FUTURE DIRECTIONS:
THE BSD HEALTH SURVEY 2019

Celebrating the health and well-being of the
Belgian Shepherd Dog
in Australia

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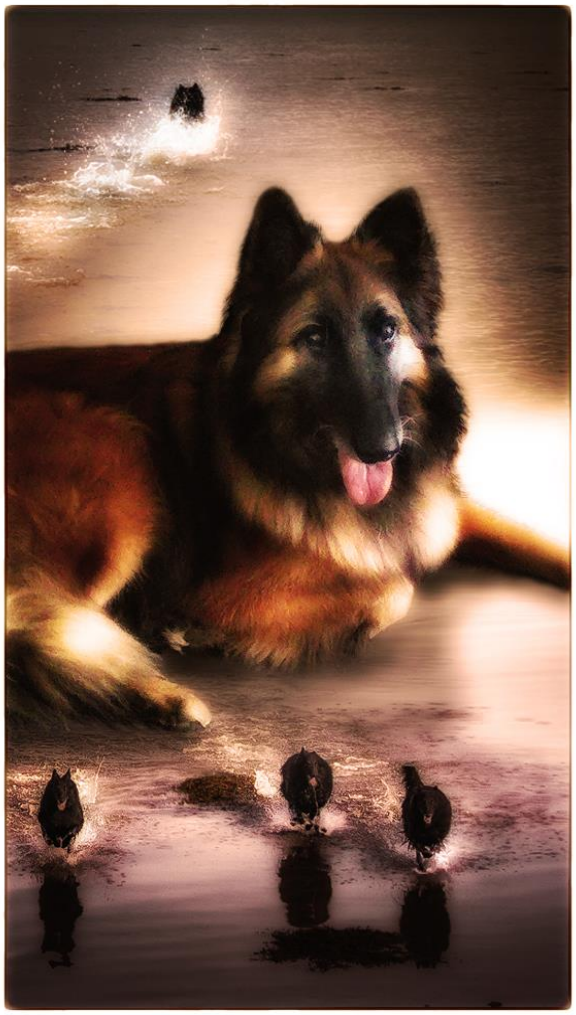

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On behalf of the Belgian Shepherd Dog Club of Queensland (BSDCQ) I would like to thank the hundreds of Belgian Shepherd Dog owners who took the time and effort to fill out the Belgian Shepherd Dog Health Survey, 2019, some of them a number of times. Without their participation in this project, we would not have been able to collect a large and valuable set of breed health data.

Kathy Prentice,

1.0 EXECUTIVE SUMMARY

The Belgian Shepherd Dog (BSD) is known as a relatively healthy dog breed. In order to assist with ensuring that the sound health status of the BSD continues into the future, in 2019 a grant of $1000.00 was awarded by the Belgian Shepherd Dog Club of Queensland to enable a survey to be undertaken entitled 'Future Directions: The current health status of the Belgian Shepherd Dog within Australia.'

Data was submitted by breeders and owners of the BSD into a web-based survey. 520 BSD were individually entered, and of these, 46% were male, and 54% were female, with the majority residing in Australia. Ages ranged between 4 weeks to 17 years. There were 27.5% of BSD's reported as having been used for breeding purposes, resulting in 185 litters of pups, with an average of six live births per litter. At the time of the survey, 62% of the BSD's entered had been neutered. The vast majority of BSD's were registered with the Australian National Kennel Club (almost 76%), with the remainder either unregistered or registered on an alternate register.

The most common health testing that had been completed was for canine hip and elbow dysplasia; a lesser number of BSD's had undertaken eye and heart health testing. The most frequent health or health related concerns identified in the survey were behavioural issues (44.62%), cryptorchidism (13.25%), cancer (11.5%), missing teeth (8.65%), skin disorders (8.27%), and seizures (5.6 %). These are explored in greater detail in the body of this report, including a comparison to other BSD surveys world-wide, and brief reference made to contemporary research. Health issues reported in the survey with under 5% prevalence are presented in table formats.

There are several limitations associated with the report, most significantly related to missing data regarding the variety of BSD's entered. Furthermore, although the survey data tended to replicate the health issues that have been noted to be relevant in the BSD internationally, it failed to capture at least one significant issue, which was the prevalence of Australian BSD elbow scores in the Malinois and Groenendael, graded as 'abnormal' through the Canine Hip and Elbow Dysplasia Scheme (CHEDS). Again, this is likely due to missing data and the possible small number of Malinois entered into the survey.

As would be expected in a healthy breed such as the BSD, the most frequently indicated cause of death was old age, or complications of old age (42% of deceased dogs). This was followed by cancer (almost 26%) and then snake bites (just under 6%).

Finally, tentative suggestions and information are provided that might potentially assist both BSD breed clubs and breeders to work on maintaining the good health status of the BSD within Australia. These include proposals for the creation of a national BSD breed club or council, an open national BSD health registry, BSD health improvement strategies, and an exploration of breeder's health related tools, such as DNA and health testing, 'Stick Dogs', coefficients of inbreeding, and estimated breeding values.

It is envisaged the survey outcomes will be of interest to anyone who is concerned about the health and well-being of the BSD in Australia. This survey offers promise in providing information that has the potential to lead to further strategies to maintain the good health of the BSD into the future.

2.0 INTRODUCTION

2.1 The Survey The Belgian Shepherd Dog is considered to be a relatively healthy, long-lived breed, with many living to between 11 to 14 years, and some even to 17 years. In order to ensure this healthy status continues into the future, in 2019 a grant of $1000.00 was awarded by the Belgian Shepherd Dog Club of Queensland (BSDCQ) to enable a survey to be undertaken entitled 'Future Directions: The current health status of the Belgian Shepherd Dog (BSD) within Australia'. This was the first major health survey to be completed for BSD's residing in Australia.

The goal of the survey was to obtain data that would allow breeders and breed clubs, and other interested parties, to gauge the health status of the BSD and to identify the occurrence of various health and potentially genetic concerns. Breeders and breed clubs could then choose to develop breeding strategies and health plans to address any identified issues, as required.

