

COAT COLOUR VARIATIONS AND POSSIBLE HYBRIDISATION OF GOLDEN JACKALS (*CANIS AUREUS*) IN HUNGARY

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3RD JACKAL SYMPOSIUM
GÖDÖLLŐ, 2022.11.04.

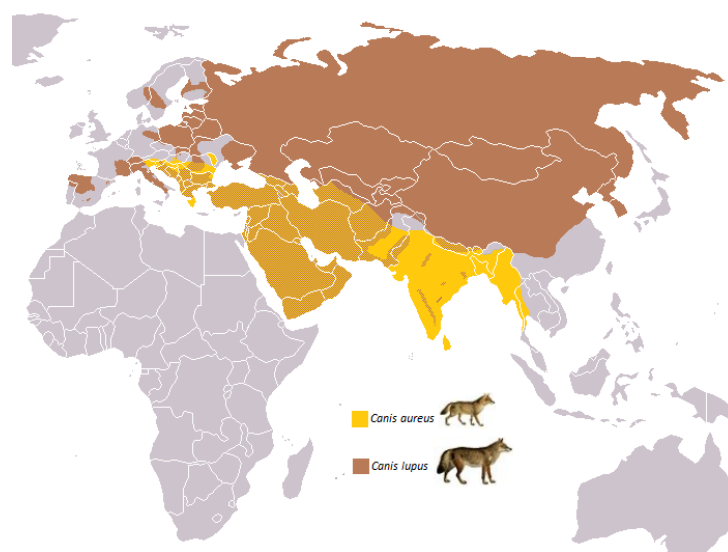
I. INTRODUCTION

- Close relatives of dogs, wolves and coyotes
- Common ancestry
- Introgression
- Share habitat with dogs and wolves



