The effect of season and parity order on fertility of rabbit does and kit growth

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ABSTRACT: The effect of season and parity order on doe fertility and rabbit growth was evaluated. Two hundred and fifty Hyplus® does were divided into five groups according to kindling, each in a given season of the year (September, December, February, April and June). Another five groups were separated by parity order (from the first to the fifth kindling). After weaning, each group of rabbits was fed until 77 days of age. The season of the year significantly affected service number of pregnancy, litter size, litter weight at birth, litter weight at 21 days, litter size at weaning as well as live weight at 77 days. Parity order affected service number of pregnancy and litter weight at 21 days in a more limited way. Significant interactions of season and parity order were determined in service number of pregnancy, with the highest values occurring in December (2.2, $P \leq 0.010$) and February (1.9, $P \leq 0.010$) at the second kindling. Litter size was the largest in December and at the fifth kindling. Significant interactions ($P \leq 0.015$) were also found in litter weight at 21 days, whereby litter weight had increased by the third kindling. However, the highest litter weight was reported after the fourth kindling in December.

Keywords: rabbit doe; season; parity order; fertility; rabbit growth

In Europe, wild rabbits (*Oryctolagus cuniculus*) have a well-defined seasonal reproduction cycle. Hammond and Marshall (1925) reported that most pregnancies occur between February and early August, with a peak in May. In intensive rabbitries, we try to reduce the effect of the season by optimization of environmental conditions like temperature, humidity, ventilation and lighting regime. In spite of the regulation of environmental conditions in rabbit houses season plays a significant role in relation to the reproduction of rabbit does. Rabbit does are very sensitive to heat stress, which could be an important factor influencing their fertility. Marai and Rashwan (2004) revealed that the doe is capable of producing 10 litters a year, but in a hot climate it has only 4 or 5 litters. Marai et al. (2004) stated that the season of the year was shown to have significantly affected litter weight at 21 days of age and kit body weight at birth.

The effect of the season on reproductive performance of rabbits could be different in does and in growing rabbits. Choudhary et al. (2001) described the highly influential effect of the season on gestation period, kindling interval and litter weight at weaning. Bhatt et al. (2002) found that litter size and weight at birth, litter size at weaning as well as litter weight at weaning were all higher during winter as compared to those during summer and the rainy season. Similar results were reported by Kumar et al. (2005) in Angora rabbits.

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As rabbit reproduction is affected by season, the effect of the season has also been revealed in weight gain. McNitt and Lukefahr (1993) reported a significant impact of the season on the growth of rabbits, with the lowest gain in summer. Also Marai et al. (2001) found that daily weight gain and feed intake of growing rabbits declined with heat stress. In concurrence with these findings, Bhatt et al. (2002) obtained the most successful results for rabbit reproduction during the winter season.

The most common reproduction rhythm on commercial rabbit farms is based on artificial insemination with a 42-day cycle. Intensive reproduction rhythms increase the annual production of the doe (Cervera et al., 1993) but the litter size, reproductive rate and lifetime length of fertility decrease (Xiccato et al., 2004; Castellini et al., 2006; Feugier and Fortun-Lamothe, 2006). Intensive reproduction results in high mortality (>30%); the turnover rate in rabbit breeding units is 120% (Guerder, 2002). Szendrö (2000) found that the parity order influences litter size, which is substantially lower on average at the first kindling than in subsequent litters. The largest litter size is to be anticipated at the second and third kindling, after which a gradual decrease has been observed. Xiccato et al. (2004) revealed that the litter size increased with parity order, while the average weight of kits borne alive decreased. Similarly, Castellini et al. (2006) described the effect of parity order on litter size, number of weaned rabbits and post-weaning mortality. Data oriented on the effect of parity order on kit growth are missing in literature.

The aim of the following study was to evaluate the effect of season and parity order on the fertility and growth of rabbits.

