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Distribution of feline AB blood types: a review of frequencies and its implications in the Iberian Peninsula

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Abstract

Objectives The objective of this study was to document the prevalence of feline blood types in the Iberian Peninsula and to determine the potential risk of incompatibility-related transfusion reactions in unmatched transfusions and the potential risk of neonatal isoerythrolysis (NI) in kittens born to parents of unknown blood type.

Methods Blood samples were obtained from blood donors of the Animal Blood Bank (BSA-Banco de Sangue Animal). Blood typing was performed using a card method (RapidVet-H Feline Blood Typing; MDS).

Results The studied population comprised 1070 purebred and non-purebred cats from Portugal and Spain aged between 1 and 8 years. Overall, frequencies of blood types A and B were 96.5% and 3.5%, respectively. No AB cats were found. Based on these data, the potential risks of NI and transfusion reactions in unmatched transfusions were calculated to be 6.8% and 2.8%, respectively.

Conclusions and relevance Unlike previous studies, no type AB cats were found in this study. Although the calculated potential risks of transfusion reaction in unmatched transfusions and neonatal isoerythrolysis were low, blood typing prior to blood transfusion and blood typing of cats for breeding purposes are highly recommended.

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Introduction

In 1981, Auer and Bell defined the currently accepted blood group system in cats, which includes types A, B and AB. Type A is the most common type worldwide, whereas AB has a global frequency lower than 1%.[1,2] In 2007, the Mik antigen was first described, allowing for speculation that other, still undescribed, erythrocyte antigens might exist.[3]

Feline blood types are defined by the expression of *N*-acetylneuraminic acid (NeuAc) and *N*-glycolylneuraminic acid (NeuGc) in gangliosides on the surface of erythrocytes.[4] Mutations in cytidine monophospho-*N*-acetylneuraminic acid hydroxylase (CMAH), the enzyme responsible for the conversion of NeuAc to NeuGc, determine the blood group.[5] The A antigen has a higher expression of NeuGc–NeuGc–galactose-glucose-ceramide ($[NeuGc]_2G_{D3}$) in its gangliosides, although it can also express NeuGc–NeuAc–G_{D3}.[4,6] The proportion of both molecules may vary between homozygous and heterozygous type A cats.[7] The B antigen has gangliosides that only express NeuAc–NeuAc–galactose-glucose-ceramide ($[NeuAc]_2G_{D3}$), so type B cats are thought not to produce a

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functional CMAH enzyme.[4,7,8] Type AB cats co-express NeuAc and NeuGc, as well as two intermediate forms of gangliosides.[4,6,7] Cats lacking both A and B red cell antigens have not been reported.[1]

The AB system blood types are inherited as simple Mendelian traits and defined by three alleles: *A*, a^{ab} and *b*. *A* is the dominant allele, being the A phenotype defined by the *AA*, Aa^{ab} or *Ab* genotypes. The a^{ab} allele is recessive to *A*, dominant over *b* and allows for antigenic co-dominance, so the AB phenotype can be the result of $a^{ab}a^{ab}$ or $a^{ab}b$ genotypes. The *b* allele is recessive, so all type B cats have a *bb* genotype.[5,9]

Blood type prevalence in cats has been reported throughout the world by several authors, evidencing geographical differences, as previously mentioned.[9] Except for Siamese cats (universally type A), these geographical differences were reported within breeds. While some studies stated a relatively high prevalence of type AB cats, others contradict such results by reporting a null prevalence. For further details, please see the supplementary material.

Cats have naturally occurring alloantibodies against the blood type defining antigens they lack.[3] It is theorised that this may result from exposure to structural epitopes to which all cats are commonly exposed to at a young age, present in a variety of organisms, including plants, bacteria and protozoa, which are similar or identical to blood-group antigens.[10] Although only approximately one-third of type A cats have measurable titres of anti-B antibodies, they all have weak anti-B antibodies capable of causing microscopic agglutination of type B red blood cells.[11] While type B cats over 3 months of age have high titres of naturally occurring high-affinity anti-A antibodies,[10,12,13] type AB cats have neither anti-A nor anti-B antibodies.[12,13]

The presence of naturally occurring alloantibodies is responsible for transfusion reactions, with severity ranging from mild to massive, premature destruction of transfused red blood cells and neonatal isoerythrolysis (NI).[11,12] Transfusion of type A or AB blood to a type B cat carries a potential risk for reactions ranging from premature erythrocyte destruction to acute, severe and potentially fatal reactions.[10,12] Owing to the low titre of anti-B alloantibodies in type A cats, transfusion of type B blood to a type A cat is associated with clinically mild transfusion reactions, which result in a rapid fall of post-transfusion packed cell volume into pre-transfusion levels.[12] The severity of a transfusion reaction is proportional and more closely related to the alloantibody titre within the recipient's blood than with the amount of antigen administered.[12]

Owing to the presence of such naturally occurring alloantibodies and the consequent risk of haemolytic transfusion reactions after unmatched blood transfusions, all donor and recipient cats should be typed prior to transfusion.[14] Cross-matching should also be performed prior to the transfusion in order to detect potential immune reactions unrelated to the AB blood-type system.[2,15]

Type A or type AB kittens born to a type B queen are at risk of NI due to the gastrointestinal absorption of anti-A antibodies present in the colostrum within 24 h of birth. Its severity depends on the antibody titres of the queen, the amount of antibodies excreted in the colostrum or milk, and the amount of antibodies absorbed by the kitten, so not all kittens are affected in the same way. Cat breeders are economically affected by NI since the associated mortality is high, despite the phenomenon being rare.[16]

To our knowledge, the risk of incompatibility reactions in unmatched transfusions and the risk of NI in kittens born to parents of unknown blood type in the Iberian Peninsula have not been described.