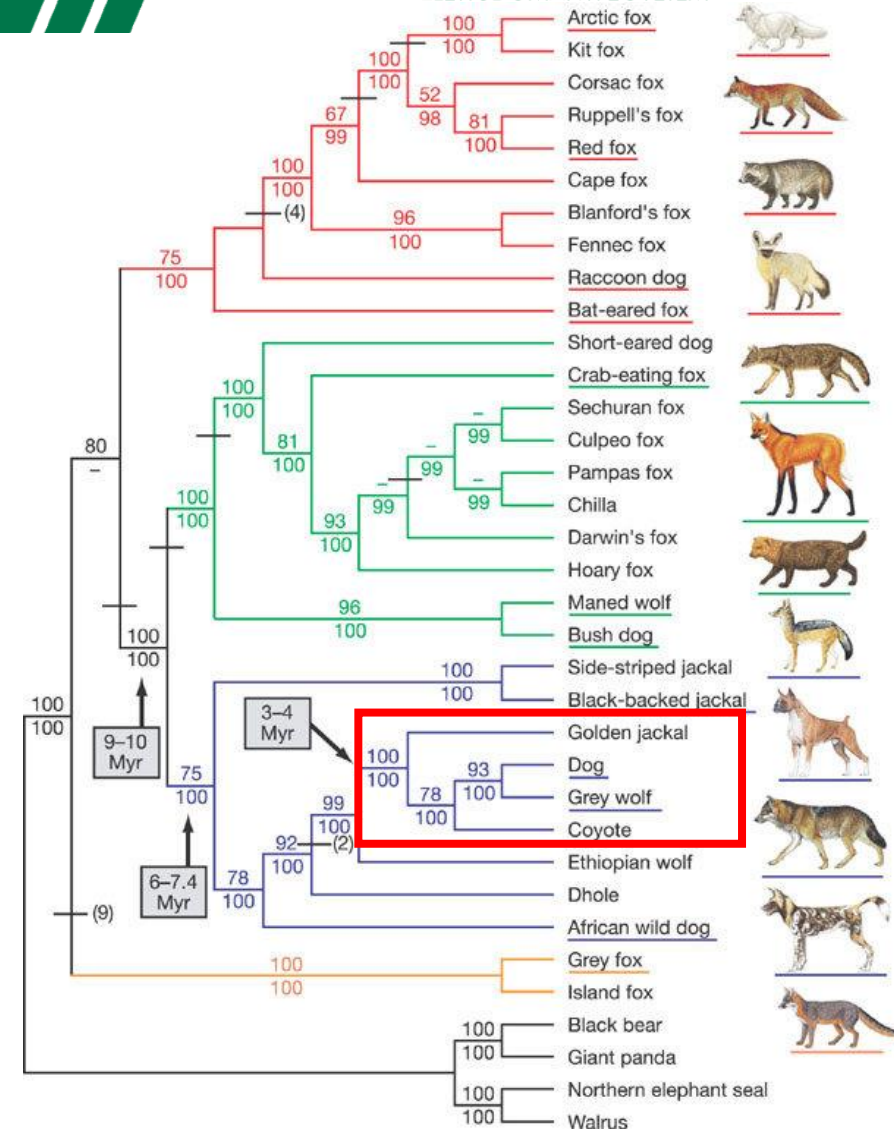
Golden Jackal

Source: The Wildlife Society ©Zweer de Bruin



Golden Jackal and wolf distribution

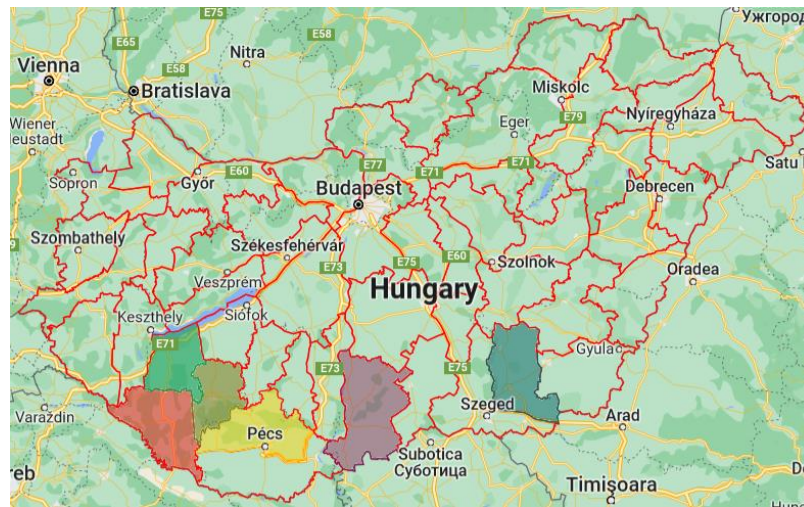
Source: Dogs, jackals, and foxes: a monograph of the Canidae



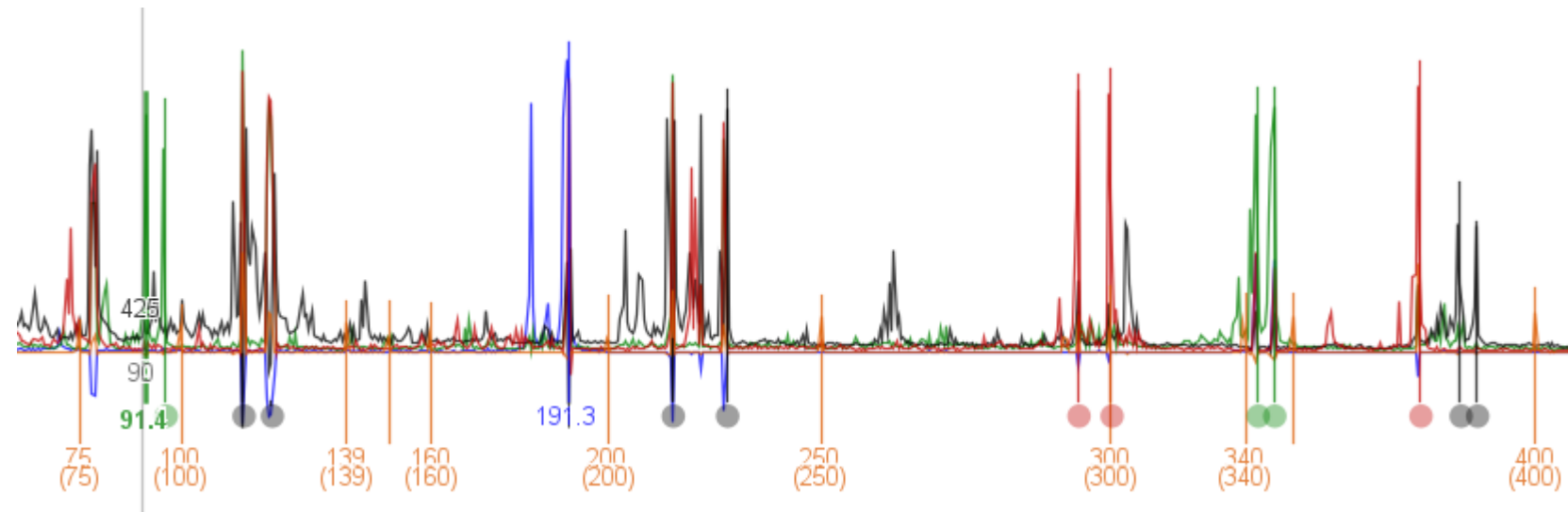
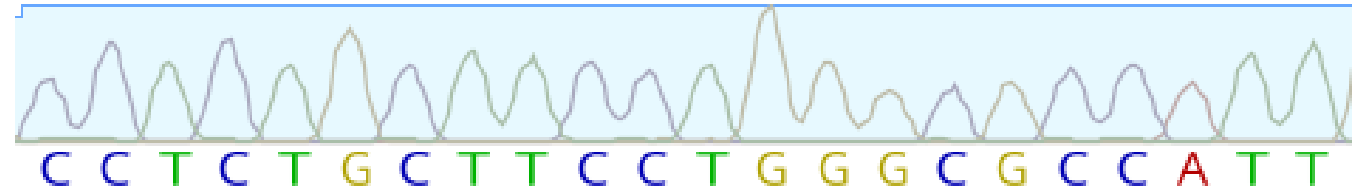
Genome sequence, comparative analysis and haplotype structure of the domestic dog, Lindblad-Toh, 2005

