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EFFECTS OF NUTRIENT SUPPPLY DURING REARING AND AGE AT FIRST INSEMINATION ON THE PERFORMANCE OF RABBIT DOES

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1. Antecedents of the research, objectives

In rabbit breeding special importance can be attributed to maternal effect, the strong connection between the doe and their kits (Rochambeau, 1988, 1997; Blasco, 1996). The maternal effect can be further differentiated into prenatal (number and intrauterine position of the foetuses) and postnatal effects (milk yield per kit). The length of the foetus phase (31-33 days) is 21-23% of the total period from the ova shed till the first mating at 16-17 weeks of age. The duration of the suckling period is 15-23% of the period lasts till the first mating depending on the age at weaning at 5 and 3-4 weeks (conventional vs. early weaning). It can be recognised that the length of the period that the kits spend with their doe is relatively long and during this period their performance is directly influenced by maternal effects. The rearing phase subsequent to weaning is 54-64% of the period that lasts till the first mating. After weaning the rabbits can only experience indirect maternal effect which however still can be substantial. The influence of the maternal effect is decreasing with the increasing age. During prenatal period the foetal nutrition is determined by the blood supply of the foetuses then subsequent to parturition it is determined by the milk yield of the doe that is the available amount of milk per kit. The productive phase of the does is only about a year depending from the mating schedule. The annual culling and mortality rate of the does can be as high as 120-130% (Guerder, 2001). Hence using the intensive production system the productive stage of the does is less than a year.

So far the influence of the environmental factors during rearing like birth weight, milk supply, feeding regime, age at the first mating on the

does' production was analysed only by a few researchers (Babile and Matheron, 1980; Babile et al., 1982; Lebas and Coudert, 1984; Szendrő et al., 1989; Biróné and Szendrő, 1990; Tudela et al., 1998; Eiben et al., 1999; 2001; Poigner et al., 2000a; Rommers et al., 2001a; 2001b; Gyarmati, 2001; Szendrő et al, 2002b). In these studies the effects of the above mentioned factors were analysed separately or maximum two or three factors were taken into account at a time. Moreover in these studies the maternal production was only monitored for a few parturitions. However, extensive study monitoring the whole rearing period has not yet been accomplished.

In my studies the main objectives were the following:

To determine the effect of the investigated factors (birth weight, number of nursing does and feeding regime) on the production of the suckling and growing rabbits, on their body weight and condition at the age of their first mating (15,5 and 18 weeks).

To estimate the separate and joint effects of the environmental factors during rearing and the age at first mating on the does' production and longevity.

Based on the results suggest a rearing method and appropriate age at first mating to the breeders that enables them to rear does of high production and longevity.

2. Materials and Methods

The analyses were conducted at the University of Kaposvár using Pannon White rabbits (n=785). The rabbits were housed in a closed rabbitry, in flat-deck wire cages. In winter the rabbit house was heated to a minimum temperature of 15-16°C. During summer without air conditioning the temperature occasionally reached levels as high as 28°C. The lighting period was 16 hours light and 8 hours dark for the whole year.

As only female rabbits were considered in the study the sex of the animals were determined at one day age. Newborn rabbits were divided into 3 groups according to their birth weight (low: 35-45 g, medium: 53-58 g, large: 65-70 g). Eight kits of the same group were placed into every litter.

To provide different milk supply, kits of each group were nursed by one or two does in equal proportion in a special cage developed for the purpose. In case of double nursing the kits were nursed by does that were delivered on the same day. One of the does was allowed to enter the nest box in the morning the other in the evening to nurse the kits for a period of 30 minutes. The creep-hole of the nest box was opened from the 17^{th} day after parturition thus the kits could freely move to the other compartment of the cage and consume the pellet of the does. On the same day the foster doe was placed into another cage. In the group where the kits were nursed by one doe the does were placed into identical cages that were used for the double nursed group. In the group nursed by one doe, the does could enter the nest boxes in the morning for a period of 30 minutes to nurse their kits.

