THE KENNEL CLUB
DOG HEALTH

Breed Health and Conservation Plan

Pug

Evidence Base

BHCP/Version 3/January 2020

CONTENTS

INTRODUCTION

The Kennel Club launched a new resource for breed clubs and individual breeders – the Breed Health and Conservation Plans (BHCP) project – in September 2016. The purpose of the project is to ensure that all health concerns for a breed are identified through evidence-based criteria, and that breeders are provided with useful information and resources to support them in making balanced breeding decisions that make health a priority.

The Breed Health and Conservation Plans take a complete view of breed health with consideration to the following issues: known inherited conditions, complex conditions (i.e. those involving many genes and environmental effects such as nutrition or exercise levels, for example hip dysplasia), conformational concerns and population genetics.

Sources of evidence and data have been collated into an evidence base which gives clear indications of the most significant health conditions in each breed, in terms of prevalence and impact. Once the evidence base document has been produced it is discussed with the relevant Breed Health Co-ordinator and breed health committee or representatives if applicable. Priorities are agreed based on this data and incorporated into a list of actions between the Kennel Club and the breed to tackle these health concerns. These actions and then monitored and reviewed on a regular basis.

DEMOGRAPHICS

The number of Pugs registered by year of birth between 1990 and 2018 are shown in Figure 1 and have increased markedly during this time. There appears to be a leap in registrations for all breeds between 1980 and 1981. Prior to 1981, breeders would record litter details only and new owners could register their puppy themselves. In 1981 it became compulsory for breeders to register all the pups themselves, leading to an apparent jump in registration numbers for all breeds.

The trend of registrations over year of birth (1980-2018) was +252.51 per year (with a 95% confidence interval of +202.63 to +302.38), reflecting the marked increase since the turn of the century.

[Put simply, 95% confidence intervals (C.I.s) indicate that we are 95% confident that the true estimate of a parameter lies between the lower and upper number stated.]

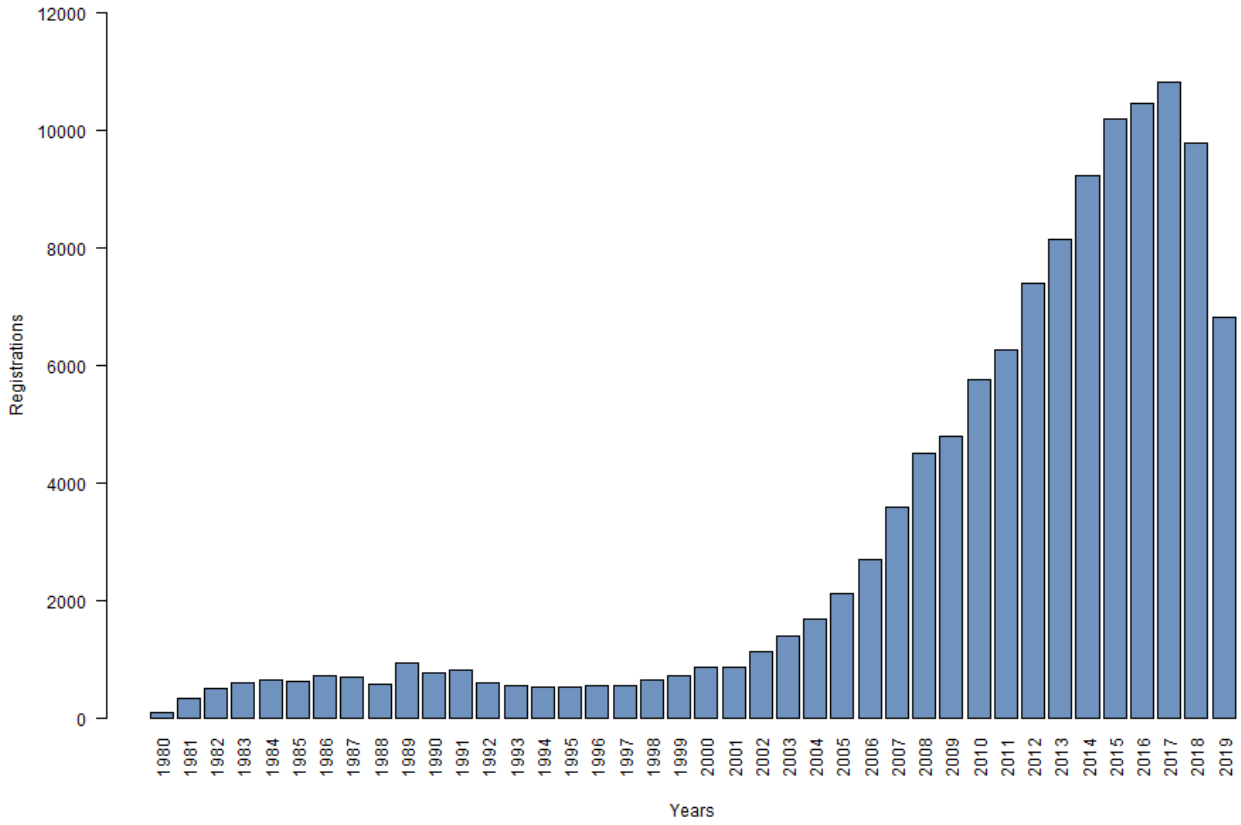

Figure 1: Number of registrations of Pugs per year of birth, 1980 – 2019

BREED HEALTH CO-ORDINATOR ANNUAL HEALTH REPORT

Breed Health Co-ordinators (BHCs) are volunteers nominated by their breed to act as a vital conduit between the Kennel Club and the breed clubs with all matters relating to health.

