conditions.

The beak is an integral component of feeding in avian species and there is an important link between the design of the beak and the feeding environment. Further, the feeding environment plays a significant part in shaping evolutionary change. Studies on variations in beak morphology in Darwin's finches have provided important clues to help explain the interaction between environmental adaptation, natural selection and populations (Abzhanov *et al* 2004; Podos & Nowicki 2004).

In this study, both groups of pigeons are classified as small breeds in terms of their general body size (Table 1). However, beak length in the short beak group (G-SB) was calculated as 39% shorter than the normal beak group (G-NB). This difference was also reflected in the values of the ratio of beak length to body length; 3.5% for G-SB group and 5.2% for G-NB group.

The basic anatomy of the avian mouthpart and the specific characteristics of feed material have been described as the main physical factors that influence the rate of feed consumption (Fraser 1985). Under *ad libitum* feeding conditions (Trial I), pigeons in the G-SB group spent more time on feed consumption than those in the G-NB group (Table 2). Although significant differences were found

between the groups in transformed data of meal length ($P < 0.001$), feed consumption was found to be similar for both groups. Variation in meal length among the pigeons of G-SB groups ($CV_{SB} = 0.56$) was an interesting finding. The variation within the G-NB group was calculated as $CV_{NB} = 0.37$. Findings at present are insufficient to allow evaluation of the variation in meal length within the group (G-SB) however it is possible to speculate that this variation could have been influenced by the morphological features of the beak. In this regard, variation coefficients for beak length were calculated as 0.05 and 0.02 for G-SB and G-NB groups, respectively.

The findings of Trial I, which lasted for 15 days, suggest that a short beak does not cause any serious problems in helping pigeons attain their physiological requirements. In fact, the pigeons in G-SB group reached similar consumption values as pigeons in the G-NB group throughout Trial I and did not incur any problems with weight loss.

The observer did note, however, that some of the pigeons in G-SB group displayed an altered feeding behaviour whereby feed ingredients, were not picked up but the beak was deployed as a grasping implement and the head was tilted backwards to aid ingestion. This altered behaviour which is thought to be linked with having a short beak and occurs under restricted environmental conditions, is typical feeding behaviour in squabs fed by their dams.

Restricted meal length in Trial II resulted in weight loss in both groups, but the level of weight loss was significantly greater in the G-SB group ($P < 0.001$). The level of weight loss in the G-NB group (2.8% of initial body-weight) suggests that small differences in meal length among individuals can be of biological significance under restricted conditions.

Restriction in meal length led to an increase in the rate of feed consumption in both groups, compared to Trial I. The rate was calculated as 1.4 and 3.6 g min⁻¹ in the G-SB group

and 3.8 and 4.9 g min⁻¹ in the G-NB group for Trials I and II respectively. Although the rate of feed consumption for the G-SB group in Trial II increased by 157%, compared to Trial I, the average total feed consumption of the G-SB in Trial II only reached 63% of the amount for Trial I. The corresponding value for the G-NB group revealed that feed consumption in Trial II reached 92% compared to Trial I. However, the actual rate of feed consumption for the G-NB group was 29% higher in Trial II compared to Trial I.

Therefore, the question of whether or not the increase in feed consumption in a given time period is determined by an adaptive mechanism has considerable welfare implications.

The inheritance of adaptation to restricted environmental conditions within natural circumstances has been addressed (Lorenz 1982). The existence of different interactions and adaptation mechanisms that occur over a long period of time are quite difficult to observe in artificial conditions. However, even under such conditions, an organism can develop short- and long-term strategies through mechanisms controlling feed intake (Illius *et al* 2002). Zeigler *et al* (1972), investigating the relationships between feed intake and control of live weight, reported that pigeons showed short- or long-term compensatory increases in feed intake following feed restriction and this compensation was directly related to loss of bodyweight. Behaviour such as faster, stronger and less accurate pecks at feed are also reported as changes in response to food restriction (Forbes 1995).

Care should be taken when the rate of feed consumption for both groups in Trial II is being evaluated. Although consumption values indicate an increase in the rate of feed consumption compared to Trial I, time-related increases in the rate of feed consumption in the groups, especially the G-SB group were not observed (Figure 1[a]). In other words, the increase in the rate of feed consumption could reflect the values of individuals who had the fastest feed consumption in the group or that the highest feed consumption rates were reached at the beginning of feed allowance. It should be borne in mind that the feeding period ended when the first bird moved from the fodder to the water. The termination of the study at an early phase due to significant levels of weight loss (Figure 1[b]) makes the discussion of this matter difficult. However, in light of present findings, it is highly suggestive that conditions which limit or terminate feed intake are of particular significance to short beak pigeons and this physical limitation can be an impediment to the development of a time dependent adaptation mechanism ie an increase in the rate of feed consumption, in response to such conditions. At this point, we need not consider the relationship between short beak and feeding behaviour in relation to beak trimming. This occurs routinely in poultry and Martinec *et al* (2002) reported that beak trimming had no effect on feed intake, meal length and feed conversion ratio in laying hens except for a short period following the application.

Frequency of aggressive behaviours increase during feeding under restricted environments (Price 2002). No significant

difference was found between the groups in terms of aggressive pecking, during the daily feeding of Trial I ($P = 0.125$). This compares to Trial II (Table 5) in which aggressive pecking was shown to be significantly higher in G-SB group ($P = 0.022$). This finding helps to illustrate the effects of restriction in the short beak group.

Preening in poultry is reported to have a social component as well as addressing feather care and the removal of dirt and/or ectoparasites (Palestis & Burger 1998). Although regarded as a comfort behaviour, Karaagac *et al* (2003) reported that preening can be observed in restricted or stressful conditions and suggested that this behaviour can be defined as “sparking over-activity”. These findings were matched by Webster (1995) who focused on the effects of feed restriction. Preening behaviour was found to be 48% higher in the G-SB pigeon group during Trial I ($P = 0.001$). This finding implies that the amount of time spent preening can be influenced by beak length with or without the influence of the factors described above. Sandilands and Savory (2002) reported that preening took a longer time in beak-trimmed hens.

Conclusion and animal welfare implications

In conclusion, problems with feed intake can be observed in pigeons that have short beaks. The present findings reveal that welfare problems may arise when pigeons with short beaks are subjected to feed restriction measures. In this regard, the provision of sufficient feed, and appropriate environmental conditions ie housing in separate cages, optimum fodder length etc are necessary requirements to properly ensure the welfare of short beaked pigeons. Research on behavioural traits associated with social hierarchy, feeding time, feeding frequency and interval, form of feed and squab feeding are also warranted.

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