

The Szekler Rabbit born through multiple genotype combination and recombination in order to obtain rare phenotypes in domestic rabbits (*Oryctolagus cuniculus*)

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Abstract. The current paper is the first publication regarding a new rabbit (*Oryctolagus cuniculus*) breed creation and improvement in Romania, namely the Szekler Rabbit (SR). The SR is the 3rd breed which has been created in the last ten years in Romania, after the Rabbit of Cluj (RC), and Transylvanian Giant Rabbit (TGR). In 2005 were made the first steps for the RC creation via a spontaneous mutation occurred in a New Zealand White rabbit population, and then with New Zealand White, Chinchilla, Californian, and Flemish Giant infusion, resulting an ash grey, meat rabbit phenotype (medium size, ≤ 5.5 kg). After the RC, in 2008 another Romanian breed loomed, based on a rustic, polymorphic local population, which was improved with infusion of Flemish Giant, Giant Papillon and Californian pure breed rabbits, resulting a giant breed (≤ 9 kg) with himalayan color pattern. It has to be mentioned that prior 2005, Romania had no recognized rabbit breed. Nowadays there is no industrial rabbit farming in Romania, but at hobby level, the rabbit breeding is on a high enough level, due to passionate and dedicated breeders, which compete toward several breeds conservation and promotion. There is no clearer proof in this regard, that this 3rd breed (SR) appearance, which enriches the rabbit world with a distinctive posture. The SR creation is based on a rustic local cross breed population, and Californian rabbit as pure breed. After five generations of selection and improvement an iron grey (sallander) rabbit resulted with a well muscled body and rustic character (unpretentious), suitable for household breeding.

Key Words: Romanian rabbit breed, new breed, novel strain, biodiversity, sallander, color genetics.

Rezumat. Lucrarea de față reprezintă prima publicație științifică oficială cu privire la crearea unei noi rase de iepure de casă (*Oryctolagus cuniculus*) și anume Iepurele Secuiesc (IS). IS este cea de-a treia rasă de iepure creată în România în ultimii zece ani, după Iepurele de Cluj (ICJ) și Uriașul de Transilvania (UTR). În 2005 s-au pus bazele creării ICJ ca urmare a unei mutații spontane într-o populație de iepuri Neozelandezi Albi (NA), iar apoi cu infuzie de NA, Chinchilla (Ch), Californian (C) și Uriaș German (UG) a rezultat un iepure cu fenotip caracteristic raselor de carne, de culoare gri cenușiu (talie medie ≤ 5.5 kg). Apoi în anul 2008 s-a demarat un nou proiect, și anume crearea rasei de iepure Uriașul de Transilvania, a cărei populație de bază a constat dintr-un efectiv local de animale cu caracter rustic (polimorfici) și s-a intervenit cu infuzie de iepuri de rasă pură: UG, Pestriț Uriaș (PU) și C, rezultând după șapte generații o rasă de talie mare (uriașă, ≤ 9 kg) cu caractere himalaia. Trebuie menționat faptul că înainte de 2005, România nu dispunea de rasă de iepure proprie. În zilele noastre în România nu există o industrie (producție) în domeniul cărnii de iepure, însă la nivel de pasiune sportivă (hobby), creșterea iepurilor se află la un nivel destul de ridicat (profesionist), datorită unui număr însemnat de crescători dedicați și pasionați, care concurează la conservarea fondului genetic și promovarea raselor. Nu există dovadă mai clară în acest sens, decât această a 3-a rasă autohtonă (IS) care a luat naștere în 2010 și care îmbogățește lumea cuniculă cu distincta-i aparență. La crearea IS s-a folosit o populație locală polimorfică și iepurele Californian. După cinci generații de selecție și ameliorare a rezultat un iepure de o culoare distinctă (sallander), cu o musculatură bine dezvoltată, cu un pronunțat caracter rustic (nepretențios), care se pretează excelent pentru exploatare gospodărească.

Cuvinte cheie: Iepurele Secuiesc, rasă românească de iepure, rasă nouă, biodiversitate, sallander, genetica culorii.

