



Review article

The main factors affecting the reproductive performance of rabbit does: A review

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ABSTRACT

This paper reviews the main factors affecting the reproductive performance of rabbit does. In the last 15 years the profitability of rabbit farms has increased mainly due to improvements in management and genetic selection but several problems related to animal welfare have also occurred. The replacement and the mortality rates of female per year are very high and the replaced does often show poor body condition and poor health status. The effect of kindling order, litter size, genetic strain, weaning age and reproductive rhythm on the reproductive performance and welfare of females and mechanisms implicated in these effects are discussed. The rabbit doe of modern strains produces a lot of milk with high energetic value, which leads to a mobilization of body fat resulting in a negative energy balance. In the current reproductive rhythms, there is an extensive overlap between lactation and gestation. The resulting energetic and hormonal antagonism reduces the fertility rate and lifespan of the doe. Strategies to optimize these parameters are discussed. An approach that combines various strategies seems to be required to meet these objectives. Since the factors involved in this system are predetermined (genetic strain, environment) the most powerful way to improve doe welfare is to choose a reproductive rhythm more adapted to the physiology of the does.

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Contents

1. Introduction	175
2. Reproductive activity of rabbit does: main physiological features and current on farm situation	175
3. Energy balance (EB) and body composition during lactation	175
4. Lactation and metabolic status, oocyte and follicular characteristics, fertility and prolificacy	176
5. Genetic selection	177
6. Reproductive behaviour and health status	178
7. Other reproductive rhythms	179
8. Conclusion	180
References	180

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1. Introduction

In the last 15 years, the mean productivity of rabbit farms has increased and become more homogeneous through the use of artificial insemination (AI; Castellini, 1996), cycled production (Maertens et al., 1995) and very prolific genetic strains (Bolet et al., 2004; Castellini, 2007). At the same time several problems related to the welfare of does have also appeared, e.g. excessive replacement, high mortality and culling rates and hypo-fertility (Facchin et al., 1999). In rabbit farms the doe replacement is about 80–150% per year (Xiccato et al., 2007) corresponding to a lifespan of about 4.7 litters per doe. Improving reproductive lifespan is desired from welfare as well as an economic point of view, because rearing costs of young does are relatively high.

The optimization of reproductive performance is one of the main facts that assure high productivity on rabbit farms. This requires that the management practices take into account the physiology and behaviour of the animals since environmental, managerial and sanitary aspects interfere with fertility and can impair it. Indeed, reproduction could be considered a “luxury” function and the female appears able to feel whether the conditions are too severe and risky for a successful reproductive cycle (Friggens, 2003).

In this review the main factors which affect reproductive performance and animal welfare will be discussed need considering that does are generally inseminated during lactation and considerations are focused particularly on many inferences would be connected to such a relevant activity. For this reason considerations will be focused on the reproductive rhythm (RR) that is commonly applied at commercial farms (AI 11 days *post-partum*) and successively others RRs will be compared.

2. Reproductive activity of rabbit does: main physiological features and current on farm situation

Reproductive activity is under the control of the neuro-endocrine axis but, genetic, feeding, and management factors strongly modify such a hormonal release. In rabbit does, ovulation is induced by coitus (Ramírez and Beyer, 1988) and females could be inseminated independently on their sexual receptivity (SR) which, in turn, is irregular, with the only exception being on the day of partum (Harned and Casida, 1969) and immediately after weaning (Theau-Clément et al., 1990; Castellini et al., 2003). Naturally, when AI is utilized, the induction of ovulation is habitually achieved by exogenous GnRH (Castellini, 1996). Gestation lasts 31–33 days and, following this period, rabbit does give birth in a nest generally early in the morning and then only nurse once or twice daily. The lactation generally last about 4–5 weeks.

Commercial producers seek a high intensity of production so the does are generally inseminated during lactation when unfortunately the SR is low (González-Mariscal et al., 2007). This fact negatively impacts reproductive performance because in most cases only SR does will become pregnant, consequently it is important that the doe is receptive at the time of AI and oestrus synchronization is needed to obtain a high fertility response. High plasma

oestradiol concentrations are found on days 1, 5–7, and 23–30 of the *post-partum* period, observing higher conception rates on day 1 and 8 and lower ones on day 6 when compared with the general mean (Ubilla and Rebollar, 1995).

