Dalmatian & Variegated Rats
Test Breeding For Genetics

By Karen Robbins

Essex x Dalmatian

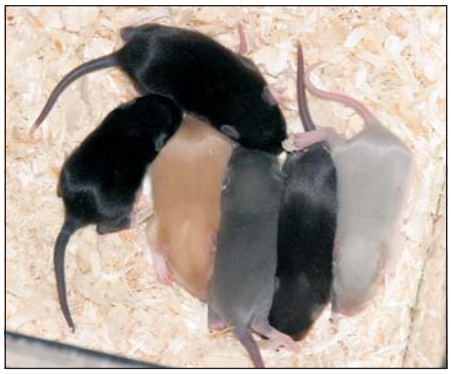
When we were making plans to go to England in 2004, one of my goals was to bring back an Essex to do a cross breeding with a Dalmatian to try and determine if Essex was the same as Dalmatian. We were able to bring back one Agouti Essex buck from Paul Threapleton/Sue Foulds, so with one of the resulting Essex kids (Russian Blue Agouti Essex) from the breeding with his Black Self sister, I was able to do a test breeding the following year.

The Test Breeding

In January 2005, I bred the Russian Blue Agouti Essex doe with a Silver Black Dalmatian buck. There were only 6 babies born February 2, and I don't know if that factors in to the fact that there appeared to be no Essex (none had head spots; one trait of the Essex is the head spot (hs) and that is how you can tell in the nest which ones are Essex). The offspring included a Silver Black English Irish/Irish (EI/I; large marking) male, a Black large-Irish male, a Black male with a white spot on chest, a Fawn male with small English Irish/Irish (EI/I) markings, a Russian Blue Irish female, and a Silver Blue Agouti Berkshire female. You can see the results at **www.afrma.org/Testbabies/testbabiesorig.html.**

The Russian Blue Agouti Essex mom of the litter. Photo ©2005 Karen Robbins.

The Silver Black Dalmatian dad of the litter. Photo ©2005 Karen Robbins.



The test litter of Essex x Dalmatian at 9 days old. L–R: the two Black males, Fawn EI/I male, RB Irish female, Silver Black lg. EI/I male, Silver Blue Agouti Berkshire female. Photo ©2005 Karen Robbins.

With this breeding it was as if I had bred the Dalmatian to a Self rat with what I got in the litter [which we now know the Essex is not a marking gene so you don't get various markings when bred to others]. When Essex is bred with Self, you get Essex and Self, not various kinds of English Irish/Irish/Berkshire, etc. So even though Essex is a "Berkshire" marked rat, it is not a Berkshire marking gene, but rather a "color fading" gene that just happens to have white markings.

Variegated Stock

The Variegateds I have all go back to the Variegateds we imported from the N.F.R.S. in November 1983 as we did not have Variegated before this. I have done some outcrossing since then so they are no longer pure English. My Variegateds produce Variegated, hs Berkshire, and occasionally Capped, capped-type/very lightly marked Variegated.

I breed my Dalmatians with Variegated all the time and get Dalmatian, Variegated, and sloppy Berkshires. I find when I breed Dalmatian to Dalmatian, they usually have smaller litters; when bred with Variegated or Berkshire, then they will have normal/large litters and type and size is better maintained.

My Variegateds are predominately Black, with occasional Beige and Blue, and more recently Russian Blue.

Dalmatian Rats

The Dalmatians came from a breeding of two Variegateds back in 1986 (see article pg. 45). The colors I have gotten are the Silver Black (most common), some Blue and Russian Blue Dalmatians (we had Champagne in the beginning but they are so light in color it is hard to see the markings, so sticking with a dark color is best for this variety).

I have also gotten PEWs in many recent litters of both Dalmatian and Variegated—I crossed a huge PEW lab rat into the line many years ago but the PEW hadn't shown up prior.

The one prevailing marking in both Dalmatian and Variegated litters is the presence of hs Berkshires.

Breeding The F1

The Silver Black EI/I (lg. mkg.) male from

F1: Silver Black lg EI/I and Blue Variegated's litter, owned and bred by Mayumi Anderson. Photo ©2005 Mayumi Anderson. I took a Silver Black Dalmatian female from this litter and bred with a Black Variegated; a Silver Black Dalmatian male was kept from the resulting litter and bred with the Agouti in the "Self x Dalmatian" test breeding (next section).

The Silver Black EI/I (lg EI) male from the Dalmatian x Essex cross that was kept back and bred with two Variegated females, which then produced Dalmatian marked kids. You can see how silvered he is which is the trait of the Dalmatian gene. Photo ©2005 Karen Robbins.

F1: Silver Black lg. EI/I x Black Variegated's litter, owned and bred by Mayumi Anderson. Photo ©2005 Mayumi Anderson.

F1: Silver Black EI/I x Essex litter, owned and bred by Mayumi Anderson. Photo ©2005 Mayumi Anderson.

the Essex x Dalmatian cross was bred with a Blue Variegated and we got Dalmatian, Berkshire, heavy (hvy.) Var./Hooded type, hvy. Variegated, and Irish??? (I didn't see the babies in person); bred with a Black Variegated we got Dalmatian, Variegated, hvy. Variegated, Irish??? (again didn't see in person); when bred to an Agouti Essex, there were Self, Essex, hvy. Variegated/Collared type, and Berkshire/Essex type.

One of the Dalmatians from the Silver Black lg. EI/I x Variegated pairing was used to do test breedings with a Self. See the next section "Test Breeding Dalmatian & Variegated."

Conclusion

The conclusion was Dalmatian and Essex are not the same gene, and both are dominant genes.

Essex is not a marking gene but rather a "Self" color fading gene that happens to have "Berkshire-type markings."

The Dalmatian gene color can be made in other markings. If the rat is Silver Black in color, it is a Dalmatian gene rat. Breeding to Variegated gets it back to the correct show-type markings.

