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N.B.: When citing this work, cite the original article.

Original Publication:

Beatrix Eklund and Per Jensen, Domestication effects on behavioural synchronization and individual distances in chickens (*Gallus gallus*), 2011, Behavioural Processes, (86), 2, 250-256.

<http://dx.doi.org/10.1016/j.beproc.2010.12.010>

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Postprint available at: Linköping University Electronic Press

<http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-65991>

**Domestication effects on behavioural synchronization and individual distances in chickens (*Gallus gallus*)**

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## **Abstract**

Behavioural synchrony (allelomimetic behaviour), and inter-individual distances are aspects of social and anti-predator strategies which may have been affected by domestication. Chickens are known to adjust synchronization and inter-individual distances depending on behaviour. We hypothesized that White Leghorn (WL) chickens would show less synchronized behaviour than the ancestor, the red jungle fowl (RJF). Sixty birds, 15 female and 15 male WL and the same number of RJF (28 weeks old) were studied in groups of three in furnished pens (1 x 2 m) for 24 consecutive hours per group, following 24 hours of habituation. Video tapes covering four hours per group (dawn, 9-10 am, 1-2 pm and dusk) were analysed. Red junglefowl perched significantly more, but there were no breed effects on the frequency or daily rhythm of any other activities, or on average inter-individual distances. Red junglefowl were more synchronized during perching and a tendency for the same was found for social behaviour. After performance of the two most synchronized behaviours, perching and comfort behaviour, individual distance increased more for RJF than WL. According to this study domestication of chickens appears not to have significantly altered the relative frequencies of different activities or average inter-individual distances, but have caused some changes in behavioural synchronization and maintenance of activity-specific inter-individual distances in chickens. The changes may indicate an adaptive response to captivity and domestication.

Keywords: allelomimetic, social behaviour, inter-individual distance, White Leghorn, red junglefowl.

## Introduction

Domestication of animals is known to change their appearance, physiology and behaviour (Price 1984). The main reasons for these changes are thought to be the relaxation of important natural selection pressures in environments supervised by humans, such as shortage of feed, predation and intra-specific competition. Mostly these effects are seen in altered frequencies of different behaviour patterns, mediated by changes in release thresholds, and less in the shape and function of the behaviours.

Several studies indicate that certain behaviour patterns seem to be less affected by domestication than others. For example, nest building in pigs is virtually unaffected in frequency and temporal organization (Jensen 1993), whereas aggressive and other social behaviour may be substantially altered in ducks for instance (Desforges and Wood-Gush 1975). It might be conceived that behaviours which have been important for high fitness in captivity have been highly conserved, while those which do not confer such advantages have been selected against, either passively or actively. Passive selection would for example occur in traits which carry a fitness cost, while simultaneously not conferring significant fitness benefits (Boice 1973

). Several aspects of social behaviour could fit into this category. For example, high levels of aggression could be costly in terms of energy and risk of injury, while not providing the more aggressive animals increased reproductive opportunities under captive conditions.

Another aspect of social behaviour which has not received much attention in domestication research is allelomimetic behaviour, defined by Scott (1956) as “any behaviour in which animals do the same thing with some degree of mutual stimulation and consequent coordination” (Scott 1956). This is often thought to have evolved as a trade off response to intra-specific competition and predator avoidance. By synchronizing their activities, animals may reduce the risk of being spotted by a predator, but at the same time may increase the competition for resources such as space, feed and shelter (Clayton 1978). Synchronized behaviour is known to be affected by factors such as group size (Rands et al. 2008), age, body size, sex (Ruckstuhl and Neuhaus 2001) and the resource in question (Hoppitt and Laland 2008). Hence, since domestication has relaxed

the pressure from competition and feed shortage, as well as from predation, we would expect domesticated animals to show less synchrony as an adaptation to saving energy. Furthermore, one could hypothesise that domestication might even favour less synchronization, as a response to an environment in which food and other resources are essentially unlimited, but may be spatially concentrated. For example, whereas food is often offered ad lib, the feeding space is usually highly limited. Unsynchronised feeding may therefore provide advantages in the form of less competition.

