Short Communication / Kort Mededeling

A comparison of optimum and maximum reproduction using the rat as a model

M.M. Scholtz,* C.Z. Roux and D.S. de Bruin

Animal and Dairy Science Research Institute, Private Bag X2, Irene 1675, Republic of South Africa

* To whom correspondence should be addressed

Received 7 June 1990; accepted 7 December 1990

No experimental evidence exists on the biological advantages of frequent or maximum reproduction compared to lower or optimal levels of reproduction. Twenty unrelated rats, divided into two groups, were thus used in the biological comparison between optimum and maximum reproduction. No difference between the two systems were found in terms of feed required/biomass (cumulative litter mass plus female mass). This experiment, therefore, indicates that maximum reproduction is not necessarily more efficient in a biological sense than optimum reproduction and that experimental evidence is needed to support the contention that frequent reproduction is the best approach to increasing biological efficiency.

Daar bestaan geen eksperimentele getuienis dat gereelde of maksimale reproduksie biologies meer voordelig as laer of optimale reproduksievlakke is nie. Twintig onverwante rotte, wat in twee groepe verdeel is, is derhalwe gebruik in 'n biologiese vergelyking tussen maksimum en optimum reproduksie. Geen verskil is tussen die twee sisteme gevind in terme van voer benodig/biomassa (kumulatiewe werpselmassa plus massa van wyfie) nie. Hierdie eksperiment dui dus daarop dat maksimum reproduksie nie noodwendig biologies meer doeltreffend as optimum reproduksie is nie en dat eksperimentele getuienis benodig word voordat gereelde reproduksie as 'n algemene manier om biologiese doeltreffendheid te verhoog, gepropageer kan word.

Keywords: Biological efficiency, maximum reproduction, optimum reproduction, rats.

No experimental evidence exists on the biological advantages of frequent or maximum reproduction compared to lower or optimal reproduction levels. However, frequent reproduction is generally accepted as one of the ways to improve biological or economic efficiency. For example, the implementation of accelerated lambing systems in sheep has been advocated for some years now (Notter & Copenhaver, 1980; Robinson, 1980; Dzakuma *et al.*, 1982; Karberg *et*

Table 1 A comparison between optimum and maximum reproduction at 330 days of age

Trait	Optimum reproduction	Maximum reproduction	% Deviation from optimum
Age at first litter (days)	102,7 ± 6,2	89,8 ± 3,7	-12,5***
Number of litters	4,0 ± 0,0	6,0 ± 1,0	50,0***
Litter interval (days)	71,8 ± 4,4	48,8 ± 7,2	-32,0***
Litter size at birth	10,2 ± 0,7	10,2 ± 1,5	-
Individual pup mass, birth (g)	6,5 ± 0,8	6,4 ± 1,1	-1,5
Litter size at weaning	9,3 ± 1,1	7,4 ± 2,2	-20,4**
% Females loosing mass (3-12 days)	11,1%	28,0%	152,3
% Deaths prior to weaning	9,4%	27,6%	193,6
Litter mass at weaning (g)	383,4 ± 14,4	262,9 ± 75,0	-31,4***
Individual pup mass (g)	41,4 ± 2,8	35,7 ± 2,5	-13,8***
Female mass at 330 days (g)	348,0 ± 35,6	353,0 ± 44,7	1,4
Total feed intake (g)	8469 ± 505	8898 ± 734	5,1
Feed required/weaning mass	5,52	5,64	2,2
Feed required/biomass [b]	4,50	4,53	0,7

[b] Biomass includes litter mass and female mass.

* 10% level; ** 5% level; *** 1% level of significance.

al., 1985; Schindler & Amir, 1985; Iniguez *et al.*, 1986; Rawlings *et al.*, 1987; Greeff, 1990), as has early weaning of pigs to increase reproduction rate of sows (te Brake, 1978; Walker *et al.*, 1979; Kemm *et al.*, 1980). However, no experimental evidence exists that this strategy would in fact improve biological efficiency.

In this pilot experiment, an attempt was made to compare systems of optimum or maximum reproduction using the rat as model. Twenty unrelated female rats (Wistar line), randomly divided into two groups of 10 animals each, were used for the comparison between optimum and maximum reproduction. In this case, optimum reproduction refers to fitness and not necessarily to biological efficiency.

Table 2 A comparison between the lifetime performance of optimum and maximum reproduction

Trait	Optimum reproduction	Maximum reproduction	% Deviation from optimum
Number of litters	5,3 ± 0,4	8,7 ± 0,9	64,2***
Litter interval (days)	74,3 ± 4,3	49,4 ± 8,3	-33,5***
Age at last litter	496,3 ± 59,8	517,7 ± 76,5	4,3
Litter size at birth	8,7 ± 0,8	8,4 ± 1,6	-3,4
Individual pup mass, birth (g)	6,5 ± 0,8	6,3 ± 1,0	-3,1
Litter size at weaning	7,8 ± 1,1	6,0 ± 3,7	-23,1**
% Females loosing mass (3-12 days)	12,7%	18,9%	48,8
% Deaths prior to weaning	9,0%	28,4%	255,0
Litter mass at weaning (g)	329,2 ± 15,2	231,2 ± 71,4	-29,8***
Individual pup mass (g)	42,2 ± 2,6	38,3 ± 2,3	-9,2***
Female mass at last litter (g)	336,5 ± 21,1	347,3 ± 29,1	3,2
Total feed intake (g)	11424 ± 1091	12942 ± 1207	13,3***
Feed required/weaning mass	6,51	6,46	-0,8
Feed required/biomass [b]	5,46	5,50	0,7

[b] Biomass includes litter mass and female mass.