Rabbit does can sustain lactation and gestation simultaneously but this overlap depresses several aspects of reproductive activity (sexual receptivity, ovulation, fertilization, implantation, embryo survival) due to hormonal antagonism between prolactin and gonadotropins (Kermabon et al., 1994; Theau-Clément and Fortun-Lamothe, 2005) and energy deficit (see Sections 3 and 4).

Semi-intensive RR (AI at 11 days *post-partum*) is widely used but does not take into consideration the physiology of lactating rabbit does (Castellini et al., 2003) and requires treatment for oestrus synchronization.

In rabbit farms the most widely used hormone in lactating, non-receptive does is eCG (equine chorionic gonadotropin). Receptivity, conception rate and prolificacy can be improved in lactating does by injection of 8–30 IU 48 h before AI (Bourdillon et al., 1992; Theau-Clément et al., 2008). Unfortunately, eCG worsens the ovary functions (Stradaïoli et al., 1997) and can induce immune responses in the does receiving the treatment (Lebas et al., 1996). Accordingly, a progressive loss of reproductive efficiency has been reported after use of eCG in successive inseminations (Boiti et al., 1995).

With increasing animal welfare concerns, more emphasis has been shifted to developing alternative methods to hormones to synchronize estrus (biostimulation; Theau-Clément et al., 1998). Some of these strategies include change of cage, transient doe–litter separation, energetic flushing, changing the lighting schedule or putting a buck near the does. Doe–litter separation for 24–48 h in early lactation followed by one nursing and immediate AI (Bonanno et al., 2004; Theau-Clément and Fortun-Lamothe, 2005), or two-day controlled suckling (Rebollar et al., 2008a) appear as the most effective methods. The pituitary response to this treatment is clear: doe–litter separation results in a decrease in plasma prolactin concentrations that could promote growth of follicular waves and high steroidogenesis activity (Ubilla et al., 2000; Rebollar et al., 2008a). In a recent study, transient doe–litter separation (24 h) seems to improve ovarian follicle and oocyte quality compared with an eCG treatment (Arias-Álvarez et al., 2010a). Does synchronized with eCG show higher number of mid-atretic follicles and lower cytoplasmic maturation rate of oocytes, in terms of cortical granule migration rate, compared to biostimulated does.

However, the impact in specific environments and the variability in outcome among breeds and genetic lines, as well as the greater manpower requirements make difficult to apply some of these non-hormonal strategies.

3. Energy balance (EB) and body composition during lactation

The body condition and the energy balance of female in commercial rabbit farms are generally critical. *In vivo* body composition of rabbit does can be estimated with different rapid and safe methods (ultrasound: Dal Bosco et al.,

Table 1

Live body weight (LBW \pm s.d.) and estimated body composition at parturition and insemination time (day 11 pp), in rabbit primiparous does previously fed with high (HL) and standard lignin (SL) diets during the rearing period (from Arias-Álvarez et al., 2009c).

	Diet		Time	
	HL	HL	Parturition	Day 11 pp
LBW	3813.7 \pm 3.9	3798 \pm 3.9	3834.7 \pm 3.9	3777.1 \pm 3.9
Body composition (%)				
Water	62.9 \pm 0.2	62.9 \pm 0.2	63.9 \pm 0.2	61.3 \pm 0.2
Ash	3.1 \pm 0.1	3.1 \pm 0.1	3.1 \pm 0.05	3.2 \pm 0.05
Proteins	17.6 \pm 0.1	17.6 \pm 0.1	17.3 \pm 0.1	17.9 \pm 0.1
Lipids	13.2 \pm 0.5	13.2 \pm 0.5	12.5 \pm 0.5	14.3 \pm 0.5
Energy (kJ/100 g)	1024.5 \pm 2.5	1024.5 \pm 2.5	986.4 \pm 2.5	1080.9 \pm 2.5

2003a,b; Pascual et al., 2004; bioelectrical impedance analysis – BIA: Fortun et al., 2002; Arias-Álvarez et al., 2009a,b; Rebollar et al., 2009b; Nicodemus et al., 2009; body condition scoring – BCS: Bonanno et al., 2005; Cardinali et al., 2008).

