Low Fertility in Rose Comb Breeds

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Author's note: This paper was written for a class entitled Avian Reproduction. Though it is not about Rosecombs per say, they are certainly a rose comb breed!

INTRODUCTION

Breeders of domestic fowl (better known as chickens) have noticed for quite some time that comb genotype appears to have an impact on the behavior of their birds. In particular, breeders noticed that White Wyandottes had especially poor fertility. Several studies attempt to explain these observations. This paper will summarize some of the major studies done on behavior and fertility of chickens of various comb genotypes, focusing primarily on low fertility in rose comb breeds.

PEA COMBS

Pea comb refers to a particular comb genotype found on several breeds of chickens.

Effects on behavior?: Siegel and Dudley (1963) studied pea comb versus single comb chickens to determine the effects of the two comb types on the birds' behavior. The number of agonistic encounters between males with pea combs was significantly greater than the number of encounters between single comb males. When males of the two comb types were placed together, single comb males won more encounters (with both single and pea comb males) than did the pea comb males. Pea comb cockerels were subordinate to the single comb cockerels, (Siegel and Dudley 1963).

Pea combs and fertility: In 1968, Buckland and Hawes did a study to determine whether there is a relationship between comb genotype (specifically rose comb and pea comb) and semen characteristics or testes structure. Several aspects of fertility were considered (Buckland and Hawes 1968).

Fertility: Results showed that the males homozygous for rose combs (RRpp) had lower fertility and that this was even more so for RRPP (walnut comb) males. Males homozygous for pea combs without R alleles were equally fertile to single comb (rrpp) males. Single comb and homozygous pea comb males were consistently superior to rose comb males (Buckland and Hawes 1968).

Hatchability: Males with the R allele had no significant difference in terms of hatchability. Males with homozygous walnut combs (RRPP) had lower hatchability levels than all the others (Buckland and Hawes 1968).

Semen characteristics: This test showed that homozygous walnut (RRPP) and rose (RRpp) males had significantly lower percentages of dead spermatozoa. Heterozygous pea (rrPp) and rose (Rrpp) males, on the other hand, had the highest percentage of dead sperm. There is no explanation why RRpp and RRPP males would have the lowest percentage of dead sperm, considering their poor fertility (Buckland and Hawes 1968).

Other characteristics: Tests showed that comb genotype had no effect on any testes characteristics. However, heterozygous pea comb (rrPp) males had lower testes weights than homozygous (RRpp) and heterozygous (Rrpp) rose comb males (Buckland and Hawes 1968).

THE ROSE COMB GENE

Rose comb is another comb genotype found in many breeds of poultry. Breeders of rose comb birds had noticed that they had especially poor fertility compared with that of other breeds.

Inheritance of rose combs: Rose combs are the result of a dominant autosomal gene, abbreviated as R. The recessive allele, r, causes a single comb. Homozygotes (RR) and heterozygotes (Rr) are phenotypically indistinguishable and can only be differentiated by using breeding tests. (A homozygous male bred to a single comb female would produce all

rose comb offspring. A heterozygous rose comb male bred to a single comb female would produce some rose and some single comb offspring (Crawford and Smyth 1964a).
White Wyandottes: White Wyandottes are an old breed of chicken, and were one of several dual purpose breeds that were once the basis for the poultry industry. They were used for production of table fowl, and strains that laid considerable amounts of eggs were also developed. Unfortunately, breeders of the White Wyandotte had long complained about their poor reproductive ability (Hutt 1940).
Professor Hutt's study: Professor F.B Hutt compared their fertility and hatchability to that of White Leghorns and Rhode Island Reds. He found that Wyandottes had consistently higher infertility. The White Wyandottes also had significantly higher levels of weak, crippled, or otherwise defective chicks (Hutt 1940).
His conclusions: Professor Hutt concluded that some aspect of the genetic constitution of the White Wyandotte must be incompatible with good reproductive efficiency, He was not able to determine if these low reproductive rates were the result of low fertility, or if the embryos had a high level of early mortality. He also proposed the idea that the white color may be part of the problem. Since White Wyandottes are recessive white, he hypothesized that there may be a lethal gene linked with this color. It is not known whether the colored varieties if Wyandotte have this same fertility problem (Hutt 1940).
Low fertility in rose comb breeds: Crawford and Smyth studied low fertility in rose comb breeds of chickens. They recorded the average fertility of both males and females of the RR, Rr, and rr genotypes (Crawford and Smyth 1964a).
Fertility of males: Average fertility of RR males was significantly lower than the fertility of males of the other genotypes. The average fertility for heterozygotes and single comb males was almost the same (Crawford and Smyth 1964a).
Fertility of females: The fertility averages for the females of the three genotypes were not significantly different (Crawford and Smyth 1964a).
Impact on hatchability: Although the proportion of eggs containing live embryos was much lower for RR males, the proportion of eggs containing dead embryos for all three genotypes was low and nearly identical. This suggests that fertility differences among the male genotypes are due to low fertility and not early embryo death (Crawford and Smyth 1964a). The R allele showed no significant effect on hatchability (Buckland and Hawes 1968).

ROSE COMBS AND MATING BEHAVIOR

Since it was known that birds with rose combs had low fertility, the next step was to determine the cause for this. Since Professor Hutt's study in 1940, several more studies have been done, one of which investigated mating behavior in rose comb breeds.

