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Improving of reproductive performance of rabbit does in small and medium scale rabbit farms. Recommendations for developing countries[1]

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ABSTRACT

The paper focuses on factors which can be utilized in small and medium scale rabbit farms in the developing countries. Management of rabbit does starts from their birth. The best selection strategy is to choose females from large litters with medium or high birth weight where the number of teats are 10. Selected kits should be nursed in medium or small litters in order to provide them adequate milk supply. After weaning (or from 10-11 weeks of age), application of restricted feeding regime or using pellet with higher fibre content is suggested to avoid their forced growth. In this case the first breeding can be delayed until an older age accompanied with a better maturity of the does. Before the first mating sexual receptivity can be increased with flushing (ad libitum feeding of pellet with high energy, protein etc.). Using double mating (either with the same or with two different bucks) the fertility will be higher. In the primiparous does, the number of kits per litter has to be limited and a delayed remating is advantageous to avoid the negative body energy balance (loosing too much fat deposit). Remating (reproductive rhytm) of the multiparous does depends on their feeding level. Applying controlled and free nursing for the primiparous and multiparous does, respectively the mortality of their kits can be reduced. Changing the free nursing of lactating does 2-3 days prior to mating to controlled nursing the receptivity, fertility and litter size can be increased. Crossing different breeds results some heterosis effects on reproductive traits (fertility, litter size, milk production, kit mortality). Increasing the daily illumination 7-8 days before mating (insemination) both receptivity and fertility can be increased. The optimal environmental temperature for rabbit does is 16-18°C. Using different cooling systems or preventing the does from heat accumulation is advantageous avoiding low production level.
(Keywords: doe rabbits, management, breeds, reproduction, developing countries)

ÖSSZEFOGLALÁS

Az anyanyulak termelésének javítása kis- és közepes méretű nyúltelepeken. Javaslatok fejlődő országok részére

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A cikk elsősorban a fejlődő országok kis- és közepes méretű nyúltelepein, az anyanyulak termelésre szempontjából fontos tényezőkkel foglalkozik. Az anyanyulak termelésre való

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felkészítése a születéskor kezdődik. Legjobb a nagy létszámú almokból a közepes vagy nagy születési súlyú, tíz csecsbimbós nőivarú nyulakat kiválasztani. Annak érdekében, hogy megfelelő legyen a tejjel való ellátottságuk, közepes létszámú vagy annál kisebb almokban célszerű őket nevelni. Elválasztás vagy 10-11 hetes életkor után korlátozott takarmányozással vagy nagy rosttartalmú takarmány etetésével elkerülhető az elhízásuk. Ebben az esetben a nőivarú nyulak kissé idősebb korban, érettebben vehetők tenyésztésbe. Flushing alkalmazásával (az első termékenyítés előtt magasabb energia és fehérje szintű takarmány ad libitum etetésével) az ivarzás javítható. Jobb vemhesülési arány érhető el két egymást követő fedeztetéssel, akár ugyanazzal, akár két különböző bakkal. Az először fialó anyanyulaknál az alomlétszám csökkentésével és későbbi újrafedeztetéssel javítható a szervezet energia-egyensúlyi állapota, és elkerülhető a zsírtartalékok túlzott csökkenése. A szaporítási ritmust a takarmányozás színvonalával összhangban kell megválasztani. Az először szoptató anyanyulaknál egyszeri, a többször fialtaknál szabad szoptatással csökkenthető a szopósnyulak elhullása. Szoptató anyanyulaknál a receptivitás és a vemhesülési arány javítható, ha a fedeztetés előtt 2–3 nappal a szabad szoptatásról egyszerire térnek át, vagy a napi megvilágítást 7–8 nappal korábban megnövelik. Fajták keresztezésével a szaporasági tulajdonságokban (vemhesülési arány, alomlétszám, tejtermelés, nevelőképesség) a heterózis kedvező hatásával lehet számolni. Az anyanyulak számára 16–18 °C környezeti hőmérséklet az ideális. Meleg égövi klímán különböző hűtési rendszerek alkalmazásával elkerülhető a termelési szint csökkenése.

(Kulcsszavak: anyanyúl, nevelés, fajták, termelés, fejlődő országok)

INTRODUCTION

The reproductive performance of rabbit does is influenced by several genetic, physiological and environmental factors. The basis of the production is the genotype but the manifestation of genetic effect depends on numberous elements from the moment of fertilisation. The surroundings in the uterus (space and blood supply of foetuses), the milk supply of kits, the nutritional and environmental conditions during rearing, the age at first mating, the rebreeding interval and the physiological status at mating etc., can modify the performance of does. In this paper some of these elements are summarized with demonstrating their main effects and giving some recommendations. We focus on those factors which can be utilized in small and medium scale rabbit farms in developing countries.

GENETIC, PHYSIOLOGICAL AND ENVIRONMENTAL FACTORS

Breeds

In most of the developing countries the rabbit production in small scale farms is based on local breeds. Local (native) breeds are generally small mature-sized and have low productivity but they are well-adapted to the local environment (e.g. hot climate, low nutritional level, local feedstuffs) (*Lukefahr*, 1992). Increasing their productivity by selection takes very long time.

The easiest and the quickest way is crossing them with intensive breeds (lines). Although imported breed should be selected carefully. In order to improve reproductive or productive performances the best choice could be the New Zealand White, the Californian or other similar type of medium-sized breeds.

Local ♀ × New Zealand White ♂

↓

F_1 { - larger body size
- better profilicacy, milk yield etc.
- higher body weight gain etc.

Selected under local condition — a second crossing can be performed to improve their productivity (F_1 × New Zealand White = R_1)

The number of crossing depends on environmental and nutritional conditions

- under lower level of conditions: F_1 is used as a synthetic line (breed)
- under higher level of conditions: R_1 or R_2 is used as a synthetic line (or breed)

It is important to find a balance between the adaptability to the local conditions and production. This method is used in some breeding programs in Egypt and in Saudi-Arabia (*Garreau et al.,* 2004) and it is suggested by *Cheeke* (1983) and *Lukefahr* (1992) as well. The crossbred (F_1 or R_1) rabbits may be selected for one or two traits. After some generations these more adapted rabbits can be crossed again with an intensive breed. The selection criteria could be the teat number and growth rate.