During lactation, the high energy output associated with milk production is not entirely compensated by feed intake and rabbit does meet this energy deficit by increasing the mobilization of body reserves and loose body energy (Xiccato et al., 1999) which impacts negatively on reproductive performance. As well as the requirement for milk, in late pregnancy, body fat, energy and protein requirements also become relevant because of the development of the pregnant uterus and the foetal protein turnover (Arias-Álvarez et al., 2009a).

Body fat and fat mobilization are not independent since, for example, too thin does show less fat mobilization during lactation. Some fat mobilization is normal but it has short- and long-term consequences when it differs from an optimum rate. Does that are not able to mobilize body fat have little chance of maintaining a long productive life (Quevedo et al., 2005); at the same time, a low fat level and high fat mobilization determines low fertility (Castellini et al., 2006) and increases the risk of being eliminated (Theilghard et al., 2006).

Several factors affect EB that is particularly negative in primiparous does because the energy requirement must sustain lactation, pregnancy as well as body growth for the achievement of adult weight (Parigi Bini and Xiccato, 1998). Management mistakes at this early stage can compromise the entire reproductive career of does. Many authors agree on the importance of specific feeding plans for young does in order to increase their intake capacity (Rommers et al., 2004; Xiccato et al., 1999). Fibre rich diets fed during rearing has been studied as a strategy for improving the feed intake of primiparous does. These diets increase feed intake during pregnancy (Nicodemus et al., 1999; Rebollar et al., 2008b) due to their lower digestible energy and the faster digestive transit. Later on, in the lactation period, when a more concentrated feed is furnished, some authors (Xiccato et al., 1999; Pascual et al., 2002) observed an increase in feed intake (+12 and +19 g dry matter/day kg^{0.75}) but also a failure to improve body composition at early *post-partum* period (Table 1; Arias-Álvarez et al., 2009b). In addition, a high-lignin-based diet during the rearing period does not lead to reproductive physiology enhancement in primiparous lactating rabbit does. These animals showed higher

rate of follicular apoptosis, lower index of oocyte maturation and lower number of *in vivo*-recovered viable embryos compared to those fed with a standard lignin diet (Arias-Álvarez et al., 2009c).

According to the latter results, some authors (Bonanno et al., 2004, 2008; Rommers et al., 2004; Castellini et al., 2006) recommend delaying the first AI after weaning, since too early AI has negative effect not only on the current reproductive performance but also on the future career of does. The efforts to improve the EB during lactation by increasing the digestible energy of the diets (Parigi Bini and Xiccato, 1998; Fortun-Lamothe, 1998) seem ineffective because the higher energy intake was accompanied by a simultaneous increase in milk production. The reason why lactating rabbit does are not able to ingest sufficient nutrients is not clear. It could be argued that rabbits do not completely adapt to the increase in fat or/and starch. Indeed, the rabbit diet under natural circumstances consists largely of grass, roots, leaves and other rough material which is partially digested in the small intestine and partly fermented in the hind gut (large intestine and caecum). Both parts of the intestine affect the regulation of feed intake: the small intestine the short-term regulation and the hindgut the longer term regulation (Badman and Flier, 2005). Diets contain high levels of fat and starch are predominantly digested in the small intestine, resulting in only short-term feed intake regulation. Consequently, the role of the hind gut in the physiological feed intake of rabbit become marginal (Berman, 1990) and further researches on this topic could result in an increased availability of energy for the rabbit doe.