Test Breeding Dalmatian & Variegated

I spent almost 3 years doing test breedings to try and determine the genetics of Dalmatian and Variegated with the help and advice of our genetics expert Nichole Royer on what pairings to make, while she would try to figure out a genetic code for these two varieties. I kept photo records of each litter (top and bottom views) to send her so she could see the results and give advice on what to breed for the next generation in this endeavor.

The Silver Black Dalmatian male used in the Self x Dalmatian test breeding. Photo ©2007 Karen Robbins.

The Agouti female used in the Self x Dalmatian test litter. Photo ©2007 Karen Robbins.

Making The F1, or Self x Dalmatian

The first breeding was to do a Self to a Dalmatian. For this I used a Silver Black Dalmatian (goes back to the Russian Blue Agouti Essex x Silver Black Dalmatian cross with the resulting Silver Black lg. EI/I being bred with Variegated and producing Dalmatian; See "Essex x Dalmatian: Test Breeding" topic above) bred to an Agouti Self that produced 15 babies (#1990 litter; 7 Agouti and 8 Black – 2 of which were Silver Black Berk.) who were all English Irish or EI/I, and head spot Berkshire-type messes. I kept 4 from this F1 litter—2 Black EI and 2 Silver Black hs Berkshires.

Some of the 1990 litter Agouti EI or EI/I. Photo ©2007 Karen Robbins.

Some of the head spot Berkshires in the 1990 litter. Photo ©2007 Karen Robbins.

Regarding the outcome of this litter, Nichole replied, "It's really interesting how the markings divided out. The ones with head spots are clearly Berks.—and a couple look like pretty good ones. The ones without [head spots] are EI (with

some extra white) but all have considerably less white on their underside than the ones with head spots. It's NOT the range I got either time I bred Hooded to Self. Those were EI/I messes—none of whom approached true Berkshire and none that came close to EI. In fact the closest recognized designation they came to was English Berk."

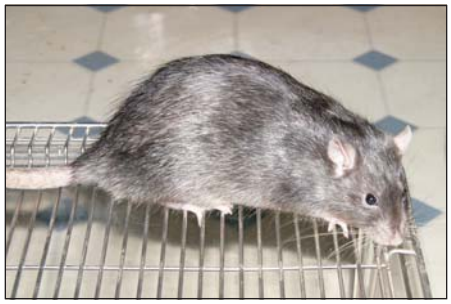
Since I had never produced hs Berk. out of any of my Hooded breedings (they came only from Var. or Dal. rats), Nichole thought I "may be about to prove that 'American Berkshire' is genetically different than 'English Berkshire.' In the process you may find out some interesting things about true EI." The Agouti Self mom used in this test breeding of Dal. x Self went back to an English Cinnamon Pearl cross I had done with one of my Selfs and the resulting rats I was using in my Rex breedings. In Ann Storey's 1995 Genetics article she talks about English Cinnamon Pearl EI rats being *Hh*^{i} since two of these bred together don't produce Hooded like other EI x EI do, and I found that to be the case. I did one breeding of English EI rats together and did get Hooded but all my English EI x EI since then did not produce Hooded.

. . . Mis-marked Barebacks are not Barebacks. . . they are Variegated rats with too much white . . . Berkshire with way too much white is just as likely to be Variegated with too much color . . . Berkshire with way too little white would be what we would consider EI/I messes

At this point Nichole commented, "I'm beginning to think Variegated may not be on the H locus at all, and may be responsible for a different "Berk./Irish" look than *Hh* gives. That's what evidence is pointing towards, anyway." And back in 2002 regarding Variegated and marked genetics, she said ". . . the genetics of marked rats have always been a great debate. If you check 10 different sources, you come up with 10 different versions. There are way too many theories out there and not a single one fits in completely with what we have observed." She had also made these comments during that time regarding markings out of Variegated, ". . . it's all in the eye of the beholder. Mis-marked Barebacks are not Barebacks . . . they are Variegated rats with too much white (or too little color). They will breed like Variegated rats, and are genetically Variegated. Berkshire with way too much white is just as likely to be Variegated with too much color. Berkshire with way too little white would be what we would consider EI/I messes. Berkshire with a head spot come out of Variegated (our Selfs are true Selfs and don't have the white modifiers needed to produce head spots)."

F1 Breedings (1990 litter) To Make The F2

Nichole's theory on the outcome when I did these breedings of EI x EI and the Berk. x Berk. was that I would produce Variegated out of both litters and the Silver Black Berks. would give Dalmatian.



The Silver Black tiny hs Berkshire male kept from the 1990 litter, used to make the 1996 litter. Photo ©2007 Karen Robbins.

The Silver Black hs Berkshire female kept from the 1990 litter, used to make the 1996 litter. Photo ©2007 Karen Robbins.

The pairing of the two Silver Black Berk. (from 1990 litter) produced 13 babies (#1996 litter; 2 were dead with anasarca [picture next page] so ended up with 11 live ones) in Black, Silver Black, and Russian Blue with 1 having a tiny spot on the chest, a Collared/Berk., 4 EI/I messes (1 with a hs), 1 hs EI/Berk., 1 EI/Berk. with no hs, 1 nicely marked hs Berk., and 2 heavy Dal., but no Var. The nicely marked Black Berk. female, a Silver Black hvy. marked Dal. male, and a Black Collared/Berk. male were kept. So I did get Dalmatian, though they were heavy marked. Nichole thought

The Black very nicely marked hs Berkshire female kept from the 1996 litter. Photo ©2007 Karen Robbins.

The Silver Black heavy marked Dalmatian male that was kept from the 1996 litter and used to make the 2019 and 2026 litters. Photo ©2007 Karen Robbins.

The Black Collared/Berkshire male that was kept from the 1996 litter. Photo ©2007 Karen Robbins.

because of the anasarca babies that Dal. could be a dominant homozygous lethal as this suggests exactly that. With the Silver Black hs Berks. parents being light black when in the nest and getting silvered later, Nichole said, ". . . another factor suggesting that Dal is a dominant that 'extends' the amount of white in the coat (produces more solid white than the markings otherwise dictate, and silvers the coat)."