The suckling rabbits were weaned at the age of 3 weeks. Two rabbits were placed into a fattening cage. All the six groups were halved randomly and then the rabbits were fed either ad libitum or restricted. Restricted feeding which was planned to correspond to 80-85% of the ad libitum feed intake, was achieved by reducing the time available for eating: 10 hours a day at 4-6 weeks of age, 9 hours at 6-9 weeks of age, 8 hours at 9-12 weeks of age, 7 hours a day at 12-15 weeks of age, and 6 hours a day at 15-18 weeks of age (till the first mating). The restricted group was fed ad libitum during the last four days prior to their first mating. Prior to the insemination all the groups were randomly halved and the rabbits were inseminated at either 15.5 or 18.5 weeks of age. The rabbits failed to conceive were re-inseminated 3 weeks after the first insemination. The does that were not become pregnant after three successive insemination or showed bad condition and were sick were culled. Body weight and feed intake of the growing rabbits (n=785) were measured from the age of 3 weeks. Daily weight gain, daily feed intake and feed conversion ratio of the rabbits was calculated. Mortality of the rabbits was recorded continuously. At the age at first mating the condition of the rabbits was determined using CT (Siemens Somatom S40 spiral scanner). Evaluating the cross-sectional scans it was possible to determine the so called fat index. The HU variables were analysed using Hunsfield scale between -200 and +200 corresponding to fatty and muscle tissue. These sections were marked by scans for density analysis. From the obtained variables the index value could be calculated (Romvári, 1996).

In a randomly chosen group of the does (n=328) the daily feed intake was measured from the day of the first insemination till 3 days

before parturition then for 17 day initiating at the day of parturition for the first four parity. During their whole productive period body weight at parturition conception rate, litter size (total, alive, after equalization and at 21 days of age), litter weight at 21 days of age and mortality during the suckling period was recorded for all the does (n=464). The statistical analysis of the experimental data was carried out by means of multivariate analysis of variance (SPSS 10). Conception rate of the does and the mortality rate of the suckling rabbits were evaluated with Chi square test, while the various age groups' survival was compared applying survival analysis (SPSS 10).

In the course of survival analysis the certain groups were monitored during three successive periods: 0-21 days of age, 22-105 days of age and from the first insemination (15.5 or 18.5 weeks of age) till mortality or culling. Significance among the survival functions of the various groups were determined by the Log-Rank test (Kleinbaum, 1996).

3. Results

3.1. Performance during the rearing period

Feed consumption

Birth weigh had a significant effect on the feed intake at all age categories. Apart from the 3-4 weeks old groups where the difference was large (38%) the feed intake of the high birth weigh group exceeded

that of the low group by 8-15%. The effect of the number of nursing does on the feed intake was only significant at the age of 9-12 weeks. Double nursed rabbits consumed 7% more pellet at this age than those rabbits nursed only by one doe ($p<0.01$). The difference found among these groups (3-5%) at the age of 3-9 weeks was not significant. After the age of 12 weeks the feed consumption of the two groups was almost identical. The restriction of the time available for eating had a significant effect on the feed consumption between the ages of 4-18 weeks and resulted a difference of 21%, 15%, 16%, 18% and 16% between the two groups.

Body weight

Birth weight significantly affected the body weight up to 18 weeks of age (3, 4, 6, 9, 12, 15 and 18 weeks). The difference between the high and the low groups increased from 128 g to 287 g between the age categories of 3-15 weeks. The body weight of the groups nursed by two does exceeded that of the groups nursed by one doe by 123 g, 112 g, 159 g, 180 g, 182 g, 198 g and 123 g at the age of 3, 4, 6, 9, 12, 15 and 18 weeks, respectively. The difference of the body weight between the groups that were fed ad libitum or restricted was 9.3%, 9.7%, 11%, 14% and 13.8% at the age of 6, 9, 12, 15 and 18 weeks.