II. SAMPLES

- Southern Hungary
- 5 white
- 2 black
- 1 mottled
- 22 agouti



- DNA isolation from tissue samples
- Colour genetics:
 - Sanger-sequencing
 - Fragment analyses
- Hybridization studies:
 - Microsatellite analyses, 20 markers
 - Mitochondrial D-loop sequencing
- Geneious Prime
- STRUCTURE
- GenAEx
- BLAST



IV. CANDIDATE GENES – WHITE

- MC1R – melanocortin-1 receptor
- „E-locus”
- Eumelanin (black pigment) - Pheomelanin (red pigment) switch
- Effect on mammals’ fur colour

Results of MC1R mutations:

- Red hair in humans
- Chestnut/sorrel horse
- Kermode bear
- Amber/russet/copal cat
- Red racoon dog
- Cream colored fur seal



V. MC1R MUTATIONS IN CANINES

In dogs:

- 5 phenotype:
- masked c.790A>G
- White causing mutations:
 - e1: c.916C>T (p.Arg306Ter)
 - e2: Chr5:63695679C>G, ACD
 - e3: c.816_817delCT, Husky
- grizzle, dominos, Cocker-sable

Coyote, wolf:

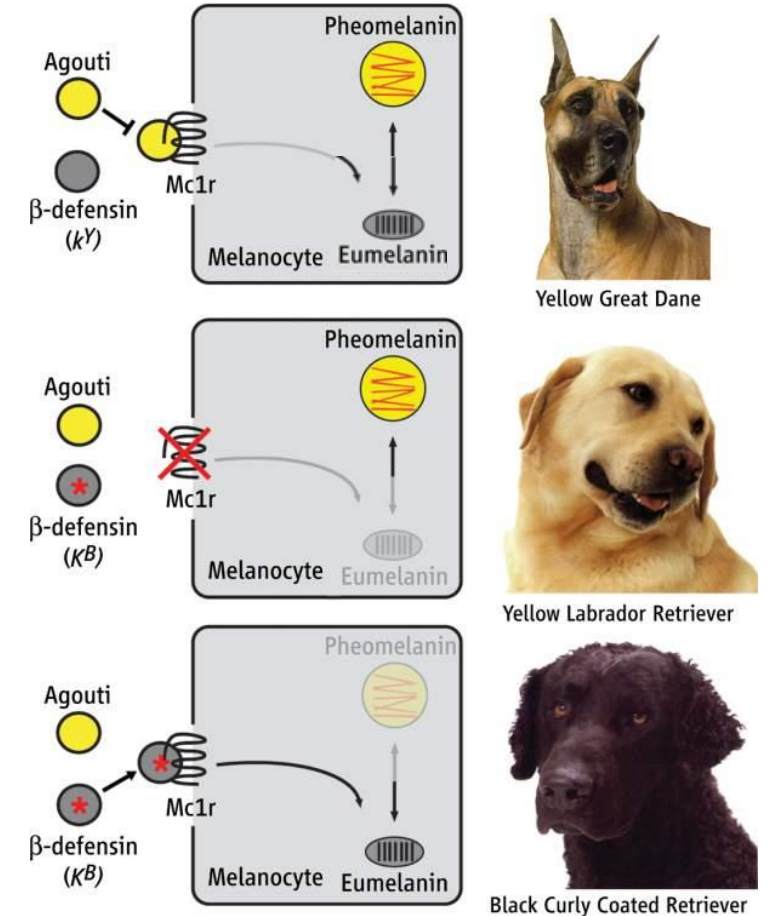
e1: c.916C>T (p.Arg306Ter)



