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REPRODUCTIVE PERFORMANCE OF MALE RABBITS OF ALGERIAN LOCAL POPULATION

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Abstract: A total of 267 rabbit does and 46 bucks from a local Algerian population were controlled during 6 generations (from G0 to G5) at the experimental farm of the University of Tizi-Ouzou. Natural mating was used and 1412 presentations were analysed. Reproductive and growing performance were analysed taking into account the effect of the buck, its age, the generation, the season of mating (or kindling) and the physiological status of does at the moment of the mating. The buck influenced the acceptance rate ($P<0.001$), kindling rate ($P=0.032$), litter size at birth and at weaning ($P<0.001$), litter weight at birth ($P<0.001$) and at weaning ($P=0.034$), the mean weaning weight ($P=0.018$) and consequently the ponderal productivity at weaning (weight of rabbits produced at weaning/mating, P<0.001). Nevertheless, the ponderal productivity was also influenced by the age of bucks, the generation, the season and the physiological status of does at the moment of mating. The highest acceptation rate was recorded in autumn in non lactating does (primiparous and multiparous). Productivity was higher for bucks 5-10 mo old but decreased thereafter. Productivity was higher in spring, particularly for multiparous and lactating does and highly varied with the generation, evidencing the importance of environmental conditions.

Key Words: rabbit, Algerian local population, buck, reproduction.

INTRODUCTION

In recent years, several works have examined the reproductive traits of Algerian local population does (Berchiche *et al.*, 2000; Zerrouki *et al.*, 2001, 2002, 2005a), but no study has been done on the local male rabbit. Male rabbits are undoubtedly the basis of reproductive success, given that farm profitability depends not only on the female's fertility but also upon the buck. Male fertility is also an interesting trait in rabbit breeding, because together with the doe it determines reproductive and productive success. Moreover, due to the fertilising capacity of semen, the male can influence not only fertility and conception but also the productivity of the does.

Thus, the aim of this study was to investigate the contribution of the bucks in the reproductive performance of the Algerian local rabbit population to provide information on their performance under natural mating which could be exploited for genetic selection.

MATERIALS AND METHODS

Animals

At the experimental farm of the University of Tizi-Ouzou, 267 females and 46 bucks of local Algerian population were systematically controlled for reproductive performance between March 1998 and August 2002, over 6 generations (G0 to G5).

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The animals came from small farms bordering the city of Tizi-Ouzou (Freha and Mekla, Algeria). These animals had a heterogeneous and variegated coat. The initial herd was composed of 32 females and 6 males, whose reproductive performance was controlled between March and September 1998. Subsequent generations were kept in closed population for 5 generations. During the G0 generation, the animals were chosen according to their health status. From G1 to G5, the animals were selected from the offspring of the best females showing regular reproduction and good health conditions.

Breeding conditions

Females were housed individually in wire cages arranged in flat-deck layout on one level. The cages were equipped with a hopper for food and an automatic watering system. Bucks were housed individually in cages in the same room as the females. Generations G0 to G2 were kept under natural lighting, whereas the next generations were maintained under an artificial photoperiod of 16 h of light per day. Day length was 10 h in winter and 14 h in summer. Winters were characterised by an average daily temperature of 12.4°C (minimum 7.4°C); in summer the daily mean temperature was 28°C (maximum 35.7°C). G0 and G1 generations were fed a commercial pelleted food containing 16.6% crude protein, 3670 kcal/kg DM total energy and 12.3% crude fibre. For the 4 following generations, another feed was formulated in the laboratory to increase the levels of energy and protein and containing 17.8% crude protein, 3990 kcal/kg DM total energy and 14.4% crude fibre. Feeding and watering were provided *ad libitum.*

Management

The first mating was performed at an average age of 4.5 mo for both males and females. The reproduction rhythm was semi intensive based on natural mating (kindling-mating theoretical interval of 10 to 12 d). Males and does were weighed at the time of mating. Those females which refused mating were presented again the following day. If they refused, they were not presented until the following week until acceptance. Females were eliminated after 5 successive failed matings, but males were removed only due to health disorders. Pregnancy diagnosis was performed by abdominal palpation of the does 10 to 11 d after mating and non-pregnant females were presented again to the male on the same day. At kindling, does' weight and litter size (total kits born, kits born alive, number of stillborn) and litter weight were recorded. Litters were not standardised after parturition. Litter size and litter weight at weaning (28 d after kindling) were also registered.

