

# Domestication and social environment modulate fear responses in young chickens

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## ABSTRACT

Domesticated species differ from their wild ancestors in a mosaic of traits. Classical domestication theories agree that reactivity to fear and stress is one of the main traits affected. Domesticated species are expected to be less fear and stress prone than their wild counterparts. To test this hypothesis, we compared the behavioural responses of White Leghorn (WL) chicks to their wild counterparts, Red Junglefowl (RJF) chicks in risk-taking situations. In order to obtain food, the chicks faced an unknown and potentially harmful object at the presence or absence of a social partner. We found that according to our predictions, RJF were more stressed and fearful of the object than the WL. Still, RJF were more explorative than WL. Additionally, the presence of a social partner reduced the fear response in both, but had a stronger effect on RJF. Finally, WL were more food orientated than the RJF. Our results confirmed classical domestication hypotheses of downregulation of the stress system and importance of the social partner in domesticated farm chicken.

## 1. Introduction

Any behaviour with a perceived uncertainty about its outcomes, its possible benefit or cost is defined as risk-taking behaviour (Trimpop, 1994). Situations subjectively perceived as risky could trigger various responses such as fear and stress and the behavioural expressions thereof. However, the response itself could vary between subjects depending on a certain number of factors. Indeed, responses to stressors depend on the stressor's perceived severity, as well as the individuals' resilience to stress and ability to quickly recover after a stressor (Ross et al., 2020). Individual resilience is subject to several components such as genetics and ontogeny as well as external effects such as social context and support (Biggio et al., 2019). It seems that feeding ecology also plays a role in how risk-prone a species is (Kawamori and Matsushima, 2012; Marshall-Pescini et al., 2017; Mettke-Hofmann et al., 2002). In addition, personality traits like boldness have been shown to influence risk-taking in different species (mice: Błazarczyk et al., 2000; cichlid fishes: Brick and Jakobsson, 2002), as well as social environment (Cimarelli et al., 2021; van Oers et al., 2005).

In fact, in numerous social species, being among other conspecifics

helps individuals to cope with stressful situations (Rault, 2012). This phenomenon is known as (emotional) social support. As a response to environmental challenges, sociality is crucial in these species (Wilson, 2000). Studies have shown that farm animals, in response to stress, will seek out social interaction (Epley, 1974; Armario et al., 1983; Geverink et al., 1998; Marin et al., 2001; Ishiwata et al., 2007; Rault, 2012), a phenomenon also observed in wild populations (Koolhaas et al., 1999). However, domesticated animals do not appear to be as easily agitated by potential stressors as their wild relatives. Such, domestication could also be a factor impacting response to stressors and risk-taking behaviours.

Indeed, domestication has altered various animal characteristics, including behavioural responses to various stimuli, and it is shown that even varying degrees of selection pressures linked to domestication, results in equivalent effects in hen laying behaviour (Darwin, 1859; Dudde et al., 2018; Wilkins et al., 2014). Domestic animals must tolerate human handling and be able to reproduce in captivity, which is an important step in the early stages of domestication (Price, 2002). They must cope with the environment humans provide, hence, reduced sensitivity and increased adaptability to environmental changes would be some of the most important behavioural changes during

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domestication (Price, 2002). Indeed, reduced stress susceptibility as a trait seems to be recurring in the so-called domesticated phenotype (Künzl and Sachser, 1999; Dwyer, 2004; Lindqvist and Jensen, 2009; Douxfils et al., 2011; Solberg et al., 2020). Domesticated animals often display a reduced stress response when compared to wild conspecifics and possibly this could be attributed to artificial selection on reduced fearfulness (Künzl and Sachser, 1999; Trut et al., 2009; Moretti et al., 2015). Additionally, domestication may have altered the stress buffering effects of social support as humans have selected for tameness and low fear animals. So, the ability to handle and recover from stressful situations might depend less on social support and social buffer in domesticated animals (Wirén et al., 2013).

However, it is not necessarily so, since experimental comparisons between equally raised and kept wolves and dogs revealed that, contrary to popular belief, dogs were less relaxed during resting and sleeping (Kortekaas and Kotrschal, 2019), that they did not differ much in their diurnal time budgets (Jean-Joseph et al., 2022) suggesting that wolves were not really more responsive to environmental stimuli than dogs.

The chicken is a good model to investigate domestication, being the most numerous (i.e., higher number of individuals) domestic species worldwide today (Wang et al., 2020; Lawler, 2016). Their wild ancestor is the Red Junglefowl (RJF), a bird native to south and south-east Asia (Abdulwahid and Zhao, 2022). RJF are shy in the wild and hide in shrubs and thickets, only venturing out in small clearings to forage, avoiding humans. As social birds, RJF lives either in small families or in larger mixed groups (Schütz et al., 2001; Siegel et al., 1992). Domestic chickens are also social; however, the environment humans provide them differs from the RJF natural environment both socially and physically. Any disturbance in their social environment can cause damaging stress in chickens and may affect their cognition as well as health and productivity (Duncan et al., 1986; Jones and Harvey, 1987; Mills and Faure, 1990; Mendl, 1999). For example, when a chick is put in an open and novel area, its two main goals would be to reinstate contact with conspecifics and to avoid detection by potential predators (Bryan Jones and Merry, 1988). The White Leghorns (WL), a common breed selected for eggs production, have not lost these behaviours, but have become less fearful than their wild relatives through the selection on increased production. Indeed, in poultry breeding and husbandry, anti-predator behaviours have not been a major selection factor as the predation pressure has been reduced, and the energy saved in this domain is channelled into reproduction (Lindqvist and Jensen, 2009; Schütz et al., 2001).