Although allelomimetic behaviour is common in domesticated animals such as pigs (Hsia and Wood-Gush 1984) and dogs (Scott and Fuller 1965

), it is not clear to what extent the degree of behavioural synchronization has changed during domestication. Understanding this aspect of social behaviour may have at least two different implications for animal welfare. Firstly, allelomimetic behaviour is closely related to maintenance of inter-individual distances, and thereby avoidance of aggression and conflict (Mallapur et al. 2009). Secondly, maintaining appropriate individual distances and synchronization may require a certain minimum space, which may not be available in production units. Mallapur et al (2009) found that chickens may increase their inter-individual distances to avoid social conflict when the available space allows so, possibly leading to less aggression, whereas small areas may lead to difficulties in maintaining normal social behaviour between all group members (Keeling 1994). The way in which animals adjust their inter-individual distance may be affected by different factors such as the relation to the closest neighbour and the spatial cohesion of the group (Arnold and Maller 1985) It has also previously been shown by (Nicol 1989) that the behaviour of chickens depends on inter-individual distance, and different breeds of chicken have different typical inter-individual distances (Tiemann and Rehkämper 2008)

In the present study, we have focused on comparing allelomimetic behaviour and inter-individual distances between red junglefowl (*Gallus gallus*) and a domesticated breed, the White Leghorn. The red junglefowl is the sole ancestor of all domesticated chickens (Al-Nasser et al. 2007; Collias and Collias 1996; West and Zhou 1988) and it inhabits field edges, groves and scrubland in South-East Asia. Red junglefowl are considerably smaller than White Leghorns (Appleby et al. 2004), and there is a large

sexual dimorphism in both breeds. The domestication of the red junglefowl probably started around 8000 years ago (West and Zhou 1988), and during the last decades breeding has been intensely directed towards production traits such as egg laying in chickens (Rauw et al. 1998); Appleby et al 2004). While a laying hen produces about 300 eggs per year, a red junglefowl may produce less than 20 (Romanov and Weigend 2001). This may have had an effect on the resource allocation by the birds, with the domesticated breed leaving less energy and resources for costly behaviour, for example during foraging (Andersson et al. 2001; Lindqvist et al. 2002; Schütz et al. 2001; Schütz and Jensen 2001). In this respect, the intense selection could have corroborated the passive selection during selection, favouring individuals that adopt a more energy conserving strategy.

Simultaneously with the immense increase in production rates, chicken housing has undergone major changes over the last decades. Laying hens in commercial conditions are either housed in highly crowded cages (typically 0,06 m<sup>2</sup>/individual, or in floor systems with groups of thousands of animals per room (a common crowding level is at least 9 individual/ m<sup>2</sup>). In the ancestor, small groups with one or a few males and 2-4 females appear to be the more common group composition (Collias and Collias 1967). Hence, the environmental changes may also have led to a selection for birds with a modified social behaviour, which may be better suited for coping with the crowded conditions in egg production.

The aim of the present study was to compare levels of allelomimetic behaviour and inter-individual distances during different activities in red junglefowl and White Leghorns, during standardized conditions. The hypotheses were that domesticated birds would show less behaviour synchronization, a larger average inter-individual distance, and weaker relationship between general activity and individual distance.

## **Materials and methods**

### *Ethical note*

The experiments were approved by the ethical committee for animal experimentation in Linköping.

### *Animals*

In total 60 animals were used for the experiment, 15 females and 15 males from each of the red junglefowl and White Leghorns. The red junglefowl originated from a zoo population, and had been maintained in the research facility for about ten generations before the experiment, with a population size of about 100 individuals per generation. The White Leghorns were of the strain SLU13, an outcome of the Scandinavian selection and crossbreeding experiment (Liljedahl 1979