MATERIAL AND METHODS

This experiment was carried out on a commercial rabbit farm in eastern Bohemia and lasted one year. Ambient temperatures during the experiment are given in Table 1. Temperature in the housing facility ranged from 8°C in winter months to 26°C in summer months with a relative humidity of 60–75%. Two hundred and fifty Hyplus® does were divided into 5 groups of 50. Group 1 was with kindling in September, group 2 in December, group 3 in February, group 4 in April and group 5 in June. In each group, does from each of the 5 litters were evaluated (10 does selected from each litter). The rabbits were grouped according to age and similar live weight. Forty-two days reproductive rhythm was used, i.e. does were inseminated 11 days after kindling. Oestrus was provoked by Sergon and ovulation by Receptal preparation. Does were kept in Pedemontana single-level individual cages (Italy, 0.75 m^2 per doe). The lighting regime consisted of 16 h light and 8 h darkness. During the entire experiment the does were fed *ad libitum* a commercial feed mixture consisting of 17.5% crude protein, 10.5 MJ metabolizable energy, 1% crude fibre and 9% starch. Water was supplied *ad libitum* as well. On the farm, the reproduction rhythm was 42 days with weaning age at 35 days. During this period, reproduction traits, gestation period and service number of pregnancy were evaluated. On the day of kindling, litter size, litter weight and number of dead kits were recorded. At the age of 21 days litter size and litter weight were analyzed. Kits were weaned at 35 days and number of kits and their live weight were evaluated. After weaning, rabbits were fattened till 77 days of age (2 035 rabbits in total). The rabbits were individually weighed at the age of 21 and 77 days. Mortality in the fattening period was recorded daily. During the fattening period rabbits were placed into Pedemontana double-level cages (Italy, 0.09 m^2 per rabbit). Rabbits were fed a feed mixture of 16% crude fibre, 10.0 MJ metabolizable energy, 16 % crude fibre and 8.5% starch. Feed and water were available *ad libitum*. A twelve-hour photoperiod was used.

Table 1. Average temperatures (°C)

Group/month	Average temperature	Maximal temperature	Minimal temperature
1. (September)	11.0	17.0	9.1
2. (December)	–3.4	1.0	–11.0
3. (February)	3.6	9.2	–1.7
4. (April)	8.6	14.6	0.3
5. (June)	18.7	27.9	13.7

The data of the experiment were evaluated employing the two-way analysis of variance with season and parity order interactions using the GLM procedure of SAS (SAS Instatute Inc., Cary, Nc.). Relationships between characteristics were evaluated using Pearson's correlation coefficient.

RESULTS

As opposed to the season of the year, parity order had a higher effect on the majority of evaluated characteristics. There was no significant effect of season and parity order on gestation period

Table 2. The effect of season and age on doe fertility

Group/month	Parity order	Gestation period (days)	Service number of pregnancy	Litter size	Number of dead kits	Litter weight (g)
1. (September)	1	30.9	1.0^{b}	8.3^{c}	0.2	503
	2	31.0	1.2^{b}	7.4^{cd}	0.2	479
	3	30.5	1.5^{ab}	9.0^{bc}	0	601
	4	30.5	1.0^{b}	10.5^{b}	1.0	612
	5	31.0	2.0^{a}	10.5^{b}	1.0	550
2. (December)	1	30.7	1.0^{b}	7.7^{cd}	0.2	494
	2	30.6	2.2^{a}	10.1^{b}	0.9	577
	3	30.8	1.7^{ab}	7.3^{cd}	2.0	450
	4	30.5	1.7^{ab}	9.8^{b}	0.3	530
	5	31.0	1.5^{ab}	10.0^{b}	0	485
3. (February)	1	31.1	1.0^{ab}	7.9^{c}	1.1	493
	2	30.4	1.9^{a}	9.4^{bc}	0.3	548
	3	30.7	1.2^{b}	8.7^{c}	1.7	485
	4	30.7	1.0^{b}	8.7^{c}	0.3	437
	5	31.0	1.0^{b}	6.3^{d}	0	400
4. (April)	1	31.0	1.0^{b}	5.9^{d}	0	373
	2	30.7	1.7^{ab}	7.4^{cd}	0.7	424
	3	30.5	1.2^{b}	9.2^{bc}	0	521
	4	31.5	1.0^{b}	4.5^{e}	0	330
	5	29.0	1.0^{b}	13.0^{a}	0	600
5. (June)	1	30.9	1.0^{b}	7.8^{c}	0	447
	2	31.3	1.1^{b}	7.3^{cd}	0	470
	3	31.0	1.0^{b}	6.0^{d}	0	400
	4	31.0	1.2^{b}	7.0^{cd}	0.5	450
	5	31.5	1.7^{ab}	7.0^{cd}	0.9	430
Season		0.438	0.028	0.050	0.458	0.013
Parity order		0.608	0.001	0.213	0.860	0.554
Season × parity order		0.387	0.010	0.024	0.607	0.168

^{a,b,c,d}statistically significant differences ($P \leq 0.05$) in columns are designated by different superscripts