Materials and methods

Blood samples were obtained from clinically healthy blood donors aged 1–8 years, with no history of severe disease nor prior transfusion, restricted outdoor access, and negative results for feline leukaemia virus (FeLV) and feline immunodeficiency virus.

Typing was performed in 1 ml blood samples collected from the jugular vein and preserved in EDTA tubes within 24 h of collection using a validated commercial card test (RapidVet-H Feline Blood Typing; DMS).[17] Unclear results and type B cats were confirmed using an immunochromatographic method (Feline Quick Test A+B; Alvedia). No spontaneous agglutination was observed in the samples.

The potential risks of incompatibility reactions following unmatched blood transfusions and NI in kittens born to parents of unknown blood type were calculated using the Hardy–Weinberg equilibrium equation ($p^2 + 2pq + q^2 = 1$; $p = 1 - q$; p = type B frequency; q = type A frequency) used by Giger et al in 1991.[18] Since this equation can only be applied assuming the inexistence of type AB cats, it was considered suitable for this study group, where no type AB cats were identified.

Results

Blood typing was performed on 1070 feline blood donors from Portugal (n = 926) and Spain (n = 144), where 1033 cats were type A and 37 cats were type B (Table 1). No AB-type cats were found. In the population there were 827 non-purebred and 243 purebred cats, including Persian, Siamese, Norwegian Forest Cat, Maine Coon, British Shorthair, Abyssinian, Scottish Fold, Siberian Forest, Russian Blue, Bengal, Angora and Somali breeds.

Based on the collected data, the potential risk of transfusion reactions in an unmatched transfusion, ie, the probability of occurrence of AB system incompatibilities resulting from random transfusions, is 6.8%. This is true for whole blood, packed red blood cells or plasma

Table 1 Feline blood types according to provenance and breed

	Portugal		Spain		Overall	
	Type A	Type B	Type A	Type B	Type A	Type B
	n	n	n	n	%	%
Non-purebred	750	21	51	5	96.9	3.1
Persian	39	5	38	2	91.7	8.3
Siamese	53	–	–	–	100.0	0.0
Norwegian Forest Cat	46	–	1	–	100.0	0.0
Maine Coon	3	–	27	2	93.8	6.3
British Shorthair	3	–	7	2	83.3	16.7
Abyssinian	2	–	2	–	100.0	0.0
Scottish Fold	1	–	3	–	100.0	0.0
Siberian Forest	–	–	2	–	100.0	0.0
Russian Blue	–	–	2	–	100.0	0.0
Bengal	1	–	–	–	100.0	0.0
Angora	1	–	–	–	100.0	0.0
Somali	1	–	–	–	100.0	0.0
Total	900	26	133	11	96.5	3.5

transfusions. The potential risk of NI in kittens born to parents of unknown blood type is calculated to be 2.8%.

Discussion

In non-purebred cats, the prevalence of type A and B was 96.5% and 3.5%, respectively. These results are in agreement with other studies. Type A prevalence in this study is similar to the documented prevalence in other studies from the Iberian Peninsula, which varied between 88.7% and 97.5%. Type B prevalence in this study is similar to the low range of previous results, 2.1–7.2% (see supplementary material). Unlike all other studies in this region, no type AB cats were found.[11,13] Similar to other studies involving Persian cats, there was a high prevalence of type A, and type B prevalence was within the previously documented range of 0.0–11.8%.[11,19–21] Only one type AB Persian cat was previously reported.[11] All Siamese cats were type A, as documented in other studies.[9,11,16,22,23] The observed type B prevalence in Maine Coon cats is not in agreement with the study of Spada et al,[24] where all Maine Coons were found to be type A, which might be explained by the geographical variability of blood-type prevalences.[9] Type B prevalence in the British Shorthair breed in this study (16.7%) was lower than in other studies (33.3–58.7%).[20,21] The conclusions that may be drawn are limited owing to the small sample size (n = 12). The small number of Abyssinian, Scottish Fold, Siberian Forest, Russian Blue, Bengal, Angora and Somali cats in this study does not allow for an accurate comparison with previous studies.

Unlike most of the recent studies of large cat groups worldwide, no type AB cats were found. Factors that might explain this result include the extremely low worldwide prevalence of type AB cats and the low prevalence of type B cats in the studied population, since the presence of type AB cats is mostly expected in populations with a high type B prevalence.[15]

It has been shown that some FeLV-infected type A cats can present AB blood-type results in card agglutination and immunochromatographic cartridge methods.[17] Since all typed cats tested negative for FeLV infection, there was a lower risk of mistyping due to agglutination caused by this infection. The selection of apparently healthy animals might have also lowered the presence of agglutination as a result of immune-mediated causes.

The calculated potential risks of unmatched transfusions do not include immunological reactions other than those associated with the AB system, like Mik antigen or plasma protein incompatibility, as well as non-immune reactions.

The potential risk of NI refers to the expected probability that type A and AB kittens born to a type B queen from random mating may develop NI. This value is expected to be higher than the observed frequency of NI, since not all animals at risk develop clinical manifestations of the disease.

Conclusions

Since NI and transfusion reactions are potentially fatal, blood typing and cross-matching prior to blood transfusion and blood typing of cats for breeding purposes are highly recommended, even in low-risk populations.

Veterinary practitioners play a major role in raising awareness about NI among cat breeders and in performing transfusion protocols that minimise the risk of

reactions, including blood typing the donor and recipient cats and cross-matching before transfusion.

Supplemental material Table to show the documented feline blood type frequencies worldwide.

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