) They have a history of selection for high number of eggs and a high egg mass favoring effective feed utilization under sub-optimal nutrition conditions. These birds had been kept in the research facility for the same time as the red junglefowl. For a full account of the backgrounds of the animal material, see (Schütz et al. 2002). All animals were hatched in the “Kruijt”-hatchery at Linköping University, where they were kept separate according to strain but not according to sex until five weeks of age, at which point they were moved to the chicken research facility “Wood-Gush”, 10 km North of Linköping. Here, the two strains were kept together in sex-separated groups of 30 animals in pens measuring 3m x 4m and containing nest boxes, elevated perches and shelves with feeding trough. They had ad libitum access to commercial chicken feed and 12 h day and 12 h night rhythm. The experiment began at the age of 26 weeks and ended when the birds were 33 weeks old. The birds of the two strains were of the same age, and in each pair of groups (see Procedure), the age was perfectly matched. After the experiment the animals were returned to their home pens and later used as the parental for the following offspring.

### *Test arena*

For the behavioural recordings, the focal animals were moved to a standard arena offering a comparative and standardized situation for both breeds. Two identical arenas were used, so observations could be carried out on both genotypes in parallel. The arenas measured 100 x 200 x 200 cm, offering a ground floor area of 20 000 cm<sup>2</sup>. The walls of the arenas consisted of solid wood up to a height of 45 cm and then netting up to the net

roof. The arenas were furnished with a feeding trough (40 cm diameter) water container (40 cm diameter), sawdust and a perch (100 cm long) at a height of 45 cm from the ground, placed 15 cm from one of the short ends. The arenas were lit by lamps in the roof, giving an even light intensity of 3-5 Lux (similar to that of the home pens), and the light was on between 06.20 h and 18.40 h, including a dawn and dusk period of 15 min. The arenas were both located in the same room as the home pens, and the animals could hear but not see each other. In each of the two arenas, a video camera (Panasonic, model no SDR-SW21) was placed over the short wall, giving a video image which covered the whole arena.

### *Procedure*

The animals were observed in groups of three birds of the same sex and breed, giving a sample of 20 groups (five of each breed and sex). The animals were kept for a total of 48 hours in the arena. During the first 24 h, the birds were left for habituation, whereafter their behaviour was recorded by 24 h of continuous video recording. For convenience, the birds were always introduced into the arena at 1100 h, so an observation period consequently started at the same time on the next day. The order of recordings was balanced so a group of junglefowl was always observed simultaneously as a group of White Leghorn of the same sex. Between two recording sessions, groups of the other sex were chosen, and the arena use was alternated to balance for sex and breed.

### *Behavioural recordings*

In order to quantify the overall behaviour frequencies, synchronization, and individual distances, the following method was used. Four time windows of one hour each for every 24 hour film period were chosen for detailed behaviour recordings (06.20-07.20, including dawn; 0900-1000; 1300-1400; and 17.40-18.40, including dusk). The behaviour patterns included in the recording are described in table 1, and were subsequently grouped into six categories; feeding, activity, passive, comfort, dustbathing and social. The behaviour of each of the three birds in the group was recorded by instantaneous sampling once every 60 s, and the inter-individual distances between each of the animals were measured at the same instantaneous time point whilst the video was

Table 1.  
The ethogram of the recorded behaviours, and the categories they were grouped into.

<b>Category</b>	<b>Recorded behaviour</b>	<b>Description</b>
<b>Feeding</b>		
	Feed	Eating from food container, food hopper, or other food source
	Food peck	Distinct pecks at supplied feed
	Ground peck	Pecks at items (visible or not) on ground
	Ground scratch	Scratching at ground
	Drink	Drinking from water nipple, water bell or other water source
<b>Activity</b>		
	Explore ground	Walking or standing with head close to ground (below back)
	Explore feed	Head close to ground, eyes focusing on feed or other edible objects
	Explore/peck object	Visual inspection or pecking at the novel object
	Manipulate object	Uses beak to lift, move or otherwise manipulate object
	Stand/sit alert	Immobile in standing or sitting posture with eyes open and an alert body stance
	Vigilant	Stand alert, focus on alarming stimulus
	Locomotion	Walking or running
<b>Passive</b>		
	Sit relaxed	Standing (legs erect) with reduced attention
	Stand relaxed	Sitting (legs bent) with reduced attention
	Sleep	Stand or sit with eyes closed, neck short, no head movements
<b>Comfort</b>		
	Preen	Uses beak to trim and arrange feathers
	Scratch body	Uses feet to scratch, clean and preen feathers
	Stretch wing	Stretches wing straight backwards
	Stretch leg	Stretches leg
	Yawn	Gape
	Feather ruffle	Erects feathers, ruffles, and shakes body
	Wing flap	Flapping wings while body is kept upright
<b>Dust bath</b>		
	Dust bath	Vertical wing shake, and rubbing body in litter
<b>Social behaviours</b>		
	Severe feather pecking	Pulling feathers
	Non aggressive peck	Pecking or manipulating gently at other
	Threat and receive threat	One bird walks after the other with head held high
	Threat with wing lifting	Bird stands in an upright position and flaps its wings more than to another bird
	Chase	Bird follows another bird, both running, jumping or flying
	Attack	Bird runs, jumps or flies towards another bird and gives aggressive pecks
	Aggressive peck	Bird gives a fast peck, directed to an anterior part of another birds body
	Fight	Bird being involved in an aggressive fight, more than just one single peck
	Raised hackle threat	Quick approach with head low and hackles raised

