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CARFAX

Aggressive pecking by males in breeding groups of Japanese quail (*Coturnix japonica*)

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Abstract 1. Head injuries caused by aggressive pecking are an important welfare problem in quail farming. The aim of experiments one to three was to reduce the rate of aggressive pecking in breeder groups.

2. The quails were housed in pens containing litter, nest boxes and a dustbathing box. The experimental groups consisted of 2/14, 3/14, 5/15 or 5/35 (males/hens) quails which were introduced into the experimental pens at the age of 4, 6 or 7 weeks.

3. None of the 5 factors that varied between the pens (visual barriers, age of introduction into the pens, number of hens per 5 males, number of males per 14 hens and light intensity) had a significant effect on the rate of aggressive pecking interactions between males.

4. Because of serious head injuries 20%, 17·5% and 12·5% (experiments 1, 2, 3) of the males had to be removed from their groups.

5. In single-male groups containing 8, 12, 16 and 20 hens (experiment 4) the percentages of fertilised eggs were 92%, 84%, 77% and 69% (medians, $n = 4$ pens per group size). No males were seriously injured in these groups.

6. It is concluded that for welfare reasons multi-male breeding groups of Japanese quail cannot be recommended. Given the satisfactory fertility observed in groups with a sex ratio of 1:8 or 1:12, single-male groups are also of interest for economic reasons: food costs are reduced.

INTRODUCTION

In their natural habitat, Japanese quails spend part of their life in flocks (as members of a brood and later in winter flocks) in which the social organisation appears to be a dominance hierarchy based on a pecking order (Boag and Alway, 1980). In captivity, breeding groups typically consist of 15 to 20 birds kept in battery cages with a floor area of 1·0 m × 0·5 m and a height of 16 to 20 cm (Gerken and Mills, 1993). Under these housing conditions aggressive pecking, namely pecks directed to the head, may cause serious (sometimes lethal) injuries such as skin or eyelid lesions or eye loss, and it is one of the important welfare problems arising in quail farming (Gerken and Mills, 1993). However, serious head injuries caused by aggressive pecking occur not only under intensive housing conditions but also when small groups of quails (8 to 9 birds per 19 m^2) are kept in semi-natural outdoor aviaries (Schmid and Wechsler, 1997).

The study presented here is part of a research project that aims to develop alternative housing systems for Japanese quail (Schmid, 1997). The effect of 5 factors on the incidence of aggressive pecking was investigated in 3 experiments, on quails housed in pens containing litter, nest boxes and a dustbathing box. The 5 factors were: provision of visual barriers in the pens, age at which the quails were introduced into the experimental pens, number of hens per 5 males, number of males per 15 hens and light intensity. In order to examine fertility with a minimal number of males (one per breeder group) the sex ratio was varied between pens in experiment 4.

GENERAL METHODS

Animals and housing conditions

The quails used in experiments 1 to 4 were of a strain that is used for both egg and meat production. They had been reared in battery cages on a commercial farm and were introduced into the experimental pens at the age of 4, 6 or 7 weeks. They were group-housed in wooden experimental pens with a floor area of 200 × 100 cm and a height of 50 cm (Figure 1). These pens, arranged in two tiers of 4, had solid walls on 3 sides, while the front and the top were of wire mesh. The centre of each pen had a solid floor covered with litter, while a 100 × 50 cm area on each side was perforated. In the centre was a transparent plastic box (25 × 21 × 15 cm) filled with sand (3 cm deep) for dustbathing. There were 2 drinkers and 1 feeder in

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each pen with food and water available *ad libitum*. A fluorescent tube (36 W) was suspended 53 cm above the pen floor. The lights came on at 0530 h, and the pens were illuminated for 15 h a day with a 15 min twilight phase at the start and the end of the light period. All experiments were authorised as prescribed by Swiss animal welfare legislation (application No. 68/95).