Statistical analysis

Parameters analysed were the acceptance rate (percentage of females accepting the mating), the male's weight at mating, kindling rate (percentage of mated females giving birth and proportion of females which accepted service), prolificacy (total born, born alive, number of stillborn), number of weaned, number of kits died between birth and weaning, litter weight at birth and at weaning, the average weight of kits at birth and at weaning, productivity at weaning (number of weaned/mating) and ponderal productivity (rabbit weight produced at weaning/mating). All variables were submitted to analysis of variance using SAS software, taking into account the fixed effects of the buck (46 levels: 1 to 46), generation (6 levels: 0 to 5), the age of the buck (4 levels: <5 mo,≥ 5 and <10 mo, ≥ 10 and <15 mo, and ≥ 15 mo), the season of mating or kindling (4 levels: autumn, winter, spring, and summer), the physiological status of the doe at time of mating (5 levels: nulliparous, primiparous non-lactating, primiparous lactating, multiparous non-lactating, and multiparous lactating) and the interaction between season and physiological status. The other interactions considered 2 by 2 were not significant, so were not taken into account. However, for the data analysis at weaning, numbers were insufficient to test the interaction between season and physiological status of the does at the moment of mating. The acceptance rate and kindling rate were considered as Bernoulli variables (variable 0 or 1) and treated with the model analysis of variance above presented, as continuous classic variables. The means were compared using the Bonferroni test.

RESULTS

A total of 1412 presentations from 46 males belonging to the 6 generations were analysed, taking into account the previously mentioned parameters.

Acceptance rate

For all 46 males studied, the acceptance rate (Table 1) was significantly influenced by the buck ($P<0.001$). Acceptance rate ranged from 37.2 to 95.4% and was affected by generation ($P<0.001$), decreasing from the initial to the 5th generation. This reduction (–11.7%) was especially high between generations 2 and 3, but did not differ between the first two and the last 3 generations. The acceptance rate was also affected by bucks' age ($P<0.001$), decreasing gradually with increasing age of males. In particular, the acceptance rate was greatly reduced when the buck's age was higher than 15 mo. In addition, the acceptance rate was influenced by the season of mating ($P=0.006$), as females were more receptive in autumn and summer than in winter and spring. However, there was an interaction between season and the physiological status. As shown in Figure 1, the acceptance rate was higher in autumn in non-lactating does (primiparous or multiparous), but the physiological status of does at the time of mating had no significant effect on the acceptance rate (Table 1).

Buck's weight at mating

At mating, the mean buck's weight varied significantly ($P<0.001$) according to the bucks (Table 1). The average male weight at mating also varied according to generation ($P<0.001$), decreasing significantly from the 4th generation and remaining low in the 5th one. The age of bucks influenced the weight at mating ($P<0.001$) and younger rabbits (<5 mo) were lighter (2796 g). The weight increased steadily up to 10 mo, but did not vary significantly thereafter. The season of mating also influenced the male's weight ($P<0.001$). Bucks were heavier in winter and lighter in summer.

Fertility

The majority of the 46 bucks had good fertility and for 24 of them it ranged from 70 to 93.7%. Eighteen bucks had a fertility between 50 and 70%, and only 4 showed a fertility lower than 50%. It must be remembered that to be able to perform this analysis, no male had to be removed due to infertility. In the same way as the acceptance rate, kindling rate decreased significantly with age of the buck ($P=0.030$). Younger males (<5 mo) were more fertile (Table 1). Over 10 mo, fertility decreased (59.8 and 59.4% respectively for males whose age was comprised between 10 and 15 mo and more than 15 mo). Neither the generation, the season of mating or the physiological status of does at mating influenced the fertility.