paused. Markings with 10 cm intervals on the arena walls, visible in the video image, allowed the distance between the birds to be assessed with a precision of a few cm. The

distance was measured between any body part, i.e. we assessed the empty space between any two birds, which means that the inter-individual distances were not dependent on the body size of the birds.

In order to specifically measure how individual distances were affected by changing activities of the birds, the following method was used. The videos were scanned through all the light period (12 h). Every time all animals were observed to be totally synchronized (all three birds performing the same behaviour from the ethogram), the video was paused, and distances between each of the birds were measured as explained above. The birds were only observed to be totally synchronized during performance of comfort behaviour, dust bathing and perching, so further analysis was limited to those three activities. After this distance had been assessed, the video was forwarded until 60 s after the synchronization bout had ended (i.e., after at least one of the birds had changed its activity), then the video was again stopped, and distances were measured. This constituted a paired observation of synchronized versus non-synchronized behaviour distance in order to provide a statistical comparison (see further below). If a new synchronized bout was observed within 10 s of the end of the last one, it was considered to be one and the same bout.

### *Analysis*

For all analyses, each group (consisting of 3 animals each) was treated as an independent statistical replicate. We calculated average frequencies (% of observations/group) of each behaviour category, and the average inter-individual distances within each time frame. To assess effects of activity on synchronization, we calculated the average frequencies within each time window of observations in which two or three birds performed the same activity. Effects of breed and sex were analysed with repeated measures ANOVA, using time window as within-subject repeated variable, after confirming the necessary assumptions regarding distribution.

To analyse the effect of activity on individual distance, we compared the distance during and after a synchronized period (as described above), and calculated an average for each activity within each group. These pair-wise comparisons were then analysed for

effects of breed and sex with ANOVA, in the same way as above. Statistical analysis was performed with the software Statistica v 9.0.

## Results

For the frequencies of general activities (Fig 1) there were significant breed and sex effects on perching (breed:  $F_{1,16} = 6,86$   $p = 0,019$ ; sex:  $F_{1,16} = 16,9$   $p < 0,001$ ), where red junglefowl of both sexes perched more than White Leghorns, and males perched more than females. There were significant effects of sex (but not breed) on feeding ( $F_{1,16} = 113,4$ ,  $p < 0,001$ ), where females fed more frequently, and activity ( $F_{1,16} = 63,3$ ,  $p < 0,001$ ), which was more common in males. There were pronounced daily rhythms in all activities, shown by significant effects of the within-subject repeated variable “Time window” (perching  $F_{3,48} = 10,2$   $p < 0,001$ ; feeding  $F_{3,48} = 6,31$   $p < 0,001$ ; passive  $F_{3,48} = 3,8$ ,  $p = 0,016$ ; comfort  $F_{3,48} = 3,1$   $p = 0,036$ ).

