Theriogenology 118 (2018) 96–102

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Parental sex effect of parthenogenesis on progeny production and performance of Chinese Painted Quail (*Coturnix chinensis*)☆

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ARTICLE INFO

Article history:
Received 16 March 2018
Received in revised form
18 May 2018
Accepted 23 May 2018
Available online 1 June 2018

Keywords:
Parthenogenesis
Progeny
Hatch weight
Set weight
Egg production

ABSTRACT

Embryonic development of an unfertilized egg, parthenogenesis, is known to occur in Chinese Painted quail. However, selection for parthenogenesis in both the dam and sire leads to a reduction in hatchability following mating. Therefore, the objective of this study was to determine if selection for parthenogenesis in the dam, sire, or both also impact their progeny performance. There were 2 lines of birds used in this trial: 1 line selected for parthenogenesis and 1 line not selected for parthenogenesis (control) yielding breeding pairs as follows: control dams + control sires (CC), control dams + parthenogenetic sires (CP), parthenogenetic dams + control sires (PC), and parthenogenetic dams + parthenogenetic sires (PP). For all progeny, a dam line main effect revealed that the parthenogenetic line dams had heavier offspring hatch weight and 4 wk body weight as well as higher 1st wk chick mortality versus control line dams. However, control line dams had the highest 4th wk chick mortality versus parthenogenetic line dams. In female virgin progeny, a dam by sire interaction revealed that PP, PC, and CP had the heaviest 1st egg in the clutch position versus CC. Also, eggs from PP had the highest number of eggs and the most female progeny exhibiting parthenogenesis versus CC. There was a linear increase in egg weight as clutch position increased for progeny from PP and CC yet a linear decline for CP. In conclusion, it appears that both the dam and sire selected for parthenogenesis impact progeny performance as parthenogenetic dams and sires additively contribute to the degree of parthenogenesis exhibited by virgin female progeny. Moreover, because parthenogenesis is known to exist in the modern poultry industry, even the accidental selection of the parthenogenetic trait in either males or females could have a negative impact on overall chick production and performance.

1. Introduction

In turkeys and chickens [1] as well as smaller birds such as zebra finches [2] and Chinese Painted quail [3], embryonic development can occur in unfertilized eggs through a process known as parthenogenesis. Either suppression of extrusion of the second polar body, or re-entry of the second polar body with the egg nucleus, known as terminal fusion automixis, is thought to be responsible for parthenogenesis [1,4]. Additionally, in Beltsville Small White (BSW) turkeys [1], Dark Cornish chickens [5], and Chinese Painted quail [6] the incidence of parthenogenesis in virgins can be increased by genetically selecting for the parthenogenetic trait. Moreover, parthenogenesis is thought to be controlled by a single autosomal recessive gene in chickens and turkeys [1,7].

Interestingly, when virgin quail selected for parthenogenesis are mated, hatchability is negatively affected [8,9]. In fact, Parker et al. [10] reported that selection for parthenogenesis affects both the dam and sire's individual reproductive performance. For instance, both the parthenogenetically selected dams and sires were responsible for the increase in parthenogenetic embryos and a decrease in hatchability of their eggs. However, only the parthenogenetic line dam was responsible for heavier egg weights which contained parthenogenetic embryos, whereas the parthenogenetic line sires yielded reduced sperm-egg penetration and hence infertility.

Apart from heavier egg weights, parthenogenetic line dams were also responsible for most of the alterations in fresh egg components as opposed to parthenogenetic line sires [11]. For example, parthenogenetic line dams contribute to heavier yolk,

☆ This publication is a contribution of the Mississippi Agricultural and Forestry Experiment Station and this material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Hatch project under accession number MIS-329200.

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https://doi.org/10.1016/j.theriogenology.2018.05.027
0093-691X/Published by Elsevier Inc.

albumen, and shell weights as well as a larger percentage of albumen and ratio of albumen to yolk. Therefore, these alterations in the egg components from the dam may affect progeny production and performance. Also, as reproductive performance of the dam was affected differently than that of the sire when birds were selected for parthenogenesis, it is possible that performance of the virgin progeny will be affected by the parthenogenetic dam or sire differently. Therefore, the objective of this study was to determine if the dam, sire, or both from a line of quail selected for parthenogenesis affects the progeny's body weight and mortality as well as virgin progeny's performance and incidence of parthenogenesis. Additionally, the genetic nature of parthenogenesis in quail was also investigated.

2. Materials and methods

2.1. Housing and care

In this study, two populations of Chinese Painted quail were utilized. One population consisted of quail that were intensely selected for parthenogenesis over several generations [6,9]. The other population used was a random stock of quail that were not selected for parthenogenesis (control). Males and females from both the lines were separated at 4 wk of age and placed into separate colony cages. At 6 wk of age, females from the parthenogenetic line were placed into individual cages to monitor egg production for determination of each female's incidence of parthenogenesis. From hatch to wk 4, quail were fed a commercial quail starter diet. When birds were separated at 4 wk of age, birds were fed a commercial quail breeder diet *ad libitum* and received 17 h of light/day. Birds were treated in accordance with the Guide for Care and Use of Laboratory Animals [12].