Litter size and litter weight at birth

Litter size results are presented in Table 1. The buck had affected all variables measured at birth, except the number of stillborn and the weight of kits at birth. All variables analysed were significantly affected by the generation, with the exception of kits' weight at birth. Total born was higher in G1 and then decreased in G2 and increased again in G3 ($P=0.008$). The lowest values were recorded in G4 and G5, which did not differ significantly. The number of born alive was higher in generations G0, G1 and G3 ($P<0.001$), while lower values were recorded in generations G2, G4 and G5. In these generations, the number of stillborn was significantly greater especially in G2 (2.6 stillborn). Litter weight at birth was higher in G0 and lower in G2, and intermediate for the other generations ($P=0.004$).

The age of the buck influenced total born ($P=0.008$); the males less than 10 mo old showed higher litter sizes at birth. Kindling season did not influence either litter size and weight or individual kits weight at birth.

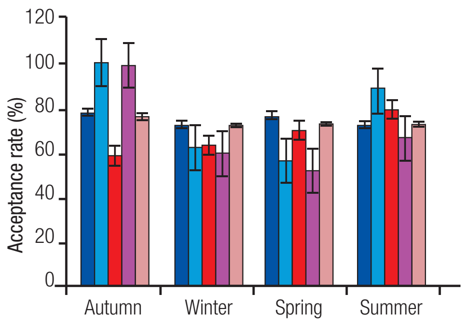

Figure 1: Interaction between the mating season and the physiological status of does on acceptance rate: Nulliparous, Primiparous non lactating, Primiparous lactating, Multiparous non lactating, Multiparous lactating.

Table 1: Acceptance rate, buck's weight at mating and performances at birth, according to the buck, its age, generation, mating season and physiological status of the doe. Results of variance analysis (least square means).

	No.	Acceptance rate (%)	Buck's weight at mating (g)	Kindling rate (%)	Total born	Born alive	Stillborn	Litter weight (g)	Mean kits weight at birth (g)
Mean	1412	77.7	3065	71.6	7.12	5.35	1.76	291	50
Standard error		39.3	249	44.0	2.37	2.93	2.51	113	11
Buck (*P*-value)	1412	$P<0.001$	$P<0.001$	$P<0.01$	$P<0.001$	$P<0.001$	NS	$P<0.001$	NS
Generation									
0	134	82.8^{ab}	3232^{a}	65.9	7.31^{abc}	6.37^{a}	0.93^{a}	327^{a}	49
1	256	80.0^{a}	*	77.4	7.69^{a}	6.09^{a}	1.60^{a}	295^{ac}	46
2	310	80.6^{a}	3138^{b}	66.9	6.81^{bc}	4.21^{bc}	2.60^{b}	242^{bc}	47
3	267	68.9^{bcd}	3222^{a}	63.6	7.27^{ab}	6.19^{a}	1.08^{a}	299^{ac}	48
4	182	66.5^{cd}	2914^{c}	64.0	6.75^{bc}	5.19^{ac}	1.56^{a}	284^{ac}	51
5	263	56.6^{d}	2986^{c}	73.5	6.31^{c}	4.45^{c}	1.86^{ab}	260^{c}	49
P-value		$P<0.001$	$P<0.001$	NS	$P<0.01$	$P<0.001$	$P<0.001$	$P<0.01$	NS
Age									
<5 mo	200	82.8^{a}	2796^{a}	82.5^{a}	7.42^{ab}	6.25	1.17	323	49
≥5 and <10 mo	727	81.4^{a}	3115^{b}	72.3^{a}	7.61^{a}	5.88	1.74	299	48
≥10 and <15 mo	425	72.3^{b}	3228^{c}	59.8^{b}	6.91^{b}	5.23	1.68	288	49
≥15 mo	60	53.8^{c}	3255^{c}	59.4^{ab}	6.15^{b}	4.31	1.84	228	47
P-value		$P<0.001$	$P<0.001$	$P<0.01$	$P<0.01$	NS	NS	NS	NS
Mating season									
Autumn	279	82.7^{a}	3097^{a}	70.3	7.04	5.15	1.89	286	50
Winter	361	65.6^{b}	3173^{b}	64.4	7.27	6.23	1.04	315	49
Spring	437	66.3^{b}	3104^{c}	69.9	6.97	5.47	1.49	283	47
Summer	335	75.5^{a}	3021^{a}	69.5	6.83	4.83	2.00	254	46
P-value		$P<0.01$	$P<0.001$	NS	NS	NS	NS	NS	NS
Physiological status			-						
Nulliparous	400	75.1	-	67.2	6.34^{a}	4.60	1.74	242^{a}	45^{a}
Primiparous non lactating	91	76.5	-	68.0	7.20^{ab}	5.45	1.74	277^{ab}	45^{a}
Primiparous lactating	281	67.9	-	67.6	6.74^{ab}	5.02	1.71	296^{b}	51^{b}
Multiparous non lactating	134	69.2	-	65.5	7.77^{b}	6.61	1.16	308^{b}	48^{ab}
Multiparous lactating	506	74.0	-	74.3	7.08^{ab}	5.41	1.67	300^{b}	52^{b}
P-value		NS	-	NS	$P<0.005$	NS	NS	$P<0.001$	$P<0.001$
Interaction			-						
Season×physiological status (*P*-value)		$P<0.01$	-	NS	NS	NS	NS	NS	NS

