rabbit genetics

The Transylvanian Giant Rabbit: an efficient selection for qualitative and quantitative genetic traits

Andrei C. Grădinaru

University of Agricultural Sciences and Veterinary Medicine Iași, Faculty of Veterinary Medicine, Iași, Romania. Corresponding author: A. C. Grădinaru, andre_gradinaru@yahoo.com; a.c.gradinaru@uaiasi.ro

Abstract. The Transylvanian Giant Rabbit is a new breed in Romanian cuniculture characterized by a normal weight of about 6.0 kg with limits between 4.5 and 9.0 kg. Its color pattern is Himalayan, several shades of black for the fur at the extremities being observed. Although Romania is not a country with a tradition in rabbits' breeding and their meat consumption, a local working team put the bases for its obtaining and homologation. The aim of this paper was review the most important steps in the Transylvanian Giant Rabbit breed obtaining, and to discuss the genetic mechanisms involved in coat color determinism, focused on the parental breeds and this new one.
Key Words: genetics, coat colours, rabbits, *Oryctolagus cuniculus*.

Introduction. *Oryctolagus cuniculus*, or the domestic rabbit, represents the only species of *Oryctolagus* genus, nowadays living in Europe and North Africa. It is a part of *Leporidae* family, together with the wild rabbit or hares (*Lepus* genus) (FAO 1997). These two species were established with a different number of chromosomes, 2n=44 in *Oryctolagus cuniculus,* and 2n=48 in *Lepus timidus*. Cytogenetics studies revealed other differences among their chromosomes which lead to different morphological groups. However, although the morphology of these animals suggest a close phylogenetic connection, their chromosomes revealed striking differences which make impossible viable offspring obtaining from their mating (Dave et al 1965).

Domestication of the rabbit began about the 7th century A.D. in French monasteries. Although rabbits were kept in captivity and used for meat production in the Iberian Peninsula in the first century B.C. during the Roman occupation, the lack of selection among individuals determined this period to do not be recognized as one of the rabbits' domestication (Lukefahr et al 2013; Carneiro et al 2011). In Romania, *Oryctolagus cuniculus* was introduced in the wild before 1900s in Transylvania, in 1905 in Moldavia region (Iași, Cristești), and after 1973 in many other Romanian counties (Oroian et al 2014).

Romania is not a country with a tradition in rabbits' breeding and their meat consumption, although the rabbit meat is considered one of the most nutritious white meat. Comparing to beef, chicken, turkey or pork meat, the rabbit's has lower contents in fat and cholesterol, and a higher content in protein (Beal et al 2004). Among European countries, the biggest importer of rabbit meat, and probably the most important consumer, is Italy, followed by Belgium and France (FAO 1997). Their imports are significant (thousands of tonnes) and open perspectives for neighbour countries to produce and supply rabbit meat.

Rabbits are animals with a high rate of prolificacy, their farming requiring minimum investments in infrastructure and equipments. Although their breeding may increase the rate of family incomes, in Romania and possible in many other countries, their rearing is based more on the owner's passion for their temperament and colours, secondly for family food providing and less for financial gain. However, these facts may be changed as a result of people's interest increasing for rabbit meat consumption. There are necessary genetic improving workings in rabbit populations in order to obtain hybrids characterized by a higher efficiency of feed consumption recovered in weight gain. These may be followed by others in which a description of rabbit meat quality and its consumption benefits for human health are well-pointed out.

Up to now, several researchers fullfiled these requirements for a solid development of Romanian cuniculture (Frunză et al 2015, 2014; Petrescu-Mag et al 2014b; Botha et al 2013, 2011; Petrescu-Mag et al 2012, 2011, 2009). Petrescu-Mag, Botha and their collaborators successfully performed workings in Romanian cuniculture in order to obtain and to characterize new rabbit breeds (Petrescu-Mag et al 2014b; Botha et al 2013, 2011; Petrescu-Mag et al 2012, 2011, 2009). Frunză and her collaborators studied different characteristics of rabbit meat and found a higher water loss in rabbit meat that in hare meat, without significant differences between sexes. They also reported the highest protein content in Longissimus dorsi muscle and the highest lipid content in intercostal muscles of Belgian Giant Rabbits (Frunză et al 2014, 2015). These works are important and should be continued in order improve the new obtained rabbit breeds and to characterize their meat.