Daily weight gain

The daily weight gain was affected by the birth weight only at the age categories of 3-4 weeks and 12-15 weeks. The groups of larger birth

weight grew 31-33% and 6-10% faster than the rabbits of the low birth weight group. Number of nursing does affected the body weight gain significantly only between 4 and 6 and between 15 and 18 weeks of age. During the first period rabbits nursed by two does showed 6.7% higher weight gain than rabbits nursed by one doe. In the latter period however the weight gain of the rabbits nursed by one doe was superior (24%). Feeding regime exerted a significant influence on the weight gain at all age categories. Compared to the restricted group, the rabbits fed ad libitum achieved 20.4%, 10.3%, 13.1%, 11.3% and 8.5% higher body weight gain at the subsequent periods.

Feed conversion

Apart from the age of 9-12 weeks the feed conversion was independent from the birth weight. Generally the low birth weight groups showed better feed conversion than the other birth weight groups but the difference was not significant. Number of nursing does significantly affected the feed conversion between 9 and 12 weeks of age. The rabbits that were nursed by one doe achieved 8.8% better feed conversion than the double nursed rabbits.

Between 6 and 9 and 12 and 18 weeks of age the group nursed by one doe also showed more favourable feed conversion than the other group, the difference however could not be proven statistically. Feeding regime did not affect feed conversion in most of the cases. The ad libitum group had somewhat better feed conversion at all ages except in the period between 9 and 12 weeks of age; however, significant difference (21.1%) was found only between 15 and 18 weeks of age ($p<0.05$).

Mortality and survival of the suckling and growing rabbits

Mortality rate of the low birth weight groups exceeded that of the medium and large birth weight groups by 14.2% and 16.6% during the first 3 weeks and was also higher (8% and 6.9%) between 3 and 9 weeks of age. Although the mortality of the former group was also higher between 9 and 15 weeks of age this difference was not significant. Survival analysis also showed the significant effect of birth weight on the survival of rabbits. The cumulative survival of the medium and large birth weight was significantly higher than that of the low birth weight group between 0-21 days and between 22-108 days of age ($p<0.001$; $p<0.01$).

Mortality of the rabbits reared with one doe was 5% higher than the mortality of the group nursed by two does during the first three weeks which can be the consequence of the inferior milk supply experienced by the former group. Survival curves of the two groups were parallel during the first days after parturition but after the 4-5th day significant differences could be observed and the group reared by two does showed superior survival rate. Cumulative survival at the 21st day was 80.4% and 85.4% ($p=0.55$) for the groups reared with one or two does respectively. After the weaning at the age of 21 days the mortality of the groups were identical and the survival analysis between 21 and 108 days of age did not show any significant differences between the survival curves of the groups ($p=0.735$).

The rabbits weaned at the age of 3 weeks and then were fed ad libitum or restricted showed similar mortality at all ages. Similar conclusions could be drawn from survival analysis that is feeding regime

did not significantly affect the cumulative survival of the growing rabbits ($p=0.772$).

The pooled effect of the birth weight and the number of rearing does showed that during suckling high birth weight and nursing with two does had favourable effects on survival. After weaning large birth weight was favourable and low birth weight was unfavourable for the cumulative survival.

Condition determination by means of Computerised Tomography at the first insemination

The effect of birth weight was significant ($p<0.05$), the rabbits born with low birth weight showed less fat deposition as the muscle: fat pixel ratio was the highest in this group. The number of rearing does did not affect the condition though the double nursed group show somewhat higher fat deposition (lower pixel ratio). Feeding regime exerted a significant influence on condition, the restricted group had significantly higher muscle: fat pixel ratio than the ad libitum group ($p<0.001$). Age at first insemination also significantly affected muscle: fat pixel ratio. Those rabbit inseminated at the age of 18.5 weeks showed higher fat deposition than that of those rabbits that were first inseminated at the age of 15.5 weeks ($p<0.05$).

Detailed analysis of the various groups showed that muscle:fat pixel ratio of the restricted group first inseminated at the age of 15.5 and 18.5 weeks of age and of the ad libitum group first inseminated at the age of 15.5 and 18.5 weeks were 2.74, 2.59, 2.10 and 1.98, respectively.

3.2. Doe performance

3.2.1. First insemination and parturition

Body weight of the does

The does' body weight at the first insemination was significantly affected by all four factors; however, the body weight at parturition was only affected by the birth weight, number of nursing does and the feeding regime. The rabbits of higher birth weight, nursed by two does, fed ad libitum and inseminated at latter age had larger body weight ($p<0.001$).