A pilot of the survey was conducted in early August, 2019. The survey was then undertaken between August and November 2019, using the web-based survey platform 'SurveyMonkey'. Electronic and paper versions of the survey form were available for those who did not wish or were unable to use the web version, however, there were no responses submitted in this format. The survey was advertised by the BSDCQ, Dogs Queensland, and some other State canine bodies; it was heavily promoted on breed discussion lists within social media. The survey outcomes were then analysed in December 2019 and January 2020 by the grant recipient.

2.2 The BSD's: Surveys were completed primarily by the breeder, the breeder/owner, or current owner. Creating a simple code system for each BSD allowed a check for duplicate answers. As one BSD was submitted twice, one of these surveys was eliminated from the data set.

Data was submitted for 520 dogs, of which 46% were male, and 54% were female, with the majority residing in Australia. The ages of the BSD's entered into the survey ranged from four weeks to 17 years. Almost half (41%) of these BSD's were deceased, and the cause of their death is explored in detail below. As approximately 70% of the dogs entered were over the age of five years (or deceased from various causes), this allowed the data to capture any health issues which are purported to have a genetic basis and are often age related, for example, dementia and some eye diseases.

Of these BSD, 27.5% were reported as having been used for breeding purposes, resulting in 185 litters of pups, with an average of six live births per litter. At the time of the survey, 62% of the BSD's were entered as having been neutered. The vast majority of BSD's were registered with the Australian National Kennel Club (almost 76%), with the remainder either unregistered or registered on an alternate register. Between 2000 and 2019, 5263 BSD's were registered with the ANKC, comprised of 1847 Groenendaels, 1756 Malinois, 1471 Tervuerens, and 189 Laekenois.

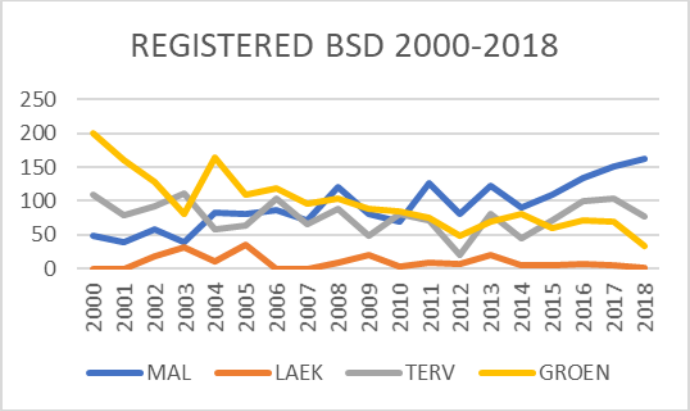

Figure 1: Summary of BSD ANKC registrations 2000-2019

2.3 Health Screening: Although the BSD remains a relatively healthy breed and is not particularly prone to any major health concerns (Honkanen, 2018), a number of overseas canine schemes have identified relevant health (disease) tests for breeding dogs across the four varieties of the BSD. These range from the minimum requirement of hip, elbow and ophthalmologist examinations (Kennel Club, 2018) through to undertaking hip, elbow and ophthalmologist examinations along with autoimmune thyroiditis, cardiac and dentition examination (American Kennel Club, N/D).

Within Australia, screening of hips and elbows are the most commonly practiced health tests employed by BSD breeders. The Australian Veterinary Association (AVA) and the Australian National Kennel Council (ANKC) jointly established the Canine Hip and Elbow Dysplasia Scheme (CHEDS) in January 2000, and since that time the AVA had been responsible for administering the scheme from its Canberra office. The AVA has since ceased participation in the scheme, and the ANKC became the sole manager on 30th April, 2016.

The ANKC recommends members should base decisions about the appropriate method for screening for canine hip dysplasia on the best evidence currently available. Coxofemoral laxity is considered to be the best phenotypic predictor of hip dysplasia and is able to be determined at an early age.

Current screening schemes test for slightly different criteria. The CHEDS scheme is weighted towards secondary joint changes associated with hip dysplasia, and these may not be fully evident at 12 months of age and often not before 24 months of age Other schemes are available that assess a dog at an earlier age, for example, the PennHIP® scheme gives an estimate of the risk for osteoarthritis of canine hip dysplasia later in life, and this can be assessed as early as four months of age. The Pupscan Project began in 2015, a not-for-profit research organisation. This project employs diagnostic ultrasound images of a pup's hips and elbows from 14 days to 16 weeks of age, confirming that the hip (or other relevant joint) is developing normally for age, gender and breed

Of the 520 BSD's, just under 35% had completed hip and elbow screening, primarily through the CHEDS scheme. Reported scores in the survey for hips ranged from 0:0 to 18:20, and for elbows 0:0 to 0:2.

Data was also retrieved from ORCHID, the ANKC's health database, with results as below:

VARIETY	AVERAGE	MEDIAN	COUNT
Groenendael	7.82	5.50	22
Malinois	5.69	6.00	29
Tervueren	6.72	5.00	39

Table 1: Live hip scores updated daily (26.01.2020) for dogs x-rayed in the last five years only. Retrieved from http://orchid.ankc.org.au/Home/HipScores

VARIETY	SCREENED	NORMAL	GRADE 1	GRADE 2	GRADE 3	Total % graded higher than 0
Groenendael	22	18	2	2	0	18.8%
Malinois	26	15	9	2	0	42.31%
Tervueren	37	34	2	1	0	8.11%

Table 2: Live elbow scores updated daily (26.01.2020) for dogs x-rayed in the last five years only. Retrieved from http://orchid.ankc.org.au/Home/ElbowScores

At least 33% of the surveyed BSD's had completed one eye screen under the Australian Canine Eye Scheme (ACES), with three quarters returning normal test results. Identified eye disorders were persistent pupillary membranes and 'cataracts'. BSD's are stated by the ACES scheme as being 'recognised' for non-congenital hereditary cataracts and are 'under investigation' for persistent pupillary membranes (see also Appendix 2, The Australian Canine Eye Scheme: Snapshot of BSD Eye Assessments Completed 2010-2018).

From our surveyed BSD's, most had not completed health screening by a specialised veterinary cardiologist for evidence of cardiac disease. Of the 20 dogs who were reported as having been screened, the majority (80%) showed no auscultatory evidence of cardiac disease; two had been diagnosed with patent ductus arteriosus (hole in heart).