The BHC's Annual Health Report 2017 yielded the following response to 'please list and rank the three health and welfare conditions that the breed considers to be currently the most important to deal with in your breed':

1. Obesity
2. Eyes
3. Brachycephalic obstructive airway syndrome (BOAS)

Actions listed to attempt to address these were using the breed specific body condition scoring chart that the University of Cambridge have created; including eyes in the visual health assessment and participation in ongoing research into pigmentary keratitis; and including BOAS in the health scheme and participation in ongoing research at the University of Cambridge.

The 2018 report listed the following conditions as the top three concerns currently in the breed:

1. BOAS

2. Spinal issues
3. Eyes

During this year the breed collaborated with the University of Cambridge and the KC to develop the Respiratory Function Grading (RFG) scheme, monitored referral cases of hemivertebrae submitted to Dick White Referrals and held a breed specific eye testing day to monitor information on eye conditions in the breed.

A report has not yet been received for 2019.

BREED CLUB HEALTH ACTIVITIES

The breed has a health committee/group/council and active Breed Health Coordinators.

Two health schemes are currently in place for the breed, the 5 Star Health Scheme, run by the Pug Breed Council, and the Northern Pug Dog Club Health Scheme, with the latest data for the schemes shown below.

The 5 Star Health Scheme

The 5 Star Health Scheme was launched at Discover Dogs 2017.

The five components of the scheme are:

1. Visual Health Assessment – a non-invasive assessment by the owners' own vet, addressing the general health and wellbeing of the dog.
2. Patella testing – the Putnam classification scheme is used for grading.
3. BOAS – grading by the RFG scheme
4. PDE DNA test – using the UC Davis test, which gives an indication of risk. Can be done at any age.
5. Hemivertebrae (HV) screening – radiographs must be submitted to Dick White Referrals in Newmarket.

The National Pug Health Scheme

The National Pug Health Scheme was launched in November 2018 and is comprised of three levels, bronze, silver and gold. Similarly to the Council Health Scheme dogs must be of 12 months of age prior to inclusion in the scheme.

Bronze

- Heart auscultation – must have a clear result
- BOAS testing and recording of any evidence of surgery (any grade permitted to next level)
- Eye examination (grading chart) – must have a clear result
- Skin grade (0 – 3)
- Ear canal stenosis (0 – 3)

- Patella grading – Putnam scoring system
- Pug Dog Encephalitis (PDE) DNA test (optional)

Dogs will not be able to proceed to the next level if they show any sign of aggression.

Silver

- Must be in possession of a bronze certificate
- PDE certification
- Hemivertebrae clear x-ray
- BOAS tested – must be grade 2 or below

Dogs that are grade 3 BOAS, have received treatment for BOAS, or have been graded 3+ for patellas will not be granted a silver certificate.

Gold

- Dogs must be over a year of age and have both a bronze and silver certificate
- BOAS tested – grade 0 or 1
- Patella grade 0 or 1

BREED SPECIFIC HEALTH SURVEYS

Kennel Club Purebred and Pedigree Dog Health Surveys Results

The Kennel Club Purebred and Pedigree Dog Health Surveys were launched in 2004 and 2014 respectively for all of the recognised breeds at the time, to establish common breed-specific and breed-wide conditions.

2004 Morbidity results: Health information was reported for 461 live Pugs of which 248 (54%) reported no conditions and 213 (46%) had at least one reported health condition. The top categories of diagnosis were ocular (22.1%, 81 of 367 reported conditions), reproductive (9.0%, 33 of 367 reported conditions), respiratory (9.0%, 33 of 367 reported conditions) and dermatological (8.7%, 32 of 367 reported conditions). The most frequently reported conditions were corneal ulcer (38 cases, 8.2% prevalence), seizures/fits/epilepsy (21 cases, 4.6% prevalence), undiagnosed skin irritation (17 cases, 3.7% prevalence) and cystitis (15 cases, 3.3% prevalence).

2004 Mortality results: A total of 163 deaths were reported in the breed. The median age at death for Pugs was 11 years (min = 2 months, max = 17 years). The most frequently reported causes of death were old age (36 dogs, 22.1% of deaths), cancer (18 dogs, 11.0% of deaths), perioperative or anaesthetic-related (11 dogs, 6.7% of deaths) and heart failure (11 dogs, 6.7% of deaths).

2014 Morbidity results: Health information was reported for 555 live Pugs of which the median age was 2 years. Some 61.3% of dogs (n=340) were reported to be affected by no conditions and 38.7% of dogs (n=215) were affected by at least one

condition (minimum conditions affected by = 1, maximum = 13). The most commonly reported disease condition in descending order is shown in Table 1 below.

Table 1: The most frequently reported health conditions for 555 Pugs in the 2014 Pedigree Breed Health Survey. The proportion of dogs affected is the number of cases divided by the total number of responses received for the breed.

