

# **GCCF**

## **Recommended Breeding Policy for the Singapura Cat**



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## **INTRODUCTION**

This breeding policy has been prepared by the Singapura Breed Advisory Committee, which is composed of representatives of the Singapura Cat Club and the Progressive Singapura Cat Club, to give advice and guidance to UK breeders of Singapura cats, both in carrying out their own breeding programmes, and introducing cats from recognised breeding programmes in the USA and elsewhere. It follows the general principles set out in the GCCF Breeding Policy (Guidelines for Healthy Breeding) and accompanies and supplements the Singapura Registration Policy and should be read in conjunction with those documents.

The aim of the breeding policy is to give advice and guidance to ensure breeders observe what is considered “best practice” in breeding Singapuras. The over-riding objective is to maintain the type and health of the Singapura cat, working to meet all aspects of the Singapura Standard of Points, which describes the ideal cat.

Unlike the majority of breeds introduced into the cat fancy in the last quarter century, the Singapura is neither the result of cross-breeding between existing breeds of cat, nor the product of a single genetic mutation (although the development of the breed followed some of the same principles as in the latter case).

The Singapura cat is a type which originated in a single location (Singapore). All present day cats can trace their line back to cats of this type from Singapore. Breeders have concentrated on improving type and health (in particular eliminating tail deformities which were common in the native cats, and retaining the unique ticked coat with its distinctive markings), by selective breeding and the Singapura BAC is committed to continuing this work without losing the unique charm of the Singapura.

**HISTORY OF THE SINGAPURA**



Puss'e of Usaf



Usaf's Gladys



Little Singh Bull



Usaf's George



Chiko of Rya



Tes of Usaf

In order to understand the genetic heritage of the breed it is necessary to set out the history of its development. There is a certain degree of conflicting information about the Singapura's origins and the breed founder, Mrs Tommy Meadow, revised her story about how the breed came to be when information came to light which cast doubt on it. Originally she had described finding three cats, a brother and sister called Ticle and Tes, and a third similar cat called Puss'e, while she was living in Singapore in 1975 and taking them back to America. When documents surfaced showing that she had imported three Abyssinian cats called Ticle, Tes and Puss'e, along with some Burmese cats, from the USA to Singapore when she moved there in 1974 she admitted that her original story was a fabrication.

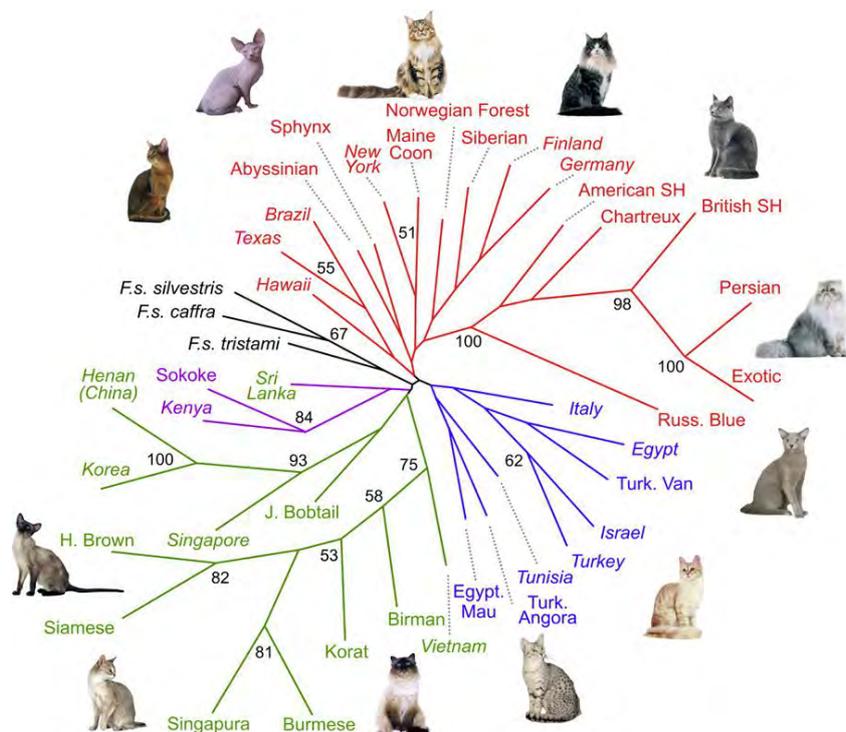
In February 1991 she attended a meeting of the board of the Cat Fanciers' Association to provide an explanation. At this meeting she stated that her husband Hal, who was working in Singapore in 1971, sent three Singapore street cats to her in the USA during that year. She explained that these cats were the grandparents of Tes, Ticle and Puss'e and that the description on the import documents as Abyssinians was incorrect. Her explanation for the original deception was that her husband had been on a secret mission at the time. There were never any records of the three original Singapuras being sent to America, Mrs Meadow never told anyone what their names were or the names of their offspring, who would have been the parents of Tes, Ticle and Puss'e. No information was given about the matings used to produce the first two generations of kittens and whether the cats were mated to each other or to Mrs Meadow's Burmese. No photos of these first two generations of the Singapura breed were ever produced and Mrs Meadow stated that she had no veterinary records for them and was unable to remember the name of the vet whose care they were under to obtain any proof of their existence.