The aim of this paper is to review one of the most important work in the nowadays cuniculture, the obtaining of Transylvanian Giant Rabbit breed. Its obtaining is considered a real success both for qualitative and quantitative traits, this review being focused on colour and productive traits of this breed.

Which was the starting point in the Transylvanian Giant Rabbit breed obtaining? During 2008-2009, a flock of 20 native rabbits was aquired, considered as a maternal breed and crossed with other breeds. The first paternal breed was represented by a Californian male reared in Romania. The following matings included Giant Papillon Rabbit females and a German Giant Rabbit male, each one having a specific role in the Transylvanian Giant obtaining. For example, the Californian breed contributes with the uniformization of colour pattern (himalayan) in the resulted offspring from mating with native females, and a good skeletal and muscular support. Both Giant Papillon Rabbit and German Giant Rabbit concur at the improvement of the body size, the German Giant Rabbit having a greater contribution in this regard (Botha et al 2015; Ilyés et al 2016; Petrescu-Mag et al 2014a, 2012, 2009).

The genetic bases of coat colour in rabbits, with discussions focused on the used breeds and the obtained Transylvanian Giant Rabbit. The color pattern of the Giant of Transylvania Rabbit is pointed black white (Himalayan), as a result of c^hc^h genotype at C locus and other favourable combinations at different loci. But, what does „loci" means and how they are involved in the colour pattern of rabbits' coat? A „locus" (plural „loci") represents a gene position in the structure of a DNA molecule. In metaphase, the DNA reaches its maximum of condensation, being visible for the first time the bicromatidic chromosomes. The specific number of chromosomes for a given species is represented by the half of its chromosomal pairs (in domestic rabbits: 44 chromosomes disposed in 22 pairs). Each chromosomal pair contains a maternal and a paternal chromosome with the same morphology and similar genetic information, called homologous chromosomes. The homologous chromosomes get together in the egg cell of each individual as a result of different gametes or sex-cells combination (one gamete coming from the maternal genitor and the other, from the paternal genitor). The simplest variant of a character encoding involves the interaction among two genes which are on the same position („locus") on homologous chromosomes. In the course of evolution, a gene from a specific locus may suffer different mutations, resulting different variants called „alleles". For each animal, only two alleles can be found at each locus on homologous chromosomes, but at the level of entire population can be found more mutated alleles in different genotypic combinations. However, in rabbits not only a single locus is involved in coat colouring, but five different loci, each locus with different alleles containing. In addition to them, other minor (modifier) genes tend to change (modify) their expression in coat colourings (Lukefahr et al 2013).

The most important genes for coat color in rabbits are named accordingly to the name of their product or effect: A – Agouti, B – Black/Brown, C – Colored, D – Dilution, E – Extension.

At *Agouti locus* are known three allelic variants in the following order of dominance: $A>a^t>a$. Individuals carrying *A* allele (*AA*, Aa^t or *Aa* genotypes) express agouti phenotype which is the result of black (eumelanin) and red (pheomelanin) pigments distribution in the structure of the hairs. The hairs of an agouti rabbit are with different areas of colors, black at their tips, a yellow band in the middle, and black to bluer at their base (FAO 1997). The recessive allele a^t to *A* allele is responsible for black fur on the dorsal region of the body, including the head and ears. Therefore, individuals with a^ta^t or a^ta genotypes at this locus are without the agouti color in these regions (Lukefahr et al 2013). The non-agouti mutation is recessive to both *A* and a^t alleles. Individuals with *aa* genotype do not have a yellow band in their hairs, being uniformly dark (solid-colored or „self") (Lumpkin & Seidensticker 2011).

