

## Norwegian Forest Cats in Amber ... the show must go on!

by Dr.vet. Marc PETERSCHMITT / France - Copyright 2009

The story began in 1992 with two Swedish Norwegian Forest Cat kittens from strange colours born in the well-known « WILDWOOD's » cattery: S\* WILDWOOD's Imer and its brother S\* WILDWOOD's Iros. Such colours may have existed already before the nineteen's but of unknown genesis. Nobody knew exactly how these colours should be classified and from where they were coming out. By the way they could not be explained by their parents' colour genotype. These unusual colours appeared months later in Germany, with D\* Bedellin av TAKESKOG born in 1994. A cat has been found among the ancestors of all these litters, its name was N\* KLØFTERHAGENS Babuschka, which is likely to be the only foundation ancestor for this colour in the Norwegian Forest Cats population. KLØFTERHAGENS Babuschka straightly goes back to PAN's Truls, the progenitor of nearly all Norwegian Forest Cats. Who did transmit this characteristic to Babuschka ? Nobody knows for sure. First of all, breeders thought, that these colours were chocolate resp. lilac. In the middle of the nineteen's breeders started to name these colours as cinnamon resp. fawn.

At last these colours were named as X-Colours according to the EMS-code, because all the above mentioned colours had not been recognized in the NFO breed in the FIFe. A first approval in 1998 failed, because relevant NFO breeders and judges thought, that these colours could only be the result of crossbreeding with other breeds (e.g. Somali). That was a thesis, which is always questionable in a breed, where novices can be found even in pedigrees of some current European breeding cats. There was especially a shooting fear, caused by the assumed Somali crossbreeding, to get their predisposition for inherited diseases (e.g. PRA, patella luxation) into the NFO population.

Nevertheless more and more X-Colour cats (resp. carriers) were exported in the following years everywhere in Europe, especially in Germany and in Netherlands (S\* PORFYRGÅRDENS Yeni, S\* ROYAL IMP's Maurice, S\* ROYAL IMP's Tinne, S\* TAILOR HILL's Kastor, S\* TAILOR HILL's Kassiopeia and S\* WILDWOOD's Peter Pan, for listing some of the most well-known names). As these cats and their offsprings caused numerous polemics in the European NFO scene, testmatings were progressively achieved in Sweden (Cattery KATTBOSENS), in Germany (Cattery vom ARLESBRUNNEN) and in Netherlands (Cattery van MORAJA) to learn a little more about these X-Colours. These matings proved that X-Colour cats are genetically black and neither chocolate, nor cinnamon. Such a result was obviously expected by insiders, because X-Colour cats have black paw pads. Considering these first results, the FIFe (Fédération Internationale Féline) recognized this colour on the 1<sup>st</sup> January 2005. Moreover X-Colour was renamed as amber/amber-tabby and amber cats were allowed to be exposed in the corresponding FIFe colour groups. Actually the amber colouration has been introduced onto different coat colours and coat pattern

backgrounds to produce a large colour variability: amber tabby with the four patterns (ticked, mackerel, spotted and blotched), or amber non-agouti (solid) with ghost tabby pattern. Amber colour also exists in dilution, silver or smoke, eventually in tortoiseshell and with white.

All these points strongly supposed that a new mutation was responsible for this strange 'new' colour. But which gene was standing behind this mystery ? There was no answer...

The X-Colour Norwegian Forest Cats (renamed amber) hovered like a nightmare during seventeen years above the European NFO scene. But X-Colour finally decided to reveal its mystery after a long and silent time. We know a little more about this colour thanks to the scientific research, which should hopefully convince the last obstinate disputants.



