The Genetic Diversity of Salukis in the United States

by
Savannah Van Why

A THESIS

submitted to

Oregon State University

Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Biochemistry and Molecular Biology
(Honors Scholar)

Presented May 22, 2018
Commencement June 2018

AN ABSTRACT OF THE THESIS OF

Savannah Van Why for the degree of Honors Baccalaureate of Science in Biochemistry and Molecular Biology presented on May 22, 2018. Title: The Genetic Diversity of Salukis in the United States.

Abstract approved:____

Michelle Kutzler

Many domesticated animals, especially dogs, are selectively bred within a small population to select for and "fix" certain traits. This leads to decreasing genetic diversity and the potential for inherited health issues over time. The Saluki is a relatively rare breed of dog in the U.S. The Society for the Perpetuation of Desert Bred Salukis records information about Salukis imported into the U.S. from the Middle East (desert-bred) for breeding purposes. We hypothesized that desert-bred Salukis add diversity to the gene pool which is demonstrated by decreasing the coefficient of inbreeding (COI). Popular parents are more likely to be bred outside their line; they have a large number of desirable traits that other kennels want to work into their own lines. Therefore, we also hypothesized that the progeny of popular parents (at least four mating partners) will have a lower COI than the progeny of less popular parents (three or fewer mating partners). Data was collected from the online breed archive for Salukis born from 1986 to 2016. The coefficient of inbreeding was calculated using the tabular method. The coefficient of inbreeding for Salukis with desert bred ancestors that had six full generations available was significantly higher than for Salukis with desert bred ancestors that had only two generations. The coefficient of inbreeding Salukis with desert bred ancestors that had 2-6 full generations was significantly lower compared to Salukis with no desert-bred ancestors in ≥7 full generations. In addition, there was a trend for the coefficient of inbreeding in the all of the offspring of popular parents to be lower than the coefficient of inbreeding for Salukis who were not from popular parents. The average COI levels seen in all subsets analyzed were at low levels that would lead to modest to nonexistent detriments.

Key Words: American Kennel Club, Breed archive, Coefficient of inbreeding, Desert-bred Salukis, Inbreeding, Popular parents, Society for the Perpetuation of Desert Bred Salukis

Corresponding e-mail address: vanwhys@oregonstate.edu

The Genetic Diversity of Salukis in the United States

by
Savannah Van Why

A THESIS

submitted to

Oregon State University

Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Biochemistry and Molecular Biology
(Honors Scholar)

Presented May 22, 2018
Commencement June 2018

Honors Baccalaureate of Science in Biochemistry and Molecular Biology project of Savannah Van Why presented on May 22, 2018.

APPROVED:

Michelle Kutzler, Mentor, representing Animal and Rangeland Sciences

---

Timothy Hazzard, Committee Member, representing Animal and Rangeland Sciences

---

Reni Stewart, Committee Member, representing Chintimini Kennel Club

---

Toni Doolen, Dean, Oregon State University Honors College

I understand that my project will become part of the permanent collection of Oregon State University, Honors College. My signature below authorizes release of my project to any reader upon request.

Savannah Van Why, Author

ACKNOWLEDGEMENTS

I would like to thank my thesis advisor, Dr. Kutzler, for her assistance throughout my thesis project. I would also like to thank my committee members, Dr. Hazzard and Mrs. Stewart, for their help with my thesis project and Dr. Howard Meyer for his assistance with the statistical analyses completed. Finally, I would like to dedicate my thesis to Luka, my first Saluki and the inspiration for my thesis.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF APPENDICES

I. Introduction

I. A. Domestication and Purpose

Salukis are a breed of dog that originated in the Middle East at least 5,000 years ago. The nomadic Bedouin people of North Africa and the Arabian Peninsula began breeding and keeping Salukis to chase prey such as hares and gazelles (Saluki Club of America, 2017). The exact origin of the Saluki's name may refer to one of several places. There is an Arabic word "Saluqi," which describes things from Saluq or Saluqiyah; however, there were two ancient places called Saluq and three called Saluqiyah that the breed may have been named after (Clark, 2009a).

Most dogs were considered unclean in Islamic cultures and weren't allowed into tents or even to be touched by Muslims (Saluki Club of America, 2017). Salukis were an exception; they were allowed into their owners' tents and called "clean" because they were considered sacred gifts (Saluki Club of America, 2017). Young Salukis were first trained to hunt jerboas (nocturnal jumping rodents) then later sent after larger prey such as hares (van Hecke, 2009). Salukis received much of the same food as their owners, and they were often finicky about their food, refusing stale food and dirty water (van Hecke, 2009).

Several physical characteristics were developed from the need for Salukis to see and chase down prey. The Saluki's head is long and narrow; due to its purpose of medium-distance chases, it has a larger heart than the average dog (Belkin, 1993). Salukis also have a well-muscled, moderately long neck; if one needs to catch prey that suddenly turned, it may twist its neck around to catch it, and in the process, it may fall (Belkin, 1993). The long neck allows the Saluki to reach for prey, while the muscle allows them to withstand falling and tumbling (Belkin, 1993). The legs of a Saluki are muscular, and its coat has no thick undercoat (Belkin, 1993). Beyond that, Salukis were ran on a wide variety of terrain and chased many prey animals. Traits such as back length, foot shape, tail weight and build, and overall size vary as a result (Belkin, 1993). In addition, Salukis have varying amounts of feathering, or silky hair found in specific locations, including the ears, the backs of legs, between the toes, and on the underside of the tail. Salukis have thin skin, so their feathering can protect them from sand and heat. Feathering on a Saluki's feet protects them when running on sand and rocks, and feathering on the rest of the Saluki can protect its legs and tail when it lies down (Belkin, 1993). While some Salukis have dense feathering, others have very sparse feathering or no feathers at all. These unfeathered Salukis are called smooth Salukis (Saluki Club of America, 2017).

Due to the geographical spread of Salukis and the similarities between them and a few other breeds from northern Africa and the Arabian Peninsula, the relation between Salukis and certain other breeds have been questioned. One of these questions was whether Salukis and Sloughis are separate breeds since Sloughis and smooth Salukis look extremely similar. This was further complicated by the fact that both breeds are referred to by both names in Arabic (Crapon de Crapona and Fritzch, 2004). Crapon de Crapona and Fritzch (2004) used mitochondrial DNA to confirm that Sloughis and Salukis are separate, distinct breeds despite external appearances.

Salukis vary much more between populations in their region of origin than many breeds due to the wide geographic spread of this breed (Clark, 2009a). This variation developed as groups of people settled and bred dogs for their locations and available game (Clark, 2009a). One notable, non-genetic difference in the appearance of Salukis between their region of origin and western countries is the prevalence of cropped ears in countries of origin (Clark, 2009c). People gave various reasons for cropping the ears, and it was most common in Kurdish areas. These reasons included beauty, speed, damage prevention, and identification (Clark, 2009c).

In Kalar (northeast Iraq), Salukis are bulky, tall (dogs are an average of 27 inches tall), and have light feathering (Clark, 2013). In Tel Afar (northwest Iraq), Clark met a hunter named Subhi; he kept a line of Salukis his family had bred for generations, and he only used smooth Salukis because he believed the feathered Salukis were all crossed with other breeds (Clark, 2013). In Rutba (western Iraq), Salukis are usually well-feathered due to the area’s cold winters (Clark, 2013). Near Baghdad, Salukis are moderately feathered; in Baghdad and throughout the rest of Iraq, Salukis varied widely in build and feathering (Clark, 2013).

In the Arabian Peninsula, several varieties of Saluki are present due to modern transport of Salukis between countries (Clark, 2015a). However, one variety was more common in the Arabian Peninsula than the others, indicating it may have originated on the Arabian Peninsula. This variety is muscular, smooth, and has a lower ear set and a wider, rounded skull than most varieties of Saluki (Clark, 2015a). In Abu Dhabi, the Salukis are more compact and lightly feathered compared to those in England and the United States (Clark, 2015a).

Syrian Salukis tend to fall into four varieties; some are similar to those seen in the Arabian Peninsula, some have pronounced tucks and lighter builds, some are stocky and well-feathered, and some are similar to these but are smooth or almost smooth (Clark, 2009c). Near Hama, hounds wear coats in winter, so their feathering isn't needed to keep them warm; their owners also put henna on their feet, both for appearance and to protect their feet (Clark, 2009c).

Salukis in Iran are often well-muscled and are rare today due to the decline in open space and game to hunt as well as laws prohibiting all dogs, including Salukis, from being seen in public (Clark, 2009b). Salukis in eastern Turkey look like those seen in Syria; Southwestern Anatolia includes a few Salukis with turned back ears (Clark, 2012a).

Over the centuries, Salukis' geographic spread grew further with dogs imported from Uzbekistan to Germany (Clark, 2015b). The populations of hound housed in the Kyrgyzstan's mountains shift gradually from more Saluki-like hounds through Taigans (a breed from Kyrgyzstan) to Afghan Hounds (Clark, 2015b). In China, a hound known as the Xigou exists that looks very similar to Salukis. While the Xigou is noted as different from Salukis due to a different muzzle shape (a "sheep's head" or "banana-shaped nose"), many Xigou have straight noses and look almost identical to Salukis seen throughout the Middle East (Clark, 2015b).

What is most likely the most notable "country of origin" is in fact on the edge of the Saluki's region of origin. The Honorable Florence Amherst first imported hounds from Egypt in 1895; she was one of the first involved in establishing the western breeding lines (Clark, 2012b). Unfortunately, Salukis are now rare in Egypt due to an official hunting ban and less land for hunting (Clark, 2012b).