White coyote,
Source: Salmonier National Park



Colour range of MC1R white mutation



A β -Defensin Mutation Causes Black Coat Color in Domestic Dogs
By Sophie I. Candille, Christopher B. Kaelin, Bruce M. Cattanach, Bin Yu, Darren A. Thompson, Matthew A. Nix, Julie A. Kerns, Sheila M. Schmutz, Glenn L. Millhauser, Gregory S. Barsh

VI. CANDIDATE GENE - BLACK

- Canine Beta-defensine, CBD103
- „K-locus”
- A 3 basepair deletion ($\Delta G23$)
- Eumelanistic colouration: only black pigment
- Known in wolves, coyotes, hybrid golden jackals (Galov et al. 2015)



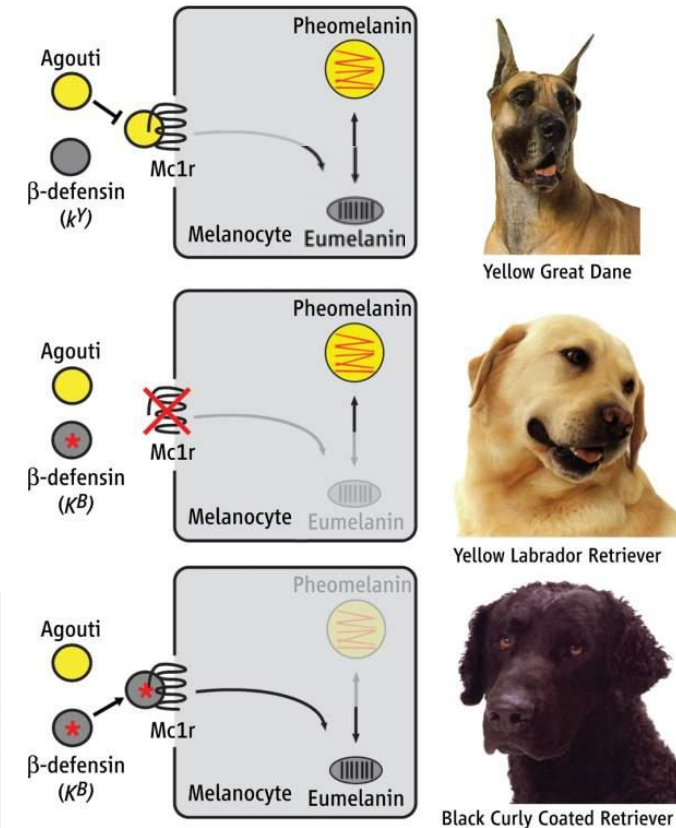
Melanistic wolf
Source: Andy Skillen



Black coyote
Source: Atlanta Coyote Project



Black jackal-dog hybrid
Source: Galov et al (2015): First evidence of hybridization between golden jackal (*Canis aureus*) and domestic dog (*Canis familiaris*) as revealed by genetic markers

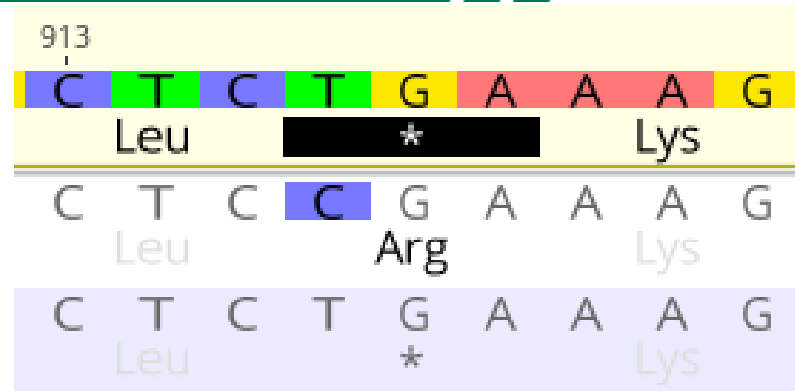


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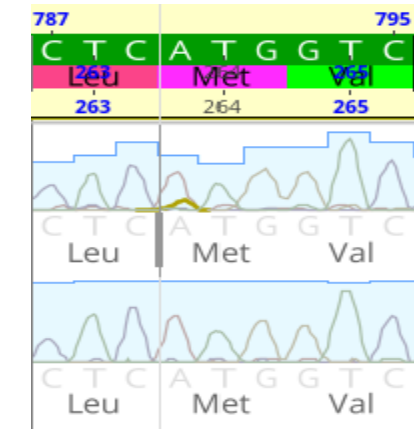
VII. COLOUR RESULTS – MC1R

MC1R:

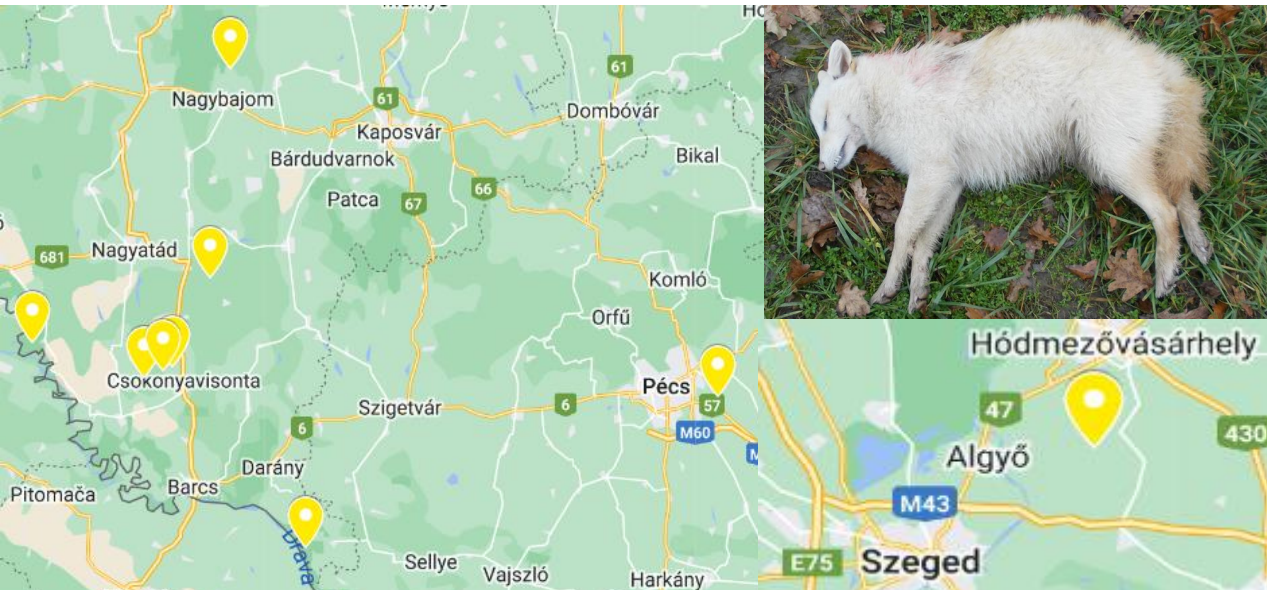
- All white samples are homozygous for c.916C>T
- 1 black, 2 agouti animals are heterozygous
- Mottled animal is heterozygous for c.790A>G
- Jackal-specific SNP at c.475C>T, P205S
- White-specific SNP at c.476C>A



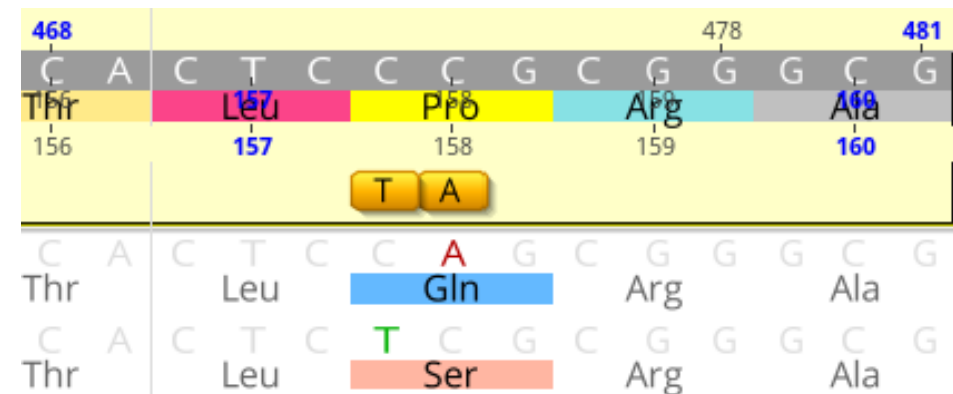
The terminating mutation at c.916



Heterozygosity at c.790



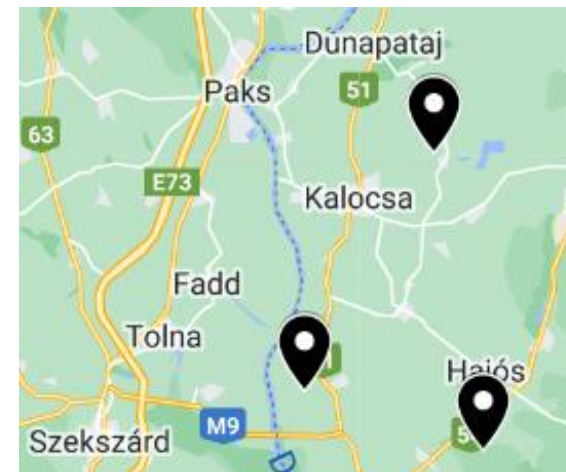
The origins of white and white carrier samples



