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Comparative Performance of Artificial Insemination in Broiler Breeders Housed on the Floor Versus Cages on Commercial Scale

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ABSTRACT

Research trials were conducted at commercial farms (n=147,500) to explore the performance of artificial insemination technique at various frequencies in meat-type floored and cage-housed breeder flocks during 1st and 2nd egg-laying cycles under the controlled environment where the average house temperature and RH were 25-28°C;75-85% and 21-24°C; 50-65% during summer and winter seasons, respectively. Birds were divided into six groups; the cage-housed flocks were either artificially inseminated on each 5th (n=20,000) or 7th day (n=20,000) whereas the floored flocks were either naturally mated (n=10,000) or inseminated artificially on 7th (n=10,000) or 5th (n=49000) day during 1st and 2nd egg lay (n=38500) cycles. The egg lay and hatch data was recorded for complete flock cycles and analyzed using SPSS software. Artificially inseminated hens produced 16% more ($P<0.01$) chicks than naturally mated flocks for 25 weeks long post-peak phase (41-65 weeks) during 1st egg lay cycle without any significant decline in egg lay. Floored flocks produced 2% more eggs during pre-peak but 2% fewer eggs during peak and post-peak phases compared to cage-housed hens ($P>0.05$). The Hatchery percentile was the same before the peak and then improved ($P<0.05$) by 4 and 10% during and after the peak, respectively. Insemination frequency, cockerels' body weight, and production cycle had no significant effect ($P>0.05$) on both parameters, however, the effect of cockerels' body weight on hatch was considerable ($P<0.09$). Artificial insemination exploits the optimal role-play of both the male and female lines to overcome low fertility in commercial poultry and may replace natural mating as per business needs, particularly after the peak egg-laying period.

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Key words
Artificial insemination, Fertility, Breeder, Flock, Cockerels

INTRODUCTION

Intensive selection based on growth traits in meat-type breeder flocks has resulted in their moderate but constant decline in fertilizing potential. A negative correlation between reproductive and growth traits may be responsible for the decline in the fertilizing potential of birds selected for rapid growth (Brillard, 2004). This may ultimately favor the emergence of breeds with less intensive growth rates and/or the extension of artificial insemination (AI). Maximizing the proportion of fertile eggs is of the greatest priority to the breeder industry (Akhlaghi *et al*., 2014). Apart from the critical role of the male bird in flock fertility (Saemi *et al*., 2012; Ommati *et al*., 2013) the female bird makes a central contribution to egg production and provides an optimal microenvironment in the oviductal sperm storage, for the subsistence of residing spermatozoa (Bramwell *et*

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al., 1996). AI exploits the optimal role of the gender to overcome low fertility in commercial poultry, particularly in turkeys, which results from unsuccessful mating consequently of large, heavily muscled birds being unable to physically complete the mating process. As managing commercial broiler breeders to maximize fertility becomes more challenging, the use of AI in commercial poultry operations is becoming more common, in countries where labor is cheaper. Certainly, the use of AI in chickens, as in turkeys, can improve fertility; however, the cost of implementing AI on a large scale is often cost-prohibitive in developed countries. AI in avian species has relative advantages as compared with natural mating (Fuquay *et al*., 1976; Brillard, 2003). These advantages of AI include the increased number of settable eggs, and better overall fertility and hatchability, thus reducing the cost of production per unit of day-old chicks (Brillard, 2003). Several factors must be synchronized for the optimum success of AI, and they include breeder stock management, sperm quality and quantity, sperm dosage, depth of insemination, frequency, and timing of AI (Lake, 1978; King *et al*., 2002). AI in each poultry breeder house should not be done around the time of lay for maximum insemination results (Brillard, 2003). Fertility decreases in naturally mated hens with the increasing flock age due to the physiological conditions of individual hens and with the male's advancing age due to physical problems. These problems include roost mating competition, physical injuries, and decreased libido due to aging. Thus, both increased body weight and age reduce fertility in broiler breeders (Bramwell *et al*., 1996). The current trials were aimed to evaluate the comparative performance of AI in broiler breeders housed on the floor versus cages on a commercial scale.

MATERIALS AND METHODS

Study location

The field study was carried out in commercial poultry farms located in Lahore, Pakistan. The city is characterized by a long (December-January) and short (August) rainy season. The first experiment was conducted on floor-housed flocks from May through October 2014 followed by 2nd experiment on cage-housed flocks from November 2015 through April 2106 and 3rd experiment on molted flocks from July through December 2016 under the controlled environment where the average outside temperature ranged between months. The average house temperature and RH during all the trials were 25- 28^o C; 75-85% and 21-24^{o}C; 50-655 during the summer and winter seasons, respectively.