I. B. Bringing the Saluki to England and the United States

Prior to 1895, there were very few Salukis in England; these were brought by soldiers and travelers, and they were not often exhibited at dog shows. The Honorable Florence Amherst was in Egypt in 1894 when she and her family visited an Englishman named Wilfred Jennings-Bramly at the Giza Zoological Gardens. While touring the gardens, she saw a few Salukis owned by Jennings-Bramly's tracker, Dau. Before leaving Egypt, she visited Jennings-Bramly and asked him to find a pair of Salukis for her (Duggan, 2009). In November 1895, her first two Saluki puppies arrived at her home, sent by Jennings-Bramly. She later bred them; she would not always register the puppies, but by 1904, she had at least ten Salukis (Duggan, 2009). The Honorable Florence Amherst wrote down many traits of the breed; she also had trouble deciding what to call them, and she referred to the breed interchangeably as Salukis, Persian Greyhounds, and Gazelle Hounds (Duggan, 2009). This was also how the spelling of Saluki changed from the more direct spelling "Saluqi" (Clark, 2009a).

A Saluki named Sarona Kelb was born in 1919 in Damascus; Brigadier-General F. Lance later brought him to England. This dog was an important influence on the breed due to his use as a stud dog (Duggan 2009). He was one of many Salukis that were taken to Western Europe by those involved in rearranging the political boundaries in the Middle East after World War I. As the number of Salukis in Europe grew, Brigadier-General F. Lance and The Honorable Florence Amherst formed the first Western Saluki-centric club, the Saluki or Gazelle Hound Club, in 1923. This was also when the Kennel Club of England recognized the breed (Saluki Breed History, 2007). Their breed Standard is flexible and was written to allow for the full variety that is seen in Salukis in the Middle East (Saluki Breed History, 2007).

Starting in 1861, a few individual Salukis were taken to the United States; however, none of these were bred. The founding members of the breed in America weren't imported until later (Saluki Club of America, 2017). During the early 1920s, several Salukis were brought to the United States, both from the Middle East and from England (Saluki Club of America, 2017). In 1927, the Saluki Club of America (SCOA) formed, and the American Kennel Club (AKC) recognized the breed (Saluki Club of America). The SCOA and AKC adopted the 1923 breed standard from the Kennel Club of England; this standard has not changed in the United States since then (Saluki Breed History, 2007).

In 1930, Stephen Macomber, from Rhode Island, and Colonel Brydon Tennant, from Virginia, were among the earliest breeders in the United States. Their Salukis were mostly from two kennels: Brigadier-General Lance's kennel and Miss Barr's kennel (Saluki Club of America, 2017). Mrs. Hills from Massachusetts imported several Salukis from The Hon. Florence Amherst's kennel and helped Edward K. Aldrich start the Diamond Hill kennels in Rhode Island, which included dogs who later were used to start other kennel lines. These included the Jen Araby kennel and the Srinagar kennel, two lines on the west coast (Saluki Club of America, 2017).

In 1945, Mrs. Knapp obtained two desert-bred Salukis; this new addition was so beneficial to the breed that the AKC ruled these two Salukis' descendants could be registered (Saluki Club of America, 2017). This is a rare occurrence. The ruling in 1945 was the second time the AKC ever made such a ruling (Saluki Club of America, 2017). This line was then bred with the Diamond Hill line to produce several kennels (Saluki Club of America, 2017). Many American Salukis have ancestors from England (Saluki Breed Archive, 2006).

I. C. Health Issues for This Breed

According to a 2011 report from The Kennel Club (Britain's official national kennel club) and British Small Animal Veterinary Association Scientific Committee, the most common causes of death were liver cancer and lymphoma (The Kennel Club, 2011). Both of these diseases have risks associated with genetics (Dobson, 2013; Elvers et al., 2015). The report did not try to specify what percentage of liver cancers were primary liver cancer and what percentage was from other cancers that metastasized. Canine lymphoma is usually treated using chemotherapy; however, long-term survival usually does not occur (Pawlak et al., 2016).

Sighthounds, including Salukis, were all bred to chase down and kill prey, which requires a better ability to run quickly or for long distances than most non-sighthound breeds need. As a result, they have a long list of medically-relevant differences from other dogs that affect anesthesia (Court, 1999). Their lean bodies increase their risk of hypothermia while under anesthesia (Court, 1999). Since they were bred to run for moderate distances, they have more cells and less serum protein in a given volume of blood than other breeds. Preanesthetic blood work is often misinterpreted or difficult to interpret in these breeds (Court, 1999). Finally, their livers are less able to process drugs, causing certain anesthetics to need a longer recovery and increasing the risk of interactions between drugs (Court, 1999).

In addition, sighthounds have lower thyroid hormone concentrations than other breeds. As a result, they are often diagnosed with hypothyroidism while healthy, and they are at a higher risk for hypothyroidism (Zaldivar-Lopez et al., 2011). Hypothyroidism can cause lethargy, weight gain, exercise and cold intolerance, loss of coat quality, diarrhea, and several other symptoms (Mooney, 2011). While sighthounds have lower thyroid hormone concentrations than other breeds, they have breed-specific "normal" levels; if these are used instead of the generic values, a Saluki can be checked for hypothyroidism more accurately (Zaldivar-Lopez et al., 2011).

Sighthounds show signs of the "white-coat effect" on their blood pressure (Marino, 2011). In clinical settings, sighthounds have higher blood pressure readings than non-sighthounds and higher blood pressure readings than they have at home or in comfortable surroundings (Marino, 2011). Sighthounds show significantly lower amounts of the "white-coat effect" when blood pressures are taken at home instead of in a clinical room (Marino, 2011).

Salukis have several differences between their hearts and the average dog (Sist, 2010). Many Salukis have heart murmurs, arrhythmias, and enlarged hearts compared to other similar size breeds (Sist, 2010). The most common issue seen in the Salukis studied was thickening of nodes near the mitral valve, which prevents the valve from closing properly (Sist, 2010). This was severe enough to cause the death of 26 percent (25 of the 96) dogs studied (Sist, 2010). Hemangiosarcoma, a rare vascular cancer, was found in 24 of the dogs studied with over half of the dogs studied having at least one form of cancer that contributed to their deaths (Sist, 2010). Cardiac hemangiosarcoma was found in between .008% and .023% of dogs of other breeds, while it was found in 30.9% of Salukis reported in 2000 (Bell and Sist, 2000).

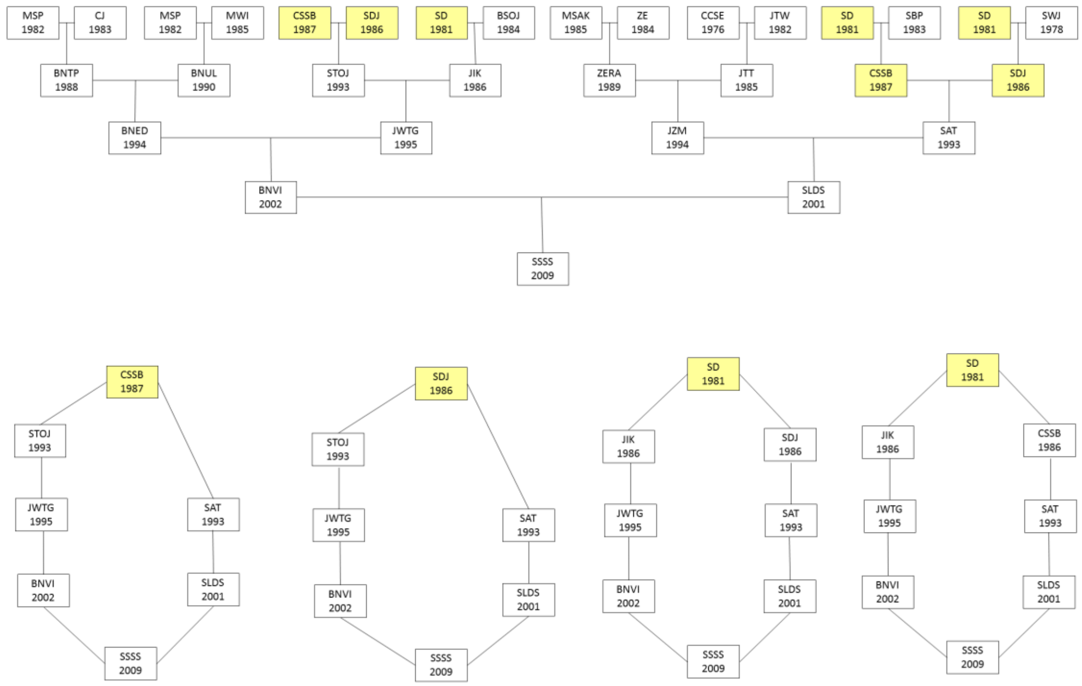
According to a survey by the Association of Veterinarians for Animal Rights, autoimmune hemolytic anemia and autoimmune thrombocytopenia both occurred frequently in Salukis (Sist, 2000). Autoimmune hemolytic anemia occurs when the immune system attacks its own red blood cells, causing the dog to have too few red blood cells (Swann and Skelly, 2016). Thrombocytopenia, on the other hand, occurs when the immune system attacks its own platelets (Chartier, 2015). This makes it more difficult for the blood to clot; and therefore injuries will not stop bleeding as quickly, and the dog will have many of the same symptoms as a hemophiliac (Chartier, 2015).