Data collection and analysis

In experiments 1 to 3 'all occurrences' (Altmann, 1974) of aggressive pecking between males, that is, pecks directed to the head, were recorded. Repeated pecks directed at the same individual within 2 s were recorded as one interaction, as we found it impossible to count the exact number of single pecks. On 4 to 6 d per week each pen was observed for 1 or 2 periods of 10 minutes each in the morning. All males were marked with coloured leg rings and wing bands to facilitate recognition. All birds were checked daily for head injuries. Seriously injured males or hens were removed from the pen. Data are presented as numbers of pecking interactions per male per 30 min. Where males had to be removed because of serious head injuries, daily pecking rates were standardised by dividing the number of interactions by the actual number of males present. After square-root transformation pecking rates were analysed using a one- or two-way ANOVA (Systat, 1992) with 'week' as a repeated measure. Further analysis was by Wilcoxon matched-pairs signed ranks test, Wilcoxon–Mann–Whitney test and Jonckheere test for ordered alternatives (Siegel and Castellan, 1988). Except for the Jonckheere test, all *P*-values are two-tailed.

Experiment 1

In experiment 1 we tested the hypothesis that the incidence of aggressive pecking between males is influenced by the presence of visual barriers in the pen. We predicted that visual barriers would allow subordinate males to get out of sight of dominant males.

Methods

Eight groups, each of 5 males and 15 hens, were introduced into the experimental pens at the age of 6 weeks. In 4 pens, 2 visual barriers (70 × 20 cm) each (with a passage of 10 × 10 cm in the middle) were placed on the litter floor (Figure 1). Hemp shavings were used as litter material. Light intensity ranged from 39 lux in the corners to 370 lux in the centre of a pen. In the rear left corner of each pen there was a nest box (dimensions 33 × 21 × 14 cm) with a curtain made of strips of green plastic at its entrance. Temperature varied between 12° and 21°C.

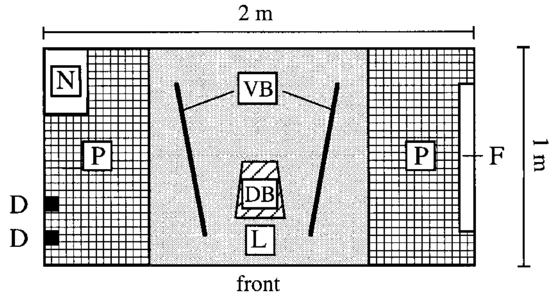

Figure 1. *Pen design and location of the visual barriers (VB) in experiment 1. The pens contained 1 feeder (F), 2 drinkers (D), a nest box (N) and a dustbathing box (DB). The centre part of the floor area was solid and covered with litter (L), whereas the side parts were perforated (P).*

Data collection was started at the beginning of week 7, one day after the introduction of the quails into the experimental pens. During weeks 7 and 8 each pen was observed for 10 min during the morning on 6 d per week. At the end of week 8 light intensity was reduced to between 1 and 5 lux to test whether this would result in lower pecking rates. Data collection continued on 5 d in week 9.

The pecking rates of weeks 7 and 8 were compared between pens with and without visual barriers using a one-way ANOVA with 'week' as a repeated measure. Pecking rates of week 8 (full light intensity) and week 9 (reduced light intensity) were compared using the Wilcoxon matched-pairs signed ranks test.

Results

The rate of aggressive pecking interactions between males varied between 0·1 and 3·0 per male per 30 min in week 7, between 3·3 and 9·0 in week 8 and between 0·6 and 3·2 in week 9 (Figure 2). The visual barriers had no significant effect on pecking rates ($F_{1,6} = 0{\cdot}07$, $P = 0{\cdot}80$). Dominant males chased subdominants persistently even if the latter tried to get out of sight by entering the nest box in the corner of the pen. There was a significant increase in pecking rates from week 7 to week 8 ($F_{1,6} = 72{\cdot}67$, $P = 0{\cdot}0001$). After reduction of the light intensity, pecking rates were lower in week 9 compared to week 8 (Wilcoxon matched-pairs signed ranks test, $n = 8$, $T^+ = 36$, $P = 0{\cdot}008$).