4. Lactation and metabolic status, oocyte and follicular characteristics, fertility and prolificacy

The hypothalamus controls the secretion of gonadotropins by the pulsatile release of GnRH. In addition, complex interactions with other endocrine factors have been recently described (Boiti, 2004). In particular, leptin blood concentrations could reflect the amount of stored body fat and energy and it influences rabbit reproductive function by modulating ovarian physiology through its receptor (Brecchia et al., 2006). Leptin receptors have been detected in granulosa cells of follicles, oocytes and oviducts (Zerani et al., 2004). Moreover, leptin enhances nuclear oocyte maturation in *in vitro* studies recently performed in rabbit (Arias-Álvarez

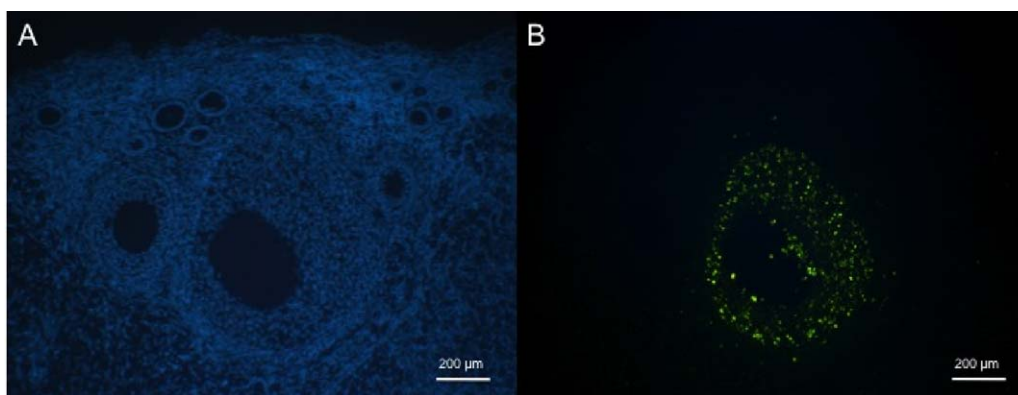


Fig. 1. Follicular apoptosis at insemination time measured by TUNEL in ovarian sections of primiparous rabbit does under semi-intensive rhythm (a). Control section showing ovarian cells marked with 40,6-diamino-2-phenylindole (DAPI). (b) Follicular apoptotic cells labelled (scale bar = 200 µm).

et al., 2010b). On the other hand, several metabolites have been proved to play a role in the relationship between energy balance and reproductive efficiency in rabbit as, non-esterified fatty acids (NEFA), glucose and long-chain fatty acids (Fortun-Lamothe, 2006). During *post-partum* period, mammary glands and feto-placental units use the same substrates such as glucose, long-chain fatty acids, and free fatty acids (Fraga et al., 1989; Stephenson et al., 1990). In this sense has been shown that better body composition in terms of higher body protein, lipids depots and energy content, in the post-weaning period compared with the early *post-partum* time, is linked with an increase in serum protein, NEFA and leptin concentrations (Arias-Álvarez et al., 2009b). These metabolic markers and lactation status definitively affect ovarian follicle and gamete quality, underling the impact of metabolic stress in the early *post-partum* period on reproductive parameters in primiparous rabbit does (Fig. 1) (Arias-Álvarez et al., 2009b). These authors have shown that strand breaks of DNA occurring during the follicular cell apoptosis process are higher on ovaries of rabbit does on day 11 *post-partum* compared to those of non lactating does. In line with the follicular characteristics observed, the developmental potential of oocytes is also affected by the reproductive rhythm. Oocytes *in vitro* matured from does inseminated on day 11 *post-partum* showed a decrease in both nuclear and cytoplasmic maturation rates compared with the oocytes from rabbits inseminated after weaning (on day 32 *post-partum*) (Fig. 2).

5. Genetic selection

Natural selection acts to make the best use of feed resources and to adapt animals to local environmental stress (Beilharz et al., 1993). The feed resources are partitioned among the different demands (maintenance, reproduction, movement and reaction to environmental stress) to ensure the best survival of the animal species.