There was speculation about whether the breed had in fact originated with matings between Burmese and Abyssinians, or Burmese and Singapore street cats. A number of matings did take place with early Singapuras mated to Burmese, Abyssinians and other breeds (see below), ostensibly to test mate Singapuras to establish the genetic make-up of the breed, including that the colour distribution of the Singapura coat was a product of the Burmese colour restriction gene, and to find out which of them were carriers of the non-agouti gene. None of the offspring were registered as being used in the Singapura breeding programme, but it was suspected that some of these were absorbed into the Singapura gene pool to provide some new blood and revive the breed when a number of young kittens died at the beginning of the 1980s.

In October 2007 a study of the genetic diversity of the domestic cat (M.J. Lipinski, et al., *The ascent of cat breeds: genetic evaluations of breeds and worldwide random-bred populations*, Genomics (2007), doi:10.1016/j.ygeno.2007.10.009) was published which finally shed some light on the true origins of the Singapura breed. It demonstrated that the Singapura is almost genetically identical to the Burmese breed and is less genetically similar to the Singapore street cat. This demonstrates that Burmese probably were used at some point in the establishment of the Singapura. A further discovery, that a gene originating in Abyssinians was widespread in Singapuras established a link with that breed. This was the gene causing Pyruvate Kinase Deficiency (PK Def) and action was subsequently taken to remove it from the Singapura gene pool in the GCCF through a DNA Screening programme initiated by the BAC.

The Lipinski study also concluded that the Singapura had the least genetic diversity of all cat breeds and recommended that breeders take action to address this. This is as a result of the very small number of cats used to found the breed. The BAC took action to address this and approved an outcrossing programme to improve the breed's genetic diversity.

**Figure 1. The Feline Phylogenetic Tree**



*This diagram shows the genetic connections between different breeds and different random-bred populations. It demonstrates the close connection between the Singapore and the Burmese (which the study says “could not be distinguished as distinct breeds”) and the more distant relation to random-bred cats from Singapore. No strong correlation was found with the Abyssinian.*

Regardless of the breed’s origins, the history of its subsequent development is well documented. Mrs Meadow decided to develop the cats she had into a pedigree breed. She had two kittens from Ticle and Puss’e that she called Gladys and George. Ticle was then neutered and George took over as the stud cat.

Mrs Meadow carried out a planned breeding programme, using these kittens, and their offspring to fix the breed type. Tommy was then back in the States and was joined by other breeders who saw the potential in these beautiful cats. Numbers grew slowly initially, but the breed steadily gained in popularity.

There were worries about the small gene pool so in 1980 Brad and Sheila Bowers travelled to Singapore to find a cat to import as a new blood line. They found a female with a sepia ticked coat in a Singapore Society for the Prevention of Cruelty to Animals rehoming centre. The cat, named Chiko, had a short bobtail typical of many cats on the island. The Bowers managed to persuade the centre’s vet, Dr Lee, to let Chiko leave the centre without her being spayed, seeing as she was being taken out of the country. She was sent to American breeder Barbara Gilbertson (prefix 'Rya') in April 1980. She was then bred to descendants of Tommy's cats in a carefully arranged breeding programme.

Gerry Mayes of Little Singh Cattery went to Singapore in 1987 and returned to the US with several cats including Little Singh Bull, a very typical Singapura, who was also incorporated into the breeding programme

Singapuras were given official breed recognition in America in 1976 by TICA (The International Cat Association) and achieved full championship status in 1979. The larger Cat Fanciers' Association gave initial recognition in 1982 and full championship recognition in 1988.

The first Singapuras in the UK were imported in 1988 by Carole Thompson of Gloucestershire. She brought in a pregnant female called Imagos Faye Raye of Usaf, who subsequently gave birth to three kittens: Mimi, Muffy and Kuan. Another import followed: a male named Sricobery's Indah, who was a suitable match for Faye, Mimi and Muffy. Another significant import in the early days of the British Singapura breeding programme was Changis Singing Purs Theo, imported by breeder Debbie van den Berg, who was also instrumental in setting up the Singapura Cat Club. The Governing Council of the Cat Fancy promoted the breed to championship status in 2005.