Kivonat. A jelenlegi dolgozat az első hivatalos tudományos közlemény egy új házi nyúlfajta (*Oryctolagus cuniculus*), azaz a Székely Nyúl (SzNy) kitenyésztéséről. A SzNy a harmadik kitenyésztett nyúlfajta Romániában az elmúlt tíz év alatt, a Kolozsvári Nyúl (KNy) illetve az Erdélyi Óriásnyulat (EÓ) követően. A

KNy kitenyészése 2005-ben kezdődött el egy Új-zélandi Fehér (ÚF) populációban spontán mutáció révén létrejött egyedből kiindulva, majd ÚF, Chinchilla (Ch), Kaliforniai (K) és Német Óriás (NÓ) infúzióval, folytatódott a nemesítési munka. Ennek eredményeképpen egy hamuszürke, hús fenotípusú nyúlfajta jött létre (közepes fajta ≤ 5.5 kg). 2008-ban kezdődött el az EÓ projekt, amely alapját egy kimondottan polimorfikus helyi parlagi populáció képezte, illetve fajtatizta NÓ, Tarka Óriás (TÓ) és K infúzióval hét generáción keresztül egy egyedi küllemű, himalaya jegyekkel rendelkező nagy (≤ 9 kg) nyúlfajta lett kitenyészve. Megjegyzésre méltó, hogy 2005 előtt Románia nem rendelkezett saját nyúlfajtaival. Napjainkban Romániában nem folyik ipar nyúltermelés, viszont hobby szinten, a nyúltenyésztés elég magas szakmai színvonalon történik, számos szenvedélyes tenyésztőnek köszönhetően, akik hozzájárulnak a genetikai örökség megőrzéséhez és a nyúlfajta népszerűsítéséhez. Mi is lenne erre jobb bizonyíték, mint a harmadik romániai nyúlfajta, a SzNy, amely kitenyészése 2010-ben kezdődött és amely különleges küllemi és termelői tulajdonságaival gazdagítja a nyúlvilágot. A SzNy kitenyészése egy helyi polimorfikus populáción és egy K bakknnyúl alapult. Öt generációs szigorú szelekciós és nemesítési munka eredményül létrejött egy különleges jellemű/színű (szallander), rideg (igénytelen), jó izomzattal rendelkező nyúlfajta, amely kitűnően alkalmas a háztáji gazdálkodásra.

Kulcsszavak: Székely Nyúl, romániai nyúlfajta, új fajta, biodiverzitás, szallander, szín genetika.

Introduction. The Szekler Rabbit (SR) foundation goes back to 2010 when Mr. Zsigmond Rákossy being at the state to graduate his BSc, chooses his direction in order to write his degree thesis at the University of Agricultural Sciences and Veterinary Medicine at Cluj-Napoca, Romania (USAMV Cluj). In this connection he ruled in favor of the Genetics Department, Faculty of Veterinary Medicine, and with his mentor they choose the following title: Color genetic determinism at Leporidae.

In terms of novel (and recent) rabbit breed creation in Romania we should mention the Rabbit of Cluj (RC), where the breeding program started in 2005 (Zmaranda 2015a; Botha et al 2014, 2013, 2011; Botha 2014), and the Transylvanian Giant Rabbit (TGR) whose breeding program was initiated in 2008 (Zmaranda 2015b; Petrescu-Mag et al 2009).

The RC was born via a spontaneous mutation (Botha 2014; Botha et al 2011) in a New Zealand White (NZW) rabbit population, and after, the breeding program included NZW, Chinchilla (Ch), Californian (C), and Flemish Giant (FG - chinchilla colored) infusion in order to outline the new breed morpho-productive features.

For the TGR creation started using a local rustic heterogenous population, which was improved by infusion of FG, Giant Papillon (GP - black spotted), and C, resulted in a new giant breed with Himalayan color pattern (Oroian et al 2014; Petrescu-Mag et al 2012, 2011).

Nowadays all these three Romanian breeds are nationally recognized and they participate at the regional and national rabbit exhibition shows. The above mentioned two previous breeds (RC and TGR) recognition is started also abroad (Hungary, Slovakia), and culminating with participation at the European Shows (TGR at Leipzig - Germany in 2012, and in Metz - France in 2015; RC in Metz - France in 2015).