Disease condition	Number of cases reported	Proportion of dogs affected
Corneal ulcer	36	6.49%
Umbilical hernia	26	4.68%
Hypersensitivity (allergic) skin disorder	21	3.78%
Keratoconjunctivitis sicca (Dry Eye)	21	3.78%
Seizure/fitting	20	3.60%
Narrowed nostrils	18	3.24%
Entropion	14	2.52%
Epilepsy	13	2.34%
Patellar luxation	13	2.34%
Pigmentary keratitis	13	2.34%

Further analysis of the morbidity results suggested that the Pug was at increased risk of BOAS, corneal ulcer, distichiasis, entropion, keratoconjunctivitis sicca, regular reverse sneezing, seizures/fitting, umbilical hernia, unspecified eye conditions and unspecified respiratory conditions compared to the average risk for dogs of all breeds.

2014 Mortality results: A total of 24 deaths were reported. The most frequently reported causes of death were old age (4 deaths), cardiac failure (3 deaths) and surgical complications (2 deaths).

A health survey has been prepared by the KC and is awaiting approval from the Breed Health Co-ordinator prior to dissemination.

UK LITERATURE REVIEW

The literature review lays out the current scientific knowledge relating to the health of the breed. We have attempted to refer primarily to research which has been published in peer-reviewed scientific journals. We have also incorporated literature that includes dogs residing within the UK primarily, and literature that was released relatively recently to try to reflect current publications and research relating to the breed.

Cancers

Superficial Corneal Squamous Cell Carcinoma: A study of 26 cases of this rare tumour diagnosed in dogs at the Comparative Ocular Pathology Lab of Wisconsin, USA, between 1978 and 2008 reported a strong breed predisposition in

brachycephalic breeds with 35% of cases (9 of 26) occurring in Pugs (Dreyfus et al 2011). Some 77% of cases in the study were in brachycephalic breeds, and the authors suggested that chronic inflammatory conditions of the cornea (including keratoconjunctivitis sicca) may be risk factors for primary corneal squamous cell carcinoma.

Mast cell tumours: A literature review of breed predispositions to particular cancers listed the Pug as being previously over-represented in studies investigating mast cell tumours (Dobson, 2013). The author noted that Pug mast cell tumours appear to be lower grade tumours in comparison to other breeds. A VetCompass study has been undertaken for mast cell tumours, and details the breed's risk under the VetCompass section on page 12).

Endocrine conditions

Diabetes mellitus: An American study reported the Pug to be at increased risk of this endocrine condition. A search of the medical records of all dogs admitted to the Veterinary Hospital of the University of Pennsylvania between January 1993 and May 1998 identified 221 dogs with diabetes mellitus and 42,882 without; the Pug had an odds ratio of 3.87 (85% C.I. 1.20 – 9.68; 5 cases and 239 non-cases) compared to mixed breed dogs suggesting an increased risk of developing the condition (Hess et al, 2000). No more recent reports or prevalence estimates could be found in the literature for UK dogs.

Obesity: A study investigating undesirable behaviours in obese dogs included the Pug as a breed with a possible predisposition to obesity (German et al, 2017). An odds ratio of 4.04 (95% CI 2.14 – 7.63) was established for obese dogs with regard to undesirable behaviours, implying obese dogs were more likely to exhibit negative behaviours. The authors found that neutering status was positively associated with obesity in the breed.

General

The Pug had the second highest count of disorders resulting directly from selection for conformational traits, with 33 disorders listed, among the top 50 Kennel Club-registered breeds in 2007 (Asher et al, 2009). However, no attempt was made by the authors in that study to consider whether the research included referred to UK dogs or dogs from other countries.

Haematological conditions

May – Hegglin Anomaly: This rare, inherited, blood platelet disorder in which the platelets are abnormally large, caused by a mutation in the *MYH9* gene, has been reported in a Pug presented to the University of Tennessee Veterinary Medical Centre, USA (Flatland et al, 2011). In humans, the mutation is inherited in an autosomal dominant fashion. The mode of inheritance in Pugs, if this was not a spontaneous mutation, has not yet been established and no prevalence estimates could be found in the literature. A DNA test is available for the condition.

Hepatic conditions

Portosystemic shunt: A study of electronic patient records of 90,004 dogs examined at the University of California-Davis Veterinary Medical Teaching Hospital, USA, between 1st January 1995 to 1st January 2010 found the Pug to be the third most frequently affected breed with congenital portosystemic shunt, with a breed-specific prevalence of 5.88% compared to a mixed breed-prevalence of 0.35% (Bellumori et al, 2013). However, prevalence estimates could not be found for a UK population.

Musculoskeletal conditions

Legg-Calve-Perthes Disease (avascular necrosis of the femoral head): This condition is considered to be common among small breed dogs. Robinson (1992) assessed the genetic aetiology of the condition in four different breeds in the UK: West Highland White Terrier, Yorkshire Terrier, Pug and Miniature Poodle. Of five litters of the breed studied, seven out of 18 puppies were affected with the condition which was reported to fit with an autosomal recessive mode of inheritance although could also suggest it is a complex condition. In a study based on American veterinary teaching hospital data the Pug had an odds ratio of 65.6 (95% C.I.28.1-152.9) compared to mixed breeds, however this result was based on just 11 cases and three non-cases in the breed (LaFond et al, 2002).

