Control of fertility in domestic birds, Tours (France), July 2-4 1990.
Ed. INRA, Paris, 1990 (Les Colloques de l'INRA, nº 54)

Interactions between light regimes and feed restrictions on semen output in two meat-type strains of cockerels

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Abstract

Adult broiler breeders tend to gain too much weight and put on excess fat unless they are feed restricted all over their life. However feed restriction can delay the onset of sperm production and do not prevent it from declining during the reproduction period.

In Cornish type cockerels (I99 line from ISA), we have evidenced that increased daily photoperiods given at the time at which the onset of sperm production normally occurs can compensate for the delay of sexual maturity induced by feed restriction. This leads to maintain the same cockerels under "long" days during the adult period, and these long days were found as the main cause of the decline of the sperm production, for it did not occur under "short" days combined with feed restriction starting from 2 or 6 weeks of age. In this case, the sooner the feed restrictions were started and the later but also the higher was the sperm output.

In other meat–type cockerels (T55 line) the responses of the sperm output to similar feed restrictions combined with the same photoschedules were quite different, evidencing a strong genotype environment interaction. T55 males appeared to be unique as their sperm output declined even under 8L:16D as if they perceived this short daylength as a long day.

Introduction

One of the main reproduction problems encountered in meat–type cockerels is the decrease of the sexual activity and of the sperm production 3 to 6 weeks after sexual maturity has occured. Though these cockerels are expected to be used as breeders till 60–70 wks. of age, 20 to 35 % of them do not produce enough semen from 45 wks. of age onwards as attested by the semen collections done in the farms using artificial insemination.

The main cause of this decrease was believed to be the tendency of adult broiler breeders to put on excess weight, a result of the very efficient genetic selection on growth rate. Therefore various methods of feed restrictions have been proposed, the most efficient being to reduce the daily amount of feed given to the birds from very young. A restriction programme was proposed in Nouzilly some 17 years ago (de Reviers et al., 1973) : in spite of a reduction in the testicular weight and in the sperm production at 24 wks. of age, the restricted cockerels used by natural mating were able to give higher fertility results for a longer time than controls (de Reviers, 1974) probably via a higher sexual activity, as recently evidenced by Blockhuis and Van der Haar (1988).

However, experimenting on sperm production in broiler breeders is made easier by the use of individually caged birds, and this allows their feed consumption to be precisely adjusted. We found in Nouzilly (de Reviers and Brillard, 1982) that 1.2–1.3 MJ ME were enough to maintain the adult body weight of meat–type cockerels previously restricted during growth. However, cockerels restricted this way and submitted to a standard photoschedule i.e. to daylengthes did not maintain their sperm production after sexual maturity (de Reviers, 1986).

This decline therefore probably resulted from other causes than the fattening of adult cockerels. The decline in the testicular weight and in the sperm production observed under long days (16L:8D) in cockerels fed ad libitum is no more found under short days (8L:16D) in egg–type as in meat–type males (de Reviers, 1973, 1982). It was therefore tempting to combine feed restriction programmes with various photoschedules and particularly with short days. It is in fact difficult to know what daylength is perceived as a short day by the birds. Furthermore, feed restrictions are known to delay the sexual maturity in cockerels (Breneman, 1940 ; Wilson et al., 1965 ; Jones et al., 1967) an effect probably more marked under short days, had they the ability to maintain the sperm production during the adult period. Short days and late maturing cockerels are particularly disadvantageous in the case of natural mating for the hens require long days and reach their sexual maturity at 22–24 weeks. The possibility of maintaining the sperm production for a long time is however interesting in the case of artificial insemination, because males and females can be raised separately all through their life.

In the present work, we have evidenced that nearly the same combinations of restrictions programmes with photoschedules can in fact give very different results according to the genetic origin of cockerels.

Materials and Methods

We have experimented with the two main types of meat cockerels which can be found in France :

– the first type (17 % of the total broiler production) corresponds to slow growing males (adult weight : 4.5 kg) the offspring of which is used as broilers at 11–13 wks of age only (live weight : ca. 2 kg).

– The second type (83 % of the broiler production) are the classical fast growing males used in the industry (adult weight : ca. 6 kg) for the production of 6 wks broilers (live weight/ 1.8 to 2 kg).