There was a significant breed effect on the frequency of synchronized perching behaviour ( $F_{1,16} = 4,62$ ,  $p = 0,047$ ), where red junglefowl were synchronized in a significantly higher proportion of observed perching events than White Leghorns, and there was also a tendency that red junglefowl had a higher degree of synchronization in social behaviour, which included performing feather pecking ( $F_{1,13} = 4,34$ ,  $p = 0,058$ ), (Fig 1). There was also a significant sex effect on synchrony in feeding, where females were more synchronized than males ( $F_{1,16} = 47,2$ ,  $p < 0,001$ ) and in activity, where males were more synchronized than females ( $F_{1,16} = 40,1$ ,  $p < 0,001$ ).

The average inter-individual distance between the animals did not differ between the two breeds, or between the sexes, and there was no significant effect of “Time window” on this variable (Fig 2). When analyzing the inter-individual distances separately for each behavioural category, red junglefowl had significantly shorter individual distances during bouts of perching ( $F_{1,14} = 4,60$ ,  $p = 0,05$ ), but there was no effect of sex on this variable. There was no difference during any other behaviour. Red junglefowl increased their inter-individual distance significantly more than White Leghorns after the completion of a bout of perching ( $F_{1,13} = 4,80$ ,  $p = 0,047$ ) and after a bout of comfort behaviour ( $F_{1,15} = 4,7$ ,  $p = 0,046$ ) (Fig 3).