^{a,b,c} Within columns, means with different letters at each trait are significantly different $P<0.05$.

*No weight on G1. NS: No significant

The physiological status of does at mating significantly affected the number of total born (P=0.041). The lowest value was recorded in nulliparous does but did not greatly differ from those in primiparous and multiparous lactating does, but the total number born was significantly higher in multiparous non-lactating does. Litter weight at birth was also significantly lower in nulliparous does when the individual kits' weight was significantly the lowest in nulliparous and primiparous females. Interaction between season and physiological status was not significant in any of these variables.

Litter size and litter weight at weaning

The mean litter size and litter weight at weaning are reported in Table 2. Apart from the number of kits that died before weaning, which was at the limit of significance (P=0.057), the buck had significantly affected all the variables measured at weaning. Generation influenced all variables (P<0.001) except the pre-weaning mortality. However, the age of the male did not affect litter size and litter weight at weaning. Kindling season only influenced the average kits' weight at weaning (P=0.037); the kits born in winter are heavier at weaning, but their weight did not differ significantly from those born in autumn. The physiological status of the doe at the time of mating did not affect the weaning parameters.

Table 2: Litter size at weaning, viability and productivity, according to the buck, its age, generation, season of kindling and physiological status of the does. Results of variance analysis (Least square means).

			Birth-weaning	Litter weight at	Mean weight at	Productivity at weaning	
	No.	Weaned	mortality	weaning (g)	weaning (g)	Weaned/mating	g/mating
Mean	1103	5.33	0.99	2263	454	2.82	1196
Standard error		2.17	1.50	800	109	2.65	1093
Buck (P-value)		P<0.001	NS	P<0.01	P<0.01	P<0.001	P<0.001
