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Overview

The methods for feeding broiler breeder males have evolved over recent decades, and further revisions will likely be needed as males become more challenging to manage. Since the introduction of separate male feeding systems in the early 1980's, breeder males' nutrient needs have been better managed via daily feed restriction. If a breeder operation can effectively produce, haul, and store a separate male diet, then it provides more options to use different nutrient levels or feed additives that are designed to enhance fertility. This article will outline the history of male-separate feeding and revisit nutritional research on fertility of broiler breeder males. While the male usually gets much of the attention when fertility is the topic of discussion, the receptivity of the hen to the male is also a necessity for fertile egg production. Excessive feather loss in females is sometimes blamed for poor fertility, so management and nutritional factors that influence hen feathering are also discussed.

Feeding Males Separately from Hens

History of Male Feeding Practices

Prior to the 1980's, mature broiler breeder males and females were typically fed from the same feeding system in a breeder house. With this arrangement, the daily feed allotment was determined for the hens, while males simply ate "hen feed" from a common feeding system. The diet was formulated to meet the nutritional needs of the hens. In the early 1980's, Dr. Gayner McDaniel from Auburn University and Mr. Gerald Bailey from Gold Kist Inc. began exploring ways to exclude males from the feeder and provide a new separate feeding system for males. While others were involved, these two gentlemen are considered pioneers for developing this concept that is widely used today. Initially, the "male exclusion grill" was placed on the hen feeder that allowed hens to eat, but mature males were unable to access the hen feed because their larger heads and combs prevented entry. Current day male exclusion grills usually have horizontal openings that are 1 $^{5}/_{8}$ – 1 $^{11}/_{16}$" wide and vertical openings that are typically 2 - 2 ½" tall. PVC pipe is sometimes attached inside the top of the grill, to further restrict the vertical opening size. The size of these openings will have a great influence on the age when males are first "locked out" of the hen feeder, and it should be taken into consideration when determining the male feed allotments, especially for the first 6-8 weeks in the breeder house. During the inception of the exclusion grill, McDaniel and Bailey also developed a way to feed males from a feeder that excluded the hens. Initially, a single straight-line pan system was placed in the breeder houses, either over the scratch area or over the slats. Hens were (and still are) excluded from the male feeder by winching the feeder to a height that is just high enough for the males to reach, but slightly out of reach for the hens. This concept is widely used today, and the separate feeding system has allowed males to get more appropriate amounts of feed, rather than being grossly overfed from the hen feeder. Figure 1 provides an example of common feed allotments for male and female breeders, which displays the large differences in their daily feed intakes, especially during peak egg production. In initial field trial data conducted by McDaniel and Bailey (unpublished data), limit feeding males 26-28 lb/100 males/day in a separate feeder with a lower protein diet (11-12% CP) provided large advantages in fertility, and this was attributed to improved body weight control of males, better footpad conditions, and a higher percentage of males producing semen. These findings led to further trials that are discussed in the following sections.

Potential Issues with Male-Separate Diets

Compared to feeding a single hen diet to both hens and males, producing a separate feed for males presents logistical challenges. Feed mills are required to make an additional feed type, keep it separate throughout milling and delivery, and get it into the correct feed bin on the farm. Since males eat a relatively low volume of feed each day, the deliveries should be small and frequent so that feed inventory can be rotated regularly and kept fresh. An additional feed bin with concrete pad is often needed on the farm too. If the male bin on the farm is not allowed to empty on a routine basis, the bin will rust prematurely. Each of these things should carefully be taken into consideration before deciding to use a separate male feed.

Nutrition Research with Broiler Breeder Males

Protein and Calcium

Research by Wilson et al. (1987) reported that a greater percentage of caged males produced semen when fed 12-14% CP, rather than 16 or 18%. In naturally mated males, Hocking (1990) compared 11 to 16% CP and noted that the low protein treatment had improved fertility in naturally mated males, especially at 49 to 60 weeks. However, Hocking and Bernard (1997) later compared 12 and 16% CP in two strains of broiler breeder males and found no dietary influence on fertility.

