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Evidence of Genetic Relationships Between Sociality, Emotional Reactivity and Production Traits in Japanese Quail

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ABSTRACT: The social behavior of animals, which is partly controlled by genetics, is involved in their adaptation to large breeding groups. Genetic relationships between different social behaviors, fear behaviors and production traits were estimated in a second generation cross of two lines of Quail divergently selected for their social reinstatement behavior. A strong genetic correlation existed between sexual and aggressive behaviors, both being significantly positively correlated to the response to the novel object test. Strong genetic correlations between behaviors and productions were also highlighted. Higher weights were genetically associated with increased emotional reactivity estimated by the duration of tonic immobility. The age at first egg was earlier in birds with high social reinstatement behavior but delayed in case of higher emotional reactivity. A higher egg production was genetically associated with a lower emotional reactivity toward a novel object but also with higher sexual and aggressive behaviors.

Keywords: Social behavior; Selection; Bird

Introduction

In modern farms, the birds live mostly in large breeding groups of animals from the same age and sometimes the same sex. These particular conditions may favor the expression of deleterious behaviors (such as aggression, feather pecking, and cannibalism in the most severe cases) or stress-related pathologies that affect both productivity and animal welfare (Mignon-Grasteau and Faure (2002); Veissier et al. (2007)). In addition to optimized rearing practices, adaptability of animals is of major importance to prevent welfare problems. The aim of our study was to investigate the genetic control of different social behaviors (social motivation, sexual motivation, aggressiveness) and fear behaviors (tonic immobility, reaction to an unknown object), and their relationships with production traits (weight and egg). The analysis focused on individuals from a second generation cross (F2) between two lines of quail divergently selected on their social reinstatement behavior (Mills and Faure (1991)).

Materials and Methods

Animals and housing conditions. A total of 912 F2 chicks (452 males and 460 females) were produced from 4-week interval. F2 chicks were reared in groups of about

40 birds in battery cages until three weeks of age. After sex determination from plumage color, the quail were individually housed in battery cages from three weeks old to the end of the experiment. Males and females were in the same room from three to five weeks old and thereafter they were housed in two independent rooms. Lighting was continuous for the first three weeks and temperature was progressively reduced from 38 to 20°C. In individual battery cages, the birds were exposed to a light cycle of 12L:12D until five weeks of age and 16L:8D thereafter. Temperature was held constant at 20°C. Water and food were provided ad libitum.

Behavioral tests and production traits. Several behavioral tests were performed, and for each, several measures were recorded. Intra-test measurements being highly correlated, a single measurement per test was chosen for further genetic analyzes.

Reaction to social isolation (day 1 to 3): The quail were first familiarized in groups of 20 individuals in a wooden cage then placed alone in a cage similar to the previous one. Their behavior was analyzed for 3 minutes by a software monitoring the movement. The distance traveled in the periphery of the cage (DistIso) was retained as a measure of social motivation (the higher the distance the more motivated the bird).

Social reinstatement behavior (day 6 to 8) and tonic immobility (day 9 to 10): The procedures used are those described by Mills and Faure (1991) for the selection of the lines: the treadmill test was used to estimate the social motivation and the tonic immobility test (a behavioral inhibition induced by restraint of the animal) to estimate fear. The variables used were the distance on the treadmill (DistSR) and the duration of tonic immobility (TI). The higher TI, the more fearful the bird.

Reaction to novel object (day 37 to 38): An unknown object was placed in the feeder in front of the cage, so as not to be viewed by quail from other cages. The number of scans in which the quail had its head through the wire of the front of the cage (touching the object or not) was used (HeadNO). It is considered that the more the individual is frightened by the object, the lower HeadNO.

Aggressive behavior of males (day 55 to 56): Quail were gently placed in the center of an arena in which a

mirror had been stuck. The quail was allowed to interact with its reflection for 2 min. Every 10 s we recorded whether the quail had pecked vigorously at the mirror (aggressive pecks) or had pecked gently (less vigorous pecks, with non-aggressive posture). The number of aggressive (AgrP) or gentle pecks (GentleP) was used in the genetic analysis.

Sexual motivation of the males (day 62): This test was performed in the same arena and following the same procedure as for the aggressive behavior test, except that the mirror was removed and a stuffed female quail in a receptive posture was placed in the center of one of the half side of the arena. The number of mounts over the 2-min period of the test (Mount) was recorded.

Production traits: Birds were weighed at 17 days of age (W17) just before being transferred to individual cages, and after the last behavioral test at 65 days of age (W65). The age when the first egg was laid (AFEgg) and the number of eggs laid (NEgg) until 24 weeks were recorded for all the females.

Genetic parameters estimation. The production traits as well as DistIso and the logarithm of DistSR and TI were treated as Gaussian variables. Other behavioral traits (HeadNO, Mount, AgrP, GentleP) were converted into classes, with a class corresponding to the “0” value and two classes of an equal number of individuals for values strictly superior to 0. The heritability (h^2) and genetic correlations (r_g) were estimated for each combination of two traits using TM software (Legarra et al. (2011)) which can process continuous and categorical traits. Variance and covariance components (as well as the corresponding h^2 and r_g parameters) were estimated by Gibbs sampling. A total of 100,000 iterations were realized, from which the first 20,000 iterations were discarded and one estimation every 20 iterations was saved. The model used included the fixed effects of hatch and sex, the additive genetic effect of animal, and the maternal permanent environmental effect for body weights and age at first egg.