Birds and experimental conditions

The experimental trials were conducted Hubbard Broiler Breeder flock (n=147,500) housed in cages (n=40,000) and floor (n=107,000) during the 1st (n=107,000) and 2nd (n=38700) egg lay cycles. For the first production cycle, the chicks were first raised in floor pens on litter till the age of 18 weeks. The flock was divided into five groups, at the time of shifting to production houses. Two groups, each comprising 20,000 hens were randomly selected and shifted to two separate sheds equipped with a cage housing system, whereas the other three groups each comprising 10,000, 47000, and 10,000 hens were maintained on the floor. Each group was separately housed under the same environmental conditions. The cage-housed flocks were artificially inseminated on each 5th day in one shed (Group-1) and on the 7th day in the other shed (Group-2). Group-3 from the floor-housed flock was naturally mated while the 4th and 5th where groups were floored and artificially inseminated on each 5th and 7th day, respectively. The 6th group (n=38700) consisted of a flock during the 2nd egg lay cycle that was floored and inseminated each 5th day. In battery cages manufactured by Guangzhou Guangxing Poultry Equipment Company Limited, hens were housed in Hot Dip Galvanized 3 tier cages, measuring, 658 cm^2 area per female bird and 3 birds per cage, 1645 cm^2 area per male bird, and one male per cage. The floor houses were equipped with semi-automated feeders being picked up 15 mins after feeding thereby reducing the hen house floor space requirement to 1.88 square feet per bird. It is 13% less than the usually required for layers in tropical climate studies conducted by (Banga-Mboko *et al*., 2007; Maba, 2008). The cage-housed hens occupied 0.89 square feet of floor area per hen. The floor pen included nests and an elevated area with a perch. Wheat straw was used as a floor substrate in the pens. Each cage and each deep-littered floor pen was equipped with an automatic water supply and manual feeding troughs. The cage housing had the facility of automatic manure removal daily. Both groups were subjected to the same lighting schedule of 16 light hours with 60 LUX and 8 dark hours with zero light intensity during the entire production period.

Feeding and vaccination

Feed was formulated as per management guidelines for the Hubbard breed that contained 2750 Kcal kg 1, 16% crude proteins, 3.5% calcium, and 0.06% methionine (Maba, 2008). The floor-housed hens were daily offered 125 gms on the 24th week which peaked at 175/day/hen on the 28th week. The caged house hens were daily offered 105 gm a hen which peaked at 155 g/

day/hen. The flocks were vaccinated against Newcastle, IB, coccidiosis, Mareks, IB Variant, IBD (live and attenuated), ILT, AI H9, *E. coli*, IBH, and EDS.

Insemination and mating

Hens in all the groups were inseminated with fresh and pooled semen at 2 PM on the scheduled day. Semen was collected from cockerels on an alternate day. Semen is taken from every 4 cockerels used to be pooled together, mixed with 0.4 cc diluent (30% extender) that approximately made the final volume of 2cc and gently stirred to inseminate 28-32 hens. Each injector contained 2 million sperms with an average penetration value of >60. In the 1st and 2nd groups, the caged housed hens were inseminated with fresh and pooled semen throughout the production period on the 5th day and 7th day, respectively. Group-3, from the floor, reared flocks was naturally mated having 10% males at 23 weeks and gradually reduced to 8% at 65 weeks through the production period. The 4th and 5th groups on the floor were naturally mated till the 39th and 47th weeks and inseminated artificially on each 5th and 7th day, respectively. In the 6th group, hens in the 2nd production cycle were inseminated each 5th day. Groups 1, 2, 4, 5, and 6 were inseminated at the age 24, 24, 48, 40, and 60 wks and onwards for consecutive 40, 40, 5, 25, and 23 weeks. Three persons were involved in the insemination process. The first person carefully caught and restrained one hen at a time with his hands. The second person carried out abdominal massage of the breeder hens according to the method of (Lake, 1978), and as soon as there was partial eversion of the cloaca, he exerted controlled pressure on the lower abdomen for eversion of the vagina. Thereafter, the tuberculin syringe with pooled semen was inserted into the hen's vagina by the third person, who released the semen intravaginally as soon as the vagina started to relax. Settable eggs were collected from hens and properly tagged. Daily fertile egg collections were transported to the incubation and hatching facilities and stored at 16° C for a maximum of seven days and then incubated in a Buckeye incubator (Lopen Group, Mill Lane Lopen, South Pertheron Someset, TA 13 5JS, England) at 37.6 °C according to the method of (Tona *et al*., 2003). Percent fertility and hatchability were determined following candling on day 18 of incubation and at hatching on day 21, respectively.