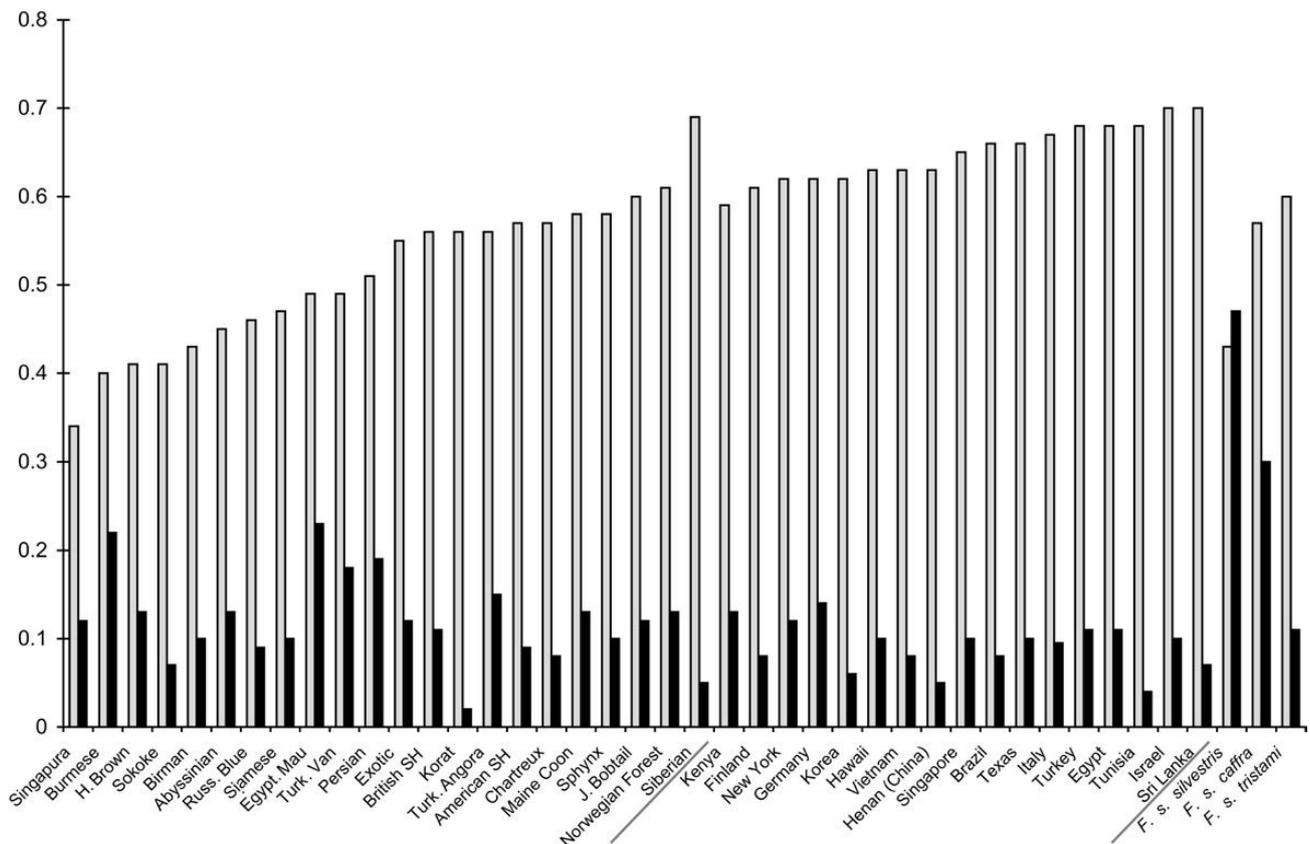
### **THE SINGAPURA GENE POOL**

The Singapura gene pool is reputedly based on only five known cats, namely Ticle of Usaf, Tes of Usaf, Puss'e of Usaf, Chiko of Rya and Little Singh Bull, described above. While the study *The Ascent of Cats Breeds* by Lipinski et al shows a connection between the Singapura and the Burmese, the arcane origins of the Singapura mean that it is not possible to know whether this means that Burmese genetic input was present in the original three cats or whether it was introduced from subsequent matings.

In population genetics the concept of 'Effective Population Size', which was first described by the geneticist Sewell Wright, describes the size of the gene pool in relation to the number of individuals in a breeding population. The Singapura's was extremely small because of its low number of breed founders.

*The Ascent of Cat Breeds* in 2007 showed the Singapura as being the cat breed with the smallest gene pool and least genetic diversity. An outcrossing programme has been approved to address this issue.

**Figure 2.**  
**Genetic diversity indices of breeds, random-bred populations, and wildcats (Lipinski et al)**



This shows cat breeds and random-bred populations listed in ascending order of heterozygosity. The Singapura currently has the lowest heterozygosity at 0.34 compared to a breed average of 0.51 and a random-bred average of 0.65. The average allelic richness of the Singapura was also the lowest of all breeds surveyed at 1.98 compared to an average of 2.74 and a range across breeds of 1.98 to 3.45.