Eight out of 40 males (20%) had to be removed from their groups because of serious head injuries. In week 8, 5 males were removed from 4 pens. In week 9, after reduction of light intensity, another 3 had to be removed from 2 pens. Four males were removed from 3 pens with visual barriers and 4 from 2 pens without visual barriers. Also in week 8, 2 out of 120 hens (1·7%) had to be removed because of serious head injuries.

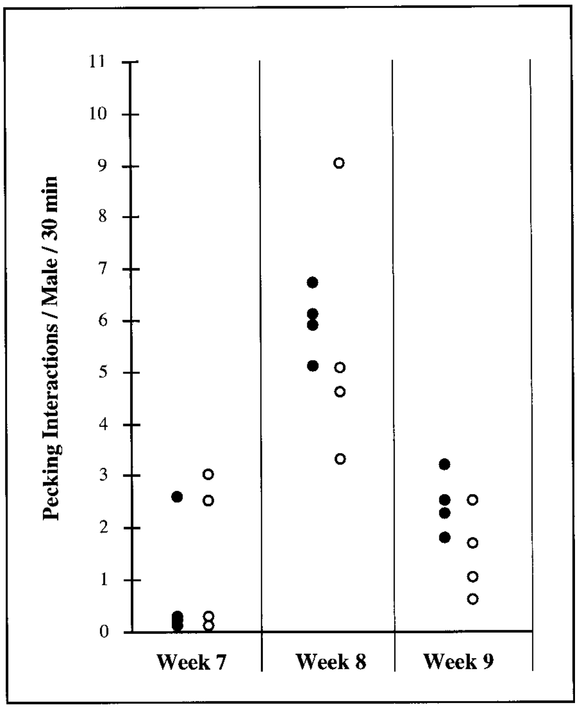

Figure 2. *Rates of pecking interactions (experiment 1) between males in 4 pens containing visual barriers (●) and 4 pens without visual barriers (○). Light intensity was high in weeks 7 and 8 and reduced in week 9.*

Experiment 2

In experiment 2 it was tested whether the incidence of aggressive pecking between males is influenced by age of introduction into the experimental pens (before reaching sexual maturity or at onset of maturity) or by group size. Both factors were varied independently in a 2 × 2 factorial design. Each of the 4 possible combinations was assigned to 2 pens. We expected that aggressive pecking at maturity would be reduced if the males were grouped early allowing them to establish dominance relationships before the onset of reproductive behaviour. We also predicted that pecking rates would be lower in larger groups because competition between males for hens might be reduced when there were more hens per male. Also sexual activity might be more pronounced at the expense of aggressive behaviour and furthermore persistent chasing of subordinates by dominants might be more difficult in crowded conditions.

We also recorded whether males are pecked predominantly by other males and rarely by hens, and whether males removed because of serious head injuries receive more aggressive pecks than males without such injuries.

Methods

There were 4 groups of 5 males and 15 hens and 4 groups of 5 males and 35 hens. Two groups of each composition were introduced into the pens at the age of 4 and 6 weeks, respectively. The pen design was changed slightly from that used previously. There were no visual barriers. In experiment 1 low light intensity appeared to reduce pecking, so light intensity was reduced to between 7 and 36 lux (corners and centre of a pen, average values of 6 measurements in all 6 directions at 15 cm above the pen floor) in order to minimise serious injuries. Because hen number was increased in the large groups, all pens were provided with 4 nest boxes (same type as in experiment 1) instead of one. In the centre of the pens the floor was covered with chaff instead of hemp shavings. Temperature varied between 11°and 24°C.