(Table 2) but generally, gestation period grew longer as the doe grew older. On the other hand, service number of pregnancy was affected by both factors. A significantly higher service number of pregnancy ($P \leq 0.028$) was recorded during winter months (December and February) and in the second kindling. In addition, significant interactions ($P \leq 0.01$) were found. It seems that the service number of pregnancy is a parameter of doe fertility which is influenced by both the season of the year and age. Significant interactions ($P \leq 0.024$) were determined also in litter size. The largest litter size in kindlings was in December and the smallest in April. In the majority of the cases studied, the highest number of kits per litter was in the fifth kindling. In spite of the fact that the largest litter size

Table 3. The effect of season and age on kit growth

Group/month	Parity order	Litter weight at 21 days (g)	Litter size at weaning	Rabbit weight at weaning (g)	Number of kits at 77 days	Rabbit weight at 77 days (g)
1. (September)	1	2 406^{d}	7.7	840	6.2^{ab}	2 673
	2	2 597^{c}	8.2	836	7.5^{ab}	2 635
	3	2 763^{bc}	8.0	865	7.8^{a}	2 536
	4	2 725^{bc}	8.0	898	7.5^{ab}	2 681
	5	2 585^{c}	7.5	917	7.0^{b}	2 754
2. (December)	1	2 625^{bc}	7.0	827	7.0^{b}	2 762
	2	2 885^{b}	7.2	918	7.0^{b}	2 661
	3	2 840^{b}	7.3	903	7.0^{b}	2 721
	4	2 650^{c}	8.5	830	8.2^{a}	2 735
	5	2 990^{b}	8.0	931	7.5^{ab}	2 793
3. (February)	1	2 862^{b}	6.8	953	6.5^{bc}	2 715
	2	2 917^{b}	7.8	888	7.6^{ab}	2 803
	3	2 485^{c}	7.0	863	7.0^{b}	2 720
	4	2 020^{e}	6.0	916	5.3^{c}	2 827
	5	2 596^{c}	6.0	890	5.7^{c}	2 751
4. (April)	1	2 681^{bc}	7.3	891	7.1^{b}	2 710
	2	2 737^{bc}	7.7	854	7.2^{ab}	2 661
	3	2 748^{bc}	7.0	801	6.3^{bc}	2 605
	4	1 875^{f}	4.0	983	4.0^{d}	2 783
	5	2 490^{c}	7.0	843	7.0^{b}	2 543
5. (June)	1	2 086^{e}	7.0	880	7.0^{b}	2 689
	2	2 448^{dc}	6.0	851	5.8^{c}	2 655
	3	3 350^{a}	7.0	1 000	7.0^{b}	2 671
	4	2 758^{bc}	6.1	897	5.9^{c}	2 665
	5	2 642^{c}	6.8	845	6.4^{bc}	2 659
Season		0.005	0.018	0.177	0.549	0.025
Parity order		0.020	0.815	0.533	0.746	0.300
Season × parity order		0.015	0.186	0.191	0.028	0.900

^{a,b,c}statistically significant differences ($P \leq 0.05$) in columns are designated by different superscripts

was registered in December, the highest number of dead kits occurred in this litter. Season also significantly affected ($P \leq 0.013$) litter weight. The heaviest litters were in September and the lightest in April. It seems that during warmer months of the year the characteristics such as litter size and litter weight were negatively influenced. This is presumably so because after winter does are in poorer health compared to the other months of the year. The effect of parity order on litter size was not significant. The lowest litter size was found in the first kindling and litter size gradually increased until the fifth kindling. Litter weight at 21 days (Table 3) was also found to be influenced by season and by parity order, the heaviest litters being in December. Litter weight increased until the third kindling, after which it declined. Significant interactions ($P \leq 0.005$) were determined by this factor.

Both factors had a lower impact on the growth of kits (Table 3). The live weight at weaning age (35 days) was significantly influenced neither by season nor by parity order. On the other hand, at the end of the growth experiment, at 77 days, a significantly higher live weight ($P \leq 0.025$) was reached by rabbits from kindlings in February; the lightest were in September and April. The mortality of growing kits was not affected. The number of kits at weaning and at 77 days of age correlated mainly with litter size at weaning. Significant interactions ($P \leq 0.028$) were revealed in the number of kits at 77 days, with the highest numbers in litters from December and at the fourth kindling.

