

A rare and modern trait of the domestic rabbit (*Oryctolagus cuniculus*): The Japanese brindling

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Abstract. Our paper is a brief explanatory note on the Japanese rabbit breed and the genetic basis behind this color trait. It is a work with illustrations and theory of classical genetics, explaining the polyallelic relationship existing at the E locus in *Oryctolagus cuniculus*. The e^j allele from the E locus is a gene with extremely high versatility. In combination with other alleles and non-alleles it can produce a multitude of different color patterns that are extremely spectacular in domestic rabbits, such as calico cats or calico koi carps.

Key Words: Harlequin rabbit, mammals, rodents, calico, tricolor, E locus, e^j gene.

The meaning of rabbit breed. Hundreds of rabbit breeds have been created and described worldwide and, of these, over 300 breeds are existing breeds. These breeds are standardized by international fora such as Entente Européenne d'Aviculture et de Cuniculture (EE), the American Rabbit Breed Association in the US (ARBA), or the British Rabbit Council (BRC).

Breeds of rabbits appeared by natural selection combined with selective reproduction for certain traits such as: body size or shape, length, quality and color of hair, feed conversion rate, adaptability to specific climatic factors, temperament, precocity, prolificacy, lactation potential, average daily body weight gain, etc (Botha et al 2013; Naff & Craig 2012; Petrescu-Mag et al 2012, 2014, 2020).

Japanese breed and E locus. Some breeds were created mainly for ornamental purposes (show rabbits). This is the case of the Japanese breed, also called the Harlequin rabbit. This breed has certain peculiarities at locus E (extension) (Figure 1A) (Fontanesi et al 2010; Oroian et al 2016).

Polyallelic interaction is the phenomenon in which there are several alleles for a given locus between which there are relations of dominance, codominance and recessiveness. This is the case of E locus in the domestic rabbit. Alleles located at E locus control the presence and extent of black pigmentation on hair tips and also in undercolor (Figure 1). More extension causes the tipping to expand further down the shaft of each hair, and less extension keeps it only at the tips (minkhollow.ca) (Figure 1B). Non-extension trait gets rid of the tipping altogether, and the Japanese allele causes the black pigmentation to appear in patches rather than on each hair (Figure 2), similar to the calico pattern known in cats (minkhollow.ca) (Figure 3) (Crosta et al 2020; Crabtree 2020). A similar trait is observed in the skin of calico goldfish or koi carps (Figure 4) (Petrescu-Mag 2007).

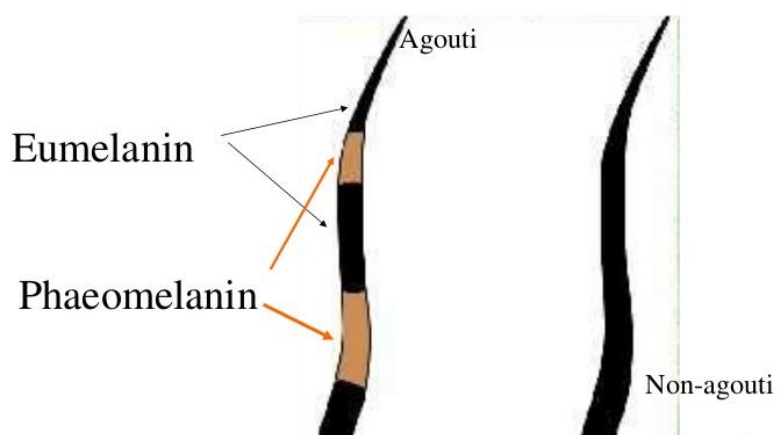
The Japanese extension (e^j allele) has a randomizing effect on the distribution of color in the fur. In a solid rabbit, it is responsible for the harlequin trait (minkhollow.ca). It is the only e-series gene that is acceptable in harlequin rabbits by standards. The black-orange and blue-cream carry the C gene for full color development, and the

magpies (chocolate-white and black-white) carry the chinchilla gene (c^{ch}) (minkhollow.ca). An agouti rabbit or otter rabbit with one full extension (E) and one Japanese gene (e^j) will always show the randomizing effect which is most notable inside the ears and around the eyes (minkhollow.ca).