Data collection began in week 6 with the quails introduced at 4 weeks and continued in all pens from week 7 to 10. Each pen was observed for 2 periods of 10 min during the morning on 4 d per week. 'All occurrences' of aggressive pecking interactions between males and also 'all occurrences' of pecking interactions initiated by a hen and directed to the head of a male were recorded. Identities of males pecked were recorded.

Analysis

To examine possible treatment effects on aggressive behaviour between males the pecking rates from weeks 7 to 10 were analysed using a two-way repeated measures ANOVA. In addition, pecking rates in week 7 for groups which had just been moved into the experimental pens at the age of 6 weeks and groups which had already been living in the experimental pens for 2 weeks were compared using the Wilcoxon–Mann–Whitney test. Only pecking interactions between males were included in these analyses.

For each male the rate of pecking interactions (per 30 min of contact time) was calculated separately for pecks originating from another male or from a hen. For each, the average rates (per pen) were compared using the Wilcoxon matched-pairs signed ranks test. The rates of pecking directed at males removed because of injury and at non-injured males were compared using the Wilcoxon–Mann–Whitney test.

Results

In week 6, when there were only 4 groups, the rate of aggressive pecking interactions between males was 0 in 3 pens and 0·1 in one pen. In week 7, with all 8 experimental groups, it varied between 0·3 and 5·7, in week 8 between 0·4 and 5·1, in week 9 between 1·0 and 5·4 and in week 10 between 0·9 and 6·7 (Figure 3). Neither the age at which the quails were introduced into the experimental pens ($F_{1,4} = 0{\cdot}77$, $P = 0{\cdot}43$) nor group size ($F_{1,4}, = 2{\cdot}21$, $P = 0{\cdot}21$) had a significant effect on pecking rates. The interaction between the 2 factors was also not significant ($F_{1,4} = 0{\cdot}53$, $P = 0{\cdot}51$). There was no significant change in pecking rates over weeks 7 to 10 ($F_{3,12} = 1{\cdot}85$, $P = 0{\cdot}19$). In week 7, the differ-

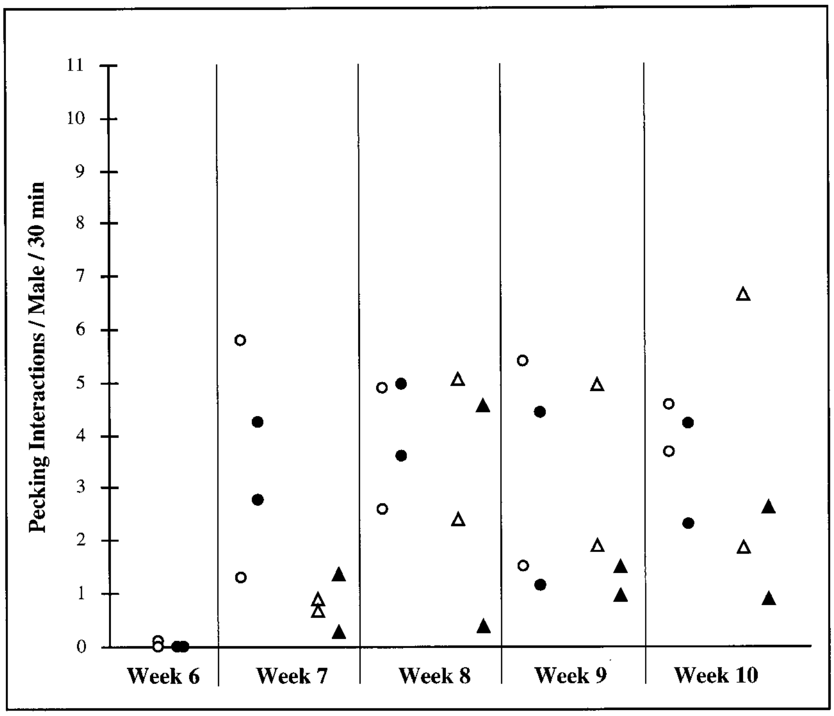

Figure 3. *Rates of pecking interactions (experiment 2) between males for weeks 6 to 10. Four groups were introduced into the pens at the age of 4 weeks (circles) and 4 groups at 6 weeks (triangles). The groups were composed of 5 males and 15 (open symbols) or 35 (filled symbols) hens.*