The two heavy marked Dalmatian females (#2 & #1) that were kept from the 2018 litter. Photo ©2008 Karen Robbins.

This breeding was repeated (#2018 litter) to see if there would be any variation in the results. This time there were 12 born with 4 dead (1 anasarca; picture this page) which left 8, with 1 with thin white line on the belly, 3 hs EI/Berk., and 4 heavy marked Dal., and again, no Variegated. Colors produced were Black, Silver Black, and Russian Blue. So basically the same results were in this litter as the last litter. Two Silver Black hvy. Dal. females were kept out of this litter.

One of my questions to Nichole at this time, "I'm thinking with the latest litter not producing Var., that when Dal. is bred with Var., it just breaks up the pattern more. Would this be correct?" "That is correct" she said, "and is one of the fascinating things about this breeding that I

. . . one of the fascinating things about this breeding . . . you produced heavily marked youngsters, but they aren't what we usually think of as Dalmatian

wasn't expecting. You produced heavily marked youngsters [in the #1996 and #2018 litter], but they aren't what we usually think of as Dal. The original Dal. used in this breeding experiment had to be Var. + Dal. Where did Var. go? Why did it disappear? I'm still puzzling that one out. We are missing a piece of the puzzle and I'm not sure why. I'll go back and look again at the breeding results you got out of Variegateds in the past to see if I can come up with anything."

The pair of Black EI (from the 1990 litter) were bred together and produced 17 babies (#1998 litter), all Black in 1 Self, 8 EI or EI/I (1 had tiny markings), and 6 hs Berk., with no Dal. or Var. Since I did not

Four of the head spot Berkshires from the 1998 litter. Photo ©2007 Karen Robbins.

One of the English Irish from the 1998 litter. Photo ©2007 Karen Robbins.

get Hooded, then they have to be the Hh^i gene, and not *Hh.* Three hs Black Berks. were kept for the next generation.

The #1998 (EI x EI) litter produced Self, EI, hs Berk., similar to *Hh* x *Hh* where you get Self, Irish, Hooded, and in about the same proportions. And Nichole's reply to this, "Yep, and my feeling is that you essentially 'proved' a markings gene which is separate from 'H.' Call it 'head spot Berkshire' or 'American Berkshire.' The big difference here is not only that you did not get Hooded, but that you got those head spot Berks. In all the Hooded breedings Nancy and I did, we did not produce a single head spot Berk. . . . nor did we produce anything that looked like American Berkshire. We got everything from more or less EI to messy EI/Berk. From looking at what you got out of this breeding I think heterozygous head spot Berk. gives far better EI than the '*h*' gene does." And I can add to what Nichole says, that in my 52 litters of Self *HH* to Irish *Hh,* I also never got hs Berk. In the 11 years of breeding Hooded rats and the Irish out of Hooded (before we got the English imports), I only ever got 2 litters that had EI with the triangle on the chest—in 1979 in a litter that had three in it, and again in 1982 with one in the litter—all at a time before we imported the rats from England in November 1983. However, I did not keep any of these to pursue breeding this marking. In 1975, I did get a rat with a spot on the chest that did produce more, but they were only spots, which Self rats can have.

And Nichole adds, "So . . . based on these breedings it appears that Heterozygous head spot Berk. gives EI (or EI/Berk.). Homozygous head spot Berk. gives head spot Berk. Heterozygous head spot Berk. + Dal. gives silvered head spot Berk. Homozygous head spot Berk. + Dal. gives 'spotted' (you called them heavy Dals)."

Conclusions So Far

At this point it was proven that:

1. ***Dal is a dominant trait***
   Nichole gave it the symbol *Daldal*
2. ***There is no reason to think that Dal. is on the "H" locus***
3. ***Dal. appears to be homozygous lethal***
   Based on the fact in my experience over the years, when breeding Dal. to Dal., I would normally get average to smaller litters—though did get one litter of 14 that were all live—and occasionally anasarca babies—6 times out of the many Dal. x Dal. breedings; the first ones in a litter Dec. 27, 1994, from two rats from my mom—dad was a hvy. marked Dal. and mom a Silver Black Berk.—produced 4 anasarca; next time I saw this was in one litter in 1996 that had 2, then one litter in

An anasarca baby from the Dal. x Dal. breeding (2018 litter). They are always born dead; looks and feels "gelatinous." Photo ©2008 Karen Robbins.

   2002 with 2 more, then two of the test litters listed above had it in them with the father of both test litters being the same male, and a litter from him later with a different female (whose grandfather was this male's father) produced a litter with 2 in it; normal colored rats from these litters with anasarca siblings never produced it and it seems to come only from the Dal. males kept, i.e. Dal. females (from a litter that had anasarca in it), didn't produce it when bred with other males.
4. ***Dal. is a color gene that acts to "extend" the amount of white in the coat, creating silvering and increasing white markings.***

Since the Dal. silvering is not caused by poor color, then if something is Silver Black, even if it is an EI, Capped, or Berk. marking, you will get more Dal. colored rats; when bred with Var., it will break up the pattern into the show version of Dal.

F3 Litters – Head Spot Berkshire Tests

For this generation, planned breedings with the hs Berk. (1998 litter) were breeding the hs Berks. together, breeding a hs Berk. with Var., as well as to something on the "H" locus.

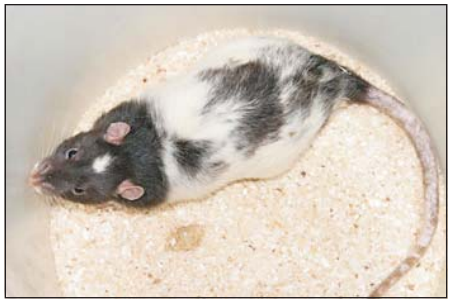
Head Spot Berkshire x Head Spot Berkshire: From the 1998 litter, both hs Black Berk. females were bred to their hs Black Berk. brother. The first litter (2008) produced 9 babies and all were hs Berk. in Black, Beige, and Russian Blue. None were kept for further test breedings.

The Russian Blue head spot Berkshires from the 2008 litter. Photo ©2008 Karen Robbins.

