ADVANCES IN THE NUTRITION AND MANAGEMENT OF THE MALE AND FEMALE BROILER BREEDER

R M GOUS

SUMMARY

Poultry nutritionists have based the feed requirements of broiler breeder hens on the principles designed for the feeding of commercial laying pullets because of the lack of information specific to these birds. The practice of restricting the feed intake of broiler breeders during both the rearing and the laying periods differs from the that of feeding commercial pullets, and was introduced as a necessity because of the rapid growth rate of broilers, but there is still debate about the reason for the benefit derived from this practice. The extent to which feed should be restricted; the optimum time of release from the restriction programme; the basis on which the amino acid requirements for maintenance and for egg output are calculated; and the optimum intake of energy at various stages of the production period, arc all aspects 0f broiler breeder nutrition that require further definitive experimentation. Some recent information indicates that the nutritional principles applied to commercial laying pullets cannot be used without modification for broiler breeders, and that computer simulation of a population of these birds will lead to progress in defining the optimal feeding strategy for broiler breeders.

INTRODUCTION

A perusal of the literature pertaining to broiler breeder nutrition leads to the conclusion that these birds have been neglected by research nutritionists. The few experiments that have been reported generally lack the philosophical approach that is necessary in scientific endeavour. Does the broiler breeder differ from the other, commercial, laying breeds, and if so, in what way should the nutrition and management of these birds be adjusted to take account of these differences? Can a nutritionist, with the information available, formulate a feeding strategy that will optimise the feeding of these specialized laying birds?

It has been established that the genetic potential of a breed can rarely be expressed, either because some environmental factors are limiting and it is not economically viable to correct these deficiencies (these factors could refer to housing, feeding, management or disease), or because there is information lacking of the optimum conditions required by the breed to allow it to express that potential. The Reading Model (Fisher et al. 1973) provides a useful means of determining the economic optimum amino acid supply for a flock of laying hens, considering both the potential of the flock and the ratio of cost of nutrient to value of egg, but the assumptions in this Model are largely ignored when applying the theory to broiler breeder hens. To an extent this failing is due to insufficient knowledge being available on such basic information as the variability in food intake (in both the males and females) and egg output in a flock subjected to feed restriction; the relative efficiencies of different stimuli promoting the onset of sexual maturity; and the efficiencies of utilisation of amino acids for maintenance and for egg production. Some of this information has become available as a result of a series of experiments conducted at our research institute, where broiler breeder males and females are housed individually in laying cages and are fed given amounts of feed of known composition daily. It is this information that is presented below, together with some thoughts on experiments that need to be done in the future to answer some of the voids that still exist in our knowledge of broiler breeder nutrition.

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Feed restriction during rearing

Broiler breeder pullets should bc rcarcd on a feed restriction programmc, ostensibly to reduce the amount of carcass fat around thc ovary and oviduct so that thc production of eggs should not be hampcrcd by this mass of unneccssary tissue, although Hocking (1987) has shown that the value of fccd rcstriction is to reduce the extent to which broiler breeders will super-ovulate in the first few weeks of lay. In either case, it is economical to reduce the amount of food allocated to the birds during rearing, and the extent to which this is done depends on, among other things: the resultant delay in sexual maturity; the size of the eggs that arc laid initially, and whether these could be incubated for the production of chicks: thc cffcct on cgg production, uniformity, and mortality. For this rcason, broilcr breeding companics rccommcnd a targct body weight at 20 wccks of age, which is usually strictly applicd or cnforccd by most pullct rearcrs.

Three obvious questions regarding the validity of such target body weights are:

(a) Does it matter along which path thc birds grow, as long as they achieve the desired body weight at point-of-Iay?

(b) Is the body weight' targct necessarily the best target under all circumstances, considering the variable demands for egg size, and hence chick weight; considering endemic discascs to which the birds will be subjected; and considering the differing levels of managcment to which the growing birds would be subjected?

(c) Could the feeding strategy not bc altcrcd to suite broiler breeder pullets that have not achieved the target weight set by the breeding company, thereby achieving levels of production similar to thc breed standard?

(d) Is body wcight ncccssarily thc bcst mcasurc of future potential, or would carcass composition not bc a bcttcr critcrion?

How should birds be fed during the pre-laying period?