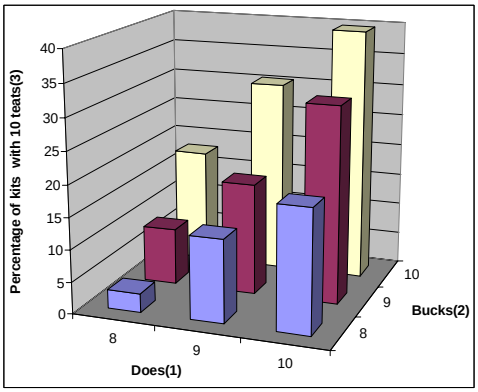
Teat number

There are 8, 9 or 10 teats on most of the rabbits independently of their sex (female or male). This is a highly heritable anatomical trait correlated with some low heritable reproductive performances such as litter size or suckling mortality. They can be counted on newborn rabbits.

The percentage of kits with 10 teats born from crossing does and bucks with 8, 9 or 10 teats are shown in *Figure 1*.

Figure 1

Ratio of kits with 10 teats depending on the teat number of their parents (8, 9 or 10)



Source (*Forrás*): *Szendrő et al*. (1992)

1. ábra: A 10 csecsbimbós újszülött nyulak aránya a szüleik csecsbimbószámától (8, 9 vagy 10) függően

Anya(1), Bak(2), 10 csecsbimbós ivadékok aránya(3)

From the matings of parents both having 8 or 10 teats, 6% or 40% of the progenies had 10 teats, respectively (*Szendrő et al*., 1992). The distribution of progenies with 7, 8, 9, 10 or 11 teats was significantly different which confirmed the high heritability of teat number.

Data in *Table 1* show that rabbit does having 10 teats kindle significantly more kits per litter which have better survival up to 21 days of age than those mothers with 8 teats. Increasing the teat number on does leads to better reproductive and rearing performance.

Table 1

Effect of doe teat number on litter size at birth, suckling mortality till 21days, and litter size at 21days of age (Unpublished data)

Breeds (1)	Litter size at birth (2)		Litter size at 21d (4)		Suckling mortality, % (3)	
	Teat number of does (5)					
	8	10	8	10	8	10
Californian (6)	8.4^{ab}	8.8^{b}	28^{b}	21^{a}	6.6^{a}	7.3^{b}
New Zealand White A (7)	7.7^{a}	8.8^{b}	24^{b}	19^{a}	6.2^{a}	7.4^{b}
New Zealand White B (7)	8.2^{a}	8.8^{b}	30^{b}	25^{a}	6.3^{a}	7.0^{b}
New Zealand White C (7)	8.0^{a}	8.6^{b}	12^{b}	7.0^{a}	7.0^{a}	7.7^{b}

^{ab} values in the same row for each parameter with different superscripts are significantly different ($P<0.05$) (*Az egy sorban levő értékek közötti különbség P<0,05 szinten szignifikáns*)

1. táblázat: A születéskori és a 21 napos alomlétszám, valamint a szopóskori elhullás aránya az anyanyulak csecsbimbószámától függően

Fajta(1), Alomlétszám fialáskor(2), Szopóskori elhullás, %(3), 21 napos alomlétszám(4), Anyanyulak csecsbimbószáma(5), Kaliforniai(6), Új-zélandi fehér(7)

Teat number is not connected with milk production. It seems that the mammary gland (milk yield) has the same size of does with different teat numbers but kits have more chance to catch a teat during the short nursing time. Despite of similar milk production their chance to suck some milk is higher in case of 10 teats.

It is suggested to mark and select female and male newborn rabbits with 10 treats to improve the productivity.

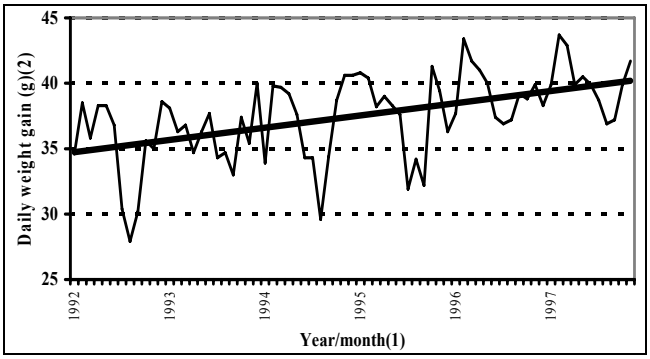
Growth rate

Daily weight gain between weaning and slaughtering is a moderately heritable trait and direct selection could be taken for genetic improvement (*Lukefahr*, 1992). As *Figure 2* shows the selection for weight gain in our Pannon White breed was effective since the average daily gain increased by 0.64 g per year. The genetic improvement was confirmed by *Garreau et al*. (2000).

At the same time the litter size increased from 8.04 to 8.55 due to the selection for teat number. These results proved that simultaneous selection for teat number and weight gain could be a good approach in medium-sized farms.

Figure 2

Daily weight gain of Pannon White rabbits between 1992 and 1997 with seasonal fluctuation



Source (*Forrás*): *Szendrő et al*. (1998a)

2. ábra: A Pannon fehér nyulak súlygyarapodásának alakulása 1992 és 1997 között, szezonális ingadozással

Év/hónap(1), Napi súlygyarapodás, g(2)

Rearing of breeding females

Milk supply

The effect of milk supply of kits on their reproductive performance as adults was examined by *Rommers et al*. (2001a) and *Gyovai* (2006). *Rommers et al*. (2001a) reared 6, 9 and 12 kits per litter. The body weight of does was lower at first mating (at 14.5 weeks of age) and there was a decreasing tendency in the total litter size in group of 12 kits. It was suggested to perform a limited standardization level at 9 kits and postpone the first mating to older age (at 17.5 weeks) for increasing the reproductive performance. *Gyovai et al*. (2004) and *Gyovai* (2006) compared the reproductive traits of does nursed by one or two does (lower or higher milk supply). Nursing by two does was beneficial in a manner of body weight (condition) of does, number of kits born total and alive (8.76 vs 8.35 and 8.39 vs 7.99, resp.) and lifespan production (number of litters 8.7 vs 8.4, number of kits born total and alive: 58.2 vs. 53.2 and 53.9 vs 49.1, resp.).