I. D. Inbreeding

Inbreeding involves breeding related animals to produce desired traits in offspring (Wright, 1922). When related animals are bred, they are more likely to produce an offspring with homozygous alleles inherited from the same ancestor at any given locus (Wright, 1922). These homozygous alleles may cause the offspring to have a desired trait, such as the breeder’s desired head shape for their Salukis; this benefit to inbreeding becomes more likely to occur with more closely related animals. However, many unfavorable traits can also occur and become difficult to remove from a line; this risk also increases with more closely related animals (Wright, 1922). By the early 1920s, people were aware of the benefits and risks of breeding related animals; however, there was no mathematical measurement for inbreeding and for benefits and risks.

A mathematical method for measuring inbreeding is called the coefficient of inbreeding (Wright, 1922). This method is used for measuring the benefits and risks of a mating by measuring the shift towards complete homozygosity seen as inbreeding increases (Wright, 1922). This is calculated by using pedigrees and determining the coefficients of inbreeding at each level. Calculating a dog's coefficient of inbreeding is more accurate and higher when a larger number of generations is included in the calculation (Wright, 1922). At low levels of inbreeding, which Miglior et al. defined as less than 12.5%, detrimental effects of inbreeding are modest to nonexistent (Miglior et al., 2012).

Wright proposed the equation $F_x = \sum[\left(\frac{1}{2}\right)^N (1 + F_A)]$ to calculate the coefficient of inbreeding of an individual (Wright, 1922). This equation is used for the "path method" of calculating the coefficient of inbreeding (Figure 1). F_x is the coefficient of inbreeding of the individual of interest, F_A is the coefficient of inbreeding for the common ancestor, and N is the number of individuals in a path from one parent to the other through the common ancestor (Food and Agriculture Organization of the United Nations, 1999). If the common ancestor's coefficient of inbreeding is unknown or is known to be zero, the equation is simplified to $F_x = \sum[\left(\frac{1}{2}\right)^N]$. If more



CSSB:
N=6
F_A=.1137

SDJ:
N=6
F_A=.2239

SD (path 1):
N=7
F_A=.1255

SD (path 2):
N=7
F_A=.1255

$$F_x = \sum\left[\left(\frac{1}{2}\right)^N (1 + F_A)\right]$$

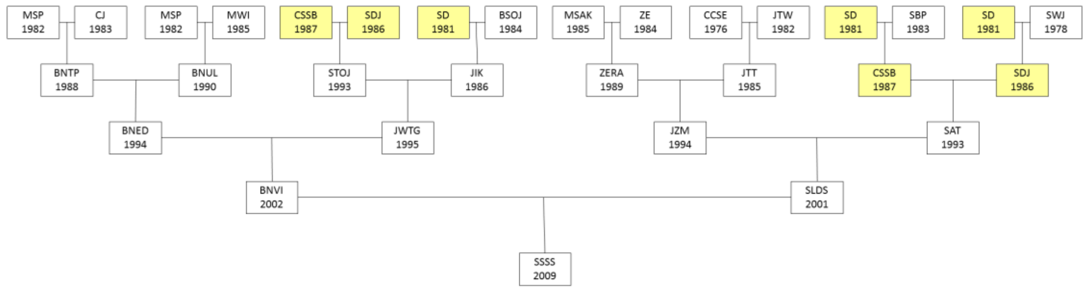
$$F_x = [\left(\tfrac{1}{2}\right)^6(1.1137)] + [\left(\tfrac{1}{2}\right)^6(1.2239)] + [\left(\tfrac{1}{2}\right)^7(1.1255)] + [\left(\tfrac{1}{2}\right)^7(1.1255)]$$

F_x = .054111=5.4111%

Figure 1. An example of calculating a coefficient of inbreeding from a four-generation pedigree using the path method. Boxes highlighted in yellow represent the common ancestors present in the pedigree. Note that two paths connected the sire and dam through the common ancestor labelled SD, so both paths contributed to the total coefficient of inbreeding.

than one path exists, each path contributes to the total F_x additively (Food and Agriculture Organization of the United Nations, n.d.).

The coefficient of inbreeding can also be calculated using the tabular method (Figure 2). Each individual involved in the tabular method is given a number, and these numbers are written from oldest to youngest in a row and column, forming the table used for the rest of the method (Christensen, 2003). The parents of each individual are listed above their number in the row. Next, all cells in a row and column of a matching individual are filled in with a 1. Then, the first row (for animal 1) is filled in; for each cell, the values in the animal's parents' cells for the first row are added together, and the total is divided by two (Christensen, 2003). If the parent of an ancestor is unknown, the parent's contribution is treated as zero. This value is then recorded in the cell. Once the row is filled in, the results are copied into the corresponding cells in the column for the first animal (Christensen, 2003). The process is repeated for each row and column, working from the oldest animal to the youngest. If an animal's parents are related, their relationship should be added to the "1" in the cell for that specific animal. The coefficient of inbreeding for the animal of interest is the value from the cell with the animal of interest in both its row and column minus one (Christensen, 2003).



	0	0	0	0	0	0	1/2	1/3	0	0	0	0	0	4/5	4/6	7/8	1/9	10/11	12/13	14/15	16/17	18/19	7/8	20/21	22/23	24/25
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
1	1	0	0	0	0	0	.5	.5	0	0	0	0	0	0	0	.5	.5	0	0	0	.5	0	.5	.25	.25	.25
2	0	1	0	0	0	0	.5	0	0	0	0	0	0	0	0	.25	0	0	0	0	.125	0	.25	.0625	.125	.09375
3	0	0	1	0	0	0	0	.5	0	0	0	0	0	0	0	.25	0	0	0	0	.125	0	.25	.0625	.125	.09375
4	0	0	0	1	0	0	0	0	0	0	0	0	0	.5	.5	0	0	0	0	.5	0	0	0	.25	0	.125
5	0	0	0	0	1	0	0	0	0	0	0	0	0	.5	0	0	0	0	0	.25	0	0	0	.125	0	.0625
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	.5	0	0	0	0	.25	0	0	0	.125	0	.0625
7	.5	.5	0	0	0	0	1	.25	0	0	0	0	0	0	0	.625	.25	0	0	0	0.4375	0	0.625	0.21875	.3125	.26563
8	.5	0	.5	0	0	0	.25	1	0	0	0	0	0	0	0	.625	.25	0	0	0	0.4375	0	0.625	0.21875	.3125	.26563
9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	.5	0	0	0	.25	0	0	.125	0	.0625
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	.5	0	0	0	.25	0	0	.125	.0625
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	.5	0	0	0	.25	0	0	.125	.0625
12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	.5	0	0	.25	0	0	.125	.0625
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	.5	0	0	.25	0	0	.125	.0625
14	0	0	0	.5	.5	0	0	0	0	0	0	0	0	1	.25	0	0	0	0	.625	0	0	0	.3125	0	.15625
15	0	0	0	.5	0	.5	0	0	0	0	0	0	0	.25	1	0	0	0	0	.625	0	0	0	.3125	0	.15625
16	.5	.25	.25	0	0	0	.625	.625	0	0	0	0	0	0	0	1.125	.25	0	0	0	.6875	0	.625	.34375	.3125	.32813
17	.5	0	0	0	0	0	.25	.25	.5	0	0	0	0	0	0	.25	1	0	0	0	.625	0	.25	.3125	.125	.21875
18	0	0	0	0	0	0	0	0	0	.5	.5	0	0	0	0	0	0	1	0	0	0	.5	0	0	.25	.125
19	0	0	0	0	0	0	0	0	0	0	0	.5	.5	0	0	0	0	0	1	0	0	.5	0	0	.25	.125
20	0	0	0	.5	.25	.25	0	0	0	0	0	0	0	.625	.625	0	0	0	0	1.125	0	0	0	.5625	0	.28125
21	.5	.125	.125	0	0	0	.4375	.4375	.25	0	0	0	0	0	0	.6875	.625	0	0	0	1.125	0	.4375	.562	.21875	.39063
22	0	0	0	0	0	0	0	0	0	.25	.25	.25	.25	0	0	0	0	.5	.5	0	0	1	0	0	.5	.25
23	.5	.25	.25	0	0	0	.625	.625	0	0	0	0	0	0	0	.625	.25	0	0	0	.4375	0	1.125	.21875	.5625	.39063
24	.25	.0625	.0625	.25	.125	.125	.21875	.21875	.125	0	0	0	0	.3125	.3125	.34375	.3125	0	0	.5625	.5625	0	.21875	1	.10938	.55469
25	.25	.125	.125	0	0	0	.3125	.3125	0	.125	.125	.125	.125	0	0	.3125	.125	.25	.25	0	.21875	.5	.5625	.10938	1	.55469
26	.25	.09375	.09375	.125	.0625	.0625	.265625	.265625	.0625	.0625	.0625	.0625	.0625	.15625	.15625	.32813	.21875	.125	.125	.28125	.39063	.25	.39063	.55469	.55469	1.05469

$$F_x = 1.05469 - 1 = 5.469\%$$

Figure 2. An example of calculating the coefficient of inbreeding from a four-generation pedigree using the tabular method. Boxes highlighted in yellow in the pedigree are individuals who occur multiple times in the pedigree. The cell highlighted in yellow is associated with the dog of interest, labeled as 26 in the table.

Purebred dogs recognized by kennel clubs have a closed gene pool, which can result in the levels of inbreeding to increase over time. The genetic diversity in a breed can be used to produce less inbred offspring by breeding two unrelated dogs together. The average coefficient of inbreeding for ten popular dog breeds using either five or ten generation pedigrees is 11.25% or 16.43%, respectively (Dreger et al., 2016). The Saluki has a reported average coefficient of inbreeding of 23.4% when calculated from single nucleotide polymorphism data and 15.9% when calculated from whole-genome sequencing data (Dreger et al., 2016).