Genetic programs have different objectives and consequently the resources are mainly focused towards the physiological processes related to the selected traits (Rauw et al., 1999). The selection of a productive trait could be detrimental to other physiological, behavioural or immune

processes (Rauw et al., 1998); for example recent reviews regarding dairy cow showed a close negative relationship between milk yield and fertility (Lucy, 2003; Webb et al., 2004). Antagonism between milk yield and fertility is probably due to a pleiotropic gene which induces changes in energy partitioning with a consequent reduction in metabolic fuel availability for reproductive organs (Veerkamp et al., 2003).

Rabbit does are mainly selected for litter size (De Rochambeau, 1998); consequently, milk production (Lebas, 1987) and nutritional requirements increase. Feed intake also increases with litter size (Lebas, 1987) but such an increase is not enough to compensate for the higher needs for milk production; consequently the EB and the body fat depots decrease (Fig. 3; Fortun et al., 1999; Fortun-Lamothe and Gidenne, 2000; Castellini et al., 2003, 2006). In prolific strains the lactation takes a priority as a physiological function and the rabbit mobilizes a large part of its body reserves to satisfy its requirements (Fortun et al., 1999). Thus, when pregnancy and lactation overlap there is competition between the mammary glands and the gravid uterus to the detriment of foetal growth. In many species the partition of nutrients toward lactation leads to females

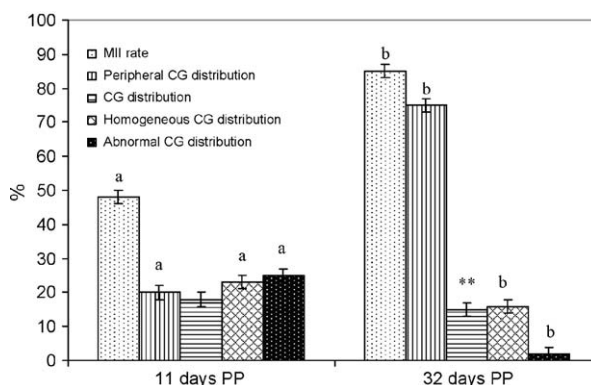


Fig. 2. *In vitro* oocyte maturation in primiparous does inseminated during lactation (11 days; S) or after weaning (32 days *post-partum*). Nuclear and cytoplasmic maturation was measured in terms of metaphase II rate (MII) and cortical granules migration. Different letters in the same column indicate differences ($P < 0.05$), $**P = 0.08$ (from Arias-Álvarez et al., 2009b).

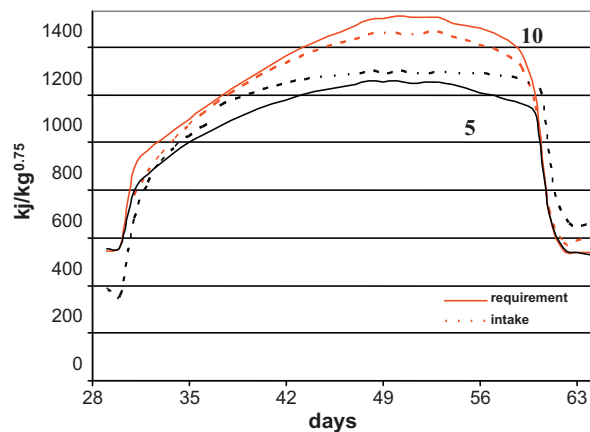


Fig. 3. DE requirement and voluntary intake of does with different litter size (5 vs. 10; modified from Castellini et al., 2003; Cardinali et al., 2008).

with lower body condition and higher infertility (Lucy, 2003).

The comparison of performance and longevity between selected vs. old rabbit strains has been reported (De Rochambeau, 1998; Quevedo et al., 2005; Costa et al., 2004). Nevertheless, the low fertility of primiparous females is attributable to poor body condition and experiments on the effect of litter size showed that does nursing small litters (4–6 pups) have greater sexual receptivity, higher fertility rate (Fortun-Lamothe and Gidenne, 2000; Castellini et al., 2003) and the lowest risk of dying or culling (Theilgaard et al., 2006).