Neurological conditions

Necrotizing Meningoencephalitis (NME, Pug Dog Encephalitis, PDE): This inflammatory central nervous system disease is reported to be common in Pugs but similar conditions have been reported in other toy breeds. An American study investigated the condition in 60 pugs and reported that the median age at onset of clinical signs was 18 months. Female dogs appeared to be more commonly affected (40 of 60 cases) with all cases suffering seizures and on average affected dogs lived 93 days from onset of clinical signs (Levine et al, 2008). A subsequent American study of 43 affected Pugs and 147 unaffected Pugs identified three loci associated with the dog leukocyte antigen (DLA) class II complex on chromosome 12; affected dogs were more likely to be homozygous for specific alleles at each locus, and these alleles were linked forming a single high risk haplotype (Greer et al, 2010).

Hemivertebrae: These congenitally malformed, wedge-shaped vertebrae are considered to be more common in screw-tailed breeds such as the Pug and indeed it has been suggested that the kinked tail is due to hemivertebrae in the coccygeal region. Many affected dogs do not show any clinical signs, but when clinical signs do occur they are considered to be a consequence of progressive vertebral canal stenosis (narrowing) and vertebral column instability.

A study of Pugs, Bulldogs and French Bulldogs which had attended the Small Animal Referral Hospital at the Royal Veterinary College between October 2010 and February 2016 reported a prevalence of 4.7% (9 of 192 Pugs) for thoracic vertebral malformations causing clinical signs in the Pug (Ryan et al, 2014). Considering a subgroup of 68 Pugs without any neurological signs, 26.5% (18 Pugs) had no

thoracic vertebral malformations, 25.0% (17 Pugs) had only 12 thoracic vertebrae instead of the normal 13, 17.6% (12 Pugs) had hemivertebrae and 30.9% (21 Pugs) had transitional vertebrae (i.e. vertebrae which have the characteristics of two different types; in this case the final thoracic vertebra had characteristics of a lumbar vertebra). In addition some 38.2% (26 Pugs) of these Pugs without neurological signs were found to have spina bifida, affecting the first thoracic vertebra in all cases (Ryan et al, 2014). Comparing the three breeds, neurologically normal Pugs had the lowest prevalence of thoracic vertebral malformations and hemivertebrae in particular. However the Pug had the highest prevalence of spina bifida and transitional vertebrae in neurologically normal individuals of the three breeds; the Pug also had the highest prevalence of thoracic vertebral malformations causing clinical signs.

Spinal arachnoid diverticula (SAD): SAD is a result of dilations or lesions within the subarachnoid space (area between two membranes surrounding the brain) leading to progressive myelopathy, characterised by neurological clinical signs such as imbalance (ataxia). A total of 122 dogs were examined at the Animal Health Trust (AHT) with the Pug being the most commonly represented breed (n=21). Across three veterinary hospitals the percentage of Pugs affected by SAD were 4.5% (AHT), 3.4% (University of Ghent, Belgium) and 0.0% (Royal Veterinary College). The median age of onset for the breed was 59 months. Seven of the 21 Pugs had concurrent disease, with four suffering from intervertebral disc extrusion and three with vertebral malformation.

Ocular conditions

Keratoconjunctivitis sicca (KCS): An American study found the Pug to be at increased risk of this condition (Kaswan and Salisbury, 1990). A more recent study of dogs referred to the University of Glasgow Small Animal Hospital with the condition, in which 229 cases from 44 different breeds were represented, one case in a Pug was included which was not an overrepresentation (Sanchez et al, 2007). However, the condition does not always require referral so that study population may not have been representative of the wider population.

Pigmentary keratitis (pigmentary keratopathy): This refers to corneal pigmentation which develops as a response to irritation of the cornea such as may occur due to entropion or KCS. It is a clinical sign rather than a diagnosis, and its presence should prompt thorough investigation to identify and if possible treat the underlying cause (Labelle et al, 2013). A study of 295 Pugs attending a dog show and two “social dog events” in America, of which 80% (236 dogs) were fawn and 20% (59 dogs) were black detected corneal pigmentation in at least one eye of 82.4% (243 dogs) of Pugs examined (Labelle et al, 2013).

Respiratory conditions

Brachycephalic Obstructive Airway Syndrome (BOAS): This syndrome is considered to be common in the Pug and features which are involved include stenotic nares

(narrow nostrils), overlong soft palate and secondary effects such as tracheal collapse.

The BOAS research team at the University of Cambridge have been researching this condition. Their studies have used whole-body barometric plethysmography (WBBP) to measure and categorise upper airway obstruction in French Bulldogs, Bulldogs and Pugs. Dogs referred to the Queen's Veterinary School Hospital at the University of Cambridge were admitted to the study (n=100 for each breed) and excluded if <1 year of age, had history of previous upper airway surgery, history or clinical findings of lower airway disease, on medications that may alter respiratory parameters, or combination of these factors. Dogs were graded through a four-point functional BOAS grading system (grade 0 to grade 3) before and after an exercise tolerant test, underwent a body conditioning score (1-9 point scale) and then underwent WBBP. The body conditioning score for the Pug was significantly increased compared to controls, with 62% of dogs being classed as obese (score of 7-9). 58.2% of Pugs were classed as having stenotic nares (OR = 4.3 (CI: 1.69-10.97%), with 7% scoring grade 0, 26% grade I, 50% grade 2 and 17% grade 3, therefore 59.8% of Pugs were found to have BOAS (CI: 48.9-69.7%) (Liu et al, 2016).