The general GCCF Breeding policy cites studies which show that for a breed's gene pool to be sufficiently wide and variable for long term viability it needs to have a minimum of 50 to 60 unrelated individual cats as foundation cats or outcrosses in its gene pool. The Singapura breed has only five, so in order to avoid future problems careful and controlled introduction of new blood lines will be used to maintain the health of the breed.

Only with recent advances in DNA testing has it been possible to realistically consider undertaking an outcrossing programme in the Singapura breed without the risk of introducing a range of unwanted genes. In April 2013 the BAC gained approval for an outcrossing programme to improve genetic diversity in the breed. Matings are permitted between Singapuras and cats from the approved outcross list (Foundation Singapuras from Singapore or neighbouring countries, Abyssinians (ABY n/o/b), Burmese (BUR n/a/b), Korat or Domestic Shorthair (DSH n or n 25)). Matings to other cats are not permitted. Progeny of outcross matings cannot be shown as Singapuras and are registered separately on the genetic or reference registers for three generations or more and have to undergo a series of DNA tests to prove they have correct genotype. This level of scrutiny and requirement for generational advancement is necessary to ensure that new outcross lines are appropriate for use in Singapura

breeding and to protect the special characteristics of the breed, while also allowing improvements to be made to the genetic diversity of the breed.

## **GENETIC MAKE-UP**

The genetic make-up of the Singapura Cat is well documented, because it has a specific appearance, with only one variety: the Brown Ticked, resulting from a specific genotype: AA, BB, c<sup>b</sup>c<sup>b</sup>, DD, ii, ll, T<sup>a</sup>T<sup>a</sup>, which is explained below.

In the early days of breeding in the United States some Singapura to Singapura matings produced solid brown kittens, including those involving both Ticle and Tes. An extensive test mating programme was begun in order to establish the genetic makeup of the breed for presentation to the registering organisations, and to establish which cats were carriers of the non-agouti gene.

After extensive test matings to Siamese, Burmese, Abyssinian and blue cats in America, breeders have been able to determine accurately that the genotype for the Singapura should be as noted above, the early test matings established the homozygous genotype.

No other recessive gene should be carried with respect to colour and pattern. In test-mating Singapuras to Burmese, Siamese, and blue cats, the American breeders found no carriers of non-agouti, dilute of the Siamese gene in the cats tested.

In 1982 the majority of American breeders opted for the wording in the breed standard to read "...warmer, lighter shades preferred" in reference to colour. Breeders had inadvertently selected against solid colour carriers by choosing the warmer, lighter cats from the beginning. As a result, after test mating, only seven cats were neutered because they carried solid colours and no blood lines were lost.

The most effective method of testing for the non-agouti gene was found to be a Singapura-Burmese cross. It was established that if a Singapura were to give birth to seven ticked kittens after being mated to a Burmese cat, then the chance of the Singapura parent being clear of the non-agouti gene would be 99.2 per cent. (Statistics taken from Roy Robinson's "Genetics for Cat Breeders", 3rd edition, Pergamon Press.) All our British cats originate from this test-mating programme in the mid 1980's, and another later testing by Dr Bella Toga in France in the mid 1990's. And all our cats breed true to only one colour, which is "Brown Ticked".

Since this test mating programme took place scientific advances have brought us DNA testing for cats, so similar programmes would be unnecessary for any future new foundation Singapura lines.

As noted above, these test matings were reputedly carried out solely to establish the genetic make-up of the Singapura breed, and in particular the genetics of the unique Singapura coat colour and pattern.. None of the crossbred kittens resulting from these matings were eligible to be registered as Singapuras (the majority were neutered and placed as crossbred pets).

In 2013 a genetic study of the Singapura was carried out by Dr Cecilia Penedo of UC Davis. Part of this study looked at the incidence of recessive colour and pattern genes across 88 Singapuras from 13 different countries. The largest numbers of cats were from the USA, Australia and Japan. This study

showed that early test mating programmes had achieved a high level of success in reducing the unwanted colour and pattern genes. Only one carrier of non-agouti was found, only one carrier of the dilute gene, only 3 carriers of the Siamese gene and only 6 carriers of chocolate. None of the cats carried the longhair gene.

### **The key genes for the Singapura**

**A/a Agouti/Non-agouti gene.** The Singapura is homozygous for agouti (AA), meaning that it has two copies of the dominant agouti allele and does not carry non-agouti. The agouti gene causes the Singapura to have a tabby pattern.

**B/b/b1 Black, Chocolate, Cinnamon gene.** This gene codes for tyrosinase related protein-1, an enzyme involved in the metabolic pathway for eumelanin pigment production. The Singapura is homozygous black (BB), meaning that it has two copies of the dominant black (B) allele and does not carry either recessive chocolate or cinnamon.