Several methods have been tried to increase genetic diversity in purebred dogs. One method is importing and breeding to dogs from other countries (Oliehoek et al., 2009). Unfortunately, breeders may assume dogs from other countries aren't related and will choose the "best" representatives of their breed to import, possibly leading to related dogs being imported (Oliehoek et al., 2009). In addition, introducing a new sire but then breeding its offspring to unrelated dogs in the breed will remove most of the genetic diversity introduced by the new dog (Oliehoek et al., 2009).

More organized genetic interventions may be necessary to save the breed. The Norwegian Lundehund had an average coefficient of inbreeding of 87% in 2013 (Pfahler and Distl, 2013). The geneticists involved in this intervention suggested introducing multiple breeds with morphologic and genetic similarities to the Norwegian Lundehund to add genetic variation without disrupting the breed characteristics (Stronen et al., 2017). These breeds included Norwegian Buhunds, Icelandic Sheepdogs, and Noorbottenspets. It is too early to know how successful this intervention will be.

In Salukis, importing desert-breds (Salukis from the breed's countries of origin) to reduce the coefficient of inbreeding is a good solution. Salukis have a wide geographic range and several varieties of Salukis are seen. Desert-bred Salukis are genetically diverse, both from each other and from western-bred Salukis (Clark, 2009a). The Society for the Perpetuation of Desert Bred Salukis (SPDBS) registers Salukis with desert-bred ancestry, and the American Kennel Club (AKC) allows Salukis with three-generation pedigrees with the SPDBS into the AKC studbook as purebred Salukis (Society for the Perpetuation of Desert Bred Salukis, 2016). The genetic diversity seen in desert-bred Salukis, combined with the relative ease in importing and including them in the western breeding stock, makes reversing the coefficient of inbreeding feasible.

Popular parents may also influence the coefficient of inbreeding. For the purposes of this thesis, "popular" is defined with at least four self-reported mating partners over their lifetime. The average ± standard deviation number of mating partners for Salukis with at least one mating partner is 1.48 ± 1.02. Therefore, Salukis with four or more mating partners are at least two standard deviations away from the mean and represent the five percent of Salukis with the most mating partners. When a Saluki is bred to only a few mating partners, they are often bred to others in their line in an attempt to fix a certain trait in that line. Popular parents are more likely to be bred outside their own line; they often are high-winning dogs and therefore have a large number of desirable traits that other kennels want to work into their own lines. However, if a popular parent is bred often enough, it will be difficult to find mating partners for their offspring who are not half-siblings of those offspring. As a result, while a popular parent's offspring may have a lower average coefficient of inbreeding than a less popular parent's offspring, the offspring of litters from the popular parent may have a higher average coefficient of inbreeding.

Breeds with populations bred in countries with conformation shows (such as the United States) and separate populations in their countries of origin face a dilemma when considering how to preserve their breed. Breeding to dogs from the countries of origin (outcrossing) should decrease the average coefficient of inbreeding over time. However, the risk of these outcrosses in Salukis is that dogs from countries of origin may have a mixed heritage (not purebred), which is not desirable because it adds extreme variability to the phenotype. Since Saluki pedigrees are often not written in countries of origin, and breeders in the area will breed based on function or will use appearance to determine a dog's purity, a desert-bred may have a non-Saluki in its heritage without it being recorded as such in a pedigree. Data on Salukis, including coefficients of inbreeding and sires, is available on the Saluki Breed Archives website. This data can be collected and analyzed to determine how popular parents and desert-bred Salukis affect the Saluki gene pool in America.

I. E. Hypotheses

We hypothesize that desert-bred Salukis will add diversity to the gene pool, which will be demonstrated by decreasing the average coefficient of inbreeding. We also hypothesize that progeny of popular Saluki parents will have a lower average coefficient of inbreeding than progeny of less popular parents and that the progeny of litters from popular Saluki parents will have a higher average coefficient of inbreeding than the progeny of litters from Saluki parents that were not as popular.

II. Materials and Methods

II. A. Data Collection

Data was collected on all Salukis born from 1986 to 2016 in the self-reported breed database (n= 3327) at https://saluki.breedarchive.com/. The number of Salukis born in each decade included in the data collected is in Figure 3. Since this archive is self-reported, it is unknown how many Salukis registered by the American Kennel Club (AKC) are missing from this database. Data collected included the number of full generations in each Saluki's pedigree, the number of mating partners each Saluki had, and each Saluki's coefficient of inbreeding. The coefficient of inbreeding was calculated using the tabular method including seven generations.

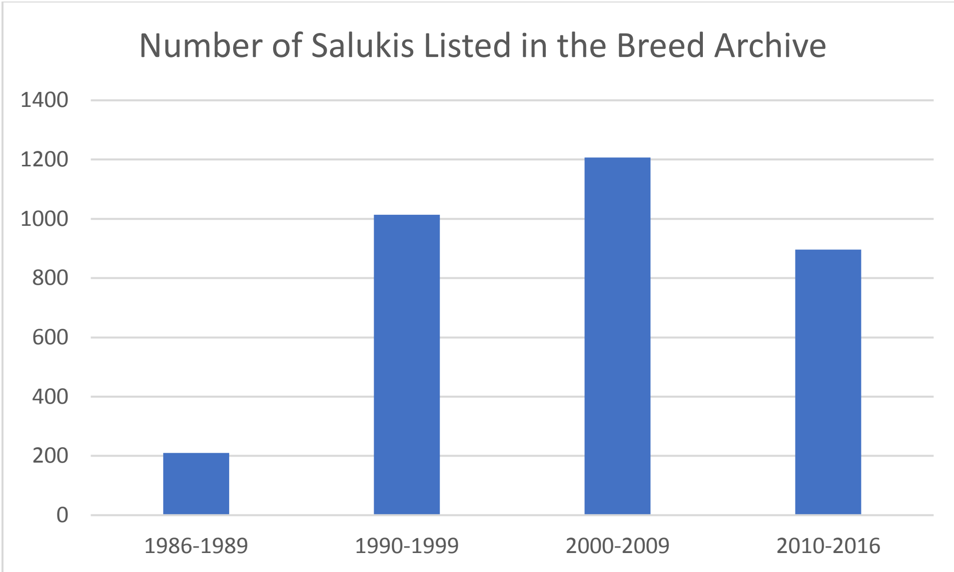


Figure 3. The number of Salukis whose data was recorded from the breed archive with AKC registration numbers by year born.

II. B. Data Analysis

The coefficients of inbreeding (average ± standard deviation) were determined for subsets of Salukis with recent desert-bred ancestors that had at least 2 full generations and up to 6 full generations in their pedigrees. The coefficients of inbreeding for Salukis with recent desert-bred ancestors were compared by the number of generations available using a one way analysis of variance (ANOVA; GraphPad Prism® v7, La Jolla, CA). The coefficient of inbreeding (average ± standard deviation) for all Salukis with AKC registration numbers without recent desert-bred ancestors (≥7 full generations in their pedigrees) was also determined. The coefficient of inbreeding for all Salukis with desert-bred ancestors in the past 2-6 generations was compared to the coefficient of inbreeding for Salukis with no recent desert-bred ancestors using a Students *t* test (Microsoft Excel® 2016, Redmond, WA). The coefficients of inbreeding (average ± standard deviation) for the offspring of popular parents with 4-7 mating partners (4F1) and the offspring of the 4F1 generation (4F2) as well as the offspring of popular parents with ≥8 mating partners (8F1) and the offspring of the 8F1 generation (8F2) were compared using a one way ANOVA (GraphPad Prism® v7). These coefficients of inbreeding were compared to the average coefficient of inbreeding for all Salukis who were not from popular parents using a Students *t* test (Microsoft Excel® 2016). Significance was defined as $p<0.05$.

III. Results

The coefficient of inbreeding for Salukis with desert bred ancestors that had six full generations available (6.15 ± 7.82) was significantly higher than for Salukis with desert bred ancestors that had only two generations (2.94 ± 4.88; $p=0.0426$; Figure 4). The coefficients of inbreeding for Salukis with desert-bred ancestors in the other generation subsets did not differ significantly. However, the coefficient of inbreeding Salukis with desert bred ancestors that had 2-6 full generations (n=504) was significantly lower (5.19 ± 7.14) compared to Salukis with no desert-bred ancestors in ≥7 full generations (n=2768; 8.62 ± 8.17; $p<0.0001$). With respect to popular parents, the coefficients of inbreeding for the offspring of Salukis with 4-7 mating partners (4F1) and their offspring (4F2) as well as the offspring of Salukis with ≥8 mating partners (8F1) and their offspring (8F2) did not differ significantly (Figure 5). However, there was a trend for the coefficient of inbreeding in the all of the offspring of popular parents (4F1, 4F2, 8F1, 8F2) (n=833) to be lower (7.61 ± 8.08) than the coefficient of inbreeding for Salukis who were not from popular parents (n=2514; 8.06 ± 8.14; $p=0.080$).