Urological conditions

Urolithiasis - struvite: A study analysed 14,008 uroliths from UK dogs which had been submitted to the University of Minnesota Urolith Centre between 1997 and 2006 to identify breed-associated risk factors. A total of 6933 stones consisting of struvite were admitted to the study, of these 48 of the dogs affected were Pugs giving an odds ratio for the breed of 4.71 (CI: 3.28-6.77) (Roe et al, 2012).

VETCOMPASS

The Kennel Club work closely with VetCompass at the Royal Veterinary College. VetCompass is a broad welfare research programme that collects anonymised clinical information from more than 1800 UK veterinary practices and includes over 7.5 million dogs. VetCompass research can be used to identify common breed-specific conditions, or condition-specific concerns which affect a range of breeds. A breed specific VetCompass paper has been published for the Pug which is shown below and, in addition, the Pug is included in the condition-specific studies also detailed below.

Breed specific study: A study published in 2016 aimed to use VetCompass data to describe the demography and common disorders of Pugs in the UK (O'Neill et al, 2016). A link to the study is provided in the reference list at the end of this document, and infographics from the study can be found here: http://www.rvc.ac.uk/vetcompass/learn-zone/infographics/canine/pug.

Considering the 1009 Pugs under veterinary care in the study during 2013, 68.19% of Pugs (668 dogs) had at least one disorder recorded. The most common disorders

recorded were overweight/obese (133 cases, 13.18% prevalence), corneal disorder (88 cases, 8.72% prevalence), otitis externa (76 cases, 7.53% prevalence), unspecified ear disorder (75 cases, 7.43% prevalence), anal sac impaction (66, 6.54% prevalence) and periodontal disease (62 cases, 6.14% prevalence). The most prevalent disorder groups were ophthalmological (164 cases, 16.25% prevalence), dermatological (157 cases, 15.60% prevalence) and aural (152 cases, 15.06% prevalence).

Looking at the specific disorders mentioned in the literature review above, the following prevalence estimates were reported in this study: BOAS 52 cases, 5.15% prevalence; intertrigo 32 cases, 3.17% prevalence; keratoconjunctivitis sicca 19 cases, 1.88% prevalence; hypersensitivity (allergic) skin disorder/atopic dermatitis 14 cases, 1.39% prevalence; patellar luxation 12 cases, 1.19% prevalence; seizures/fitting 12 cases, 1.19% prevalence; Legg-Calve-Perthes disease two cases, 0.2% prevalence and meningoencephalitis two cases, 0.2% prevalence (O'Neill et al, 2016).

Cancers

Mast Cell Tumours (MCTs): A study assessing the prevalence and risk factors for MCTs in UK based dogs found the Pug to be at greater odds of MCTs compared to crossbreed dogs (Shoop et al, 2015). The study used VetCompass data consisting of 168,636 dogs attending 94 veterinary practices in England between 2007 and 2013, of which 453 dogs met the case inclusion criteria. Overall MCT prevalence was estimated at 0.27%. The Pug was one of the breeds that exceeded this with MCT prevalence of 0.50% (95% CI: 0.13% - 0.88%). The number of pugs affected was 2% of the population (n=7) and the breed was established as having a 10.0 times odds of developing MCTs compared to dogs of no recognisable breed with an odds ratio of 2.8 (95% C.I.1.1-7.2).

Ocular conditions

Corneal ulceration: In a VetCompass study of 104,233 dogs attending 110 first opinion veterinary practices in England, the Pug had the highest prevalence of corneal ulceration with a breed-specific prevalence of 5.42% compared to an all-breed prevalence of 0.80% (O'Neill et al, 2017). The Pug had an odds ratio for corneal ulceration of 15.13 (95% C.I. 10.74-21.32) compared with dogs of no recognisable breed.

Pigmentary keratitis: This condition is characterised by development of corneal pigmentation and associated inflammation, which can result in visual impairment or even blindness. A recent breed-specific study on 210 Pugs recruited from UK shows/ social events established pigmentary keratitis in 87.8% of eyes, with 91.9% of dogs being affected in at least one eye (Maini et al, 2019). Overall, 46.3% of eyes were mildly affected and 49.9% moderately. Older age (odds ratio 1.76 (95% CI 1.31 – 2.36)) and entropion of the lower eyelid (odds ratio 9.98 – 13.19, dependent on grade) were both factors found to be correlated with the severity of pigmentary keratitis.

Neurological conditions

Chiari-like malformation (CM)/ syringomyelia (SM): Chiari-like malformation (CM) results in overcrowding of the caudal fossa, obstruction of cerebrospinal fluid (CSF) flow and consequential secondary syringomyelia (SM). The condition was first identified in the Cavalier King Charles Spaniel (CKCS) in 1997 and has been identified in other toy breeds since. A VetCompass study of several breeds, of which 1,726 were Pugs, only diagnosed one of these dogs with CM/SM, giving an estimated breed prevalence of 0.06% (95% 0.01 – 0.36).