**BILD 01:**

**S\* WILDWOOD's Imer light-amber-tabby-spotted (EMS-code NFO at 24)**

**and S\* WILDWOOD's Iros amber-tabby-classic (EMS-code NFO nt 22)**

copyright : Erikérs - Cattery S\* WILDWOOD's

Since S\* WILDWOOD's Imer and S\* WILDWOOD's Iros dressed this X-Colour coat in 1992 possibly for the first time, I was the lucky and first one person to identify and describe this polemical mutation. The mutation is actually very minimal and doesn't look <<overwhelming>>. Therefore I did not see it immediately in the

analysed DNA sequences. Nevertheless I spent nights in reading and looking for something new in these results, because I was firmly convinced that the amber key was hidden here.

By discovering the mutation, a long shivering overcame me and I won't probably never more experience such a feeling. My sleepless nights brought 17 long and polemical years to knees and also brought to the European NFO breeding THE answer that geneticists wanted to have since several decades. Indeed such a mutation has never been described on the *Extension* gene from the Felidae family contrary to the numerous *Extension* mutations in other animal species.

### **Extension - what is it?**

The murine pigmentation knowledge led me to suspect the *Extension* gene after a long study about the amber genotype and phenotype. Actually this gene was the only one in the pigmentation pathway, which could explain most of the amber colour characteristics.

Three different pigments are described in cats :

- 1) The black pigment, also called **eumelanin** (e.g. black cats)
- 2) The yellow/tawny pigment, also called **phaeomelanin** (e.g. "golden tabby" cats). Caused in the polygenetic mechanism of the rufism, phaeomelanin also can vary from yellowish to reddish.
- 3) The red pigment, also called **trichochrom** or **orange** (e.g. red cats); it is bounded to the female allosome (x-chromosome); further is red/orange epistatic to amber. Today it is known that trichochrom is NOT eumelanin, but an independent pigment.

The *Extension* gene action is well known in other animal species, it contributes to the MC1-R synthesis, a protein which is also called Melanocortin 1 Receptor. **This receptor is necessary and essential to produce the black pigment (eumelanin)** after the alpha-MSH hormone binding into this MC1-R receptor and a following chemical chain reaction. The *MC1R* gene enables the black pigment extension in hair, that's why it's also called <<*Extension* gene>>.

On the contrary the yellow pigment (phaeomelanin) will be synthesized, as soon as the eumelanin synthesis is impossible, for example when the MC1-R receptor is mutated and therefore ineffective for the eumelanogenesis.

There is also a second opportunity for the phaeomelanin synthesis with a perfectly functional MC1R receptor. The **A\*** allele (in agouti cats) enables the agouti protein synthesis and has strong and complex interactions with the MC1-R receptor: the agouti protein can actually bind in the MC1-R, it prevents therefore the alpha-

MSH hormone binding and acts as an antagonist for the MC1-R receptor. Consequently the phaeomelanin synthesis is promoted, whereas the eumelanin synthesis remains marginal. These  $A^+$ - cats are agouti (=tabby) and have a more yellow colour as the non-agouti  $aa$  cats (solid or self). The agouti protein in non-agouti cats is actually mutated and consequently does not prevent the alpha-MSH hormone binding into the MC1-R receptor. Therefore non-agouti cats can always produce eumelanin pigment and look black.

This MC1-R characteristic explains also the strange interactions between amber and agouti. It was always supposed in the past that there were only amber agouti cats (tabby), because all amber cats showed a tabby pattern. Nevertheless the amber non-agouti colour (solid) is currently well-known and existed since many years with a misleading ghost tabby pattern that caused confusion with the amber agouti cats.