This question reduces to, " How is scxual maturity induced in a broiler brccdcr "? Two stimuli are known to inducc scxual maturity, the onc bcing light; thc other, food. The minimum amount of light rcquircd to inducc sexual maturity i.e. the amount that will allow a bird to lay, is about six hours pcr day. Broiler breeders will lay, although not very well, on such short day-lengths. Some food is undoubtedly needed to meet the requirements for maintenance and for egg production, but a broiler breeder will lay, although not very well, on an intakc of only 100g food /day.

The age at which a broiler breeder bcgins to lay will depend on the extent to which these two stimuli vary from the minima given above, and on the amounts of food and light given during rearing. An increasing daylength during rearing will induce an earlier sexual maturity , whereas a decreasing daylength will have the opposite effect (Morris 1968). Similarly, an increase in thc daily allowance of food will be a potent stimulus to induce earlier sexual maturity. Thc two stimuli are not necessarily additive in this effect, and it is therefore unlikcly that both need to be, or even should bc, applied in order to induce sexual maturity: Food intakc is necessarily being increased each week during the pre-laying period, to rclcasc thc birds from the severe restriction programme that is used in the growing period, thc goal bcing a daily allocation that will provide sufficient nutrients to meet thc requirements for both maintenance and egg output. This is logically the better stimulus to usc as a means of inducing sexual maturity, with daylength increases being used only later to increase performance at, and after, peak production. If the food allocatcd to the birds each day is increased too rapidly, the value of a restriction programme during the rearing period is largely undone, as the birds gain too much weight before they begin to lay eggs. Increasing the light at the same time would cause an earlier sexual maturity, but such an induced early maturity would be accompanied by prolapse, small eggs and poor viability.

Bowmaker (1987) has shown that the rate of increase in food allocation in the pre-laying period does not have an effect on the rate of development of the reproductive organs; that these organs grow very rapidly as soon as the stimulus of a release from a feed restriction programme occurs (Fig. 1.); and that this increased food intake probably does not have to continue to ensure that the organs develop normally, as more than sufficient dietary nutrients are usually available in the food allocated to the birds each day to meet the requirements for maintenance and for growth. Whereas both Cave (1984) and Brake et al. (1985) recommend a high protein feed for broiler breeders during the pre-laying period, in order to build up reserves in the liver of protein and fat on which the breeders can draw during subsequent production, Bowmaker (1987) concluded that there was no nutritional advantage in feeding such a feed during this period, as there was no difference in the protein or fat content of the liver a few weeks after applying such a treatment, and as, from calculations of the amounts of protein required for the purposes of maintenance and growth of the body and of the reproductive organs, only 10 g of protein was required per bird each day.

