



Detection of Microsatellite Polymorphisms in Van Cats on Some Phenotype Characteristics

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Received: 25.09.2025

Accepted: 09.01.2026

ABSTRACT

Using molecular genetic markers, it is possible to determine the desired genotypes while preserving the genetics of endangered species, thereby increasing or decreasing genetic diversity in populations. The Van cat is one of the endangered species living in the Lake Van region. Microsatellite markers are commonly used to estimate genetic diversity and genetic differentiation in a population. The aim of this study was to characterize the genetic structure and determine the genetic differentiation of the protected Van cat population based on the phenotypes of eye color, coat length and three points on the head. For this purpose, 25 male and 41 female cats were selected and four microsatellite loci (FCA 176, 478, 547, 688) were selected from the whole genome of the domestic cat. Based on the results of the statistical analysis, it was found that the influence of the 4 microsatellites on gender was not significant ($p \geq 0.05$). In addition, loci FCA176, 478, 547 and 688 had no effect on eye color and distribution. Although coat length and locus FCA176 were not statistically significant, it had a value of $p=0.0534$, which is very close to the p -value of 0.05. An important result was that the association between the three-point birthmark on the head and the FCA478 marker was highly significant ($p \leq 0.05$).

Keywords: Genetic polymorphisms, Genetic resources, Microsatellite markers, Van cats.

ÖZ

Van Kedilerinde Mikrosatellit Polimorizmlerinin Bazı Fenotip Karakteristiklerinde Saptanması

Moleküler genetik belirteçler kullanılarak, nesli tükenme tehlikesi altında olan türlerin genetik yapısı korunurken istenilen genotiplerin belirlenmesi ve böylece popülasyonlarda genetik çeşitliliğin artırılması veya azaltılması mümkün olmaktadır. Van kedisi, Van Gölü havzasında yaşayan ve koruma altındaki türlerden biridir. Mikrosatellit belirteçler, bir popülasyondaki genetik çeşitliliği ve genetik farklılaşmayı tahmin etmek amacıyla yaygın olarak kullanılmaktadır. Bu çalışmanın amacı, Van kedisi koruma popülasyonunun genetik yapısını karakterize etmek ve göz rengi, tüy uzunluğu ve baş üzerinde bulunan üçlü benek fenotiplerine dayalı olarak genetik farklılaşmayı belirlemektir. Bu amaçla, 25 erkek ve 41 dişi kedi seçilmiş olup evcil kedinin tüm genomunda yer alan dört mikrosatellit lokusu (FCA176, 478, 547, 688) incelenmiştir. İstatistiksel analiz sonuçlarına göre, dört mikrosatellitin cinsiyet üzerine etkisi önemsiz bulunmuştur ($p \geq 0.05$). Ayrıca FCA176, 478, 547 ve 688 lokuslarının göz rengi ve dağılımı üzerinde herhangi bir etkisinin olmadığı belirlenmiştir. Tüy uzunluğu ile FCA176 lokusu arasındaki ilişki istatistiksel olarak anlamlı bulunmamış olmakla birlikte $p=0.0534$ değeri, 0.05 anlamlılık düzeyine oldukça yakın çıkmıştır. Çalışmanın önemli bir sonucu ise baş üzerinde bulunan üçlü benek ile FCA478 belirteci arasındaki ilişkinin yüksek derecede anlamlı olarak bulunmuştur ($p \leq 0.05$).

Anahtar Kelimeler: Genetik kaynaklar, Genetik polimorfizm, Mikrosatellit belirteçler, Van kedileri.



INTRODUCTION

Due to its geographical location, the Lake Van basin is home to some region-specific animal species such as the Pearl Mullet, the Karakaş, and the Norduz sheep and goats. Like other animals native to the Lake Van region in eastern Türkiye, the Van cats, which belong to the Felidae family, are among the characteristic breeds found in the Lake Van region at an altitude of 1726 meters with the coordinates 38.6140° N, 42.9182° E (Vigliotti et al. 2014).

In addition, the name of this appealing breed of cat comes from Van, the city in eastern Türkiye, and Lake Van, the largest soda lake in the world, which surrounds it. Van cats are also well adapted and have evolved naturally in certain regions of southwest Asia, such as the western parts of Armenia, Azerbaijan, Georgia and Iran. Furthermore, the characteristic phenotypes of Van cats include a heterochromatic eye color, a silky white coat color and a birthmark on the head between the two ears, which is characterized by three black dots (a three-point birthmark). This birthmark on the head often disappears in the first 6–8 months after birth. Besides, several positive behaviors are not observed in other cat breeds, including a strong emotional bond with humans, a dog-like loyalty to people, and a preference for swimming and playing with water (Odabaşoğlu and Ateş 2000).