At the *B locus* are found only two alleles: *B* and *b.* The dominant allele *(B)* is responsible for eumelanin production so individuals with *BB* or *Bb* genotypes are with black fur (they must contain an *aa* genotype at *A locus*). The *b* recessive allele produces brown pigment instead of black, when individuals are with *bb* genotype. The brown color is expressed in different varieties when the A locus is occupied by dominant, recessive or combined genotypes *(AA,* a^ta^t*, aa,* Aa^t*, Aa,* a^ta*),* but this is not a reliable statement without taking into account the remaining three major loci.

At the *C locus* different alleles are found. Among them, a complete dominance and sometime an incomplete dominance are claimed. The most dominant *C* allele is responsible for the full amounts of melanin production in the fur, skin, eyes, and hence, for the expression of coloring (Covrig et al 2013; FAO 1997). The recessive *c* allele inhibits the melanin synthesis, individuals with *cc* genotype being albino, without pigment in hair, skin or eyes (the albinism locus is epistatic over the color loci). Among *C* and *c* alleles are known c^{ch} allele for chinchilla type, in which the expression of coloring is suppressed in the middle band of the hair, and c^h allele for Himalayan type, in which only hairs at the body extremities are black (Lumpkin & Seidensticker 2011; FAO 1997).

At the *D locus* only two alleles are found. The *D* allele produces normal pigmentation density (in *DD* or *Dd* individuals), whereas the *dd* genotype causes a dilution of the pigment granules „translated" into a blue phenotype in the case of black dilution, or beige phenotype in the case of yellow/brown dilution (FAO 1997).

E series include five alleles in the following order of dominance: E^d (black agouti) > E^s (steel agouti) > *E* (agouti) > e^j (Japanese brindling) > *e* (red or yellow). These alleles control the normal extension of black (*E* alleles) or yellow (*e* allele), with the possibility of changing the balance between eumelanin and pheomelanin in agouti hair. For example, an individual with *aa* genotype at the *A* locus will be with black fur; if its genotype formula is completed by the *ee* genotype at the *E* locus, there will increase the pheomelanin pigment in the hair, tending to replace the eumelanin. The yellow and red rabbit breeds have to posses the *ee* genotype at this locus (Oroian et al 2016; Lukefahr et al 2013; Lumpkin & Seidensticker 2011; FAO 1997).

Considering the breeds involved in Transylvanian Giant Rabbit obtaining, there are possible several remarks:

- The genetic structure of native females firstly used as a maternal breed of Transylvanian Giant Rabbit is difficult to be established because of widely variation in their phenotype (Petrescu-Mag et al 2009).
- The first male of Californian breed which was used in crossings with native females was with Himalayan pattern of its coat. This phenotype occur best in the condition of c^hc^h genotype at the *C* locus. As Ilyés et al (2016) noticed, the other genotypes at the remaining four loci must be favorable for this pointed black white expression: without agouti dominance at *A* locus *(aa),* with black possibility of expression *(B_)* (instead of the underline may be found either a dominant or recessive allele, the resulted phenotype being not changed)*,* with black hairs arranged only at extremities *(*c^hc^h*),* without any

possibility of black dilution *(DD)* or black replacing pigment in the structure of the hair *(E^d_)*.