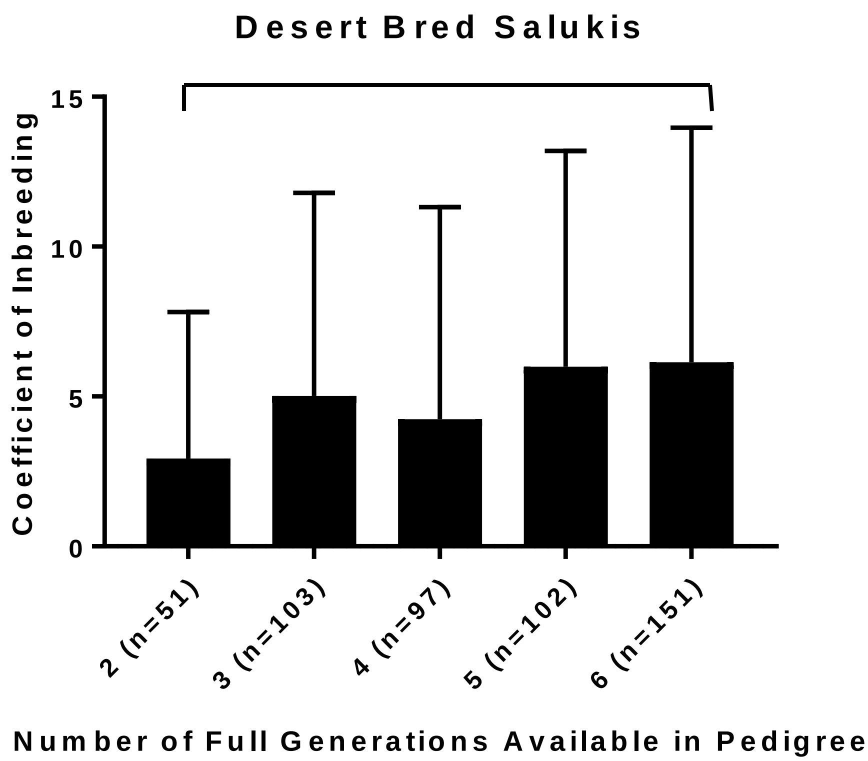


Figure 4. Coefficients of inbreeding (average ± standard deviation) for each subset of Saluki based on the number of full generations in their pedigrees. The average coefficient of inbreeding for Salukis with six full generations available is significantly higher than for Salukis with two full generations (brackets). The coefficients of inbreeding did not differ between the other generation subsets.

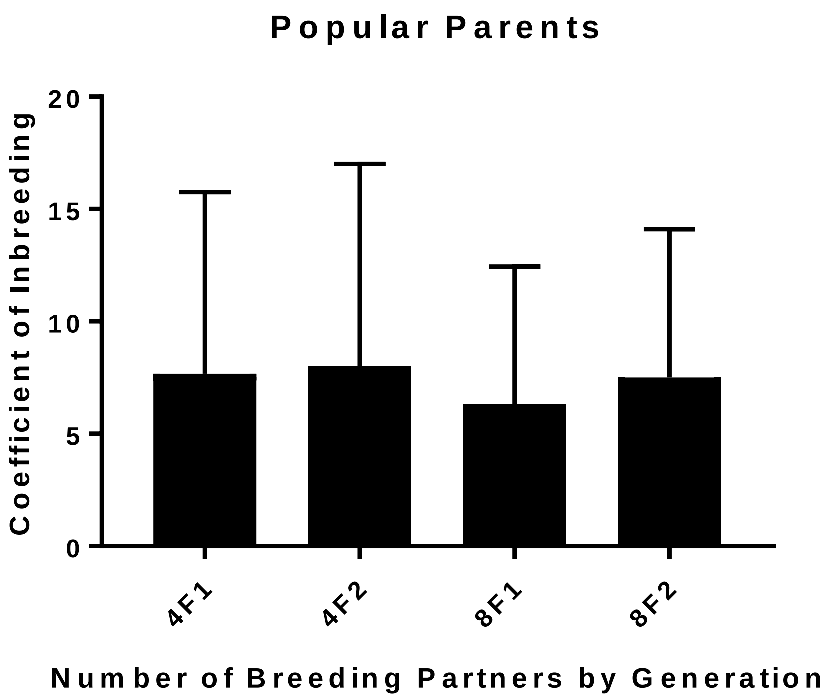


Figure 5. Coefficients of inbreeding (average ± standard deviation) for the offspring of Salukis with 4-7 mating partners (4F1) and their offspring (4F2) as well as the offspring of Salukis with ≥8 mating partners (8F1) and their offspring (8F2). The coefficients of inbreeding did not differ between the subsets of popular parents..

IV. Discussion

The coefficients of inbreeding of all subsets of Salukis in the United States studied were well below the value (12.5%) that has been associated with risks and detriments (Miglior et al., 1992). Having said this, Salukis with desert-bred ancestors in their recent pedigree (within the past 2-6 generations) had a significantly lower coefficient of inbreeding from those Salukis who did not have the incorporation of the desert-bred gene pool. Introduction of desert-bred lines could potentially decrease the rates of health issues seen in Salukis (e.g. liver cancers and lymphoma) as these problems are not reported in desert-bred and Middle Eastern Salukis. It should be noted that the coefficients of inbreeding calculated for Salukis with recent desert-bred ancestors may be actually lower than reported because direct desert-bred Salukis have at least one unlisted parent in their pedigrees, and most have no listed parents, these Salukis have an assumed coefficient of inbreeding of 0.00%.

The coefficients of inbreeding of did not differ between subsets of offspring from popular parents, but these offspring tended to have a lower coefficient of inbreeding than offspring from parents with fewer breeding partners (p=.00496). This is likely to be because when a Saluki is bred to only a few mating partners, they are often bred to others in their line in an attempt to fix a certain trait in that line. Popular parents are more likely to be bred outside their own line; they often are high-winning dogs and therefore have a large number of desirable traits that other kennels want to work into their own lines.

V. Conclusion and Future Studies

This thesis reviewed coefficients of inbreeding of Salukis available on the Saluki Breed Archives website with specific interest in the influence of popular parents and desert-bred Salukis on the coefficient of inbreeding. The coefficient of inbreeding for Salukis with desert bred ancestors was significantly lower compared to Salukis with no desert-bred ancestors. In addition, there was a trend for the coefficient of inbreeding in the offspring of popular parents to be lower than for Salukis who were not from popular parents.

It is important to mention that the coefficient of inbreeding is not the only way to measure genetic diversity in a population. Analyses of mitochondrial DNA and microsatellite DNA can be used to analyze genetic diversity more directly than relying on coefficients of inbreeding (Ghanatsaman et al., 2018, Irion et al., 2003). Analysis of microsatellite DNA and mitochondrial DNA in Salukis will provide more concrete, accurate information on the genetic diversity added by incorporating desert-bred Salukis into the American Saluki breeding pool. As such, an in-depth study of microsatellite markers could be more indicative of the genetic diversity added by introducing desert-bred Salukis to the American Saluki breeding pool than comparing the average coefficients of inbreeding for each portion of the population.

The genetic diversity added by introducing desert-bred Salukis to the American breeding pool and the presence of genetic markers and risk factors for health issues present in Salukis could also be analyzed by sequencing most or all of the genome in a large number of Salukis. Sequencing full genomes is becoming less expensive, faster, and more feasible. If the genomes of Salukis were sequenced and analyzed, several genetic risk factors and markers for health issues prevalent in the breed, such as liver cancer, lymphoma, and hemangiosarcoma, could be determined. Breeders could then use this information and genetic tests to determine whether to breed a Saluki without either risking producing a litter with a high risk for cancers or waiting until the Saluki is over halfway through their life to see if cancer develops before breeding.

VI. References

Belkin, D. (1993). The Functional Saluki [transcript]. Retrieved on 2/24/2018, from http://saluqi.home.netcom.com/belkin.htm

Bell, T., and Sist, M.D. (2000). Saluki Heart Hemangiosarcoma [Partial presentation outline]. Retrieved on 2/23/2018, from http://www.salukiclub.org/hemangiosarcoma.html

Chartier, M. (2015). Canine Primary (Idiopathic) Immune-Mediated Thrombocytopenia. Clinician's Brief 9: 82-86.

Christensen, K. (2003) Calculation of Inbreeding and Relationship, the Tabular Method. Retrieved on 6/3/2018, from http://www.ihh.kvl.dk/htm/kc/popgen/genetics/4/5.htm

Clark, T. (2009a). Desert-Bred Saluqis. Retrieved on 2/26/2018, from www.saluqi.net

Clark, T. (2009b). Saluqis in the Countries of Origin: Iran. Retrieved on 2/26/2018, from http://www.saluqi.net/id17.html

Clark, T. (2009c). Saluqis in the Countries of Origin: Syria and Jordan, Palestine and Israel. Retrieved on 2/26/2018, from http://www.saluqi.net/id16.html

Clark, T. (2012a). Saluqis in the Countries of Origin: Turkey. Retrieved on 2/26/2018, from http://www.saluqi.net/id19.html

Clark, T. (2012b). Saluqis on the periphery: North Africa. Retrieved on 2/26/2018, from http://www.saluqi.net/id20.html

Clark, T. (2013). Saluqis in the Countries of Origin: Iraq. Retrieved on 2/26/2018, from http://www.saluqi.net/id14.html

Clark, T. (2015a). Saluqis in the Countries of Origin: The Arabian Peninsula. Retrieved on 2/26/2018, from http://www.saluqi.net/id15.html

Clark, T. (2015b). Saluqis on the periphery: Central Asia and China. Retrieved on 2/26/2018, from http://www.saluqi.net/id21.html

Court, M.H. (1999). Anesthesia of the Sighthound. Clinical Techniques in Small Animal Practice 14(1): 38-43.

Crapon de Caprona, D., and Fritzch, B. (2004). Sloughi, Saluki, Saluqi… Retrieved on 2/25/2018, from http://sloughi.tripod.com/SFAA/MitochondrialDNA.html

Dobson, J.M. (2013). Breed-Predispositions to Cancer in Pedigree Dogs. ISRN Veterinary Science 941275. doi: 10.1155/**2013**/941275.