As already mentioned, the most remarkable phenotypic characteristic of Van cats is their different eye color, known as heterochromia. Heterochromia is a change in the color and structure of the iris that can be congenital. The color change can affect one eye alone or both eyes and can be partial, segmental, or complete. Heterochromia is caused by the absence of melanin in the whole eye or in part of the eye (Olson et al. 1989; Cargill et al. 2003; Bergstrom et al. 2014; Guha et Matiy 2014; Deane-Coe et al. 2018; Moscatelli et al. 2020).

Although the heterochromatic eyes in Van cats have three different phenotypic structures; both blue, both amber, or one eye blue and the other amber, the blue-amber colors are not constant in the right-left direction.

Various molecular genetic methods and gene markers are used in the study of living organisms at the genome level, in molecular identification and in the detection of genetic variation. The development of DNA-based genetic markers has revolutionized genome research for more than three decades. In addition, different gene markers have been used together with the polymerase chain reaction (PCR), particularly in the mapping of plant, animal and human genes and in molecular genetic studies. These include RFLP (Restriction Fragment Length Polymorphism), RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphism), SSLP (Single-Strand Length Polymorphism), Simple Sequence Repeats (SSRs) or microsatellites and SNP (Single Nucleotide Polymorphisms) (Weber and May 1989; Koyun et al. 2021).

Microsatellites are present in both prokaryotic and eukaryotic genomes. These are commonly referred to as simple sequence repeats (SSRs), short tandem repeats (STRs) and simple sequence length polymorphisms (SSLPs). There are approximately 100 microsatellites per locus, each of which has a length of 1–6 bp. Microsatellite repeat elements are usually present in the form of double, triple, and quaternary nucleotide sequences. In the mammalian (especially human) genome, microsatellite sequences CA and TG are the most abundant. Moreover, microsatellite loci are very widely distributed and

abundant in the in the genomes of living organisms (Vaiman et al. 1994; Velmala et al. 1994). Furthermore, microsatellite polymorphism is defined as repeated base sequence motifs that differ in number from one living genome to another. Polymorphism information coefficients (PIC) are high, averaging 60% (Koncagül et al. 2024). They are very useful for the study of genetic differences within a population and between populations because they are highly variable, have a high mutation rate, occur in large numbers and are distributed throughout the genome, are passed on co-dominantly, and are not affected by selection. They also allow easy and inexpensive genotyping of individuals studied in the laboratory using the PCR technique. Therefore, microsatellites are widely recognized as highly informative genetic markers for the analysis of phylogenetic trees, population structures, genomic variation, evolutionary processes and fingerprints (Eizirik et al. 2003).

Microsatellite gene markers are also widely used in the genome of domestic cats (*Felis catus*) worldwide, for genetic variation, genetic distance, parental identification, and determination of disease QTLs (İmes et al. 2006; Haeringen et al. 2007; Lipinski et al. 2007; Ur Rehman 2008).

The number and density of melanin pigments in the anterior part of the iris determine eye color in mammals. If there is too much melanin, brown eyes develop. There is a difference in color between the two irides, called heterochromia or heterochromia iridum. The entire iris may be affected, or only part of the iris may be affected (sectoral heterochromia). The condition of heterochromia, which refers to a cat with two different colored eyes, is usually inherited. In most cases, heterochromia is harmless to the cat and does not affect its vision. Furthermore, one eye of an odd-eyed cat is blue, while the other eye is either green, yellow, amber or brown. Cats also are prone to having complete heterochromia, which occurs in some other animals, including humans. Sectoral (partial) heterochromia occurs when two different colors coexist in the same iris. White cats are most likely to be affected by this condition, but so are cats of any other color. (Geigy et al. 2007; Hartwell 2017; Chomdej 2018; Nganyongpanit 2018; Lui and Stokkermans 2023).