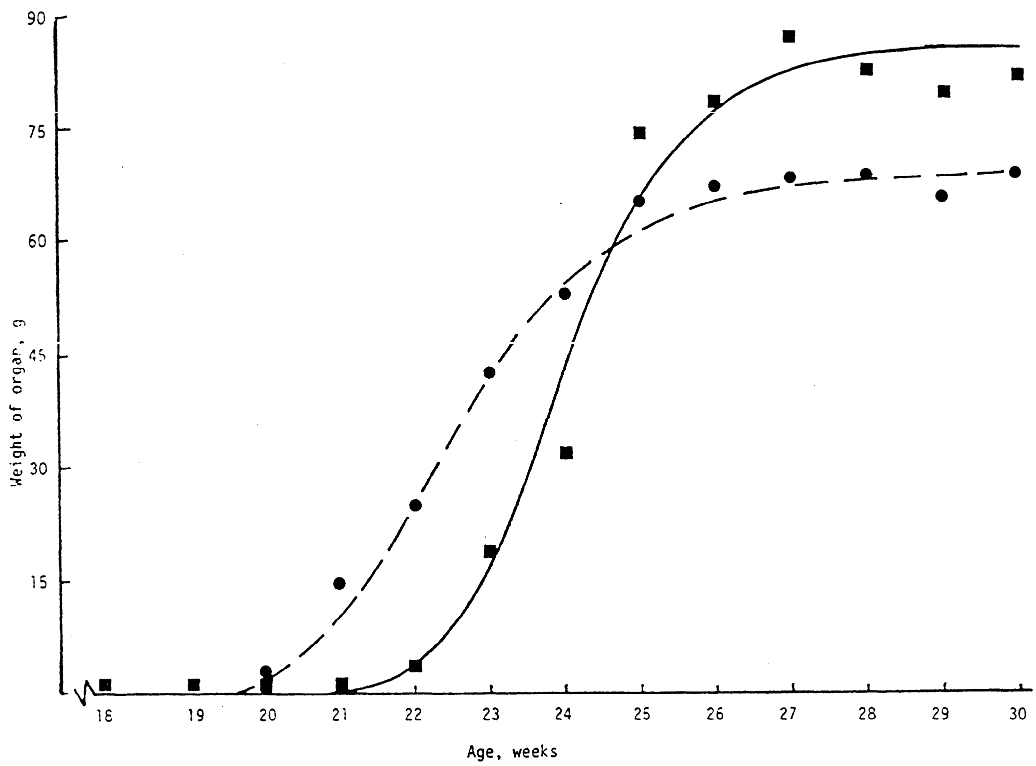

Fig. 1. Growth of oviduct and ovary of broiler breeder pullets between 20 and 30 w of age. Points represent means of observations over all treatments (oviduct : ovary). Broken line represents Gompertz equation fitted to observed oviduct weights; unbroken line represents growth of ovary.

Investigations of the interaction between light and feeding as stimuli used to induce sexual maturity, and the consequences of applying one or the other, and to different degrees, would prove beneficial in our understanding of the physiology of broiler breeders. Comparative investigations with laying-type pullets would indicate whether, by intensive selection for egg production, as has been accomplished in the latter type of layer, the response to lighting or to feed stimuli is more sensitive in these birds than in broiler breeders, where the accent has been on selection for growth rate rather than for egg output.

Optimising the feeding strategy in the laying period

Very little information specific to broiler breeders is available about the nutrient requirements of these birds during lay. Amongst the most useful publications are those of Pearson and Herron (1982), who showed that the daily protein intake of between 23 and 25 g/bird d, recommended by many broiler breeding companies, was in excess of that required by these birds for maximum production; and Whitehead et al. (1985) who discovered that the requirement for biotin was linked to the protein level (maximum fertility at high protein levels only being possible when supplemental biotin was added to the feed), but that egg production and fertility were better at the lower protein level.

Previous experiments, including those mentioned above, have not addressed the central issues of (a) whether the efficiencies of utilisation of nutrients, specifically amino acids, by broiler breeders differ from those of laying pullets; and hence (b), whether the amino acid requirements of broiler breeders for maintenance, for growth and for egg production can be estimated using the same parameters as are used for this exercise with laying pullets. Information required for such an analysis would include measurements of the potential egg output of these birds (both in egg weight and in rate of laying, and the distribution of these variables in a flock); responses to specific amino acids rather than to dietary crude protein; and whether food intake varied in proportion to level of production.

Amino acids

If the egg output of a flock of broiler breeders followed a normal frequency distribution, then the nutritionist would be justified in using the Reading Model (Fisher et al. 1973) to determine the optimum daily intake of each amino acid to be fed to the flock. Because a measured amount of feed is allocated to the birds daily, it would be a simple matter to determine the concentration of each amino acid to be included in the feed, assuming that all birds consumed the same quantity of food.

In the majority of trials conducted in our broiler breeder facility, in which birds are housed individually in laying cages, the frequency distribution of egg outputs is decidedly non-normal. There is a large group of birds in each experiment whose egg output, even on the most generous feeds, is zero, or up to a maximum of about 10g per day (i.e. one egg every seven days). If these birds were excluded from the analysis, the mean egg output of a flock would increase by about 5g /bird day, which is a considerable correction if this variable is used in calculating the optimum amino acid intake of the flock. The Reading Model is based on the assumption that the egg output of a flock of laying hens follows a normal distribution.

Another question regarding the amino acid nutrition of broiler breeder pullets that requires closer scrutiny, is the extent to which the maintenance requirements are related to body weight as opposed to body protein content. Because these birds have considerable lipid reserves, it is unlikely that the amino acids required for maintenance (as defined by the **b** value of the Reading Model) would be related to the body 'weight of the bird. A more accurate estimate of the amount required for maintenance would be that related to the protein content of the body and the degree of maturity, as suggested by Emmans and Fisher (1986). These authors suggest that the unit of maintenance should be $P_m^{-0.27}.P$. When the **b** coefficient of McDonald and Morris (1987) is applied to the body weight of broiler breeders, an inflated estimate is obtained, resulting in a shift of the response curve, relating amino acid intake to egg output, to the right of the observed response (Bowmaker 1987). Relating this requirement to protein content results in a more accurate estimate of response. Because such a change needs to be implemented, a simple and accurate method of determining the carcass fat content of broiler breeders would be imperative, and would add a degree of accuracy to the rather hit-and-miss approach that is currently being used.