DNA testing is becoming more commonplace, particularly in Queensland, as the State canine body Dogs Queensland mandates Parentage Profiling, and some breeders and/or owners take advantage of testing for genetic diseases and genetic traits. The types of tests vary with the genetic service provider. Of the surveyed BSD's, 15% of those entered had undertaken testing (most often with Orivet - https://orivet.com) with no genetic diseases identified.

There was a small number of other health tests completed, usually related to screening for presenting illnesses. The main other tests undertaken were full blood works and thyroid function tests.

3.0 HEALTH OUTCOMES

3.1 THE TOP TEN HEALTH DISEASES IN CANINES

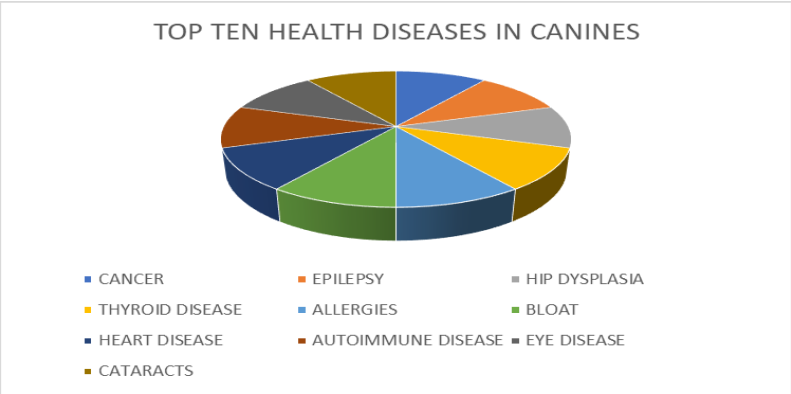

Figure 2: Top ten health diseases in canines (Ostrander, 2018).

As stated at 2.1, the BSD is a relatively healthy breed of dog, however, like all other species, including humans, it is able to inherit and develop a range of illnesses and disorders. Figure 2 summarises the top ten reported health diseases seen in canines (Ostrander, 2018). Given that Australian breeders will only ever have a limited number of dogs to breed from, it is important that regular breed health surveys are conducted by breed clubs to monitor for the presence and changing prevalence of genetic disorders within the breed.

3.2 BSD HEALTH SURVEY 2019 OUTCOMES

The Belgian Shepherd Dog Health Survey 2019 outcomes are attached at Appendix 1.

Limitations: As is to be expected, there are a number of advantages and limitations when conducting this type of survey. Some of the advantages are that they allow for a large number of canines to be studied with relative ease; they can be conducted quickly; and are relatively cost effective. Limitations are that not everyone will be willing and/or able to provide information; some of the information provided may be inaccurate; and each question could mean something different to different respondents, as occasionally highlighted in the survey outcomes. There was also missing survey data in relation to the variety of BSD submitted, and potentially low numbers of Malinois and Laekenois entered. This has implications for the development of future health plans and will be discussed in detail at the BSDCQ BSD Health Forum (02.02.2020).

Some breed specific health surveys have allocated a heading according to the % of dogs affected by a disease or disorder. For example, the Australian Shepherd Health Survey (2010) designated their findings as extremely common health issues (10% + affected); very common health issues (4-9% affected); common health issues (2-3% affected); rare health issues (1% or less affected); and extremely rare health issues, where only one dog was identified. Their rationale for doing so is "2-3% might not seem like much but the reader should bear in mind that if a disease is inherited via a recessive mutation, this level of affected individuals in a population indicates 24-29% of the breed are carriers. If multiple genes are involved the numbers might be much higher" (Sharp, 2010).

<u>The outcomes highlighted below present the data outcomes as they stand and it is for readers to interpret the findings and choose their future directions</u>.

There are a number of tools that can assist in this, for example, The Kennel Club (United Kingdom) has a wealth of information to assist breed clubs in developing breed health improvement strategies. Collins, Asher, Summers, Diesel and McGreevy (2010) developed the General Illness Severity Index for Dogs (GISID), which is a very useful tool to prioritise diseases based on their severity, and will be used in the BSD Health Forum that is a component of this project.

Individual breeders have a number of excellent tools at their disposal to assist them in making sound breeding choices, for example, health testing, developing databases, using coefficients of inbreeding and overall savvy breeding practices. These, and a number of other useful resources are discussed towards the end of this report.

3.3 HEALTH ISSUES (Over 10%)

3.3.1 Behavioural Issues – 44.62%

As a herding breed, the BSD was originally selected for specific levels of cooperativity with humans, with resulting great interest in this area of study. Puppy buyer's expectations nowadays are for a BSD that will live happily in a family household, without issues such as excessive timidity or separation-related problems occurring.

Almost 55.5% of owners reported no behavioural concerns in their BSD.

The most frequently reported concern, in almost a quarter (23.46%) of the surveyed BSD's was non-social fears, for example, sudden or loud noises; in heavy traffic; in response to strange or unfamiliar objects; during thunderstorms; when first exposed to unfamiliar situations; in response to wind or wind-blown objects. Other behaviours, such as timidity (11.7%), separation related behaviours (10.6%), dog directed aggression (8.3%), and stranger related fear (8.1%) also yielded notable outcomes.

Blackwell, Bradshaw and Casey (2013) reported that sensitivity to different types of loud noises (thunder, fireworks and gunshots) had a high correlation; if the dog was afraid of one noise, it was most likely afraid of all the others as well (70.1%-92.9%). Dale et al., (2010) found that 68% of dogs that were afraid of fireworks were also afraid of thunder, gunshots and other loud noises and it may be that this similarity causes the strongly correlated behavioural response in dogs. They also found the behavioural reactions toward these noises were similar. Both thunder and fireworks triggered pacing, hiding, trembling, panting and low tail position most frequently (> 50% frequency). Their results suggested that characteristics of dogs, early environment and exposure to specific loud noises are involved in the development of fear responses to noises. One could also argue that a fear of thunder and other unusual noises is highly adaptive.

Pongrácz, Alvarez Gómez and Lenkei (2019) recently explored if historical selection for the level of working interaction intimacy with their handlers may have resulted in the fundamental differences between the main working dog types and their behavioural reactions when separated from their owner. They reported former breed selection for particular working tasks in dogs shows association with the intensity of separation-related stress behaviours such as excessive barking, whining, frustration, restlessness, pacing and attempts to escape.

