

# SEX-LINKED DILUTION THE OTHER ALLELE OF BARRED/CUCKOO ( $B^{Sd}$ )



$B^{Sd}$  allele of barring/cuckoo also called sex-linked dilute, hobby name in Australia 'spotty'.

On the left: a homozygous male from the research paper.

The evolution of Sex-linked barring alleles in chickens involves both regulatory and coding changes in CDKN2A (PLoS.org 2017)

The heterozygous male ( $B^{Sd}/b^{+}$ ) and hemizygous ( $B^{Sd}/-$ ) female look like 'our' normal 'dark' cuckoo.

According to Crawford (1990) the order of dominance is:  $B^{Sd} > B > b^{+}$

The cock here has still quite a lot of colour, even less colour is possible.

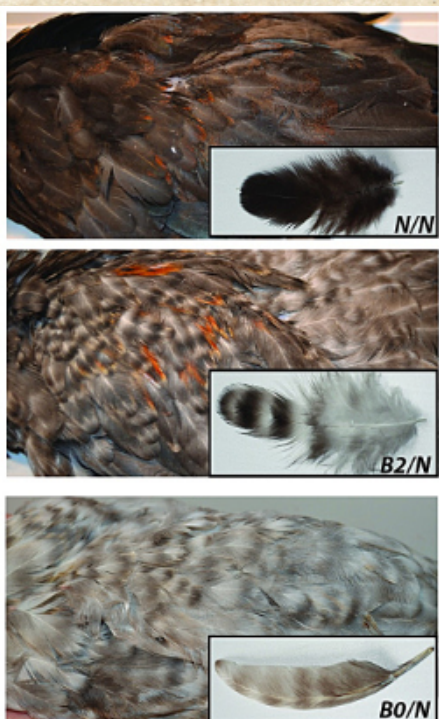
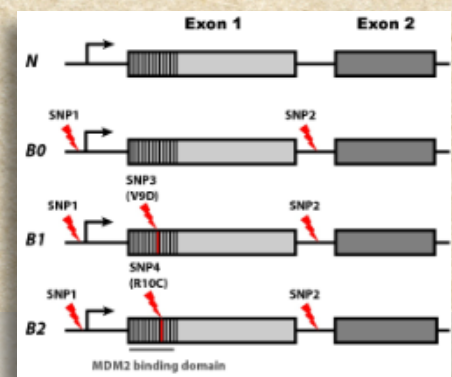


B1 is what we know as the normal Barred, where the heterozygous male has the same colour (amount of colourless stripes) as the hemizygous female. The study did not look at what the chickens themselves looked like, but rather sequenced the area where the gene for barred (CDKN2A) is located. Much was already clear about this, but new techniques were used to look a little deeper in 2017. By the way, this gene CDKN2A is the most studied (cancer, melanoma) gene in humans (<https://pubmed.ncbi.nlm.nih.gov/30482142/>).

The Barred Chicken

Geneticists were surprised that a large part of the chicken population has a mutated version of this gene, even 3 different mutations (three B

*The locations where mutations hit the gene.*



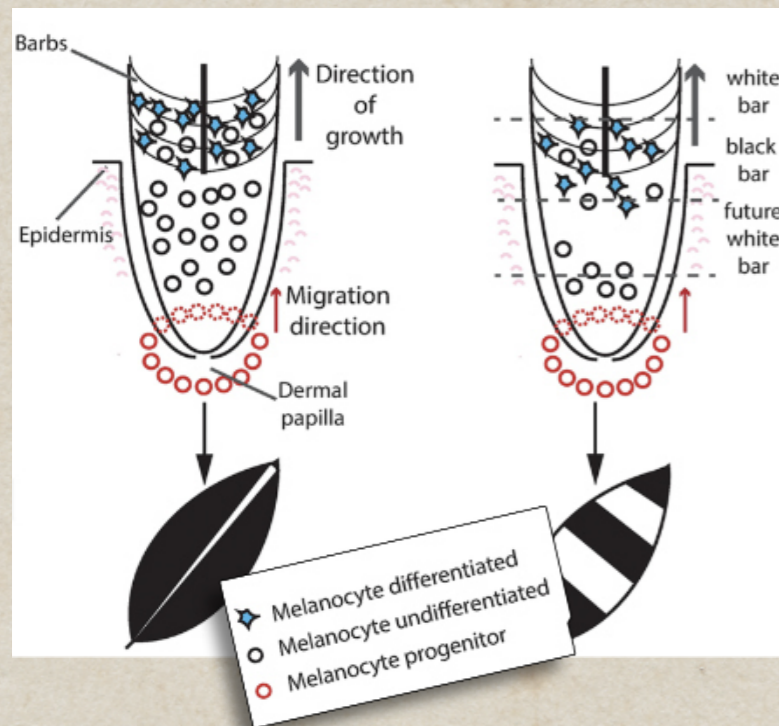
N is wildtype which we call  $b^{+}$ . B0 is an odd mutation because there was no way to see it

"All Sex-linked barred chickens studied so far carry either the B1 or B2 alleles, whereas the phenotype associated with the B0 allele remained unknown. In our previous study the B0 allele was only found in White Leghorn chickens where the Dominant white allele (I), a strong dilutor of black pigment, prevents the observation of any patterning and is thus epistatic to Sex-linked barring [3] < paper from 2010." In this 2017 paper B0 is visible you see the photo of heterozygous B0/N on the bottom left. Could it be possible the 55 Flowery hens are actually B0/B0 super sex-linked überdilute? The more white in hobby 'spotties' it is B0 and not B2? The B0/N reflects the colour of the female if it works similar to  $B/b^{+}$  vs.  $B/-$  'our' normal barred/cuckoo.