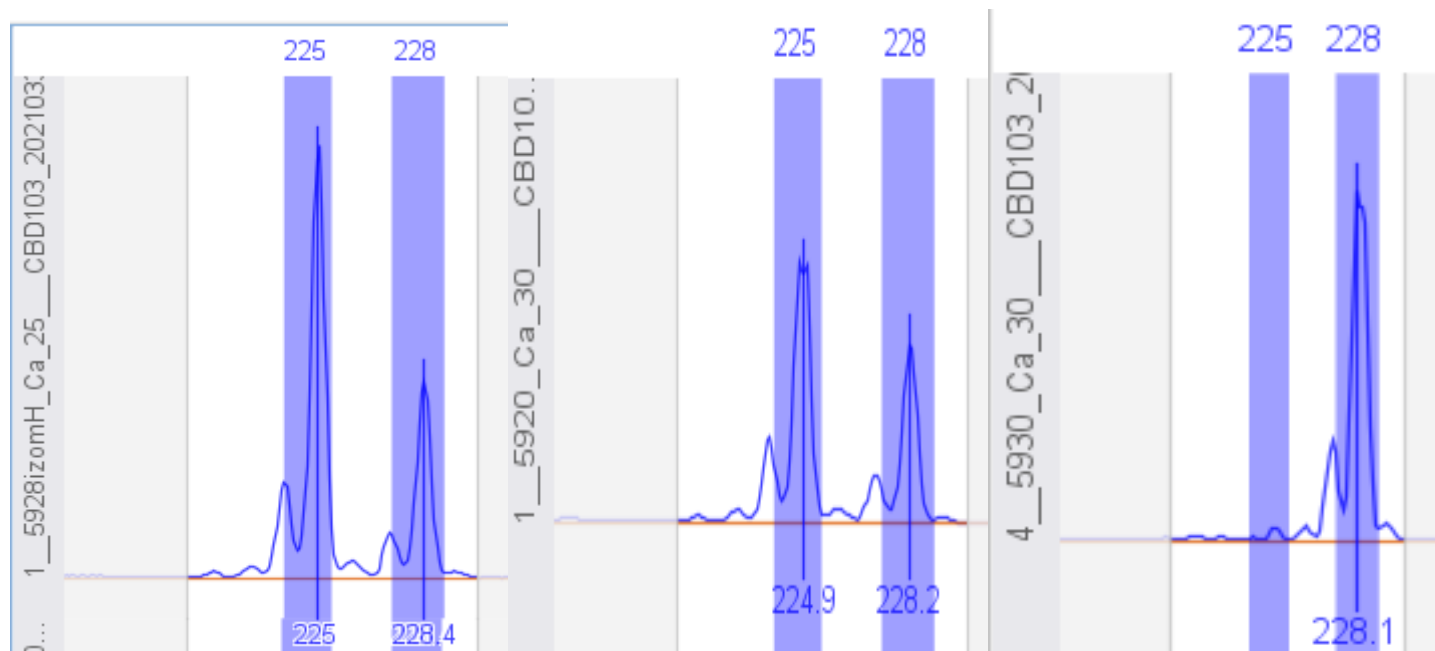
SNPs at c.475-476

VIII. COLOUR RESULTS – CBD103

- Dominant quality
- Fragment analysis
- Black animals are heterozygous for CBD103 Δ G23



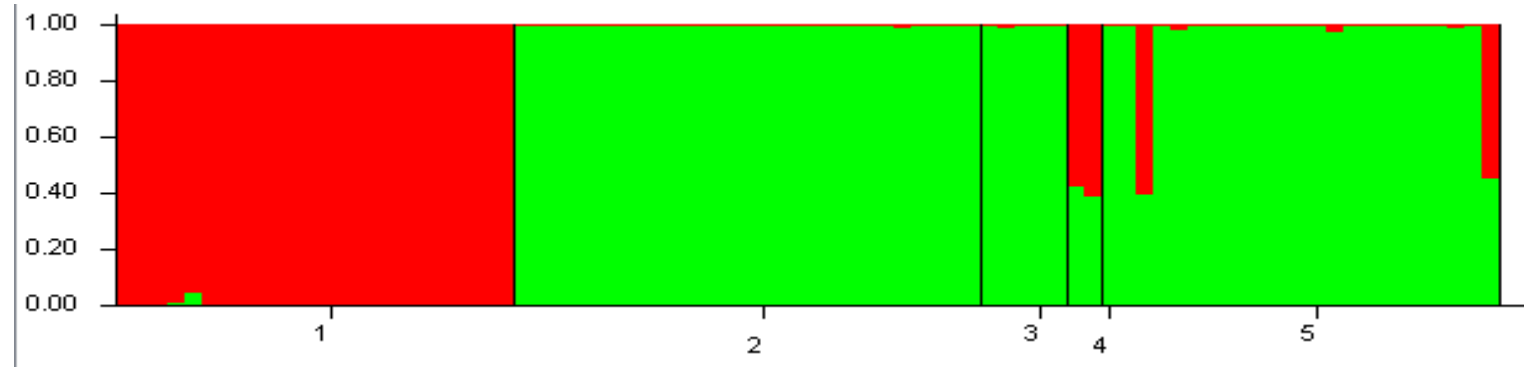
Origins of the black and mottled animals