Measurements and hatchability

Two output variables were measured: egg production and hatchability. Following the transfer of pullets to cages and on the littered floor, daily egg production was recorded. These data allowed for calculating the number of settable fertile eggs laid. Eggs were set in the forced-air incubator for 18 days at 99-99.5°F and 60- 65% relative humidity (83-88°F wet bulb) and transferred to a hatcher where temp and humidity were 98.2°F to 98.5°F and 90%, respectively. Random samples from male and female birds were taken to record body weight on weekly basis.

Statistical analysis

Data were processed using version 22 of SPSS software. ANOVA was performed and mean values obtained from the floor pen groups and the battery cage groups were compared using the LSD at 1 and 5% significance levels.

RESULTS

Table I shows the effect of insemination on the production and hatchability of eggs obtained from naturally mated and artificially inseminated breeder hens. Naturally mated hens laid 1.8% more eggs than artificially inseminated hens before peak but the trend reversed during and after peak egg laying. However, this variation in egg-laying was not significant. Artificially inseminated flocks hatched more chicks during all phases of lay than naturally mated flocks. Hatchability was almost similar before the peak and varied significantly during and after the peak with housing. The results for the effect of AI on the production and hatchability of eggs laid by floored and cage-housed breeder hens are presented in Table II.

Table I. Insemination performance in comparison with natural mating (Mean±SD).

Performance parameter	Mating type	Production stage			P. value
		24-29 wks	30-40 wks	41-65 wks	
Egg production	Natural	43.24±32.4	83.92±1.88	63.14±9.99	0.745
	Artificial	41.44±32.3	85.60±2.55	63.83±9.07	0.745
Hatchability	Natural	60.30±34.2	86.16±1.59	69.24±7.91	0.000
	Artificial	60.80±34.4	90.17±1.33	85.84±3.60	0.000

Table II. Insemination performance in floor versus cage housing (Mean±SD).

Performance parameter	Housing system	Production stage 24-29 wks	30-40 wks	41-65 wks	P. value
Egg production	Floor	43.24±32.4	83.71±2.07	62.64±9.91	0.577
	Cage	41.44±32.3	85.88±2.21	64.68±8.55	0.577
Hatchability	Floor	60.3±34.2	86.2±1.56	77.1±9.90	0.005
	Cage	60.8±34.4	90.31±1.17	86.28±3.82	0.005

Table III. Insemination performance in egg lay cycles.

Performance parameter	Egg lay cycle	Mean±SD	P. value
Egg production	1st Cycle	65.89±17.3	0.535
	2nd Cycle	68.58±8.61	
Hatchability	1st Cycle	82.91±13.6	0.310
	2nd Cycle	86.26±3.13	

Egg laying did not vary significantly. Although floored hens lay more eggs than cage-housed hens before peak less during and after peak egg laying. The hatchery percentile was the same before the peak and then improved (P<0.05) during and after the peak by 4 and 10%, respectively. The effect of insemination on the production and hatchability of eggs obtained during 1st and 2nd egg lay cycles of breeder hens are compared in Table III. The egg lay and hatch differed in the two cycles but this difference was non-significant. Hens laid more eggs and hatched more chicks in the 2nd egg-lay cycle than in the 1st cycle by 2.69 and 3.35%, respectively. Table IV shows the effect of insemination frequency on the production and hatchability of eggs obtained from breeder hens artificially inseminated each 5th and 7th days. Percentile hatch remained almost similar with insemination frequency; however weekly inseminated hens laid 2% fewer (P>0.05) eggs than 5th-day inseminated hens. Interphase variation in both parameters was significant. The results regarding the effect of body weight of floor-housed cockerels on the hatch performance by naturally mated floored flock are tabulated in Table V. Hatchery percentile considerably improved (P<0.09) with advancing body weight of the mating cockerels till the 36th week of flock age but declined at heavy weight after that.

DISCUSSION

Percentile hatch in the initial two phases of egg laying and egg production during all the phases did not vary significantly with mating type. Artificially inseminated hens produced 16% more (P<0.01) chicks than naturally mated flocks for 25 weeks long post-peak phase (41-65 wks) during 1st egg laying cycle without any significant decline in egg lay. The current trials demonstrate the effective role of AI in preventing fertility decline with advanced age in the post-peak phase. These results resemble with findings of (Habibullah *et al.*, 2015; Christensen, 2001). However, Kooper and Sayyahzadeh (2011) couldn't significantly correlate the insemination type with hatch. Fertility decreases in naturally mated hens with the increasing flock age due to the physiological conditions of individual hens and with the male's advancing age due to physical problems. These problems include rooster mating competition, physical injuries, and decreased libido due to aging. Thus, both increased body weight and age reduce fertility in broiler breeders (Bramwell *et al.*, 1996). Floored flocks produced 2% more eggs during pre-peak but 2% fewer eggs during peak and post-peak phases compared to cage-housed hens (P>0.05). The trend reveals that eggs lay inclined more rapidly on the floor at the onset of production as compared to the cage-housed flock. The hatchery percentile was the same before the peak and then improved (P<0.05) by 4 and 10% during and after the peak, respectively. The current results for the post-peak phase resemble the 5% rise in the hatch for the cage-housed artificially inseminated flock reported by Sayyazadeh and Shahsavarani (2005).