Results

Heritability estimates: Heritability coefficients were moderate to high (Table 1). For behavioral traits, h^2 ranged from 0.19 to 0.36 for DistSR, DistIso, TI and HeadNO and from 0.39 to 0.49 for Mount, AgrP and GentleP. For production traits, h^2 was moderate for AFEgg (0.30) and higher (between 0.39 and 0.49) for W17, W65 and NEgg.

Genetic correlation estimates: As shown in Table 1, quite a high positive genetic correlation (0.90) was found between Mount and AgrP. Moreover, the two traits were positively correlated with HeadNO, highly for Mount (0.89) and more moderately for AgrP (0.63). GentleP was positively correlated to HeadNO (0.63) and Mount (0.73), while it was not significantly genetically correlated to AgrP (0.20). As expected, W17 and W65 exhibited a strong positive genetic correlation (0.72), and AFEgg and NEgg a strong negative genetic correlation (-0.88). In addition, significant genetic correlations were found between behavioral and production traits. This was the case between TI and W17 (0.76) as well as W65 (0.79). NEgg was positively genetically correlated with Mount (0.82) and AgrP (0.58), as well as with GentleP (0.72) and HeadNO (0.61). AFEgg was negatively correlated with GentleP (-0.81), DistSR (-0.71) and Mount (-0.68), but positively correlated with TI (0.74).

Discussion

Even if several factors such as age of the bird, environmental conditions (e.g. housing in group or \dots), this result is consistent with the marked response observed on DistSR or TI in experimental divergent lines wselected on these traits in Japanese quail (Mills and Faure (1991)).

Our results highlighted quite close genetic determinisms of behaviors related to sexual motivation (Mount) and aggressiveness (AgrP). This supports the relationships already described in Japanese quail and domestic fowl in

Table 1. Heritabilities (on diagonal) and genetic correlations (above the diagonal) between behavioral and production traits.

Trait	DistSR	DistIso	TI	HeadNO	Mount	AgrP	GentleP	W17	W65	AFEgg	NEgg
DistSR	0.19¹	0.16	-0.35	0.37	0.32	0.05	0.29	0.14	0.03	-0.71	0.32
DistIso	-	0.34	-0.33	-0.08	0.00	0.35	0.45	-0.33	-0.44	-0.21	0.04
TI	-	-	0.21	0.24	-0.22	0.01	-0.24	0.76	0.79	0.74	-0.35
HeadNO	-	-	-	0.36	0.89	0.63	0.63	0.49	0.44	-0.55	0.61
Mount	-	-	-	-	0.49	0.90	0.73	0.18	0.36	-0.68	0.82
AgrP	-	-	-	-	-	0.42	0.20	-0.29	0.00	-0.38	0.58
GentleP	-	-	-	-	-	-	0.39	0.45	0.28	-0.81	0.72
W17	-	-	-	-	-	-	-	0.48	0.72	0.48	-0.06
W65	-	-	-	-	-	-	-	-	0.49	0.11	-0.21
AFEgg	-	-	-	-	-	-	-	-	-	0.30	-0.88
NEgg	-	-	-	-	-	-	-	-	-	-	0.39

¹ Significant parameters are indicated in bold.

which aggressive and sexual behaviors show similar patterns in males (Blohowiak et al. (1985); Sefton and Siegel (1975)). The response to a novel object (HeadON) also had a high positive genetic correlation with sexual motivation (Mount) and, to a lesser extent, with aggressiveness (AgrP). The use of a mirror and of a lure rather than live birds in the aggressive and sexual behavior tests can have enhanced the novelty effect due to the testing situation and could explain why the responses in these two tests were so strongly correlated to the novel object test. No genetic correlation was found between the number of gentle pecks (GentleP) and aggressive pecks (AgrP). This result suggests that the two traits are not the low and high levels of expression of a same phenotype, but rather behaviors with different motivations: positive interactions (search of contact) in the first case and agonistic interactions in the second. A higher number of gentle pecks in the test of aggressiveness was genetically positively correlated with a higher number of scans (in which quail passed their heads through the wire) in the novel object test which could, in both tests, reflect a look for contact (i.e. attraction) in birds with a low level of fear and aggressiveness.

Several significant genetic correlations were found between behavioral and production traits. Some of them pointed out a possible negative impact of selection applied on production traits on the emotional reactivity and the social behaviors of the birds. Indeed, marked positive genetic correlations were found between the weight at 17 and 65 days and the level of emotional reactivity of the bird estimated by the duration of tonic immobility. On the other hand, an unfavorable genetic correlation was observed between the number of eggs laid and aggressiveness (AgrP). In the same time, our results suggested that we could take advantage of favorable genetic relationships between sociality or emotional reactivity and production traits. Indeed, positive genetic correlations were found between the response to the novel object test as well as gentle pecks and the number of eggs laid. This implies that

birds selected for a lower level of fear or a higher level of positive interactions could show more abundant eggs. On the other hand, the selection criteria of our divergent lines, i.e. the distance run on a treadmill to rejoin congeners, and the tonic immobility duration showed strong correlations with the age of laying onset, showing that less fearful birds or birds with higher social motivation would lay earlier. Similarly in the study by Marin et al. (2002), in which social motivation was assessed by the time taken by individuals to join conspecifics in a T-shaped maze (with two exits, one empty, the other one containing conspecifics), the most socially motivated individuals showed earlier puberty and laid more eggs per day.

Conclusion

Our study brought new insights on the genetic control of social and fear behaviors in birds. Strong genetic relationships with production traits were also evidenced. Such genetic data should be acquired in other species and in commercial populations, to evaluate the interest for welfare and production level of taking into account traits of sociability and emotional reactivity in the breeding schemes.

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