- The phenotype of the Giant Papillon Rabbit is determined by the *En* gene (which is in addition to the *A-E* series). The White Spotting gene *(En)* is dominant to the normal *(en)* gene, the preferred phenotype of Giant Papillon Rabbit resulting from the heterozygous genotype *Enen*. The dominance degree seems to be incompletely, the dominant homozygous rabbits *(EnEn)* being whiter than the heterozygous ones, and the *enen* rabbits are blacker (Lukefahr et al 2013; FAO 1997).
- The German Giant Rabbit, the German Grey Rabbit or the Grey Giant (bred from the Flemish Giant Rabbit) is predominantly steel grey in its color due to *A_B_* genotypes which favors agouti pattern, and E^s_ which favors steel agouti. The *C_* genotype favors the full coloring of the hairs and the *D_* genotype allows a normal pigmentation density without any dilution of the pigment granules. Lukefahr et al (2013) consider the genetic formula *A_B_C_D_*E^sE the most suited for the steel agouti phenotype.
- In Transylvanian Giant Rabbit the pattern color is Himalayan. Several shades of black for the fur at the extremities were obtained because of incomplete dominance of c^h allele. Lukefahr et al (2013) reported that the rabbit with c^hc genotype is a fader version of c^hc^h genotype. Oroian et al (2016) consider the gray extremities a result of the Himalayan genes at the *C* locus *(c^hc^h)* associated with the *EE* genotype at the *E* locus. They also consider that a quite perfect Giant of Transylvania Rabbit in term of its color is when the Himalayan genes at the *C* locus *(c^hc^h)* are completed with an E^dE genotype (which corresponds to a white rabbit with black extremities).

It is not just the bigger, it is the biggest rabbit with Himalayan pattern … so far. The Californian Rabbit was previously considered the biggest rabbit of Himalayan type, with a body weight ranged between 3.5-4.5 kg (Petrescu-Mag et al 2009). To be a Himalayan giant, the body weight of the Transylvanian Giant Rabbit fitted between 4.5 and 9.0 kg, with a normal weight of about 6.0 kg (Petrescu-Mag et al 2014a; Petrescu-Mag et al 2014b, 2013). The standard of arbitration in rabbit exhibitions proposed for the Giant of Transylvania by Petrescu-Mag et al (2012, 2011) also included the necessity of an slightly elongated body (42-60 cm), with a symmetrical back line rounded in the back side. The tail should be tight to the body and neck short, with no longer hairs than 3 to 4 cm on its body and no longer ears than the 3rd part of the body length (14-18 cm). In 2012, this standard was accepted by the Commission of Standardization and Judgment of Entente Européene (Petrescu-Mag et al 2014a). A first statistical report published in 2014 by Petrescu-Mag demonstrated the achieving of the assumed goals at the beginning of this project.

Conclusions. The obtaining of Transylvanian Giant Rabbit is considered a great success in the Romanian cuniculture of the last decades. As every new breed, the Giant of Transylvania possesses a genetic burden which is responsible for different variations in undesired limits for various traits. For their removing, this project is necessary to continue, with more intensive breeding and efficient selection of individuals according to the proposed criterias.

References

Beal M. N., McLean-Meyinsse P. E., Atkinson C., 2004 An analysis of household consumption of rabbit meat in the southern United States. Journal of Food Distribution Research 35(1):24-29.

Botha M., Hettig A., Petrescu-Mag I. V., 2011 The Rabbit of Cluj: a new phenotype obtained, maintained and improved in Cluj-Napoca (Transylvania), Romania. ABAH Bioflux 3(1):42-47.

Botha M., Petrescu-Mag I. V., Hettig A., 2013 The first full morphological description of Cluj Rabbit (*Oryctolagus cuniculus*). North-Western Journal of Zoology 9(2):441-442.

Botha M., Rákossy Z., Petrescu-Mag I. V., Gavriloaie C., 2015 The Szekler Rabbit born through multiple genotype combination and recombination in order to obtain rare phenotypes in domestic rabbits (Oryctolagus cuniculus). Rabbit Gen 5(1):13-22.

Carneiro M., Afonso S., Geraldes A., Garreau H., Bolet G., Boucher S., Tircazes A., Queney G., Nachman M. W., Ferrand N., 2011 The genetic structure of domestic rabbits. Mol Biol Evol 28(6):1801-1816.

Covrig I., Oroian I., Pătruțoiu T. C., 2013 The C locus: rabbit genetics for full color development, chinchilla, seal, sable, pointed black and red-eyed full white. Rabbit Gen 3(1):23-32.