The 2009 litter of head spot Berkshire x hs Berkshire = all hs Berkshire. Photo ©2008 Karen Robbins.

The other sister's litter (2009) had 12 babies, and again, all were hs Berk. in Black and Russian Blue. None were kept from this litter either.

So these two breedings show hs Berk. x hs Berk. only produces more hs Berk.



The Black Variegated father to the 2014 litter. Photo ©2008 Karen Robbins.

The Black head spot Berkshire mom to the 2014 litter. Photo ©2008 Karen Robbins.

Three of the Variegateds from the 2014 litter. Photo ©2008 Karen Robbins.

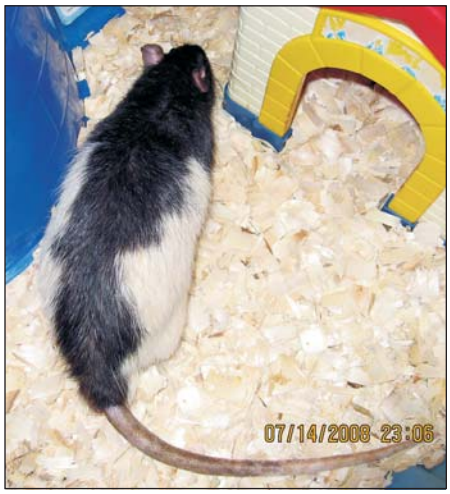
Breedings to a Variegated: Breeding one of the hs Berk. females with a Var. male produced a litter of 14 (2014 litter), with 8 hs nicely marked Berk. and 6 nicely marked Var., in Black and Russian Blue. I kept 4 of the nicely marked Var. for further Var. breedings.

Head Spot Berkshire x English Irish: One other test breeding done to see if we could pull out Var., was one of the hs Berk. females (1998) with the EI male (1990). This litter of 16 (3 dead; 13 live; #2023) produced a litter of 8 hs Berks. that also had white tail tips (some were very nicely marked Berk. with even edges), and 5 EI or EI/I, in Black and Blue, but no Var. None were kept back for further test breedings.

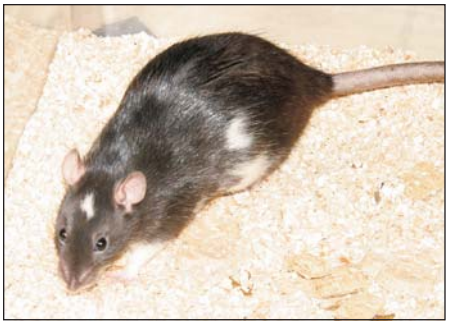
The two Blue head spot Berkshires in the 2023 litter. Photo ©2008 Karen Robbins.

The 2015 litter which were all "hooded Berkshires" with no head spot, and EI or EI/I. Photo ©2008 Karen Robbins.

Breedings to the "H" Locus: To do the test litter of a hs Berk. (1998) with something on the "H" locus, I had a Russian Blue Irish male (mom was Irish, grandmother was Berk., and the great-grandmother was a Var., but rest were Self) at the time that was the closest to fitting the description. In this pairing, 16 babies were born (2015 litter) with 8 Berk. that had *no* hs, 7 EI or EI/I, and 1 Irish. None had the



The Black Hooded male used to make the 2022 litter. He was heavy in the spine marking but had a pretty decent chest mark. Photo ©2008 Ken Van Doren.



The Black head spot Berkshire mom to the 2022 litter. Photo ©2008 Karen Robbins.

The belly of the Berkshire mom to the 2022 litter showing the white on the chin/throat/chest area typical of the "Variegated/Dal. Berkshires." Photo ©2008 Karen Robbins.

The "hooded" Berkshire female kept from the 2022 litter with no head spot and no white on the chin/throat area typical for the "hooded" version of Berkshire. Photo ©2008 Karen Robbins.

white chin/throat/chest area typical of the hs Berk., but they did have white on the rest of the belly area; colors were Black and Russian Blue. None were kept for further testing. This would confirm the Irish dad was *Hh.*

I then found a real Hooded rat I was able to breed one of the hs Berk. (1998) females to. This litter of 13 (#2022) produced an entire litter of Black Berks. with no hs but all had white tail tips (wtt). They also did not have any white on the chin/throat/chest area but the rest of the belly had white. One male and one female that had the calmest temperaments were kept for the next generation of test litters.

F3 Litters – "Spotted Dalmatian" Tests

Breeding the "spotted Dal." (a.k.a. heavy Dalmatian) kids together and to Var. (to prove one of the "spotted Dal." to a Var. should produce Dal.) were the goals for this round of test litters.

Breeding the "Spotty" Rats: Breeding two "spotted/heavy Dal." together (male from the 1996 litter; female from the 2018 litter; photos above as babies) produced a litter of 11 (all live; #2026) with 1 Black Berk. no hs, 2 Russ. Dove little bit hvy. Dal,, and the rest were hvy. marked Dal./Berk. types in Silver Black, Russ. Blue,

Some of the 2026 litter with the two little bit heavy Dalmatian Russian Doves on the right. Photo ©2008 Karen Robbins.

and a Blue-Beige (back 4 and 5 generations is Lilac and Blue, plus both parents had Russ. Blue siblings). The two little bit heavy marked Russ. Dove Dals. were kept for further Dal. breedings.

"Spotty" Dalmatian x Variegated: The other test breeding of the heavy marked Dal. male from the 1996 litter with a nicely marked Var. (not out of any test breedings) produced a litter of 14 (#2019) that had 8 Dal. in Silver Black and a light Russ. Blue, 3 hs Berk. in Black and Russ. Blue, 2 Black Var., and 1 Silver Black hvy. Dal. One Dal. female was kept for Dal. breedings. I was surprised at the

The Black Variegated mom to the 2019 litter. Photo ©2008 Karen Robbins.

The Dalmatian males in the 2019 litter with mostly butt and head markings. The females were more broken up on the butt. Photo ©2008 Karen Robbins.