**Fig. 02: Y-litter av BARNEDROEM**

from left to right:

- amber classic tabby (D\* Yorid av BARNEDROEM; EMS-code NFO nt 22)**
  - black (D\* Ynger av BARNEDROEM; EMS-code NFO n)**
  - amber (D\* Yosina av BARNEDROEM; EMS-code NFO nt)**
  - amber classic tabby (D\* Yngvi ARNEDROEM; EMS-code NFO nt 22)**
  - amber (D\* Ybro av BARNEDROEM; EMS-code NFO nt)**
  - amber (D\* Yordis av BARNEDROEM; EMS-code NFO nt)**
- copyright : Balda - Cattery D\* av BARNEDROEM



**Fig. 03:**

**left : Ybro av BARNEDROEM - amber (non-agouti) with ghost tabby pattern (EMS-code NFO nt)  
and right : Yngvi av BARNEDROEM – amber classic tabby (EMS-code NFO nt 22)  
copyright : Balda - Cattery D\* av BARNEDROEM**

You may have heard about S\* TAILOR HILL's Cupido (\*04.02.1993) and his surprising life story. At the beginning he was registrated in blue tabby but everybody agreed to say that he had a very strange colour and nobody knew in 1993 which colour he effectively had. His father S\* WILDWOOD's Imer and his sister S\* TAILOR HILL's Concordia were both amber tabby cats. It's currently firmly supposed that Cupido has been the first amber non-agouti Norwegian Forest Cat (light amber). He always conserved his particular colour and is likely to be the oldest living amber cat in the world. S\* TAILOR HILL's Dione is born a few months later in the same year, she was the first amber tortie cat (non-agouti).



Fig. 04: S\* TAILOR HILL's Cupido  
light amber (non-agouti) (EMS-code NFO at)  
copyright : Hårdén - Cattery S\* TAILOR HILL's

More recently, in August 2008, a seven kittened-litter is born in the Norwegian «TINGOSKATTENS» cattery and has practically illustrated this paradox of amber non-agouti colour with strong ghost tabby pattern. Father is S\* SANNAFJÄLLET's Kaxe, a male in black/white (EMS-code NFO n 09) and mother is N\* TINGOSKATTENS Gisela a female in blue (EMS-code NFO a). As both parents are non-agouti cats, there could not be any tabby kittens. Moreover both parents are obviously amber carriers, because there were kittens in black and blue **but also in amber non-agouti with strong ghost tabby pattern** - q.e.d. = quod erat demonstrandum - and that had to be demonstrated by the breeding practice since 1992 !



**BILD 05: N\* TINGOSKATTENS M-Wurf**

von links nach rechts :

- amber/white (N\* TINGOSKATTENS Mar; EMS-code NFO nt 09)
  - black/white (N\* TINGOSKATTENS Marte; EMS-code NFO n 09)
  - amber (N\* TINGOSKATTENS Marja; EMS-code NFO nt)
  - amber/white (N\* TINGOSKATTENS Marion; EMS-code NFO nt 09)
  - black (N\* TINGOSKATTENS Marco; EMS-code NFO n)
  - blue (N\* TINGOSKATTENS Martin; EMS-code NFO a)
  - light-amber (N\* TINGOSKATTENS Marielle; EMS-code NFO at)
- copyright : Schjervheim - Cattery N\* TINGOSKATTENS

### The amber mutation

The murine pigmentation bibliography brought me several arguments, which led me to the ***Extension gene*** hypothesis. Firstly the NFO amber coat is a yellowish recessive and autosomale colour like some coats in other animal species. Moreover the amber mutation concerns only the hair colour (not the skin) and all amber animals are genetically black : their coat is yellowish and their skin black, what can be seen at the dark paw pads, dark eye rims and dark leather nose (last for non-agouti amber cats only, contrary to pink-nosed amber agouti cats).



Fig. 06 / 07 / 08: back paw pads, underside, ca. 6 weeks old,  
 amber (non-agouti); amber tabby (agouti) and black tabby  
 Cattery av BARNEDROEM  
 copyright : Balda - Cattery D\* av BARNEDROEM

Paw pads from amber non-agouti cats are dark since the birth contrary to amber agouti cats in which they are firstly pinkish-sooty, then pinkish and finally completely dark. Moreover all amber cats have light hairs between the toes contrary to black tabby cats.