Some more recent studies have evaluated both CP and Ca levels to compare a hen-type diet to a male diet with relatively low CP and Ca. In a large trial with commercial flocks, Silviera et al. (2014) reported 1.5% and 4.1% improvements in fertility and hatchability, respectively, when males were provided a male feed (13.5% CP, 0.95% Ca, 2750 kcal/kg) after 27 weeks instead of a series of hen feeds (14.0-15.5% CP, 3.1-3.7% Ca, 2740-2850 kcal/kg). Tyler et al. (2021) fed a combination of four dietary treatments (both Ca and CP at low and high levels) to caged Ross 308 males. The authors concluded that there were no consistent dietary effects on sperm quality over time, but there were cases where higher Ca intake negatively affected sperm concentration, especially in the diet that most resembled a hen ration with high CP and high Ca.

One question that is often asked is if there are detrimental effects of feeding 3 to 4% Ca to males. According to NRC (1994), the Ca requirement for meat-type breeder males is a mere 0.2 g Ca/male/day, which would equate to approximately 0.20-0.25% Ca under normal circumstances. Rosa et al. (2010) stated that 0.9% Ca was adequate for breeder males, and Kappleman et al. (1982) reported that Ca level (0.5, 1.0, 3.1 or 6.2%) had no effect on semen quality or fertility of artificially inseminated hens, suggesting that 0.5% dietary Ca was sufficient for males. While these data did not report any detrimental effects of feeding higher Ca levels, they all agree that Ca requirements of breeder males is much lower than Ca required for breeder hens. Janssen et al. (2000) reported that breeder males with epididymal stones have reduced fertility and testosterone levels, but we should not make the quick assumption that these stones are due to excessive dietary Ca intake. In fact, Mahecha et al. (2002) reported the epididymal stone formation was not directly correlated to Ca or Vitamin D intake. These researchers also stated that IBV infection was not correlated to lithiasis in males. Jackson et al. (2006) later reported a link between prepubertal exposure to the live attenuated avian infectious bronchitis virus and increased frequency of epididymal stones. For further reading on this topic, please see the review article written by Oliveira and Oliveira (2011).

Even if the higher calcium levels provided in a hen diet (3 to 4%) may not be detrimental to mature males, these high levels are certainly not needed or required for normal reproductive function of males. There is also convincing evidence that the low protein (low amino acid) approach can help keep male weights and fleshing under control, ultimately improving fertility. These research findings support the male nutrient recommendations provided by primary breeder companies (Table 1).

Vitamin E and Selenium

Vitamin E and Selenium get a great deal of attention when considering male fertility, due to their antioxidant properties. Due to the maximum allowable level of 0.3 ppm Se in poultry diets in the United States, inclusion of some selenomethionine is warranted in breeder diets to enhance semen quality and antioxidant status of the breeder and their progeny. Several research trials have been conducted to evaluate the effects of Vitamin E level on sperm quality. In a meta-analysis conducted by Hayanti et al. (2022), they reported the optimal dose of Vitamin E for breeder males to be 101 and 166 mg/kg for oxidative status (MDA level) and sperm viability, respectively (Table 2). These values are comparable to Vitamin E levels recommended by both Aviagen (130 IU/kg) and Cobb (100 IU/kg) for breeder males.

Omega-3 Fatty Acids

Numerous research trials have shown that feeding diets rich in omega-3 fatty acids improves semen quality and fertility in broiler breeder males. However, this application has been slow to catch on in the United States for various reasons. Supplementing male diets with high omega-3 fat sources would often require an additional fat storage tank at feed mills, and the high PUFA content will make these oils more susceptible to peroxidation. In lieu of feeding a liquid product high in omega-3, the incorporation of a dry omega-3 product or specifically docosahexaenoic acid (DHA) may be an alternative if it becomes more economical and oxidation can be prevented.

Amino Acids and Metabolites

Amino acids and their metabolites have also been explored because of influences on either sperm quality and/or male libido. Guanidinoacetic acid (GAA) is synthesized from arginine and required to produce creatine, which is phosphorylated to yield phosphocreatine with the generation of energy (Ostojic, 2016). Tapeh et al. (2017) reported that GAA improved fertility when included in male diets (600, 1200 or 1800 mg/kg) for 26 consecutive weeks when hens were artificially inseminated. D-aspartic acid has increased testosterone level, sperm concentration, sperm motility, sperm penetration, and fertility when fed at a rate of 200 mg/kg of body weight (Giacone et al., 2017). Feeding L-carnitine (150 mg/kg diet) improved fertility in older roosters, by increasing semen production and quality parameters (Elokil et al., 2019).