It has been suggested that the increased energy demand of selected strains can be satisfied by higher feed efficiency and by an increased mobilization of body reserves during lactation (Quevedo et al., 2005; Costa et al., 2004). However, if the latter condition is associated with a RR which does not allow a restoration of a suitable body fat level the fertility rate decreases (Castellini et al., 2006) as well as the chance of does survival (Theilgaard et al., 2006). Thus, the lifespan of the does is correlated with the body fat: the animal needs a certain amount of fat during lactation to ensure sufficient resources to maintain the offspring without losses in other body functions (Theilgaard et al., 2006). This result suggests that body fatness is an important factor that affects both longevity and current and future reproduction performance: does with two extreme scores, too fat and too thin, have higher relative risk and lower fertility respect to those with an optimum fat level.

Therefore, even if the effects of selection programs on feed intake, energy balance, reproductive performance and length of reproductive career must be verified in long-term experiments, it seems that modern prolific strains, inseminated in the early lactation, have more difficulty to become pregnant.

6. Reproductive behaviour and health status

Few studies have been done on the welfare status of mature does but some trends can be inferred from other papers. When the requirement of space and feeding is reached, the intensity of production is the factor that plays

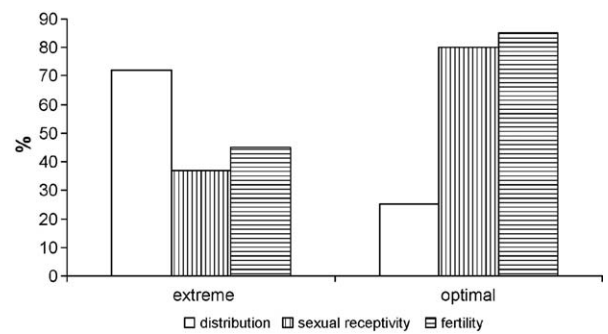


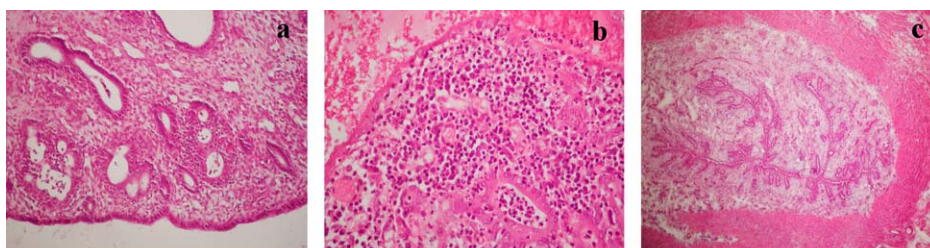
Fig. 4. Percentage, sexual receptivity and fertility rate in does with optimal or extreme body conditions inseminated at 11 days *post-partum* (from Cardinali et al., 2008).

the major role in physiological traits, performance and management aspect.

The management of reproduction should respect the peculiar sexual behaviour of does, allowing adequate body reserves to be reconstituted and to determine sustainable fat mobilization. If all these points are considered, then the reproductive performance generally improves. With regard to this, the AI at 11 days *post-partum* has a lot of limitations. Many does showed at AI a low sexual receptivity (Fig. 4; 37.2%), a poor body condition score (71.2%) and a low fertility rates (50.9%) (Cardinali et al., 2008).

The estimated energy deficit and body mobilization increased when the RR is more intensive (Castellini et al., 2006) and the risk of elimination is negatively correlated with the interval between insemination ($r = -0.37$), with the age at first mating ($r = -0.31$) and with kindling interval ($r = -0.36$) (Rosell and De la Fuente, 2009). Due to this, semi-intensive rhythm generally implies high replacement of does (120% per year; high mortality and culling rate; Guerder, 2002) and has repercussion on the viability of young rabbits. About 50% of such replacements occur before the third litter is weaned (Rosell and De la Fuente, 2009) with the major reasons for this being mortality, diseases, poor body condition and reproductive problems.