The two Black Variegateds in the 2019 litter. The one on the left has its markings concentrated mostly down the spine while the other one isn't broken up much. Photo ©2008 Karen Robbins.

number of Dals. in this litter. It's interesting with this breeding, I got fairly decent marked Berks. but the Dals. were not very spotted (all butt and hd. marks). Also, one of the Var. had the markings very concentrated down the spine and the other one wasn't broken up very much. I was expecting better marked Dals. with dad being so splotchy and good Var. with mom being nicely marked.

Heavy x Good Dalmatians: Another test I did to make more Dal. was to take the hvy. Dal. female with more color on the back (2018-1) and breed with a good marked Dal. This litter produced 11 (#2035) of which there were 3 good Dals., 5 hs Berk., and 3 hvy. Dal. in Silver Black, Russ. Blue, and lt. Russ. Blue. Several were kept back for Dal. breedings.

F4 Litters – Hooded Carriers Test

For this test, the two Black Berk. with no hs (2022 litter) were bred together. The breeding produced a litter of 17 (2 dead; 15 live; 2028 litter) all Black in 3 Var.(!), 2 extremely lightly (ex. lt.) marked Var. (1 had one spot on the back, the other had no spots), 1 hs Berk. with wtt, 2 EI/I, 5 Berk. with no hs and all had a wtt, and 2 Hooded.

Four of the Berkshires with no head spots in the 2028 litter. None were kept. Photo ©2008 Karen Robbins.

The three Variegateds in the 2028 litter. Their markings are concentrated down the spine and not broken up very much. Two were kept back for the next generation of testing. Photo ©2008 Karen Robbins.

The two extremely lightly marked Variegateds in the 2028 litter. These were kept for further test breedings. Photo ©2008 Karen Robbins.

The two Hoodeds in the 2028 litter. The female on the right was kept back (the other was a male). Photo ©2008 Karen Robbins.

A pair of Var., the 2 ex. lightly marked Var., and the Hooded female were kept back.

This litter really threw us for a loop when the Var. showed up when it had not shown up in the many litters prior to this. My theory was Var. needed the Hooded to work with to show up, just like Dal. needs Var. to make correctly marked Dals. In my past breedings of Var., I've gotten Var. both by breeding Var. to something and breeding two non-Var. together, i.e. Dal. x Dal., Dal. x Berk., Dal. x Capped, Capped x Berk.

F5 Litters – Continuing The Hooded Carriers Test

Since we had Var. show up in the two Black Berk. no hs Hooded carriers, we continued on with further test breedings to see how Var. played out in these rats.

First breeding was done with one of the ex. lt. marked Var. back to his no hs Berk. mom. This litter only had 2 in it (#2041); one died at a couple days of age (looked like a Berk.) and the other one (a Black Hooded male) had to be put down at 6 days as it looked like it wasn't getting anything to eat and was emaciated.

The emaciated Black Hooded baby at 6 days from the 2041 litter of Black Berkshire mom with no head spot bred to her extremely lightly marked Variegated son. Photo ©2009 Karen Robbins.

The breeding was repeated to see if this was just a fluke, and the next litter was normal with 15 born (2044 litter), 12 of

The Variegated males from the 2044 litter showing the range from very heavy marked to extremely lightly marked. Photo ©2009 Karen Robbins.

. . . and the female Variegateds from the 2044 litter. Variegateds always have a head spot where the Hoodeds don't, so you can tell when they are getting their color which are which. Photo ©2009 Karen Robbins.

The two Hoodeds from the 2044 litter. Photo ©2009 Karen Robbins.

which were Var. in Black and Russ. Blue, 2 Black Hooded, and 1 Black Berk. with no hs. The Vars. all had their markings concentrated down the spine and ranged from no spots, to broken up Var., to having the Var. all run together into one big patch on the back (hvy. marked). The two Hoodeds had very messy/uneven spine markings. The Black Berk. with no hs had the typical black chin/throat/chest area with the rest of the belly completely white. None were kept back.

In breeding the two poor/ex. lt. marked Var. together, that litter of 13 (#2042) were all poor/ex. lt. marked Var. in Black and Russ. Blue; none were kept.

From the two Var. bred together, this produced a litter of 11 (#2043) that were

The males from the 2042 litter that were all poor/ex. lightly marked Variegateds. The entire litter was like this. Photo ©2009 Karen Robbins.

The female Variegateds from the 2043 litter (the males were similar in markings). Photo ©2009 Karen Robbins.

The three poorly marked Variegateds from the 2040 litter. Photo ©2009 Karen Robbins.

The three heavy marked Variegated females from the 2040 litter (the male was similar). Photo ©2009 Karen Robbins.

all Black in 9 Var. (1 was poorly marked with only 1 spot) and 2 hs Berk. There were *no* Hooded. None of the Var. were broken up very much as both parents had their Var. run together. None were kept.

The last breeding was the Hooded with the Var. (hvy. marked). This was done to see what you would get if Hooded that had Var. in the background was bred with the Var. This litter of 11 (#2040; all Black) had 4 Var. (hvy. marked), 3 poor/ex. lt. Var., 3 Berk. no hs, and 1 Hooded. None were kept.

Aggression Issues In The Hooded Stock

The original Hooded male used for these test breedings had shown signs of aggression to his cagemate prior to using with my female. The F1 generation kids out of my female were fine. However, when the Hooded was then "doubled up" by breeding brother/sister, the aggression came back out in the next generations. I had several of these rats (both male and female) literally trying to kill other rats. Therefore, all the rats from the original Hooded male and all the resulting litters were euthanized when severe aggression started showing up in his grandkids.

In the past I've had rats killed by other rats, one time a male tried neutering another younger male, plus the many injuries sustained from rats fighting with each other, as well as being bit by aggressive rats and knowing others who have been bit with some of them requiring stitches, has made me have *zero* tolerance now for aggression in rats. Aggression should ***never*** be tolerated as it can not only result in rats doing damage to or killing other rats, but they can also become aggressive to people or anything that comes near them, especially if they smell like another male. Aggression can be passed down on both sides (male and female), so don't think if you don't keep any males or don't breed back to the aggressor, you won't continue to have a problem. Cutting out aggression in your rats is a ***must***.

