Extender dark brings good results for short term but is a bad perspective for the artificial selection of Transylvanian Giant Rabbits

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Abstract. In this paper we discuss on the negative effect of extender black (E^d) gene on the offspring quality in Transylvanian Giant Rabbit. E^d gene makes the agouti rabbits looking like the black rabbits even if they are heterozygous (E^dE), due to its dominance. In the presence of a pair of c^h genes at C locus (c^hc^h), a rabbit $c^hc^hE^dE$ can be of ideal colour: white with black extremities. The problems appear in offspring when the genes at the E locus segregate, resulting in c^hc^hEE individuals. In Transylvanian Giant Rabbits the black on the extremities is preferred to be the result of the interaction of genes at the loci A and B. Such black phenotypes are due to recessive genes and generally do not segregate. The breeder can identify the right genotypes by progeny testing. A good management of the "black genes" can increase the percentage of rabbits with best color for show and/or livestock production. The first observation on the dominant black phenotype in Transylvanian Giant Rabbit was made by Moise Salejan and reported to Ioan Valentin Petrescu-Mag and collaborators.
Key Words: rabbit genetics, *Oryctolagus cuniculus*, E series, extender black, extension.

Introduction. Prior to any process of rabbit domestication, they were all of agouti colour pattern which is considered the ancestral phenotype, and it is characterized by alternating bands of black and red colour on the shaft of the hair. *Oryctolagus cuniculus* has a number of 2n = 44 chromosomes. Most part of the genes which affect the colour of the rabbit coat is placed on not more than four pairs of chromosomes. These genes have been categorized by geneticists into a system referred to as the coat colour series and are labeled A, B, C, D and E, more exactly: agouti or not, black or chocolate, complete colour or shaded or albino, dense or diluted colour, and extender/colour extension or its limitation or elimination (McNitt et al 2013). In this paper we discuss on E locus, and mainly on extender black gene, noted E^d (E^d standing for extender dark) and its significance for the Transylvanian Giant Rabbit breeding and selection.

E series - Extension. The series is particularly interesting in its expression. This locus controls the presence, and extent of black on tips of hair and in undercolour. More extension causes the tipping to extend further down the shaft of each hair, and less extension keeps it at the tips of the hair. Non-extension gets rid of the tipping altogether, and the Japanese allele causes the black to appear in patches rather than on each hair (McNitt et al 2013), the pattern being analogue to the calico pattern observed in cats (Table 1).

The dominant black (E^d) gene makes an agouti rabbit to look like a black rabbit. Therefore such a gene can be of interest in solid coloured rabbits, but not in broken ones. The steel (E^s) allele causes the darker undercolour to be extended. The ticking may also appear longer. This turns the short-haired areas dark and makes an agouti rabbit look like the top coat is too heavy. It also tends to turn the belly dark.

E is the normal extension which allows the banding and colours to show through naturally. The Japanese extension (e^j) has a randomizing effect on the distribution of colour. In a solid rabbit, it is responsible for the harlequin phenotype (Fontanesi et al

2010). The last allele of this series is e, and it causes non extension, resulting in red or yellow coloured rabbits (Rabbit Coat Color Genetics 2016). New Zealand Red and Burgunder breeds are such examples of rabbits showing non extension (UGCPPAMR 2010).

Table 1

Extension series of alleles observed in rabbits

Genes	*Colours/patterns*
E^d	Black agouti; the most dominant allele of the series
E^s	Steel agouti; causes the black on the hair to be extended, often covering the middle band with dark
E	Agouti; it is the normal variant
e^j	Japanese brindling; responsible for harlequin patterns
e	Red or yellow; causes non-extension

Extender black in Transylvanian Giant Rabbit. Transylvanian Giant was recently accepted as a new rabbit breed, and is one of the three rabbit breeds produced in Romania (Petrescu-Mag et al 2009; Petrescu-Mag et al 2011; Petrescu-Mag et al 2012a, b; Petrescu-Mag et al 2014) (Figures 1-3). The other two breeds are the Cluj Rabbit and the Szekler Rabbit (see detailed information in Botha et al 2011; Botha et al 2013; Botha et al 2015). In this article we point out the negative effect of extender dark (E^d) gene on the quality of selection in Transylvanian Giant Rabbit. E^d gene makes an agouti rabbit to look like a black rabbit even it is heterozygous (E^dE). In the presence of a pair of Himalayan genes (c^hc^h) at C locus, a rabbit $c^hc^hE^dE$ can be quite perfect in terms of colour: white with black extremities. However, the problems appear in offspring when the genes at the E locus segregate, resulting in c^hc^hEE individuals, which look like the rabbit in Figure 4 (see detailed description of C series in Covrig et al 2013).

Figure 1. Adult Transylvanian Giant Rabbit, showing the perfect phenotype for the variety with black extremities (photo by Sorin Florea).

Figure 2. Young Transylvanian Giant Rabbits (photo by Teodora Inache).

Figure 3. Two possible early phenotypes observed Transylvanian Giant Rabbits: white and gray; the gray rabbits turn their colour to white at the adult age (photo by Sorin Florea).

Figure 4. Adult Transylvanian Giant Rabbit showing an accepted but unwanted phenotype: gray extremities (original).

In Transylvanian Giant Rabbits the black on the extremities is preferred to be the result of the interaction of genes at the loci A and B. Such black phenotypes are due to recessive genes and generally do not segregate (except the brown extremities, which are not unwanted). On the other side, the dominant black phenotype is encoded by the dominant gene E^d which can be E^dE^d or E^dE. Two E^dE parents will always produce sooner or later some EE offspring which look like the rabbit presented in Figure 4. The breeder can identify the right genotypes by progeny testing. A good management of the "black genes" can increase the percentage of rabbits with perfect color for show (exhibition) or livestock production.

Conclusions. In this paper we discuss on the negative effect of extender black gene on the offspring quality in Transylvanian Giant Rabbit. E^d gene makes an agouti rabbit to

look like a black rabbit even it is heterozygous (E^dE). In the presence of a pair of c^h genes at C locus (c^hc^h), a rabbit $c^hc^hE^dE$ can be of ideal colour: white with black extremities. The problems appear in offspring when the genes at the E locus segregate, resulting in c^hc^hEE individuals. In Transylvanian Giant Rabbits the black on the extremities is preferred to be the result of the interaction of genes at the loci A and B. Such black phenotypes are due to recessive genes and generally do not segregate. The breeder can identify the right genotypes by progeny testing. A good management of the "black genes" can increase the percentage of rabbits with best color for show or livestock production.

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