Fig. 09 / 10 / 11: leather nose, ca. 6 weeks old  
 amber tabby / amber (non-agouti) / black tabby  
 Cattery av BARNEDROEM  
 copyright : Balda - Cattery D\* av BARNEDROEM

These amber characteristics are obviously unusable when amber cats have white marks in these body regions and the colour diagnosis can become very difficult.

**This scientific work is currently enriched by an available genetic test for the amber mutation.** The often suspected gene for cinnamon/fawn is a complete other gene at another chromosome.

"Felis catus, MC1-R, p.D84N": a barbarian name for a polemical mutation ! This name means that the 84<sup>th</sup> amino acid in the MC1-R protein (an asparagine acid, which carries a negative electrostatic load) is replaced by an asparagine, which does not carry any electrostatic load. This mutation causes thereby electrostatic changes in the MC1-R receptor and destabilizes it. It's consequently no more effective for producing eumelanin.

The *Extension* gene is very good conserved in the different animal species, and our study proved that it was also true in cats. We found this "p.D84N" mutation for at least 70 cats: all amber cats were tested homozygous for this mutation, whereas all carriers were heterozygous. Other breeds cats and other Norwegian Forest Cats lineages did not have this mutation.

We know two other mammals, which possess a similar mutation in their MC1-R receptor : humans with red hair and chestnut horses. This MC1-R region and the 84th asparagine acid load are well-known in that proteins family since several years and are very important for the good receptor working. If this 84<sup>th</sup> amino acid is so good conserved in these proteins, it's probably for the good hormone binding.

