rabbit genetics

The efforts toward genetic potential improvement concerning prolificacy in rabbits (*Oryctolagus cuniculus*) and nowadays technological practices: A paradox

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Abstract. The present paper discusses the contrast between prolificacy improvements in rabbit (*Oryctolagus cuniculus*) and the new tendencies in the applied technologies which actually cancel all achievements in this field. It is about culling nests to 6 or 8 kits/nest (ideal to 6 individuals) in order to obtain satisfying production indices (uniform nests in term of individual weight, low mortality rate during suckling, weaning and fattening period, and high individual and total weight at weaning at the end of fattening period), while research is still conducted in order to increase prolificacy, which is already exhibiting more than satisfying values.
Key Words: genetic potential, culling, reproductive biology, domestic rabbit, maternal traits, heritability, genetic correlation.

Rezumat. Lucrarea de față discută contrastul dintre programele de ameliorare genetica a iepurilor (*Oryctolagus cuniculs*) privind prolificitatea și noile tendințe tehnologice din domeniu, care practic conduc la inutilitatea eforturilor depuse de-a lungul zecilor de ani pentru îmbunătățirea performațelor de reproducție prin prisma prolificității. Concret este vorba despre practica actuală de a forma cuiburi a câte 6 sau 8 indivizi (ideal 6) în vederea obținerii unor indici de performanță (uniformitatea indivizilor în cadrul unui cuib sub aspectul greutății, mortalitate redusă în perioada alăptării, înțărcării și îngrășării, respectiv greutate individuală și totală cât mai ridicată la înțărcare și la sfârșitul perioadei în îngrășare) superiori în timp ce lucrările de ameliorare în vederea creșterii prolificității constituie în continuare obiectul cercetărilor, deși acest indicator prezintă valori mai ridicate decât cele necesare (suficiente).
Cuvinte cheie: potențial genetic, biologia reproducției, iepure de casă, calități materne, heritabilitate, corelații genetice.

Kivonat. A jelen dolgozat a házi nyúl (*Oryctolagus cuniculus*) szaporaság növelését célzó nemesítési programok és azok az aktuális gyakorlati praktikák közötti ellentétet tárgyalja, amelyek gyakorlatilag feleslegessé teszik az eddig elért eredmémyeket. Konkrétan a 6 illetve 8 fiókára/alom (ideálisan 6 fiókára) való selejtezés gyakorlatárol van szó. Bebizonyosodott, hogy ezzel az eljárással a termelési mutatók javulását/ növelését érhetjük el (egyenletes almok kialakítása, alacsony elhullási arány elérése a szopós fióka stádiumban, választásnál illetve a hizlalás végén és nem utolsó sorban minél nagyobb egyedi és össztömeg elérése). Eközben a nyúl szaporaság növelése napjainkban is a nemesítési programok szerves részét képezik, annak ellenére, hogy ez a termelési mutató értéke jóval a szükséges szint felett van.
Kulcsszavak: genetikai potenciál, selejtezés, szaporodásbiológia, hazi nyúl, anyai tulajdonságok, öröklődés, genetikai korreláció.

Introduction. Camps (1976) affirmed long time ago that "the productivity of rabbit-breeding is determined by the rhythm of parturition, the prolificacy and viability of young rabbits". Commonly the standard breeding programs for rabbits are based on selection within lines for prolificacy and growth (Sánchez et al 2014). Cifre et al (1998a,b), in order to improve prolificacy traits in rabbits, have been used an alternative approach within-line selection, following some successful hyperprolificacy techniques applied in the swine sector, described by Bichard & David (1985), Sorensen & Vernersen (1991), Herment et al (1994), Noguera et al (1997).

Although the domestic rabbit (*Oryctolagus cuniculus*) is popular due to its favorable biological characteristics as short generation interval and a high fecundity and prolificacy (FAO 1997; Lukefahr & Hamilton 1997; Lukefahr et al 2013; Sorhue et al 2013; Blaga & Burny 2014), several research still focus on the improvement of the prolificacy (see any program of commercial rabbit), by developing artificial maternal lines with superior reproductive traits.

Tendencies of the rabbit prolificacy improvement programs worldwide and their results. In 2009 at the Rabbit World Congress held in China the researchers concluded that the prolificacy is adequate (Tables 1, 2) and does not need to be improved further, because anyway does wouldn't be able to rise bigger nests in optimal condition, in terms of: number of weaned individuals, individual weight, total weight. Instead, researchers should focus on the equalization of the individual weight, because numerous litters with low individual weight are as detrimental as small litters with high individual weight. Offspring with lower body weight than 35 g is culled in the first days. Therefore, in the research stations, instead of prolificacy increment the main focus is on the equalization of kits birth weight within the nest. Serious reduction in litter mates individual weight differences can be achieved after only a few generations (Szendrő 2009). On some French industrial rabbit farms was recorded a mortality for the first 21 day of 2% (Szendrő 2009), so the prolificacy improvement is not justified to overcome losses during the suckling period.