ence in pecking rates between 4-week and 6-week introduction also failed to reach significance (Wilcoxon–Mann–Whitney test, $W_x = 11$, $P = 0{\cdot}057$). However, there was a trend to lower pecking rates in the newly introduced groups (0·8 ± 0·5, mean ± SD compared to 3·5 ± 1·9).

During the experimental period 7 out of 40 (17·5%) males (from 6 pens) had to be removed because of injury. No hens ($n = 200$) had to be removed. More pecking directed to males originated from other males than from hens. The mean (± SD) rates (per bird per 30 min) were 3·1 ± 1·5 and 0·5 ± 0·3, respectively (Wilcoxon test, $n = 8$ pens, $T^+ = 36$, $P = 0{\cdot}008$). Removed males ($n = 7$) received significantly more pecks per 30 min (6·0 ± 3·1) than non-injured males ($n = 33$; 3·0 ± 1·7; Wilcoxon–Mann–Whitney test, $z = 2{\cdot}62$, $P = 0{\cdot}009$).

Experiment 3

In experiment 3 we examined the influence of male numbers in a breeding group on the incidence of aggressive pecking between males. Because of evidence from experiment 1 that pecking rates declined when light intensity was reduced, this factor was varied between pens from the beginning in experiment 3. Both factors were varied independently in a 2 × 2 factorial design. Each of the 4 combinations of factors was assigned to 4 pens.

Methods

There were 16 pens with a floor area of 100 × 100 cm each. Wood-shavings were used as litter. All pens contained 14 hens. There were 2 males in 8 pens and 3 males in the other 8 pens. The birds were introduced at the age of 7 weeks. Light intensity was either high (170 lux, average of 6 measurements in all 6 directions at 15 cm above the floor at the brightest spot) or low (15 lux). There was one nest box per pen. Temperature varied between 8° and 21°C.

Data collection began on week 8, 2 days after introduction of the birds. During weeks 8, 9 and 10 each pen was observed for 10 min during the morning on 4 d per week. In contrast to experiments 1 and 2, seriously injured males were not only removed but also replaced by new males of the same age. This was done to keep the sex ratio constant for the measurement of egg fertility (see experiment 4).

Analysis

To establish whether number of males or light intensity influenced aggressive behaviour between males, pecking rates from weeks 8 to 10 were analysed using a two-way repeated measures ANOVA.

Results

The rate of aggressive pecking interactions between males varied between 0 and 5·6 in week 8, between 0 and 4·0 in week 9, and between 0 and 10·1 in week 10 (Figure 4). Neither number of males per pen ($F_{1,12} = 2{\cdot}45$, $P = 0{\cdot}14$) nor light intensity

