Effect of does parity order on litter homogeneity parameters

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Research

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Abstract

Background: In rabbits reproductive performance, litter size and litter weight at birth, growth rate and mortality rate are the main factors that help to define the productive potential and they are influenced by the parity order. Birth weight represents a basic parameter in the management of a rabbit farm, because it is linked to mortality rate and weaning weight. Litter size affects the weight gained by suckling rabbits at weaning and it is connected with the chance of kits to find an available teat during the suckling period. For these reasons, it is of prime importance to study individual newborn and an intra-litter homogeneity parameters. This experimental study aimed to consider the litter homogeneity weight at birth, both within each litter and in the whole population, in order to suggest a proper litter homogenization practice.

Results: The 1st and 6th parity order showed respectively the lowest and highest values in litter size, born-alives, litter weight, born-alives weight and homogeneity. These parameters decreased in greater parity order. Not significant effects on still-borns number and mortality rate were recorded. All these litter homogeneity evaluation parameters appeared interesting in describe differences between parity orders.

Conclusions: The results of this research confirm that does parity order influences litter size and born-alives weight, but also the intra- and inter-litter homogenization. Litter homogenization is crucial to ensure proportionate share of milk, more equal growth and better productive performances. Based on these results we suggest equalizing primiparous with primiparous litters, and, consequently, the following parity orders among them.

Background

Reproductive performance of rabbit does, as well as litter size (LS) and litter weight at birth (LW), growth rate and mortality rate (MR) are the main factors that help to define the productive potential in a rabbit farm (Rebollar *et al.*, 2009). In rabbits, the parity order influences LW, individual weight and LS, which, on avarage, is substantially lower in the first kindling than in the subsequent litters (Szendrô, 2000). Litter size increases with parity order, while the average weight of kits born alive decreases (Xiccato *et al.*, 2004). Individual birth weight is about 60-70 g, but it can range from 35-40 to 80-90 g (Poigner *et al.*, 2000), and it generally diminishes when LS increases. It is well known that the birth weights of individual rabbits in large litters are lower than those in small litters (Vincente *et al.*, 1995). High birth weight represents a basic parameter in the management of a rabbit farm, because it is linked to a lower MR (Szendrô *et al.*, 1996; Di Meo *et al.*, 2004) and a higher weight at weaning (Di Meo *et al.*, 2004). Szendrô and Barna (1984) observed a mortality rate of about 50% in young rabbits between 35 and 45 g because energy reserves and thermoregulatory capacity were reduced, while beyond this weight level birth weight mortality was reduced to 7%. Moreover, LS significantly affects the weight gained by suckling rabbits at weaning: in fact, kits of larger litters generally show a lower weight at weaning than kits of smaller litters for the corresponding weight (Poigner *et al.*, 2000). This effect is connected with the chance of kits to find an available teat during the suckling period and on their milk intake. As acknowledged, with an increasing LS, the individual milk share is reduced (Lebas, 1975; Ferguson *et al.*, 1997) due to reduced access to the teat (Szendrô and Kampits, 1985). For these reasons, it is of prime importance to obtain a high individual weight and an intra-litter homogeneity weight at birth in order to reduce the MR, to increase the weight at weaning and, consequently, to improve the productive potential of the farm. However, litter homogenization is a common practice in rabbit farms in order to avoid high MR. Researchers demonstrate that, in homogenized litter for birth weight, mortality in the pre-weaning period is reduced from 13.3 to 10%, compared to inhomogeneous litters (Poigner *et al.*, 2000). A relevant number of studies that have been published focuses on the relationship between parity order and litter size, and on that of litter weight at birth and at weaning (Poigner *et al.*, 2000; Di Meo *et al.*, 2004). In these previous studies, however, nobody had never considered the intra-litter homogeneity at birth as a fundamental parameter, able to influence the following breeding productive phases.

This experimental study aimed to confirm the known effects of does parity order in litter parameters, e.g. litter size, litter weight, individual kits weight and mortality, since these data are really important in rabbit genetic centers. Moreover, this is the first experimental study that considers the litter homogeneity weight at birth, both within each litter and in the whole population, in order to suggest a proper litter homogenization practice.