Generation							
0	94	5.80[a]	0.47	1990[ab]	386[a]	3.42[ab]	1029[ac]
1	124	5.71[a]	1.25	2207[a]	421[a]	3.37[a]	1267[a]
2	124	4.23[b]	0.86	1873[b]	480[b]	2.50[bc]	1072[ac]
3	105	5.17[a]	1.21	2532[c]	523[c]	3.63[a]	1740[b]
4	57	4.30[b]	1.44	2049[ab]	512[bc]	2.54[bc]	1145[ac]
5	76	4.31[b]	1.15	1968[ab]	480[b]	1.93[c]	850[c]
P-value		P<0.001	NS	P<0.001	P<0.01	P<0.001	P<0.001
Age							
<5 mo	124	5.20	1.69[a]	2314	461	3.69[a]	1598[a]
≥5 and <10 mo	283	5.40	1.16[a]	2268	447	3.66[a]	1506[a]
≥10 and <15 mo	158	4.96	0.73[b]	2099	461	2.67[b]	1082[b]
≥15 mo	15	4.16	0.70[b]	1732	499	1.58[b]	549[c]
P-value		NS	NS	NS	NS	P<0.001	P<0.001
Kindling season							
Autumn	96	4.74	1.09	2068	466[ab]	3.01[a]	1302[a]
Winter	125	4.81	1.25	2185	498[b]	0.78[b]	312[b]
Spring	195	5.22	1.03	2177	460[a]	3.99[c]	1655[c]
Summer	164	4.94	0.91	1983	444[a]	3.81[ac]	1466[ac]
P-value		NS	NS	NS	P<0.01	P<0.001	P<0.001
Physiological status							
Nulliparous	159	4.86	0.82	1958	452	2.49	979[a]
Primiparous non lactating	27	5.05	1.11	2087	455	2.41	895[ab]
Primiparous lactating	104	4.92	0.96	2089	473	3.06	1239[bc]
Multiparous non lactating	45	4.84	1.31	2156	476	3.40	1466[c]
Multiparous lactating	245	4.98	1.16	2225	479	3.13	1341[c]
P-value		NS	NS	NS	NS	NS	P<0.001
Interaction							
Season×physiological status		-	-	-	-	NS	P<0.01

[a,b,c] Within columns, means with different letters at each trait are significantly different P<0.05.

NS: No significant

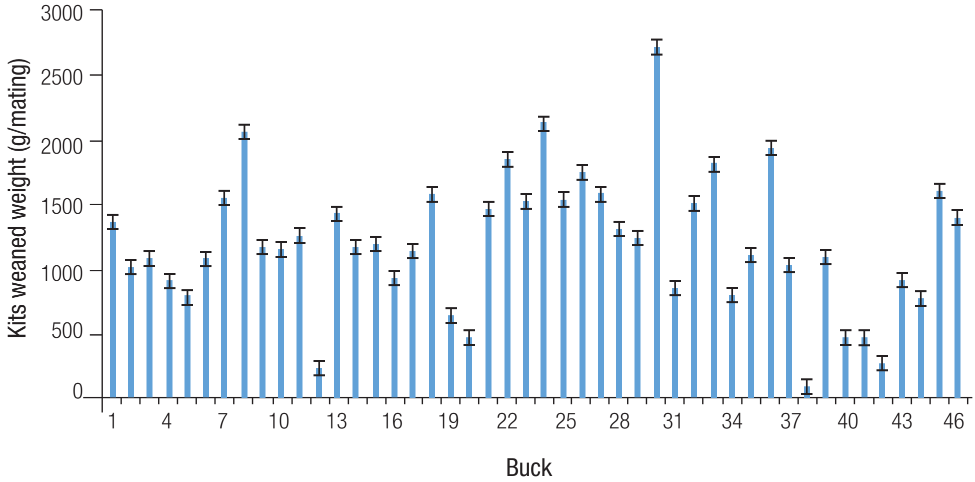

Figure 2: Ponderal productivity of the 46 bucks (kits weaned weight/mating).

Productivity at weaning

Productivity (number of weaned/mating) and ponderal productivity at weaning (Table 2) were significantly affected by buck (P<0.001, Figure 2), Generation also influenced productivity (P<0.001). Productivity at weaning was significantly higher in G3, while the lowest productivity was recorded in G5. The buck's age affected productivity at weaning (P<0.001), which was higher for males whose age was lower than 10 mo (Table 2).