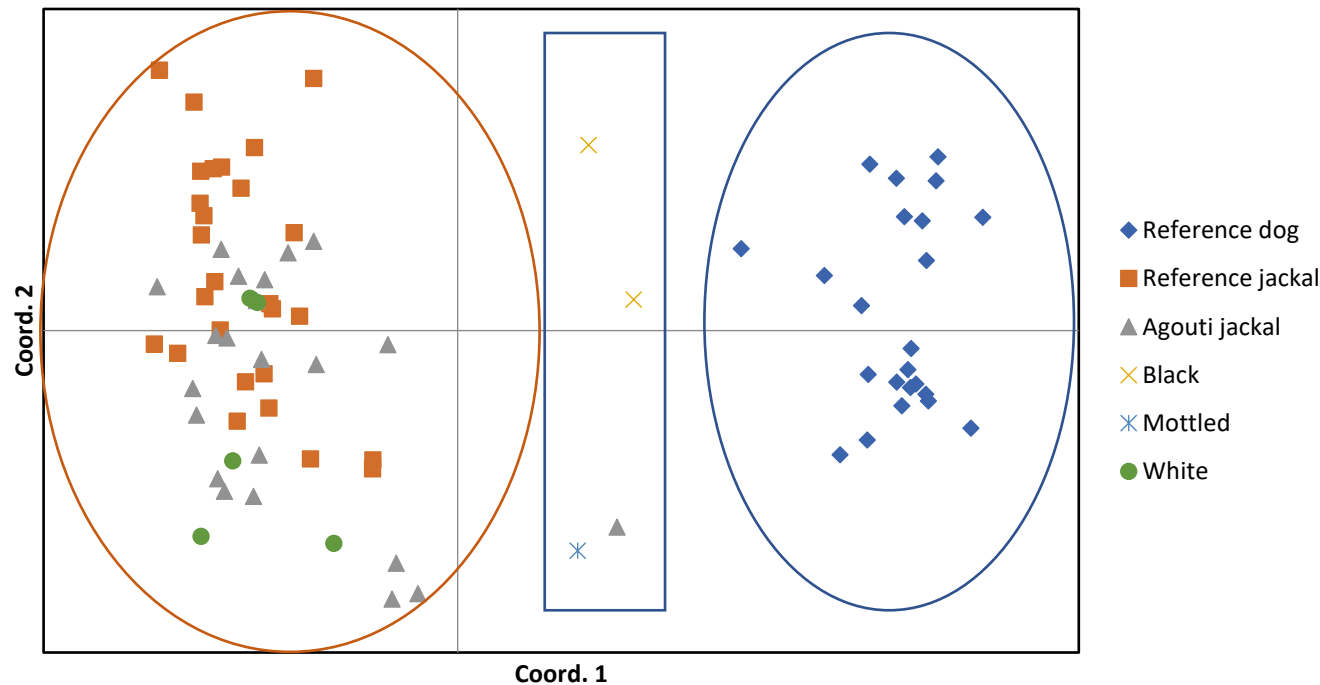
CBD103 results of 2 black and a mottled animal

IX. HYBRIDIZATION ANALYSES

- Microsatellite analysis, 20 markers
- 4 hybrids: black, mottled, agouti



Principal Coordinates (PCoA)



- 1 – reference dogs, n=23
- 2 – reference jackals, n=27
- 3 – white jackals, n=5
- 4 – black jackals, n=2
- 5 – agouti jackals, n=22
- 6 – mottled, n=1

X. HYBRIDIZATION ANALYSES

- Mitochondrial D-loop
- 1 black has dog maternity

Canis lupus familiaris mitochondrial partial D-loop, isolate Canada_Sort

Sequence ID: [LR742845.1](#) Length: 16132 Number of Matches: 1

Range 1: 15500 to 15943 [GenBank](#) [Graphics](#)