**C/c<sup>b</sup>/c<sup>s</sup> The albino series gene.** This gene codes for enzymes related to pigment production. The Singapura is homozygous for Burmese Colour Restriction (c<sup>b</sup>c<sup>b</sup>), meaning that it has two copies of the c<sup>b</sup> allele and that neither the allele for full colour (C), nor the allele for colourpoint (c<sup>s</sup>) are present. The action of this allele is to restrict pigment, reducing the amount of eumelanin produced and turning black pigment into a sepia brown colour.

**D/d Dense/Dilute gene.** This gene controls the way in which pigment is laid down within hairs and therefore whether a cat's colour is dense (e.g. black) or dilute (e.g. blue). The Singapura is homozygous for dense colour (DD), meaning that it has two copies of the dominant dense (D) allele and does not carry dilute.

**L/l Hair Length gene.** This gene the length of hair. The Singapura is homozygous for short hair (ll), meaning that it has two copies of the dominant short hair (l) allele and does not carry long hair.

**T<sup>a</sup>/t<sup>a</sup> Ticked Tabby/Non-ticked tabby.** The gene modifies any agouti (tabby) cat's pattern to make it a ticked tabby. The Singapura is homozygous for ticked tabby (T<sup>a</sup>T<sup>a</sup>), meaning that it has two copies of the dominant allele for ticked tabby and does not carry the recessive allele for non-ticked. Ticked tabby cats carrying the non-ticked allele have a different appearance to cats which are homozygous for ticked. Carriers have heavy barring in their limbs.

**Other genes.** The Singapura does not have the red gene (O), the White gene (W), the White Spotting gene (S), the Silver gene (I), or any gene for widebanding, hairlessness or rexing.

The combination of genes in the Singapura genotype creates a cat which is a ticked tabby with the sepia brown colouration caused by Burmese Colour Restriction.

### **BREEDING SYSTEM**

Listed above are the main genes that help define the Singapura cat through the expression of pattern, colour and coat, but of course there are a large number of other genes that together create the distinctive physical shape and confirmation which is the essence of Singapura breed type.

In order to ensure the maintenance of the good Singapura breed type already achieved, while allowing scope to further improve aspects of type, coat, pattern and colour, to meet the ideal described in the Standard, breeders need to have a clear, definite and well understood **breeding system**. This means the development and management of a breeding programme in which certain cats are affirmatively selected to be bred to others, for predetermined reasons. Equally important, it also means that breeders allow no matings until they have given careful consideration to the outcome. In particular three key rules must be followed:

- **Health must be the overriding consideration in any Singapura breeding programme.**
- **The good and bad features of the individual cats should be assessed and weighed against each other before any mating.**
- **When planning a breeding programme, breeders must realise that doubling of the good traits in a cat also results in doubling the defects; the breeding of cats with similar faults should be avoided at all costs otherwise there is a danger of fixation.**

The prime motive is to perpetuate the Singapura as a recognisable breed; to improve the quality of the breed as measured against the Standard; and also to gain success on the show bench.

The skill in breeding lies in the choice of the individual cats and how these cats may be mated with each other – these two acts should be regarded as completely separate, although interconnected.

### **Selection**

The phenotype of the individual cat is made up of a large number of genetic characteristics of varying expression. The ideal Singapura is one in which the expression of each of these characteristics is just right in the eyes of the breeder – this means that an intermediate expression will be required for some characteristics, but a more extreme expression required for others. This expression is controlled by selective breeding. However, selection by itself is not very efficient in eliminating heterozygous genotypes (the producers of variation and diversity) – it is one of the tools available, but has its limitations.

### **INBREEDING**

Inbreeding is an inclusive term covering many different breeding combinations and degrees of relationship – including the more distant, less intense. It is consistently more efficient in eliminating heterozygous (varying and diverse) genotypes and increasing homozygous (same) genotype, thereby ensuring a greater likelihood that kittens will closely resemble their parents. Used here, the term does not mean close, purposeful, inbreeding of closely related cats (brother/sister, father daughter), but rather the moderate form that results from the mating of not too distantly related (but not directly related) cats (first cousins, half brother/half sister, second cousins, etc). Some in-breeding is essential to stabilise conformation around a definite type. In-breeding is the act of mating individuals of various degrees of kinship, and if continued it produces ever increasing homogeneity in the offspring.

It is important to monitor the percentage intensity of inbreeding for any mating – use this consideration as a key part of the decision making process when considering any mating, and remember: ***“The more***

***intense the in-breeding, the more careful must be the selection”. “Loss of innate genetic variability must not be too great”.***

The overall approach should be one of balance and moderation in the degree of inbreeding coupled with consistent selective breeding with a clear objective in mind – i.e improvement of key aspect and/or the elimination of weak traits or defective genes.