The question of whether non-laying birds consume as much feed as do laying birds was investigated by Bowmaker (1987). who found that ail birds, irrespective of output, consumed all the feed that was allocated to them, except if that feed was severely limiting in some nutrient. In such a case, the food intake decreased in proportion to the degree of limitation of the nutrient; in some cases food intake dropped from the 150g allocated, to only 90g /day. Thc nutritionist can therefore not assume that the poor, or non-producers, will only eat a small amount of food, which if it were so, would simplify the decision about the optimum concentrations of nutrients to include in the feed.

Birds producing fewer than onc cgg every two days, i.c. those birds not laying in closed cycles, have been shown to utilise thcir dictary nutrients lcss-cfficicntly than do birds that lay in closed cycles. Fisher (1976) demonstratcd this with laying pullets, and Bowmaker (1987) found the same tendencv with broiler breeder pullets. Although there is a great deal of variation around the mean efficiency of amino acid utilisation of 1.00, for birds laying in closed cycles, there is a significant decline in efficiency as the rate of laying drops below 0.5. Whereas the a coefficicnt, relating lysine intake to that required per g of egg output, was 13.85 in the experiment of Bowmaker (1987) before correction, it was reduced to 6.52 when birds laying at a rate of less than one egg every two days were excluded from the analysis. This, too, makes the task of the nutritionist more difficult, as differences in efficiency of utilisation of amino acids are not considered in the Reading Model, and this Model therefore appears to be increasingly inappropriate for flocks of broiler breeder hens. The differnces between the observed responses to both lysine and methionine (Bowmaker 1987) and the egg outputs estimated by means of the Reading Model are considerable (Fig. 2.) if no account is taken of the difference in maintenance units between laying hens and broiler breeders, or in the reduced efficiency of utilisation of amino acids by broiler breeders for egg production.