[▼ Next Match](#) [▲ Pre](#)

Score	Expect	Identities	Gaps	Strand
817 bits(442)	0.0	443/444(99%)	0/444(0%)	Plus/Plus
Query 1	TATGTCAGTATCTCCAGGTA AACCTTCTCCCTCCCTATGTACGTCGTG CATTAAATGG	60		
Sbjct 15500	TATGTCAGTATCTCCAGGTA AACCTTCTCCCTCCCTATGTACGTCGTG CATTAAATGG	15559		
Query 61	TTTGCCCCATGCATATAAGCATGTACATAATATTATATCCTTACATAGGACATATTA ACT	120		
Sbjct 15560	TTTGCCCCATGCATATAAGCATGTACATAATATTATATCCTTACATAGGACATATTA ACT	15619		
Query 121	CAATCTCATAATTCACCTGATCTTCAACAGTAATCGAATGCATATCACTTAGTCCAATAA	180		
Sbjct 15620	CAATCTCATAATTCACCTGATCTTCAACAGTAATCGAATGCATATCACTTAGTCCAATAA	15679		
Query 181	GGGCTTAATCACCATGCCTCGAGAAACCATCAACCCTTGCTCGTAATGTCCTCTTCTCG	240		
Sbjct 15680	GGGCTTAATCACCATGCCTCGAGAAACCATCAACCCTTGCTCGTAATGTCCTCTTCTCG	15739		
Query 241	CTCCGGGCCATACTAACGTGGGGTTACTATCATGAAACTATACCTGGCATCTGGTTCT	300		
Sbjct 15740	CTCCGGGCCATACTAACGTGGGGTTACTATCATGAAACTATACCTGGCATCTGGTTCT	15799		
Query 301	TACTTCAGGGCCATAACTTTATTTACTCCAATCCTACTAATTCTCGAAATGGGACATCT	360		
Sbjct 15800	TACTTCAGGGCCATAACTTTATTTACTCCAATCCTACTAATTCTCGAAATGGGACATCT	15859		
Query 361	CGATGGACTAATGACTAATCAGCCCATGATCACACATAACTGTGGTGCATSCATCTGGT	420		
Sbjct 15860	CGATGGACTAATGACTAATCAGCCCATGATCACACATAACTGTGGTGCATSCATCTGGT	15919		
Query 421	ATCTTTTAATTTTAAggggggAA 444			
Sbjct 15920	ATCTTTTAATTTTAGGGGGGAA 15943			

Job Title: 5928_Dloop

RID: [NRJT8X9Z013](#) Search expires on 10-29 20:29 pm [Download All](#) ▼

Program: BLASTN [?](#) [Citation](#) ▼

Database: nt [See details](#) ▼

Query ID: lcl|Query_7533

Description: Contig_1

Molecule type: dna

Query Length: 444

Other reports: [Distance tree of results](#) [MSA viewer](#) [?](#)

Filter Results

Organism *only top 20 will appear* exclude

Type common name, binomial, taxid or group name

[+ Add organism](#)

Percent Identity: to

E value: to

Query Coverage: to

[Filter](#) [Reset](#)

Descriptions | Graphic Summary | Alignments | Taxonomy

Sequences producing significant alignments [Download](#) ▼ [Select columns](#) ▼ Show 100 ▼ [?](#)

select all 100 sequences selected [GenBank](#) [Graphics](#) [Distance tree of results](#) [MSA Viewer](#)

Description	Scientific Name	Max Score	Total Score	Query Cover	E value	Per Ident	Acc. Len	Accession
<input checked="" type="checkbox"/> Canis lupus familiaris mitochondrial partial D-loop, isolate Canada_Sort	Canis lupus famil...	817	817	100%	0.0	99.77%	16132	LR742845.1
<input checked="" type="checkbox"/> Canis lupus familiaris mitochondrial partial D-loop, isolate TRF.02.19_NorthGL_Historical_complete mitochondri...	Canis lupus famil...	817	817	100%	0.0	99.77%	16116	LR742834.1
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<input checked="" type="checkbox"/> Canis lupus familiaris mitochondrial partial D-loop, isolate TRF.01.49_East_GL_AD1885	Canis lupus famil...	817	817	100%	0.0	99.77%	16124	LR742827.1

- 1 sibling pair in whites 99,19%

XI. CONCLUSIONS

- White animals are homozygous for MC1R c.916
- Black animals are heterozygous for CBD103ΔG23
- Hybridization between jackals and dog is possible in the wild
- Genetic anomalies, diseases, behaviour



Dog-jackal hybrids in West Bengal, source: Ambar Chakraborty



THANK YOU FOR YOUR ATTENTION!