Response to stress is an important parameter, determining how adaptive a species is and how well it will cope with its environment. In domesticated chickens like WL, the meaning of, and the responsiveness to, stressors was modified by selection for production. In the present study, we compared wild chickens (i.e., RJF) and domestic ones (i.e., WL) with respect to their response to a stressor and how the social environment would modulate this response. We first determined the risk-taking behaviour of young chicks facing a potentially frightening object when obtaining food. Secondly, we compared RJF chicks to domesticated WL chicks to assess how domestication has changed risk-taking behaviour. In agreement with current domestication hypotheses, we expected the domesticated chicks to be less fearful and less stressed, as well as being generally more food-orientated under these conditions than wild chicks. Finally, we assessed how environment - non-social or social - impact risk-taking behaviours in both types of chickens. We predict that the presence of a social partner would affect both wild and domesticated chicks but that the effect would be less in domesticated chicks as domestication would have relaxed the need for a partner to overcome stress and fear.

## 2. Material and methods

### 2.1. Ethical note

The experiments were carried out under the ethical licence from Linköping Animal Ethics Committee, licence no. 14916–2018. All procedures were carried out according to the protocol.

### 2.2. Subjects

We tested young (16 days old) unsexed chicks from two different breeding line: the Red Junglefowls (RJF; *Gallus gallus*), the ancestor of domestic chicken and a domestic breed of chicken, the White Leghorn (WL; *Gallus gallus domesticus*) originally selected and bred for egg production. The RJF ( $n = 20$ ) were hatched at Linköping University, Sweden, from a captive pedigree-bred population. This population is kept at the facility for ongoing research (see details in Campler et al., 2009). The WL ( $n = 20$ ) from the Lohmann LSL strain (Lohmann Tierzucht, Germany) were also hatched at Linköping University. The parental lines of the RJF were kept at the breeding facility of Linköping University, while the WL chicks came from commercial lines. After egg collection, the eggs from each of the two breeds were kept in the same type of incubator with the setting 37.8 °C and 5% relative humidity. The eggs were transferred separately on incubation day 18 to a hatcher (Masalles Type 25 HS), which was set to 37.5 °C and 65% relative humidity. The hatching happened in darkness, in groups. After hatching, the chicks were taken out of the incubator, weighed, wing-tagged and vaccinated. Throughout the entire experiment, RJF and WL were kept separated in identical pens equipped with wood chips, food and water and a heat lamp. From hatching they were kept in a pen (70 cm × 70 cm × 160 cm) in the hatching facility. The room had a 12-hour light/dark schedule and temperature of 20°C. Three days before the test the chicks were moved to the test room and placed in in two identical pens (0,7 m × 0,68 m × 0,57 m, daylight from 07:00 AM to 07:00 PM, temperature: 21°C). The birds were kept on wood chips and given *ad libitum* access to food and water, as well as heating lamps, throughout the experiment.

### 2.3. Test arena

The test arena was a circular pen (diameter 1 m) made of cardboard, with a cardboard wall (25 cm long x 20 cm high, see Fig. 1, D) providing a possible hiding place in the middle of the arena. The novel object was a desk fan (diameter 10 cm, see Fig. 1, A) with five three cm long pieces of red ribbon attached to it. The fan could be turned on remotely, which would make the ribbons move in an unpredictable fashion and blow air toward the subject. It was placed against the edge of the arena facing the

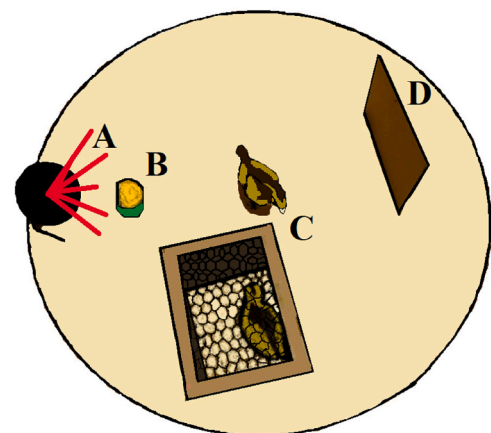


Fig. 1. Drawing of the test arena. A: the fan and ribbons, B: the feeder, C: the social box, D: the wall.

**Table 1**

Ethogram of behaviours recorded during the social and non-social test in chicks of Red Junglefowl and White Leghorn.