About 200 cockerels of each type (respectively : T55 from SASSO*, and I99 from ISA**) were received at the lab as day–old chicks. They were collectively raised on the floor till 16 wks of age, then individually caged in batteries.

a) The T55 males were submitted to the following photoschedules :

– 8L:16D all through the life ("short days")

– 8L:16D till 16 weeks of age, then the daily photoperiod was increased (+ 2L at 16, 18, 20 and 22 wks of age) up to 16L:8D, and the last daylength ("long days") was maintained thereafter till the end of the experiment (56 wks of age). The expected effect of this photoschedule was to counteract the delay of the sexual maturity often induced by severe feed restrictions.

In each photoschedule, the cockerels were restricted from either 2 or 8 wks of age onwards ("early" or "late" restrictions, respectively), according to Fig. 1, the maximum amount of feed they were given during the restriction period being 105 ± 5 g/bird/day (ME : 11.7 MJ/kg Crude Protein : 15 %).

Cockerels maintained under 8L:16D and fed ad libitum were kept as controls.

b) The I99 males were submitted to a very similar experimental design, using the same photoschedules, combined with feed restrictions starting from either 2 or 6 wks of age rather than 8 weeks. The maximum amount of feed given during the restriction period was 110 ± 5 g/bird/day. Apart from the diet used in T55 males, another diet with the same ME (11.7 MJ/kg) but at a lower protein level (11 %) was also experimented. No males were kept as ad lib controls in this line for they do not survive in good condition when caged.

* SASSO : Société Avicole de la Sarthe et du Sud–Ouest

** ISA : Institut de Sélection Animale

All cockerels were indivually weighed once a month till 50 (T55) or 40 (I99) wks of age, then every other month.

Semen was collected by massage. The volume of ejaculates was determined from their weight taken at the nearest mg. The sperm concentration was evaluated from 1:200 semen dilution in saline Na Cl_{aq} 9°/∞) using a calibrated IMV photometer. The semen collections were started from 18 wks of age onwards and then performed twice a week to determine the age of first ejaculate. The cockerels detected as semen donors were then collected once a day for five consecutive days each month up to 56 weeks of age in the T55 line. The I99 line was controlled the same way till 73 (16L:8D) or 82 (8L:16D)wks of age.

Results

1. Body growth

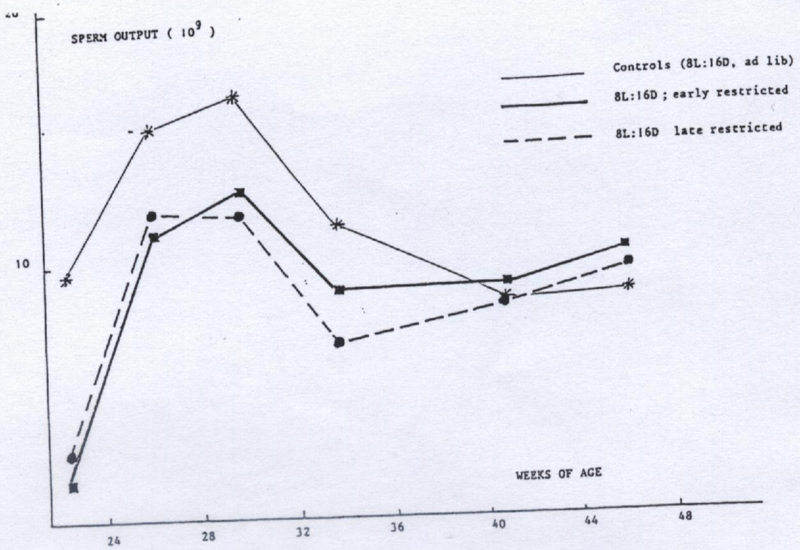
As expected, the age at which feed restrictions were started was by far the main factor influencing the body growth of cockerels in both lines. This trivial effect was particularly obvious at 12 wks of age ; the later started the restrictions and the heavier were the cockerels, particularly in the I99 line : at 40 wks of age, their mean body weight was 4.3 ± 0.2 kg vs. 3.3 to 4.0 kg in the T55 line. At this time the body weight of the control T55 cockerels was ca. 4.3 kg and it was maintained at a higher level than in restricted cockerels of the same line till the end of the experiment (56 wks of age).

No marked differences were observed for body weight between the two photoschedules. However the cockerels from the T55 line submitted to 8L:16D tended to be somewhat heavier than those passed to 16L:8D, an effect not found in the I99 line.