It can be concluded that low milk supply could have a negative effect on the performance of primiparous does, while higher milk supply at suckling age could be advantageous during the whole life period of does. Rearing females to be breeding animals, a standardization to a lower litter size is suggested.

Restricted feeding

Restricted feeding during rearing of female breeder rabbits is advantageous for young and older does. According to the results of *Rommers et al*. (2001b) restrictive feeding of females with delayed first mating to 17.5 weeks of age can prevent excessive fat deposition without reducing body protein and ash content. *Maertens* (1992) suggested the restriction of young does' ration to 35 g pellet/day/kg live weight and postpone the time of first mating combined with a 4-day flushing (*ad libitum* feeding) before

breeding. In this case females are more mature and the flushing positively affects the receptivity and fertility of primiparous does. *Eiben et al.* (2001) found higher kindling rate, litter size, litter and individual weights at 21 days of age with using 130-140 g daily feed portion or 9 hours' daily access to feed compared to the control (*ad libitum* feeding). *Hartman and Petersen* (1995) also reported improved fertility from the second parity in the group of does raised on the 85% of the *ad libitum* level.

The long-term effect of feed restriction could be connected with the higher feed intake of does after finishing the restriction (*Gyovai*, 2006). The body weight of restricted does was higher after the first parturition than that of the *ad libitum* fed control rabbits.

Nizza et al. (1997) published higher performance (litter size, litter and individual weights at 35 days) in group of does fed a fibrous diet (crude fibre: 22.8%) during rearing.

According to these results it seems that restricted feed (energy) intake before the first mating is advantageous for primi- and multiparous does.

In developing countries the nutrient supply of females during rearing could be similar to rabbits fed restricted or fibrous diet. Positive effect could be achieved in case of feeding higher nutritive level diet after the first mating.

Age to breed

First mating is applied when females reach 75 to 80% of their mature body weights (*Lebas et al*., 1986). The optimal age at first mating depends on breeds (lines) and rearing methods: e.g. *Rommers et al.* (2001b) inseminated at 14.5 or 17.5 weeks of age, *Gyovai et al.* (2004) at 15.5 or 18.5 weeks of age, *Szendrő et al.* (2004) at 16.5 weeks of age, *Theau-Clement and Mercier* (2004) at 17.5 weeks of age. In the opinion of *Rommers et al.* (2001b) young females have to reach an optimum (or minimum) body weight at first mating as well, which was about 4 kg in her experiment. In this case, rabbits are mature enough to begin their reproductive life.

Receptivity

Rabbit is sexually receptive if her vulva is turgid and reddish or purple (*Rodriguez and Ubilla* 1988). Receptivity is a strong indicator of fertility. This is why the main aim of is to increase receptivity at the time of insemination by hormonal (PMSG) treatment (*Maertens et al*., 1995) or by biostimulation (*Theau-Clement*, 2000).

Maertens et al. (2003) showed a significant effect of vulva colour on reproductive performance using natural mating (*Table 2*).

Table 2

Effect of vulva colour on reproductive performance of does using natural mating

Traits (1)	Vulva colour (2)			
	White (3)	Pink (4)	Red (5)	Purple (6)
Accepting of service, % (7)	17.0	76.6	93.4	61.9
Conception rate, % (8)	44.9	79.6	94.7	100.0
Litter size (9)	6.7	7.7	8.0	8.8

Source (*Forrás*): *Maertens et al.* (2003)

2. táblázat: A természetesen pároztatott anyanyulak termelése a vulva színétől függően

Tulajdonságok(1), Vulva színe(2), Fehér(3), Rózsaszín(4), Piros(5), Lila(6), A baknyúl elfogadási aránya(7), Vemhesülési arány(8), Alomlétszám(9)

The effect of receptivity is also significant when does are artificially inseminated (*Table 3*).

Table 3

Effect of receptivity on conception rate and litter size of does inseminated 11 days after parturition

Turgidity (1)	**Vulva colour (2)**			
	White (3)	**Pink (4)**	**Red (5)**	**Purple (6)**
	Conception rate, % (9)			
Turgid (7)	43[a]	60[ab]	**78**[b]	**76**[b]
Non-turgid (8)	44[a]	44[a]	53[a]	48[a]
	Litter size (10)			
Turgid (7)	4.2[a]	8.9[b]	**10.2**[b]	9.1[b]
Non-turgid (8)	9.0[b]	8.6[b]	**10.0**[b]	8.3[b]
	Number of kits born per AI (11)			
Turgid (7)	1.8	5.3	8.0	6.9
Non-turgid (8)	4.0	3.8	5.3	4.0

Source (*Forrás*): *Szendrő et al*. (2006)
See *Table 1* (*Lásd 1. táblázat*)

3. táblázat A vemhesülési arány, az alomlétszám és az egy termékenyítésre jutó nyulak számának alakulása a receptivitástól (vulva színétől és duzzadtságától) függően)

Duzzadtság(1), Vulva színe(2), Fehér(3), Rózsaszín(4), Vörös(5), Lila(6), Duzzadt(7), Nem duzzadt(8), Vemhesülési arány(9), Alomlétszám(10), Egy inszeminálásra jutó megszületett nyulak száma(11)

It seems that in case of artificial insemination (AI) the conception rate mainly depends on vulva turgidity but the litter size relies on vulva colour (reddish). The best results (number of kits/AI) were achieved when the vulva was turgid and red or violet.

Mating

With natural mating, receptivity is only considered as a sign of accepting the buck. If the female does not show any sign of receptivity (lordosis), it could be tried to mate her but after refusing the buck she has to be mated in the next days. If the doe is in heat but refuses the first buck she has to be presented to another male. Using forced mating the conception rate is much lower compared to the case when the doe is ready for mating. Doe should always be taken to the buck's cage for mating. In reverse case the doe may fight and defend her territory (cage) against the unfamiliar animal (buck).

In an experiment, the reproductive performance of single mated does was compared with females mated twice differently: in rapid succession (immediate twice mating or the does were left together with the bucks in his cage for two hours after the first mating) or performed in the morning and then in the afternoon (*Table 4*).