Methods

Rearing building, equipment and management

The trial was carried out in Martini Group S.p.A. genetic center located in the Emilia Romagna region (Italy). The does (Genetica Martini hybrid) were housed in two different brick sheds with a temperature ranging between 18-28 °C, with a conditioning air system and submitted to a constant photoperiod of 16-h light and 8-h darkness. The animals were kept in individual cages from fecundation to parturition. Does were bred individually, in cages (410 x 940 x 400 mm) made of galvanized wire net equipped with automatic drinker and manual feeder. The cages were equipped with a nest box (410 x 210 x 300 mm) made of galvanized sheet walls and a double wire floor, with manual closure. The nest was prepared with a mixture of wood shavings and chopped straw, and it was attached to the front side of the maternal cage just before kindling. Does were fecundated 11 days after kindling. Until the 10th day of pregnancy, they are fed ad-libitum with the “Lactation diet”, then with the “Pre-weaning diet”; the latest contained almost the same ingredients as the first one, but at different inclusion rates. The chemical composition and nutritive value of the diets followed the recommendations of De Blas and Mateos (1998), listed in Table 1. The chemical analysis of the two diets was made according to the AOAC official methods (2016) for dry matter (oven drying method), ash (muffle furnace incineration), ether extract (solvent extraction), crude protein (Kjeldahl method) and crude fiber (Weende method) determinations.

Table 1. Composition of the diets fed to does (as fed).

	Lactation[1]	Pre-weaning[2]
Chemical composition, %		
Crude Protein, %	17.3	16.2
Ether Extract, %	3.9	3.3
Ash, %	7.8	8.2
Crude Fiber, %	15.6	17.3
Calcium, %	0.97	1.20
Phosphorus, %	0.55	0.54
Sodium, %	0.21	0.21
Lysine, %	0.78	0.77
Methionine, %	0.29	0.26
Vitamins, minerals and additives, per kg		
Vit. A, UI	15000	15000
Vit. D3, UI	1500	1500
Vit. E, mg	90	100
Mn, mg	50	50
Zn, mg	70	70
Co, mg	0.13	0.13
Cu, mg	10	10
Fe, mg	150	150
I, mg	3	3
Se, mg	0.1	0.1
Robenidine Cloridate, mg	66	66
Formic Acid, mg	1125	1125

[1] Lactation diet ingredients: wheat bran, alfalfa meal, barley, partially decorticated sunflower extraction meal, decorticated sunflower extraction meal, dehydrated alfalfa meal, wheat middling, dehydrated beat pulp, grass hay meal, cane molasses, wheat, corn oil, calcium carbonate, sodium chloride, palm oil, magnesium oxide.

[2] Pre-weaning diet ingredients: partially decorticated sunflower extraction meal, wheat bran, barley, dehydrated beat pulp, dehydrated alfalfa meal, alfalfa meal, wheat middling, grapeseed extraction meal, grass hay meal, cane molasses, decorticated sunflower extraction meal, calcium carbonate, corn oil, sodium chloride, magnesium oxide.

Animals and experimental measurements

The measurements were performed twice in spring, within 15 days from each other, according to the insemination protocol used in the genetic center. All the parturient rabbit does that were in the center on that dates, were enrolled in the study. Does hybrid maternal line was internally selected by the genetic center. A total of 531 does at different parity order were involved; 176 (33.15%) primaparous and 355 (66.85%) pluriparous (from the 2^{nd} to the 17^{th} parturition). The proportions of the pluriparous were the following: 15.63% 2^{nd}, 15.63% 3^{rd}, 10.73% 4^{th}, 11.86% 5^{th}, 6.78% 6^{th}, 3.39% 7^{th}, 5.46% 8^{th}, 4.33% 9^{th} and 3.77% from the 10^{th} to the 17^{th} parturition (1.88% 10^{th}, 1.13% 11^{th}, 0.38% 12^{th}, 0.19% 13^{th} and 0.19% 17^{th} parturition). A schematic division of the parity order of does is reported in Table 2.

Table 2. Schematic representation of does parity order distribution.

	Parity order													
	Prim.	Plur. (n° = 355)												
	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}	7^{th}	8^{th}	9^{th}	10^{th}	11^{th}	12^{th}	13^{th}	17^{th}
N° does	176	83	57	63	36	18	29	23	26	10	6	2	1	1
%	33.15	66.85												
		15.6	10.7	11.9	6.8	3.4	5.5	4.3	4.9	3.8				
										1.9	1.1	0.4	0.2	0.2

Within 24 hours from the delivery, the reproductive and litters data, e.g. litter size (LS), born-alives number (BA) and still-borns number (SB) per delivery, were recorded. Each born-alive kit was individually weighted using an electronic scale of 3000 g capacity and 1 g resolution. Total litter weight (LW) was calculated by adding to each alive newborn a singular weight. Mortality rate (MR) was calculated as a percentage of SB/LS *100.