Behaviours	Description
Agitated	Standing or walking, with eyes opened and A) neck stretched with, even doing rapid heads-flicks from side to side with focus on the source of agitation. B) Escape-attempt, the bird tries to escape from the test arena by jumping or making fly attempts towards the roof
Alert	Stands (legs erect) or walks 3 or more steps, with open eyes, attending to the surrounding or Sits (legs bent, body touches ground) with open eyes, attending to the surroundings
Feeding	Eating from food container + Distinct pecks at supplied feed
Freeze	Stiff posture, stand, sit or lie motionless, vigilant, open eyes
Object investigation	Head close to the object of interest, eyes focusing on the object. Being at least one body length away from the object, the subject can peck at object of interest, including fittings in environment and use its beak to lift, move or otherwise manipulate object
Ground Investigation/foraging	Walking or standing with head close to ground (below back), eyes focusing on ground items. Subject can also scratch and peck at the ground. Subject's eyes focusing on feed or other edible objects in case of foraging
Relaxed	Standing (legs erect) with reduced attention, eyes may be partly closed, neck short, no alert head movements or Sitting (legs bent) with reduced attention, eyes may be partly closed, neck short, no alert head movements, performing grooming (used beak to trim and arrange feathers, used feet to scratch, clean and preen feathers)
Locomotion	Two or more steps in any direction, including walking and running.
Latency to peck at the food	Time until the subject pecks at the food for the first time
Latency to move	Time until the subject takes a first step in any direction from the moment light turns on
Latency to approach object	Time until the subject approach the scary object
Latency to approach conspecific	Only during the social condition. Time until the subject approach the social partner in the box, e.g., go in front of the open side of the box with maximum of one body length away from the wire mesh.
Proximity to food	Time spent in proximity (10 cm or less) of the food
Proximity to conspecific	Time spent in proximity of the conspecific

inner part of it. A feeder filled with corn was put between the inner wall and the novel object at a distance of 10 cm. A cage that could contain a social partner (20 cm × 17 cm x 15 cm, see Fig. 1, C) was made out of cardboard on three sides and of fence on the top and the back side. Hence, the social partner could not see the novel object but could still see and interact with the tested subject on one side of the box. For an overview of the arena, see Fig. 1.

#### 2.4. Test protocol

One week before the first test, all the subjects were fed once a day with corn in addition to their usual food to habituate them to the food reward to be used during the test. Two days before the test, all the subjects were put into the empty arena (without food or novel object) in a group of 10 individuals for 15 min to get habituated to the arena. The day before the test all subjects were individually put in the empty arena for 5 min to get habituated to being alone in the arena. During testing, the chick was either on its own in the arena, or together with a companion from the same group that was placed in the cage in the arena.

For testing, one chick was randomly taken out of its pen. The bird was identified by its wing-tag and weighed, then the lights of the test room were turned off and the chick was placed in the middle of the arena while in darkness. After two minutes the lights were turned on, and the test started and lasted five minutes. After one minute of the light period, the novel object (i.e., the fan with ribbons) was turned on for 30 seconds then turned off again for the remaining period of the test (i.e., three minutes and 30 seconds). At the end of the test the chick was removed and placed back in its pen with the other already tested birds. All chicks were tested twice, once in the social condition and once in the non-social condition. The order of the conditions was counterbalanced between the birds, so half of them started with the social condition and the other half started with the non-social one. It is crucial to note that even with counterbalanced conditions between the birds, each animal encountered the novel object twice, with true novelty presented only during the initial trial. The tests were recorded with a camera (GoPro Hero5) placed on the top of the arena. From the videos, we coded the duration of the behaviours outlined in Table 1, as well as the latency to move, to approach the object, and to feed. Moreover, we measured the time the chicks spent in proximity to the food. In the social condition, we also measured the latency to approach the social partner and the time spent in its proximity.