In two cases of the three Romanian breeds (TGR and SR) the breeding program was started using local rustic local populations, which founded a genuine rustic character, with enduring physiological features, and not at least with a good unprocessed forage capitalization capacity, which leads to this breeds outstanding low cost exploitation.

The aim of this paper is to present the beginnings of the SR breeding, until the state of a well stabilized color and morphological characteristics outlined population.

Material and Method. The experiments were initiated at two private small farms with an initial animal stock consisting in seven phenotypes as follows (the genetic code for colors are displayed first the European style [Holdas & Szendrő 2002; Sandu 1986; Vintilă 1981] followed by the US style [Robinson 1958]): agouti (A_B_C_D_G_) (A_B_C_D_E_), albino (aa _ _ _ _) (_ _ cc _ _), black (A_B_C_D_gg) (aa B_C_D_E_), but it also could be (a^{chi}B_C_D_gg) (aaB_c^{chd}c^{chd}D_E_), himalayan (aⁿaⁿB_C_D_gg) (aaB_c^hc^hD_E_), chinchilla (a^{chi}a^{chi}B_C_D_G_) (A_B_c^{chd}c^{chd}D_E_), Thuringer (A_bbC_D_gg) (aaB_C_D_ee) and broken pattern (A_B_C_D_ggKk) (aaB_C_D_E_Enen). Because the initial breeding stock wasn't compounded by pure breed individuals but crossbreeds (Figure 1), multiple test-cross: test-cross with homozygous and test-cross with heterozygous was used as method to identify the complete genotype of the

breeders, and to elucidate the involved color genes. As result the following allelic genes were found: locus A(C): A, a^{chi}, aⁿ, a; (C, c^{chd}, c^h, c) locus B(E): B, b (E, e); locus C(B): C (B); locus D(D): D; locus G(A): G, g (A, a) and locus K(En): K, k (En, en) (Pusta et al 2013). After the genotypes elucidation for each individual, very precise mating was established in order to obtain rare phenotypes.



Figure 1. The initial breeding stocks phenotype (original).

Results and Discussion. In the Table 1 appears the final genotypes for the genitors which were deduced after multiple test-cross experiments (with homozygous and heterozygous individuals), just it was described in Material and Methods. The obtained offspring's color pattern served forward as a selection base in order to achieve the experiments aim.

Table 1

The obtained genotypes after the first several matings (processed after Pusta et al 2013 and Rákossy 2010)