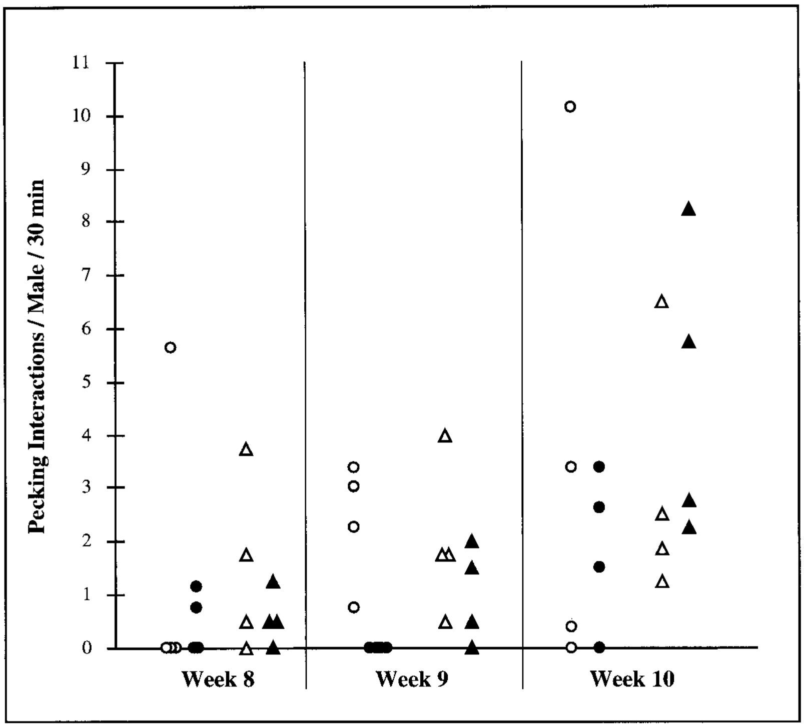

Figure 4. *Rates of pecking interactions (experiment 3) between males for weeks 8 to 10. Eight groups with either 2 (circles) or 3 males (triangles) were housed with 14 hens. Light intensity was either high (open symbols) or low (filled symbols).*

($F_{1,12}$, = 2·10, P = 0·17) had a significant effect on pecking rates. The interaction was also not significant ($F_{1,12}$ = 0·97, P = 0·35). However, there was a significant increase in pecking rates over time ($F_{2,24}$ = 7·69, P = 0·003). These were 1·0 ± 1·6 (mean ± SD, week 8), 1·3 ± 1·3 (week 9) and 3·3 ± 2·6 (week 10).

Five out of 40 males (12·5%) had to be removed because of serious head injuries. Four were from 3 pens with 3 males and high light intensity, the fifth was from a pen with two males and low light intensity. Six out of 240 hens (2·5%) had to be removed because of serious head injuries.

Experiment 4

In experiments 1, 2 and 3, 20%, 17·5% and 12·5% of males had to be removed because of serious head injuries. In experiment 4 we investigated whether egg fertility was different when 14 hens were housed together with 1, 2 or 3 males. In addition egg fertility was measured in single-male groups with different sex ratios.

Methods

We used the 16 groups of experiment 3 after the end of data collection on aggressive pecking. Fertilisation rates (FR) were determined 3 times: in week 11, when there were 2 or 3 males per group (FR 2/3); in week 13, after removal of one male from each group, with one or two males per group (FR 1/2); and in week 15, when one male per pen was grouped with 8, 12, 16 or 20 hens (FR 1/8 to 20). Whenever group composition was changed, eggs for measuring FR were collected after 10 d delay, because a hen can lay fertile eggs for up to 10 (Woodard and Abplanalp, 1967) or 11 d (Adkins-Regan, 1995) after removal of the male. For each determination of FR, 50 eggs were collected per pen on 6 (FR 2/3), 5 (FR 1/2) and 8 d (FR 1/8 to 20), respectively. They were stored at room temperature (12 °C to 18 °C). After incubation for 5 d (at 37·8 °C) the eggs were opened to check whether they were fertilised or not. FR was calculated as the percentage of incubated eggs that were fertile. For FR 1/2 and FR 2/3 light intensity was the same as in experiment 3 (8 pens 170 lux, 8 pens 15 lux). For the measurement of FR 1/8 to 20, light intensity was the same for all pens (170 lux).

Analysis

After arcsine square-root transformation the percentages of fertile eggs were analysed using a two-way ANOVA with FR 1/2 and FR 2/3 with the 2 factors being number of males and light intensity. With FR 1/8 to 20 the Jonckheere test for ordered alternatives was used, hypothesising that fertilisation rate should decrease with increasing number of hens per male.