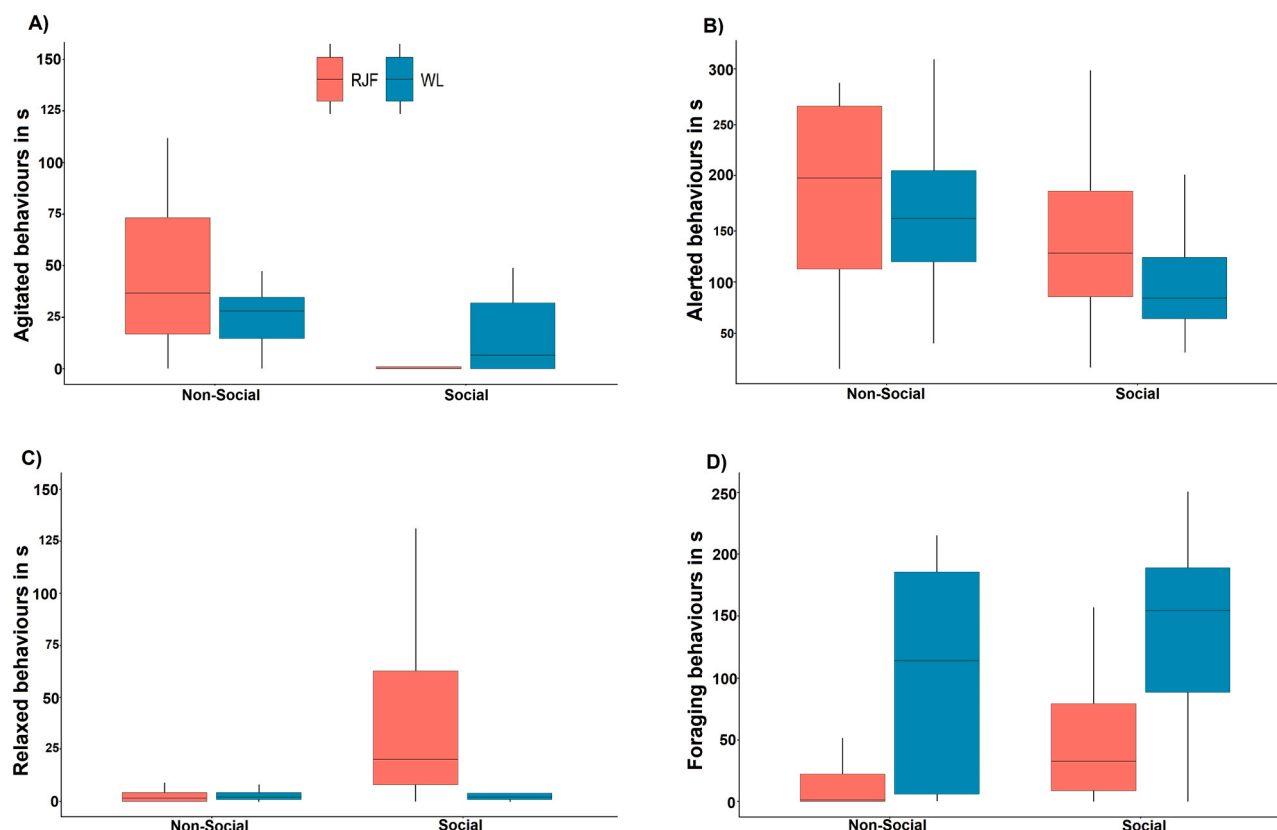
#### 2.5. Statistical analyses

We fitted the models in R (version 4.0.5; R Core Team, 2021) using the package lme4 (Bates et al., 2014), function lmer for the linear mixed model (LME, (Baayen, 2008)) and the packages survival (3.2–10) and coxme (2.2–16) for the survival model used to analyse latencies. Species (RJF or WL), condition of the test (social or non-social) and their interaction were included as fixed factors. We added order of the condition (social first vs non-social first) as a control factor. Moreover, we added the body mass of the birds as a control factor since it is one of the most visible differences between the RJF and WL chicks. Furthermore, subject identity was included as a random factor to account for individual differences and subjects being tested twice. Body mass was z-transformed (to a mean of zero and a standard deviation of one) to facilitate model computation.

For each model, we visually inspected qqplots and the residuals plotted against fitted values. Both indicated no violation of the normal distribution and homogeneity assumptions. We checked for model stability by excluding subjects one at a time from the data and comparing the model estimates derived for these subsets of the data with those derived for the full data set. We inspected Variance Inflation Factors (VIF, (Field, 2005)) using the function VIF of the R-package car (Fox and Weisberg, 2018), applied to a standard linear model excluding the random effects and interactions. This revealed that species and body mass were collinear with a VIF of 42.77 and 48.16, respectively. However, there was considerable variation of body mass within both species and, hence, the results obtained for these two predictors should not be distorted by collinearity among them.

To reduce the risk of cryptic multiple testing and keep type I error rate at the nominal level of 0.05 (Forstmeier and Schielzeth, 2011) we tested the significance of the full model as compared to the null model (comprising only body mass, order of the condition and the random effect) by means of a likelihood ratio test (R function anova with argument test set to “Chisq”; (Dobson and Barnett, 2018)). To allow for a likelihood ratio test we fitted the models using maximum likelihood (rather than Restricted Maximum Likelihood; (Bolker et al., 2009)). P-values for the individual effects were based on likelihood ratio tests comparing the full with the respective reduced models (Barr et al., 2013); R function drop1).

Moreover, we tested whether the time spent in proximity of a social partner differed between RJF and WL. To this end, we followed the procedure described above and we fitted a model comprising species as a fixed effect factor, body mass and order of the condition as control factor



**Fig. 2.** Duration in seconds of the different behaviours of Red Junglefowl (RJF) and White Leghorn (WL) according to the condition of the 5 min test, the boxplots show median values  $\pm$  one quartile and the maximum and minimum range. The condition was either non-social, or social. A) Agitated Behaviour. B) Alert Behaviour. C) Relaxed Behaviour. D) Foraging behaviour.

and the identity of the social partner as a random factor.

Furthermore, we tested whether the latency to approach the scary object, the latency to peck the corn and the latency to first move at the beginning of the test, were affected by species (RJF or WL) and condition of the test (social, non-social). These three response variables (latency to approach object, latency to move, latency to peck) were analysed in separate mixed cox regression models. For each response variable, we included the two-way interaction with species and condition. To control for the effect of treatment order, we included the order in which the subject passed the tests as a fixed effect. The body mass of the chicks on the days of the test was also included as a control factor. Moreover, subject identity was included as a random factor to account for individual differences. Additionally, we tested whether species of the subject affected their response to the social condition. We fitted a mixed cox regression model with latency to approach conspecific as responses variable. Species, order of treatment and weight were included as fixed factors. Identity of the subject was included as a random factor.

The sample size for most of these models was 79 observations made on 40 individuals (20 RJF, 20 WL). One data point was missing due to a technical issue during recording (one WL in social condition). The models concerning the proximity to the social partner and the latency to approach the social partner had a sample size of 39 data points.

### 3. Results

All tested chicks but two (one RJF and one WL) contacted the companion during the social test. The different behaviours according to the condition of the test is given in Fig. 2.