Other Breedings Of Variegated

During the time of breeding the Var. and Hooded ones together, I bred a separate Var. x Var. litter. I got 2 Capped out of a litter of 4 (#2038) with the others being a Var. and a hs Berk. I had not gotten Capped out of Var. in quite a while; had only been the hs Berk. and Var. You can

The 2038 litter of Variegated x Variegated that resulted in two Capped. You can see the white notch on the back of the cap splitting up the color compared to the poorly marked Variegateds in the 2040 litter that have solid color on the back of the head/neck/shoulder area behind the head spot. The Variegated male and Black Capped female were kept. Photo ©2009 Karen Robbins.

tell a Capped from a poor/ex. lt. Var. by the white notch that runs from the hs area to the back of the neck where a poor/ex. lt. marked Var. will have a defined head spot with color then behind it to the shoulders. The Var. and one of the Capped were kept from this litter.

The Black Capped female (#2038) was then bred with an English Mink Self (no markings in background) that produced a small litter of 5 (#2066), all of which were Black Berk. with no hs and white only on the belly (none on the chin/throat/chest, which makes them the Hooded Berk. version). None were kept.

The 2066 litter from the Capped x Self. All were Berkshires with no head spot. Photo ©2009 Karen Robbins.

With a different breeding of Var. x Var. (same father as the one used in the Var. x Var. [2038 litter] and the moms were sisters), I also got 2 hvy. marked Capped (#2046; ran too far behind ears). Others included 7 Var. and 3 hs Berk. (1 with a stripe-blaze) in the litter of 12. Several were kept, including the 2 Capped and 2 hs Berks.

Breeding these Capped (2046) together

The 9 males from the 2061 litter (Capped x Capped = all Capped; 2046) showing how the entire litter looked. Photo ©2009 Karen Robbins.

The 3 head spot Berkshire females from the 2060 litter (all the colored ones were hs Berks.) with the one on the left having a crooked stripe-blaze (from head spot Berkshire x head spot Berkshire breeding; 2046). Photo ©2009 Karen Robbins.

only got me an entire litter of 16 Capped (#2061; 1 had a crooked stripe-blaze [grandfather had a crooked st.-blz.]; none were kept).

Another breeding done with the two hs Berk. (from the 2046 litter) produced 12 babies (#2060 litter) that had 7 hs Berk. (one had a crooked st.-blz.) and 5 PEW (12 generations back a HUGE PEW lab rat, "PC Ratzilla," was bred with a Lilac Var.), but again, no Var.

Some of Nichole's comments regarding Capped, Masked, and BEW: "Capped, Masked, and BEW are all the same thing. I'm betting they are genetically identical to color headed white in dogs. Color is restricted to the head, with modifiers determining how much color is there." And "Breedings of rats with color just on their heads do not give rats with color except on their heads; these have to be a homozygous allele."

Additional Breedings Of Variegated & Hooded Types

By this time I had a good idea what resulted from the different breedings of

Three from the 2069 litter: L–R: Russian Blues in a Self Satin male (color looks darker due to the satinization), Variegated male, and a head spot Berkshire female. The rest of the litter were Self, EI, EI/I, Irish, and I/B. Photo ©2010 Karen Robbins.

Variegated and Hooded. Also, there is a clear difference between a "Hooded Berk." with no hs vs. a "Var./Dal. Berk." with hs.

Two litters I had bred during this time of a Self with a hvy. marked Var. (repeat breedings; litters #2052 and 2058) produced a lg. Irish female and a male with a small white spot on the stomach (wss) that I kept to breed together for making improvements on the type of my Self Satins. When I bred those two together, they produced a litter of 11 (litter 2069; all Russ. Blue) – 2 Self, 1 EI, 1 EI/I, 1 Irish, 4 Irish/Berk. (I/B) with no hs, 1 hs Berk., and 1 Var. When I saw the I/B looked like "Hooded I/B," I thought by breeding those I would get Hooded.

So, next step was to breed the two Russ. Blue I/B together. This produced a litter of 13 (#2073), with 1 Self, 2 with sm. spot on the chest, 1 EI, 1 EI/I, 1 Irish, 1 lg. Irish, 2 I/B no hs, and 4 Hooded. The Hoodeds didn't have very good spine markings, but they were Hooded.

The four Hoodeds from the 2073 litter; the two outside ones are Satin (color looks darker due to the satinization). Photo ©2010 Karen Robbins.

The hs Berk. (2069) female was then bred with a Var. and produced a litter of 12 (2080) Black and Russian Blues in 4 hs Berk., 5 Var., and 3 hvy. marked Var.

Past Breedings Of Variegated To Self

In the past I had done two breedings of Var. x Self. In those litters there were 1 with sm. white spot stomach, 2 EI/I, 1 Berk. no hs, 3 hs Berk., and 3 Berk. (not recorded about hs).

A "Variegated" In 1979

One interesting baby that showed up in one of my Irish x Self/Irish/Hooded (mom was with 3 sons) litters in 1979, was "a Black Hooded male with a 'bad Hood' and star on head." At the time, Variegated was completely unknown to us. In this litter of

The baby born Dec. 9, 1979, that looks like what we now know as a light marked Variegated. Photo ©1979 Geri Hauser.

6 there were 3 Irish, 2 Hooded, and the 1 "Hooded" with star. Unfortunately, it died before its eyes opened, but looking at the photo years later, it looks like a light marked Var. It was so unusual at the time, I had to get a photo of it. I tried unsuccessfully to get more of this marking from the siblings bred together, mom to the son from the litter with "star," kids kept back from those litters and bred together, but no more of the "bad Hooded with Star."