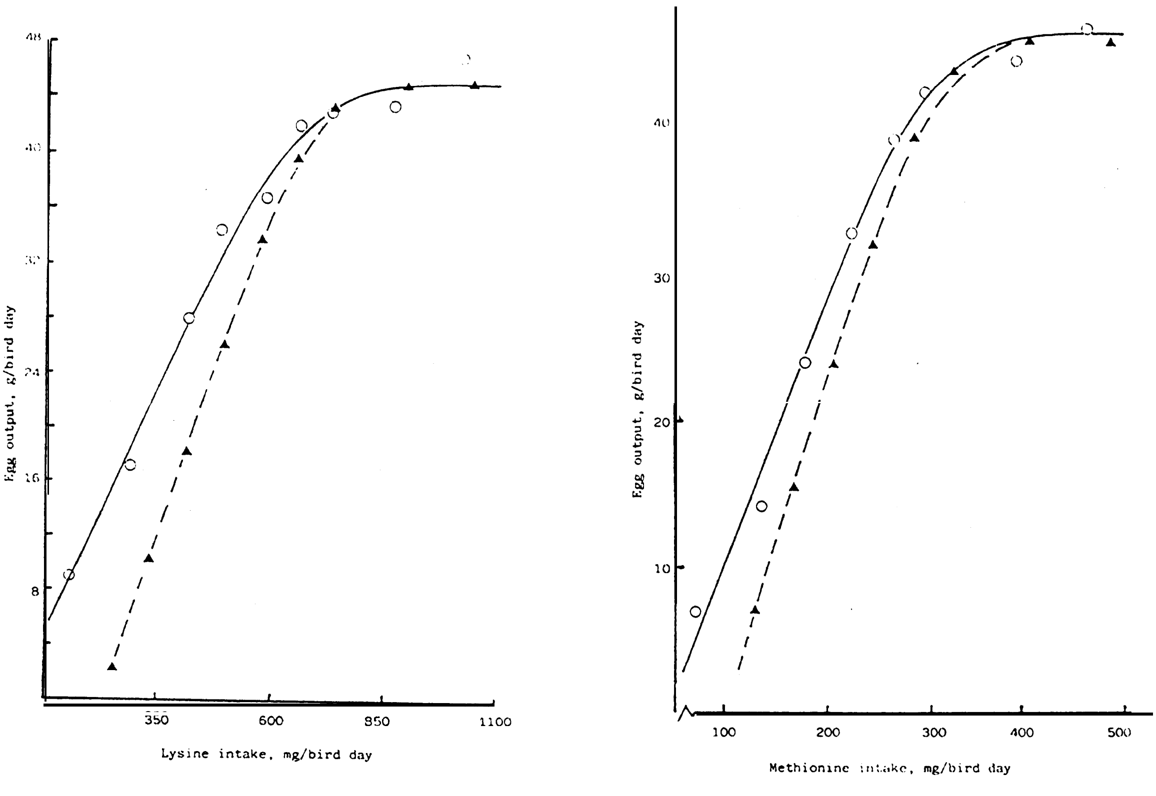

Figure 14 The relationship between egg output and lysine intake (a) and methionine intake (b) in broiler breeder pullets. A response curve based on the Reading Model was fitted to the observed means ( ). A second response curve was fitted ( ), using the coefficients of response suggested by McDonald and Morris, 1985). (After Bowmaker 1987)

The most appropriate means of determining the optimum intakes of amino acids for flocks of broiler breeders would therefore not be by means of further experiments with differing levels of nutrients, but rather by means of computer modelling, or simulation. A population could be made up as follows :

with a known distribution of egg output (not a normal distribution)

with body weights uncorrelated with egg output (as was found by Bowmaker 1987)

with a known correlation between rate of lay and egg weight, which will in turn be used to calculate egg output, and hence efficiency of utilisation of amino acids by each hen

with food intake uncorrelated with potential egg output

Various amino acid intakes could be "offered" to this simulated population, the value of the resultant egg output being compared at each intake with the cost of supplying those nutrients. Once the amount of each of the amino acids is known for a range of egg outputs, the mixed integer programming method (Gous and Kleyn 1988) could be used to optimise the amount of food that should be allocated to the birds each day, that would both supply all birds with the desired amino acid intakes and would minimize the cost of feeding, considering such variables as miller's margin, transport cost and energy supply.

Although a flock of broiler breeders is expected to include a high number of low or non-producers, which has the effect of lowering the mean egg output of the flock, nevertheless there are birds in the population that have the capacity to produce in excess of 75g egg output/d. These birds should not be penalized by under-feeding the flock, on the grounds that the average egg output is only 40 to 45 g/bird d. Because broiler breeder eggs are so valuable, it is worthwhile feeding for maximum egg output, and accepting that some of the flock, the poor producers, will be over-supplied with nutrients. On the other hand, feeding for maximum production does not imply over-feeding the entire flock. Computer simulation, again, can be used to determine the optimum feeding level. Because a limited quantity of food is allocated to the birds each day, accurate estimates of the amino acid concentrations to be included in the feed can be determined. An even distribution of this feed to all the birds in the flock is then necessary, but this is an engineering problem, not a nutritional one.

Energy

It is not possible to calculate the optimum energy intake for a flock of broiler breeders in the same way as one can calculate the optimum amino acid supply. Birds have a reservoir of lipid which, it is assumed, they can draw upon when the dietary energy supply is inadequate, and which they can add to when energy is surplus to requirement. Considering the excessive amounts of carcass fat present in a broiler breeder hen at all stages during the laying period, one could conclude that, if these birds were able to draw on lipid reserves to supply the body with energy, it would be unlikely that energy would be the limiting factor in egg production, and that these birds are therefore being supplied with energy in excess of their needs. Alternatively, the lipid stores may not be labile reserves from which the bird can obtain energy when required, in which case this energy source cannot be utilized, nor can we make assumptions about the adequacy of dietary energy supply by observing the carcass fat content of broiler breeders.

A definitive experiment is needed to ascertain whether, and to what extent, broiler breeders can utilise lipid reserves as a source of energy. Such an experiment would involve feeding breeder pullets a high energy feed, or alternatively, an excessive amount of a normal broiler breeder feed, such that the lipid reserves are considerably increased during this preliminary period. Following on this “fattening” period would be a period when birds would be subjected to a number of treatments designed to measure to what extent they can make use of the lipid reserves: energy content of the feed could be progressively reduced in a series of treatments, whilst maintaining the amino acid intakes constant; or the intake of a feed supplemented with amino acids could be reduced such that the bird would be required to draw on reserves of energy if egg production is to be maintained. It would be essential to measure the change in the state of the birds during the experimental period, to supplement the measurements of changes in egg production. An experiment, based on the above principles, is under way in our facilities at present.