Analysing the effect of feeding regime it was observed that the body weight rank of the ad libitum and the restricted group has been changed between the insemination and parturition. At the first insemination the body weight of the restricted group was significantly lower but from the initiation of the flushing these rabbits consumed more pellet consequently by the time of their first parturition they not only reached the level of body weight of the other group but showed superior body weight. The does inseminated at the age of 15.5 weeks obviously showed lower body weight compared to those rabbit inseminated at the age of 18.5 weeks (3.34 vs. 3.52 kg) but this difference disappeared by the time of the first parturition.

Conception rate, number of inseminations per parturition

The birth weight did not significantly affect the efficiency of the first insemination or the necessary number of inseminations for the first

parturition. Analysing the effect of the number of nursing does it could be concluded that both groups showed similar conception rates after the first insemination but the necessary number of inseminations for the first parturition was lower for the double nursed group by 10.6% ($p<0.05$). The restricted group inseminated at the age of 15.5 showed highly unfavourable conception rate. The difference of the conception rates between the restricted and ad libitum groups and between the groups inseminated at the age of 15.5 and 18.5 weeks were 36.1% and 14.9% respectively. The conception rate of the restricted group was unfavourable even when the rabbits were inseminated at a latter age (18.5 weeks). However, the ad libitum group showed conception rate above 75% even at the inseminating age of 15.5 weeks. Similar tendency was found for the number of inseminations per parturition but the size of the differences was much lower because the does that were not conceived after the first insemination showed high conception rate at the next insemination.

Litter size

At the first insemination the number of kits born alive and the total number of born kits were affected significantly only by the number of nursing does and by the feeding regime. The rabbits nursed by two does and fed ad libitum produced larger litters. The effect of the birth weight and age at first parturition on litter size was not detectable. The smallest litters were produced by does nursed by one doe and fed restricted while the double nursed and ad libitum fed does produced the largest litters. The difference (21%) was significant. The litter size at day

21 showed small nonsignificant differences among the various groups. Conceived either at the first or at the second insemination the number of total born kits, the number of kits born alive and the litter size at day 21 (from parturition) was only affected significantly by the number of the nursing does. In every occasion the litter size was higher by 0.52-0.54 kits in the groups nursed by two does.

Individual and litter weights at the age of 21 days

Born after the first insemination the litter weight was not affected significantly by any of the examined factors. Individual weight however was larger in the group that was fed restricted and inseminated at the age of 15.5 weeks. This result could partly be caused by the litter size as these does reared smaller litters.

Irrespective of the success of the first mating litter weight measured 3 weeks after parturition was only influenced significantly by the number of nursing does and by the feeding regime. In the former case the effect could partly be attributed to litter size as the individual weights in the two groups were not different. From the aspect of nutrition the restricted feeding after weaning had favourable effect as in this group both the individual and the litter weight was higher than in the group fed ad libitum. Although the offspring of the does inseminated at the age of 15.5 weeks showed higher individual weights than that of the does inseminated at the age of 18.5 weeks. The difference could be attributed to the different litter sizes of these groups as the litter weights were the same.

Mortality during the suckling period

Mortality during the suckling period was not affected by any of the examined factors and it varied between 6.6-8.3% regardless of the fact that the kits were born from the first or from the second insemination.

3.2.2. All parturitions

Feed intake of the does

Feed intake of the doe was not influenced by the birth weight in any of the examined period. During the flushing and the first gestation the rabbits nursed by one doe consumed more pellet but subsequently the feed consumption of the double nursed does was higher. The observed difference was significant at the first gestation and at the second lactation. The does fed restricted during the rearing period consumed more pellet in every period (except in the third lactation) than the does fed ad libitum during the rearing period. Nevertheless significant differences were found only during flushing and the forth lactation ($p<0.05$).