Phytochemicals

There is an extensive list of phytochemicals that may enhance fertility through improving antioxidant status or other related benefits. These include but are not limited to a variety of flavonoids (rosemary leaves, cinnamon, dried apple pomace, chrysin) and carotenoids (lycopene, canthaxanthin, curcumin from turmeric). There is a great deal we can learn about how these type products influence reproductive performance in breeders and effect their progeny. For more detailed reading on phytochemicals and other feed additives for male fertility, I would encourage reading the review article by Fouad et al. (2020).

Hen Receptivity and Fertility Effects

In some cases, fertility problems have been attributed to poor hen feathering in broiler breeder flocks. Some feather wear or “tread wear” is normal in naturally mating flocks, but severe feather loss or premature feather loss generally does not bode well for flock performance. Below is a list of items that may be considered when dealing with feathering issues in broiler breeder pullets and hens:

- Erratic behavior and excessive feather-picking.
- Insufficient floor space or feeder space in rearing and lay.
    - Be cautious if females have less than 1.3 ft^2/pullet in rearing or less than 1.8 ft^2/hen in lay.
- Slow or uneven feed distribution and lack of feeder space.
    - Watch birds feed to verify that all birds have enough space to eat simultaneously.
- Gut health and disease challenge (compromised nutrient absorption).
- Poor light distribution.
    - This can result in digging directly beneath light bulbs and cause also contribute to uneven floors and piling.

- Light intensity.
    - While some may believe that low light intensity is an animal welfare concern, I would argue that relatively low light intensity (after brooding) has a calming effect on pullets and can be used to control feather-picking behavior in rearing.
- Male aggression or "over-mating."
    - This may involve early maturing males and/or an excessive number of males per 100 hens.
- Rough handling by crews at vaccination or transfer.
- Breed influences.
- Underfeeding hens or rapid feed reduction after peak.
- Proper nutrition and nutrient targets, especially in rearing diets (further comments below).

If a flock already has poor feathering prior to photostimulation, then it will likely be a long and difficult future for those hens. It is best to take a preventative approach and attempt to build a good "foundation" of feathers during rearing, with the understanding that some feather loss will occur after hens start breeding. Meeting amino acid requirements is critical, especially when feeding strains that are more susceptible to feathering problems. Primary breeder companies have adjusted amino acid recommendations over recent years to combat feathering issues. Diluting pullet developer diets by reducing calories and increasing fiber level may become a necessity as appetites increase and feed cleanup times shorten, to give the birds a sense of satiety and discourage pecking/picking behavior. The nutritionist should also understand the operation's "normal" feed allotments at critical periods in the life cycle (immediately before and after transfer, peak, and sell age) since chickens do not understand percentages.

Summary

Achieving high levels of fertility and hatchability in broiler breeders will likely become more challenging as primary breeders select for optimal broiler traits. Utilizing separate male feeders in the United States has become common practice since the concept was first introduced in the early 1980's. The United States industry has been slower to adopt a separate male feed type because of logistical challenges in some cases, even though research has confirmed that feeding a low protein and low Ca diet to males has benefits on reproductive performance. There is also potential to improve fertility through supplementation of male diets with nutrients and feed additives that support antioxidant status. If introducing a separate male diet in a poultry operation, all involved should understand the logistical challenges and additional management steps before starting this practice. If there are underlying management issues contributing to poor fertility, feed formula adjustments should not be considered as a "silver bullet" or miracle cure.

Hen feathering and receptivity to males also plays a role in fertility. Some basic factors that can influence feathering and pecking behavior are feed distribution, nutrient levels/feed formulation, feed allotments, bird density, feeder space, gut health/disease, improper bird handling, and breed.

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Table 1. Nutrient Recommendations for Broiler Breeder Males as Defined by the Primary Breeder Performance Guidelines

Source	**Aviagen [1]**	**Cobb-Vantress[2]**
Lysine (dig. %)	0.35	0.50
M+C (dig. %)	0.58	0.48
Tryptophan (dig. %)	0.15	0.12
Threonine (dig. %)	0.43	0.44
Arginine (dig. %)	0.68	0.55
Valine (dig. %)	0.47	0.38
Isoleucine (dig. %)	0.41	0.40
Calcium	0.70	0.95
Av Phos	0.35	0.42

1. Adapted from Aviagen, 2021.
2. Adapted from Cobb-Vantress, 2020.

Table 2. Meta-Analysis of Vitamin E Supplementation Effects on Chicken Sperm Quality[1]