A year later, the same author (Szendrő 2010) reported that significant improvement of prolificacy in rabbits takes twelve generations of selection.

Table 1

Some familiar hybrid rabbit's performances (Holdas 2000)

Parameter	*Hybrid*			
	Hyplus	*Hycole*	*Zika*	*Hyla*
Birth rate %	70-80	75-85	75-85	70-85
No. of total kits/kindling	9.5-10.5	9.0-10.0	8.5-9.5	8.5-9.5
No. of born alive kits/kindling	9.0-10.0	8.5-9.5	8.0-8.5	8.0-9.0
No. of weaned kits	8.0-8.5	7.5-8.5	7.0-7.5	7.5-8.0
Weight at birth (g)	58-60	60-62	60-65	60-63
Weight at 28 days (g)	650-700	550-600	550-600	-
Weight at 35 days (g)	900-950	-	-	750-850
Weight at 70 days (g)	2,400-2,500	2,200-2,400	2,200-2,400	2,400-2,500
Weight at 77 days (g)	-	2,400-2,600	2,500-2,700	2,600-2,700
Weight at 84 days (g)	-	-	2,700-3,000	2800-2900
DWG (g)	38-43	35-40	40-45	40-43
Forage consumption g/day	125-135	120-130	130-150	130-150
Forage capitalization g/g	3.0-3.3	3.1-3.3	3.1-3.3	3.2-3.4
Dressing %	58-60	57-59	58-59	58-59

DWG – daily weight gain.

Table 2

Summary statistics by genetic type (LP and V) for prolificacy, fertility, and cumulative production (Sánchez et al 2014)

Prolificacy						
Item	*LP*			*V*		
	n[1]	*Mean*	*SD*	*n*	*Mean*	*SD*
TB[2]	1,760	9.57	2.815	1,634	9.70	2.992
BA[2]	1,760	8.89	3.162	1,634	8.97	3.267
NV[2]	1,677	7.88	2.770	1,557	7.91	2.892

Fertility				
	LP		V	
	Pregnant	Nonpregnant	Pregnant	Nonpregnant
n	1,824	460	1,711	435
Proportion[3]	79.86%	20.14%	79.73%	20.27%

Cumulative production				
	LP		V	
	Censored	Uncensored	Censored	Uncensored
n	127	136	100	164
Proportion	48.29%	51.71%	37.88%	62.12%
Mean	73.14	28.93	72.79	30.74
SD	14.661	23.203	15.159	23.713
Minimum	37	0	33	0
Maximum	122	91	115	100

LP & V - maternal rabbit lines selected for hyperprolificacy.
[1]Number of records.
[2]TB - total born; BA - born alive; NW - number of young at weaning.
[3]Proportion within line.

Sinkovics (2000) reported an experiment where culling of nests to 6 kits/nest showed more desirable production indices than the control group, where all the born young were kept (Table 3).

Table 3

Evolution of health and productive indices in A (nest with 6 kits) and B (control) groups, at the weaning age (32 days) (Sinkovics 2000)

Parameter	*Group*	
	A	*B*
Followed females	118	105
Total no. of born offspring	967	819
Mean offspring/kindling	8.1	7.8
Culled	259	-
Total starting suckling kits	708	819
Mortality until weaning	37	194
Mortality % until weaning	5.2	23.6
Weaned individuals	671	625
Total weight at weaning (kg)	624	437.5
Mean weight at weaning (kg)	0.93	0.70
Weight difference at weaning (kg)	+ 186.5	-

Meanwhile the improvement programs of the modern production rabbits still focus on the improvement of the rabbit species prolificacy, where 9-10 kits/kindling is a common value (Tables 4, 5, 6).

Table 4

Target performances for the French Hycole female parent line rabbits (http://media.hycole.com/10091.pdf) (see the hybrid in Figure 1)

Parameter	*Value*
Teats	85% of females presents 9 or more functional teats
Birth rate	≥87%
No. of born alive kits/kindling	10.20 to 10.50
Weaned/kindling	8.90 to 9.20
Viability during fattening	≥97%
Productivity	19 to 20 kg/I.A.
Renewal	100%
Productivity/female career	65 rabbits

The parameters correspond to the results obtained in 2014 from the top 10% breeders using HYCOLE genetics (20 breeders – 100.669 I.A.).

Figure 1. Hycole parental female line (http://www.hycole.com/en/femalelines/).