Body weight of the does

Birth weight exerted a significant influence on the body weight of the does. The body weight of does born with large birth weight exceeded the body weight of does of the other birth weight groups at every

measurement. The effect of the number of nursing does was significant for the first four parturitions. The body weight of the double nursed does was higher at every measurement (with 140 g on average) although the 6.9% difference at the beginning of the flushing was reduced to 4.5% till the fourth parturition. The restricted feeding had the largest impact on body weight. The does fed restricted during rearing but ad libitum during flushing and after their first insemination consumed more pellet than those fed ad libitum both in the rearing and productive period which resulted that the rank of body weight of these groups changed over time compared to each other. During the first four parturitions the body weight differences of the groups were 175, 137, 75 and 102 g in favour of the restricted group. These differences however were only significant at the first and at the second parturitions and after the seventh parturitions the body weigh differences between these groups decreased to minimum. The does that were inseminated at a younger age (15.5 weeks) showed lower body weight (3.34 kg) at the first insemination than the does inseminated at the age of 18.5 weeks (3.52 kg) yet at the first parturition the body weight of the former groups was slightly higher. The difference between the groups increased till the fourth parturition then decreased.

Number of inseminations per parturition

Birth weight and number of nursing does did not have a significant effect on the number of inseminations necessary for a successful parturition. The effect of the feeding regime was significant. Viewing the parturitions together the ad libitum group's performance was better (1.24 vs. 1.34; $p<0.05$) but from the third parturition the

performance of the restricted group was superior compared to the ad libitum group. Examining the average performance of all parturitions the does inseminated at 15.5 weeks of age showed higher performance than the does inseminated at the age of 18.5 weeks (1.28 vs. 1.36; $p<0.001$). The difference between the groups decreased over the successive parities but the above mentioned tendency has been remained.

Litter size

The effect of the birth weight on the litter size could no be proven. Litter size (total, alive and at 21 days) was affected by the number of nursing does, the double nursed does showed better performance. The does that were fed ad libitum produced significantly higher litters (total and alive) compared to the restricted group but this difference was not significant 3 weeks later. The does first inseminated at 15.5 weeks of age achieved better results for number of kits born alive and for total number of kits ($p<0.05$). Litter size at day 21 was the same for the two groups.

Litter weight and individual weight at the age of 21 days

Taking the average performance of the subsequent parturitions no significant differences were found among the groups.

3.3. Survival of the does

The survival of does was dependent on the initial birth weight ($p<0.05$). The number of the nursing does did not influence the doe s'survival ($p=0.923$). The cumulative survival of the restricted and ad libitum group practically was the same at the age of one year ($p=0.772$) but the survival prospects of the restricted group proved somewhat higher than that of the other group from the age of 700 days ($p=0.141$). The survival of the does was independent of the age at first insemination (15.5 vs. 18.5 weeks; $p=0.711$).

3.4. Life performance of the does

The does' lifetime production of the number of kits born alive was independent of the does' birth weight although the does of the low birth weight group showed better performance (+10.1 and 8.4%). Analysing the effect of the number of nursing does showed that the double nursed does' performance was better compared to the other group (8.8 and 9.8%) but the difference was not significant. The feeding regime during rearing also affected the lifetime production. The restricted group of the does had more parturition (+8.1%) and gave birth to more kits than the ad libitum group which was the consequence of their better condition. Age at first insemination did not affect the lifetime performance though the group inseminated at the age of 15.5 weeks showed somewhat better performance.

The most substantial effect was experienced throughout the whole experience could be attributed to the number of nursing does and feeding regime. Significant differences were not observed but the best performance was achieved by using two nursing does and restricted feeding during the rearing period.

4. Conclusions and recommendations

The objective of our analyses was to detect those rearing methods (nutrition circumstances) during the certain phases and age at first mating that improve the does' production level lengthen their longevity and increase their lifetime performance.

Birth weight has a strong effect on the mortality observed during the suckling period but the application of cross fostering (based on birth weight) can substantially reduce the mortality of the kits of low body weight and vitality. Better milk supply by itself does not guarantee better survival as kits nursed by two does also show higher mortality if their body weight was low. Kits of low body weight experienced higher mortality also after weaning. These results suggest that malnutrition during the foetal stage has an effect on the whole lifespan.