Very large datasets are required for accurate analysis of behavioural traits in canines, and if they are potentially related to genetic or nongenetic causes. Thus, even though these traits are extremely

important for the well-being of both a dog and its owner, the heritabilities for companion dogs, usually not subjected to any formalised behaviour testing, are still largely unknown (Ilska, Haskell, Blott, Sánchez-Molano, Polgar, Lofgren, & Wiener, 2017). These authors identified substantial genetic variance for several traits, including fetching tendency and fear of loud noises, while other traits revealed negligibly small heritabilities.

One ongoing research project is being conducted at the University of California, Davis. In the Malinois, a single copy allele of DAT-VNTR has been found to be associated with owner-reported seizures, loss of responsiveness to environmental stimuli, episodic aggression and hyper-vigilance in the Malinois, and behavioural changes are associated with differential treatment by handlers. These findings should be considered preliminary until replicated in a larger sample (Lit, Belanger, Boehm, Lybarger, & Oberbauer, 2013). A link to participate in this research can be found below at section 6.

3.3.2 Cryptorchidism – 13.25%

Of the 234 males entered, almost 87% were reported as being entire (having both testicles).

Of the 19.23% of male BSD who were reported as having a disorder of the reproductive system, approximately 69% of these were suffering from unilateral or bi-lateral cryptorchidism. This equates to just over 13% of the surveyed males. These Australian outcomes are three times higher in comparison to other surveys. For example, the outcomes of the 'Kennel Club Dog Health Survey, 2014', reported cryptorchidism in 3.41% of Tervueren and 1.79% of Groenendael (Kennel Club, 2014).

Cryptorchidism, or retained testicles, has been established as one of the most common birth defects in purebred dogs. The incidence of cryptorchidism varies in different dog breeds and populations with a reported range of 1–11% (Amann & Veeramachaneni 2007). The heritability of canine cryptorchidism was estimated at 0.22 in a study of 2929 pure-bred boxer dogs from 414 litters when a monogenic model was applied (Nielen et al. 2001). It is generally perceived that cryptorchidism is recessive but may involve more than one main effect gene. Other factors including epigenetic and environmental components may contribute to the occurrence of cryptorchidism (Amann & Veeramachaneni 2007). Currently, there is no genetic diagnostic test to predict the risk of this disease in a dog or it's progeny.

3.3. Cancer - 11.5%

Over 87% of the BSD's were reported as not experiencing any form of cancer.

However, 11.5% were reported as having experienced at least one cancer, with over 25% of deceased dogs succumbing to the disease. The most commonly described cancer was stomach cancer (28% of total cancers, or 3.27% of the surveyed BSD's), mammary (15% of total cancers), lymphoma (15% of total cancers) and osteosarcoma (12% of total cancers).

Other BSD health surveys have reported relatively high figures for cancer in BSD's, for example, the Orthopedic Foundation for Animals (OFA) survey 'A Belgian Tervuren Health Survey 2014 – Deceased Dogs (2006 - 2014)' (OFA, 2014) reported 45 of the BSD's (39.9%) died from cancer, of which stomach cancer was the most prevalent at 10%. The outcomes of the 'Kennel Club Dog Health Survey, 2014' (Kennel Club, 2014) reported cancer in 3.41% of Tervueren and 3.57% of Groenendael.

Stomach cancer is a particularly distressing and lethal disease, with some dogs dying only a couple of weeks post-diagnosis. In 1991, Scanziani, Giusti, Gualtierei and Fonda examined seven cases of gastric carcinoma in BSD's, in addition to eight cases reported in 1989. An examination of the pedigree of

eight of the BSD's demonstrated that they were related, at that time suggesting a genetic mechanism in the pathogenesis of the disease.
Other studies have expanded on this early work, and Seim-Wikse, Jörundsson, and Nødtvedt (2013) explored the proportion and possible breed predisposition to canine gastric carcinoma using the Norwegian Canine Cancer Register for calculations of proportional morbidity ratios (PMRs), for the period 1998–2009. The highest relative proportion of gastric carcinoma was observed in Tervueren, Bouvier des Flandres, Groenendael, Collie (rough or smooth not specified), Standard Poodle, and Norwegian Elkhound. Tervueren had a PMR of 56, indicating that this breed is 56 times more likely to be diagnosed with gastric carcinoma than the average breed in this database. There did not appear to be increased risk of gastric carcinoma in the Malinois or the Laekenois. It is unknown whether this is due to the Malinois and Laekenois being less frequent types of Belgian Shepherd dog or whether there is a different prevalence between the varieties (Seim-Wikse, Jörundsson, & Nødtvedt, 2013).

3.4 HEALTH ISSUES (5-9%)

3.4.1 Missing Teeth – 8.65%

Almost 90% of the BSD's were reported as having full dentition.

However, as highlighted within the survey, sometimes BSD's can lack one or more teeth, usually premolars (60% of total reported missing teeth). Whilst absent premolars alone do not usually impact jaw function significantly, absence of multiple teeth diminish a BSD's capacity to grip and gnaw. As a function-based breed that uses its mouth in the course of its work, BSD's require their teeth!

The ANKC breed standard (2014) states that the BSD should have "strong, white teeth, regularly and strongly set in well-developed jaws. Scissor bite, a pincer bite that is preferred by sheep and livestock herders is tolerated. Complete dentition according to the dental formula. The absence of two premolars 1 (2 P1) is tolerated and the molars 3 (M3) are not taken into consideration" (ANKC, 2014). Of the 520 surveyed BSD's 93.85% were also described as having a scissor or level (pincer) bite, with 2.88% being described as undershot.

Inheritance of missing teeth appears to be complex, but from studying BSD pedigrees, it can be seen that dogs that have missing teeth (or which are from lines where there are missing teeth) are more likely to subsequently produce dogs that have missing teeth. However, there is limited research available about missing teeth in canines.