The best results were achieved when the does were mated twice in rapid succession (Groups T and R). The weaker results of group L (mating in the morning and in the afternoon) were confirmed in another experiment. Two bucks (a white and a coloured) were used for mating a white doe. The intervals between two matings were 0, 2, 4, 6, 8 or 24 hours. With increasing the interval between matings the ratio of the second

unsuccessful mating increased and the ratio of kits originating from the second buck decreased (*Table 5*).

Table 4

Effect of mating methods on reproductive performance of does

Traits (1)	Mated once (2)	Mated twice immediately one after another (3)	Mated in the morning and in the afternoon (4)	Does left in buck's cage for 2 h after first mating(5)
	O	T	L	R
Conception rate, % (6)	71.3	80.2	75.4	81.3
Litter size (7)	7.99	8.36	8.55	8.47
No. of kits/mating (8)	5.70	6.70	6.45	6.89

Source (*Forrás*): *Szendrő and Tag-El-Den* (1987)

4. táblázat: A fedeztetési mód hatása az anyanyulak termelésére

Tulajdonságok(1), Egyszer fedeztetve(2), Kétszer, közvetlenül egymás után fedeztetve(3), Reggel és délután fedeztetve(4), Az első fedeztetés után az anyanyulak két órára a baknyúl ketrecében maradnak(5), Vemhesülési arány, %(6), Alomlétszám(7), Egy fedeztetésre jutó újszülöttek száma(8)

Table 5

Effect of interval between two matings on the success of the second buck

Traits (1)	Duration between two matings in hours (2)					
	0	2	4	6	8	24
Unsucessful second mating, % (3)	0	5.2	6.9	15.9	18.8	38.5
Kits originated from (%) (4)						
only the first buck (5)	31.6	42.9	57.6	55.0	83.6	100.0
only the second buck (6)	26.3	14.2	12.1	10.0	4.2	0.0
both bucks (7)	42.1	42.9	30.3	35.0	12.5	0.0

Source (*Forrás*): *Szendrő and Tag-El-Den* (1987)

5. táblázat: A két fedeztetés között eltelt időszak hosszának hatása a másodiknak fedező bak sikerességére

Tulajdonságok(1), Két fedeztetés között eltelt idő, óra(2), A másodiknak fedező bak sikertelen próbálkozása(3), A kisnyulak származása, %(4), Csak az első baktól(5), Csak a második baktól(6), Mindkét baktól(7)

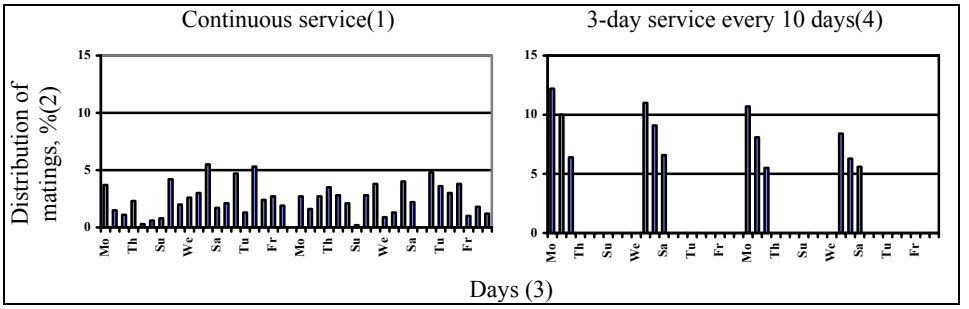
Das and Yadar (2007) obtained similar results, however the differences between groups were not significant because of the small number of animals.

It is worth reducing the mating period to some days. In case of continuous mating service, mating takes place every day (*Figure 3*) and in small farms fostering could be difficult. It seems that applying a 3-day mating period every 10 days (or less frequent,

depending on the number of does at a farm) is a good solution. In this case more does kindle at the same time.

Figure 3

Distribution of matings in a 42-day period in case of continuous or discontinuous services



3. ábra: Egy 42 napos időszakban a fedeztetések megoszlása folyamatos vagy szakaszos pároztatás esetén

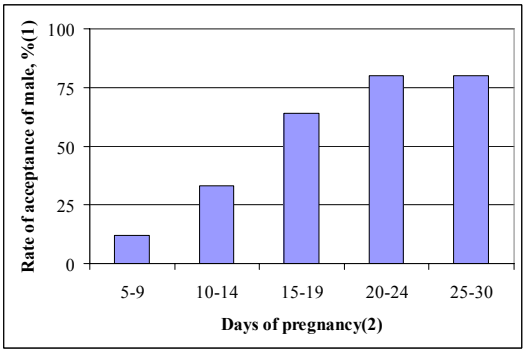
Folyamatos fedeztetés(1), Fedeztetések megoszlása, %(2), Napok (Mo, We, Fr, Su, stb. = hétfő, szerda, péntek, vasárnap, stb.)(3), Tíz naponként 3 napos fedeztetési időszak(4)

Pregnancy diagnosis

Test-mating (sexual behaviour of does) is not an exact method to determine pregnancy because several pregnant does accept mating throughout the gestation period (*Moret*, 1980; *Figure 4*), but others refuse the buck even though they have not conceived.

Figure 4

Mating acceptance during gestation



Source (*Forrás*): *Moret* (1980)

4. ábra: A fedező bak elfogadása a vemhességi időszak alatt

Baknyulak elfogadási aránya, %(1), Vemhesség napjai(2)

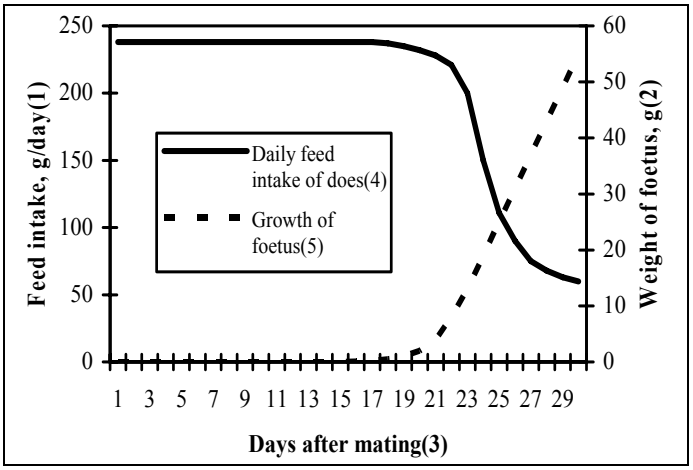
The most common, accurate and the quickest method to determine pregnancy is the abdominal palpation performed at 10-14 days after the mating. This method is used in all large farms in Europe. The empty does have to be remated as soon as possible.