Final Results In The Test Breedings

Test Breeding the Dalmatian:

- Self x Dal. = 6 EI or EI/I, 1 lg. EI/I with hs, 8 hs Berk.
- Sil. Blk. (SB) Berk. (or Dal. Berk.) x SB Berk. (Dal. Berk.) = 1 Self, 1 tiny spot on chest, 1 Collared/Berk., 4 EI/I messes (1 with hs), 4 hs EI/Berk. or Berk., 1 EI/Berk. no hs, 1 nicely marked hs Berk., 6 hvy. Dal. (2 litters; 19 babies)
- hvy. Dal. x hvy. Dal. = 8 hvy. Dal./Berk., 2 little bit hvy. Dal., 1 Berk. no hs
- hvy. Dal. x Var. = 3 hs Berk., 2 Var., 8 Dal., 1 hvy. Dal.
- hvy. Dal. x gd. Dal. = 5 hs Berk., 3 gd.

Dal., 3 hvy. Dal.

Test Breeding from the Initial Self x Dalmatian:

- EI x EI = 1 Self, 8 EI or EI/I, 6 hs Berk.
- hs Berk. x hs Berk. = all hs Berk. (2 litters; 21 babies)
- EI x hs Berk. = 8 hs Berk., 5 EI or EI/I
- hs Berk. x Var. = 8 hs Berk., 6 Var.
- hs Berk. x Irish (*Hh*) = 8 Berk. no hs, 7 EI or EI/I, 1 Irish

Test Breeding to Hooded:

- hs Berk. x Hooded = 13 Berk. no hs
- Berk. no hs x Berk. no hs = 3 Var., 2 poor/ex. lt. Var., 1 hs Berk., 2 EI/I, 5 Berk. no hs, 2 Hooded (this litter was the head scratcher)
- Berk. no hs x poor/ex. lt. Var. = 12 Var., 3 Hooded, 2 Berk. no hs (2 litters; 17 babies)
- poor/ex. lt. Var. x poor/ex. lt. Var. = 13 more of the same
- Var. x Var. = 8 Var., 1 poor/ex. lt. Var., 2 hs Berk.
- Hooded x Var. = 4 Var. (hvy. marked), 3 poor/ex. lt. Var., 3 Berk. no hs, 1 Hooded

Other Breedings for Variegated

- Self x Var. = 2 Self (1 wss), 5 EI or EI/I, 4 I/B no hs, 2 Berk. (2 litters)
- hs Berk. x hs Berk. = 7 hs Berk., 5 PEW (1 litter)
- hs Berk. x Var. = hs Berk., Var. (1 litter)
- Self x Capped = 5 Berk. no hs
- Capped x Capped = 16 Capped (1 litter)
- Var. x Var. = 8 Var., 4 hs Berk., 4 Capped (2 litters)

Some of the results of various marked breedings from 1975–2007 (before all the test breedings)

- Self x Self = Self (44 litters)
- Eng. Self x Eng. Self = Self, EI (some just spot on chest) (21 litters)
- Irish (*Hh*) x Self = Irish, Self (52 litters); 2 litters prior to arrival of Eng. rats were Self, EI
- Irish x Irish = Irish, Hooded, Self (117 litters)
- One breeding I did of an English EI x English EI, bred as if it was an Irish x Irish as I got Self, EI, Irish, Hooded
- EI (Hh^i) x EI (Hh^i) = EI or EI/I, Self (7 litters)
- EI x Irish = range of Self, EI, Irish (3 litters)
- EI x Berk. = Self, EI or EI/I, Berk.; EI/I (2 litters)
- Berk. x Self = range of Self, EI or EI/I, Irish, I/B, Berk. (8 litters)
- Berk. x Berk. = Berk. (6 litters)
- Hooded (*hh*) x Self = Irish (21 litters); 1 litter bred with Eng. rat = EI/I, I/B, Berk., Self
- Hooded x Irish = Irish, Hooded (62 litters)
- Hooded x Hooded = Hooded (168 litters); Hooded, PEW (40 litters)
- Dal. x Berk. = Dal., hs Berk., Var. (in half the litters), EI/I (2 litters had EI/I which can be called lightly marked Berk.) (16 litters total)
- Dal. x Var. = Dal., Var., hs Berk., Capped (in 2 litters) (12 litters total)
- Dal. x Dal. = Dal, hs Berk., Var. (in 3 litters) (6 litters total)
- Dal. x Irish = Dal., Self (1 litter of 3)
- Dal. x Hooded = Berk., Collared (1 litter)
- Dal. x Collared = hs Berk., Var., then some Dal., Collared, and one litter also had EI (4 litters total)
- Dal. x Capped = Var., Capped, hs Berk., Dal. (1 litter)
- Dal. x Essex = Self/EI (w/sm. spot chest), EI/I, Irish, Berk. (no hs)
- Var. x Self = 3 Berk. (not recorded if they had hs or not), 3 hs Berk., 1 Berk. no hs, 2 EI/I, 1 Self w/sm. wss (2 litters)
- Var. x EI = Berk. (not recorded if they had a hs or not), EI or EI/I, Var. (3 litters)
- Var. x Berk. = Var., hs Berk., then some EI or EI/I, Capped (17 litters)
- Var. x Hooded = Berk., Var., "Bareback" or "Bareback/Hooded" were either poor/ex. lt. Var. or poor Hooded (3 litters)
- Var. x Var. = hs Berk., Var., then some Capped, hvy. Var., ex. lt. mkd. Var., or hvy. Capped (22 litters)
- Var. x Capped = hs Berk., Var., Capped (1 litter)
- Capped x Self = 6 Berk. (not recorded if they had a hs or not, but probably not since the recent litter I did, did not have any) (2 litters)
- Capped x EI = Berk. (not recorded if they had a hs or not), EI/I (3 litters)
- Capped x Berk. = range of EI or EI/I, Capped or mismarked Capped, Irish, Berk., Var. (6 litters)
- Capped x Capped = Capped (11 litters)
- With the Capped Odd-Eye rats I was working with separately since January 1983 (they usually were Capped with stripes or Blazes up the face or plain Capped), I only ever got more of the same type of marking unless I bred with a Berk., then I got Capped and Berk., sometimes some Self, Irish, and I/B, but never Var.