Minimum values were obtained in bucks aged 15 mo or over. Productivity at weaning was affected by the kindling season (P<0.001); it was higher in spring and in summer, while the lowest values were recorded in winter. The physiological status showed a significant effect on ponderal productivity at weaning (P<0.001). Multiparous lactating and non lactating females were more productive. Season and physiological status interaction influenced only ponderal productivity at weaning (P=0.0011), so multiparous non-lactating does were the most productive especially in autumn and spring (Figure 3).

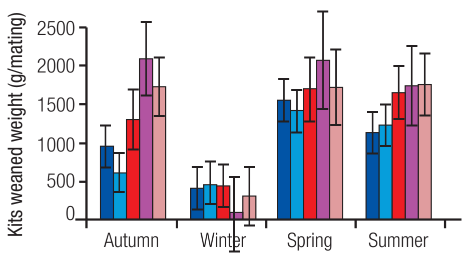

Figure 3: Interaction between the kindling season and the physiological status of the does on ponderal productivity (kits weaned weight/mating): ■ Nulliparous, ■ Primiparous non lactating, ■ Primiparous lactating, ■ Multiparous non lactating, ■ Multiparous lactating.

DISCUSSION

This work showed that the buck had a significant effect on all studied variables except for the number of stillborn, birth-weaning mortality and average individual weight of kits at birth. According to Matheron and Rouvier (1978), these characters are related to the female traits, including maternal behaviour and abilities of dairy does. The male significantly affected acceptance rate and fertility, which are traits that depend on both the female and the male. However, according to Theau-Clément *et al.* (2012), the contribution of the buck to the expression of the doe's sexual receptivity is very low. In natural mating, Lefevre and Moret (1978) and Berepudo *et al.* (1993) reported that the proximity of males and females increased the acceptance rate.

Moreover, Moret (1980) and Rodríguez de Lara (2008) confirmed a high variability of sexual behaviour of does and bucks which could be related to genetic variation.

The effect of the buck was also very significant in prolificacy. Several authors (Rouvier *et al.*, 1973; Hulot and Matheron, 1979 and Theau Clément *et al.*, 1996) attributed this effect to differences in the survival of the semen that could affect the fertilising capacity and embryo viability. In addition, the male contributes through its genetic effects on prenatal and postnatal growth traits transmitted to the offspring (Rochambeau, 1989). The buck also affected the productivity at weaning; moreover, it should be noted that kits born from males with low prolificacy showed a higher weight at weaning than those born from more efficient bucks. Therefore, according to Zerrouki *et al.* (2005b), despite the increase in does' milk production with litter size, the quantity of milk available for each young decreases.

The effect of subsequent generations was significant on all parameters studied except fertility, mean weight at birth and birth-weaning mortality. However, this effect is confounded, especially with the year and the breeding conditions. In addition, replacements were from the same stock, which could raise the level of inbreeding in subsequent generations that might affect reproductive performance. Moreover, the lowest level of live born was recorded in generation G2. These results could be partly explained by the high number of stillborn, which could be related to the loss of the whole litter and birth outside the nest box, in addition to the cannibalism found during this generation. As for the reduced productivity at weaning in G5, according to Daoud-Zerrouki (2006) who worked on the same stock, it may be attributable to low milk production of females during the 21 d after kindling of this generation. Indeed, in the same period, a quake damaged the rabbit farm, likely reducing reproductive performance.

The buck's age influenced the acceptance and fertility rates, buck's weight at mating, total born and productivity at birth and at weaning. The weight of the males did not increase from 10 mo, corresponding to the adult weight. However, the youngest animals (<10 mo) showed better reproductive performances, which does not agree with the results of Theau-Clément *et al.* (2009), who reported that bucks over 10 mo expressed better sperm production than younger ones. Our results could also be influenced by the lack of elimination of infertile males; indeed, among the 46 males, the fertility of 6 of them did not exceed 50%.