Breeding systems and practices need to operate so as to ensure the Singapura gene pool contains enough variation to give scope to continue improving the breed and avoid the danger of either fixing type too quickly (before the ideal of the standard is reached) or deleterious genes being expressed and fixed in the breed. Breeders need to use acceptable levels of inbreeding to gain sufficient homogeneity to fix recognisable Singapura type, but with sufficient variation to both enable improvement, and maintain health and vigour, avoiding fixation of defective genes or unwanted traits (and to ensure the elimination of anomalies).

The golden rule is that health is paramount and must be constantly and consistently monitored; any evidence of weakness or the emergence of lack of vigour must be dealt with immediately through modification of the breeding system. No cat with any evidence of health problems or lack of vigour should be used for breeding.

Breeders should also be aware that research has shown that highly inbred animals are less likely to be show winners. Although a certain level of acceptable inbreeding can help to fix desirable traits, inbreeding depression can cause asymmetries and weaknesses that can be damaging to a cat’s potential show success.

### **Inbreeding Depression**

A breed, breeding line or individual can suffer from inbreeding depression when inbreeding coefficients are raised to high levels and a loss of heterozygosity results. Inbreeding depression can result in a general loss of vigour, even if the animals in question are not suffering from specific recessive genetic diseases. A small gene pool can result in inbreeding depression in a breed. A popular and numerous breed with a small gene pool has a low 'effective population size', regardless of the numerical size of the breed's population. A popular breed with a small effective population size can be compared to an overinflated balloon.

Inbreeding depression can compromise a cat's immune system and make it less able to resist disease. A group of genes called the Major Histocompatibility Complex, or MHC plays an important role in the immune system. The way in which the genes in the MHC are inherited means that it is particularly vulnerable to inbreeding depression and a loss of genetic diversity in the MHC can impact on the health of the cat.

Inbreeding depression can manifest in different ways depending on the particular make-up of the gene pool in question. Few cases of inbreeding depression will manifest all of the signs. Although these are problems which can occur in any random-bred cat, a combination of some of these signs could well indicate a problem with inbreeding depression. A Singapura breeder who is worried about inbreeding levels in their lines should consider introducing Singapura cats from different lines or outcrossing to new Singapura foundation lines.

Signs of inbreeding depression include slow growth rate, small adult body size, small litter size, reduced fertility, increased kitten mortality, increased prevalence of allergies, reduced ability to fight infections, physical asymmetries, especially facial, an increase in congenital abnormalities, increased prevalence of cancers, increased incidence of genetic disease, and reduced life expectancy.

### **Acceptable levels for Co-efficients of Inbreeding;**

0 to 10 % = Low

10 to 20 % = Fair

20 to 25% = Acceptable

25 to 40% = High. Only to be undertaken by experienced breeders for specific reasons.

40%+ = Not advised

N.B. Inbreeding co-efficients should ideally be calculated back to foundation. Fewer generations will not give a fully accurate reading. This is particularly important for the Singapura compared to other breeds because of the small number of initial founders.

The Singapura has a small gene pool as a result of its small number of founders. This means that the gene pool needs to be managed carefully. Singapuras are generally healthy cats and no studies have been carried out to examine how widespread incidences of specific health conditions might be, but with the small gene pool it is a risk in the breed, particularly for lines where insufficient attention is given to inbreeding co-efficients.

### **BREEDING GUIDANCE**

As noted above, while the breed was developed from a relatively small gene pool (five cats, of which three were thought to be related) the breed has now been in existence for over 30 years, is well established internationally, and is not known to be subjected to any genetic defects which are specific to the breed. Nevertheless, it is recognised that in the UK the actual number of breeding cats is relatively small, and that care must be taken to ensure the continued health of the breed by carefully monitored breeding practices.

If a self cat suddenly appears then it is either a mutation, or the result of unauthorised cross-breeding (i.e. not bred Singapura to Singapura). The Singapura Breed Advisory Committee recommends that breeders should never knowingly breed from Singapuras which originate from untested stock, and should re-test the line in question, using DNA testing, if any litter contains non-agouti kittens, neutering any carrier cats from the breeding programme. Our objectives are to maintain the integrity of the Singapura breed through selective breeding only within the breed, keeping the physical appearance and only one colour of cat.

It should be noted that although the Singapura coat is superficially similar to that of the Asian Ticked Tabby, the Singapura does not have the silver gene or polygenes for widebanding in its gene pool and these would both be very undesirable.

The health of the cat is paramount. Although the breed is described in some sources as 'small' it is not a miniaturised breed. The GCCF Breeding Policy specifically states that it does not encourage the

breeding of 'any miniaturised breed' and Singapura breeders should avoid planning matings solely on the basis of size. Breeders should ensure that females are of sufficient size and robustness to carry a litter (typically 2-4 kittens) to term and deliver naturally.