One interesting project is being managed by the OFA. The Dentition Database was established in late 2011 at the request of the American Rottweiler Club. The purpose of the database is to certify dogs with all adult teeth fully erupted. Each dog is examined and classified by a licensed veterinarian. The examining veterinarian will determine whether all adult teeth are fully erupted, identify any persistent (retained) deciduous teeth, as well as any missing teeth. The exam form (see Appendix 3: Application for Dentition Database) contains a dental chart, and any retained or missing teeth are marked "P" (persistent) or "M" (missing). If the owner authorises release of any abnormal information, the dental chart identifying the specific missing or persistent deciduous teeth will be included on the dog's OFA webpage. The OFA Disease Database (as of 2018) graded dentition in 8.40% of Tervueren, 6.5% of Groenendael, and 4.76% of Malinois as 'abnormal' (OFA, 2018).

3.4.2 Skin Disorders – 8.27%

Over 91% of BSD's had not experienced a skin disorder.

Skin disorders were reported in 8.27% of the surveyed BSD's. The majority reported the skin conditions as unknown (just under 33%) with food sensitivity (just under 14%) and flea sensitivity (just under 12%) being the most commonly diagnosed causes of skin related disorders. The 'Kennel Club Dog Health Survey, 2014', reported Groenendaels and Tervueren as experiencing hypersensitivity skin disorders of 7.14% and 2.27%, and chronic itching of 1.79% and 1.14% respectively (Kennel Club, 2014).

Dermatological problems are one of the most frequently reported and hardest to resolve problems encountered by veterinarians in small animal medicine (Scott et al., 2001). Hill et al. (2006) studied 2322 dogs attending a small animal clinic in the UK and found 20% of such presentations were for skin disorders. Dog skin disorders can be grouped into categories according to the causes, for example, immune-mediated skin disorders, physical and environmental skin diseases, infectious skin diseases, flea allergy dermatitis, hereditary and developmental skin disease, and cutaneous manifestations of internal diseases.

3.4.3 Seizures – 5.6 %

Overall, almost 90% of the BSD's had not experienced any nervous system conditions.

Just over 10% had, with the majority of these (57%) being seizure related. Of these, it was thought that 4% suffered from idiopathic epilepsy. The Australian outcomes are similar to those within other BSD surveys. For example, the outcomes of the 'Kennel Club (UK) Dog Health Survey, 2014', reported epilepsy/seizures in 5.7% of Tervueren and 5.45% of Groenendael (Kennel Club, 2014). In an Orthopedic Foundation for Animals (USA) survey of 581 Groenendaels 6.4% had been diagnosed with idiopathic epilepsy, and 2.4% with occasional/random seizures (OFA, n.d.).

These are lower statistics than those reported by Gullov, Toft and Berendt (2012) who stated "Belgian Shepherds suffer from focal genetic epilepsy. The prevalence of epilepsy has been estimated to 9.5% in the breed" (p. 1115).

Idiopathic (or primary) epilepsy is characterised by recurrent seizure activity without an identifiable underlying anatomic defect. In idiopathic epilepsy, there is no obvious underlying neurological deficit causing the seizures. This is in contrast to symptomatic or secondary epilepsy, in which a specific initiator of the seizure is identifiable (e.g., illness, trauma, hepatic insufficiency).

Seizures have been reported in nearly all breeds of dogs, and when compared with other domesticated species, the dog has the highest incidence of epilepsy. Although the general prevalence of idiopathic epilepsy in dogs is typically considered to be 0.5% - 5%, it can be much higher within a single breed (Ekenstedt & Oberbauer, 2013). A growing body of evidence supports a hereditary basis for idiopathic epilepsy, with a variety of genetic inheritance models proposed.

In the Tervueren and Groenendael, epilepsy is described as being highly heritable with a polygenic mode of inheritance, though influenced by a single autosomal recessive locus of large effect (Oberbauer, Grossman, Irion, Schaffer, Eggleston, & Famula, 2003). In 2012, a new epilepsy gene for idiopathic epilepsy in the Tervueren was found in the canine chromosome 37 (Seppälä, et al. 2012). Such exciting discoveries bode well for the future, with the potential to develop a DNA test for epilepsy

in the Tervueren. This will permit breeders to undertake selective breeding and assist in reducing the frequency of this debilitating condition.

3.5 Table 3. HEALTH ISSUES (2 - 5%)

CONDITION	PERCENTAGE
Pyometra	5.0
Allergies	4.62
Adverse reaction medication	3.85
Prostate gland disorder	3.84
Undershot bite	2.88
Osteoarthritis	2.88
Lymphoma	2.88*
Persistent pupillary membrane	2.5
Idiopathic vestibular disease	2.11

3.6 Table 4. HEALTH ISSUES (1% - 2%)

CONDITION	PERCENTAGE
Hip dysplasia	1.92
Urinary tract infections	1.73
Mammary cancer	1.73
Addison's Disease	1.53
Osteosarcoma	1.35
Anterior cruciate ligament tear	1.35
Exercise induced collapse	1.35
Cataracts	1.15
Umbilical hernia	1.15

3.7 HEALTH ISSUES - OTHER

3.7.1 Although the survey data tended to replicate the health issues that have been noted to be relevant in the BSD internationally, it failed to capture at least one significant issue. This can be demonstrated when comparing the BSD elbow scores reported in the survey with the BSD elbow scores reported within the CHEDS (see Table 2), where it was noted that a percentage of Malinois (42.31%) and Groenendael (18.8%) were graded as 'abnormal'.

3.7.2 Several breeders within Australia publish open health statistics for BSD of their breeding, and this is an extremely valuable source of information. Although it was beyond the capacity of the current project to be able to analyse their web databases, I was very interested to see if these databases would yield similar data to the survey. I completed a rapid review of one such database, choosing a breeder who I was aware had not entered the majority of the BSD they had bred into the survey. It was interesting to compare the similarities and differences between the survey outcomes and the breeder database. **Table 5.** Australian breeder's web database outcomes

BSD BREEDER WEB DATABASE	NUMBER OF BSD	CANCER	SEIZURES	CRYPTORCHID
Breeder 'A'	335	14	17	23
		4.17%	5.07%	6.86%

4.0 MORTALITY

The open birth date range for the survey was chosen so that a percentage of the dogs being submitted would be deceased. Almost 41% of the BSD were reported as no longer living at the time of the survey. The average age of death/euthanasia was 9.3 years. The youngest to die was aged just four weeks, and the longest reported lifespans were 17 years.