#### 3.1. Agitated behaviours

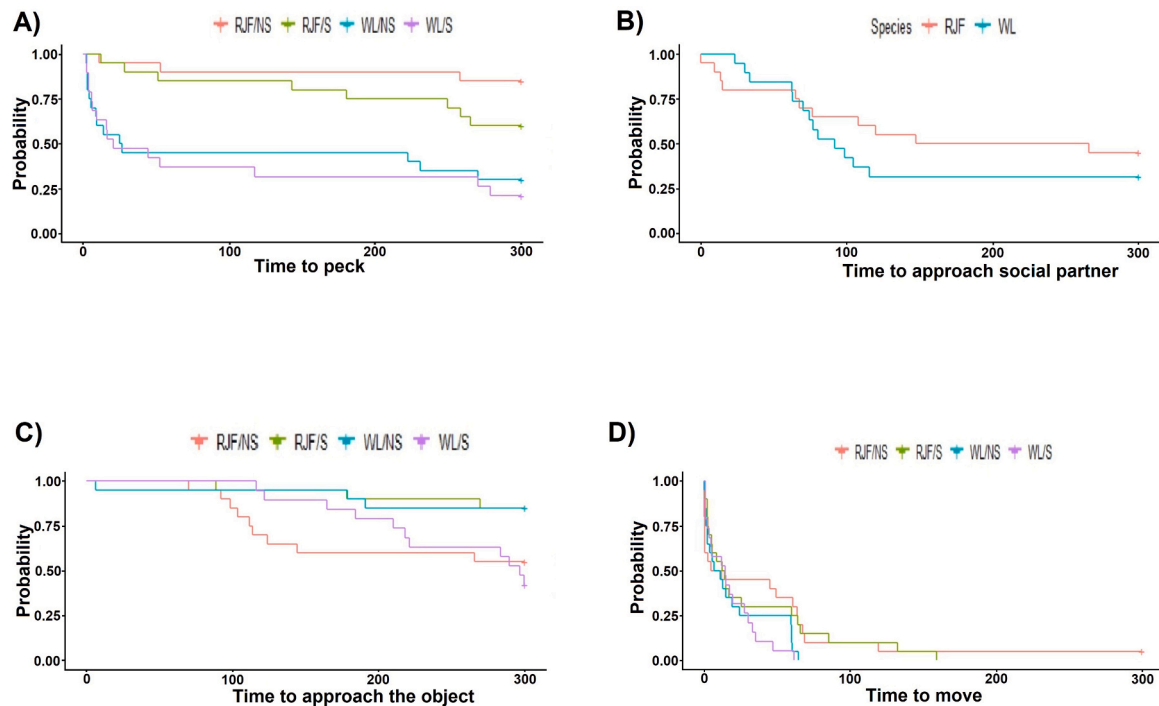
In the non-social condition the RJF were more agitated than the WL, however in the social condition it was the reverse, RJF were less agitated than WL (Fig. 1A). Overall, the full model was significant compared to the null model (likelihood ratio test:  $\chi^2 = 27.22$ ,  $df = 3$ ,  $P < 0.001$ ), i.e., species, conditions, or their interaction, body mass and order of the condition affected how agitated the chicks behaved. More specifically, the interaction between species and conditions was significant indicating that both species and conditions had an effect on how agitated the chicks were ( $\chi^2 = 7.02$ ,  $df = 2$ ,  $P = 0.008$ ; Table S1; Fig. 1A).

#### 3.2. Alert behaviours

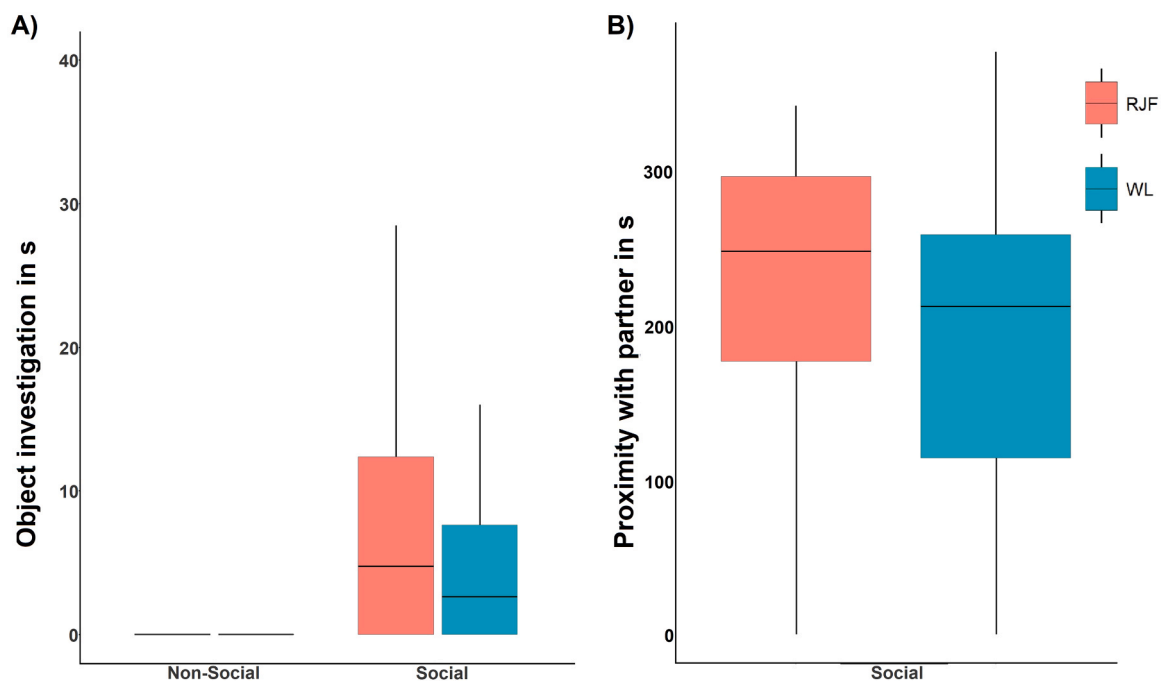
RJF showed more alert behaviour than WL in both the social and non-social condition, and both breeds showed less alert behaviour in the social condition (Fig. 2B). Overall, the full model was significant compared to the null model (likelihood ratio test:  $\chi^2 = 15.28$ ,  $df = 3$ ,  $P < 0.001$ ), i.e., species, conditions, or their interaction, body mass and order of the condition had an effect on the alertness of the chicks. However, since the interaction between species and condition was not significant (likelihood ratio test:  $\chi^2 = 0.31$ ,  $df = 1$ ,  $P = 0.5$ ), we removed it from the model to explore the significance of the factors species (WL or RJF) and conditions (social or non-social) separately. Conditions was significant ( $\chi^2 = 14.52$ ,  $df = 1$ ,  $P < 0.001$ ; Table S2; Fig. 2B).

