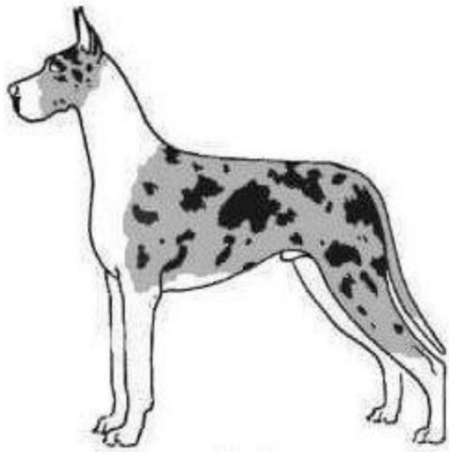
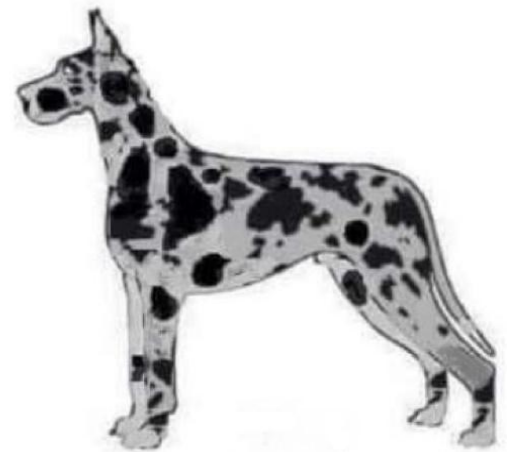