Due to the low chance of survival of kits with body weight at birth lower than 45g, as reported by Szendrô and Barna (1984), we introduced this parameter in the data analysis as born-alives number <45g (BAW <45g) number (n°) and percentage (%).

Mean born-alives weight (mn-BAW), standard deviation born-alives weight (sd-BAW) and 1^{st} and 3^{rd} quartiles born-alives weight (1^{st} and 3^{rd} q-BAW) were calculated. Considering the entire population, mn-BAW, sd-BAW and 1^{st} and 3^{rd} q-BAW resulted, respectively, 59.39g, 12.57g, 51g and 58g. These thresholds were used for comparing each BAW grouped by parity order. The born-alives distribution parameters 1^{st}-3^{rd} q-BAW, <1^{st} q-BAW, >3^{rd} q-BAW, number (n°) and percentage (%) were evaluated. Kits included in 1^{st}-3^{rd} q-BAW represented the population part most homogeneous in weight; this part is between the 25% lighter (<1^{st} q-BAW = 51g) and the 25% heavier (>3^{rd} q-BAW = 68g). The choice of using quartiles was made because it better describes kits homogeneity compared to the entire population. We introduced these new parameters since the evaluation of the litter homogeneity is a crucial point in rabbit genetic centers.

Statistical analysis

The items LS, BA, SB, MR, LW, BAW<45g, mn-BAW, sd-BAW and q-BAW, and related parameters, were analyzed using the model for parity order effect according to the One way Anova procedure. Significant differences were declared for $P < 0.05$, very significant for $P < 0.01$ and trends for $P < 0.10$ were noticed. Differences were separated using Tukey's adjusted P-values when a significant F-test ($P < 0.05$) was detected. All data were processed using R value (version 3.6.3, 2020-02-29).

Results

Results regarding LS, BA, SB, MR, LW and BAW <45g n° and % are reported in Table 3. The LS and BA at birth were significantly affected by parity order ($P < 0.01$). They were lower in the first parturition (8.96 and 8.36, respectively), then gradually increased until the 6th parity order, when the maximum numerical values were reached (12.39 and 12.22, respectively). After the 7th parity order, these parameters decreased significantly. The parity order effect on SB and MR did not result significantly different (P = 0.71 and 0.54, respectively). Especially SB number was stable until the 4th parturition (0.59 on average), then numerically decreased from the 5th to the 7th parturition (0.22 on average); after high variability was observed. MR had a specular pattern among parity orders. LW significantly increased among parity orders (P < 0.01) with the minimum in the 1st (456.39 g) and the maximum in the 6th (719.78 g) parturition, according with LS and BA results.

At last, BAW <45g n° and % were significantly affected by parity order (P < 0.01). The highest values of these parameters occurred in the 1st parturition (1.83 and 18.69, in BAW <45g n° and % respectively).

Table 3. Effect of parity order on litter performance/parameters.

	Parity order											
Item	1	2	3	4	5	6	7	8	9	+	SEM	P
LS, n°	8.96^{B}	10.26^{A}	10.23^{AB}	10.94^{A}	9.91^{AB}	12.39^{A}	11.00^{A}	10.52^{AB}	10.08^{AB}	9.80^{AB}	0.47	<.01
BA, n°	8.36^{C}	9.64^{B}	9.64^{BC}	10.39^{AB}	9.66^{ABC}	12.22^{A}	10.76^{AB}	9.91^{ABC}	9.92^{ABC}	9.25^{ABC}	0.49	<.01
SB, n°	0.60	0.62	0.59	0.56	0.26	0.17	0.24	0.61	0.15	0.55	0.24	0.71
MR, %	6.22	6.17	6.25	4.96	2.60	1.28	2.46	6.81	1.35	4.22	2.30	0.54
LW, g	456.4^{C}	582.6^{B}	616.8^{AB}	655.8^{AB}	598.5^{AB}	719.8^{A}	659.9^{AB}	610.4^{AB}	622.1^{AB}	581.4^{AB}	23.11	<.01
BAW <45g, n°	1.83^{A}	1.35^{AB}	0.84^{AB}	0.88^{B}	1.20^{AB}	1.67^{AB}	1.41^{AB}	0.83^{AB}	0.62^{AB}	0.90^{AB}	0.34	<.01
BAW <45g, %	18.69^{A}	12.44^{AB}	7.67^{B}	7.20^{B}	10.31^{AB}	11.76^{AB}	10.05^{AB}	6.98^{AB}	5.51^{B}	9.51^{AB}	2.97	<.01