Table 5

The German Zika tetra-linear hybrid rabbit's performances (http://www.nyultermektanacs.hu/index.php?page=menu&id=39) (see the hybrid in Figure 2)

Parameter	*Value*
No. of born alive kits/kindling	9.1
Weight at 28 days (g)	600
Weight at 56 days (g)	2,000
Weight at 70 days (g)	2,500
Weight at 84 days (g)	3,100
Forage capitalization (g/g)	3
Adult female weight	4,500
Adult male weight (g)	5,500

Figure 2. Zika rabbits (http://www.zika-kaninchen.de).

Table 6

The Hungarian White of Debrecen hybrid rabbit's performances
(http://www.nyultermektanacs.hu/index.php?page=menu&id=38) (see the hybrid in Figure 3)

Parameter	*Average values*
Breeding age	17-18 weeks for females 20-22 weeks for males
Birth rate %	70-80
Mean offspring/kindling	8-10
Kindlings/year/doe	6-7
Weight at 6 weeks of age (g)	1,100-1,300
Weight at 10 weeks of age (g)	2,400-2,600
Forage capitalization (between 6 and 10 weeks of age)	2.9-3.4 kg/kg live weight
DWG (g)	42-44
Dressing %	58<
Adult weight (kg)	4.4-4.8

DWG – daily weight gain.

Figure 3. The White of Debrecen (http://hazinyultartas.hu/nyulfajtak/debreceni-feher-nyul). (The White of Debrecen breed can also exhibit Himalayan color pattern).

Szendrő (1980) cited by Holdas (2000), working with New Zealand White rabbits (Figure 4), emphasizes the same case reported by Sinkovics (2000) of the numerous litters against the smaller litters. The bigger is the litter size, the lower are the individual and total body weights, regardless of the considered age (Table 7). It is worth thinking if bigger litter size is mandatory.

Figure 4. New Zealand White rabbits – production line.
(http://theselfsufficientliving.com/best-meat-rabbit-breeds/)

Table 7
New Zealand White rabbits body weight evolution according litter size (Szendrő 1980 cited by Holdas 2000)

Age (weeks)	*Litter size (individuals)*			
	4-5	*6-7*	*8-9*	*10-11*
	Body weight (g)			
0	71.8	65.9	62.9	60.9
1	183.7	153.8	138.6	132.7
2	299.0	264.7	237.3	220.4
3	430.8	369.1	320.2	276.0
4	665.8	584.0	511.8	490.4
5	924.2	798.6	729.1	702.2
6	1,181.7	1039.7	986.0	952.6
7	1364.2	1270.9	1217.5	1181.1
8	1593.3	1482.6	1438.2	1405.6
9	1804.2	1691.7	1646.9	1600.4
10	2006.7	1903.7	1866.9	1814.1
11	2207.5	2144.0	2094.6	2047.0
12	2451.7	2360.3	2330.6	2284.4

Oseni & Ajayi (2010) reported similar results to those presented by Szendrő (1980) cited by Holdas (2000) concerning correlations between litter size and some productive indices. Therefore, average weight of kits at kindling and at day 28, as well as kit survival rate (SR) and daily weight gain (DWG) were significantly higher in low-sized litters, when compared to intermediate- and large-sized litters (P<0.05).

Sánchez et al (2014) reported research about a rabbit line founded for hyperprolificacy, where differences concerning prolificacy traits (0.22) recorded between some populations was generated by the genotype x environment interaction.

Ramon & Rafel (2002) mention an average value for prolificacy in a Spanish commercial rabbit population of about 9 kits/parturition, and the average value for all parturitions during the whole productive life of a doe approximately 8.

Prolificacy improvement may have some arguments like overcoming disadvantages of the embryonic resorption and the mortality in different stages. However according to Holdas (2000) the mortality increases in both too small and too large litters. In New Zealand White litters with less than 5-6 kits the occurrence of the whole nest loss will increase due to the low maternal abilities. In contrast, in the exceptional numerous litters (more than 9-10 kits) the number of the unviable individuals will increase due to the lower individual weight (Holdas 2000).

Studies have shown processes of embryonic resorption mainly at the beginning of the gestation, but they can occur also in the terminal stage. Embryonic resorption was deducted after several observations when 12-18 yellow bodies were found in the ovaries but only 6-8 embryos in the uterus. In this case the embryos number can reflect the biological potency of the species (Sinkovics 2000).

In optimal conditions 12.06 yellow bodies can be found in most of the Californian and New Zealand White female rabbits, usually slightly more in Californian's than in New Zealand White's (Holdas 2000).