As would be expected in a relatively healthy breed such as the BSD, the most frequently indicated cause of death was old age, or complications of old age (42% of deceased dogs). This was followed by cancer (25%) and then snake bites (just under 6%).

This is similar to the outcomes of the 'Kennel Club Dog Health Survey, 2014', which found the leading cause of death of 43 BSD's were cancer, gastric cancer, old age, and osteopathy (Kennel Club, 2014).

5.0 FUTURE DIRECTIONS: FUTURE POSSIBILITIES.

The following information is a very brief summary of the kind of resources that are available, or could be developed, to assist both breed clubs and breeders who are interested in addressing any health issues related to the BSD. It is certainly not exhaustive, and as further resources become known and/or developed, these will be highlighted in the Health Section of the BSDCQ web site**.**

5.1 BREED CLUBS

5.1.1 A National BSD Breed Club or Council?

The main purpose of breed clubs is to be the guardian of their breed for future generations. People who breed and show dogs often belong to breed clubs, along with other canine sports enthusiasts and companion dog owners. Any breed may have several breed clubs, but often there is a national breed club, which tends to be the largest. Clubs are autonomous, but often work together on important matters that relate to the breed.

Some breeds also have a Breed Council, which is a formal way of bringing several clubs together to work collaboratively for the benefits of a breed. For example, the BSDA of GB has an Inter Variety Breeding Commission which ensures that when inter-variety matings are being proposed by breeders that certain criteria is in place that was collectively agreed upon by the UK breed clubs (the Belgian Shepherd Dog Association of Great Britain, the Northern Belgian Shepherd Dog Club and the Working Belgian Shepherd Dog Society).

One way of better maintaining communication about the health of the BSD within Australia may be through the formation of a National BSD Breed Club or Breed Council.

5.1.2 Educational Opportunities?

The BSD health survey outcomes provide an excellent opportunity for breed clubs and breeders to provide education about the relatively good health enjoyed by the BSD, and the strategies that will enable this to continue.

Some of the health issues identified may have a genetic basis, some may not and some are a quantity unknown. As a minimum, decisions about best practice for health (disease) testing and clarifying which conditions might require educative programmes and preventative strategies developing would be a positive start.

5.1.3 An Open National BSD Health Registry?

Creating an Australia wide (or using an existing) BSD open health registry could be of great benefit. This way breeders and others can access information about a BSD and its near relatives when assessing whether an individual might be a useful addition to their breeding programme.

In Australia, the ANKC is expanding the Officially Registered Canine Health Information Database (ORCHID), and contains outcomes of the CHED and ACES schemes. A number of European countries have similar registries, for example, Finland and Sweden. The Swedish Kennel Club is one of the longest standing and makes health records available via their web site. Most of these registries include at least the results of eye, hip and elbow exams. Screening for diseases prevalent in particular breeds may also be included, for example, DNA health screening.

The Kennel Club's (UK) health database is only one component of its excellent health strategy. The Kennel Club Charitable Trust supports research into dog diseases and dog welfare charities and funds the Kennel Club Genetics Centre and the Kennel Club Cancer Centre at the Animal Health Trust, both of which are at the forefront of pioneering research into dog health. Their Assured Breeder Scheme provides certification to breeders who meet certain standards of breeding practice, including breed-specific health screening requirements and recommendations.

The Canine Health Information Centre, also known as CHIC, is a centralised canine health database jointly sponsored by the AKC Canine Health Foundation (CHF) and the Orthopedic Foundation for Animals (OFA). CHIC, working with participating parent clubs, provides a resource for breeders and owners of purebred dogs to research and maintain information on the health issues prevalent in specific breeds.

5.1.4 Develop a BSD Breed Health Improvement Strategy?

Every breed can benefit from a Health Improvement Strategy as a way to prevent health issues from developing, tackle a problem if it does arise, and assess the good practices already being undertaken. The Kennel Club (UK) states that an effective Breed Health Improvement Strategy has four underpinning themes, each of which is supported by a number of activities that a breed could be doing:

- Improving breed health
- Engaging with breeders and owners to implement health plans
- Developing plans for health improvement
- Leading and setting the breed's direction for health improvement.

Links to these excellent toolkits, providing breed clubs with step by step guides for developing and implementing Breed Health Improvement Strategies and Health Plans, can be found at Section 6.

5.2 BREEDERS

5.2.1 DNA and health testing?

Breeders have access to a number of canine health schemes within Australia and overseas, most of which have been previously referred to, for example, hips, elbows, eyes, cardiac, and various blood screens. There are also a number of tools available to evaluate the temperament of the canine, for example, the Canine Behavioral Assessment & Research Questionnaire (C-BARQ). This was developed and validated by Yuying Hsu and James Serpell in 2003, and has been available for completion via a publicly accessible online website at the University of Pennsylvania, since 2005 (see Section 6).

Breeders could request their puppy buyers complete the C-BARQ online when their BSD is between one to two years old. The C-BARQ is an invaluable tool for developing and maintaining breed-specific behavioural profiles over time. Breeders can thus evaluate the behaviour of the offspring of particular sires and dams; monitor the progress of behavioural selection within breeds or lineages over time, and obtain reliable phenotypic measures of behaviour.

There are currently few breed-specific DNA tests available for disorders seen in BSD's. However, BSD's, especially the Malinois, can suffer from an autosomal recessive syndrome called Spongy Degeneration with Cerebellar Ataxia (SDCA1 and SDCA2) for which genetic testing is available. The Degenerative Myelopathy (DM) mutation was also observed in BSD's, and genetic testing is available for this

disorder; however, more research is needed before an assessment can be made regarding the relevance of genetic testing for DM in BSD's, and before conclusive breeding advice can be given.

As time passes there are an increasing number of DNA screening tests being made available. One of the greatest advantages to using such tests are that in testing the genotype, rather than the phenotype, you can find out which dogs may be affected before symptoms develop.

BSD's offered at public stud would be recommended to undertake every relevant DNA test available for the breed; it only takes one popular sire to turn a relatively infrequent disease into a common one. Once results are known, a breeder knows the genotype of their BSD. This can help to ensure puppies that will be affected will not be produced. If a carrier is never bred to another dog that has the same mutation, a puppy will never be produced at risk for the disease.