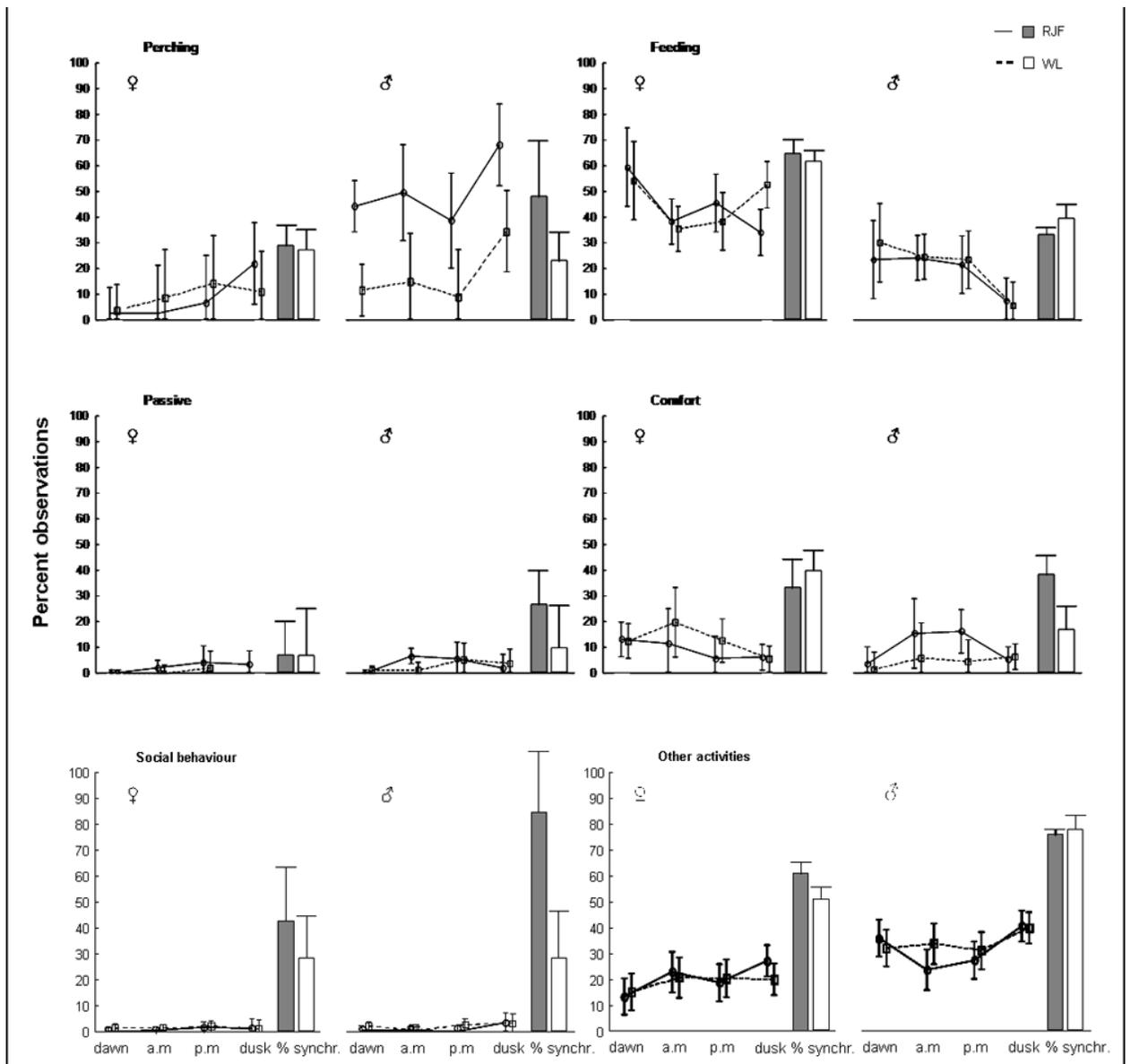


Fig 1: Percent of observations (average  $\pm$  SEM) of different behaviour categories during four different times of day, for male and female red junglefowl (RJF) and White Leghorns (WL). The bar graphs show the percentage of observations of each behaviour during which at least two out of the three in a group were synchronized with respect to this behavioural category.

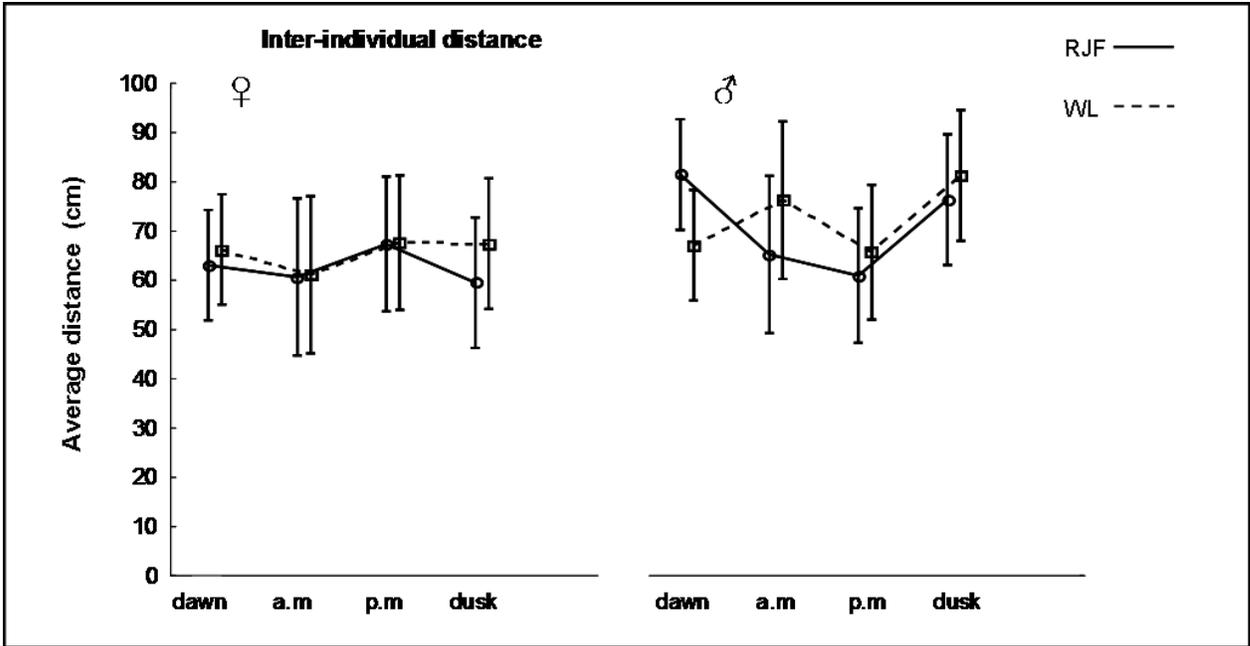


Fig 2: Average inter-individual distance ( $\pm$  SEM) in groups of male and female red junglefowl and White Leghorns, at four different times of day.