Table IV. Insemination performance with respect to insemination frequency (Mean±SD).

Performance parameter	AI Frequency	Production stage 24-29 wks	30-40 wks	41-65 wks	Interphase value	Entire egg lay and hatchability	P. value
Egg production	5th Day	41.44±34.2	85.88±2.27	64.68±8.64	0.000	67.53±18.6	0.588
	7th Day	41.44±34.2	85.34±2.86	63.41±9.33	0.000	65.69±16.0	
Hatchability	5th Day	61.2±36.7	90.81±1.07	87.16±3.35	0.000	84.97±15.0	0.742
	7th Day	60.4±36.3	89.58±1.31	85.18±3.57	0.000	84.11±11.7	

Table V. Effect of floored Cockerels body weight on hatch by naturally mating flock.

Body weight (g)		Corresponding age (Weeks)	Hatch (Mean±SD)	P. value
Min.	Max.	Floor		
3500	3999	25 to 36	75.75±25.2	0.092
4000	4499	37 to 48	83.35±4.14	
4500	5000	49 to 60	77.09±9.99	
>5000		60 to 65	70.00±10.8	

The decline in hatch during the pre-peak phase of a lay show a similar trend reported by (Brillard, 2003; Penfold *et al*., 2000; Mahmoud *et al*., 1996; McDaniel *et al*., 1996) who linked the depression in fertility with lower semen densities in the afternoon collections and intrinsic biological activity that may lead to the diurnal rhythm. Although hens in the 2nd cycle laid more eggs and hatched better in the 2nd egg-laying cycle than in the 1st cycle by 2.69 and 3.35%, respectively, but this improvement was not significantly different (P>0.05). Custodio *et al*. (1996) have reported a 12% rise in the hatchery percentile for artificially inseminated hens in their 2nd production cycle compared with natural mating (81.0%). The mating type might have contributed to this mismatch rather than the egg lay cycle. Neither egg laying nor hatching differed significantly among 5th day and weekly inseminated flocks for the same phase of egg lay and only slight improvement with more frequent insemination was recorded. The inter-phase variation was, however, significant for both of the parameters. Subfertility is associated with differing sperm transport among hens, rather than insufficient sperm produced by roosters (Brillard and Antoni, 1990). Gumuka and Capcuswka (2005) lengthened fertility duration by 2 days post-insemination and concluded that high values for effective fertility can be obtained from broiler breeders' inadequate environmental and technological conditions of AI. Bhattarai *et al*. (2015) also concluded a similar trend reporting a 33, 23, and 10% increase in the hatch and a 10, 0.5, and 9.5% decrease in egg lay for insemination frequencies at 3 vs 14, 7 vs 14, and 3 vs 7th days, respectively. These results also resemble the findings of positive association insemination interval with hatch and differ for egg laying by Orunmuyi *et al*. (2013). Hatchery percentile improved with the advancing body weight of cockerels by the 36th week of flock age until their weight hindered mating. The decline in the hatchery percentile at the heavy weight of cockerels may be attributed to the physical problems faced by them. These problems include rooster mating competition, physical injuries, and decreased libido due to aging.

CONCLUSIONS AND RECOMMENDATIONS

Artificially inseminated meat-type floored and cage-housed breeder flocks successfully at the commercial level during 1st and 2nd egg lay cycles at weekly and 5th-day insemination intervals. AI improved (P<0.01) hatchery percentile by 16% for 25 weeks long post-peak phase (41-65 wks) during 1st egg lay cycle without any decline in egg lay (P>0.05). The highest egg production and hatchability were obtained from caged housed hens inseminated on the 5th day. However, this rise in the hatch was not significantly better than 7th day insemination. AI exploits the optimal role-play of both the male and female lines to overcome low fertility in commercial poultry and may replace natural mating, particularly during the post-peak period or the advanced avian housing systems where natural mating may not perform well or is otherwise not applicable.

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IRB approval

The experimental work was approved by the Advanced Studies and Research Board (No.521/DASAR/AUP, dated 07/09/2016), The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan.

Ethical statement

This study was approved by the animal welfare and care committee of the Faculty of Animal Husbandry and Veterinary Sciences (FAHVS), The University of Agriculture, Peshawar, Pakistan, before the practical execution of this experiment, and all the measures and tools were considered to minimize the pain and discomfort of birds during the conduction of this experiment.

Statement of conflict of interest

The authors have declared no conflict of interest.

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