Chicken type	Age (week)	Number of animals	Parameters that were examined	vitamin E dosage (mg/kg)	Dosage recommended (mg/kg)
Broiler roosters	45	24	Volume, concentration, viability, MDA, fertility, testosterone,	30 and 200	200
Broiler cockerels	32, 42, and 52	48	Volume, concentration, motility, sperm vitamin E	30 and 200	200
Ross broiler rooster	30	24	Motility, viability, and MDA	30 and 200	200
Mandarah native chickens	32	45	Volume, concentration, pH, motility, viability, fertility, total sperm cell	20.5 and 150	150
Broiler chicken	22-52	32	Volume, concentration, motility, abnormal sperm, total sperm cell	100, 200, and 300	200
Kadaknath native cockerels	30	135	Volume, concentration, motility, sperm vitamin E, viability, dead, abnormal, fertility	10, 100, and 200	100
Mandarah native roosters	32-52	54	Volume, concentration, pH, motility, viability, fertility, total cell sperm	67 and 150	150
Kampong rooster	60-64	45	Volume, concentration, motility, viability, dead, and abnormal cell sperm	0, 134, and 268	268
Taiwan native chicken	23-52	90	Concentration, viability, fertility	0, 20, 40, 80, and 160	20-160
Hubbard male broiler	65	180	Volume, concentration, motility, dead	33.5 and 67	67
White Leghorn broiler cockerels	38-53	320	Volume, motility	20, 200, and 400	400
Ros broiler rooster	45	36	Volume, concentration, motility, viability, MDA, fertility, testosterone, total cell sperm	30 and 200	200
Native cocks	28	60	Volume, pH, abnormal, total sperm cell	0, 67, 670, 6700, and 13,400	67
Rhode Island Red Broiler cockerels	24	60	Sperm vitamin E	0, 20, 200, and 1000	200
Native roosters	45	120	Motility, viability, MDA, testosterone	0 and 200	200
Mandarah native chickens	40	36	Volume, dead, total sperm cell	0 and 200	200
Broiler roosters	45	30	Volume, concentration, motility, viability, MDA	0 and 200	200
Broiler chickens	18	50	volume, concentration, motility, viability	45, 145, and 245	245
Broiler male	22-54	64	Fertility	30 and 120	120

1. Adapted from Hayanti et al., 2022.

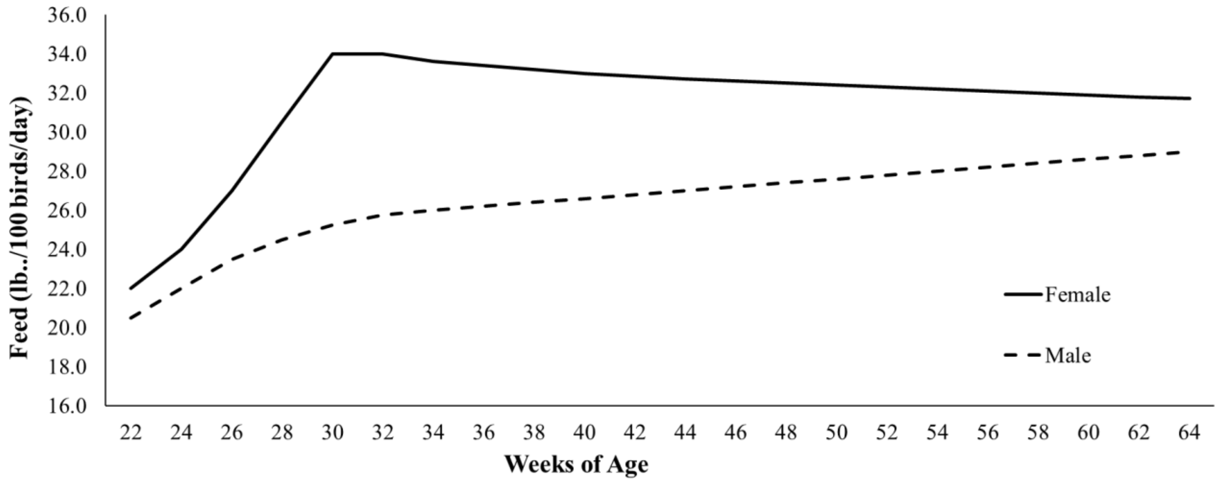

Figure 1. Example of Daily Breeder Male and Female Feed Allotments