In managing a small gene pool like that of the Singapura, a good ratio of male to female breeding cats is advised in order to maintain genetic diversity and avoid excessive influence from the genes of the males which are used. Therefore, Singapura stud cats should not be used extensively and the number of matings they are used for should be limited.

### **BREEDING SELECTION FOR PHYSICAL ATTRIBUTES**

In appearance the Singapura is a compact cat, with noticeably large ears and eyes, a well-proportioned body and a proportionately short tail (which should reach to the point of the shoulder). The coat is of ticked tabby pattern, sepia brown, fading to pale ivory on under-parts. The breed standard describes the cat and its markings in detail, but it is important to note that no one feature should be emphasised in a breeding programme to the detriment of any others, or at hazard to the health of the breed.

The likelihood of producing high quality kittens in relation to desired appearance is increased by selecting cats to breed with that most closely conform to the breed's standard of points. Show critiques and awards gained can help to show which cats have been assessed as excellent examples of the breed by GCCF judges, but breeders should use their own judgement and the advice of other breeders, exhibitors and judges to determine the quality of cats which have not been shown or which have only been to limited numbers of shows.

The head should be rounded with good width and a short, broad muzzle. A cat with a narrow head or long muzzle does not have the desired typical Singapura expression. The large ears should be correctly set at an angle slightly wide of parallel. Low set ears are incorrect. Large, open eyes accentuated with a dark outline are a vital characteristic feature and small eyes are a withholding fault. Breeders should select for good eye colour, which should be hazel, green or yellow, showing brilliance. The body and legs must have a moderate, muscular build; cobby type is a fault but allowances can be made for a more slender body type in adolescents.

Attention should be paid to ensure that good ticking is maintained in the coat, and coat texture is fine, close-lying and silky. The length should be distinctly short and overly long or dense fur is undesirable. The coat colouring should appear refined and delicate, but breeders should avoid selecting for paler and lighter colour. The coat should not look grey-toned or silvery and should have warmth with a golden ivory colour. Barring should ideally be restricted to the inner front legs and back knees. An unbroken dark outline should be present across the top of the nose leather and 'Cheetah' lines should extend from the inner corners of the eyes to just behind the whisker pads.

Breeding cats should be matched to mates that will balance out any weaknesses; mating together two Singapuras with the same faults could lead to kittens which become fixed for that fault or have a more extreme expression of the fault.

## **GENETIC DISEASE**

### **Pyruvate Kinase Deficiency (PK Def).**

Erythrocyte Pyruvate Kinase Deficiency (PK Deficiency) is an inherited hemolytic anemia caused by insufficient activity of this regulatory enzyme which results in instability and loss of red blood cells. The anemia is intermittent, the age of onset is variable and clinical signs are also variable. Symptoms of this anemia can include: severe lethargy, weakness, weight loss, jaundice, and abdominal enlargement. This condition is inherited as an autosomal recessive.

The gene which causes PK Def was found to be present in Singapuras (Grahn RA, Grahn JC, Penedo MCT, Helps CR, Lyons LA. *Erythrocyte Pyruvate Kinase Deficiency Mutation Identified in Multiple Breeds of Domestic Cats*. BMC Veterinary Medicine 2012). Any Singapura cats used for breeding should be proven to be clear of the PK Def gene by DNA testing or by virtue of being bred from two parents who are themselves clear.

Effective use of DNA testing should remove the gene from the Singapura gene pool in the UK. Imported Singapuras should be from tested lines or should be tested themselves. Further information about DNA testing for PK Deficiency can be obtained from the BAC.

Potential outcomes of DNA testing for PK Deficiency	
Result	Interpretation
Homozygous	Cat has two copies of the mutation. Inherited from both parents and will have PK Deficiency
Heterozygous	Has one copy of the mutation and may pass to offspring. Does not have full blown PK Deficiency
Normal	The cat does not have the genetic mutation which causes PK Deficiency

The 2013 genetic study of the Singapura breed by Dr Cecilia Penedo of UC Davis found no incidence of Korat-GM1, Korat-GM2, Burmese-GM2, Burmese Head Defect, Burmese Hypokalemia, Polycystic Kidney Disease, and Progressive Retinal Atrophy (two forms).

## **GENETIC ANOMALIES**

The problem of the genetic anomaly is something of which all breeders should be aware – this is not to suggest that such anomalies are common but the cat must be expected to have its quota of defects just as are found in other animals.

### **Tail tip faults**

The GCCF Standard List of Withholding Faults for all breeds includes the following;

*Fixed Deviation (kink) of the Spine or Tail at any point - Small bony excrescences need not debar the cat from being placed, but should be taken into consideration.*

Tail tip faults have been seen in Singapura cats. These can take the form of a slight deviation in direction at the final or penultimate vertebrae, or of a small bony excrescence at the final vertebrae.

These are undesirable and breeders should aim to select cats without this trait for breeding. When breeders do use Singapuras with tail tip faults for breeding they should place all kittens displaying the trait on the non-active register.