B1 is 'our' hobby barred or cuckoo.

B2 is sex-linked dilution the gene mentioned by Crawford in 1990 and the picture of the cock on top of this page.

B0 is Leghorn sex-linked dilute maybe as in the 55 Flowery Hens.



#### How does barred/cuckoo work?

In solid coloured feathers, melanocyte progenitor cells migrate up from the feather base and start expressing CDKN2A in the barb region leading to differentiation of melanocytes and pigment production without exhausting the pool of undifferentiated melanocytes. In sex-linked barred feathers, up-regulated ARF expression may lead to premature differentiation of pigment cells and a lack of undifferentiated melanocytes that can replenish the ones producing pigment. As the feather keeps on growing, no more melanocytes are available to produce pigment resulting in the white bar. A plausible explanation for the cyclic appearance of white and black bars is that new recruitment of melanocyte progenitor cells takes place after the undifferentiated melanocytes have been depleted.

**In donaldduck-language the above says:** In solid coloured feathers, unripe pigment cells go up along the feather base and when they are at the region where the feather barbs are formed from the pulp in the middle, they become pigment cells that produce red or black pigment according to the software (feather colour or pattern) and they give the pigment to the keratine. This goes on in a steady flow from the bottom up to where the transaction between pigment cell and feather barbs of keratine happens.

When there is a mutation like barred/cuckoo, this process is interrupted. The gene makes the pigment producing cells to develop themselves too soon and they don't get the signal what pigment to produce. This leads to jeopardizing the transaction of pigment (there is none) to the keratine of the feather barb. Therefore for that time, there is no pigment put into the feather which continues to grow, hence a white bar. The process is restored when new unripe pigment cells are grown at the base of the feather and migrate upwards and are not confused by a mutated CDKN2A gene.

Chickens without a mutation on CDKN2A (barred/cuckoo gene) have normal coloured feathers without non-pigmented parts in them.

**Do we have this B2 sex-linked dilute and B0 sex-linked Leghorn dilute in hobby chickens?**

That is well possible, think of 55 flowery hens from the Swede Silverruds. They look like Leghorn derivatives which are known for having B0 (see previously) or B2, that's only possible to know after sequencing. The 1955 flowery (cuckoo mottled) whatever colour there is in them, looking mostly like duckwing e+ brown Leghorn. The males have sex-linked dilute, they are almost white with a few coloured feathers only. The hens have a 'normal' colour as in not extra diluted. Add mottled and they get mostly white flights and main tails.

Greenfire Farms in the US imported a bunch and has nice photos of them on their [website](https://www.greenfirefarms.com/).



**55 Flowery Hens from Silverruds with sex-linked dilute and mottled. Can be B2 or B0 from Leghorn.**



Photo: Karen Johns (Australia)



Photo: Karen Johns (Australia)

**B^Sd from Game to Pekin to Silkie. Little photo: a gold laced barred on henry-feathered male, by Karen Johns.**

**The Australian 'Spotty' gene is sex-linked dilute, an allele of barred/cuckoo?**

This gene came from Game fowls and Karen Johns put it from there into her Pekins and in Silkies to create 'three coloured' paints. Paints are solid black Silkies impure for dominant white, the leaking black feathers give spots as on paint horses due to the silkied feathers. In smooth chickens they look white with here and there a black feather. Red will not show as spots in heterozygous dominant white because it cannot block red pigment, so this will show as on pyle. Paint is not exchequer, which is a black chicken with hysterical mottled.

Spotty is B^Sd probably, because the cocks vary in the amount of colourless and coloured feathers and some feathers are indeed cuckoo. The hens are cuckoo as in all other cuckoo alleles (B/-) because they can only have one dose so the (sex-linked) dilution doesn't happen in them, nor in heterozygous cocks. Karen says the Pekin cock is gold laced cuckoo (hobby name 'candy corn' in the US on Paduas) with the spotty gene.

**Keep in mind, chickens bred for genetic research don't resemble our sophisticated ones 100%**

**Barred/cuckoo has 3 alleles, order of dominance is B^Sd > B0? > B > b+**

**'Our' barred is now B1, sex-linked dilute is B2, Leghorn sex-linked dilute is B0**

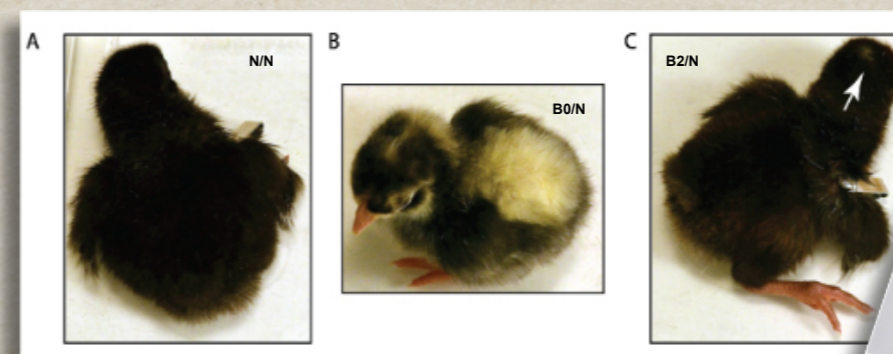


Fig S1. Phenotype of chicks at hatch with different CDKN2A genotypes: (A) N/N which is wildtype, (B) B0/N as in Leghorn sex-linked dilute and (C) B2/N allele as in Australian 'Spotty'. The arrow marks the characteristic white spot associated with Sex-linked barring.



Fig S2. B2/N male feathers

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