2. Sperm output

a) **T55 cockerels** : In controls (fed ad libitum and submitted to 8L:16D all through their life) the mean total number of sperm collected per bird/week rapidly increased from 18 to 26 wks of age, peaked at about 18.10^9 during the 30th wk of age, then declined down to 10.10^9 within 10 weeks, and remained stable thereafter (Fig. 1).

Under the same photoschedule, the feed restriction programmes delayed the onset of sperm output and reduced its level up to 40 wks of age : the mean total number of sperm collected per bird/week was only 1.10^9 in the controls taken at the same age. However this



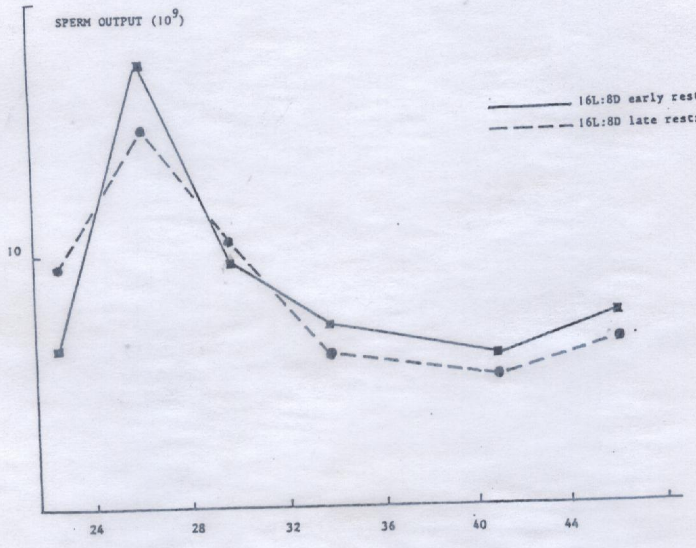


Figure 1 : Mean weekly total sperm output as a function of age in controls or restricted T55 cockerels submitted to 8L:16D all through their life (upper part) or raised under daylengthes increased from 8L to 16L (16 to 22 wks of age) and maintained under 16L:8D thereafter (lower part). Note the decline in the sperm output after 26–28 weeks of age is more marked under 16L:8D.

number increased also rapidly, peaked at nearly the same age as in controls but at a lower level. It also declined thereafter in a less marked proportion than in controls. No clearcut differences were found in the semen output as a function of the age at which the feed restrictions started (2 or 8 wks of age) though the "late" restricted cockerels tended to ejaculate a lesser number of sperm after the age of 30 wks.

In cockerels from the same line, submitted to the same restrictions programmes and raised under 16L:8D from 22 wks of age onwards, , the onset of sperm production occurred in the "late" restricted cockerels at quite the same age as in controls but was somewhat delayed in the "early" restricted cockerels. The age at first ejaculates were by far more grouped than under short days and the sperm output peaked very sharply at 26 wks of age instead of 29–30 wks in cockerels maintained under short days. Then it rapidly fell down to a level lower than that found in the 8L:16D cockerels. Again no marked differences were found between early– and late–restricted cockerels during the adult period.

In this line the increased daylenthes therefore allowed a higher mean sperm output at sexual maturity than in restricted cockerels but it was so only for a short time. A marked decline occured thereafter, irrespective of the daylength, which inequally affected the individual cockerels in each treatment. Some of them (10 to 20 %) remained at a high level of sperm output while others (10 %) stopped producing semen.

b) I99 line :

In the cockerels submitted to increased daylengthes from 16 to 22 wks of age and maintained under 16L thereafter, ~~the~~ sperm output peaked at about 17 billions/bird/week at 24 or at 28 wks of age in late or early restricted cockerels respectively (Fig. 2). Then the mean sperm output declined rapidly as in T55 cockerels particularly in the case of the late restricted I99 males fed the 15 % crude protein diet, and again wide differences were found between individual cockerels of the same treatments.

By contrast, in I99 cockerels restricted from 2 wks of age and submitted to 8L:16D, the mean sperm output reached its maximum level at 32 wks of age only (ca. 17 billions sperm/bird/week), but it was maintained at this level up to 82 wks of age instead of declining. In late restricted cockerels given the same photoschedule, the sperm output plateaued earlier (28 wks of age) but at a lower level (11 billions/bird/week) and for a shorter time for it slowly declined after 52 wks of age.