Correlation exists between the birth weight and body weight measured at latter ages. Individuals of low birth weight show lower body weight in their whole productive life than their contemporaries of higher birth weights. Our results justify that the unfavourable circumstances of the foetal period cannot be compensated for in the latter stages of life.

The reproductive performance of the does was independent of their birth weight yet the lifetime performance of does born with low

birth weight was the higher. This superiority may be explained that these does were born into large litters contrary to does that showed large birth weight. Nevertheless rabbits of low birth weights should not receive preference. Because of their low vitality their mortality rate is high which may serve as a natural selection resulting better average performance of the remaining rabbits. It may be beneficial to select the largest individuals of large litters as breeding animal candidates but to cull the problematic animals (e.g. sick) at any stage of their life.

Nursing with two does is a suitable method to improve the nutrient supply of the suckling kits. The better milk supply has a favourable effect on the mortality and result an increased body weight, better condition (higher fat deposition) that has a favourable detectable effect even for the does. Contrary to these results after insemination the does nursed by one doe showed higher conception rate and during the productive stage of the does no difference could be observed between the two groups. These findings suggest that from the viewpoint of conception higher body weight and better condition has no favourable effect.

Analysing the litter size however, the advantages of the better milk supply, higher body weight and better condition are undeniable. Besides the positive effects of the double nursing it also can be concluded that the advantages of this procedure can be achieved by alternative methods such as artificially decreasing the litter size leaving only the larger (mainly) female individuals.

The restricted feeding is a suitable procedure to control the feed intake independent of the actual age and body weight and holding the development at the optimal level. The 85% of the ad libitum feeding regime is appropriate to achieve the ideal condition at first mating. The

four day long flushing seems to be too short as even the group inseminated at the age of 18.5 showed low conception rate. According the recent literature a flushing length of 8 days can be suggested.

After stopping the restriction, the feed intake of the rabbits increases and according to the literature the digestibility of the nutrients also improves. As a result at the first parturition the body weight of the does reared under restricted feeding was higher than that of the ad libitum group. This phenomenon usually had a positive effect on the conception and following the highly unfavourable results at the first insemination the restricted group showed higher kindling rate. This improved performance however could not offset the unfavourable results experienced at the first insemination.

The insemination at the age of 15.5 weeks seems to be too early as these rabbits had low conception rate and gave birth to small litters. For the whole productive period these does needed more insemination in order to produce litters but the litter size was the higher in this group. As the age of the first insemination is determined by the mating schedule of the rabbit farm (date of the insemination after parturition) and by the number of the maternal groups it is not easy to alter the age at the first insemination. According to our results it is not worth waiting an older age for the rabbits to be inseminated but the too young age also has unfavourable effects. The comparison of the ages of 15.5 and 18.5 weeks at first insemination did not make it possible to determine the optimal age for insemination.

Analysing the various parameters of life performance it can be concluded that the number of parturitions can be improved by the restricted feeding after weaning while the total number of born kits can

be increased applying nursing with two does by 8-10%. The best lifetime production can be achieved in case of a good milk supply during suckling and 15% restriction of feed intake after weaning.

Based on the literature and on the results of our experiments the rearing of the breeding animal candidates require high attention as it is not useful to provide "favourable circumstances" at every stage of their life. Independently from their birth weight high milk supply during the suckling period, restricted feeding during the rearing period and applying a 8 day long flushing result breeding animals that produce large litters and show favourable lifetime production.

5. New experimental results

Based on our experiments the following new scientific results can be proposed:

- Nursing by one or two does and the applied feeding regime is a suitable method to influence the body weight and the condition of the does
- The better milk supply experienced during the suckling period improved the does' latter performance and resulted in increased total number of kits and number of kits born alive.
- Restricted feeding regime at 85% of the ad libitum level between weaning and first insemination resulted in higher conception rate of the does after the first parturition.
- The application of double nursing during suckling and restricted feeding during rearing favourably affects lifetime performance.

6. Publications on the subject of the dissertation

Papers published in peer-reviewed journals

Papers published in foreign-language peer-reviewed journals

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