Development (growing) of rabbit foetuses

The foetuses begin to grow quickly during the second half of gestation. The total volume of foetuses become larger and larger, take up a lot of room in the abdominal cavity, press the stomach and reduce the feed consumption of the doe (*Figure 5*). This is why in this period pregnant does are not able to consume the required amount of diet. They use their fat deposit as a source of energy and their energy balance will be negative (*Xiccato*, 1996). During the lactation of primiparous does it can reach 40% of the initial fat depots and 25–30% of the energy reserves (*Xiccato*, 1996).

Figure 5

Development of feed intake capacity during pregnancy and growth of foetus



Source (*Forrás*): *Kamphues* (1985), cit (*idézte*): *Szendrő* (2000)

5. ábra: Az anyanyulak takarmányfogyasztásának és a magzatok súlyának alakulása a vemhesség alatt

Napi takarmányfogyasztás, g(1), Magzat súlya(2), Fedeztetés utáni napok(3), Az anyanyulak napi takarmányfogyasztás (4), Magzat növekedése(5)

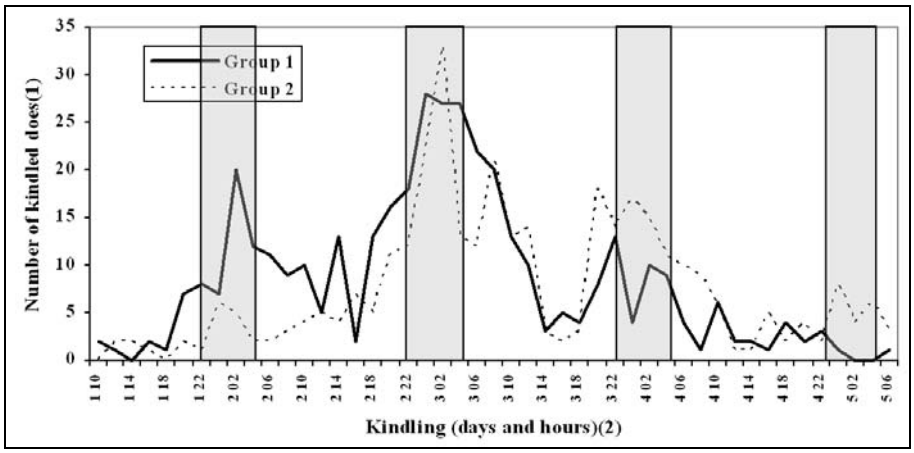
The individual weight of foetuses depends on their number (litter size), on their position in the uterine horns and on the number of the foetuses in the neighbouring uterine horn (*Lebas*, 1982; *Pálos et al.,* 1996; *Poigner et al.,* 2000). The main influencing factor on the individual weight is the blood (nutrient) supply of the foetuses.

Pregnancy duration

Rabbit does normally kindle 31-33 days after mating. Birth occurs mainly during the night (*Rashwan et al.*, 2003). In Figure 6 three peaks of kindlings can be observed in the dark period on the 31st, 32nd and 33rd days.

Figure 6

Distribution of kindlings depending on dark and light periods during the days of parturition (group 1: inseminated between 8-10 am, group 2: inseminated between 8-10 pm)



Source (*Forrás*): *Rashwan et al*. (2003)

6. ábra: A világos és a sötét napszakban fialt anyanyulak megoszlása (group 1: reggel 8 és 20 óra között termékenyítve, group 2: este 8 és 10 óra között termékenyítve)

Fialó anyanyulak száma(1), Fialás időpontja (nap és óra)(2)

Nests have to be checked during parturition and farmers have to adjust if required (in case of kindling outside of the nest box or poor quality of the nest) in order to reduce kits' mortality.

Nesting

Nest-building behaviour of does is under hormonal regulation (*González-Mariscal and Rosenblatt,* 1996; *González-Mariscal et al.,* 1998). According to the results of *Matics et al.* (2002) a minimum of 3 days is necessary to build a nest of good quality. In case of shorter time (insert the nest box on 29th day of pregnancy) an incomplete nest could be resulted.

The mortality of suckling rabbits is in connection with the nest quality. Grading the amount of the hair in the nest (0 = no hair, 5 = nest is totally covered with hair), the kits' mortality varied between 30% and 37% when nest quality was 0 or 1, but it varied between 18% and 20% in nests with the grades of 3-5 (*Szendrő and Kustos*, 1991). The amount of the hair in the nest could be affected by breeds. Californian does collect less hair into the nest than New Zealand White ones (*Szendrő and Kustos*, 1991). Similar results were published by *Hamilton et al*. (1997), the Californian had lower nest quality score than New Zealand White does. They reported that the correlation between fur placement and nest structure was high (r=0.66) because of the hormonal background: prolactin affects fur loosing and the maternal nest-building behaviour. If there is less amount of hair in the nest, rabbit does can be manually plucked without causing any pain. In spite of this, addition of fur to nest boxes did not generate better behaviour of nulliparous does (*Harris et al.,* 1983).

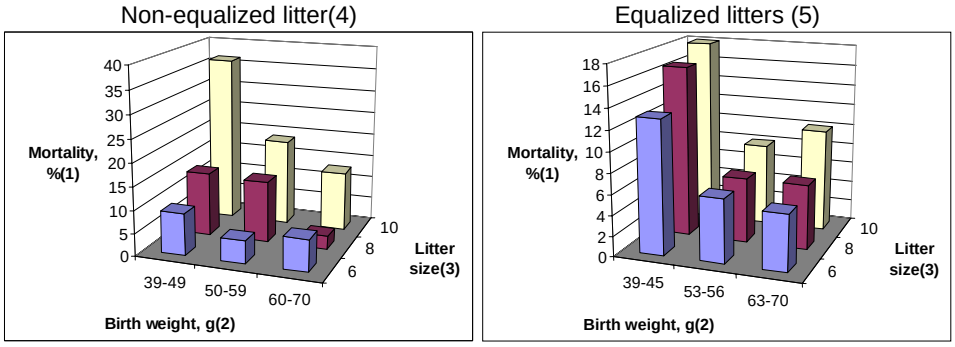
Fostering

The survival rate of kits is in close correlation with their birth weight and milk supply. With increasing litter size the average birth weight of kits decreases and the proportion of new-born rabbits with very low weight increases. The short nursing time reduces the chance of nursing all of the kits if the litter size is higher than the number of teats. In the competition for reaching a teat, the weakest kits lose. It was found that all kits weighing 25-30 g at birth and half of them weighing 35-45 g died during the first week of their life (*Szendrő and Barna*, 1984). Similar results were published by *Vicente and Garcia Ximénez* (1992). Using fostering kit mortality may reduce.