# Merle, the gene we needed but did not know it.



Neil O'Sullivan PhD

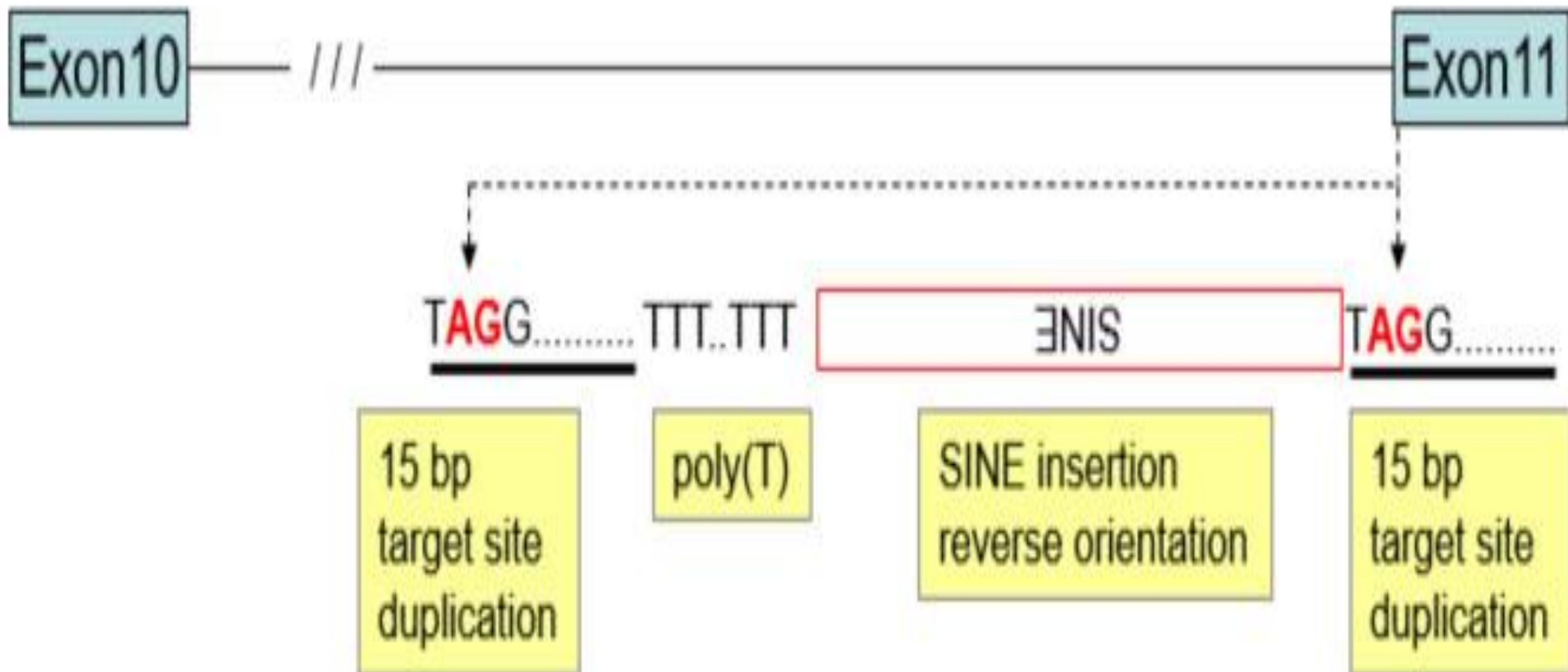


A Presentation for

## Midland & West of England Great Dane Club

# Merle (the technical stuff)

- ❖ The gene resides on chromosome 17 and it is the premelanosome protein (PMEL) with a short interspersed nuclear element (SINE) commonly known as a poly (T) tail.
- ❖ None merle is the homozygous recessive (mm genotype). Mantles and Blacks are normally mm genotypes.
- ❖ Merles and Harlequins are heterozygous, so they carry one copy of the dominant merle allele and one copy of none merle Mm genotype.
- ❖ SINE will vary in length as repeat elements are subject to errors in transcription and so the length of the poly (T) tail varies. This variation in length results in different intensities of expression of the merle phenotype.



# Merle, variation in expression.

- ❖ Whites and Merlequins are homozygous for the merle gene. They have two copies of merle (MM genotype).
- ❖ SINE variable length results in different levels of expression of merle.
- ❖ A small percentage of Mantles and Blacks will have short poly (T) tail and express almost no merle at all, this form is called the **cryptic merle**. A Mantle or Black looking dog for the most part but with significant merle, but not full expression of merle has a poly (T) tail which is longer than the cryptic merle but shorter than the regular merle and is called **atypical merle**. A poly (T) tail longer than the normal merle results in a rare expression of merle known unfortunately as the **harlequin merle**. It is not the true harlequin.
- ❖ M is normal merle, M<sup>c</sup> is cryptic merle, M<sup>a</sup> is atypical merle, M<sup>h</sup> is harlequin merle, and m is no merle.

# Mating Harlequin to Harlequin produces many different colors. Why is this the case?

## Harlequin to Harlequin Breeding

Both parents are not carrying any undesirable color genes

(Harlequin:  $a^y a^y$  BB DD ee Hh KK Mm  $s^i s^i$ )

Segregating genes are H and M

Each parent will produce four different gametes (eggs & sperm)

HM, Hm, hM, hm

**PROCEED with caution due to White, and Merlequin progeny**

Harlequin to Harlequin mating	HM	Hm	hM	hm
HM	HHMM	HHMm	HhMM White	HhMm Harlequin
Hm	HHMm	HHmm	HhMm Harlequin	Hhmm Mantle
hM	HhMM White	HhMm Harlequin	hhMM Merlequin	hhMm Merle
hm	HhMm Harlequin	Hhmm Mantle	hhMm Merle	hhmm Mantle

Harlequin to Harlequin produces

Average results of this mating are:

**33% Harlequin**

**25% Mantle**

**17% Merle**

**17% White, 8% Merlequin**

# Harlequins are all Merles

- ❖ The Harlequin is typically a Black Mantle that has one copy of merle gene Mm, and one copy of harlequin gene Hh.
- ❖ Two copies of harlequin are an in-utero lethal HH
- ❖ Whites, are homozygous merles, MM, that carry one copy of harlequin, Hh.
- ❖ Merlequins, are homozygous merles, MM, that do not carry for harlequin, hh.
- ❖ All harlequins are dual obligate heterozygotes.
- ❖ All homozygous merles, have a high risk of lacking pigmentation in the inner ear resulting in deafness. They also have a risk of microphthalmia, leading to blindness.
- ❖ Many countries ban matings where both parents carry merle genes.