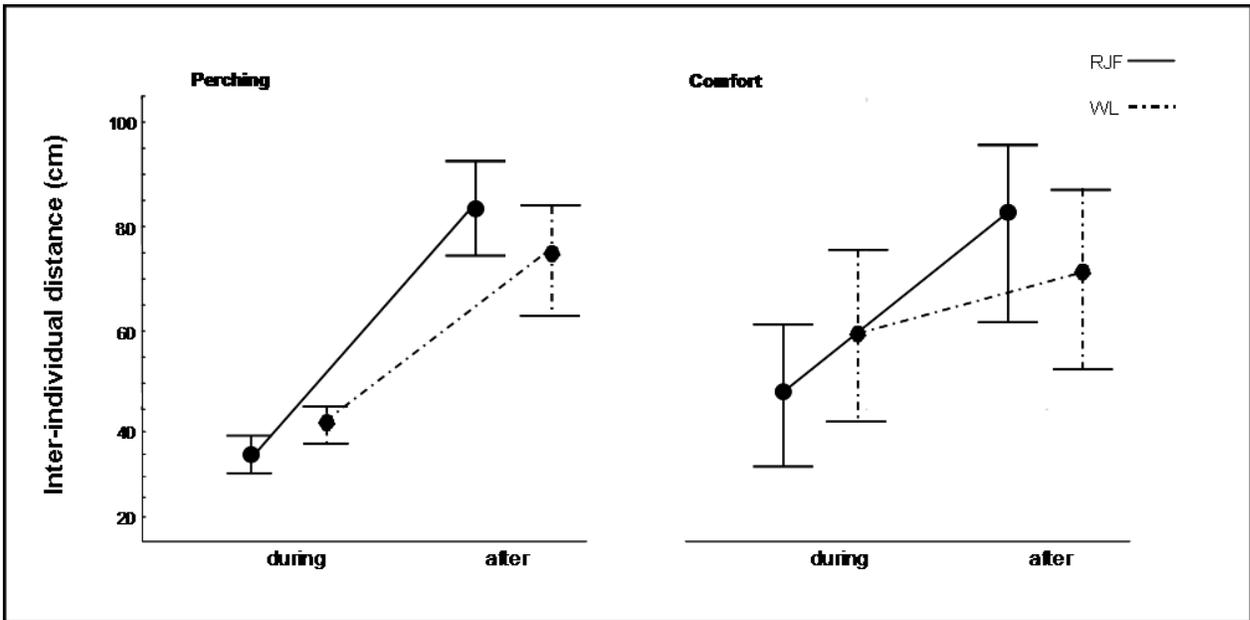


Fig 3: Average ( $\pm$  SEM) inter-individual distance within the group during and 60 s after the end of a synchronized bout of (A) comfort behaviour, and (B) perching for red junglefowl (RJF) and White Leghorns (WL).

## Discussion

The results showed that there were significant effects of breed on the frequency of synchronized perching behaviour, and that red junglefowl overall were more synchronized during perching, an important part of the normal anti-predator behaviour of chickens. There was also a significant difference between the two breeds in how much the inter-individual distance increased after performance of the two most synchronized behaviours, perching and comfort behaviour. We found no breed effects on the average daily frequencies of different activities or the average inter-individual distance between the chickens, and no effects on the overall level of synchronization. Taken together this suggests that domestication appears not to have significantly altered the relative frequencies of different activities, but has affected some aspects of behavioural synchronization. This could indicate an adaptation to domestication, where there is less competition and predation.

The results from this study strengthen the common observation that domestication has not changed fundamental aspects of behaviour of animals, such as form and frequencies (Price 1999). This has been found in many other domesticated animals as well, for example in pigs (Jensen 1988, 1993) ducks (Desforges and Wood-Gush 1975), and guinea pigs (Kunzl 1997; Lewejohann et al.). Even though this is largely an expected finding, it is remarkable that the intense selection for increased production, which has more than doubled the growth and increased the egg production many-fold compared to the ancestor (Rauw et al. 1998), has left fundamental behaviour rather unaffected. Since different behaviours have different metabolic costs (Lemon 1991), one could have expected a reallocation of the time budget, but this was not the case. Other studies have also found that basic behaviour in chickens is little affected by domestication, for example in anti-predator behaviour (Newberry et al. 2001) and social behaviour (Väisänen et al. 2005).