Crawford and Smyth's experiment: The birds in this study consisted of three comb genotypes: homozygous rose (RR), heterozygous rose (Rr), and single comb (rr). Males of each genotype were observed in the presence of females of each genotype. Behavior of males towards females, and behavior of females toward males was recorded (Crawford and Smyth 1963).
Behavior types: It was found that males and females each had specific behavior types in reaction to particular situations.
Males: There were three distinct forms of male display. When males were placed with females for the first time they would often violently chase the females. This typically ended in copulation. The second display is most often termed "waltzing," a motion where the male lowers one wing and "waltzes" sideways. This was most frequently observed when the males were first placed in the pens, and is used to establish dominance. The third and most successful display is termed the "rear approach." The male approaches the female from behind, with his head high and hackles raised. This display is used only after dominance has been established (Crawford and Smyth 1963).
Females: The only female display used in response to males was crouching, which is then followed by copulation. RR females were courted most by males of all genotypes. In addition, RR females were courted least often with the "rear approach," suggesting that they are more aggressive than the other female types. The "waltz" was directed most often towards RR

females in order to establish dominance. Females crouched to RR males least often, suggesting that RR males were somewhat less effective at courting (Crawford and Smyth 1963).

Frequency of mating: Single comb males mated most often, followed by Rr males, then RR males. Both types of rose comb males mated significantly less often than single comb males. This poses the question of whether the rose comb is directly related to mating behavior, or whether the difference is caused by the physical appearance of the two phenotypes. Although homozygotes and heterozygotes are phenotypically indistinguishable, there were significant behavioral differences between the two. It seems likely that the behavioral differences are linked to the alleles for rose and single combs (Crawford and Smyth 1963).

CAUSES OF LOW FERTILITY

Several studies have been done to determine the cause of the widely known problem of low fertility in rose comb breeds.

Duration of fertility: One possibility for the noticeably low fertility in rose comb breeds could be that the spermatozoa simply do not live long enough to fertilize many eggs.

Crawford and Smyth's study: Crawford and Smyth set out to study whether homozygous rose comb birds had lower fertility in comparison to heterozygotes and single comb birds. Duration of fertility was measured as the number of days between fertilization and the last fertile egg laid as a result of that insemination (Crawford and Smyth 1964b).

When males of the three genotypes were mated to rr females, it was found that RR males had a duration of fertility that was roughly half that of Rr and rr males. Moreover, RR males had about 30% more sterile matings than other males. RR females, on the other hand, appeared to have an increased duration of fertility in comparison to females of the other comb genotypes (Crawford and Smyth 1964b).

Differences in insemination: When females were inseminated intravaginally, RR males consistently had the lowest duration of fertility. It was thought that if the morphology or motility of the sperm was faulty it might have trouble moving to the uterovaginal sperm storage sight. However, even with intrauterine insemination, RR males still had the lowest duration of fertility. Since the methods of insemination did not change the duration of fertility they concluded that sperm transport was not the cause of low fertility in rose comb breeds (Crawford and Smyth 1964b).

Sperm metabolism and motility: Another possible explanation for low fertility in rose comb breeds is that there is a problem with the sperm itself. Several comparative physical aspects of spermatozoa have been analyzed.

Petitjean and Cochez's study: Petitjean and Cochez studied what they termed "motility" of sperm in RR, Rr, and rr males. Sperm had two forms of motion: oscillating, or movement over one spot, and swimming (the correct movement). Highly motile sperm would have high levels of swimming sperm, whereas less motile sperm would oscillate more. They found that RR males had significantly weaker motility than both Rr and rr males (Petitjean and Cochez 1966).

Effects of motility agonists: Caffeine and Ca++ are both known sperm motility agonists. Normally the metabolic rate of sperm from RR males is only around 76% to 77% of the metabolic rate of Rr males. This was not improved my the presence of Ca++. However, caffeine significantly improved the metabolic activity of the RR sperm to the level of 86% of that from Rr males. Caffeine was not as stimulatory to Rr or rr males (Kirby et al. 1993).

Testicular sperm versus ejaculated sperm: It has been shown that sperm from RR and Rr males did not behave similarly following intravaginal insemination. The fertilizing ability of RR sperm could be improved by using intramagnal insemination, since motility would not longer be an issue. When testicular sperm from RR and Rr males was used to intramagnally inseminate females, it was found that there was no difference in fertilizing ability. Ejaculated sperm from Rr males was superior to RR males. This suggests that the problem related to

aberrant sperm motility occurs in the final stages of maturation before ejaculation (Kirby et al. 1994).
Other hypotheses: One study presented the idea that reduced metabolic activity and motility of sperm from RR males was due to reduced glycolic enzyme activity (McLean and Froman 1996).

CONCLUSION

The studies done on comb type and its influence on behavior and fertility have shown that the comb genotype does indeed have an impact. Particularly in rose comb breeds, the gene for heterozygous rose comb is linked with poor reproductive ability. There are several factors that appear to contribute to this. RR males are less successful at courting females. They have a higher percentage of sterile matings, and have a much shorter duration of fertility. No difference was found in the fertility of RR females. From recent studies it appears that the biggest problem may be with sperm metabolism and motility, although the exact cause for low fertility in rose comb breeds has yet to be determined for certain.

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