Cats with odd-eyed coloration have either the dominant white gene, which masks all other color genes, or the recessive white gene. The white-spotted gene not only causes a bicolored coat but also prevents the production of melanin. The result is a cat with one blue eye and one green, yellow, amber or brown eye. About 15 to 40% of solid white cats have one or two blue eyes (Geigy et al. 2007). Moreover, interestingly, a three-point birthmark on the head, which appears after birth and gradually disappears later in life, has been identified as a phenotypic trait in Van cats (Odabaşoğlu and Ateş 2000).

For almost 20 years, Van cats have been protected and cared for at the Van Cat Shelter of Van Yuzuncu Yil University, taking into account management, nutrition, reproduction, health and welfare. The Van cat has long been threatened with extinction because its genotype has deteriorated or been lost due to uncontrolled breeding by its owners and animal smuggling. Although it has no great economic value, the survival of these animals is very important for the preservation of native genetic resources. However, for the continuation of the Van cat lineage, it is very important to establish pedigrees to determine the associations between (or among) genetic markers and phenotypic characteristics of the Van cat breed, such as

eye color, coat color, and a three-point birthmark on the head along with their behavioral characteristics.

The purpose of this study is to initially determine microsatellite polymorphisms in Van cats and whether there is a genetic relationship between microsatellite markers and some phenotypic traits of eye color, coat texture, and a three-point birthmark on the head.

MATERIAL AND METHODS

This study was conducted with the approval document of the Local Ethics Committee for Animal Experiments of Van Yuzuncu Yil University (YÜHADYEK) dated 09.02.2009 with the number B.30.2.YYÜ.0.0506.00/300-0053. Thus, no invasive procedures were performed on the animals and no animal experiments were performed according to the legal definitions in Europe (Subject 5f of Article 1, Chapter I of Directive 2010/63/eu of the European Parliament and of the Council). Furthermore, we declare that animal welfare and safety were priorities in this study and that the Helsinki principles and protocol were carefully followed.

Animal Supply and Phenotype Records and Measurement

66 experimental animals were selected from the Van Yuzuncu Yil University cat house by selecting and

recording the mother and kittens (25 males and 41 females) of different ages for the study. The quantitative data set was created based on phenotypic data of cats according to their eye color structure and coat appearance. The phenotypic characteristics in the dataset were sex, age, eye color right-left, coat length (long-short), and a three-dot birthmark on the head (present-absent).

DNA Isolation, and Oligo-Selection

Feline genomic DNA was extracted from individual samples by buccal cell collection using the Buccal Amp DNA Extraction Kit (<http://www.epibio.com/docs/default-source/protocols/buccalamp-dna-extraction-kit-quickextract>). Oral epithelial cells were collected with a brush from the cheeks and tongues of cats. The collected brushes were soaked in a special solution of the kit, vortexed for 10 sec and incubated at 65°C for 1 min. The samples were incubated at 98°C for 2 min after vortexing for 15 sec. Finally, the purified genomic DNA was stored at -20°C after vortexing for 15 sec.

Considering oligos, microsatellite loci with high PIC coefficients from 4 different cat chromosomes were identified by accessing the cat GenBank (access: <http://www.ncbi.nlm.nih.gov/genome/guide/feliscatus/index.html>) and based on (Monetti-Raymond et al. 1999) Table 1 and 2).

Table 1: Information on cat microsatellites and PCR conditions.

Micro satellites	Chromosomes	Forward Primer	Reverse Primer	TM F/R
FCA547	C2	TGGTCATACAGGTGACAAAACA	CTGACAGTATGGAGCCTGCA	58.9/60.0
FCA176	A1	GGAAACTTGGAAAGCAAAACC	TCCACAGTTGGAGTTCTTAAGG	60.0/58.4
FCA478	X	TATATGTATGTGCCGCTGTACC	GATCGTGGTTTTTTGACACTTG	58.5/59.5
FCA688	A3	GTCAGGCTTTGTGCTGACAA	TACAGATCTGCACAAGAATCCC	60.0/59.2

Table 2: Four different microsatellite loci chosen from the genome of the domestic cat (*Felis catus*), along with the heterozygosity coefficient and PCR yields.

Microsatellites	Locus	Heterozygosity (%)	PCR yield (base pair; bp)
FCA176	A1	0.97	215-251 bp
FCA478	X	0.85	194-218 bp
FCA547	C2	0.81	237-251 bp
FCA688	A3	0.85	288-320 bp

PCR Conditions and Visualization of PCR Products

The best PCR conditions were found for each locus, focusing on the amount of MgCl₂ and the hybridization temperature. The following PCR mixing solutions and concentrations were used, as shown in Table 3.