There needs to be transparency in making a dog's DNA health status very clear to people who have potential mates, and preference be given to breed 'normal/normal' matings. Over time, this will lower the frequency of the mutation in a breed. However, carriers may no longer need to be taken out of a breeding programme when you can verify that their future mate is a non-carrier.

5.2.2 Savvy breeding practices?

As breeders of the BSD, we should learn everything we can about the inheritance of the diseases relevant to the BSD, and what individuals have produced it. We need to **be open with others** about our dog's pedigrees and ask other's to be the same with us.

Breeders must keep talking about inherited diseases, including sharing information on affected dogs, or we will never be able to significantly reduce the frequency of these diseases. We need to share information and resources. We need to learn. We have a right to talk about our own dogs, and respectfully listen to others who do the same.

5.2.3 A breeder's database?

Careful and detailed record-keeping is a must. We need to gather as much information as we can on our BSD's and store it in an easily retrievable fashion. We need to keep information on all of our dog's, what they have produced, and who the relatives are and what they have produced. The following is a non-exhaustive list of the type of information that is useful:

1. Your BSD: Its appearance, behaviour, skills and accomplishments in competitive events. The dog's DNA and other health screening tests.

2. Your BSD's production record: The more you know about what a particular BSD has produced, the better idea you have of its genetic makeup. A dog that consistently produces traits you want is likely to do so again. Hence the old saying 'If you like the son, breed to the father'.

3. Your BSD's relatives: Knowledge of a BSD's extended family will further enhance understanding of his or her genetic potential. Consider canine hip dysplasia (CHD); breeding the highest scoring dogs to each other will not significantly reduce the amount of CHD. However, if you combine hip scores (the phenotype) and information about the hip status of it's offspring, predecessors, and other relatives, you are in a much better position to reduce the risk of producing dogs with HD.

Where do you find all of this information? Personal observation. Watch dogs at events; not just in the show ring or agility arena, but out of it as well. Speak to the owners or handlers and interact with the

dogs themselves. Network with other breeders and breed enthusiasts who will help fill in the gaps in data and provide new information. Many breeders maintain a website. The information offered can give you valuable insights into the breeder's dogs and breeding goals.

Some breeders will also post significant health information. Other online databases like those offered by ORCHID can tell you about breed results. Some health information can be gleaned from breed club web sites and Facebook sites, in dog newspapers, magazines and newsletters, along with items like titles earned, event results, competitive rankings, and upcoming litters.

Health tracking can be complex. Consider the BSD's most common and most serious health issues. Some information can be gleaned from this survey, and the links to be found at Section 6. Listings of common health concerns can also be found on BSD breed club or other breed health organisation websites. Some issues with severe health impacts may not occur frequently in the BSD but should be noted because you wouldn't want to double up on genes for that type of trait. Gathering family history is key here. Dogs that have a disease often don't appear in pedigrees; make note of near relatives of affected dogs as those are far more likely to appear on a pedigree.

There are a number of pedigree software database programmes now available, for example Breedmate, Kintraks, Pedigree Database Online, and Breeder's Assistant, ranging in cost from a $25 one off fee to over $200 per annum subscription. Many have interesting tools regarding inbreeding and mating, and genetic tools like the prediction of genetic geno- and phenotypes, so could be useful for both breed clubs and breeders to consider.

5.2.4 Stick dogs?

If your chosen sport is conformation, you may wish to evaluate and record details of structure and type on multiple generations of dogs; one excellent idea is Dr. Carmen Battaglia's 'Stick Dog' concept (Battagilia 1995). The link in Section 6 provides information of how to use this interesting pictorial method of keeping data. Breeders may also wish to consider how this concept could be adapted to reflect the key aspects of behaviour and physicality pertinent to your particular area.

5.2.5 Pedigree analysis?

Pedigree analysis is the process of reviewing a pedigree to determine what traits – good or undesired – you are apt to get in a given mating. The more you know about the BSD's in the pedigree (hence the need for your database) the better your educated guesses will be. 'Stick dog' (Battagilia, 1995) is great for analysing the traits you want to see.

But what about undesired traits? Because full information on serious faults of conformation or behavioural and health issues is rarely available, and because many of these traits are influenced by multiple genes, it is important to consider breadth of pedigree. Develop a method of noting not only dogs that have undesirable traits, but their parents and grandparents, as well. The number of BSD's in a pedigree that connect to an unwanted trait is important. A pedigree with a dozen connections is apt to be more risky than a pedigree with only one or two. Find a consistent way of scoring a pedigree that accounts for how many BSD's with connections to the trait appear in the pedigree, where they appear and what degree of relationship those BSD's have to an affected BSD.

Not all traits are equal, so you need to set priorities. What are the traits that are most important to your breeding goals? Which are less so? Health issues that can potentially impact the dog's soundness or quality of life are a much greater issue than something that is readily treated, and the GIRID is an excellent tool to assist with these endeavours.

5.2.6 Coefficients of inbreeding?

Research in the fields of genetics, immunology, and veterinary medicine, is turning up more and more information indicating that high levels of inbreeding can have deleterious effects on health. Inbreeding depression, a complex of behavioural and physical reproductive problems, has long been recognised. “Inbreeding depression” has been defined as “the decrease in fitness with increased genome-wide homozygosity that occurs in the offspring of related parents” (Huisman, Loeske, Kruuk, Ellis, Clutton-Brock, & Pemberton, 2016, p.3585). Inbreeding can increase the frequency of a disease in a population, sometimes quite rapidly.

Breeders have been advised to retain as much genetic diversity as possible within the existing breed population in order to avoid or reduce unwanted health problems (Jansson & Laikre, 2018). Along with health screening and maintaining detailed health records, another tool available to you is Wright’s Coefficient of Inbreeding (COI). You can calculate COIs on your BSD’s. Calculate them on proposed matings, with an eye to keeping the numbers low and lowering them where possible.

