Relationship between the reproductive potential and the degree of development of the secondary sexual characters in male broiler breeders

Simona Popova-Ralcheva[1], Vesselina Sredkova[1], V. Gerzilov[2], E. Petkov[3] D. Gudev[3]

1. Institute for Information, Agricultural Academy, Bulgaria, 2. Agricultural University – Plovdiv, Bulgaria, 3. Institute of Animal Sciences - Kostinbrod, Bulgaria

SUMMARY

This study was carried out with 80 White Cornish males from strain A and 80 White Plymouth Rock males from strain C (40 F_0 males of unknown origin and their offspring 40 F_1 males in each strain) in the Department of Poultry Science at the Institute of Animal Science - Kostinbrod. Broiler breeder males from both generations were first tested for response to abdominal massage at 18 and then at 19 and 20 weeks of age. The sperm assessment carried out from 24 to 56 weeks of age in the F_0 males of unknown origin and their F_1 progeny. For establishment of the relationship between the main semen traits and cockerel response to massage it was allocated two groups for each generation (F_0 and F_1) and from each strain - first group cockerels responded positively to the first massage for receiving of semen and second group cockerels responded to the second and third massage. It was found that the response to massage at 18 weeks of age and the size of development of the secondary sexual characters at 7 weeks of age can be used as predictive criteria for sperm characteristic in broiler breeder males from the A and C strains. The males of both strains that responded to the first massage had better developed combs and wattles and better semen traits. Also, they had higher sexual activity demonstrated by the higher rate of ejaculation in response to abdominal massage. There were pronounced genotype differences regarding ejaculate volume and less pronounced differences with respect to sperm motility and concentration that were in favor of strain C relative to strain A. The response of cockerels to massage at early age and the size of development of their secondary sexual characters can be used as criteria for prediction the quantity and quality of sperm production in broiler breeder males.

Keywords: broiler breeder male, cockerel, semen, secondary sexual characters

INTRODUCTION

Broiler reproduction requires selection of broiler breeder males and early prediction of their reproductive performance. The development of secondary sexual characters (comb and wattle) and the response to abdominal massage in cockerels are closely related with their future reproductive performance and constitute the main traits that must be taken into account in the early selection of broiler breeder males (Taneja and Gowe, 1962; Tuncer, et al., 2006; Tuncer, et al., 2008).

Gebriel et al. (2009) found that the secondary sexual characters had positive phenotypic correlations with most semen physical traits. Whereas the genetic correlations between comb and wattle measurements with semen traits were mostly positive, which can be used as indicators for high semen physical traits in Norfa cocks.

Similarly, some authors (Konopleva, 1986; Wishart and Palmer, 1986; Etches, 1996) reported that broiler breeder males that responded positively to abdominal massage at an early age demonstrated better reproductive performance with age. According to Popov and Vasilevna (1986) cockerels should be selected at the age of 150 – 160 d based on their response to massage and expression of the secondary sexual characters. They argued that cockerels that responded positively to the first abdominal massage were supposed to have higher reproductive performance throughout their reproductive life and must be chosen for breeding purposes. Bakst and Brillard (1995) reported higher ejaculate volume and sperm concentration in cockerels that responded positively to abdominal massage at an early age. The data demonstrates the potential of this trait as a selection criterion for higher sperm production.

Sometimes the one-sided selection for response to massage could cause for decrease of egg production in their daughters (Popov and Vasileva, 1986; Bakst and Cecil, 1997). Several authors have reported highly significant correlation between cockerel response to massage and the expression of secondary sexual characters (Bakst and Brillard, 1995; Cooper, 1965). They recommended that cockerel selection should be conducted at 16-18 weeks of age.

The purpose of the present investigation was to study the possible to predict the main semen traits in White Cornish broiler breeder males from strain A and White Plymouth Rock broiler breeder males from strain C by the development of the secondary sexual characters and the response to massage at early age.

MATERIAL AND METHODS

Experimental birds and rearing.

Eighty White Cornish males from strain A and 80 White Plymouth Rock males from strain C (40 males of unknown descent - F_0 and their offspring - 40 males in each strain) were raised in the Department of Poultry Science at the Institute of Animal Science in Kostinbrod.