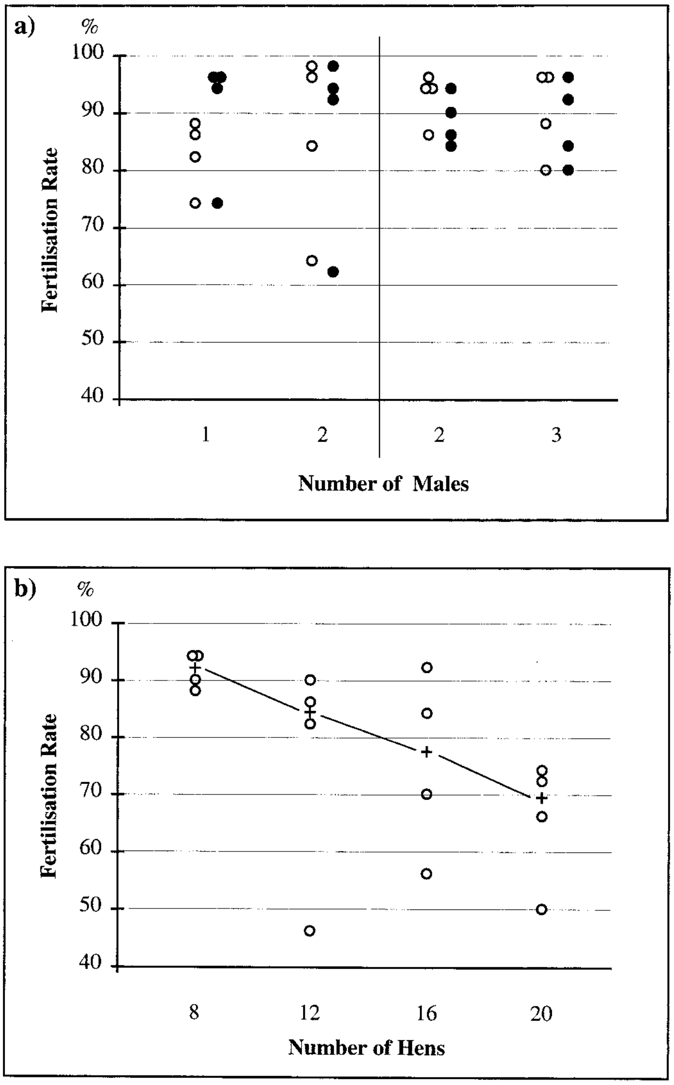

Figure 5. *Fertilisation rates (a) in groups of 14 hens with 1, 2 or 3 males (FR1/2 and FR2/3) and (b) in single-male groups with 8, 12, 16 or 20 hens. Light intensity was either high (○) or low (●). Each data point was calculated from a sample of 50 eggs. The + signs mark the median values.*

Results

With FR 1/2 (week 13), on average 86·3% and 86·0% of the eggs were fertile in groups with 1 and 2 males, respectively (Figure 5a). Neither number of males ($F_{1,12}=0{\cdot}05$, $P=0{\cdot}83$) nor light intensity ($F_{1,12}=0{\cdot}63$, $P=0{\cdot}44$) had a significant influence on FR 1/2. The interaction was also not significant ($F_{1,12}=0{\cdot}40$, $P=0{\cdot}54$). With FR 2/3 (week 11), on average 90·5% and 89·0% of the eggs were fertile in groups with 2 and 3 males, respectively (Figure 5a). Neither number of males ($F_{1,12}=0{\cdot}12$, $P=0{\cdot}74$) nor light intensity ($F_{1,12}=1{\cdot}09$, $P=0{\cdot}32$) affected FR 2/3. The interaction was also not significant ($F_{1,12}=0{\cdot}12$, $P=0{\cdot}74$).