Gene	Name	Description	Examples
E_s	Steel	With agouti, covers the middle band with dark pigment. Darkens the agouti type landmarks: eye circles, triangle at nape of neck, feet, legs, and inside of ears. Leaves white guard hairs (ticking).	Black, Chestnut, and Chinchilla Steel
E	Normal Extension of dark pigment	Working with the C series genes, allows the complete expression of the dark brown pigment.	New Zealand Black
e^j	Japanese brindling	Works with Agouti gene to cause the black and yellow colors to be arranged in areas instead of individual hairs in a mosaic pattern.	Rhineland (with the E series genes), Harlequin
e	Non-extension of the dark pigment	Working with the C gene series and the rufus modifiers, this gene removes all or most of the dark pigment, leaving yellow, orange or white.	New Zealand Red, Sable Point Dwarf, Frosted Pearl Dwarf

A

Agouti (banded) hair



B

Figure 1. Alleles located at locus E and the effect on hair pigmentation. Sources: <https://www.debmark.com/rabbits/genetics.htm> (A), <https://i0.wp.com/> (B).



Figure 2. Harlequin phenotype (Japanese), caused by the e^j allele together with the agouti gene (photo by Vicențiu Hossu).

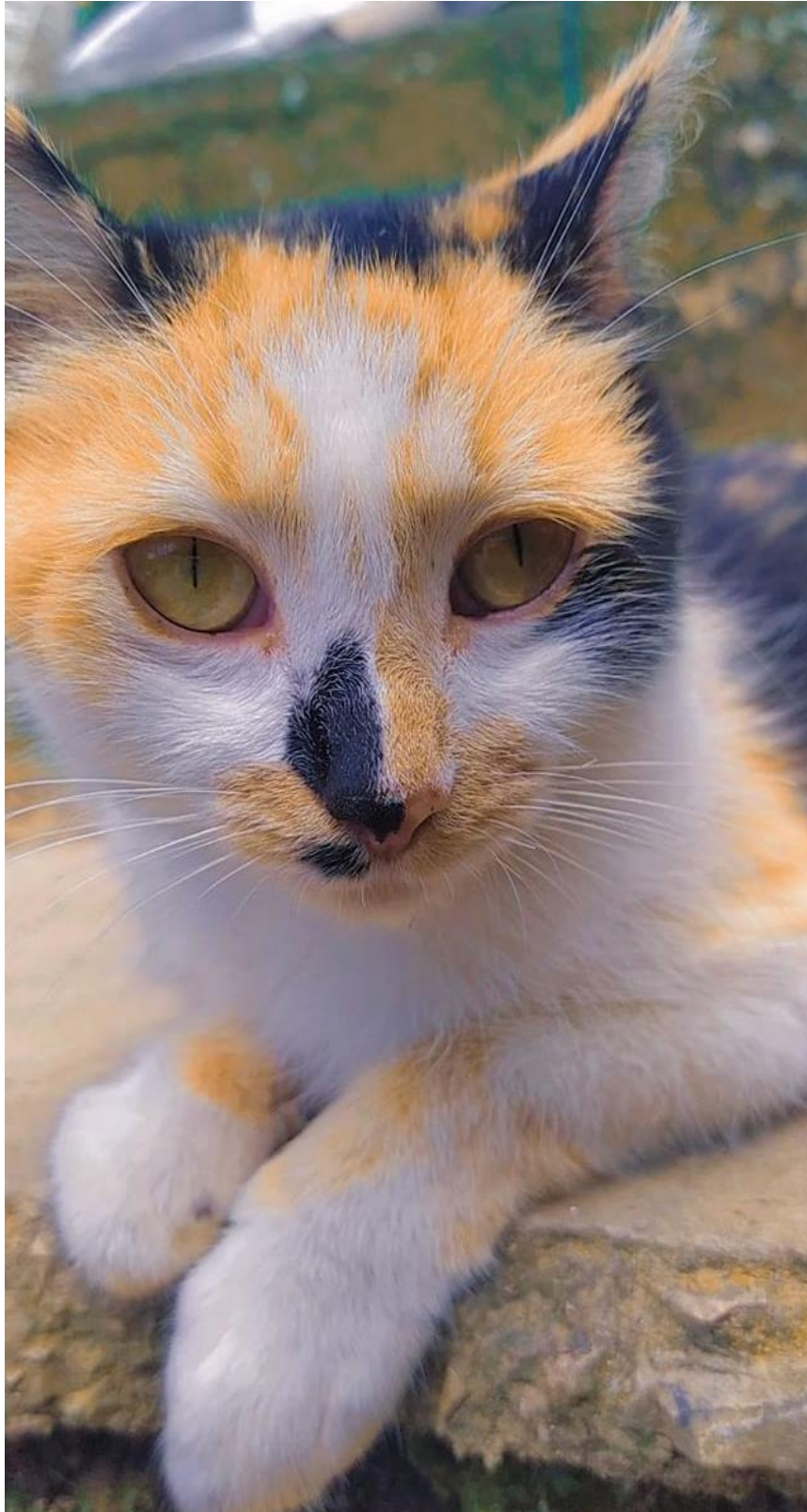


Figure 3. Calico cat, or tricolor, which is similar to Japanese rabbit trait (photo by Vianey Sánchez Antonio).



Figure 4. The calico koi carp (photo by Neil Vincent Maribao).

Conclusions. The e^j allele from the E locus is a gene with extremely high versatility. In combination with other alleles and non-alleles it can produce a multitude of different color patterns that are extremely spectacular in domestic rabbits, such as calico cats or calico koi carps.

References

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