Epilepsy: The Pug was established as a breed with an elevated odds of developing epilepsy when compared with the Labrador, with an odds ratio of 3.41 (95% CI 2.71 – 4.28) (Erlen et al, 2018). Of all breeds, the Pug had the highest seizure prevalence, at 1.88% (95% CI 1.52 – 2.24), based on 101 cases out of a total of 5,376 Pugs. The median age of cases was 4.95 years.

Musculoskeletal conditions

Patellar luxation: Out of a total of 1,998 Pugs included in a VetCompass study, 3.5% were established as being affected by patellar luxation (95% CI 2.1-4.9). An odds ratio of 3.7 was produced for the breed (95% CI 2.3-5.8)

Reproductive conditions

Dystyocia: From a study population of 18,758 female dogs attending UK veterinary practices, the Pug was found to be the fourth most commonly affected breed with a breed prevalence of 14.5% (95% CI 10.9 – 19.4) (O'Neill et al, 2017). An odds ratio of 11.3 (95% CI 7.1 – 17.9) was produced. Across all breeds, bitches aged between 3.0 and 5.9 years had 3.1 times the odds of dystocia compared with bitches under the age of three.

Respiratory conditions

BOAS: A VetCompass study investigated the epidemiological associations between brachycephalic breeds and upper respiratory tract (URT) disorders in England based dogs. A total of 170,812 dogs were admitted to the study with 200 dogs from each breed (French Bulldog, Bulldog, Pug) randomly selected to be included. Considering the 200 Pugs admitted to the study 26.5% (n=53) were affected by at least one URT disorder, 14.5% (n=29) by nares/nasal cavity disorder, 4.0% (n=8) by hard and soft palate disorder, 2.0% (n=4) by pharynx disorder, 1.5% (n=3) by larynx disorder, 5.5% (n=11) by trachea disorder, 6.5% (n=13) by BOAS and 13.0% (n=26) by multi-site URT disorders (O'Neill et al, 2015). Compared to the control breeds the Pug was found to have an odds ratio of 6.9 (CI: 3.6-13.3) for developing at least one URT disorder (O'Neill et al 2015). This was the highest odds ratio out of all the breeds.

Skin conditions

Demodicosis: This condition is a result of abnormal and excessive numbers of the mite *Demodex canis* which resides in the skin, resulting in skin lesions and

secondary bacterial skin infections. The Pug was one of seven breeds with the greatest prevalence of this condition across all ages, as well as for dogs affected under the age of two years, and dogs over the age of four years, based on analysis of 50 out of a total of 788 cases (O'Neill et al, 2019). The prevalence of demodicosis in dogs under two years was 1.91%, dogs over four years 0.15% and all ages 6.7%. The authors established an odds ratio of 5.41 (95% CI 3.87-7.55) for the breed, with this being the fifth highest ratio.

INSURANCE DATA

There are some important limitations to consider for insurance data:

- Accuracy of diagnosis varies between disorders depending on the ease of clinical diagnosis, clinical acumen of the veterinarian and facilities available at the veterinary practice.
- Younger animals tend to be overrepresented in the UK insured population.
- Only clinical events that are not excluded and where the cost exceeds the deductible excess are included

UK Agria data

Insurance data were available for Pugs insured with Agria UK (Table 2). 'Exposures' are equivalent to one full policy year; between July 2016 and June 2017 there were 588 free exposures, 1,928 full exposures and1,833 claims, between July 2017 and June 2018 these figures were 549, 1,658 and 1,762 respectively.

Full policies are available to dogs of any age. Free policies are available to breeders of Kennel Club registered puppies and cover starts from the time the puppy is collected by the new owner; cover under free policies lasts for five weeks from this time. It is possible that one dog could have more than one settlement for a condition within the 12-month period shown.

Table 2: Top 10 conditions and number of settlements for each condition between 1st August 2017 and 31st July 2018 for Pugs insured on full policies with Agria UK

Condition	Number of settlements
Ulcerative keratitis (Corneal ulceration)(unspecified)	281
Epilepsy	93
Hypersensitivity (allergic) skin disorder (unspecified)	84
Brachycephalic airway obstruction syndrome (BAOS)	82
Atopy finding	64
Skin (cutaneous) disorder (unspecified)	36
Patellar luxation - medial	34
Entropion	33
Mast cell tumour (site unspecified)	30
Epilepsy - idiopathic generalised	28

[$] N.B. - Allergy is any exaggerated immune response to a foreign antigen regardless of mechanism. A dog can be allergic without being atopic. Atopy is a genetic predisposition to an exaggerated Immunoglobulin E (IgE)-mediated immune response to allergens in the environment. The treatment of atopy will be different to the treatment of non-atopic allergy.

Swedish Agria data

Swedish morbidity and mortality insurance data were available from Agria for the Pug. Reported rates are based on dog-years-at-risk (DYAR) which take into account the actual time each dog was insured during the period (2011-2016). A dog insured for one year is equivalent to 1 DYAR. DYAR for the breed was 10,000 < 15,000.

The most common specific causes of Veterinary Care Events (VCEs) for Agria-insured Pugs in Sweden between 2006 and 2011 are shown in Figure 2. The top five specific causes of VCEs were corneal ulcer, infected/inflamed cornea/sclera, otitis, dermatitis/pyoderma/folliculitis and vomiting/diarrhoea/enteritis.