Although form and frequency of behaviour appears highly resistant to correlated selection responses, strategies (when, where and how long to perform a behaviour) may be more easily modified. For example, domesticated chickens have a different foraging strategy than wild-type birds (Andersson et al. 2001), and similar differences have been

observed in pigs (Gustafsson et al. 1999), in both cases probably as a passive, adaptive secondary response to selection for increased production. Behavioural synchronization (allelomimetic behaviour) and inter-individual distances are examples of social strategies which could have been affected in similar ways. We found that red junglefowl were more synchronized than White Leghorns during perching, which may indicate such strategy differences. Perching is considered an important part of the anti-predator behaviour of chickens (Appleby et al 2004), so our results may indicate that the degree of protective behaviour has decreased during domestication. Keeling and Duncan (1991) have shown that inter-individual distances in chickens change in a seemingly adaptive fashion in relation to the activity performed. Even if we did not find any difference in overall inter-individual distances, we found that red junglefowl had significantly shorter distances during perching, and that they were closer together than White Leghorns during synchronized perching and comfort behaviour, compared to times when they were not synchronized, again suggesting a possible relaxation of protective behaviour domesticated birds. Similar effects have been observed in the guinea pig (Künzli and Sachser 1999), indicating that this may be a general response to the altered selection pressures during domestication. Of course, other explanations for the differences in the inter-individual distance between the two breeds are possible. For example, the closer distance during perching could be related to thermoregulatory differences, and red junglefowl could be more agile and quicker to move out of distance after a perching or comfort bout. However, we have no indications that heat sensitivity would differ between breeds, and the 60 s time slot we allowed before second measurement of distance should have been more than sufficient for both breeds to assume their preferred inter-individual distances. Hence, we believe that alterations in social strategy offers the most likely explanations of our results.

A behavioural strategy can evolve when trade-offs between costs and benefits are optimized (Krebs and Davies 1991). One of the possible benefits of synchronization is protection from predators (Clayton 1978), while the costs are probably associated with increased intra-specific competition. Since competition has been reduced by ad lib supply of food, and predation has been reduced by human protection, it is conceivable that the synchronization strategy may have been modified as an adaptation to captivity. The

differences we have observed are subtle, but nevertheless indicate that domestication and selection for increased production may cause unintended correlated responses.

Our studies are limited by the fact that we have used small groups of birds, and only observed them indoors in relatively small enclosures during one 24 h period. However, the high degree of standardization in the experiment makes it more likely that the observed differences between sexes and breeds are reliable, even if the results might have been clearer in, for example, a semi-natural setting. Schütz & Jensen (2001) observed red junglefowl and two different domesticated breeds in large enclosures, and found that domesticated birds had a generally lower activity level, which was not found in the present study. Although the red junglefowl used in the study was kept in larger groups than found in the wild, the same population of birds raised under similar conditions have nevertheless showed typical wild type behaviour in earlier studies (Campler et al. 2009; Lindqvist et al. 2009). We can not exclude that they have gradually adapted to a more confined environment during the generations in captivity, but that would suggest that the differences in social synchronization and inter-individual distance would be even larger if we would compare Leghorns to a fully wild population.

In conclusion, red junglefowl perched significantly more than domesticated White Leghorns, and were significantly more synchronized during perching. Red junglefowl were also closer together than White Leghorns during synchronized perching and comfort behaviour than at other instances, and increased their inter-individual distance more after a bout of perching or comfort behaviour. Apart from that, there were no breed effects on any other behavioural activity, or on overall inter-individual distances. These results suggest that domestication has caused subtle changes in social behaviour in chickens, which may be adaptive responses to reduced intra-specific competition and reduced predation.

## Acknowledgements

This study was financed by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas), and by the Swedish Research Council (VR).

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