<i>Mating schema</i>	<i>Resulted genotypes (individuals)</i>
♀ Albino (aa_bCCDDGg) (AaBBccDD_) x ♂ Thüringer (AabbCCDDGg) (aaBBC_DDee)	5 albino (aa_bCCDD_g) (_aBBccDD_e) 2 thüringer (AabbCCDDgg) (aaBBCcDDee) 1 yellow (AabbCCDDGg) (AaBBCcDDee)
♀ Albino (aa_bCCDDGg) (AaBBccDD_e) x ♂ Black himalayan (a ⁿ a ⁿ BCCDDgg) (aaBBc ^h c ^h DDEE)	4 black himalayan (a ⁿ a ⁿ B_C_D_gg) (aaBBc ^h c ^h DDE_) 3 agouti himalayan (an_B_CCDDG_)(A_BBc ^h _DDE_)
♀ Albino (aa_bCCDDGg) (AaBBccDD_e) x ♂ Black himalayan (a ⁿ a ⁿ BCCDDgg) (aaBBc ^h c ^h DDEE)	3 albino (aa__CCDD_g) (_aBBccDD__) 2 black (AaB_CCDDgg) (aaBBCcDDE_) 2 black himalayan (a ⁿ a ⁿ B_CCDDgg) (aaBBc ^h _DDE_) 1 agouti (AaB_CCDDG_)(A_BBc ^h c ^h DDE_)
♀ Thüringer (AabbCCDDgg) (aaBBCDDee) x ♂ Thüringer (A_bbCCDDgg) (aaBBC_DDee)	5 thüringer (A_bbCCDDgg) (aaBBC_DDee)
♀ Thüringer (AabbCCDDgg) (aaBBCDDee) x ♂ Black himalayan (a ⁿ a ⁿ BCCDDgg) (aaBBc ^h c ^h DDEE)	7 black (Aa ⁿ BbCCDDgg) (aaBBc ^h c ^h DDEe)
♀ Thüringer (AabbCCDDgg) (aaBBCDDee) x ♂ Black broken (AaBBCDDggKk) (aaBBc ^h c ^h DDEE Enen)	3 black (A_BbCCDDgg) (aaBBC_DDEe) 3 black broken (A_BbCCDDggKk) (aaBBC_DDEe Enen)
♀ Chinchilla I (a ^{chi} a ^{chi} BbCCDDGg) (AaBBc ^{chd} c ^{chd} DDEe) x ♂ Thüringer (A_bbCCDDgg) (aaBBC_DDee)	2 black (Aa ^{chi} BbCCDDgg) (aaBBc ^{chd} c ^{chd} DDEe) 2 agouti (Aa ^{chi} BbCCDDGg) (AaBBc ^{chd} c ^{chd} DDEe) 2 sallander (a ^{chi} abbCCDDgg) (aaBBc ^{chd} c ^{chd} DDee) 1 thüringer (A_bbCCDDgg) (aaBBc ^{chd} c ^{chd} DDee)
♀ Chinchilla I (a ^{chi} a ^{chi} BbCCDDGg) (AaBBc ^{chd} c ^{chd} DDEe) x ♂ Black himalayan (a ⁿ a ⁿ B_C_D_gg) (aaBDc ^h c ^h DDE_)	5 chinchilla (a ^{chi} a ⁿ B_CCDDGg) (AaBBc ^{chd} c ^h DDE_) 2 black (a ^{chi} a ⁿ B_CCDDgg) (aaBBc ^{chd} c ^h DDE_)
♀ Chinchilla II (a ^{chi} a ^{chi} BCCDDGg) (AaBBc ^{chd} c ^{chd} DDEE) x ♂ Thüringer (A_bbCCDDgg) (aaBBC_DDee)	3 black (Aa ^{chi} BbCCDDgg) (aaBBc ^{chd} c ^{chd} DDEe) 2 chinchilla (a ^{chi} _BbCCDDGg) (AaBBc ^{chd} _DDEe)
♀ Chinchilla III (a ^{chi} aBBCCDDGg) (AaBBc ^{chd} c ^{chd} DDEE) x ♂ Thüringer (A_bbCCDDgg) (aaBBC_DDee)	3 agouti (A_BbCCDDGg) (AaBBC_DDEe) 2 black (A_BbCCDDgg, or a ^{chi} aBbCCDDgg) (aaBBC_DDEe, or aaBBc ^{chd} c ^{chd} DDEe)
♀ Black (_aBbCCDDgg) (aa BB_cDDEe) x ♂ Thüringer (A_bbCCDDgg) (aaBBC_DDee)	5 black (A_BbCCDDgg) (aaBBC_DDEe) 1 albino (aa_bCCDD_g) (_aBBccDD_e)
♀ Black (_aBbCCDDgg) (aa BB_cDDEe) x ♂ Thüringer (A_bbCCDDgg) (aaBBC_DDee)	5 black (A_BbCCDDgg) (aaBBC_DDEe) 1 albino (aa_bCCDDgg) (aaBBccDD_e)

<i>Mating schema</i>	<i>Resulted genotypes (individuals)</i>
♀ Agouti (AaB_CCDDGG) (AABBCcDDE_) x ♂ Black himalayan (a ⁿ a ⁿ BBCCDDgg) (aaBBc ^h c ^h DDEE)	5 agouti (Aa ⁿ B_CCDDGg) (AaBBc ^h DDE_) 3 agouti Himalayan (a ⁿ a ⁿ BBCCDDGg) (AaBBc ^h c ^h DDEE)
♀ Agouti (AaB_CCDDGG) (AABBCcDDE_) x ♂ Black himalayan (a ⁿ a ⁿ BBCCDDgg) (aaBBc ^h c ^h DDEE)	5 agouti (Aa ⁿ BBCCDDGg) (AaBBc ^h DDE_) 3 agouti himalayan (a ⁿ a ⁿ B_C_D_Gg) (AaBBc ^h c ^h DDE_)

The genetic code for colors are displayed first the European style (Holdas & Szendrő 2002; Sandu 1986; Vintilă 1981) followed by the US style (Robinson 1958).