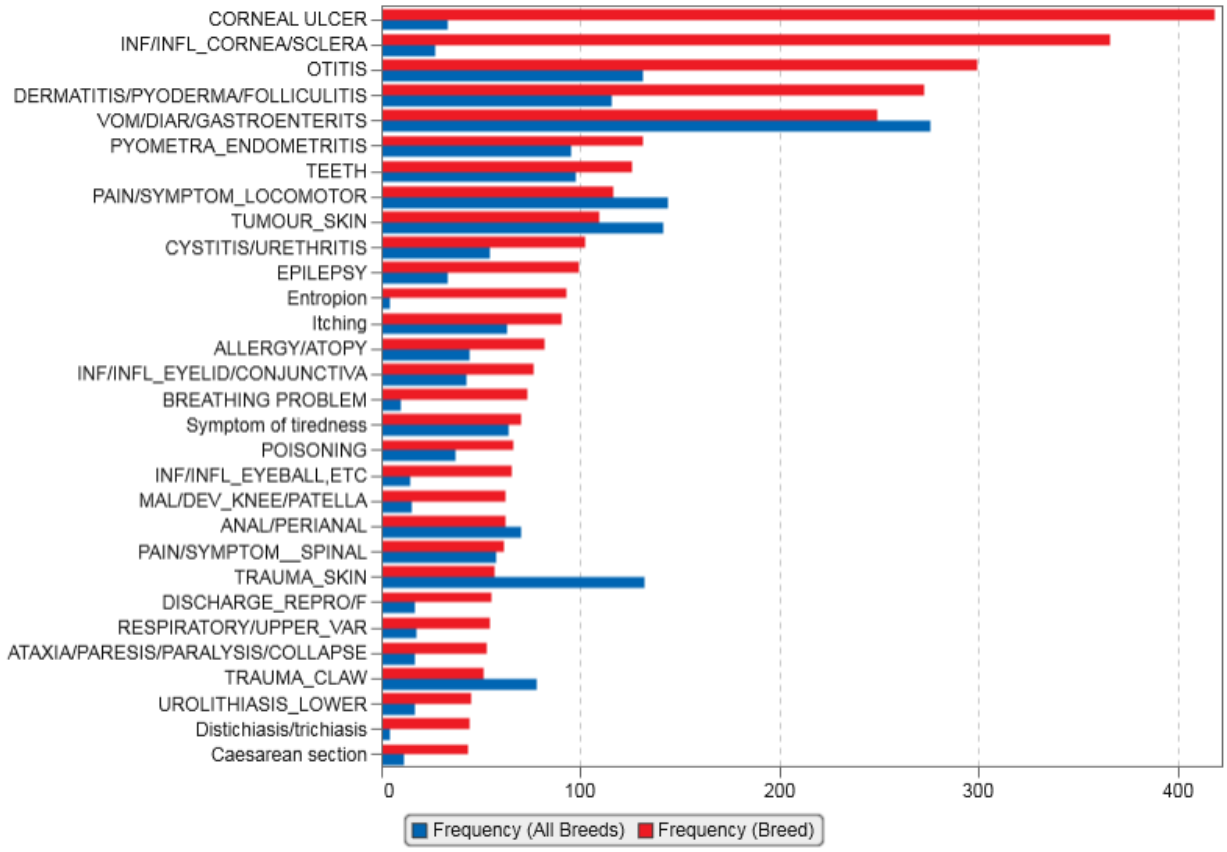

Figure 2: The most common specific causes of VCEs for the Pug compared to all breeds in Sweden between 2011 and 2016, from Swedish Agria insurance data.

When relative risk of specific causes of VCEs was compared for the Pug to all breeds, a couple of interesting findings were reported. In this analysis, the top five specific causes of VCEs ordered by relative risk were entropion, malformation or developmental abnormalities of the respiratory tract, infected or inflamed cornea/sclera, corneal ulcers and distichiasis/ trichiasis (Figure 3).