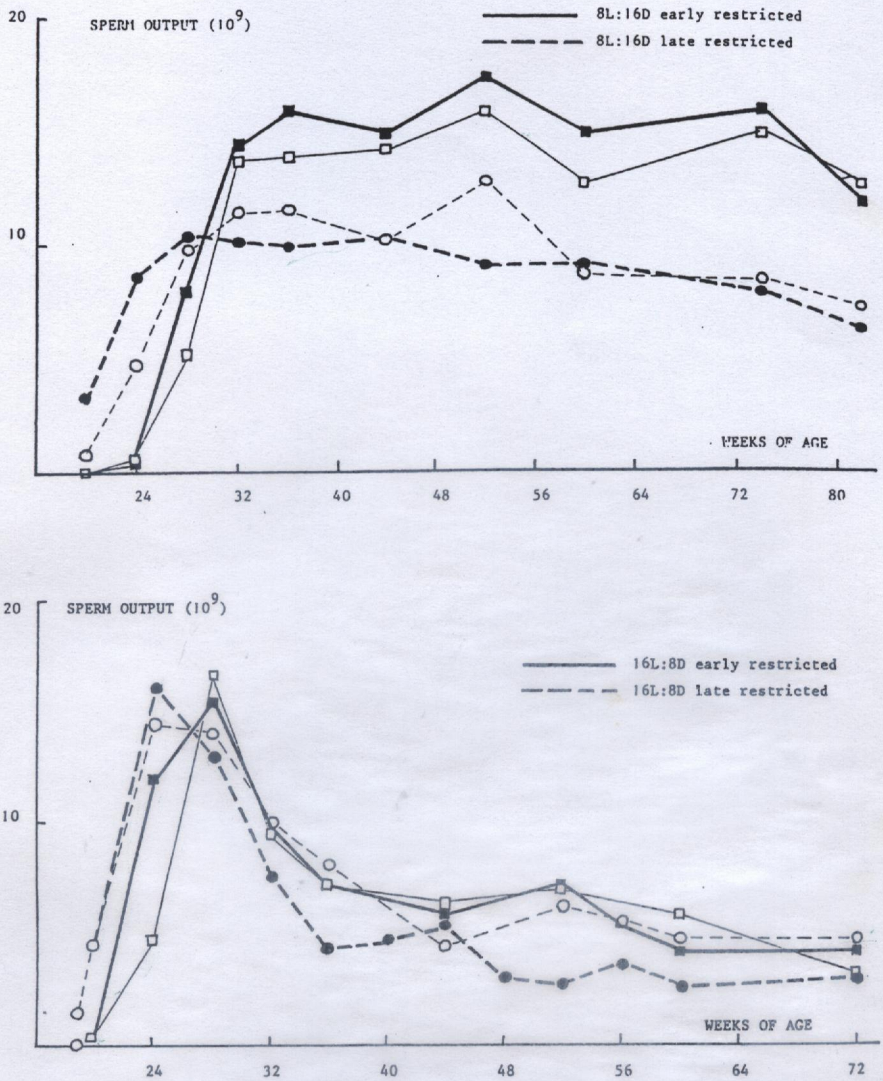


Figure 2 : In I99 cockerels submitted to combined feed restrictions and light programmes very similar to that used in T55 cockerels, the sperm output also markedly declined under 16L: 8D but it was remarkably maintained under 8L:16D and particularly high in the early restricted cockerels.

No major influence of the dietary crude protein level on the sperm output was noticed in these cockerels irrespective of the light schedule.

Therefore the age at which the sexual maturity occured in I99 cockerels was strongly influenced by the age at which the feed restrictions started as well as by the photoschedule. As expected, daylengthes increased between 16 and 22 wks or age could compensate at least partly for the delay in the onset of sexual maturity induced by feed restrictions. The long daylengthes were responsible for the decline of the sperm output during the adult period because this decline did not occur or it occured very slowly under "short" days. In the latter case, the delay observed in the sexual maturity of the early restricted cockerels was followed by a high level of the semen output, maintained over months and this was particularly interesting because it demonstrated that a high level of sperm production at the time of sexual maturity did not prevent this production from being maintained thereafter.

Discussion

Our results allow to point out that the genetic origin of cockerels can greatly influence their response (in terms of sperm output) to the combined effects of feed restriction and daylength.