- Crabtree J. S., 2020 Fundamentals of epigenetics. In: Clinical precision medicine. Academic Press, pp. 27-37.
- Crosta M. C., 2020 Coat color genetics. In: Feline dermatology. Springer, Cham, pp. 23-66.
- Fontanesi L., Scotti E., Colombo M., Beretti F., Forestier L., Dall'Olio S., Deretz S., Russo V., Allain D., Oulmouden A., 2010 A composite six bp in-frame deletion in the melanocortin 1 receptor (MC1R) gene is associated with the Japanese brindling coat colour in rabbits (*Oryctolagus cuniculus*). BMC Genetics 11(1):1-11.
- Naff K. A., Craig S., 2012 The domestic rabbit, *Oryctolagus cuniculus*: origins and history. In: The laboratory rabbit, guinea pig, hamster, and other rodents. Academic Press, pp. 157-163.
- Oroian F. C., Balint C., Gavrioloaie C., 2016 Extender 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.
- Petrescu-Mag I. V., 2007 [Sex control in guppyculture]. AcademicPres, Cluj-Napoca, Romania, 253 p. [In Romanian].
- Petrescu-Mag I. V., Bud I., Botha M., 2020 The productive phenotypic traits with high heritability in domestic rabbits (*Oryctolagus cuniculus*). Rabbit Gen 10(1):11-12.
- Petrescu-Mag I. V., Petrescu-Mag R. M., Viman O., Botha M., Hoha G., Grun E., Creanga S., 2012 The Giant of Transylvania: Standard for arbitration in rabbit exhibitions. Rabbit Gen 2(1):1-4.
- Petrescu-Mag R. M., Oroian I. G., Botha M., Covrig I., Petrescu-Mag I. V., 2014 Morphological, productive and reproductive characterization of the Transylvanian giant rabbit (*Oryctolagus cuniculus*): first statistical report. North-Western Journal of Zoology 10(2):400-403.
- *** <https://www.debmark.com/rabbits/genetics.htm> [Last view, December 30]
- *** <https://i0.wp.com/> [Last view, December 2020]
- *** <http://minkhollow.ca/> [Last view, December 2020]

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