1X TBE, a buffer solution containing Tris base, boric acid, and EDTA, was used for electrophoresis of PCR products. Agarose gels prepared at different concentrations were treated with ethidium bromide (EtBr) to visualize the PCR bands under UV light (Sambrook et al. 1989).

Allele Counting and Heterozygosity (H) and Polymorphism Information Coefficient (PIC) Calculation

Allelic variants of the microsatellites were determined and counted on agarose gels of different concentrations, and heterozygosity (H) and polymorphism information coefficient (PIC) were calculated using the formulas shown below (Ott 1992).

Table 3: PCR master mix and concentrations.

PCR master mix	µl
dH ₂ O	15.18
10X buffer	2.5
MgCl ₂	1.5
DMSO	0.32
dNTPs	0.5
Primer F	1.5
Primer R	1.5
Taq Polimerase	0.14
DNA	2.0
Total	25

For heterozygosity (H);

$$H = 1 - (\sum p_i^2) \quad (1)$$

p_i : frequency of an allele of the gene

For the polymorphism information coefficient (PIC);

$$PIC = 1 - (\sum p_i^2) - \sum p_i^2 p_j^2 \quad (2)$$

p_i : the frequency of an allele of a gene

p_j : other allele frequencies of the gene

Statistical Analysis

Statistical relationships between genetic markers and phenotypic traits were determined with the Proc Glimmix procedure in SAS software using the statistical software package (SAS 2023).

$$Y_{ijkl} = Sex_i + \sum_{j=1}^4 \sum_{k=1}^3 marker_{jk} + e_{ijkl}$$

where,

Y_{ijkl} = eye color, head birthmark or coat structure

Sex_i = effect of i^{th} sex (male or female)

$\sum_{j=1}^4 \sum_{k=1}^3 marker_{jk}$ = effect of k^{th} genotype of j^{th} locus (FCA176, FCA478, FCA547, FCA688)

e_{ijkl} = random residual

RESULTS

The distribution and frequency of eye color observed in cats are shown in Figure 1. Accordingly, the frequencies of cats with eye color BB and cats with eye color BA were the highest and equal (0.30). The frequency of cats with eye color AA was 0.23, while cats with eye color AB had the lowest frequency (0.17).

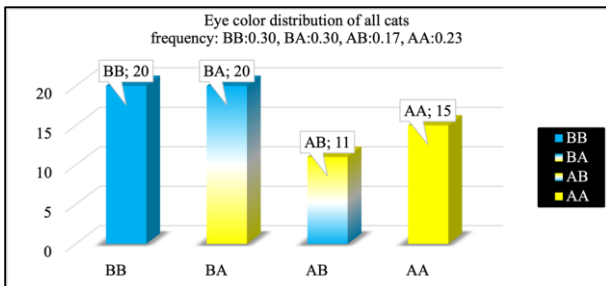


Figure 1: Distribution and frequency of all cats according to eye color and position. (AA; both eyes in amber color, BB; both eyes in blue color, AB; right amber-left blue, BA; right blue-left amber).

In Figure 3, male cats with BA eye color and position had the highest frequency (0.32), while male cats with AB and BB eye color and position had the lowest frequency (0.20).

The highest frequency of female cats with BB eye color and position was 0.37, while the lowest frequency was 0.15, as shown in Figure 4.

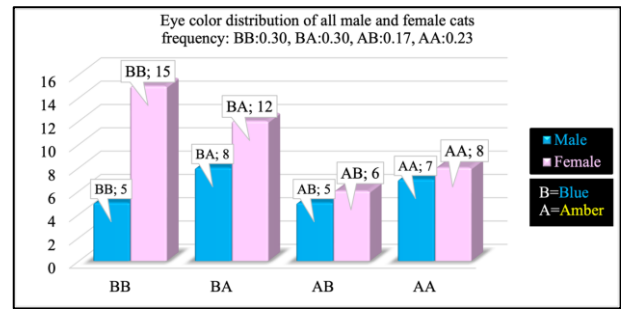


Figure 2: Distribution and frequency of all male and female cats according to eye color and position. (AA; both eyes in amber color, BB; both eyes in blue color, AB; right amber-left blue, BA; right blue-left amber).