Rearing rabbits in litter of 10 kits without equalization on the basis of birth weight, the suckling mortality of the lowest weight group (39-49 g) was 39% (*Figure 7*). Using While in case of litter equalization with respect to birth weight (low: 39-45 g, medium: 53-56 g or high: 63-70 g), the suckling mortality decreased to half (18%).

Figure 7

Effect of birth weight and litter size on suckling mortality in litters equalized or not according to the birth weight (*Poigner et al.*, 2000)



7. ábra: A születési súly és az alomlétszám hatása a szopósnyulak elhullására, a testsúly alapján kiegyenlítetlen vagy kiegyenlített almokban (Poigner és mtsai, 2000)

Elhullás(1), Születési súly(2), Alomlétszám(3), Kiegyenlítetlen alom(4), Kiegyenlített alom(5)

The results show that it is not enough to reduce only litter size but it is important to equalize new-born rabbits according to their weight at the same time in order to minimize the competition among them. Milk production of primiparous does is lower than that of the multiparous does (*McNitt and Moody,* 1990; *Rodellar et al.,* 1991; *Bonanno et al.,* 2001). This is why the parity order has to be taken into consideration at fostering (fewer kits to primiparous does).

Rebreeding schedules

Post-partum breeding is common in wild rabbits (*Oryctolagus cuniculus*). The male usually senses that doe gives birth soon and follows her closely. As soon as she leaves the nest after the litter is born, mating takes place (*Cheeke et al.,* 1986). This is a normal

sexual behaviour of rabbits. Four groups of reproductive intensity (days between parturition and mating) can be created

- *Intensive rate*: Does are reserviced just after kindling (max. 4 days after parturition) and the young are weaned at 26-28 days.
- *Semi-intensive rate:* Does are serviced about 10 days after kindling and youngs are weaned at 28-35 days.
- *Semi-extensive rate:* Does are serviced about 20 days after parturition and kits are weaned at 35-42 days of age.
- *Extensive reproduction rate:* Rebreeding is after weaning (35-42 days after kindling).

Rabbit does can be rebred within 2 weeks after kindling if the breed is high productive (intensive) and does get the required quantity and quality of feed. Mating ability was high at the days of post-partum (73-83%) but it was lower when does were mated 10-12 days after parturition (60-64%) (*Szendrő*, 1993). There is a particularly strong antagonism between lactation and reproductive functions: prolactin →← gonadotropin (*Theau-Clement and Roustan*, 1992). This is why the receptivity of does is lower at 10-12 days post partum.

In spite of lower mating ability the conception rate was higher with longer duration between parturition and remating (*Table 6*). The conception rate was 14%, 18% and 33% higher if the does were mated 10–12, 20–22 or 30–32 days after parturition compared to post-partum service.

Table 6

Effect of remating interval on the kindling rate

Genotypes (1)	Remating interval (days) (2)			
	0-2	**10-12**	**20-22**	**30-32**
A	61.1	75.4	63.3	88.9
B	53.7	69.9	77.8	89.8
C	57.4	69.9	84.4	92.6

Source (*Forrás*): *Szendrő* (1993)

6. táblázat: Az újrafedeztetés időpontjának hatása a vemhesülési arányra

Genotípus(1), Újrafedeztetés időpontja(2)

Litter size was by 0.7–0.8 lower when the does were mated just after kindling post-partum compared to does which were mated 10–12 days after parturition (*Martin and Donal*, 1976; *Surdeau et al.,* 1980, 1984; *Harris et al.,* 1982; *Partridege et al.,* 1984; *Desalvo and Zucchi,* 1985). Litter size of does remated 20–22 days after kindling was higher than that of does remated 30–32 days post partum (*Szendrő*, 1986).

The annual production of does was the highest with 0–2 d post-partum mating but there was only a slight difference between groups mated 10–12 d or 20–22 d. The weakest results were obtained in group mated 30-32 d (*Table 7*).

Using an intensive or semi-intensive breeding schedule, the main load of does is the overlap of lactation and pregnancy. In case of post-partum pregnancy the overlap is complete, this is why the conception rate and litter size were the lowest in this group.

The nutritional requirement is also high when remating takes place 10-12 days after parturition. These breeding schedules are suggested only for breeds with high productivity. In developing countries a 20-day (or later) mating is suggested.

Table 7

Number of kindlings and kits per doe per year depending on remating interval

Traits (1)	Remating interval (days) (2)			
	0-2	**10-12**	**20-22**	**30-32**
Number of litters (3)	6.6	5.9	5.9	5.1
Number of kits (at birth) (4)	53	49	49	40
Number of kits (at 21d) (5)	44	42	40	36

Source (*Forrás*): *Szendrő at al.* (1984)

7. táblázat: Az újrafedeztetés időpontjának hatása az anyánként és évente elért fialások és kisnyulak számára

Tulajdonságok(1), Újrafedeztetés időpontja(2), Almok száma(3), Újszülött nyulak száma(4), 21 napos nyulak száma(5)

Nursing

Kits can be nursed freely or controlled. In case of free nursing, the nest box is open all day and night (24h) and the doe can nurse her kits when she wants (mostly during the dark period). If controlled nursing is applied, the nest box is open for 20-30 minutes only in the morning (at about 8 o'clock) then it is closed. The duration of nursing is about 4-6 minutes after parturition and 3 minutes afterwards (*Mohamed and Szendrő*, 1992) so 20 minutes is enough for the does to nurse their kits.