2.2. Selection of parthenogenetic line dams and sires

Daily, eggs from the virgin hens were collected, labeled and incubated for 10 d at 37.5 °C and 50% RH. After 10 d of incubation (DOI), eggs were broken open to determine the incidence of parthenogenesis using a magnifying lamp at 2x magnification [3]. Eggs exhibiting parthenogenesis usually appeared as dense layers of cells covering the germinal disc [3]. For further validation albumen pH was measured, because eggs with parthenogenetic development have a lower albumen pH as compared to unfertilized eggs without development [13]. After each virgin hen laid 20 eggs, her incidence of parthenogenesis was calculated, and if her incidence of parthenogenesis ranged between 20 and 40% she was used for mating. The parthenogenetic males that were selected for breeding were chosen based on their sister's incidence of parthenogenesis as virgins which also ranged between 20 and 40%.

2.3. Combination of parental breeding pairs

The parental breeding pairs were selected from the parthenogenetic line of birds as well as the unselected control line birds. The four possible combination of parental breeding pairs were as follows: control line dams + control line sires (CC), control line dams + parthenogenetic line sires (CP), parthenogenetic line dams + control line sires (PC), and parthenogenetic line dams + parthenogenetic line sires (PP). For this trial, 14 parental pairings were created for each combination.

2.4. Evaluation of progeny performance

For each parental pair, eggs were collected daily, and labeled prior to incubation at 37.5 °C and 50% RH. Data for all of these eggs examined has been previously reported [10,11]. Progeny body weight was determined at hatch (1806 total chicks) and again at 4 wk of age. Mortality was determined weekly until 4 wk of age when males were separated from females. After separation from males at 4 wk of age, virgin progeny females were maintained in colony cages until 6 wk of age. At 6 wk of age, all virgin progeny females were moved to individual cages to monitor egg production, clutch position, and clutch length for the first 20 eggs laid by each hen (6837 total eggs). Daily, eggs were collected, labeled, and weighed immediately prior to set. Eggs were then incubated at 37.5 °C and 50% RH for 10 d. At 10 DOI, to obtain incubational egg weight loss, eggs were weighed again. To determine the presence of parthenogenesis, eggs were broken open at 10 DOI and examined using an illuminated 2x magnifying lamp [3]. If it was determined that an egg exhibited parthenogenesis, the germinal disc was measured across the widest part [3]. Because most parthenogens appeared as unorganized epithelial sheets of cells covering the germinal disc area of the yolk, embryos were not staged [14].

2.5. Statistics

A 2 × 2 factorial arrangement of treatments was created as follows: two dam lines (control and parthenogenetic line) and two sire lines (control and parthenogenetic line). Data were analyzed as a completely randomized design with each individual breeding pair serving as the experimental unit. When global $P < 0.10$, means were separated using Fisher's protected LSD with α set at 0.05 [15]. Frequencies of different genotypes in the population were calculated based on Hardy-Weinberg equilibrium [16], and Chi-square analysis was used to calculate the probability of chance deviations from expectations for parthenogenesis as an autosomal recessive trait [7].

3. Results

Parental pairing effect on offspring body weights and mortality is represented in Table 1. There were dam line main effects for hatch ($P = 0.06$) and 4 wk body weights ($P = 0.03$) with the

Table 1
Dam and sire line effects for progeny body weights and mortality.[1]

	Weights (g)		Mortality (%)				
			First	Second	Third	Fourth	Total
	Hatch	4 Week	Week	Week	Week	Week	4 Week
Dam Line							
Control	3.9[b]	34.1[b]	6.0[b]	1.6	4.5	9.9[a]	21.9
Parthenogenetic	4.0[a]	35.7[a]	17.5[a]	2.5	3.9	5.8[b]	29.7
SEM[2]	0.06	0.50	3.15	0.63	1.55	1.60	4.0
Sire Line							
Control	3.9	34.3	11.4	1.8	4.5	7.6	25.2
Parthenogenetic	4.0	35.4	11.4	2.3	4.0	8.4	26.0
SEM	0.06	0.50	3.15	0.63	1.55	1.60	4.04
Interaction							
C dam + C sire	3.8	33.54	7.3	1.8	5.8	8.4	23.3
C dam + P sire	3.9	34.9	4.3	1.4	3.0	11.6	20.2
P dam + C sire	4.0	35.4	16.1	1.8	2.9	6.6	27.4
P dam + P sire	4.0	36.2	19.0	3.2	5.0	5.0	32.2
SEM	0.09	0.70	4.45	0.88	2.19	2.26	5.71
P values							
Dam Line	0.06	0.03	0.01	0.31	0.86	0.07	0.17
Sire Line	0.70	0.14	0.98	0.56	0.88	0.74	0.88
Interaction	0.97	0.64	0.52	0.29	0.27	0.30	0.50

[a–b] For each main effect or interaction, means within a column with different superscripts are significantly different at $P < 0.10$.
[1] 1,806 total number of chicks examined.
[2] Pooled standard error of the mean.