It is known that stress caused by excessive production reduces immune response and increases the risk of diseases (Blecha, 2000). Domestic females submitted to intensive production frequently showed sub-clinical infection and inflammation of genital tract (Boiti, 2004) the latter being one of the major causes of hypo-fertility (Gram et al., 2002). Uterine infection negatively affects fertility (Facchin et al., 1999) and prolongs the life span of *corpora lutea* (Boiti et al., 1999) due to infiltration of uterine leukocytes, reduced prostaglandins synthesis and increased the re-absorption of spermatozoa. Dal Bosco et al. (2005) using an artificial model of sub-clinical inflammation in the genital tract (500 μg of lipopolysaccharide (LPS) of *E. coli*) found a significantly lower spermatozoa recovery in the uterine horn of LPS-treated does and absence in the oviducts; histological examinations of them showed an endometritis-like inflammation (Fig. 5) without presence of visible symptom. Successive trials confirmed that a moderate inflammation, restored in 72 h, reduced the number of spermatozoa capable to achieve the oviduct probably by activating and increasing leukocytes and spermato-



a: LPS-treated rabbit does (20x);
b: Rabbit does with a spontaneous endometritis (40x);
c: Healthy rabbit does (20x).

Fig. 5. Histological evaluation of uterus tissue of rabbit does treated with LPS (20×) (a), with spontaneous endometritis (40×) (b) and healthful (20×) (c) from Dal Bosco et al., 2005).

zoa re-absorption (Castellini et al., 2005). Inflammation affects many other aspects of the reproductive process and Kaushik et al. (2004) observed that LPS treatment in pregnant mice reduce the embryo implantation by altering leukocyte infiltration, degeneration of luminal glandular epithelium and determining hyperplasia in various reproductive organs.

7. Other reproductive rhythms

It seems that modern prolific strains of rabbit, particularly in the first parities, have many difficulties in balancing body condition and reproduction and require the use of different strategies to address the problem. Long-term it would seem that selection for strains with higher appetite is required along with the development of alternative nutritional strategies. However, in the short-term the only choice is to modify the RR. Theoretically, when RR is shorter, the expected productivity (litter/year) is higher. However, the lower fertility rate obtainable in semi-intensive reduces the distance between expected and actual production (Castellini, 2007).

The RRs, apart from above mentioned semi-intensive RR, can be categorized as intensive (AI *post-partum* or within 4 days from kindling) and extensive (AI after 3 weeks of lactation or after weaning). In addition, to preserve a sustainable energy balance of the body, does could be inseminated only when a certain body condition status is reached (perirenal fat depot between 15 and 30g; Dal Bosco et al., 2003a,b; Brecchia et al., 2008).

Castellini et al. (2003), when alternating AI at 1-day *post-partum* with AI *post-weaning* found this strategy reduced energy deficit of the females by 6.7% compared to AI at 11-day *post-partum*. It improved both receptivity and fertility and therefore seems to be more respectful of the doe physiology and the replacement rate of the females was also lower (80% vs. 90%).

Intensive RR has major problems due to severe impacts on litter size, fertility rate and the length of reproductive activity (Maertens and Okerman, 1988; Cervera et al., 1993). Rebollar et al. (2009a) showed that rabbit does managed with intensive RR needed more artificial inseminations to become pregnant compared to females in

semi-intensive RR. This is especially evident from the third parturition onward. Moreover, rabbit does at the mid-end of their reproductive life, when under intensive RR, have lower rates of oocyte nuclear and cytoplasmic maturation than females under semi-intensive RR (García-García et al., 2009).

Changing the weaning age also appears to be an effective strategy to reduce the energy deficit in rabbit does (Xiccato et al., 2004). Early weaning reduces the energy deficit (8, 14 and 19% for weaning at 21, 26 or 32 days, respectively) by limiting the duration of lactation. However, the sanitary risk of young rabbits could increase (Pascual, 2001) and if weaning is performed at 25 days kit mortality increases 3.6-fold compared to weaning performed at 35 days (Rebollar et al., 2009a).