Dreger, D., Rimbault, M., Davis, B., Bhatnagar, A., Parker, H., Ostrander, E. (2016). Whole-genome sequence, SNP chips and pedigree structure: building demographic profiles in domestic dog breeds to optimize genetic-trait mapping. Disease Models and Mechanisms 9: 1445-1460.

Duggan, B. (2009). Saluki: The Desert Hound and the English Travelers Who Brought It to the West. Jefferson, NC: L McFarland & Company, Inc.

Elvers, I., Turner-Maier, J., Swofford, R., Koltookian, M., Johnson, J., Stewart, C., Shang, C.Z., Schumacher, S.E., Beroukhim, R., Rosenberg, M., Thomas, R., Mauceli, E., Getz, G., Di Palma, F., Modiano, J.F., Breen, M., Lindblad-Toh, K., and Alfoldi, J. (2015). Exome Sequencing of Lymphomas From Three Dog Breeds Reveals Somatic Mutation Patterns Reflecting Genetic Background. Genome Research 25: 1634-1645.

Food and Agriculture Organization of the United Nations (1999). Calculating Individual Inbreeding Values. Retrieved on 6/3/2018, from http://www.fao.org/docrep/006/x3840e/X3840E03.htm

Ghanatsaman, Z.A., Adeola, A.C., Fozi, M.A., Ma, Y., Peng, M., Wang, G., Esmailizadeh, A., Zhang, Y. (2018). Mitochondrial DNA Sequence Variation in Iranian Native Dogs. Mitochondrial DNA Part A 29(3): 394-402.

Irion, D.N., Schaffer, A.L., Famula, T.R., Eggleston, M.L., Hughes, S.S., Pedersen, N.C. (2003). Analysis of Genetic Variation in 28 Dog Breed Populations With 100 Microsatellite Markers. Journal of Heredity 94(1): 81-87.

Marino, C.L., Cober, R.E., Iazbik, M.C., and Couto, C.G. (2011). White-Coat Effect on Systemic Blood Pressure in Retired Racing Greyhounds. Journal of Veterinary Internal Medicine 25(4): 861-865.

Miglior, F., Szkotnicki, B., and Burnside, E.B. (1992). Analysis of Levels of Inbreeding and Inbreeding Depression in Jersey Cattle. Journal of Dairy Science 75(4): 1112-1118.

Mooney, C.S. (2011). Canine Hypothyroidism: A Review of Aetiology and Diagnosis. New Zealand Veterinary Journal 59(3): 105-114.

Oliehoek, P.A., Bijma, P., and van der Meijen, A. (2009). History and Structure of the Closed Pedigreed Population of Icelandic Sheepdogs. Genetics Selection Evolution 41(39): 39-50.

Pawlak, A., Obminska-Mrukowicz, B., Zbyryt, I., Rapak, A. (2016). In: Vitro Drug Sensitivity in Canine Lymphoma. Journal of Veterinary Research 60(1): 55-61.

Pfahler, S., Distl, O. (2013). A massive reduction of the genetic diversity in the Lundehund. Animal Genetics 45(1): 154.

Saluki Breed Archive. (2006). Retrieved on 2/25/2018, from https://saluki.breedarchive.com/home/index.

Saluki Breed History. (2007). Retrieved on 2/22/2018, from http://www.salukiclubvic.com.au/breed-history.html

Saluki Club of America (SCOA). (2017). About Salukis. Retrieved on 2/21/2018, from www.salukiclub.org/about-salukis.html

Sist, M.D. (2000) Saluki Health Survey: Results. Retrieved on 2/23/2018, from http://www.salukihealthresearch.com/SHR_survey_results.html

Sist, M.D. (2010). Heart Conditions. American Saluki Association Newsletter 2: 20-26.

Society for the Perpetuation of Desert Bred Salukis (SPDBS). (2016). About SPDBS. Retrieved on 2/21/2018, from http://www.desertbred.org/public/about_spdbs.htm

Stronen, A.V., Salmela, E., Baldursdottir, B.K., Berg, P., Espelien, I.S., Jarvi, K., Jensen, H., Kristensen, T.N., Melis, C., Manenti, T., Lohi, H., and Pertoldi, C. (2017). Genetic Rescue of an Endangered Domestic Animal Through Outcrossing with Closely Related Breeds: A Case Study of the Norwegian Lundehund. Public Library of Science ONE, 12(6), e0177429.

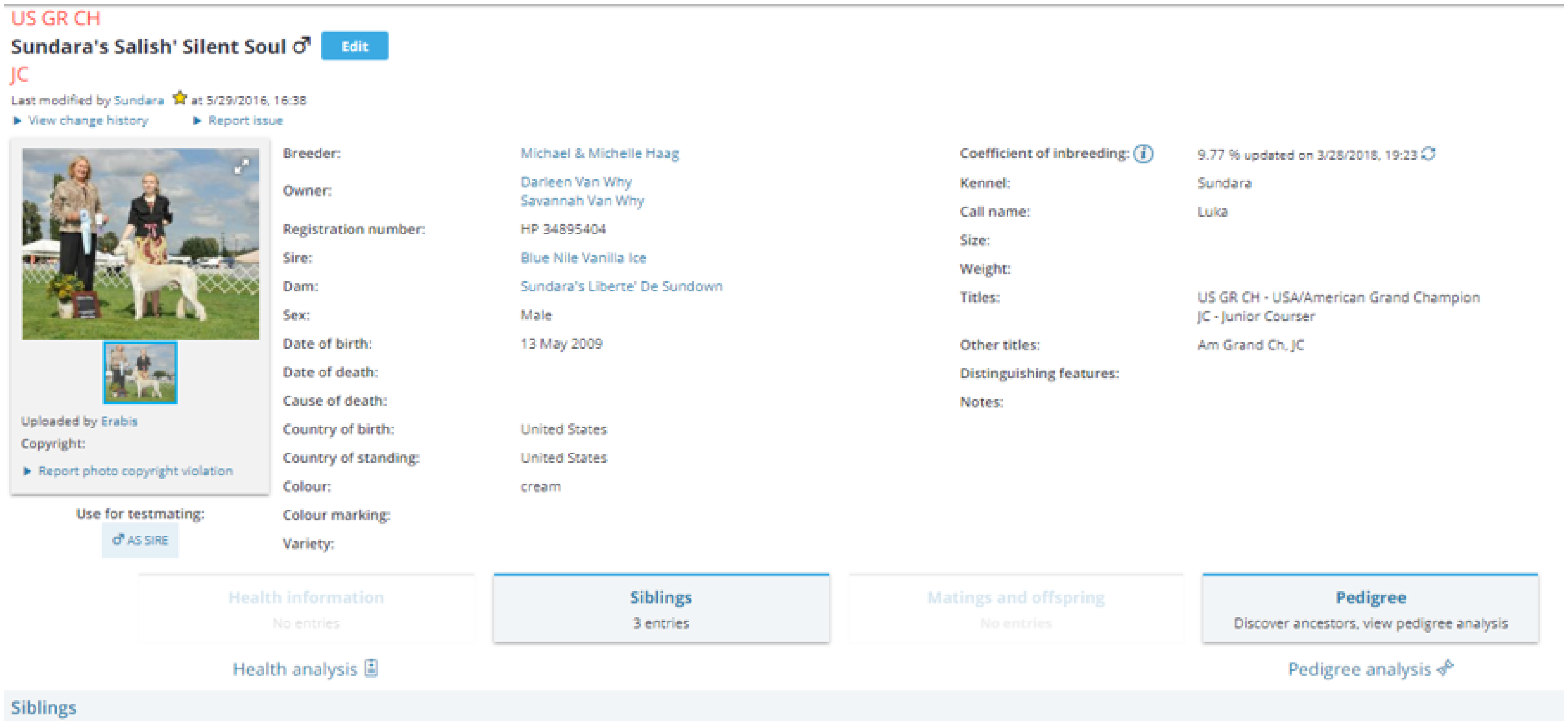
Swann, J., and Skelly, B. (2016). Canine Autoimmune Hemolytic Anemia: Management Challenges. Veterinary Medicine: Research and Reports 7: 101-112.

The Kennel Club and British Small Animal Veterinary Association Scientific Committee. (2011). Summary Results of the Purebred Dog Health Survey for the Saluki Breed. Retrieved on 2/23/2018, from https://web.archive.org/web/20110810142403/http://www.thekennelclub.org.uk/download/1619/hssaluki.pdf van Hecke, L. (2009). Hunting with hounds: Salukis could be a Bedouin's best friend. Retrieved on 2/22/2018, from www.thenational.ae/uae/hunting-with-hounds-salukis-could-be-a-bedouin-s-best-friend-1.529281

Wright, S. (1922). Coefficients of Inbreeding and Relationship. The American Naturalist 56(645): 330-338.

Zaldivar-Lopez, S., Marin, L.M., Iazbik, M.C., Westendorf-Stingle, N., Hensley, S., and Couto, C.G. (2011). Clinical Pathology of Greyhounds and Other Sighthounds. Veterinary Clinical Pathology 40(4): 1-19.