The results reported in Table 4 about mn-BAW, sd-BAW, 1st-3rd q-BAW (n° and %), <1st q-BAW (n° and %) and >3rd q-BAW (n° and %) took into consideration kits distribution relationship with the whole population. mn-BAW resulted the lowest at 1st parturition (-7.00 g comparing to following parturitions mean, P < 0.01). Similar results were observed in sd-BAW, where minor variability was observed in the 1st parturition (P < 0.01). Considering 1st-3rd q-BAW (n°), differences have been noticed only between the 1st and the 6th parity order (P < 0.01). The former had the lowest number of kits included in this range (4.27 1st-3rd q-BAW/8.36 BA), while the latter the highest (7.39 1st-3rd q-BAW /12.22 BA). However, calculating the ratio percentage of this parameter, no differences are showed (P =0.44).

Table 4. Effect of parity order on litter distribution parameters.

	Parity order											
Item	1	2	3	4	5	6	7	8	9	+	SEM	*P*
mn-BAW, g	56.23^{B}	61.54^{A}	64.36^{A}	64.17^{A}	63.78^{A}	59.56^{AB}	63.07^{A}	63.51^{A}	64.63^{A}	64.53^{A}	1.64	<.01
sd-BAW, g	6.83^{B}	8.25^{A}	8.60^{A}	9.17^{A}	8.84^{A}	9.04^{AB}	9.49^{A}	7.97^{AB}	8.94^{A}	7.98^{AB}	0.51	<.01
1st-3rd q-BAW, n°	4.27^{C}	5.54^{AB}	4.82^{BC}	5.11^{ABC}	4.66^{BC}	7.39^{A}	4.90^{ABC}	5.91^{ABC}	5.23^{ABC}	4.70^{ABC}	0.48	<.01
1st-3rd q-BAW, %	51.28	51.63	46.31	47.45	46.67	61.59	43.87	54.89	49.51	46.77	4.42	0.44
<1st q-BAW, n°	3.16^{A}	2.34^{AB}	1.69^{B}	1.53^{B}	1.77^{AB}	2.39^{AB}	2.17^{AB}	1.61^{AB}	1.58^{AB}	1.25^{AB}	0.46	<.01
<1st q-BAW, %	32.69^{A}	20.65^{B}	15.25^{B}	12.79^{B}	15.38^{B}	17.74^{AB}	16.44^{B}	13.98^{B}	13.94^{B}	12.94^{B}	4.00	<.01
>3rd q-BAW, n°	0.97^{C}	2.00^{B}	3.31^{A}	3.75^{A}	3.23^{AB}	2.44^{ABC}	3.69^{A}	2.39^{ABC}	3.12^{AB}	3.30^{AB}	0.35	<.01
>3rd q-BAW, %	16.03^{B}	27.73^{AB}	38.44^{A}	39.76^{A}	37.96^{A}	20.66^{AB}	39.69^{A}	31.14^{AB}	36.55^{A}	40.29^{A}	5.01	<.01

The 1st quartile results were statistically different in primiparous group respect pluriparous ($P < 0.01$), both in number and percentage. Many primiparous' kits belonged to the 1st quartile (3.16 <1st q-BAW/8.36 BA), while the 3rd and 4th parity order had the lowest indices (1.69/9.64 and 1.53/10.39, <1st q-BAW/BA, respectively). Percentage values were in accordance with them: primiparous had the highest percentage (32.69%) compared to the pluriparous does (15.46% on average). Similar, but opposite results were reported in values above the 3rd quartile ($P < 0.01$). In this case, the 1st parturition showed the minimum value of kits belonging to the 3rd quartile (0.97 >3rd q-BAW/8.36 BA), while the maximum number was numerically reached in the 3rd, 4th and 7th parity orders (respectively, 3.31/9.64, 3.75/10.39 and 3.69/10.76, 3rd q-BAW/BA). Similar results were reached for the percentage values ($P < 0.01$): only the 16.03% of kits in the primiparous group belonged to the 3rd quartile, compared to pluriparous (34.69% on average).