With FR 1/8 to 20 (week 15), the number of hens per male had a significant influence on the percentage of fertile eggs ($J=76$, $P<0{\cdot}01$). The respective medians were 92% (8 hens), 84% (12 hens), 77% (16 hens), and 69% (20 hens) (Figure 5b). Pairwise comparisons between the 4 treatments showed that only the difference between groups with 20 and 8 hens was statistically significant.

No male from a single-male group had to be removed because of serious head injuries.

DISCUSSION

Percentages of 20%, 17·5% and 12·5% seriously injured males in experiments 1, 2 and 3 show that aggressive pecking was indeed a welfare problem. In experiment 2, more pecks at males originated from other males than from hens and more pecks were directed to males that had to be removed because of serious head injuries than to males without such injuries. In all 3 experiments a far higher proportion of males than hens had to be removed because of serious head injuries. In single-male groups no male was seriously injured (experiment 4). It is concluded that serious injuries arise from male-male interactions. This accords with observations in semi-natural aviaries, where most pecking occurred between males, and again some had to be removed because of serious head injuries (Schmid and Wechsler, 1997).

None of the factors tested in experiments 1 to 3 was successful in preventing serious head injuries in breeding groups containing 2 or more males. The provision of visual barriers, the age of introduction, the number of hens per 5 males and the number of males per 15 hens had no significant influence on the rate of aggressive pecking between males. In experiment 3, pecking rates in groups with low (15 lux) and high (170 lux) light intensity also did not differ significantly. However, with reduced light intensity in experiment 2 (7 to 36 lux) there was a trend to lower pecking rates in week 8 compared to week 8 in experiment 1 (light intensity 39 to 370 lux). Nevertheless, several males were seriously injured in experiment 2. Only reducing the light intensity to almost complete darkness (1 to 5 lux, experiment 1, week 9) resulted in a significant decrease in pecking rates, but even under this condition 3 males had to be removed because of serious head injuries.

Pecking rates were low before the quails had reached sexual maturity (experiment 2, week 6) and also in the first week after introduction. In experiment 2, pecking was lower in week 7 in newly introduced groups than in those introduced 2 weeks earlier. Lower pecking rates were seen in newly-introduced birds in experiments 1 and 3 than in groups of the same age in experiment 2. Possibly there is a phase of adaptation which suppresses establishment of a pecking order for some days when quails are moved to a new environment.

Because as many as 12·5 to 20% of males were seriously injured, we conclude that for welfare reasons Japanese quail should not be kept in multi-male breeding groups. In the wild they live in pairs during the breeding season, with a distance between calling males of about 100 m (Schwartz and Schwartz, 1949, cited in Kovach, 1974).

In experiment 4, sex ratio was varied from 1:8 to 1:20 in single-male groups. Egg fertility was as high as 92% in groups with 8 hens (15 weeks old). Only in groups with 20 hens was the percentage of fertilised eggs significantly lower (69%). Both Woodard and Abplanalp (1967) and Narahari *et al.* (1988) varied sex ratio from 1:1 to 1:6 in Japanese quail groups. In the former study egg fertility was lower than 80% when more than 2 hens (12 to 25 weeks old) were kept per male. In the latter, in contrast, 86% of the eggs were fertilised in groups with a sex ratio of 1:6 (quails 10 to 18 weeks of age). Hughes *et al.* (1980) found no significant difference in fertility between cage-housed groups of one male and 1 to 3 hens (range 95% to 87%, quails 6 to 26 weeks old). Because fertility in Japanese quail reaches a maximum at 14 weeks (Narahari *et al.*, 1988) and decreases with age (Woodard and Abplanalp, 1967; Vogt and Steinke, 1970; Narahari *et al.*, 1988), it should be tested whether fertility maintains a satisfactory level in older single-male groups containing 8 to 12 hens. Breeder groups with such a group composition are not only preferable with respect to animal welfare but also more economical than conventional multi-male groups with a sex ratio of 1:2 or 1:3 (Cooper, 1987) because of the reduction in the costs for food per egg produced.

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