Appendix A. Saluki Breed Archive: an example of the information provided for each Saluki



US GR CH

Sundara's Salish' Silent Soul ♂ Edit

JC

Last modified by Sundara at 5/29/2016, 16:38

View change history

Report issue

Uploaded by Erabis

Copyright:

Report photo copyright violation

Use for testmating:

♂ AS SIRE

Breeder:	Michael & Michelle Haag
Owner:	Darleen Van Why Savannah Van Why
Registration number:	HP 34895404
Sire:	Blue Nile Vanilla Ice
Dam:	Sundara's Liberte' De Sundown
Sex:	Male
Date of birth:	13 May 2009
Date of death:	
Cause of death:	
Country of birth:	United States
Country of standing:	United States
Colour:	cream
Colour marking:	
Variety:	

Coefficient of inbreeding:	9.77 % updated on 3/28/2018, 19:23
Kennel:	Sundara
Call name:	Luka
Size:	
Weight:	
Titles:	US GR CH - USA/American Grand Champion JC - Junior Courser
Other titles:	Am Grand Ch, JC
Distinguishing features:	
Notes:	

Health information
No entries

Siblings
3 entries

Matings and offspring
No entries

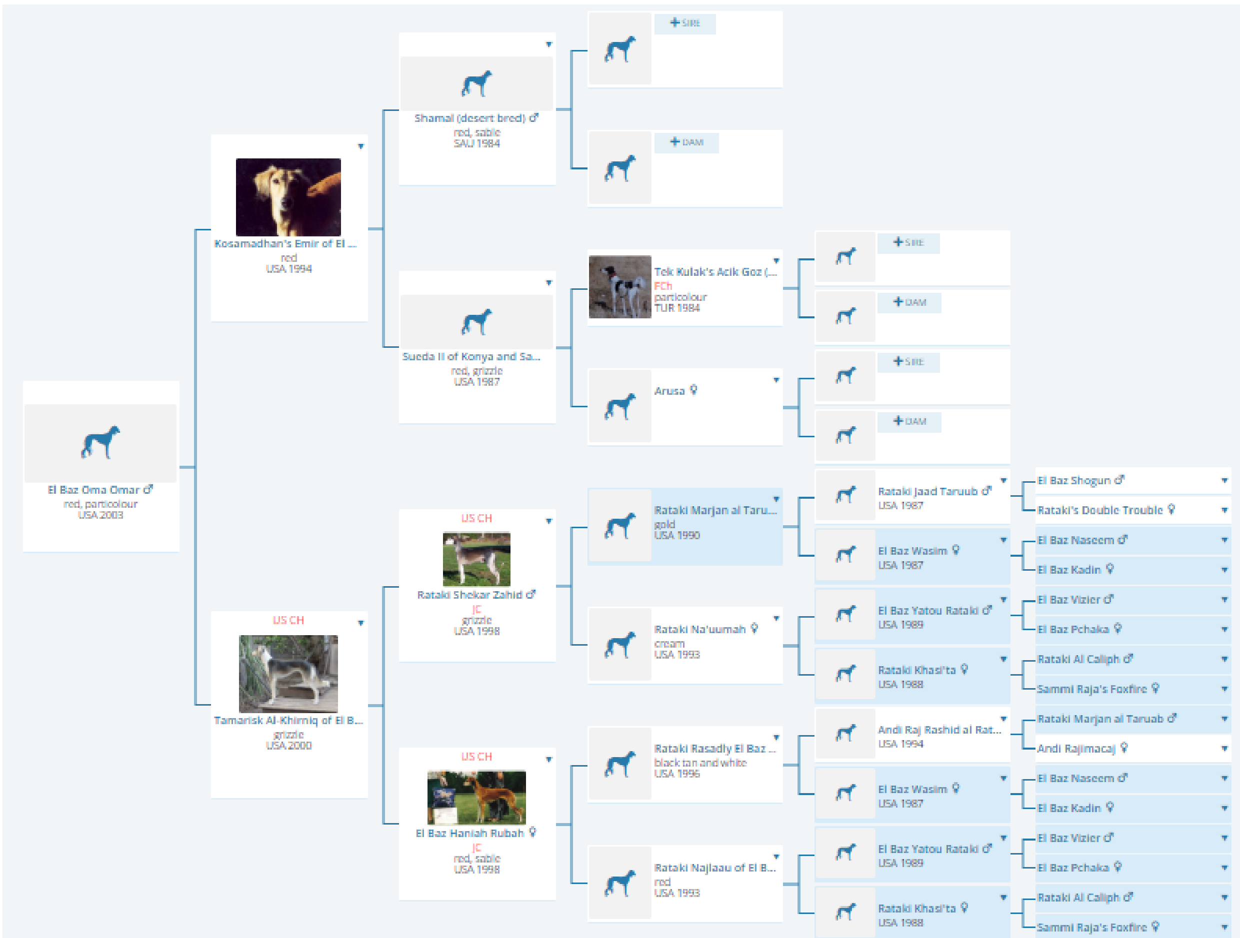
Pedigree
Discover ancestors, view pedigree analysis

Health analysis

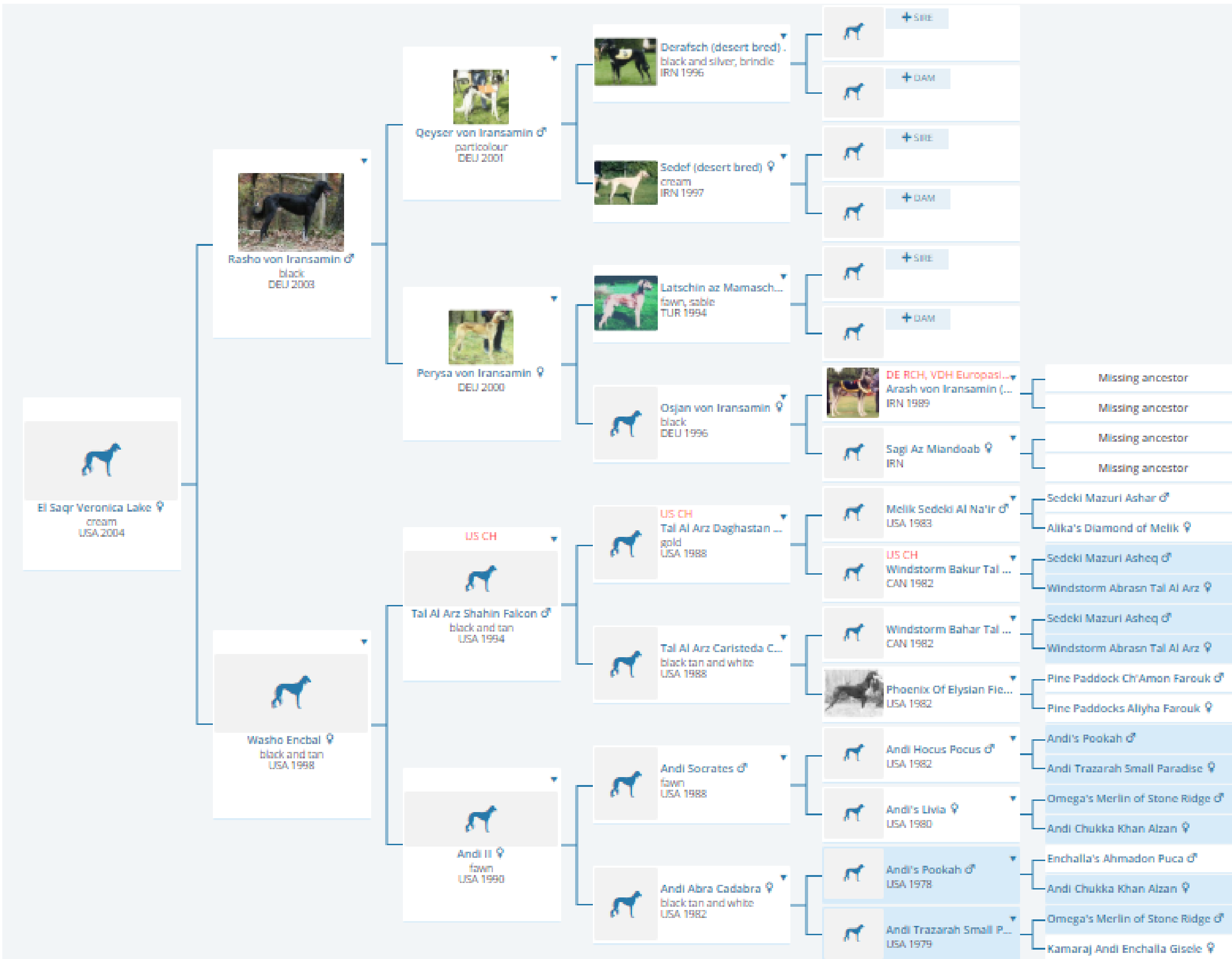
Pedigree analysis

Siblings

Appendix B. Pedigree with two full generations. Although his dam has at least four full generations in her pedigree, his sire had only one full generation in his pedigree.



Appendix C. Pedigree with three full generations. The Saluki below has three full generations in her pedigree.