Breeding season influenced the acceptance rate, being higher in autumn and summer, but did not affect the kindling rate, in agreement with the results of Daoud-Zerrouki (2006) in the same stock. The male's weight at mating was lower in summer and autumn. As shown by Lakabi *et al.* (2004) in the same population, food intake was greatly reduced in rabbits during the hot season. Moreover, the relationship between the lower bucks' weight in autumn and summer and the higher acceptance rate in these seasons could be noted. The kindling season had no significant effect on the litter size and litter weight at birth. Nevertheless, it influenced the mean individual weight of kits at weaning, which was higher when they were born in winter, as previously shown by Zerrouki *et al.* (2005a). The higher individual kit weight in winter could be explained by a better body condition and a greater food intake of does in this season. These results are similar to those of Yamani *et al.* (1991) recorded in New Zealand breed rabbits raised in Egypt and those of Gacem *et al.* (2009) in a synthetic line obtained from the crossbreeding of local Algerian population and more productive French strains. On the other hand, Ayyat and Marai (1998) in New Zealand rabbits under Egyptian conditions and Belhadi *et al.* (2002) in local Algerian rabbits showed a negative effect of summer on litter size and litter weight at weaning. In our study, litters born in winter were heavier but the difference was not significant. Productivity at weaning was higher in spring than in winter. This result can be explained by the high birth weaning mortality recorded in winter, which may be related to inadequate nest preparation and to larger litter size in this season. According to Zerrouki *et al.* (2005b), milk intake for each kit decreased with litter size. Bergaoui and Kriaa (2001) also reported high mortality between birth and weaning in winter in Tunisian rabbit populations. In agreement with the results of Daoud-Zerrouki (2006), the physiological status of does at the time of mating that combined parity and lactation in this study did not affect fertility, but significantly influenced total born. According to Rodríguez de Lara and Fallas (1999), using artificial insemination, the results of prolificacy were slightly different between lactating and non-lactating does, 11 d *post-partum*, which is the reproduction rhythm adopted in this study. However, multiparous non-lactating females were more prolific (7.77 total born); Zerrouki *et al.* (2009) showed in the same females that intensity of ovulation was higher in multiparous than in nulliparous or primiparous does. In addition, nulliparous does produced lighter litters at birth (242 g), according to Parigi Bini and Xiccato (1993), since the nulliparous does have needs for both pregnancy and growing. The status of lactation within parity did not affect either litter size or litter weight at birth. Our results partly agree with those of Depres *et al.* (1994), since they did not show any significant effect of lactation on litter size at birth. Even Poujardieu et Theau-Clément (1995) reported in natural mating 10 d *post-partum*, which was the reproductive rhythm used in our study, that the difference between lactating and non lactating means was rarely significant. Moreover, productivity at weaning was higher in multiparous does according to Zerrouki *et al.* (2005b), who found that milk production of these females was significantly higher as of the 4th parturition.

This study showed the contribution of the rabbit male to reproductive performance under natural mating. Work on selection to improve male performance is necessary to make efficient breeding stock available. In addition, the use of artificial insemination could be a promising way to optimise the breeding programmes for male fertility and prolificacy under Algerian conditions and increase rabbit meat production.

CONCLUSIONS

Our study is original because it analysed the reproductive performance of local Algerian population does in natural mating by taking into account the effect of the buck, which is generally overlooked in livestock studies. Our results showed the impact of males on reproductive performance and provided knowledge on their genetic potential.

The effect of the buck accounts for 8% of the variability of overall productivity at weaning. This result shows that it should be more conclusive to achieve better knowledge of the optimum conditions for breeding or managing of males, which will allow quicker elimination of the unproductive ones. Therefore, further studies are needed to better understand the optimal breeding of males. In parallel, the study of sperm production could quickly eliminate unproductive males.

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