After the genotypes were determined accurately, and from the obtained offspring the most rare and interesting color pattern was the sallander, further the experiments focused on the fixation of the resulted sallander color (Figures 2 & 3) in the population and to obtain as much sallander individuals as possible. Therefore the following matings were performed (Table 2).



Figure 2. Sall, the juvenile Szekler Rabbit founder male (original).



Figure 3. Sall III, the founder male descendent in the 3rd generation, exhibiting the breed characteristic color markings (original).

Table 2

The obtained genotypes after the matings that were planned to fix/strengthen the sallander color pattern (processed after Pusta et al 2013 and Rákossy 2010)

<i>Mating schema</i>	<i>Resulted genotypes (individuals)</i>
♀ Black (AaBbCCDDgg) (aaBBCcDDEe) x ♂ Sallander* (a ^{chi} abbCCDDgg) (aaBBc ^{chd} cDDEe)	3 sallander (a ^{chi} abbCCDDgg) (aaBBc ^{chd} cDDEe) 2 black (A_BbCCDDgg) (aaBBC_DDEe)
♀ Chinchilla I (a ^{chi} a ^{chi} BbCCDDGg) (AaBBc ^{chd} c ^{chd} DDEe) x ♂ Sallander* (a ^{chi} abbCCDDgg) (aaBBc ^{chd} cDDEe)	4 black (a ^{chi} aBbCCDDgg) (aaBBc ^{chd} cDDEe) 3 sallander (a ^{chi} abbCCDDgg) (aaBBc ^{chd} cDDEe) 1 chinchilla (a ^{chi} aBbCCDDGg) (AaBBc ^{chd} cDDEe)

The genetic code for colors are displayed first the European style (Holdas & Szendrő 2002; Sandu 1986; Vintilă 1981) followed by the US style (Robinson 1958).

* - Sall the founder male (Figure 2).

There is a breed calling Sallander which has its roots in the Netherlands, Salland region. This breed was produced in the 1970s by a famous rabbit judge by crossing Thüringer and the Chinchilla rabbits. Later, the breed is formally recognized in 1975. In the 1990s the breed is exported to the UK, but it barely occurs outside of The Netherlands or the UK (<https://www.omlet.co.uk/breeds/rabbits/sallander>). Even in the UK, where is recognized by the BRC, in Breed Standards appears at the chapter of rare breeds. Nowadays according to the BRC Standards (2015), the Sallander is included at the rare breeds, in the middle size category with weight limits between 2.5 and 4.25 kg. As appearance it is described as a muscular, fairly stocky rabbit with light grey markings which are darker on the flanks, cheeks, and belly. The color of the Sallander rabbit is described as a light grey that graduates to a darker grey along the extremities (face, ears, feet and tail) which provides a unique and stunning contrast on the body (<https://www.omlet.co.uk/breeds/rabbits/sallander>).

Some literature notes mention about four color varieties of the Sallander rabbit, as following (European code followed by the US code): Iron grey (a^{chi}a^{chi}bbCCDDgg) (aaB_c^{chd}_D_ee), Chocolate sallander (a^{chi}a^{chi}bbccDDgg) (aabbcc^{chd}_D_ee), Blue sallander (a^{chi}a^{chi}bbCCddgg) (aaB_c^{chd}_dd ee), and Lilac sallander (a^{chi}a^{chi}bbccddgg) (aabbcc^{chd}_dd ee), (<http://nyultenyesztok.hu/nyulakrol-altalaban/elhelyezes-tartas-takarmanyozas/egy-kis-szingeometria/>), but only one of them, namely the iron grey variety is officially recognized.