* 10% level; ** 5% level; *** 1% level of significance.

In the optimum reproduction group, the females were managed according to conventional practices (Arrington, 1972; Ruitenberg & Peters, 1986), i.e. mated for the first time at 70 days of age, with subsequent matings three weeks after each weaning (21 days of age). In the maximum reproduction group, males and females were joined at 40 days of age. From this age onwards, the males and females were kept together for 6 h per day, during which time feed was withheld. Feed was also withheld from the optimum group for 6 h per day. Mass and feed intake were measured daily from the time of weaning in the females.

Optimum and maximum reproduction was compared at 330 days of age, which is the point of peak production (Table 1), as well as over the total reproductive life (Table 2).

From Tables 1 and 2, it can be seen that more litters were born in the maximum reproduction group and that the litter size at birth was the same for the two groups. Litter size at weaning, however, differed by more than 20%, since the deaths prior to weaning were almost 200% higher in the maximum reproduction group than in the optimum reproduction group. Individual pup mass at weaning was also smaller in the maximum reproduction group. The above-mentioned differences led to an almost 30% smaller average litter mass in the maximum reproduction group, whether measured at 330 days of age or over the total lifetime.

Age at last litter and female mass were not influenced by reproduction system. Females from the maximum reproduction group tended to consume more feed but the difference was not significant at 330 days of age.

Biological efficiency may be defined as feed required/cumulative weaning mass of progeny or as feed required/cumulative weaning mass of progeny plus the final mass of the female (biomass). Tables 1 and 2 indicate no differences in biological efficiency between optimum and maximum reproduction.

Since there were no differences in pup mass or litter size at birth, but pup mass was lighter and litter size smaller at weaning, it seems evident that the milk production of dams from the maximum reproduction group must have been insufficient for adequate growth and survival. Additionally, there was a tendency for dams of the maximum reproduction group to lose mass in the period 3-12 days from birth, indicating a larger drain on body reserves. It seems that the similar values obtained for the efficiency of the optimum and maximum groups are due to the greater mortality of pups in the maximum reproduction group. If this can be prevented, a better performance of this group relative to the optimum group seems possible.

This pilot investigation with rats indicated that maximum reproduction is not automatically biologically more efficient than optimum reproduction. Although biological efficiency is not always the same as economic efficiency, in general, both probably follow the same tendency. Although there may be differences between the rat and farm animals regarding reproduction aspects such as seasonality, lactation anoestrus and involution of the uterus, these results necessitate experimental evidence before frequent reproduction can be confidently recommended as the best strategy for increasing biological efficiency in farm animals.

References

ARRINGTON, L.R., 1972 Introductory laboratory animal science. Interstate, Danville, Illinois.

DZAKUMA, J.M., STRITZKE, D.J. & WHITEMAN, J.V., 1982. Fertility and prolificacy of crossbred ewes under two cycles of accelerated lambing. *J. Anim. Sci.* 54, 213.

GREEFF, J.C., 1990. The merino in modern production systems. *Proc. Wrld. Merino Conf.* Pretoria, South Africa, 1, 3.2.

INIGUEZ, L.C., QUAAS, R.L. & VAN VLECK, L.D., 1986. Lambing performance of Morlam and Dorset ewes under accelerated lambing systems. *J. Anim. Sci.* 63, 1769.

KARBERG, F.O.C.W., FOURIE, A.J. & BARNARD, H.H., 1985. Die reproduksievermoë van Döhne Merino-ooie in 'n versnelde teelstelsel. *S.-Afr. Tydskr. Veek.* 15, 1.

KEMM, E.H.H., RAS, M.N. & SIEBRITS, F.K., 1980. Die effek van speenouderdom op die produksievermoë van die sog. *S. Afr. J. Anim. Sci.* 10, 159.

NOTTER, D.R. & COPENHAVER, J.S., 1980. Performance of Finnish Landrace ewes under accelerated lambing. I. Fertility, prolificacy and ewe production. *J. Anim. Sci.* 51, 1033.

BAWLINGS, N.C., JEFFCOATE, I.A. & HOWELL, W.E., 1987. Response of purebred and crossbred ewes to intensified management. *J. Anim. Sci.* 65, 651.

ROBINSON, J.J., 1980. Programmed yearround sheep breeding. *Aust. J. Exp. Agric. Anim. Husb.* 20, 667.

RUITENBERG, E.J. & PETERS, P.W.J., 1986. Laboratory animals: Laboratory animal models for domestic animal production. Elsevier, Amsterdam.

SCHINDLER, H. & AMIR, D., 1985. The reproductive performance of a sheep flock on a mating schedule of three restricted periods per year. *Livest. Prod. Sci.* 13, 35.

TE BRAKE, J.H.A., 1978. An assessment of the most profitable length of lactation for producing piglets of 20 kg body weight. *Livestock Prod. Sci.* 5, 81.

WALKER, N., WATT, D., MACLEOD, A.S., JOHNSON, C.L., BOAZ, T.G. & CALDER, A.F.C., 1979. The effect of weaning at 10, 25 or 40 days on the reproduction performance of sows from the first to the fifth parity. *J. Agric. Sci. Camb.* 92, 449.