# Mating Harlequin to Mantle

## Harlequin to Mantle Breeding

Both parents are not carrying any undesirable color genes, Mantle **does not** carry for Harlequin (H)

(Harlequin:  $a^y a^y$  BB DD ee Hh KK Mm  $s^i s^i$ ) (Mantle:  $a^y a^y$  BB DD ee hh KK mm  $s^i s^i$ )

Segregating genes are H and M in the Harlequin

Gametes (eggs & sperm) are HM, Hm, hM, hm from the Harlequin and hm from the Mantle

**RECOMMENDED**

# Harlequin to Mantle mating

	HM	Hm	hM	hm
hm	HhMm Harlequin	Hhmm Mantle	hhMm Merle	hhmm Mantle

Harlequin to Mantle  
the Mantle does not carry a harlequin gene

Average results of this mating are:

**25% Harlequin**

**50% Mantle**

**25% Merle**

# Mating Harlequin to Mantle

## Harlequin to Mantle Breeding

Both parents are not carrying any undesirable color genes, Mantle carries for Harlequin (H)

(Harlequin:  $a^y a^y$  BB DD ee Hh KK Mm  $s^i s^i$ ) (Mantle:  $a^y a^y$  BB DD ee Hh KK mm  $s^i s^i$ )

Segregating genes are H and M in the Harlequin and H in the Mantle  
Gametes (eggs & sperm) are HM, Hm, hM, hm from the Harlequin and Hm, hm from the Mantle

**RECOMMENDED**

# Harlequin to Mantle mating

## Mantle carries for Harlequin

	HM	Hm	hM	hm
Hm	HHMm	HHmm	HhMm Harlequin	Hhmm Mantle
hm	HhMm Harlequin	Hhmm Mantle	hhMm Merle	hhmm Mantle

Harlequin to Mantle  
Mantle does carry a harlequin gene

Average results of this mating are:

**33% Harlequin**

**50% Mantle**

**17% Merle**

# Harlequin to Merle Breeding

Both parents are not carrying any undesirable color genes  
(Harlequin:  $a^y a^y$  BB DD ee Hh KK Mm  $s^i s^i$ ) (Merle:  $a^y a^y$  BB DD ee  
hh KK Mm  $s^i s^i$ )

Segregating genes are H and M in the Harlequin and M in the  
Merle

Gametes (eggs & sperm) are HM, Hm, hM, hm from the  
Harlequin and hM, hm from the Merle

**PROCEED with caution due to White and Merlequin progeny**

# Harlequin to Merle mating

	HM	Hm	hM	hm
hM	<b>HhMM</b> <b>White</b>	<b>HhMm</b> <b>Harlequin</b>	<b>hhMM</b> <b>Merlequin</b>	<b>hhMm</b> <b>Merle</b>
hm	<b>HhMm</b> <b>Harlequin</b>	<b>Hhmm</b> <b>Mantle</b>	<b>hhMm</b> <b>Merle</b>	<b>hhmm</b> <b>Mantle</b>



# Harlequin to Merle mating

Average results of this mating are:

**25% Harlequin**

**25% Mantle**

**25% Merle**

**12.5% White**

**12.5% Merlequin**

# Mantle to Merle Mating

Both parents are not carrying any undesirable color genes, Mantle carries for Harlequin (H)

(Mantle:  $a^y a^y$  BB DD ee Hh KK mm  $s^i s^i$ ) (Merle:  $a^y a^y$  BB DD ee hh KK Mm  $s^i s^i$ )

Segregating genes are H in the Mantle and M in the Merle

Gametes (eggs & sperm) are Hm, hm from the Mantle and hM, hm from the Merle

**RECOMMENDED**

# Mantle to Merle Mating

	Hm	hm
hM	<b>HhMm</b> <b>Harlequin</b>	<b>hhMm</b> <b>Merle</b>
hm	<b>Hhmm</b> <b>Mantle</b>	<b>hhmm</b> <b>Mantle</b>