All male broilers in the F_1 generation were descendants of the F_0 cockerels that responded positively to the first abdominal massage. Cockerels in both generations were first habituated to massage response at 18 weeks of age and then at 19 and 20 weeks of age respectively by the method of Burrows and Quinn (1935, 1937). The 40 cockerels from F_0 and 40 cockerels from F_1 of each strain were allocated into two treatment groups (first group –cockerels that responded positively to the first massage and second group- cockerels that responded to the second and third massage) in order to investigate the relationship between the main traits of sperm production and cockerel response to massage.

During the reproductive period all males were maintained in enclosed houses and were feed restricted with a standard breeder diet (2700 kcal/kg diet, 13.5 % CP, 1% calcium and 0.47% phosphorous). All cockerels maintained on a 16 h L: 8 h D lighting program.

Semen collection and evaluation

Ejaculates were collected once a week from 24 to 56 weeks of age and were assessed by the following semen traits:

- ✓ Ejaculate volume (ml) - from cloacal vent by Cooper's sperm collector and direct reading.
- ✓ Sperm motility (%) – by light microscope Nikon Alphaphot-2YS2 (400 magnification).
- ✓ Sperm concentration (sperm cells $\times 10^9$/ml) – by photometer IMV.
- ✓ The pH of semen – by electronic pH meter MS 2011 Mycrosyst.

The surface areas of the secondary sexual characters (comb and wattle) were measured in the cockerels from both strains at 18 weeks of age.

Statistical analysis

Data were subjected one-way analysis of variance (ANOVA) followed by Student's t-test to determine the level of significance among mean values. The results were presented as mean ± SD, and the significant differences at $P<0.05$.

RESULTS AND DISCUSSION

At 7 weeks of age the comb surface area of the F_0 cockerels from strain A, that responded positively later on the first massage was 2.3 cm^2 while the comb surface area of those that responded positively to the second and third massage was 1.62 cm^2. The difference between the two groups regarding comb surface area was 29.57% in favor of the cockerels that responded positively to the first massage. Wattle surface areas in the first and second group of cockerels from strain A were 1.05 cm^2 and 0.78 cm^2 respectively, i.e. 25.71% lower than in the first group ($P<0.05$).The differences of secondary sexual characters (length and width of both comb and wattle) in both strains are significant ($P<0.05$). These values are similar with the values reported by Gebriel et al. (2009) in Norfa cocks and El-Sahn, (2007b) in Bandarah cocks.

The same trend was also observed in the size of development of the secondary sexual characters at 18 weeks of age: the cockerel index of comb surface area was 15.43 cm^2 and 9.42 cm^2 in the first and second group from strain A respectively, i.e. 37.2% lower than in the first group. Wattle surface area in the first group of cockerels at that age was 6.36 cm^2 while in the second group it was 4.54 cm^2, i.e. 28.62% lower than in the first group ($P<0.05$).

These results indicate that the cockerels in the first group that responded positively to massage and provided ejaculate had better developed secondary sexual characters at 7 and 18 weeks of age.

Similar regularity was observed in the F_0 White Plymouth Rock cockerels from strain C. Comb surface area in the cockerels from the first group was 1.83 cm^2 at 7 weeks of age while in the second group it was 1.63 cm^2. Wattle index, measured at the same age, was found to be equal in both groups – 0.97 cm^2. Comb surface areas measured at 18 weeks of age were 15.35 cm^2 and 12.43 cm^2 in the first and the second group respectively. There was insignificant difference in the wattle surface areas between the groups - 0.09 cm^2 ($P>0.05$).

Based on these results we assume that cockerels of both strains that have well developed combs and wattles at 7 weeks of age are much more likely to ejaculate in response to massage when they reach sexual maturity. This regularity allows us to predict cockerel response to massage at an early age based on the size of development of their combs and wattles.

These finding agree with those reported by Andersson, (1994) who was reported that the degree of development of the secondary sexual characters could affect the reproductive potential of an individual cock. Also, these results agree with those reported by El-Sahn (2007b) and Abd El Ghany et al. (2011) who observed that males with large comb had the highest semen evaluation compared with males with small comb except for percentage of live sperm.