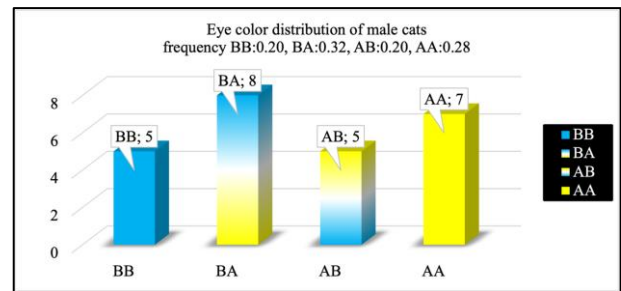


Figure 3: Distribution and frequencies of male cats according to eye color and location. (AA; both eyes in amber color, BB; both eyes in blue color, AB; right amber-left blue, BA; right blue-left amber).

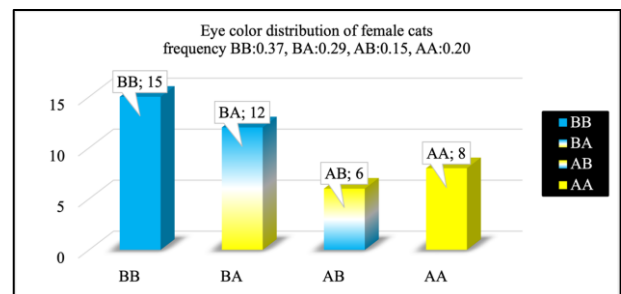


Figure 4: Distribution and frequencies of female cats according to eye color and location. (AA; both eyes in amber color, BB; both eyes in blue color, AB; right amber-left blue, BA; right blue-left amber).

PCR Results

The four cat microsatellite loci for which PCR conditions were set as a gradient (Tables 1 and 2) were observed at 56-59 °C, and the microsatellite loci of interest were amplified by PCR (at 57 °C) (Figures 5-8). Each observed individual was genotyped for four loci, and the genotype data were determined. In Table 4, the genotypic data observed for each locus were analyzed categorically (binomially). They were coded as 0(1/1), 1(1/2), 2(2/2), and their frequencies were calculated.



Figure 5: The PCR results for the FCA176 locus. A 4% agarose gel with a 100-bp DNA ladder (lane 1) and the elongation temperature was set to 57 °C.

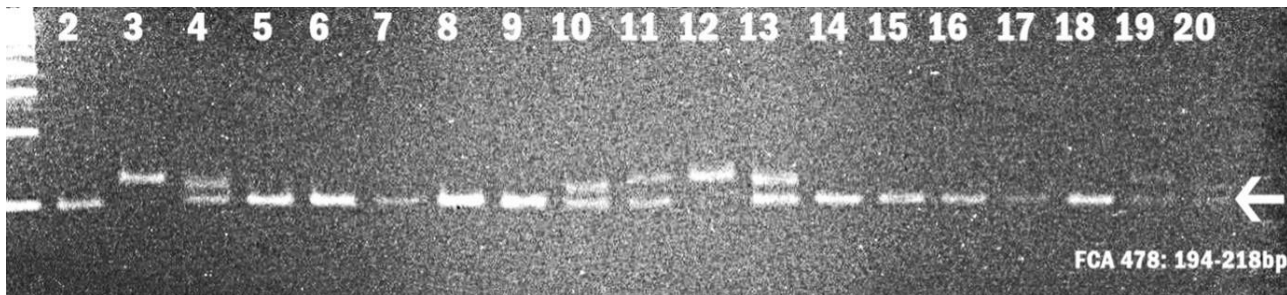


Figure 6: The PCR results for the FCA478 locus. A 4% agarose gel with a 100-bp DNA ladder (lane 1) and the elongation temperature was set to 57 °C.



Figure 7: The PCR results for the FCA547 locus. A 4% agarose gel with a 100-bp DNA ladder (lane 1) and the elongation temperature was set to 57 °C.



Figure 8: The PCR results for the FCA688 locus. A 4% agarose gel with a 100-bp DNA ladder (lane 1) and the elongation temperature was set to 57 °C.

Table 4: Observed alleles of genotyped microsatellite loci and their estimated size.