Dave M. J., Takagi N., Oishi H., Kikuchi Y., 1965 Chromosome studies on the hare and the rabbit. Proc Jap Acad 41:244-248.

Frunză G., Lazăr R., Boișteanu P. C., 2014 Research regarding nutritional quality of rabbit meat (Belgian Giant Breeds). University of Agricultural Sciences and Veterinary Medicine Iasi, Scientific Papers – Animal Science Series 62:45-48.

Frunză G., Pop C., Boișteanu P. C., 2015 Technological-quality of rabbit meat (Belgian Giant Breed) and hare meat (*Lepus europaeus* Pallas). University of Agricultural Sciences and Veterinary Medicine Iasi, Scientific Papers – Animal Science Series 63:52-56.

Ilyés K., Socol C. T., Criste F. L., 2016 The Romanian cuniculture achievements in terms of breed creation up to 2016. Rabbit Gen 6(1):26-40.

Lukefahr S. D., Cheeke P. R., Patton N. M., 2013 Rabbit production. 9th Edition, CABI, pp. 1-12; 202-220.

Lumpkin S., Seidensticker J., 2011 Rabbits-the animal answer guide. The Johns Hopkins University Press, Baltimore, pp. 49-63.

Oroian F. C., Balint C., Gavriloaie C., 2016 Extended dark brings good results for short term but is a bad perspective for the artificial selection of Transylvanian Giant Rabbits. Rabbit Gen 6(1):1-6.

Oroian I. G., Covrig I., Todoran C. F., Botha M., Blaga B. C., Petrescu-Mag I. V., 2014 Distribution of the European rabbit (*Oryctolagus cuniculus*) in Romania. Rabbit Gen 4(1):60-63.

Petrescu-Mag I. V., Oroian I. G., Botha M., Covrig I., Vesa Ș. C., 2014a Transylvanian Giant Rabbit (*Oryctolagus cuniculus*): rustic means also aggressive. Rabbit Gen 4(1):56-59.

Petrescu-Mag R. M., Oroian I. G., Botha M., Covrig I., Petrescu-Mag I. V., 2014b Morphological, productive and reproductive characterization of the Transylvanian Giant Rabbit (*Oryctolagus cuniculus*): first statistical report. North-Western Journal of Zoology 10(2):400-403.

Petrescu-Mag I. V., Petrescu-Mag R. M., Botha M., Oroian I., 2009 Transylvanian Giant Rabbit originates from Arieș and Someș areas (Transylvania, Romania). Transylv Rev Syst Ecol Res 7:187-192.

Petrescu-Mag I. V., Petrescu-Mag R. M., Păsărin B., Pop D., Botha M., Gîlcă V., Bud I., Hoha G., Creangă Ș., 2011 Proposal of standard for the judgement of the exhibition Transylvanian Gian Rabbit. ABAH Bioflux 3(1):39-41.

Petrescu-Mag I. V., Petrescu-Mag R. M., Viman O., Botha M., Hoha G., Grun E., Creangă Ș., 2012 The Giant of Transylvania: standard for arbitration in rabbit exhibitions. Rabbit Gen 2(1):1-4.

Petrescu-Mag R. M., Creangă Ș., Petrescu-Mag I. V., 2013 Mendelian laws in aquaculture and cuniculture: simple and efficient. AACL Bioflux 6(2):111-114.

*** FAO, 1997 The rabbit: husbandry, health and production. FAO Animal Production and Health Series no. 21, Lebas F., Coudert P., de Rochambeay H., Thébault R.G., Rome, Italy, pp.1-18; 61-94.

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Author:
Andrei Cristian Grădinaru, University of Agricultural Sciences and Veterinary Medicine of Iaşi „Ion Ionescu de la Brad", Faculty of Veterinary Medicine, Department of Preclinics, Romania, Iaşi, 700489, 8 Sadoveanu Alley, e-mail: andre_gradinaru@yahoo.com, a.c.gradinaru@uaiasi.ro

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