Body lipid depots are low at parturition and tend to be higher in animals undergoing an extensive rhythm than those submitted to the semi-intensive one (Fig. 6; Arias-Álvarez et al., 2009b). Extensive rhythms seem to be better suited to the reproductive physiology of rabbit and maintains a more sustainable equilibrium of body weight, fat deposit (Feugier et al., 2005) and fat mobilization simultaneously reducing production losses (44.2% vs. 32.2%; Castellini et al., 2006). Extensive rhythms virtually eliminate the hormonal and energetic antagonisms between

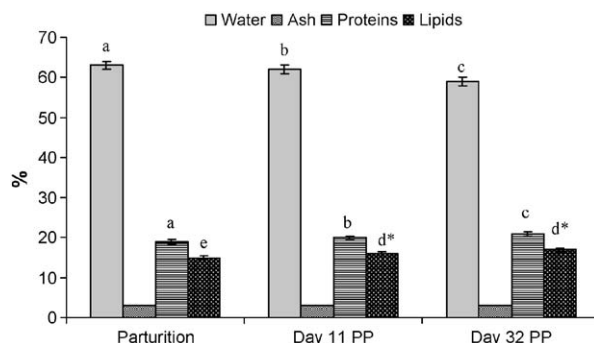


Fig. 6. Estimated body composition measured at different time points along the *post-partum* period (at parturition, on day 11 *post-partum* and on day 32 *post-partum* [post-weaned]) in primiparous rabbit does. Different letters in the same column indicate differences ($P < 0.005$), * $P = 0.09$ (from Arias-Álvarez et al., 2009b).

Table 2

Effect of sexual receptivity, lactation state and fat depot classes on fertility rate (%) of rabbit does (from Castellini et al., 2006).

Sexual receptivity		Lactation stage		Fat depot classes	
R+	R–	Dry	Lactation	Medium	Extreme (too lean/too fat)
90.1	52.8	80.0	52.1	79.3	53.7
R+		93.2	81.1	Medium	
R–		52.3	28.5	Extreme	
R+		78.5	66.3	Extreme	
R–		64.8	45.7	Medium	

R+: sexual receptive does; R–: no sexual receptive does.

lactation and pregnancy and the does partially compensate for the lower production intensity (remating interval 63 days vs. 42 days) with a higher fertility rate (79.0% vs. 60.2%; Castellini et al., 2003). A recent study on the economic evaluation of RR showed a favorable impact of extensive RR on the economic performance of the enterprise and a low level of economic risk (Bertazzoli and Rivaroli, 2007).

However, does inseminated post-weaning showed productivity lower than expected: one critical point was an excessive deposition of fat (about 18% of the does). Does that do not become pregnant after one or more AI are fat and have reduced fertility. The relationship between body composition and reproductive performance is not linear and when the physiological conditions are best (non-lactating does, sexually receptive and optimal body fat), almost all the does become pregnant (93%) whereas the results are poor if the does are lactating and/or too lean or too fat (Table 2).

Thus, reproductive rhythms that are responsive to the body condition of the doe seem more appropriate. An optimal body condition positively modulates the pituitary activity (FSH levels: 34.5 ng/mL vs. 20.0 ng/mL and preovulatory LH surge 20.3 ng/mL vs. 16.9 ng/mL) and consequently, sexual receptivity and the fertility rate (Fig. 4: 80.0% and 86.6%, respectively; Cardinali et al., 2008). Rabbit does which stand at least three consecutive AI on day 25 *post-partum* and later weaning are able to recover their energetic reserves during lactation, at least in the first 7 parturitions. As the number of parturitions increases, the cost of subsequent pregnancies is higher and it is observed that the oldest does are the leanest (Rebollar et al., 2009b).

Based on these results, the perspective of applying a simple *in vivo* method for scoring the body condition of rabbit doe appears to be promising, in light of defining a reproductive management program that is adapted to rabbit behavior and welfare.

8. Conclusion

In conclusion, some strategies allow better management of energy balance and an improvement of the body status, performance and welfare of rabbit does. A multi-factorial approach which combines various strategies seems to be required to meet these objectives.

Since most of the factors involved in rabbit production system are predetermined, at short-term the choice of a reproductive rhythm that is better suited to the physiol-

ogy of the does seem the best way to provide a suitable welfare for the rabbits. Future insights are required to find the most favorable strategies based on the respect of the reproductive physiology of these animals.

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