Tail tip faults, especially mild ones, can be very difficult to detect in kittens and may not be evident at the age when kittens go to new homes, so it is not always possible for the breeder to be aware.

This kind of tail tip fault is thought to be a dominant trait with variable expression and indeed the expression is so variable that some cats with very mild faults may go unidentified. However, if the trait is dominant then a kitten with a tail tip fault will have at least one parent with it too.

If two cats with tail tip faults are bred together there will be a smaller probability of kittens being born without the trait and some of the kittens may be homozygous for the trait.

Breeders should get used to palpating the tail tips of kittens to ascertain whether any have the fault. The tail tip should be held very gently between the tips of the thumb, index finger and middle finger, as if holding a pen. The fingers should then be very gently moved up and down the tail tip to feel for kinks or bumps. A kink may sometimes only be felt in a kitten as the fingers are pushed downwards towards the body and the tail tip shows an inclination to bend in a particular direction. This must be done very gently as the tail tip of a kitten is delicate and if it is pinched, twisted or bent permanent damage may result.

### **Uterine Inertia**

This condition is a failure of the uterine muscles to contract sufficiently during labour and it can result in the need for Caesarean section operations and/or kitten deaths. Normally it is a condition which affects older cats which have already had multiple pregnancies; however, it was seen frequently in young Singapura queens in the early days of the breed. Breeders reduced the incidence of the condition by breeding from unaffected lines. It can still occasionally occur and breeders should not normally place any kittens on the active register if they are born to a queen which has had uterine inertia or a Caesarean section, even if this occurred in a previous litter. A replacement breeding queen could be kept if needed to preserve a line, but should be carefully monitored for any recurrence of the condition.

### **Size**

The Singapura is a breed with moderate type and no extremes. The GCCF standard asks for the cat to be small to medium, so medium is acceptable and selecting for increasingly smaller and smaller size is undesirable. Multigenerational selection for smallness could result in unhealthy outcomes. Neither overly small nor overly large Singapuras are good candidates for breeding.

### **Other Faults**

GCCF standard list of withholding faults is available on the GCCF website and it lists defects which can occur in any breed. Breeders and exhibitors should be aware of the faults on this list and should not intentionally breed from cats displaying them.

### **EVALUATING KITTENS FOR BREEDING**

Breeders should make rational decisions on which kittens to retain for future breeding, or allow on the active register, based on a range of different factors. Animal breeding scientists use evaluation systems to calculate Estimated Breeding Values, or EBVs for animals. Cat breeders can use similar methods in a less formal way in order to evaluate kittens and make comparisons which can help to inform decisions.

There is a risk that breeders will make selections based on too limited a range of factors. The following should be taken into consideration;

- Closeness to the standard of points
- Number and severity of faults
- Temperament
- Health
- Development
- Co-efficient of Inbreeding
- Generational Level
- Parental/familial breeding history
- Fit with breeder's breeding goals
- Breeder's intuition

Breeding evaluation scoresheets are available for breeders to use to make assessments of their kittens.

### **MENTORING**

All new Singapura breeders should start under the guidance of a mentor, who is an experienced breeder and has already bred a number of litters of Singapura cats. This is especially important for novice breeders with little or no prior experience of cat breeding, but support should also be available to breeders who may have experience of other breeds but are new to the Singapura breed. If a new breeder does not have a mentoring relationship with the breeder of their cat a mentor will be identified through the one of the Singapura BAC's constituent clubs.

All breeders are strongly recommended to participate in ongoing education and development about cat breeding through participation in appropriate discussion forums, seminars and cat clubs.

## **BAC RECOMMENDATIONS**

The BAC recommends that breeders re-read this breeding policy, as well as the general GCCF Breeding Policy, the Singapura Registration Policy and the Singapura Standard of Points at least once a year.

Breeders will be encouraged to take advantage of any relevant official scheme, which may be devised by the BAC to test the soundness of the Singapura breed.

Singapura breeders are encouraged to work closely with other like-minded breeders to improve the breed whilst maintaining a diverse gene pool.

Breeders are urged to observe the GCCF Code of Ethics and the recommendations of the GCCF, and the advice of their own veterinary surgeons regarding cat welfare, the importance of neutering, health, inoculations etc.

The BAC recommends that breeders should think carefully before selling any Singapura cats on the active register, taking into consideration the purchaser's experience, and that no kitten should be sold on the active register to a breeder new to the breed without ensuring that a mentoring relationship is in place, either with the breeder of the kitten or another suitably experienced breeder.

For further reading on cat genetics and breeding practices breeders are advised to refer to: "Robinson's Genetics for Cat Breeders & Veterinarians" by Vella, Shelton, McGonagle and Stanglein, published by Butterworth & Heinemann.

*The Singapura Breed Advisory Committee*