Moreover, during necropsy made in industrial farms on does at the 6^{th}-10^{th} day of gestation, the embryos were found to differ in size; embryo atrophy and embryo development regress were observed. Common occurrence of the embryo resorption can be explained by the low h^2 value of the prolificacy (Sinkovics 2000). This low h^2 value of the prolificacy in rabbits was reported by several researchers (Brun et al 2016; Sorhue et al 2013; Iraqi 2008; Sinkovics 2000; Holdas 2000) (Table 8). Blasco et al (1993) confirms the low heritability of prolificacy, but also states that it is highly variable; significant genetic variation also can be found between different breeds or different populations.

Important to note that the embryo resorption can be facilitated by fever, infectious diseases and other environmental factors (e.g. high temperature) (Sinkovics 2000).

Table 8

Heritability estimates and standard errors for litter size traits (Sorhue et al 2013)

Traits	*h 2σs + se*	*h 2σd + se*
TB	0.08 ± 0.60	0.8971 ± 0.15
BA	0.02 ± 0.59	0.5477 ± 0.54
BD	0.01 ± 0.58	0.7638 ± 0.22
NW	0.94 ± 0.10	0.9695 ± 0.05

h 2σs – heritability from sire component of variance, h 2σd –heritability from dam component of variance, TB - total litter size born, BA - born alive, BD - born dead or still born, NW - number weaned.

A recent created Romanian breed, the Transylvanian Giant Rabbit (Figure 5), which was created in order to obtain a rustic (hardy) and productive large sized rabbit (Petrescu-Mag et al 2009; Ilyes et al 2016) also possess all the features concerning prolificacy (7.56±0.52 kits/female), weaned individuals/female/ kindling (7.06±0.17), average weight at weaning (at 8 weeks) (1,788.75±40.12 g), average weight at 1 month of age (722.45±7.94 g), at the age of 2 months 1,880.88±8.53 g, at the age of 3 months 2,944.18±6.18 g, at the age of 8 months 6,443.94±53.74 g, with the highest daily weight gain (DWG) at the interval of 1-2 months (38.61 g), and the lowest DWG at 7-8 months (6.56 g), as reported Petrescu-Mag et al (2014), characteristics which seem to be competitive if we would like to approach this breed from a productive perspective. Not at least its prolificacy does not need to be improved since reports of Sinkovics (2000) presented the ideal nest size as 6 kits/kindling.

It can be seen that even rabbits non-improved for prolificacy trait possess the genetic potency to satisfy today's requirements.

Figure 5. The Transylvanian Giant Rabbit (Foto: www.mircearosca.com).

Garcia et al (2012) studying the heterosis on the prolificacy in rabbits using diallelic crossing did not found significant heterosis for total born (TB) and born alive (BA) features, whose values were lower than the ones reported by Garcia et al (2013). In contrast, several researchers (Brun & Saleil 1994; Brun et al 1998; Khalil 1999; Orengo et al 2004; Brun & Baselga 2004, 2005; Al Saef et al 2008; Szendrő et al 2008; Youssef et al 2008) reported positive and significant heterosis with higher values for the TB and BA, which differs from the results obtained by Garcia et al (2013).

In attempts to obtain a satisfying heterosis in prolificacy by crossings, negative results were also reported from Saudi Arabia by Iraqi et al (2007) where the authors did not find a heterosis different from 0 (zero), and moreover, the crossing surpassed the pure progenitors with 0.40 young rabbits born alive/kindling.

Conclusions. Since rabbit does can raise in optimal condition (low mortality rate, good weight gain) no more kits than their functional teats, and researches showed that this value is 8-10, which of the first 2 teats (the pectoral ones) are frequently barren, it is unequivocal that higher litter size (9-10 and more) involves higher mortality rate at any stage (suckling, weaning, fattening) due to differences in individual weight which conduct to more or less unviable individuals. The unviable individuals which will die anyway sooner or later, during their life will consume a certain quantity of food (milk, forage, eventually medication) of which could be benefited their viable nest-mates. Experiments with weaning at 32 days, proved that nests culled to 6 kits/nest (experiment conducted on 118 nests) obtained superior values for mortality until weaning (5.2%) and higher average weaning weight (0.93 kg) against control group (105 nests) where all the born kits were kept, with an average of 7.8 kits/nest (mortality until weaning 23.6%, higher average weaning weight 0.70 kg). So it is quite evident, that if the average prolificacy was higher than 7.8 kits/nest the loss was higher. It was proven that even in cases of high rate of embryo resorption, there is obtained 8-12 kits/kindling. Therefore, improvement of productivity in the rabbit production sector should focus not on prolificacy improvement (which is already more than sufficient) but on the homogeneity of nests, on the maternal qualities of females and not at least on the technological processes improvement (weaning, fattening, foraging, welfare, etc.). Since rabbit populations/breeds which were not improved for prolificacy trait possess the genetic potency to satisfy today's requirements, one should think twice whether further improvement for this trait is still required.

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