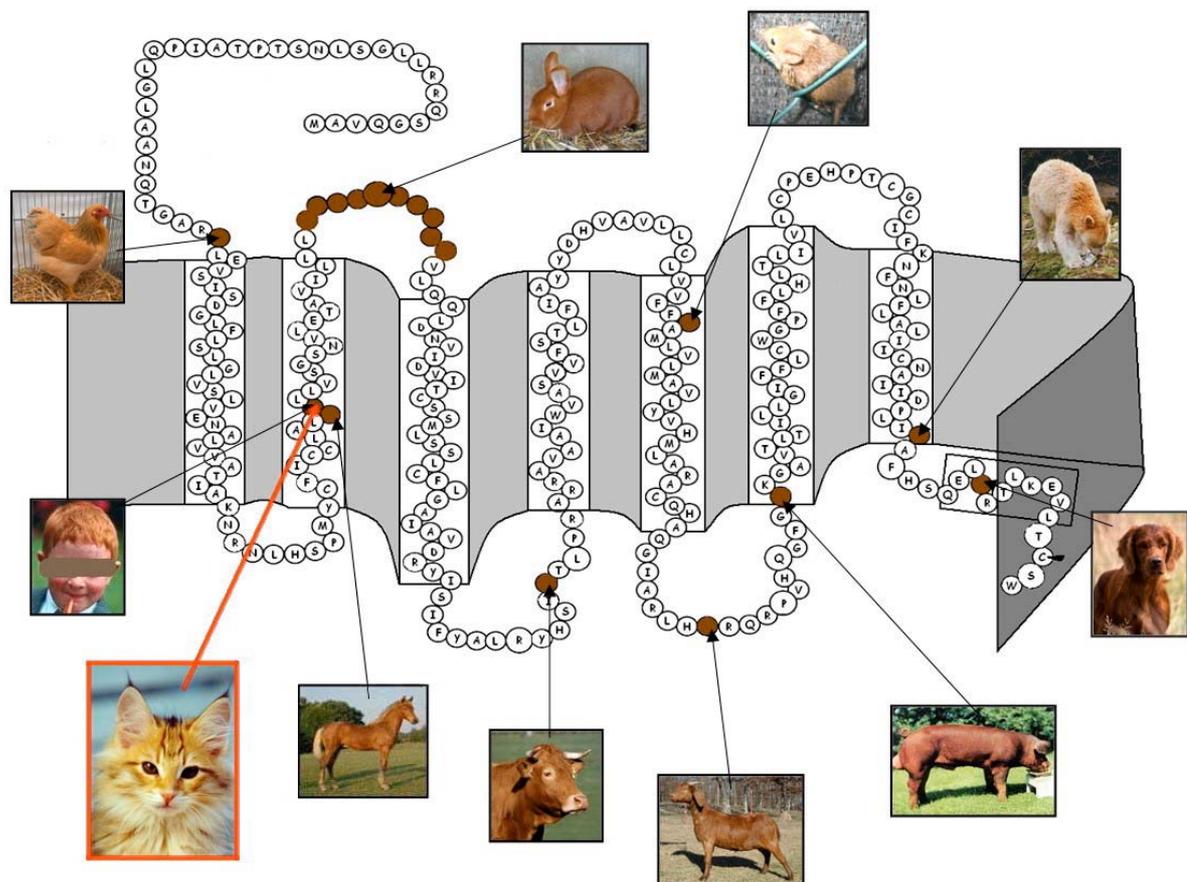


Fig. 12: some *Extension* gene mutations and their phenotype effects in different animal species  
copyright : Peterschmitt

Three-dimensional models were built for the both receptors (the amber mutated and the normal/wild type receptor) and confirmed my hypothesis. Indeed the alpha-MSH hormone fails to bind into the amber mutated receptor in a stable balance, because its positive load doesn't finds any opposite negative load in the MC1-R protein. **This description is obviously a little simplified ... but the amber mutation effect is especially due to this negative load loss.** However many questions still didn't find any explanations, and we especially would like to understand

why the amber mutation does not prevent amber embryos and kittens from producing black hairs (what is not observed in the other animal species).

It's currently well-known that N\* KLØFTERHAGENS Babuschka is the mother of this colour in the NFO population. Why did this gene mutate in this lineage ? I don't know and we are likely to never find the answer. The Nature often keeps its secrets and we just have to accept it. However, even though we will never have all the keys for understanding the amber mystery, there is at least something sure : amber is due to a little mutation in the *Extension* gene and does not come from crossbreeding with others feline breeds, since this colour and this new mutation have never been reported in the other feline breeds.

Indeed it's the first time that such a mutation (symbolized "e") has been described in cats and also in Felidae. This mutation is also the first in all species to show such strange interactions with the *agouti* gene. Indeed epistasy from <<e>> mutations to the agouti alleles has always been reported in other species. However this epistatic effect is complete only in amber adult cats (e.g. amber agouti and non-agouti kittens are easily differentiated). This difference may be explained by the feline specific tabby mutations, which determine agouti hair only in the areas between tabby stripes. The amber mutation is also the first <<e>> mutation to have such effects on the paw pads and leather nose colour. It is also the only mutation, which causes such a colour evolution during the cat's development. Why ? I have some possible explanations, but it's a long story too !



Fig. 13 / 14 / 15: D\* Ybro av BARNEDROEM - amber (non-agouti) (EMS-code NFO nt)

7 days / 9 weeks / 18 weeks old

copyright : Balda - Cattery D\* av BARNEDROEM



Fig. 16 / 17: D\* Ybro av BARNEDROEM - amber (non-agouti) (EMS-code NFO nt)  
9 months / 4 years old  
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#### SUMMARY

- ⇒ A mutation in the *Extension* gene is able to cause a mutated and ineffective MC1-R receptor. The cat cannot consequently produce any eumelanin and will only synthesize phaeomelanin. This mutation is symbolized «*e*».
- ⇒ There are particular interactions between the *Agouti* and *Extension* genes, because both genes act in the same pigmentation stage.
- ⇒ Numerous animal species are currently known to have such «*e*» mutation(s) in their genetic population pool. But we didn't know any «*e*» mutation in the cat family until now. Moreover none of these «*e*» mutations have all amber characteristics from the Norwegian Forest Cat. For example: «*e*» mutations from the other species show only an epistatic effect to the *agouti* - alleles and this epistasy is not observed completely at the amber cats (amber agouti and non-agouti colours are indeed easily differentiable).