The easiest way to incorporate COIs into your breeding strategy is to purchase a pedigree database program that will calculate them for you with COI calculation as a feature (see 5.2.3). You will also need a comprehensive pedigree database, including as many of the ancestors of your current BSD’s as possible. Once you have software that calculates COIs, a good breed database and sufficient knowledge of BSD history to decide how many generations to use in your calculations, it’s time to experiment. Whenever possible it is recommended to try to achieve litter COIs that are at or below the average COI of the two parents. Thus, if the sire had a COI of 20% and the dam was 10%, you would want the pups’ COI to be 15% or lower. “In terms of health, a COI less than 5% is definitely best” (Beuchat, 2015).

Obtaining reliable hereditary disease history on your BSD’s ancestors and on potential mates can be difficult. If you know your BSD has family background for a disease and there is no available DNA testing to let you know whether he/she might be carrying the genes for it, breeding for low COIs, whilst at the same time avoiding doubling-up on any ancestors you know are problematic, may reduce the risk of producing the problem. With a lower COI you are lowering the probability of pairing on those unwanted genes. COI’s are an important tool to apply to any breeding programme.

5.2.7 Estimated breeding values?

Estimated breeding values (EBVs) are currently in use by animal breeders and recommended by the Kennel Club (UK) as a tool in the screening of potential sires and dams for genetic diseases, which are thought to have complex inheritance or where the inheritance pattern is unknown.

The EBV measures the potential of an animal to pass a specific trait to it’s offspring and is calculated using the animal’s phenotype (where available) and those of relatives, in conjunction with pedigree relationships (Farrell, Schoenebeck, Wiener, P. et al., 2015). This is particularly useful for selection on complex traits, i.e. those influenced by multiple genes and environmental factors. EBVs have been utilised for livestock breeding for decades and have resulted in dramatic changes in various production traits.

The use of EBVs has recently been introduced into dog breeding in the context of hip and elbow dysplasia, traits with complex genetic inheritance (Farrell, Schoenebeck, Wiener, P. et al., 2015). Currently EBVs for hip and elbow scores, which measure the propensity for hip and elbow dysplasia, are available for a variety of dog breeds in several countries, including Finland, Sweden, UK and the USA.

6.0 USEFUL BSD, HEALTH RELATED, AND OTHER LINKS

- American Kennel Club Canine Health Foundation http://www.akcchf.org
- ANKC Canine Hip and Elbow Dysplasia Scheme (CHEDS) http://ankc.org.au/HealthAndWelfare
- Behaviour Propensity Belgian Malinois https://www.vgl.ucdavis.edu/services/BelgianMalinois.php
- Belgian Shepherd Dog Club of Queensland https://bsdcq.com
- Canine Behavioral Assessment & Research Questionnaire https://vetapps.vet.upenn.edu/cbarq
- Estimated breeding values
  http://www.kennelliitto.fi/en/news/frequency-of-canine-hip-and-elbow-dysplasia-decreasing-in-finland;
  http://www.thekennelclub.org.uk/services/public/mateselect/ebv/Default.aspx;
  https://secure.vet.cornell.edu/bvhip
- Finnish Canine Health Database https://www.kennelliitto.fi/en/kasvatus-ja-terveys
- Inbreeding – using COI's https://www.thekennelclub.org.uk/health/for-breeders/inbreeding
- International Register of Belgian Shepherds with Stomach Cancer https://www.belgian-stomachcancer.com/Index.htm
- Mate Select https://www.thekennelclub.org.uk/services/public/mateselect/kinship/Default.aspx
- ORCHID: Canine Health Information Database ANKC http://orchid.ankc.org.au
- Stickdog pedigree https://breedingbetterdogs.com/article/stickdog-pedigree
- Stomach cancer and epilepsy https://www.abtc.org/resources/health
- The International Epilepsy Register http://belgian-epilepsy.dk
- The Kennel Club Breed Health Improvement Strategy: A step by step guide.
  https://www.thekennelclub.org.uk/media/97934/bhcbreedhealthimpstrat.pdf
- The Kennel Club (2014). Pedigree Breed Health Survey 2014. Retrieved from
  https://www.thekennelclub.org.uk/pedigreebreedhealthsurvey
- The Kennel Club Health Information https://www.thekennelclub.org.uk/health
- The PennHip Scheme http://www.pennhip.org
- The Pupscan Project https://www.pupscanproject.org
- UCDavis Finding the genes causing epilepsy in dogs
  https://studypages.com/s/finding-the-genes-causing-epilepsy-in-dogs-747780

7.0 GLOSSARY OF TERMS

Allelles: An allele is a viable DNA (deoxyribonucleic acid) coding that occupies a given locus (position) on a chromosome**.**

Autosomal: Pertaining to a chromosome that is not a sex chromosome. In dogs, 38 pairs of autosomes (non-sex chromosomes) can be found in every nucleus, for a total of 76 chromosomes plus the two sex chromosomes (X and Y) making a grand total of 78.

Autosomal dominant: One mutated copy of the gene in each cell is sufficient for a person to be affected by an autosomal dominant disorder. In some cases, an affected person inherits the condition from an affected parent. In others, the condition may result from a new mutation in the gene and occur in people with no history of the disorder in their family.

Autosomal recessive: In autosomal recessive inheritance, both copies of the gene in each cell have mutations. The parents of an individual with an autosomal recessive condition each carry one copy of the mutated gene, but they typically do not show signs and symptoms of the condition. Autosomal recessive disorders are typically not seen in every generation of an affected family.

Coefficient of inbreeding: The standard (mathematical) measure for the level of inbreeding is the Inbreeding Co-efficient. It indicates the probability (between 0% and 100%) that genes at a randomly chosen location in the DNA are identical by descent. The technique assumes that there are 2 forms of a gene and that each form has an equal chance to be passed on to the next generation**.**

Genotype: A genotype is an individual's collection of genes. The term also can refer to the two alleles inherited for a particular gene. The genotype is expressed when the information encoded in the genes' DNA is used to make protein and RNA molecules**.**

Heterozygous: Refers to having inherited different forms of a particular gene from each parent.

Homogenous: Where an individual inherits identical forms of a particular gene from each parent.

Monogenic: Disorders that are the result of a single defective gene on the autosomes. They are inherited according to Mendel's Laws. The mutation can be spontaneous and where there is no previous family history. Inheritance patterns can be autosomal dominant, autosomal recessive or X-linked recessive.

Phenotype: The individual's observable traits.

Polygenic Inheritance: Refers to disorders caused by multiple genes and environmental factors.

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