#### 3.3. Relaxed behaviours

WL and RJF showed the same number of relaxed behaviours in the non-social condition. However, in the presence of a partner, RJF showed



**Fig. 3.** The latency to A) to peck at the food, B) to approach the social partner, C) to approach the object and D) to move, during the 5 min test. Both species, Red Junglefowl (RJF) and White Leghorn (WL) got tested once with each condition non-social (RJF = RJF/NS, WL = WL/NS) and social (RJF = RJF/S, WL = WL/S).



**Fig. 4.** Duration in seconds of different behaviours displayed by White Leghorn (WL) and Red Junglefowl (RJF), during the 5 min test. The boxplots show median values  $\pm$  one quartile and the min – max range. A) Object investigation according to the conditions of the test. B) Proximity with the social partner during the social condition.

an increase of relaxed behaviours whereas WL did not (Fig. 2C). Overall, the full model was significant compared to the null model (likelihood ratio test:  $\chi^2 = 17.20$ ,  $df = 3$ ,  $P < 0.001$ ), i.e., species, conditions, or their interaction, body mass and order of the condition had an effect on the relaxation of the chicks. More specifically, the interaction between species and conditions was significant ( $\chi^2 = 6.92$ ,  $df = 1$ ,  $P = 0.008$ ; Table S3; Fig. 2C).

#### 3.4. Foraging, proximity and latency to the food

Overall, WL reached the food earlier than RJF. Additionally, the social condition had a similar effect on both RJF and WL, both were faster to feed when a partner was present. Furthermore, WL spent more time foraging than RJF in both the social and the non-social condition, and both breeds spent more time foraging in the social than the non-



social condition (Fig. 2D). However, there was no significant difference in the time the RJF and WL spent in proximity to the food (likelihood ratio test:  $\chi^2 = 4.95$ ,  $df = 0$ ,  $P > 0.1$ ). Overall, the full model was significant compared to the null model (likelihood ratio test:  $\chi^2 = 10.47$ ,  $df = 3$ ,  $P < 0.05$ ), i.e., species, conditions, or their interaction, body mass and order of the condition had an effect on the foraging behaviours of the chicks. However, since the interaction between species and condition was not significant (likelihood ratio test:  $\chi^2 = 0.30$ ,  $df = 1$ ,  $P = 0.5$ ), we removed it from the model to explore the significance of the factors species and conditions separately. Conditions was significant ( $\chi^2 = 6.79$ ,  $df = 1$ ,  $P < 0.01$ ; Table S4, Fig. 2D), as well as body mass ( $\chi^2 = 20.68$ ,  $df = 1$ ,  $P < 0.001$ ) and order of the conditions ( $\chi^2 = 4.20$ ,  $df = 1$ ,  $P < 0.05$ ). The delay to reach the food was also different (likelihood ratio test:  $\chi^2 = 24.95$ ,  $df = 3$ ,  $P < 0.001$ ). More specifically, there was an effect of species ( $z = 3.88$ ,  $P < 0.001$ ), conditions ( $z = 2.13$ ,  $P < 0.05$ ) and order of the conditions ( $z = 3.52$ ,  $P < 0.001$ ; Table S5; Fig. 3A) on the delay to reach the food.