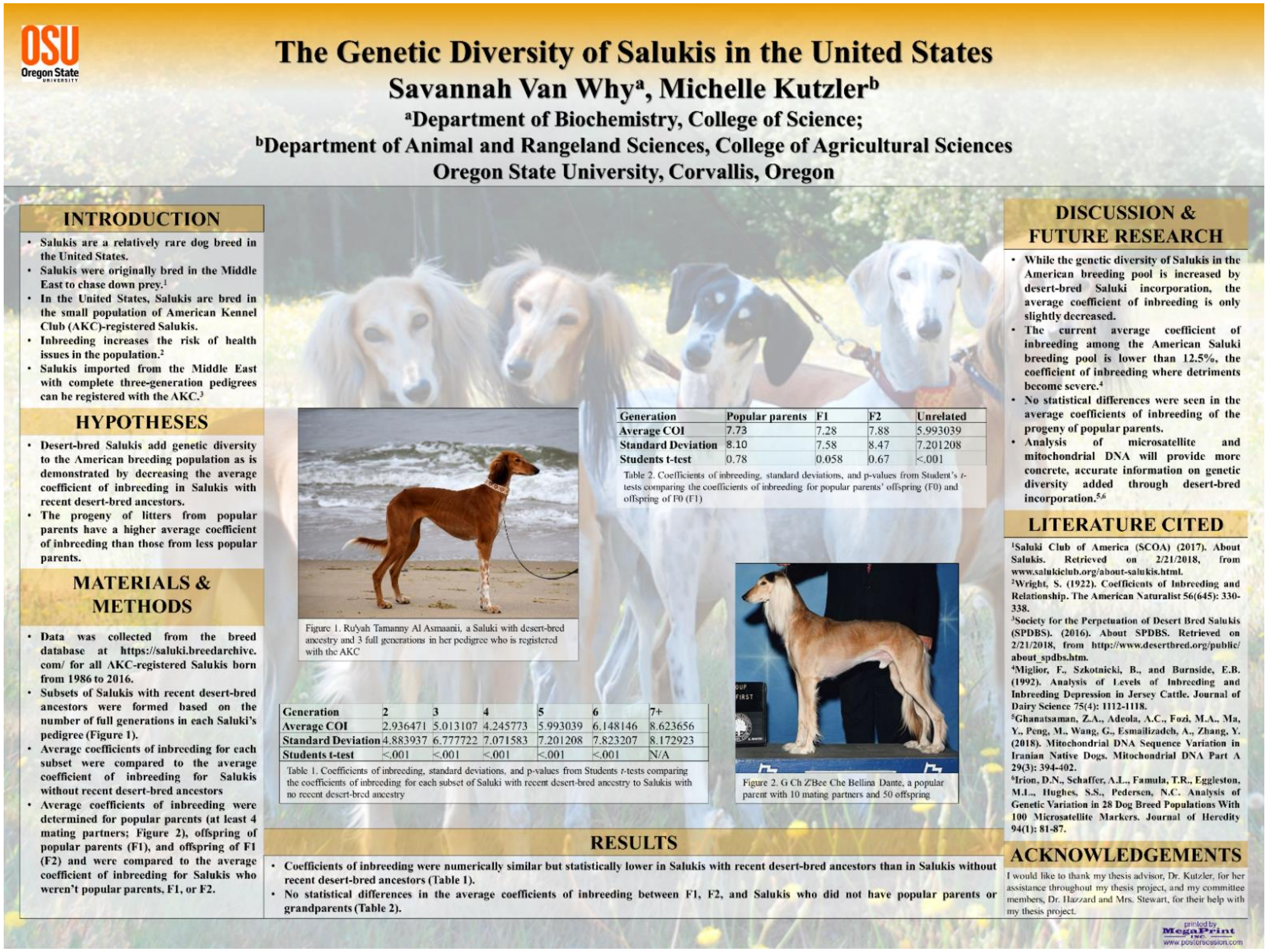


Appendix D. CUE abstract

Many domesticated animals, especially dogs, are selectively bred within a small population to select for and "fix" certain traits. This leads to decreasing genetic diversity and the potential for inherited health issues over time. The Saluki is a relatively rare breed of dog in the United States. Since the early 1970s, the Society for the Perpetuation of Desert Bred Salukis (SPDBS) has been recording information about Salukis imported from the Middle East (desert-bred). SPDBS-registered Salukis with complete three-generation pedigrees are recognized as purebred Salukis for American Kennel Club (AKC) conformation shows and breeding purposes. We hypothesized that desert-bred Salukis add diversity to the gene pool which is demonstrated by decreasing the coefficient of inbreeding (COI). We also hypothesized that the progeny of litters from popular parents (at least four mating partners) have a higher COI than the progeny of litters from less popular parents (three or fewer mating partners). Data was collected from the online Saluki breed archive for Salukis born from 1986 to 2016. The average COIs were determined for subsets of Salukis with recent (within the past six generations) desert-bred ancestors and compared to the average COI of Salukis without recent desert-bred ancestors using a Students t test. Subsets including popular parents, the offspring of popular parents (F1), and the offspring of the F1 generation (F2) were determined, and their average COIs were calculated. These COIs were compared to the average COIs for all Salukis who weren't popular parents, F1, or F2 using a Students t test. The average COI for Salukis with recent desert-bred ancestors was statistically significantly lower than the average COI for Salukis without recent desert-bred

ancestors. No significant difference was seen between the progeny of popular parents and progeny of less popular parents. The average COI levels seen in all subsets analyzed were at low levels that would lead to modest to nonexistent detriments.

Appendix E. CUE and Honors College Poster.



The Genetic Diversity of Salukis in the United States

Savannah Van Why[a], Michelle Kutzler[b]

[a]Department of Biochemistry, College of Science;

[b]Department of Animal and Rangeland Sciences, College of Agricultural Sciences

Oregon State University, Corvallis, Oregon

INTRODUCTION

- Salukis are a relatively rare dog breed in the United States.
- Salukis were originally bred in the Middle East to chase down prey.[1]
- In the United States, Salukis are bred in the small population of American Kennel Club (AKC)-registered Salukis.
- Inbreeding increases the risk of health issues in the population.[2]
- Salukis imported from the Middle East with complete three-generation pedigrees can be registered with the AKC.[3]

HYPOTHESES

- Desert-bred Salukis add genetic diversity to the American breeding population as is demonstrated by decreasing the average coefficient of inbreeding in Salukis with recent desert-bred ancestors.
- The progeny of litters from popular parents have a higher average coefficient of inbreeding than those from less popular parents.

MATERIALS & METHODS

- Data was collected from the breed database at https://saluki.breedarchive.com/ for all AKC-registered Salukis born from 1986 to 2016.
- Subsets of Salukis with recent desert-bred ancestors were formed based on the number of full generations in each Saluki's pedigree (Figure 1).
- Average coefficients of inbreeding for each subset were compared to the average coefficient of inbreeding for Salukis without recent desert-bred ancestors
- Average coefficients of inbreeding were determined for popular parents (at least 4 mating partners; Figure 2), offspring of popular parents (F1), and offspring of F1 (F2) and were compared to the average coefficient of inbreeding for Salukis who weren't popular parents, F1, or F2.

Figure 1. Ru'yah Tamanny Al Asmaanii, a Saluki with desert-bred ancestry and 3 full generations in her pedigree who is registered with the AKC

Generation	Popular parents	F1	F2	Unrelated
Average COI	7.73	7.28	7.88	5.993039
Standard Deviation	8.10	7.58	8.47	7.201208
Students t-test	0.78	0.058	0.67	<.001

Table 2. Coefficients of inbreeding, standard deviations, and p-values from Student's *t*-tests comparing the coefficients of inbreeding for popular parents' offspring (F0) and offspring of F0 (F1)

Generation	2	3	4	5	6	7+
Average COI	2.936471	5.013107	4.245773	5.993039	6.148146	8.623656
Standard Deviation	4.883937	6.777722	7.071583	7.201208	7.823207	8.172923
Students t-test	<.001	<.001	<.001	<.001	<.001	N/A

Table 1. Coefficients of inbreeding, standard deviations, and p-values from Students *t*-tests comparing the coefficients of inbreeding for each subset of Saluki with recent desert-bred ancestry to Salukis with no recent desert-bred ancestry

Figure 2. G Ch Z'Bee Che Bellina Dante, a popular parent with 10 mating partners and 50 offspring

RESULTS

- Coefficients of inbreeding were numerically similar but statistically lower in Salukis with recent desert-bred ancestors than in Salukis without recent desert-bred ancestors (Table 1).
- No statistical differences in the average coefficients of inbreeding between F1, F2, and Salukis who did not have popular parents or grandparents (Table 2).

DISCUSSION & FUTURE RESEARCH

- While the genetic diversity of Salukis in the American breeding pool is increased by desert-bred Saluki incorporation, the average coefficient of inbreeding is only slightly decreased.
- The current average coefficient of inbreeding among the American Saluki breeding pool is lower than 12.5%, the coefficient of inbreeding where detriments become severe.[4]
- No statistical differences were seen in the average coefficients of inbreeding of the progeny of popular parents.
- Analysis of microsatellite and mitochondrial DNA will provide more concrete, accurate information on genetic diversity added through desert-bred incorporation.[5,6]

LITERATURE CITED

[1]Saluki Club of America (SCOA) (2017). About Salukis. Retrieved on 2/21/2018, from www.salukiclub.org/about-salukis.html.

[2]Wright, S. (1922). Coefficients of Inbreeding and Relationship. The American Naturalist 56(645): 330-338.

[3]Society for the Perpetuation of Desert Bred Salukis (SPDBS). (2016). About SPDBS. Retrieved on 2/21/2018, from http://www.desertbred.org/public/about_spdbs.htm.

[4]Miglior, F., Szkotnicki, B., and Burnside, E.B. (1992). Analysis of Levels of Inbreeding and Inbreeding Depression in Jersey Cattle. Journal of Dairy Science 75(4): 1112-1118.

[5]Ghanatsaman, Z.A., Adeola, A.C., Fozi, M.A., Ma, Y., Peng, M., Wang, G., Esmailizadeh, A., Zhang, Y. (2018). Mitochondrial DNA Sequence Variation in Iranian Native Dogs. Mitochondrial DNA Part A 29(3): 394-402.

[6]Irion, D.N., Schaffer, A.L., Famula, T.R., Eggleston, M.L., Hughes, S.S., Pedersen, N.C. Analysis of Genetic Variation in 28 Dog Breed Populations With 100 Microsatellite Markers. Journal of Heredity 94(1): 81-87.

ACKNOWLEDGEMENTS

I would like to thank my thesis advisor, Dr. Kutzler, for her assistance throughout my thesis project, and my committee members, Dr. Hazzard and Mrs. Stewart, for their help with my thesis project.