ADVANCES IN NUTRIENT ALLOWANCES FOR OPTIMUM PRODUCTION IN BREEDING SOWS

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SUMMARY

Components for models to simulate responses of breeding sows to nutrient regime are available and adequate for the construction of a first generation of empirical models. Nutrient allowances for optimum production are best derived by use of such models.

INTRODUCTION

Recommendations for the level and composition of food allowances for pigs are best founded on the dynamics of animal response to nutrients rather than on rigid chosen values purporting to elicit optimum performance in all circumstances. The recognition that optimum animal performance requires a flexible approach to nutrient need has led toward a definition of pig response to nutrient inputs by SCA (1987). One of the most effective means of defining nutrient response is through simulation models, and such have been constructed with some degree of success; Black _et al_ (1986) in particular having also presented some novel elements of a simulation model for the breding sow. Recently, the body of information concerning the nutrition of the breeding sow has been considerably enhanced by Black and Williams and their colleagues in Australia, by the Shinfield group in UK, and by the data collected by Yang and Eastham since 1985 in Edinburgh. This review will concentrate on the contribution that can be made by the latter data set.

Field trial results are rarely presented in a form that allows their generalisation for use as model components. More frequently results from many trials are accumulated, stacked, and overall regression responses produced. The statistical and biological validity of combining experimental results in this way has, however, to be questioned and it may be more informative to pursue the possibility of modelling sow response using data sets which have allowed the construction of effective regression relationships within the confines of a single set of environmental variables. Such data sets are not common but those from Edinburgh (Eastham _et al_ (1988); Whittemore _et al_ W

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(1988); Yang *et al* (1989)) may now offer a realistic approach to empirical response prediction modelling in the breeding sow. Where not otherwise stated, the regressions used below are from Yang *et al* (1989).

ASSUMPTIONS

(a) Sow live weight at first conception is around 125kg.

(b) P2 backfat depth for sows at first conception is around 15mm.

(c) The genotype used is an improved hybrid.

(d) A cereal/soya/fish diet of 13.2MJ DE and 162g CP per kg fresh weight is offered throughout breeding life.

(e) Growth to maturity is at a rate conducive to efficiency of food use and of reproduction. Yang *et al* (1989) found this to be in the region of maternal conception to conception live body weight gains of 35, 28, 23 and 18kg for parities 1,2,3and 4 respectively, although lower values may be acceptable.

INTERVAL BETWEEN WEANING AND CONCEPTION

The weaning to oestrus interval is frequently longer in primiparous than multiparous sows; typically after parities 1,2 and 3, 20, 10, and 7 days.

Low feed intake in lactation will lengthen the weaning to oestrus interval especially in primiparous sows but also in multiparous sows. The subject has been effectively reviewed by King (1987). Excessive weight loss and excessive fat loss will be conducive to an extended weaning to mating interval. Both the absolute levels and the rates of reduction of level of protein and lipid reserves are implicated by King in his review. King (1987) gives the following regression equations for primiparous sows;

weaning to oestrus interval(days) = 28.1 - 0.28(MJ DE/day in lactation)

weaning to oestrus interval (days) = 32.5 - 0.032(g CP/day in lactation)

weaning to oestrus interval (days) = 38.6 - 0.63(kg body lipid at weaning)

weaning to oestrus interval (days) = 81.5 - 3.58(kg body protein at weaning)

weaning to oestrus interval (days) = 7.3 + 0.39(kg live weight loss in lactation)

weaning to oestrus interval (days) = 9.4 + 0.59(kg body lipid loss in lactation)

weaning to oestrus interval (days) = 9.6 + 3.44(kg body protein loss in lactation.

Yang et al (1989), for primiparous sows, present:

weaning to oestrus interval (days) = 26.6 - 1.28 P2(mm) fat depth at weaning

weaning to oestrus interval (days) = 49.1 - 0.23 live weight (kg) at weaning

weaning to oestrus interval (days) = 25.5 - 0.12 total 28-day lactation feed intake (kg)

confirming the propositions within the review of King (1987) that both body weight and fat changes in lactation have dramatic effects upon the propensity to re-breed after weaning the first litter. In the experiment of Yang _et al_ (1989) 1mm of P2 was equivalent to 3kg of total body lipid in primiparous sows; using this conversion the propositions of both Yang _et al_ (1989) and King (1987) with regard to body fat are similar.

While the modern literature (in contrast to earlier work) is clear in its view of the influence of absolute level, and the rate of change of level, of fat and body weight upon weaning to oestrus interval, there is less data relating to multiparous sows and the position is more equivocal; many workers demonstrating little or no effect. Where there is an effect it is invariably weaker in multiparous than primiparous sows. But it is also likely that those females most liable to re-breeding problems will already have been culled from the herd in consequence of primiparous phenomena and will not be present in a multiparous data set. Whittemore et al (1988) found for multiparous sows

weaning to conception or culling interval ($\log_{10}$ days) = 1.5 - 0.004 live weight (kg) at weaning

weaning to conception or culling interval ($\log_{10}$ days) = 1.2 - 0.02 P2(mm) fat depth at weaning

or, in more simple form

weaning to conception or culling interval (days) = 14 - 0.4 P2(mm) fat depth at weaning.