The correlations of evaluated indicators (Table 4) show a slightly negative effect of the season on the of majority characteristics, with a higher impact on litter weight and litter size at weaning. A limited positive influence was found in parity order. High negative correlations (–0.618) were determined between gestation period and litter size. However, litter size correlated negligibly with other charac-

Table 4. Correlations of selected characteristics

Correlated characteristics		Correlation	Significance
Season	litter weight	–0.250	0.003
	litter size at weaning	–0.266	0.002
	rabbit weight at weaning	–0.254	0.003
Parity order	service number of pregnancy	0.145	0.092
	litter size	0.234	0.006
	litter weight	0.115	0181
Gestation period	litter size	–0.618	0.001
Litter size	litter weight	0.861	0.001
	litter size at 21 days	0.097	0.262
	litter weight at 21 days	0.131	0.129
	litter size at weaning	0.102	0.239
	live weight at weaning	0.009	0.911
	litter size at 77 days	0.001	0.995
	live weight at 77 days	–0.065	0.455
Litter size at 21 days	litter weight at 21 days	0.004	0.001
	litter size at weaning	0.836	0.001
	live weight at weaning	–0.385	0.001
	litter size at 77 days	0.751	0.001
	live weight at 77 days	–0.165	0.056
Litter size at weaning	live weight at weaning	–0.344	0.001
	litter size at 77 days	0.889	0.001
	live weight at 77 days	–0.204	0.017

teristics. Negative correlations were found between litter size at 21 days of age and at weaning in addition to rabbit weight at weaning and 77 days.

DISCUSSION

The gestation period of rabbit does is an indicator affected by diverse factors in a subtle way. In accordance with Marai et al. (2004), the length of gestation was affected by the season of the year. In addition, these findings confirmed that gestation period can be influenced by parity order as well. In rabbit does from the fourth or fifth kindlings, gestation period was on average longer than 31 days. Xiccato et al. (2004) described an insignificant effect of parity order on pregnancy length. This study found longer pregnancies at the third kindling in comparison with the first or second kindling. The relationship between gestation period and parity order could be connected with litter size well, because litter size increased with doe age, with high negative correlations.

Significant interactions in the service number of pregnancy show that the fertility rate was affected by both evaluated factors, with season having a higher impact. A higher rate of insemination was required in winter months than in the other seasons of the year. The lowest service number of pregnancy was determined at the second kindling. These results correspond with findings of Xiccato et al. (2004) and Castellini et al. (2006), who reported the effect of parity order on fertility rate. Xiccato et al. (2004) found no significantly lower fertility rate at the second kindling and Castellini et al. (2006) found a higher fertility rate in multiparous does as compared to primiparous ones.

The seasonal effect on litter size corresponds with the findings of Bhatt et al. (2002), Marai et al. (2004), Zapletal and Barabasz (2005). All these authors reported larger litter sizes in winter in comparison with the other months of the year. However, in winter months there was a higher number of dead kits in litters. The smallest litter size was at the first kindling, which is in agreement with Szendrö (2000), Xiccato et al. (2004) and Castellini et al. (2006). Fortun-Lamothe (2006) stated that the lower fertility of primiparous females is often attributed to the poor body condition. Xiccato et al. (2004) reported that primiparous does have a deficit in body energy, which can be considered an important cause of lower fertility. Litter size has been found to increase by the third kindling (Szendrö, 2000; Xiccato et al., 2004) and after that to gradually decrease (Szendrö, 2000). The results of our experiment differed from these data, with our litter size increasing by the fifth kindling. Significant interactions and correlations of season and doe age in litter size show that the effects of season and parity order are important for rabbit management. Worse results may be obtained during winter months in does at the first kindling because of the higher number of dead kits.

Litter weight was affected mainly by season, with negative correlations, and the results are similar to the findings of Bhatt et al. (2002) and Marai et al. (2004). There was no significant effect of parity order on litter weight, which is in contrast with Xiccato et al. (2004). Litter weight increased by the third kindling and then declined.

The growth of kits until weaning is limited by the milk production of the doe. Litter weight at 21 days gives good information about this variable. The significant effect of season on litter weight at 21 days corresponds with the results of Choudhary et al. (2001), Bhatt et al. (2002) and Marai et al. (2004). Higher litter weight in winter months may be connected with litter size, in accordance with Szendrö (2000), who found that the number of kits per litter affects the quantity of produced milk. However, young rabbits reared in larger litters have access to a smaller amount of milk. Ferguson et al. (1997) determined correlations between litter size and the amount of milk available per suckling kit at 21 days of age – 0.46. In our experiment these correlations were not negative and these results might have been influenced by the higher number of dead kits per litter. Litter weight at 21 days was affected by parity order as well by the decrease in litter weight at 21 days after the third kindling. The relationship between litter size and litter weight at 21 days is not clear because litter size increased by the fifth kindling. In addition, significant interactions may be described outline this complex effect of different factors on this parameter.