Karen Robbins' Conclusion

- ***There are two kinds of Berk.*** = "**Hooded Berk.**" (*Hh*) has no white on chin/throat/chest, and no head spot, and the "**Var./Dal. Berk.**" always have a head spot and all white underneath; made from two different genes as can get both types of markings in a litter
- ***Var. x Var. will NOT produce Hooded*** so can't be hh^e
  Var. x Var. will NOT produce Self so can't be Hh^e
  Var. x Var. will NOT produce English Irish so can't be Hh^i, $H^{re}h^i$ or H^eh^i
  I've been breeding Var. since we got the first English ones in 1983 and I have NEVER gotten Hooded, Self, or English Irish in Var. x Var. litters.
  Var. can't be h^eh^e as that would only produce one kind of marking when bred together, and Var. x Var. ALWAYS has hs Berk. in the litters, and usually other types such as Capped, Capped-type, poor/ex. lt. Var.
- ***We have proven the Dal. is a separate dominant gene*** *Daldal*
  Dal. x Dal. will NOT produce Hooded so is not H^eh
  Dal. x Dal. will NOT produce English Irish so is not $H^{ro}h^i$ or H^eh^i
  Dal. is NOT the Essex gene so is not $H^{ro}h^i$; Dal. is a color/marking gene that extends the white and silvers the color where Essex is a color fading gene that breeds like a Self but just happens to have white "markings"
- ***Var. always has a head spot (a few hairs to a large spot);*** this can turn into a stripe-blaze/slash-blaze or full blaze
- ***Dal. & Var. litters always have head spot Berks.***
- ***Poor/ex. lt. Var. may be mistaken for***

Bareback but always has a head spot and white on the chin/throat/chest where true Barebacks are Hooded rats with the spine marking bred off

- ***Var. and Hooded should never be bred together:*** the only thing I've seen when I breed Hooded with Var., is it messes up where the Var. is— ends up mostly on the spine and takes a few generations later to get it more down the sides—and the Hoodeds have very messy spine markings
- ***Breeding ex. lt./poor Var. or v. hvy. Var. does nothing to help the markings on Var.***
- ***The way to tell a heavy Capped vs. an extremely poorly marked Var.*** is the Capped always has the notch of white in the back of the cap where an extremely poorly marked Var. will have a head spot but there won't be that strip of white running through the color onto the back of the neck
- ***There are 2 kinds of EI:*** those caused by *Hh* which produce Hooded when bred together and Hh^{i} which will *not* produce Hooded when bred together

Nichole Royer's Conclusion

So, after all that Nichole was not able to come up with a specific possible genetic code for Var. There were several possibilities until we hit the breeding of the two Berk. with no hs out of the Hooded cross. She even contacted other hobby geneticists that were specialists with their species and no one was able to come up with anything definitive. Her comments in the phone conversations I had with her regarding this:

- Based on test breedings, the genetics for Variegated are complicated, evidence shows there are at least 2 genes but probably 3–4 genes in the mix on different locus that work in combination with each other and linkage may possibly be involved
- It does not work the way any books say and listed codes did not work based on the outcome of the test litters
- We don't have a clear understanding at this time of Variegated
- It is not a simple recessive or dominant gene or one we have already dealt with
- Dal. and Var. are connected (her original belief was Dal. is Var. + some other gene that is NOT on the Hooded locus; I get Variegated out of different breeding types of Dal. litters, see Breeding Results above)
- May be several interconnected genes that need each other
- Var. appears as own thing that works in combination with Hooded
- Put in combo with other spotting genes to show up—work together
- Markings can vary for one gene depending on what the modifiers are, for example *Hh* can vary in the amount of white from EI to Irish to Berk. (with no hs); this is when Self *H* is incompletely dominant over Hooded *h* so the various markings like EI/I/Berk. are co-dominant
- Based on actual breeding experience using animals with known backgrounds, the current codes are not viable

And some interesting information from Nichole regarding BEW:

- Need pigment on ears to hear—lack of pigment = part of ear structure not formed, this applies to all mammals—marked genes only—no pigment = deaf; Dal. dogs with solid ears and patches can hear, ones with spotted ears/less patches are deaf in one or both ears—this is directly related to color

So, basically this is her conclusion: "To all appearances the genetics of markings in rats is far more complicated than is typically described in the literature. There are more than one loci that produce white markings in rats, and the assumption that all white markings are caused by alleles at the Hooded locus is inaccurate. This is further complicated by the fact that multiple loci may produce very similar "Irish" and "Berkshire" type markings. There is suspicion that both Variegated and Dalmatian are not necessarily alleles on the Hooded locus, but may interact with the Hooded locus in a rather complicated way."

And Sheila Sowter, England, says this: "Blazed rats are produced by a combination of genes, bareback and variegated are probably produced by several genes or at any rate some heterozygous combinations, but this is work-in-progress." which is what we have found to be the case for Variegated.

Some Additional Reading:

"An extreme allele of hooded spotting in the Norway rat"
http://link.springer.com/content/pdf/10.1007%2FBF00057932

"Head spot and dilute mutations in the Norway rat"
http://jhered.oxfordjournals.org/content/89/1/100.full.pdf (on page 18 of the PDF)

"High-Resolution Linkage Mapping of the Rat Hooded Locus"
www.jstage.jst.go.jp/article/jvms/73/5/73_10-0529/_pdf"

"Linkage of hooded and hood-modifier genes in the rat"
http://jhered.oxfordjournals.org/content/75/1/81

"Piebald Rats and the Theory of Genes"
www.ncbi.nlm.nih.gov/pmc/articles/PMC1091549/pdf/pnas01925-0034.pdf

"Variation in the Hooded Pattern of Rats, and a New Allele of Hooded" that has photos of Capped (Notch gene)
www.genetics.org/content/36/3/254.full.pdf

"Canine Color Genetics" by Sue Ann Bowling; according to Nichole, the description of the spotting locus in dogs is very good
http://bowlingsite.mcf.com/Genetics/ColorGen.html

Variegated rat drawing by Sheryl Leisure, CA.