# Mantle to Merle mating

Average results of this mating are:

**25% Harlequin**

**50% Mantle**

**25% Merle**

# Mantle to Merle mating

Both parents are not carrying any undesirable color genes, Mantle **does not** carry for Harlequin (H)

(Mantle:  $a^y a^y$  BB DD ee hh KK mm  $s^i s^i$ ) (Merle:  $a^y a^y$  BB DD ee hh KK Mm  $s^i s^i$ )

Segregating genes are M in the Merle

Gametes (eggs & sperm) are hm from the Mantle and hM, hm from the Merle

**RECOMMENDED**

# Mantle to Merle mating

	hm
hM	hhMm Merle
hm	hhmm Mantle

# Mantle to Merle mating

Average results of this mating are:

**50% Mantle**

**50% Merle**

# Mantle to White breeding

Both parents are not carrying any undesirable color genes, both Mantle and White carry for Harlequin (H)

(Mantle:  $a^y a^y$  BB DD ee Hh KK mm  $s^i s^i$ ) (White:  $a^y a^y$  BB DD ee Hh KK MM  $s^i s^i$ )

Segregating genes are H in both parents

Gametes (eggs & sperm) are Hm, hm from the Mantle and HM, hM from the White

**Recommended**



# Mantle to White breeding

	Hm	hm
HM	HHMm	HhMm Harlequin
hM	HhMm Harlequin	hhMm Merle

# Mantle to White breeding

Average results of this mating are:

**66% Harlequin**

**33% Merle**

# Mantle to Merlequin Breeding

Both parents are not carrying any undesirable color genes.

Neither parent carries for Harlequin (H)

(Mantle:  $a^y a^y$  BB DD ee hh KK mm  $s^i s^i$ ) (Merlequin:  $a^y a^y$  BB DD  
ee hh KK MM  $s^i s^i$ )

There are no segregating genes

Gametes (eggs & sperm) are m from the Mantle and M from  
the Merlequin

Recommended

# Mantle to Merlequin Breeding

	<b>m</b>
<b>M</b>	<b>Mm</b> <b>Merle</b>

# **Mantle to Merlequin Breeding**

Average results of this mating are:

**100% Merle**

# Merle to Merle Breeding

Both parents are not carrying any undesirable color genes

(Merle:  $a^y a^y$  BB DD ee hh KK Mm  $s^i s^i$ )

Segregating gene is M in both parents

Gametes (eggs & sperm) are M, m

**PROCEED with caution due to White progeny**

# Merle to Merle Breeding

	M	m
M	MM White	Mm Merle
m	Mm Merle	mm Mantle

# Merle to Merle Breeding

Average results of this mating are:

**50% Merle**

**25% Mantle**

**25% White**



# Merle to Black Breeding

Both parents are not carrying any undesirable color genes  
(Merle:  $a^y a^y$  BB DD ee hh KK Mm  $s^i s^i$ ) (Black:  $a^y a^y$  BB DD ee hh KK mm SS)

Segregating genes are M, S

Gametes (eggs & sperm) are  $Ms^i$ ,  $ms^i$  from the Merle and mS from the Black

**RECOMMENDED WITH TESTING**

# Merle to Black Breeding

	$Ms^i$	$ms^i$
$mS$	$MmSs^i$ Merle	$mmSs^i$ Black

# Merle to Black Breeding

Average results of this mating are:

**50% Black** (with or without White on toes and chest)

**50% Merle** (Solid with or without White on toes and chest)

# The “English” Breeding

Anne Bodey, who worked for Margaret Everton in the 1980's had a Blue bitch which to everyone's surprise carried for the harlequin gene. Anne and Margaret had an intact Merle male of Impton breeding back boarding at Chalet Impney.

Yes you guessed it Anne's Blue bitch had a tryst with the Merle male. One of the resulting puppies was a Harlequin male.