Such an experiment could also be used to test the short term and long term effects of feeding excessive amounts of energy on fertility and on egg production. These definitive experiments can only be successful if applied to individually caged broiler breeders, as there is great variability in food intake between birds within a flock housed together on the floor. The effect of pecking order and the ability to eat rapidly *is* nullified by keeping birds caged individually. Egg production is more easily measured when birds are housed in laying cages than when kept together in floor pens.

Feeding the male broiler breeder

The subject of feeding the male broiler breeder has gained prominance in the scientific and popular press as a result of the work of McDaniel (cf. Wilson et al. 1986), who designed a system of excluding males from the feed troughs frequented by the females, and vice *versa*, after discovering that the fertility of breeder males could be improved significantly by reducing their food and protein intake. An experiment was conducted in our facilities to measure the response in fertility to increasing intakes of dietary protein and calcium. Half the males on the experiment were restriced to 150 g of each feed per day, while the remainder were allowed *ad Lib.* access to the feed. Fertility was measured using a colour reaction, namely, the time taken by sperms to reduce methylene blue. This technique has been tested by us previously and is an accurate indicator of fertility.

Intakes by males on the *ad lib.* treatments averaged 223g daily, indicating the excessively large amount that may be removed from the feeding trough by dominant males if some form of feed restriction is not used. Calcium had no effect on fertility, although it should be noted that the experimental period was restricted to only ten weeks, which may be too short a time to measure the effect on fertility of excessively high calcium intakes. Of particular interest was the response to protein intake: a highly significant linear decline in fertility accompanied the increase in protein intake, measured as a progressive lengthening of the time taken to reduce the methylene blue. The fertility of males on the various concentrations of protein, both when intake was restricted and when they were allowed *ad lib.* access to the food, is illustrated in Fig. 3. A low intake of protein is clearly of benefit in improving fertility, hence the increased popularity of this feeding technique in broiler breeder flocks world-wide.

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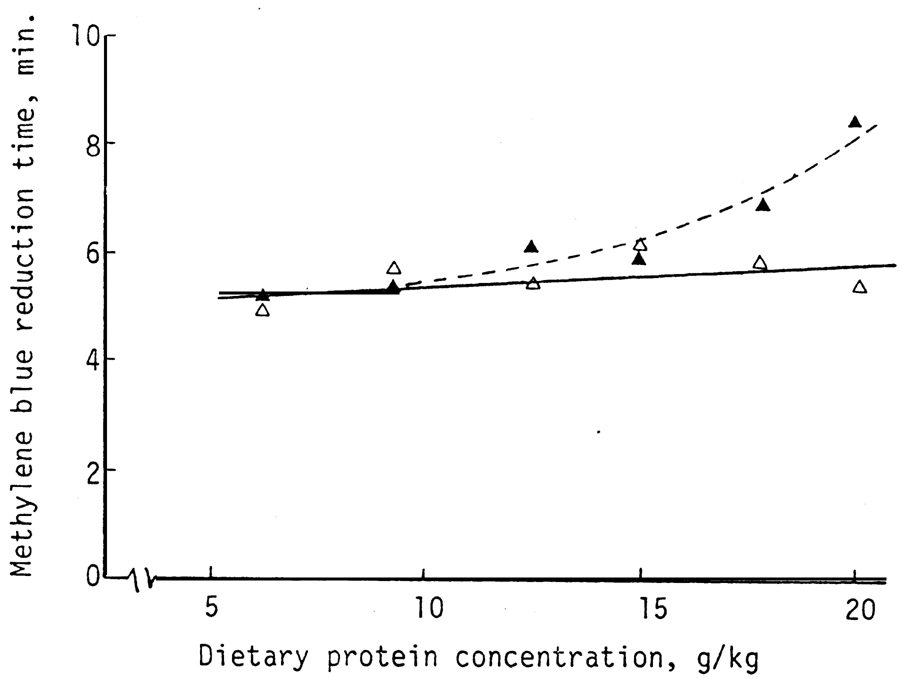

Fig. 3. Fertility of male broiler breeders, measured as the time taken to reduce methylene blue, as influenced by dietary protein concentration. Response of birds fed *ad lib.* shown as a dotted line (closed triangles); those restricted to 150 g food /d shown as a solid line (open triangles)

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