In Europe, most of the farmers applied controlled nursing (check whether kits' stomach is full or not). Comparing the two methods some opposite results were published. *Pizzi and Crimella* (1985) did not found significant difference in mortality and litter weight between the two methods. *Constantini et al.* (1986) recorded higher kits' mortality when nursing was allowed only once a day. According to our results (3 experiments), differences between free and controlled nursing were negligible in kits' mortality between birth and 3 weeks of age (6.6 vs. 6.6%, 10.2 vs. 9.8%, 7.5 vs. 9.6%, respectively) as well as in litter weight at 4 weeks of age (4.17 vs. 3.89 kg, 4.77 vs. 5.05 kg, 4.77 vs. 4.39 kg, respectively) (*Szendrő et al*., 1999). Data evaluation with more detailed analysis showed that suckling mortality depends on kindling order (*Table 8*).
Similar results were published by *Coureaud et al.* (2000a): in primiparous does, the controlled nest-access (between d 0-3 or d 0-5) resulted a lower mortality between birth and weaning (8.1%) compared to the free nest-access (18%). This is why combined nursing (free nursing during the first week and controlled later on) could reduce the suckling mortality (free: 10.2%, controlled: 9.8% and combined: 5.3%) (*Szendrő et al.,* 1999). *McNitt and Moody* (1987) observed higher mortality and lower weight gain of kits which resulted one or more kits' death, especially during the first few days.

Coureaud et al. (2000b) called attention to the importance of suckling right after birth because kits' mortality was higher among rabbits that had not been nursed right after birth (nursed or not right after birth: 15.4% vs. 20.0% in free, 2.1% vs. 14.8% in controlled groups, respectively).

Table 8

Effect of nursing method on suckling mortality and litter weight of primiparous and multiparous does

Kindling order (1)	Nursing method (2)	
	Free (3)	Controlled (4)
	Suckling mortality (%) (7)	
Primiparous (5)	12.2	6.4
Multiparous (6)	6.3	11.4
	Litter weight at 3 weeks, kg (8)	
Primiparous (5)	2.37	2.43
Multiparous (6)	2.97	2.74

Source (*Forrás*): *Szendrő at al.* (1999)

8. táblázat: A szoptatási mód hatása a szopósnyulak elhullására és az alomsúlyra, az először és a többször fialt anyáknál

Fialási sorszám(1), Szoptatási mód(2), Szabad(3), Napi egyszeri(4), Először fialt(5), Többször fialt(6), Szopós elhullás, %(7), 3 hetes alomsúly, kg(8)

Biostimulation

Changing the nursing methods

A 36-48 hour single dam-litter separation (applied before an 11-day post partum insemination) increased the fertility rate of free nursing does but reduced the growth rate of kits (*Theau-Clément*, 2000). That is why a splitting of dam-litter separation (DLS) was used.

Eiben et al. (2004) compared two groups of does. In the control group free nursing was applied during the whole lactation period (the door of the nest box was opened for 24 hours). In the group with split DLS, free nursing was changed to controlled 2 days prior to the insemination (the door of the nest box was open for 20 minutes a day in the morning). Compared to the control group (33.3%) the kindling rate increased by 17% and the number of kits born alive were 7.24 and 7.84, resp. *Bonanno et al.* (2004) observed a higher conception rate (+15%) in a similar experiment.

In the experiment of *Matics et al.* (2004) nursing method was changed to 2 or 3 days prior to the insemination. Kindling rate in the 3 groups was similar (in control, 2-day and 3-day groups: 78, 79 and 80%, resp.) but the number of kits born total and alive increased significantly in the 3-day group (in control, 2-day vs. 3-day groups: 8.56, 8.73 vs. 9.76 and 7.81, 8.04 vs. 9.01, resp.). It has to be noted that in the experiments of *Bonanno et al.* (2004) and of *Eiben et al.* (2004) the conception rate in control group was low but in the study of *Matics et al.* (2004) it was high. Similar positive results may be expected in case of natural mating.

Lighting

In Europe, wild rabbits begin to be on heat in early spring when the daily lighting period increases. Model the lighting regime upon the nature (changing the lighting schedule) the receptivity and performance of domesticated does can be increased.

Theau-Clement et al. (1990), *Theau-Clement and Marcier* (2004) and *Mirabito et al.* (1994) proved that increasing the daily lighting from 8 hours to 16 hours 8 days prior to the insemination (11 day post partum) the reproductive performance of does

increased. Using similar experimental design *Gerencsér et al.* (2006) received higher conception rate (71.9% vs. 61.4%) and more kits born total and alive (9.16 vs. 8.73 and 8.70 vs. 8.42, resp.) in the group of extended lighting. It can be concluded that increased lighting before mating could be an effective method to improve the reproductive performance of does.

Weaning

Weaning age is connected with the condition of does and their kits. Weaning rabbits at older age could be advantageous for kits (larger body weight and more developed digestible tract with more developed physiological parameters), but at the same time the delayed weaning could be disadvantageous for does (longer lactation results weaker condition). During the last stage of pregnancy and near to the peak of lactation, rabbit does are usually in a negative body energy balance, especially primiparous does and lactating rabbits when they are pregnant at the same time (*Xiccato*, 1996).

Adopting extensive reproductive rhythm was proved to be effective to avoid energy loss (*Xiccato et al.,* 2004a). It was confirmed by an experiment in which two reproductive rhythms were compared: insemination at 11 days post partum and weaning at 35 days with insemination at 25 days and weaning 2 days before it (at 23 days of age). Significant difference was found in the total body fat content measured by TOBEC (total body electrical conductivity) method (*Gerencsér*, 2007).

Similar results can be achieved with the prolongation of dry period: early weaning increases the time available for body energy restoration (*Xiccato et al.*, 2004b). The energy deficit of does whose kits were weaned at 32, 26 or 21 days were -19.4, -13.4 and -8%, respectively (*Table 9*). *Nicodemus et al.* (2002) compared two reproductive rhythms (early weaning at 25 days and traditional weaning at 35 days). Higher prolificacy and litter size at weaning were observed in the early-weaned group.