The response to massage in the experimental broiler breeder males from both parental strains – A and C as well as their offspring is presented in Fig.1.

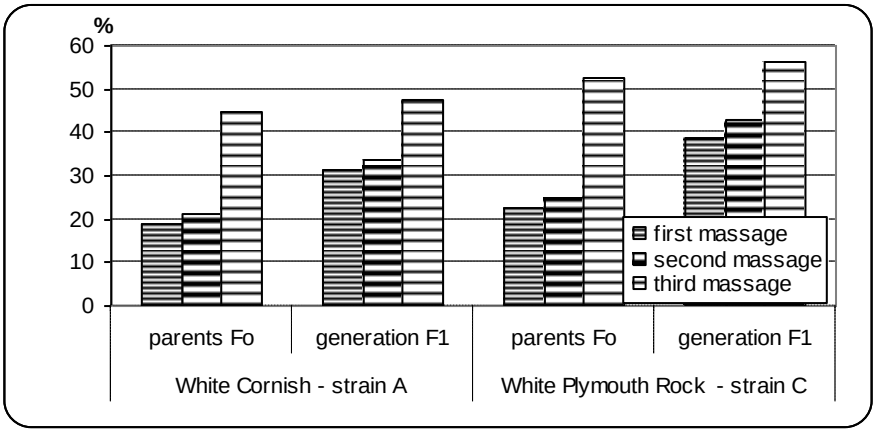

Fig. 1 Response to massage of cocks (F_o parents and F_1 generation) from strains A and C

The first massage was conducted at 18 weeks of age on a total of 80 F_0 cockerels (40 males from each strain). Seven cockerels (17.50%) from strain A and 9 cockerels (22.50%) from strain C responded positively. The F_1 cockerels that responded positively at the same age were 30% (n = 12) and 37.50% (n = 15) in strain A and C respectively. The second massage was conducted at 19 weeks of age. The number of male broilers that responded positively to the second massage increased to 22.50% (n = 9) and 25% (n = 10) in the F_0 cockerels and to 35% (n = 14) and 45% (n = 18) in the F_1 cockerels from strains A and C. The third massage was conducted at 20 weeks of age. The cockerel response to massage was as follows: F_0 - 45% (n = 15) and 52.50% (n = 21); F_1 – 47.50% (n = 18) and 57.50% (n = 22).

Taken together, these results indicate sizable increase in the number of F_1 cockerels from both strains that responded positively to the first massage relative to those of F_0 generation thus marking the beneficial effect of the F_0 cockerel selection for positive response to massage on the F_1 performance. We also found between-strain differences regarding the investigated trait. Both the F_0 and F_1 cockerels from strain C surpassed those from strain A. This difference can be explained either by a breed difference or lower body weight at the respective age. Both of them were in favor of the White Plymouth Rock cockerels.

Reproductive capacity of male birds in natural mating systems is related with their physiological and behavioral responses to female (Jones and Mench, 1991; McGary et al., 2003), while the success rate of artificial insemination depends mainly on the selection of cockerels to response to massage and the successful ejaculate induction, as well as on sperm quality and quantity. Selection of the right male on the basis of superior semen traits can increase

hen fertility and improve reproductive efficiency (Holsberger et al., 1998; Donoghue et al., 1998). In this respect are our results.

The F_0 cockerels from strain A had the highest rate of positive response to massage (from 80% to 66.25%) at 32 – 44 weeks of age, then the number of cockerels that ejaculated decreased gradually to 46.25 % in the final stage of the study. The number of F_1 cockerels from the same strain that ejaculated in response to massage up to 56 weeks of age fluctuated within narrow limits – from 86.25% to 82.50%.

Even as early as the initial period of the study the F_0 cockerels from strain C demonstrated better sexual activity than those from strain A. The share of sexually active cockerels that ejaculated remained high at 32 - 44 weeks of age – around 90% and then decreased to 66.25% at 56 weeks of age.

The main traits of sperm production – volume, motility and sperm concentration in the F_0 and F_1 cockerels from both strains are shown in Fig. 1-3.