Discussion

In this study the effects of does parity order on litter parameters were evaluated. As regards the relationship between parity order and reproductive traits, our results agreed with existing literature describing greater LS and LW at birth with an increase on parity order (Szendrô, 2000). The 1st parturition showed the lowest values in LS, BA, LW and mn-BAW, according to Szendrô (2000) and Xiccato *et al.* (2004). It is known that, when rabbit does start their reproductive life, they usually have not achieved their total body development yet (Rebollar *et al.*, 2009) and for this reason the litter parameters are lower compared to the following parturitions. In light of this assumption, in our study LS, BA and LW reached the highest values in the 6th parturition when does had already achieved adult body size. Then, LS, BA and LW started to decrease. On the contrary, mn-BAW did not differ from the 2nd parturition, confirming that kits mean weight do not change among the parity order, except for the first one.

In this study there were not significant effects of parity order on SB and MR. However, both litter size and birth weight affected mortality in suckling rabbits (Poigner *et al.*, 2000). Nevertheless, our results need more data for a deeper evaluation, because SB and MR play an important role in genetic center management.

The results concerning BAW <45g n° and % are important to evaluate the litter viability (Szendrô and Barna, 1984). Primiparous does had litters with the highest number and percentage of kits below 45g, probably indicating that young rabbits are more inclined to die in the days after the partum (Szendrô and Barna, 1984; Poigner *et al.*, 2000).

Since homogeneity evaluation is important not only within each litter, but also for the entire population, kits weight at birth was compared among the different parity orders using quartiles. Litter homogeneity was related to the number of kits in the 1st-3rd quartile range: the more kits were in this range, the more homogeneous the litter was. When the results were expressed in percentage, they showed a ratio between kits number in the 1st-3rd quartile range and born alive. Important differences among the parity orders were noticed. In particular, the 6th parity order had the highest number of kits included in the range, while the first one the lowest. This means that the 6th parity order was the most homogeneous due to the highest number of kits in 1st-3rd quartile range. On the other hand, the 1st parturition was the less homogeneous one. However, these results in percentage did not show any differences among the various parity orders, because percentage values were influenced by the size of the litter. The number of kits below the 1st quartile was the highest in the 1st parturition and the lowest in the 2nd, 3rd, 4th, 5th and 7th, whereas no differences were found in the others. The percentage values confirmed the previous statements. The highest number of kits above the 3rd quartile was in the 3rd, 4th and 7th parturition, while the lowest was in the 1st one; the other parity orders were subjected to variability. Results expressed in percentage showed minor differences. In light of the results obtained, primiparous does had smaller litters with lighter kits, homogeneous between them, but heterogeneous compared to the remaining part of the population. On the other hand, the other parity orders shared similar characteristics, such as larger litters and heavier kits at birth. In particular, the 6th parturition was the most homogeneous, while the 3rd, 4th and 7th included few light kits and many heavy kits.

Conclusions

The results of this research confirm that does parity order influences litter size and born-alives weight, but also the intra- and inter-litter homogenization.

In conclusion, given the results, authors suggest to perform litter homogenization in the genetic center. In fact, a proper litter homogenization consists in a reduced competition between kits in order to obtain a proportionate share of milk, resulting in more equal growth and better productive performances.

To achieve this result, considering the differences in body weight previously described between primiparous and pluriparous, it is preferable for the farmer to choose to equalize primiparous litters with primiparous, and, consequently, the parity orders among them.

Declarations

Ethics approval and consent to participate: this study did not need the approval by the University of Bologna, Animal Care and Use Committee, according to Italian legislation (D.lgs. 26/2014).

Consent for publication: not applicable.

Availability of data and material: the datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interest: the authors declare that they have no competing interests.

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Authors' contribution: MT, AF and DF conceived and performed the experiment; DC performed the analysis; MP and MT interpreted the results, drafted and revised the manuscript. All authors read and approved the final manuscript.

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List of abbreviations: Prim: primiparous does; Plur: pluriparous does; LS: litter size; LW: litter weight; MR: mortality rate; BA: born-alives number; SB: still-borns number**;** BAW: born-alives weight; mn-BAW: mean born-alives weight; sd-BAW: standard deviation born-alives weight; 1st q-BAW: first quartile born-alives weight; 3rd q-BAW: third quartile born-alives weight.

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