Microsatellites	Allele number	Frequency	PCR yield (bp)
FCA176	2 (0, 1)	0.51; 0.49	215-251
FCA478	3 (0, 1, 2)	0.47; 0.24; 0.29	194-218
FCA547	2 (0, 1)	0.76; 0.24	237-251
FCA688	3 (0, 1, 2)	0.13; 0.47; 0.30	288-320

According to the results of the statistical analysis, the influence of 4 microsatellites on gender was found to be insignificant ($p \geq 0.05$, Table 6-8). In addition, loci FCA176, 478, 547 and 688 had no effect on eye color and distribution. Although coat length and locus FCA176 were not statistically significant, it had a value of $p=0.0534$, which is very close to the p value of 0.05 (Table 6). An important result was that the association between the three-point birthmark on the head and the marker FCA478 was highly significant ($p \leq 0.05$, Table 8).

Table 5: Association analysis between eye color and microsatellite markers.

Effect	DF	F Value	Pr>F
Gender	1	0.46	0.5030
FCA176	1	0.17	0.6820
FCA478	2	0.32	0.7271
FCA547	1	0.68	0.4124
FCA688	2	1.20	0.3113

Table 6: Association analysis between coat length and microsatellite markers.

Effect	DF	F Value	Pr>F
Gender	1	3.03	0.0888
FCA176	1	3.93	0.0534
FCA478	2	1.17	0.3189
FCA547	1	1.87	0.1786
FCA688	2	1.57	0.2183

Table 7: Association analysis between a three-point birthmark on the head and microsatellite markers.

Effect	DF	F Value	Pr>F
Gender	1	0.26	0.6118
FCA176	1	0.98	0.3275
FCA478	2	3.38	0.0427
FCA547	1	0.01	0.9074
FCA688	2	0.08	0.9259

Table 8: Heterozygosity (H), Polymorphism Information Coefficient (PIC) of the microsatellites.

Microsatellites	H (%)	PIC (%)
FCA176	0.452	0.353
FCA478	0.431	0.341
FCA547	0.210	0.189
FCA688	0.501	0.378

Among the cats used in this study, the marker FCA547 had the lowest value (0.21) in terms of heterozygosity (%), while the microsatellite marker FCA688 had the highest value (0.501). When looking at the polymorphism information content (PIC), the marker FCA547 also showed the lowest value (0.189), while the microsatellite marker FCA688 had the highest PIC value (0.378) (Table 8).

DISCUSSION AND CONCLUSION

The research studies conducted to date on Van cats are brief; first, Şenler (1986) observed that there was no difference between the sexes in Van cats in terms of eye color, but deafness due to white coat color was noted even in small numbers. The researcher reported that the live weight of adult Van cats was 2824 g and 3568 g for females and males, respectively. Also, İnal (1992) examined the morphological characteristics of 150 Van cats. He reported that 41.35% of the Van cats were shorthair cats and 58.65% were longhair cats. The researcher reported the distribution of eye color in Van cats in terms of both eyes blue (23.99%), both eyes amber (12.68%), and one eye blue, the other amber (63.33%). Moreover, in a study (Ateş, 2000) investigating the reproductive characteristics of Van cats, the percentage of estrus, birth rate, number of kittens per gestation and gestation length were reported as 88%, 55.12%, $3.21 \pm 0.20\%$ and 62.93 ± 0.30 , respectively. In this study, measurements of the live weight and body measurements of the Van cats were also taken at various times. Besides, in a study on the content of trace elements in the serum of Van cats, Altunok et al. (2007) reported that the content of trace elements in blood serum is determined by eye color and sex.

In recent years, various studies have been carried out in Türkiye, albeit at a limited level, to identify and conserve the indigenous genetic resources of livestock and pet or companion animals, and local genotypes are being identified using molecular methods. In this context, the first genetic study on Van cats was conducted by (Ateş 2000). In this study, the polymorphism of blood proteins was examined using 7 enzyme loci in Van cats and other cats and the phylogenetic relationships were examined. In their study, neither the individual Van cats nor the specimens of other cat species showed variations in the enzyme loci CA1, SOD, GPI and GOT. However, all cats showed genetic variation in the PGD, ME and ESD loci. Thus, three of the seven gene-enzyme systems (43%) were polymorphic with two alleles, contributing to an estimated heterozygosity of between 0.33 and 0.49 in Van cats. When three polymorphic loci were examined, PGD provided the greatest discrimination. Based on the phylogenetic tree, the Van, Persian, Turkish Angora and Turkish Tekir cats are distinct from the Persian cat.