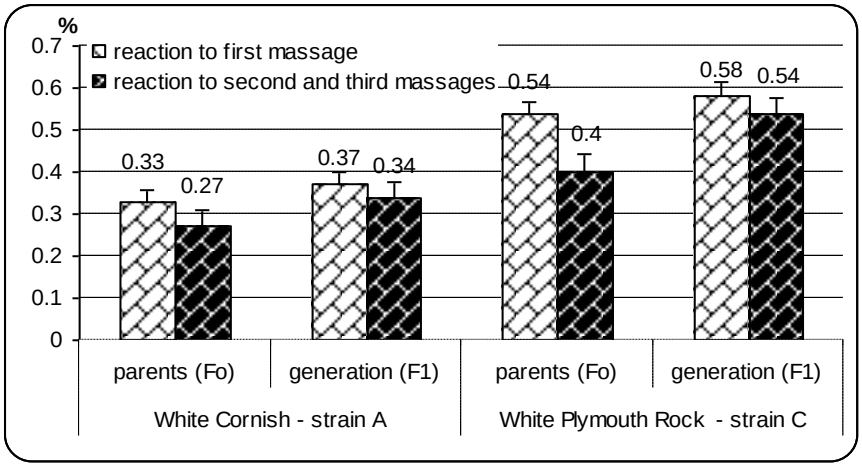

Fig. 2. Ejaculate volume of cocks (ml) – Fo parents and F1 generation from strains A and C

There were differences between the two groups of F_0 cockerels from strain A in the qualitative and quantitative characteristics of the ejaculates when assessed by the cockerel response to the first massage. The sperm traits in the first group of cockerels exceeded those in the second group. Ejaculate volume increased with age from 0.27 to 0.36 ml in the first group and from 0.23 to 0.31 ml in the second group (Fig. 2). Also, the first group of cockerels had insignificantly higher values of their sperm concentration and motility (Fig. 3 and 4).

Sperm pH-values changed between 7.0 and 7.2 in the each strain.

Ejaculate volume of the F_0 cockerels from the first group of strain C exceeded that of the second group by 0.14 ml ($P < 0.001$). It tended to increase with age from 0.46 to 0.67 ml in the first group and from 0.29 to 0.57 ml in the

second group. The rest of the traits had similar dynamics to that in strain A (Fig. 2-4).

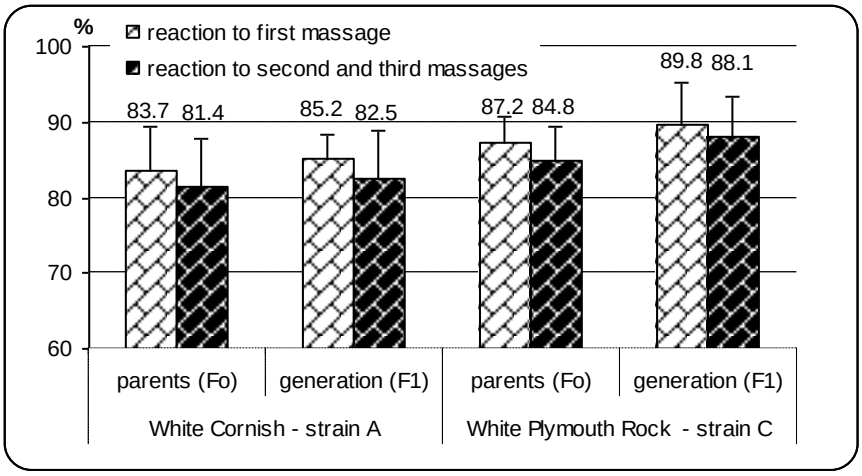

Fig. 3. Sperm motility of cocks, semen (%) – Fo parents and F1 generation from strains A and C

Similarly, ejaculate volume also increased with age in the F_1 cockerels from both strains.

Ejaculate volume in the F_1 cockerels from strain A increased from 0.30 to 0.42 and from 0.29 to 0.41 ml in the first and second group respectively. There were no significant differences regarding sperm motility and concentration.