It was known from long ago that in adult cockerels fed ad libitum and submitted to long days (16L:8D) all through their life, the testicular wright and the sperm production can be maintained or not according to the genetic origin of the birds (de Reviers, 1980). Furthermore in one type of cockerels (M55 line, de Reviers, 1981) the testicular weight was found to be maintained from 24 to 44 weeks of age under 16L:8D as well as under 8L:16D. Did these cockerels perceive the longer daylength as a "short" day?

By contrast in the T55 line used here, the sperm output (well correlated to the testicular weight when the semen collection are done at a significantly high rate) was not maintained even under 8L:16D. Did these cockerels perceive this daylength as a "long" day?

It is worth exploring the physiological mechanisms which could explain why such differences do exist between lines of cockerels and how increased daylengthes can compensate for the delay of the sexual maturity induced by feed restrictions. They probably involve the negative feedback of gonadal hormones, particularly androgens, on the hypothalamo–hypophysal system, i.e. the circulating levels of androgens and/or the sensitivity of this system to androgens. As we could not restore the semen output in T55 cockerels by increasing the daylength from 16L to 20L or from 8L to 16L or 20L, it can be assumed that a true photorefractoriness may also occur in the adult cockerel. Furthermore it has been evidenced that a maximum in the photosensivity of cockerels occurs during the 24 h cycle (de Reviers, 1981) but the time at which it occurs might change as a function of age (de Reviers, 1980) and of the genetic origin of cockerels. The understanding of these endocrine mechanisms requires working for a long time, and finding how they work, though of primary importance for our knowledge of the bird's physiology, will probably not afford ways or means to improve poultry production results for tomorrow, though some promising results have been found, allowing to interfere with the negative feedback of steroids. Therefore, in the near future, we probably have still much to expect from new management procedures. The dual feeding system of males and females popularized by Mac Daniel (1986) is very attractive in the case of natural mating, but natural mating also requires long daylengthes for the hens to lay high numbers of eggs. As long days may result into a marked decrease in the sperm production in all but a small proportion of males, many of them have to be replaced before the end of the hens' reproduction period. It is likely that the sperm output of adult cockerels could be better maintained if they were appropriately selected for some generations, but this would be successful only after a long time. Short days combined with feed restriction can immediately solve the problem, but this may imply the use of late maturing cockerels raised in another environment than females, and therefore makes artificial insemination the obligatory reproduction method. This can severely restrict the possibility of applying our results in the industry but is also a chance, for from our data, only 1 cockerel is sufficient to allow the artificial insemination of 50 to 200 females, depending on the age of hens. This is particularly economical and moreover, allows to use only the cockerels most able to transmit a high growth rate and a good conformation of their offspring.

Acknowledgements

This work was financially supported by grants from Ministère de la Recherche et de la Technologie and from Ministère de l'Agriculture to SYSAF.

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EFFET DE L'INTERACTION ENTRE LE RATIONNEMENT ALIMENTAIRE ET L'ECLAIREMENT QUOTIDIEN SUR LA PRODUCTION SPERMATIQUE DE DEUX LIGNEES DE COQS DE TYPE CHAIR

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Résumé

Les coqs adultes de type chair tendent à prendre trop de poids et à engraisser, à moins qu'ils ne soient rationnés pendant toute leur vie. Le rationnement alimentaire, cependant, peut retarder le début de la production de spermatozoïdes et ne l'empêche pas de décliner pendant la période de reproduction.

Chez des coqs rationnés, de type Cornish(I99 ISA), nous avons montré que des jours croissants, donnés au moment où la production de spermatozoïdes démarre normalement, peuvent compenser le retard de maturité sexuelle causé par le rationnement alimentaire.

Cela conduit à maintenir les coqs ainsi traités sous des jours "longs" pendant la période adulte, et ces jours longs sont bien la cause du déclin de la production de spermatozoïdes car il ne se produit pas en jours courts combinés avec un rationnement alimentaire démarrant à 2 ou 6 semaines d'âge. Alors plus tôt commence le rationnement et plus tard démarre la production de spermatozoîdes mais elle est aussi plus élevée.

Dans une autre sorte de coqs de type chair (T55) la réponse de la production de sperme à presque la même combinaison de rationnement alimentaire et d'éclairement est très différente, mettant en évidence une forte interaction génotype. Les coqs T55 sont particuliers car leur production spermatique décline même sous 8 heures d'éclairement quotidien comme si cette durée était perçue en tant que jour long.