The effect of the season on litter size at weaning corresponds with the data of Choudhary et al. (2001), Bhatt et al. (2002) and Kumar et al. (2005). Conversely, no significant effect of season or parity order on litter size at 77 days was found, but there were significant interactions of both factors. The live weight of kits at weaning was not affected by season. Nevertheless, the effect of the season on live weight at 77 days of age was observed. These results are consistent with the findings of McNitt and Lukefahr

(1993) and de Leon et al. (2002), who also described interactions of the season of the year with breed in rabbit growth.

The results of this experiment revealed the effect of season and parity order on fertility and rabbit growth. In spite of the fact that the microclimate is controlled on intensive farms, the season of the year influences the doe reproduction. The effect was noted chiefly in service number of pregnancy, which was the worst in winter, and also in litter size, with a higher number of kits in winter, however with the highest number of dead kits in litters. On the other hand, kits born in winter grew faster in comparison with rabbits born during the other seasons of the year. Parity order affected the service number of pregnancy, with the highest rate of insemination at the second kindling. Significant interactions in service number of pregnancy, litter size at 21 days and litter size at 77 days of age may give some guidance to farm managers how to control the doe reproduction and subsequent rabbit growth.

REFERENCES

Bhatt R.S., Sharma S.R., Singh U., Kumar D., Bhasin V. (2002): Effect of different season on the performance of grey giant rabbits under sub-temperate Himalayan conditions. Asian-Australian Journal of Animal Sciences, 15, 812–820.

Castellini C., Dal Bosco A., Cardinali R. (2006): Long term effect of post-weaning rhythm on the body fat and performance of rabbit doe. Reproduction, Nutrition, Development, 46, 195–204.

Cervera C., Fernandez-Carmona J., Viudes P., Blas E. (1993): Effect of re-mating interval and diet on the performance of fiale rabbits and their litters. Animal Production, 56, 399–405.

Ferguson F.A., Lukefahr S.D., McNitt J.I. (1997): Preweaning variables influence on market traits in rabbits. Journal of Animal Science, 75, 611–621.

Feugier A., Fortun-Lamothe L. (2006): Extensive reproductive rhythm and early weaning improve body condition and fertility of rabbit does. Animal Research, 55, 459–470.

Fortun-Lamothe L. (2006): Energy balance and reproductive performance in rabbit does. Animal Reproduction Science, 93, 1–15.

Hammond J., Marshall F.H.A. (1925): Reproduction in the rabbit. Eds. Olivier and Boyd, Edinburgh, UK, 210.

Choudhary H., Goswami R.N., Das D., Das A., Roycoudhury R. (2001): Genetic studies on the reproductive performance of Soviet Chinchilla breed of rabbit under the agroclimatic conditions of North Eastern region. Indian Journal of Animal Sciences, 71, 946–949.

Kumar D., Singh U., Bhatt R.S., Risam K.S. (2005): Reproductive efficiency of fiale German Angora rabbits under Indian sud-temperate climatic conditions. World Rabbit Science, 13, 113–122.

De Leon R.P., Guzman G., Pubillones O., Garcia J., Mora M. (2002): Performance imported rabbit Leeds. Evaluation of pre-weaning growth. Cuban Journal of Agricultural Science, 36, 313–319.

Marai I.F.M., Rashwan A.A. (2004): Rabbit behavioural response to climatic and managerial conditions – a review. Archiv für Tierzucht, 47, 469–482.

Marai I.F.M., Ayytat M.S., Abd el-Monem U.M. (2001): Growth performance and reproductive trans at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation under Egyptian conditions. Tropical Animal Health and Production, 33, 451–462.

Marai I.F.M., Habeeb A.A.M., Gad A.E. (2004): Reproductive trans of female rabbits as affected by heat stress and lifting regime under subtropical conditions of Egypt. Animal Science, 78, 119–127.

McNitt J.I., Lukefahr S.D. (1993): Breed and environmental-effects on postweaning growth of rabbits. Journal of Animal Science, 71, 1996–2005.

Szendrő Z. (2000): The nutritional status of foetuses and suckling rabbits and its effect on their subsequent productivity: a review. In: Proceedings 7th World Rabbit Congress. Valencia, Spain, Vol. B, 375–393.

Xiccato G., Trocino A., Sartori A., Queaque P.I. (2004): Effect of parity order and litter weaning on the performance and body balance of rabbit does. Livestock Production Science, 85, 239–251.

Zapletal D., Barabasz B. (2005): Influence of season and mating on reproductive indices of Rex rabbits. Roczniki Naukowe Zootechniki, 22, 485–488.

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