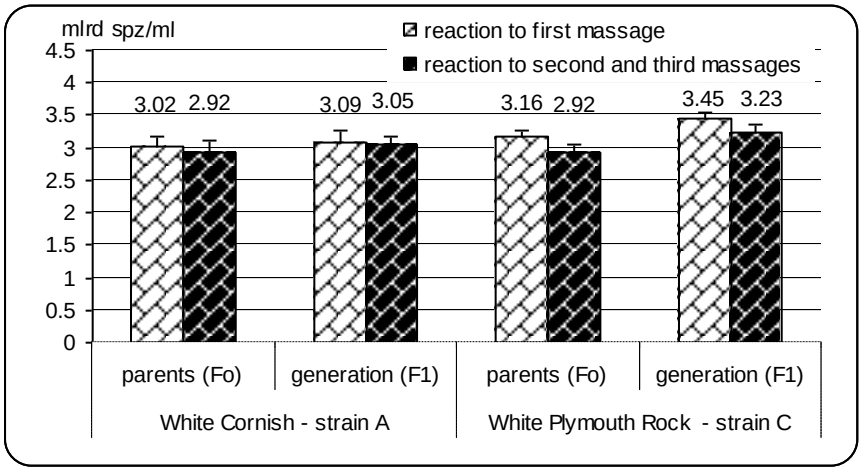

Fig. 4. Sperm concentration of cock semen (spz x109/ml) – Fo parents and F1 generation from strains A and C

Ejaculate volumes in the F_1 cockerels from strain C were within the range of 0.45 ml - 0.68 ml and 0.42 ml - 0.61 ml in the first and second group respectively. Sperm concentration and motility increased with age but the

values were higher in the first group in comparison with those in the second group ($P<0.05$). In this respect, McGary et al. (2003) provided evidence that secondary sexual characters namely comb length and wattle length might be useful to predict fertility and semen quality in broiler cocks. Also, there was a significant strong positive correlation between comb area and fertility (El-Sahn, 2007 a, b). These results concluded that secondary sexual characters, namely comb length, comb width, wattle length and wattle width had phenotypic positive correlations with most of semen physical characters which may be used as a useful tool for predicting cocks with high semen quality. (Gebriel, et al., 2009)

Data analysis indicated that the first group of F_1 cockerels from both strains (A and C) had better qualitative and quantitative characteristics of the ejaculates. We found pronounced age dynamics and between – strain differences. The F_0 and F_1 cockerels from strain C (White Plymouth Rock) had higher values of the sperm traits as compared to those from strain A. However, the increase was only significant ($P<0.05$) with regards to ejaculate volume. In our opinion the observed between-strain differences regarding the earlier response to massage and the success rate of ejaculate induction could be related with the fowl genotype. Lee et al. (1999) found that males did not respond nervously to handling or were less sensitive to massage appeared to produce less semen. According to them contamination was more serious in males that responded very nervously or were very sensitive to massage. Sensitivity to massage, like and semen volume was an invariant character.

The results in this study were similar of those received by some other authors. McGary et al. (2003) provided evidence that secondary sexual characters namely comb length and wattle length might be useful to predict fertility and semen quality in male broiler breeders. Similar conclusions were made with some local breed, where it was found that ornamental traits (comb and wattle) were good indicators of semen quality (Gebriel et al., 2009; El-Sahn, 2007 a,b; Galal et al., 2007). Before them Galal et al. (2002) established that lengths of comb and wattle had positively correlations with ejaculate volume. Abd El Ghani et al. (2011) with experiment with two local strains El-Salam and Mandarah estimated that phenotypic traits (body weight, lengths of shank and keel and comb and wattle lengths and widths) can be used as useful indicators to predict male's fertility, indicators for high semen physical quality traits, used in selection programs in early age and get rid of subfertile males for reducing production cost. Cockerels with larger combs had higher ejaculated volume, sperm concentration, and percentage of live sperm, sperm motility and percentage of fertility than others at 40 weeks of age.

CONCLUSIONS

The response of cockerels to massage at early age and the size of development of their secondary sexual characters can be used as criteria for prediction the quantity and quality of sperm production in broiler breeder males.

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