### 3.5. Object investigation & latency to approach it

In the social condition, WL and RJF behaved in a similar way and spend more time investigating the object than in the non-social condition (Fig. 4A). However, condition had an opposite effect on the latencies to approach the object. Indeed, in the social condition RJF approached the object later than in the non-social condition whereas in the social condition WL approached the object sooner than in the non-social condition. Additionally, more WL choose to investigate the object: more than 50% choose to do so whereas less than 50% of the RJF investigated the object (Fig. 3C). Overall, the full model was significant compared to the null model (likelihood ratio test:  $\chi^2 = 9.28$ ,  $df = 3$ ,  $P < 0.05$ ), i.e., species, conditions, or their interaction, body mass and order of the condition had an effect on the agitation of the chicks. However, since the interaction between species and condition was not significant (likelihood ratio test:  $\chi^2 = 1.125$ ,  $df = 1$ ,  $P > 0.5$ ), we removed it from the model to explore the significance of the factors species and conditions separately. Condition was significant ( $\chi^2 = 7.282$ ,  $df = 1$ ,  $P = 0.007$ ; Table S6; Fig. 4A), and moreover, latencies to approach the object differed between the breeds (likelihood ratio test:  $\chi^2 = 12.50$ ,  $df = 3$ ,  $P < 0.005$ ), indeed the interaction between species and condition was significant ( $z = 3.27$ ,  $P < 0.001$ , Table S7; Fig. 3C).

### 3.6. Proximity to and latency to approach the social partner

RJF spent more time in proximity of their partner than WL. However, there was no significant difference in the latency to approach the social partner (likelihood ratio test:  $\chi^2 = 1.17$ ,  $df = 3$ ,  $P > 0.05$ ; Fig. 3B). Overall, the full model was significant compared to the null model (likelihood ratio test:  $\chi^2 = 4.68$ ,  $df = 1$ ,  $P < 0.05$ ), i.e., species, body mass and order of the conditions had an effect on the time the chicks spent in proximity of their social partner. More specifically, species ( $\chi^2 = 4.68$ ,  $df = 1$ ,  $P < 0.05$ ) and body mass ( $\chi^2 = 4.07$ ,  $df = 1$ ,  $P < 0.05$ ; Table S8; Fig. 4B) were significant.

### 3.7. Locomotion and latency to first move

There was no significant difference between RJF and WL with respect to overall locomotion (likelihood ratio test:  $\chi^2 = 3.24$ ,  $df = 3$ ,  $P > 0.05$ ) or with respect to latency to take the first step at the beginning of the test ( $\chi^2 = 0.89$ ,  $df = 4$ ,  $P > 0.05$ ; Fig. 3D).

## 4. Discussion

We found evidence supporting the domestication hypothesis, since the domesticated White Leghorn (WL) chicks showed less agitated and less alerted behaviours than their wild-type counterparts, the Red

Junglefowl (RJF). Additionally, WL were faster to reach the food than RJF and spent more time foraging. But the wild chicks were more investigative than domesticated chicks, they approached the novel object sooner and spent more time in its proximity and also seemed more socially interested than WL as they spent more time near their partner and displayed more relaxed behaviours than WL in the social condition. The WL chicks foraged more and spent more time in close proximity to food. RJF, on the other hand, spent more time near their conspecific under the social condition, and they also started earlier to groom and groomed more. Grooming was one behaviour categorized as a relaxed behaviour in our study, therefore RJF appeared to be more relaxed than WL in our analysis. However, this could be deceptive, as we do not know the actual experience and emotional state (stressed versus relaxed) of the WL chicks while they were feeding versus the RJF while they were grooming.

These results are in agreement with our prediction and consistent with previous observations in RJF (Schütz et al., 2002; Schütz et al., 2001). Selection for traits such as egg production, sexual maturity, growth and food intake, has shown to be genetically linked to fear-related behaviour (Schütz et al., 2004). Moreover, our results align with previous findings within other species. Indeed, other studies on domesticated versus their wild ancestor has shown that stress susceptibility has changed through the domestication. For example, dogs were less neophobic than wolves in a novel object test (Moretti et al., 2015). Additionally, consistent with what we observed in our experiment, wolves were more investigative than dogs (Marshall-Pescini et al., 2017). In addition, rather than finding clear differences between wolves and dog's alertness at rest, Jean-Joseph and colleagues found differences based on the social context during rest (Jean-Joseph et al., 2020).

More in line with our results, Künzl and Sachser (1999) found that domestic guinea pigs were generally less alert than wild cavies. They concluded that lower responsiveness and stress levels are physiological mechanisms permitting domesticated animals to adapt to man-made environment. This decrease in vigilance and receptivity to environmental change is one of the phenotypic traits shared by most, if not all domesticated animals (Price, 1984). Rats selected for high and low anxiety-related behaviour showed significant differences in response to stressors such as emotional defeat and navigating an unfamiliar maze (Liebsch et al., 1998). Domestication might also interfere with animals' personality traits, such as boldness (Agnvall et al., 2015); in sticklebacks (*Gasterosteus aculeatus*), for example, bolder individuals were shown to display greater initiative and be to be less responsive to their social partners (Harcourt et al., 2009). In quail, a behavioural experiment on two selection lines for high or low stress responses (Satterlee et al., 2000) showed that this resulted in significant differences in their responsiveness to long-term social and physical environmental stress. In quail, a comparison between two selection lines for either low or high stress showed that the high stress line expressed more fear and had greater adrenocortical responsiveness to an immobility test, as well as exposure to a novel environment (Jones et al., 1992).