This lead me to collect all the breeding records across the UK and Ireland from Harlequin/Black/Mantle and Merles. This resulted in my first peer reviewed research paper on the inheritance of Harlequin in the Great Dane

# Merle to Blue Breeding

Both parents are not carrying any undesirable color genes

(Merle:  $a^y a^y$  BB DD ee hh KK Mm  $s^i s^i$ ) (Blue:  $a^y a^y$  BB dd ee Hh KK mm SS)

Segregating genes are D, H, M, S

Gametes (eggs & sperm) are DhMs<sup>i</sup>, Dhms<sup>i</sup> from the Merle and dHmS, dhmS from the Blue

**RECOMMENDED WITH TESTING**

# Merle to Blue Breeding

	DhMs <sup>i</sup>	Dhms <sup>i</sup>
dHmS	DdHhMmSs <sup>i</sup> Harlequin	DdHhmmSs <sup>i</sup> Black
dhmS	DdhhMmSs <sup>i</sup> Merle	DdhhmmSs <sup>i</sup> Black

# Merle to Blue Breeding

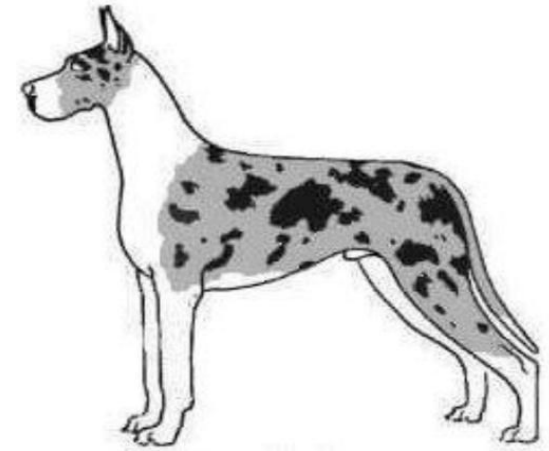
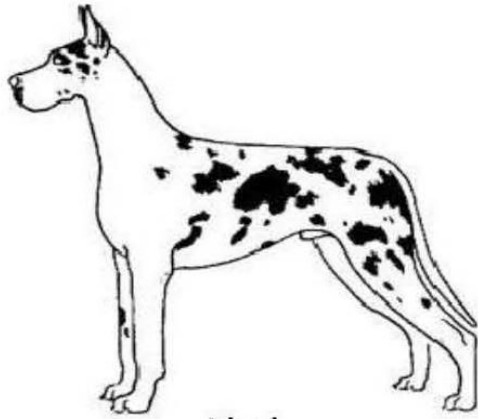
Average results of this mating are:

**50% Black** (with or without White on toes and chest)

**25% Merle** (Solid with or without White on toes and chest)

**25% Harlequin** (With markings on the neck, legs, and chest)

# Harlequins cannot be Bred without the Merle





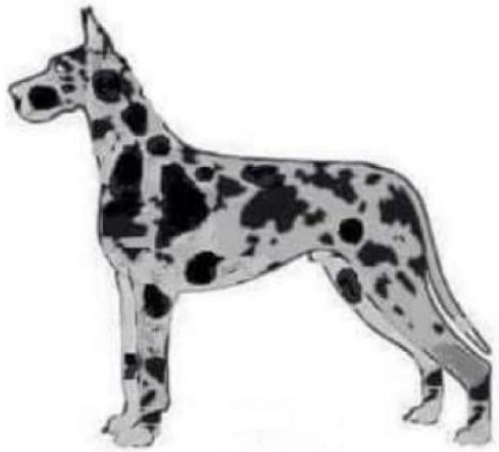
# Without the Merle we have no Harlequin.

Harlequins:

**are** modified Merles, where the harlequin gene acts to turn the dilute gray on merle to white on a harlequin.

Usually Harlequins and Merles will have the Mantle coloring, because they ideally should have been fixed for the so called Irish spotting allele  $s^i$ , however we know the Spotting gene is segregating for  $S$  = solid,  $s^i$  = mantle (Irish spotting), and  $s^p$  = piebald in Great Dane.

# Thank You



## Questions?