Table 9

Composition of empty body gain and energy balance of lactating and pregnant does between initial and final kindling

	Weaning age		
	21 days	**26 days**	**32 days**
Composition of empty body gain:			
Protein (g)	10	-4	-6
Fat (g)	-75	-129	-170
Energy (MJ)	-2.68	-4.94	-6.65
Chemical and energy balance:			
Protein (%)	1.8	-0.5	-0.8
Fat (%)	-16.9	-24.5	-35.3
Energy (%)	-8.0	-13.4	-19.4

Source (*Forrás*): *Xiccato et al*. (2004b)

9. táblázat: Az ürestest összetétel és az energia-egyensúly változása a szoptató és egyidejűleg vemhes anyanyulaknál, a kezdeti állapot és a kísérlet befejezése között

Választási kor, nap(1), Üres test összetétele(2), Fehérje(3), Zsír(4), Energia(5), Kémiai és energiai egyensúly(6)

It is important to find a balance between the requirements of kits and does. As the optimal weaning age depends on the environmental condition, genotype and on the nutritional level as well, it is difficult to offer suggestion. At the moment we can only call attention to this problem.

Heat stress

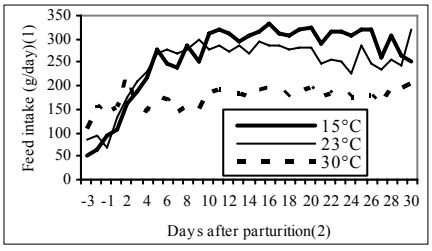
Under hot climate heat stress is one of the main impacts which influence the productive and reproductive traits. Rabbits are very susceptible to heat stress since they have just a few functional sweat glands and have difficulty in eliminating the excess of body heat when the environmental temperature is high. With increasing temperature the feed intake decreases slowly (above 20 °C) or fast (above 25 or 30 °C).

Summarizing several experimental results *Marai et al.* (2002) established that conception rate, embryonic development, litter size, litter weight and milk production decrease, while age of puberty and pre- and post weaning mortality increase by the exposure of heat stress.

Maertens and De Groote (1990) also observed lower feed intake and milk yield as a result of high ambient temperature (27–31 °C in daytime, falling to 21–25 °C during the night). In an experiment of *Szendrő et al.* (1998a) does were kept at 15 °C, 23 °C or 30 °C. Feed intake of lactating does declined slightly at 23 °C but decreased remarkably at 30 °C (*Figure 8*). Similar changes were found in milk production (*Figure 9*).

Figure 8

Effect of temperature on feed intake of does

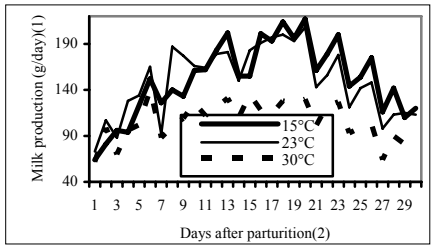


8. ábra: A hőmérséklet hatása az anyanyúl takarmányfogyasztására

Napi takarmányfogyasztás, g(1), Fialás utáni napok(2)

Figure 9

Effect of temperature on milk production of does



9. ábra: A hőmérséklet hatása az anyanyúl tejtermelésére

Napi tejtermelés, g(1), Fialás utáni napok(2)

At 15, 23 and 30 °C, the daily feed intake of does was 289, 278 and 261 g, and the daily milk yield was 161, 161 and 114 g, respectively. The litter weight and the individual weight of kits were in close correlation with the milk yield.

In Europe cooling systems are used to reduce heat and its negative effect on the performance of rabbits. In countries where the humidity is high some of these systems are not effective. In some countries (e.g. in Indonesia) hot climate is typical near to sea level but in the regions of mountains temperature can be more comfortable for rabbit breeding.

In a summer experiment rabbit does were sheared two days before insemination (11 days after parturition) (*Szendrő et al.*, 2007). The shearing had a positive effect on milk production (215 vs. 227 g/day), litter weight at 21 (2.38 vs. 2.50. kg), at 28 (3.39 vs. 3.53 kg) and at 35 days of age (5.32 vs. 5.82 kg). This effect could be stronger if rabbits are sheared before kindling (or before mating). Results confirm that shearing of does reduces the negative effects of heat stress (high temperature). Development of a new hairless breed for arid and tropical regions of the world is suggested by *Rogers et al.* (2004). Furless rabbits have better heat tolerance and higher critical body temperature zone, thus better growth performance than furred ones.

RECOMMENDATIONS

- Synthetic breed (crossing of local and intensive breeds) with good balance of adaptability and production can be used by farmers.
- Selection criteria could be the teat number and growth rate.
- Female breeding rabbits could be chosen from large litters with medium or large birth weight and with 10 teats on kits. (10-teat male rabbits are also advantageous.)
- Rearing female kits in small litters is favourable to improve their milk supply. (The small and male rabbits can be fostered to other does.)
- From about 10 weeks of age a restricted feeding or *ad libitum* feeding with a fibrous diet is recommended. (Green forage, hay and cereal based feeding is suitable in most of the developing countries)
- About one week before the first mating, a diet with higher energy and protein levels is suitable for increasing receptivity and fertility as a flushing.
- First mating can be applied when does reach 75% to 80% of their mature body weight (Mature for breeding.)
- Receptivity of lactating does can be improved by biostimulation methods (increasing the daily lighting or changing free nursing to controlled 2 or 3 days before mating). (Receptive does conceive better.)
- Mating twice (immediately one after the other) is efficient.
- Pregnancy determination is a good method to reduce the duration between two parturitions.
- Controlling the nest during and after parturition (kindling outside of the nest box or poor quality of nest) is a way of reducing kits' mortality.
- Fostering on the basis of the number and weight of kits is a practical procedure to decrease suckling mortality.
- In case of shortening the mating period for a few days the chance of fostering is better.
- Controlled nursing for primiparous and free nursing for multiparous does are proposed to reduce suckling mortality.
- The 20^{th} day (or a bit later) mating is suggested to avoid the overload of does by simultaneous lactation and pregnancy, thus to reduce the negative energy balance. A 20-day mating results more matured kits at weaning.
- For the lack of cooling system, to avoid the negative effect of heat stress, shearing the does' hair on their back and both sides is suggested.
- Most of the experimental data in the literature were published from countries having continental climate, so it could be important to help and icrease the research activity in developing countries to get more adaptable results.

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