Worldwide, as it was mentioned above, the Sallander Rabbit only has a limited following in the United States, where it is not yet recognized by the American Rabbit Breeders Association (ARBA). It is only officially recognized in the UK, by the British Rabbit Council (BRC) and is listed as a 'rare' breed under the 'Fur' section (BRC 2015).

There is polemics about this rabbit breed (Sallander) name and color. If there appears iron grey individuals (by cross breeding) should they be called Sallander rabbits or just sallander colored rabbits? Since those individuals do not descend from pure breed Sallander rabbit genitors it would be more clear and appropriate to just call them sallander colored, just in the case of the Szekler Rabbit, which is sallander colored; he descends from a local rustic polymorphic population with a multitude of allelic genes. The only pure breed which contributed to the creation of the SR, was the Californian rabbit. Therefore the SR cannot be called Sallander (as a breed), but sallander as coloration. Despite of all the enumerated aspects frequently the iron grey color is used as synonym for the sallander color in rabbits.

Although statistical report regarding the morphological, productive and reproductive characterization was published only for the TGR (Petrescu-Mag et al 2014a), which proved its real aptitude for meat production, and eventually improvement of local rustic populations, the RC and the SR proves they are competitive regarding production

yield (personal experience and personal discussion with breeders), in line with the European rabbit market needs (Botha et al 2007a).

Nowadays the SR is considered a well genetically stabilized breed, since color and eventually other morphological traits segregation occurs only accidentally, with no statistical relevance. Normally the kits from a nest show a very homogenous population, regarding its morphological traits (Figure 4).



Figure 4. A Szekler Rabbit nest, proving the homogeneity of the breed (original).

Figure 5 presents the final and most desired characteristics of the SR. Sall IV is the 4th generation direct descendent of the founder male Sall.



Figure 5. Sall IV, a guidance model for the ideal morphological characteristics of the Szekler Rabbit (original).

As temperament the SR is characterized by an easy to handle and calm breed, just as in the case of RC (Botha et al 2013, 2011), but in contrast with the TGR, which exhibit a very conservatory and territorial behavior with own conspecifics and humans also (Petrescu-Mag et al 2014b). Just as reported Petrescu-Mag et al (2014b), regarding the aggressive behavior of the TGR, Botha et al (2007e) reported similar findings observed at

Californian rabbit females, a breed having the same color pattern as TGR. Since Petrescu-Mag et al (2014b) linked this behavior pattern to the breed's origin (rusticity), Botha et al (2007e) could not find a reason for the pure breed Californian does behavior. It is not excluded a linkage between the Himalayan color pattern and above average aggressiveness behavior.

Since a new breed needs expansion and increase of individuals number of the population in order to avoid undesirable genetic involvements (inbreeding, genetic drift), there were developed several methods and techniques as described by Botha et al (2007b,c,d,) and Botha & Hettig (2007) which can be successfully used forward in the SR breeding and improvement.

Conclusions. Following the presented crossings established in the initial and followed experiments, several rare and interesting phenotypes were obtained, but the most outstanding were the sallander colored individuals, which resulted first from crossing of Chinchilla and Thüringer genes carrier genitors, and later the fixation of the obtained color was performed by using black and sallander, and chinchilla and sallander parental lines. Today even two color varieties of the SR was breed, namely the iron grey and the chocolate grey. After five years of work (selection and pair matching), resulted a clean-cut population with animals which are characterized by a well muscled, cylindrical and robust body. The weight scale is set for minimum 4 kg, desirable above 5, and with a maximum allowed of 6 kg, with normal hair length (3-3.5 cm), and 12-14 cm ear length. The eyes should be bright dark grey for the iron grey variety, and slightly lighter for the chocolate grey variety. The color of the animal is light iron grey or light chocolate on the back with darker markings on the extremities, without clear demarcation. Regarding the breed future, we can say that is in a growing trend, with about 200 individuals at 60 breeders, and they are just become increasingly more. The breeding program of the SR follows to rank together all the genitors desirable morpho-productive characteristics in order to obtain a robust animal with good production yield. The further improving of the breed also aims to conduct selection toward a rustic (unpretentious) meat producer, suitable for extensive breeding, and not at least toward an elegant, unique and distinctive morphology.

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