It was mainly molecular genetic studies using microsatellite markers that investigated the genetic distance and relationship of wild cats such as cheetahs, pumas and lions, as well as population divergence in domestic cats (Hille et al 2000; Driscoll et al. 2002; Altunok et al. 2007; Altunok et al. 2011).

In this study, genetic associations between 4 different microsatellite markers for domestic cats and the phenotypic traits of eye color and position, coat length and three-point birthmark on the head of Van cats were preliminarily investigated. When analyzing the association between the microsatellite loci FCA176, 478, 547 and 688, no statistical association was found between sex and any of the microsatellite markers (Tables 5-7). Similarly, no associations were observed between eye color and position with any of the microsatellite markers (Table 5). On the other hand, a statistically moderate but almost significant association was found between coat length and the microsatellite marker FCA 176 (Table 6). Remarkably, the association between a three-point birthmark on the head and the microsatellite marker FCA478 was statistically significant (Table 7). When Table 8 is

compared with (Lui and Stokkermans 2023), it can be said that both *H* and PIC values determined in this study are quite low. (Lui and Stokkermans 2023), used 253 microsatellite markers to capture more genomic regions and create their first-generation genetic map for the domestic cat. In addition, the number of cat samples in their study was quite high (108) and came from multiple generations.

As for the studies on heterochromia in cats, conducted a preliminary investigation to determine the association between variations in the gene and heterochromia iridis on three exons of the endothelin receptor type B gene (*EDNRB*) in Thai odd-eyed cats. Using DNA sequencing, variations near the three exons of *EDNRB* were not statistically associated with feline heterochromia iridis in this study.

Recent reports have described a new coat and eye pattern in cats. The trait, called dominant blue eyes (DBE), has been confirmed as autosomal dominant in various feline breeding lines. The condition is known as dominant blue eyes (DBE) and involves one or more blue eyes or color particles with minimal white spots. Several breeding lines have been developed for DBE in cats, and deafness has been identified as an associated trait in some of these lines (Abitbol et al. 2025).

In their previous study, Abitbol et al. (2024) used single nucleotide polymorphisms (SNPs) to identify two variants in the PAX3 (paired box 3) gene associated with DBE in Maine Coon and Celestial cats. However, there was no evidence of an underlying variant in other DBE breeding lines. On the other hand, in a genome-wide association study of British cats, they identified a single region on chromosome C1 associated with DBE. Using samples from 14 lineages of DBE cats, they genotyped the three PAX3 variants and found these variants were absent in four lineages. Furthermore, in a similar study, Abitbol et al. (2025) updated the segregation of the variant with the dominant inheritance pattern observed in this DBE line, referred to by breeders as the Agostino line.

Türkiye is one of the few countries in the world with a great diversity of animal species, and Van cats contribute to this biodiversity in Türkiye as well as other farm animals.

The use of molecular genetic techniques can be applied to improve animal breeding by determining genetic relationships in animal populations, identifying traits and genes and implementing these relationships into breeding methods. Based on the results of this study, FCA 176, which is moderately associated with coat length, and FCA 478, which is significantly associated with a three-point birthmark on this trait, could be used as potential informative markers in future genetic studies with Van cats or other domestic cats.

There is no doubt that in future studies of this type one could definitely increase the number of detected markers and achieve a much greater genomic coverage with a much larger number of cats with pedigree records. In addition, SNP markers and chip technologies should be used as much as possible to find important associations other than microsatellite markers.

CONFLICTS OF INTEREST

All contributing authors of this research have declared that there is no conflict of interest regarding this study.

ACKNOWLEDGMENT

We would like to thank the Van Yüzüncü Yıl University Scientific Research Projects Department (YYÜ-BAP) for their contributions to this research project, which was financially supported by the Van Yüzüncü Yıl University Scientific Research Projects Directorate under project number 2008-ZF-069.

This study was orally presented at the European Biotechnology Congress held in Dubrovnik, Croatia, between May 25 and 27, 2017.

AUTHOR CONTRIBUTIONS

Idea/Concept: HK, SK, CÖ, MK, HÇ, MFÜ, SK, AY, AY, KK, TA, AK

Supervision/Consultancy: HK

Data Collection and/or Processing: CÖ, MK, HÇ, AY, KK, TA, AK

Analysis and/or Interpretation: HK, SK, HÇ., MFÜ

Writing the Article: HK, SK, MFÜ

Critical Review: HK, SK, CÖ, MK, HÇ, MFÜ, SK, AY, AY, KK, TA, AK

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