In agreement with our prediction, RJF seemed to be more socially motivated than WL. RJF individuals indeed, tended to spend more time with their conspecific, when provided with one, which is in accordance with previous results (Väisänen and Jensen, 2003). The potential social support by a companion bird appeared particularly important for the wild-type birds, since the RJF chicks in our study showed a more than five-fold increase of observed Relaxed behaviour with a conspecific as compared to when they were alone, while WL only increased their Relaxed behaviour by just slightly more than 50%. Very likely, domestication is the main reason for this difference. It is possible that the WL breeds' features such as growth, feed intake and reduced fear of humans, increases their propensity to prioritize food above seeking safety. This is in line with previous studies, where RJF bred for low fear of humans (increased tameness as a proxy for early domestication), indeed, showed higher frequency of separating themselves from their group, compared to RJF selected for high fear of humans (Gjøen and Jensen, 2021).

Interbreed genetic variability in social responses has been found to exist already in four-day-old domestic chicks of genetically isolated breeds (Versace et al., 2021). In other social species also, a social companion reduces behavioural and physiological responses during a stressful event or facilitates faster recovery. In wolves and dogs, for example, the presence of a social partner or the entire pack increased investigation of a novel object (Moretti et al., 2015). Additionally, wolves and dogs rested more and were more relaxed in presence of their pack members (Jean-Joseph et al., 2020; Kortekaas and Kotrschal, 2020). Additionally, dogs were also more responsive to the presence of familiar humans than wolves during rest and their day-to-day life (Jean-Joseph et al., 2020, 2022). In horses, the effect of a social buffer depended on the stimulus delivered, but not on the familiarity status of the partner (Ricci-Bonot et al., 2021). Horses which are highly social domesticated animals, seemed to prefer any conspecifics, familiar or not to loneliness.

Also, in line with previous literature, WL fed more and more readily in our experiments than RJF, which is consistent with their heavier body mass and faster growth rate (Väisänen and Jensen, 2003; Schütz and Jensen, 2001). Regardless of condition, social or non-social, WL significantly displayed more feeding behaviour than RJF. Although this was not statistically significant, WL chicks did increase their feeding behaviour by almost 20% in the social condition, whilst it more than doubled in RJF. The RJF spent more time in contact with their social partner while WL spent more time feeding than RJF regardless of their social environment. Most likely these results are explained by a century of selection for production traits in domestic chickens, since increased egg production and growth demand more energy. A previous study on chicks of RJF and WL has also shown that these two breeds differ in social reinstatement behaviour (Väisänen and Jensen, 2004). The lower effect of social support in WL could also reflect altered social behaviour. A study on social preference in laying hens demonstrated that laying hens rapidly adapted to unknown chickens despite first preferring familiar hens (Bradshaw, 1992). Although our test animals were hatched together with the stimulus animal used in the experiment, they were separated before the testing started and housed separately. Given the reduced fear response and the increased exploratory behaviour, domestic chicks may be more likely to decide not to seek social support unlike the more fearful RJF which are less discriminatory when it comes to social reinstatement and the need to feel safety in numbers.

Domesticated animals may use less time habituating with, and getting familiar to, a stimulus (Katajamaa and Jensen, 2020) than the wild-type animals. The more familiar a situation is, the more time the chicks are likely to spend time with feeding (Jones, 1977). In our study, we did not find such an effect, most likely because two expositions to the stimulus were not sufficient to build habituation.

Our study gathered results from young, unsexed chicks prior to sexual maturation. Social motivation determines young chicks adopted strategy during stressful events as well as increases social affiliation (Bryan Jones and Merry, 1988; Marin et al., 2001). While using animals of a different age could have yielded different results, previous findings have shown that high fearfulness in chicks at six weeks of age is associated with greater plasma-corticosterone levels at 33 weeks of age. Additionally, fearfulness in a group can influence individual stress response, with even one high fearful bird increasing overall fearfulness significantly and having long-term effects on stress in laying hens (De Haas et al., 2012). However, the effect of social buffering could be different after sexual maturity due to changes related to establishing hierarchy and mating behaviour (Rushen, 1982a; Rushen, 1982b). Previous research has also shown that early sexual maturation can provide developmental advantages in establishing dominance within groups of pullets (Craig et al., 1965). As our study did not include hormonal effects related to sexual maturity and emergence of more aggressive behaviour and social dominance, the age of our subjects was important.

To conclude, our study has shown that domestication including the selection for high production rendered chickens less fearful and

susceptible to stress while at the same time reducing their exploratory behaviours and greatly increased the motivation and need to feed. In addition, domesticated chickens were less dependent on conspecific social support for coping with the stressful procedures in the experiment than individuals from the wild-type breeding strain.

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## CRediT authorship contribution statement

All authors have contributed to, seen, and approved the manuscript. HJJ: Conceptualization, Methodology, Statistical analysis, Writing-Original Draft, Data visualization. JG: Data curation, Data coding, figure drawing, Writing-Original Draft. KKot: Conceptualization, Writing-Review & Editing, Supervision, Funding acquisition. PJ: Conceptualization, Material acquisition, Subject acquisition, Writing-Review & Editing, Supervision, Funding acquisition.

## Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

## Data Availability

Data were provided in the [Supplementary material](#).

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## Ethical note

The experiments were carried out under the ethical licence from Linköping Animal Ethics Committee, licence no. 14916–2018. All procedures were carried out according to the protocol.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.beproc.2023.104906](https://doi.org/10.1016/j.beproc.2023.104906).

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