### The amber colour in France

As you may possibly know, the amber colour has been recognized thanks to this research on the 12<sup>th</sup> March 2009 in France by the L.O.O.F. (= Livre Officiel des Origines Félines, the unique breeding cat book in France). Amber cats born in France since this date can finally get a L.O.O.F. pedigree and will be able to get points and titles in L.O.O.F. expositions from the first January 2010. As it was foreseeable, there is currently a large enthusiasm for these colours in France, since amber has officially been recognized.



**Fig. 18: D\* Yella vom ARLESBRUNNEN, light amber mackerel tabby  
(EMS-code NFO at 23)  
copyright : Peterschmitt**

We can just hope that this amber-fashion will not last, because it could be very harmful for the colour and for the Norwegian Forest Cat, if there was only a selection for this colour. All amber breeders have to be reasonable, answerable and must select the new owners very attentively for avoiding that amber come to catteries that don't want to select the type but only a commercial colour.

This work is not completely finished : with my friend, Catherine BASTIDE, L.O.O.F. and TICA judge, we hope to get the amber recognition in other cat federations because this colour should be accepted in the NFO genetic pool from all countries. That's why D\* Ynouie vom ARLESBRUNNEN is currently living with Catherine BASTIDE in Paris and we would like to show her at some strategic feline expositions, for the interested public and the judges.



**Fig. 19: D\* Ynouie vom ARLESBRUNNEN**  
**amber spotted tabby/white**  
**(EMS-code NFO nt 09 24)**  
copyright : Peterschmitt



**Fig. 20: D\* Zefanja vom ARLESBRUNNEN**  
**amber tortie smoke**  
**(EMS-code NFO fts)**  
copyright : Peterschmitt

If you have any questions, do not hesitate to write me or call me. I will answer you with pleasure.

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<http://amberbabies.e-monsite.com/>

or

<http://norvegienambre.e-monsite.com/>

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**You can find further informations at the following websites:**

<http://www.v-arlesbrunnen-nfo.de>

<http://www.barnedroem.de>

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[here you can see further pictures for documentation :](#)



**Fig. 21 + 22 :**

**S\* FLORINELLA's Cendi Lavendi ; light-amber (non-Agouti) (EMS-code NFO at)  
aged 4m(21) und 24m(22)**

**NFO-male**

**copyright : Rylander ; Cattery S\* FLORINELLA's**



Fig. 23 + 24 + 25 :

D\* BALTIMOOR's Black Cola ; amber-tabby-classic (EMS-code NFO nt 22)  
aged 2y(23) and 6,5y(24+25)

NFO-male

copyright : Balda - Cattery D\* av BARNEDROEM



Fig. 26 :

D\* BALTIMOOR's Emyli-Flair - amber (non-agouti) /white (EMS-code NFO nt 09)

NFO-female

copyright : Chr. Paul/Jung - Cattery D\* BALTIMOOR's



Fig. 27 ff. :  
D\* Ybro av BARNEDROEM ; amber (non-agouti) (EMS-code NFO nt)  
different ages : 3 weeks / 5 weeks / 8 weeks / 9 months / 4 years  
NFO male  
copyright : Balda - Cattery D\* av BARNEDROEM



**Fig. 28 :**  
**D\* Oberon vom ARLESBRUNNEN ; light-amber (non-agouti) (EMS-code NFO at)**  
**NFO male**  
copyright : Utescheny - Cattery D\* vom ARLESBRUNNEN



**Fig. 29 :**  
**D\* Amber-Litter vom ARLESBRUNNEN**  
**(4× light-amber-tabby, 1× amber-tabby)**  
copyright : Utescheny - Cattery D\* vom ARLESBRUNNEN