For all parities there is also a negative effect of litter size upon weaning to oestrus interval. The effect of litter size is, presumably, also mediated through influence upon the absolute levels and rate of change of body fat stores and maternal live weight during lactation. Yang _et al_ (1989) present

weaning to oestrus interval (days) = 2.7 + 0.56 number of piglets in sucking litter

Relationships between days from weaning to oestrus and the body weight and condition of the sow are clearly only effectively demonstrated in the form of linear equations over a limited range of values for X. Sows are most unlikely to ret-urn to oestrus in less than 4 days after weaning, and it would also be erroneous to presume that there are no adverse consequences of over-fatness for re-breeding efficiency.

FOOD REQUIREMENT IN PREGNANCY

(a) Maternal fatness (P2) requires to be incremented in pregnancy (i) to supply the need for lipid catabolism in the forthcoming lactation and (ii) to maintain adequate levels of P2 backfat at the time of weaning.

(b) Maternal live weight requires to be incremented in pregnancy (i) to supply the need for lipid and protein catabolism in the forthcoming lactation and (ii) to allow maternal body tissue growth to maturity.

(c) Change in P2(mm) backfat depth in pregnancy = -9.3 + 0.036 total pregnancy food intake in pregnancy.

(d) Change in live weight (kg) in pregnancy = -27.2 + 0.215 total pregnancy food intake in pregnancy.

By use of these equations, responses in P2 fatness and in maternal live body weight to various levels of pregnancy food intake can be predicted. These equations represent efficiencies of conversion and may be taken to apply in other circumstances than the confines of the experiment in which they were measured, although the efficiency will, of necessity, include costs of environmental variables such as cold thermogenesis. The coefficients suggest 28kg food to be required for a 1mm increment of P2 backfat depth and 4.7kg food for a lkg increment of maternal live body weight gain. The latter efficiency of food use in pregnancy (5:1) is familiar, while equivalent coefficients for pregnancy food intake-of 0.042 (for P2) and 0.182 (for live weight) were measured by Whittemore et al (1988).

MATERNAL FATNESS AND BODY WEIGHT CHANGE IN 28-DAY LACTATION

(a) Change in P2(mm) backfat depth = -0.283 - 0.265 (P2(mm) backfat depth at parturition + 0.037 total lactation food intake - 0.497 number of piglets sucking.

(b) Change in maternal live weight (kg) = -3.8 - 0.150 maternal weight at parturition + 0.362 total lactation food intake - 3.33 number of piglets sucking.

These two multiple regression equations address the gross consequences upon sow fat stores and live weight of (i) the availability of those stores, (ii) the nutrient supply from food, and (iii) the lactational demand.

PROTEIN REQUIREMENTS IN LACTATION AND PREGNANCY

Conventional wisdom as forwarded by the Agricultural Research Council nutrient requirement recommendations of 1981 suggests about 800g crude protein (CP) per day to be adequate for lactating sows, and a diet of 15% CP, if eaten at 6kg daily, will supply this. Feed intakes of gilts are, however, commonly only 4.5-5.0kg daily, and in hot environments no sow may eat more than 4kg daily. It is further the case that improved hybrid sows will have a greater lactation demand for nutrients than used to be the case for unimproved sows.

In the Edinburgh experiments the body composition of the sows was analysed and it was found that CP intakes of 950g per day in lactation were consistent with maintenance of sow body protein levels. But sows given only 500g CP daily lost, in the course of the 28-day lactation, about 12kg of fat and 7kg of protein. If the efficiency of utilisation of crude protein is taken to be 50%, then 14kg CP dietary equivalent, or 500g daily, was being contributed by the sow from her body tissues in order to satisfy lactation demand. This response would suggest a total dietary requirement of l,OOOg CP daily; rather higher than previous estimates, and consistent with a sow yield of 10kg of milk daily rather than the ARC standard of around 7kg. One thousand grams crude protein daily would be supplied in a diet of 16.6% CP if the sows were to be eating 6kg of feed daily.

Calculation of the requirements of crude protein in pregnancy, based primarily on the needs for sow body tissue maintenance and growth of the foetal load in utero, suggests a daily intake of a mere 180g CP to be adequate; and this has led to proposals that dietary CP concentration can be lower in pregnancy than in lactation. While this case appears self-evident, account must be taken of the lower level of pregnancy feed intake in comparison with that of lactation, and also of the evidence from the Edinburgh experiments that, unless lactation feed intake is in excess of 6kg daily, then substantial quantities of protein may be lost from the body tissues of the sow during lactation. In addition, it seems that protein loss from the sow's body can also continue after weaning; body protein equilibrium not being achieved instantaneously. Sows were found to lose between 0.5 and 3kg of protein in the 14 days post-weaning.

It may be concluded that protein savings in pregnancy diets may be less than sometimes believed. Carcass composition studies at Edinburgh showed sow body protein gains to be around 25kg between first mating and weaning the fourth litter. This suggests that in addition to the 180g or so needed for foetal growth and body maintenance, the diet may need to supply CP additionally for sow body growth at the rate of 5kg per pregnancy, and another 4kg for possible rehabilitation of lactation losses, making 9kg in all; or at 50% efficiency about a further 180g of dietary CP per day over the whole of the pregnancy. With a daily intake of 2.5kg of diet in pregnancy, this would point to a diet crude protein concentration in the region of 15%.

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CTW 16/1/89