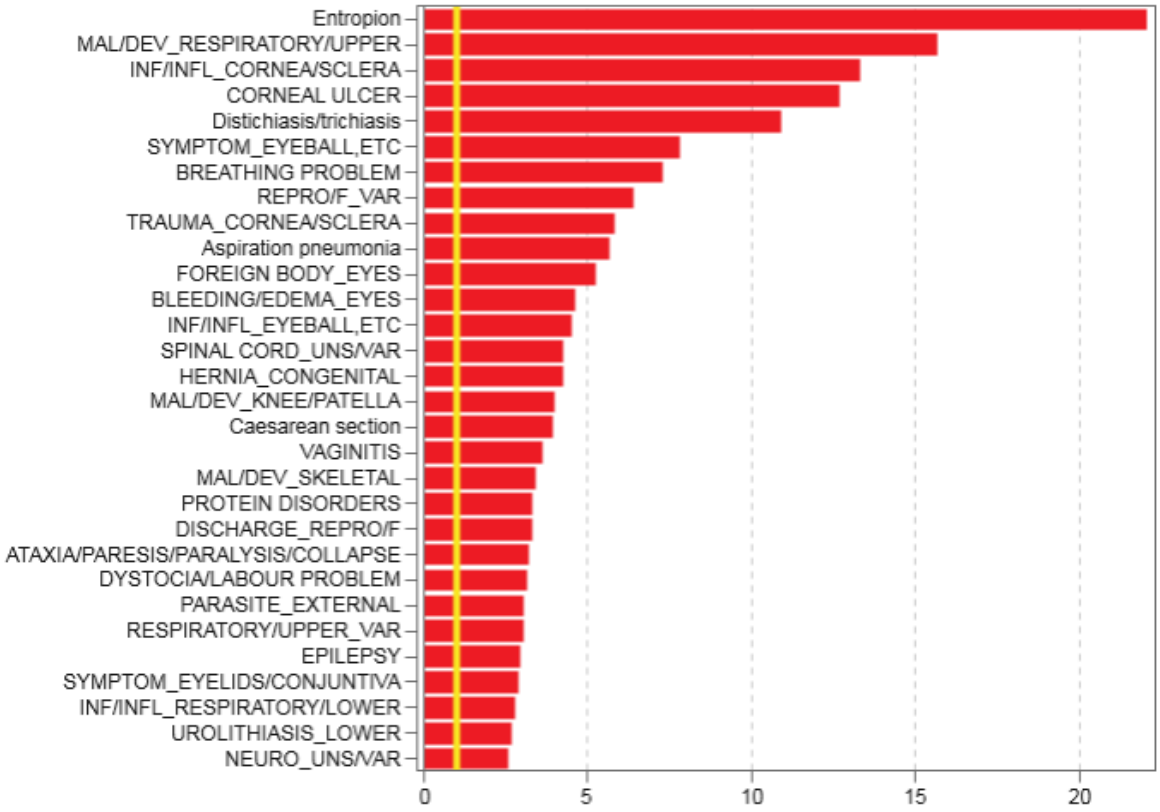

Figure 3: The specific causes of VCEs for the Pug ordered by relative risk compared to all breeds in Sweden between 2011 and 2016, from Swedish Agria insurance data.

The most common specific causes of death for the Pug are shown in Figure 4, the top five causes were hit by dead/ euthanised, ataxia/ paresis/ paralysis/ collapse, epilepsy, hit by car/ train/ vehicle, and breathing problem.

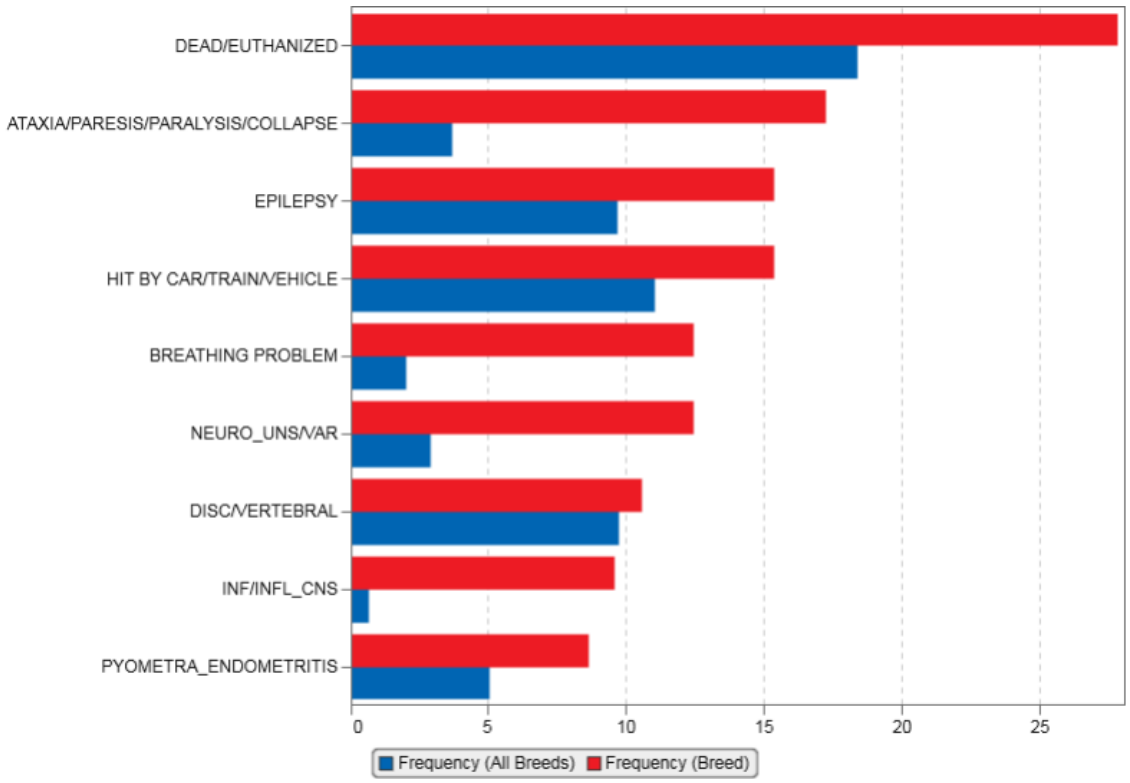

Figure 4: The most common causes of death for the Pug compared to all breeds in Sweden between 2011 and 2016, from Swedish Agria insurance data.

BREED WATCH

As a category three breed judges' health monitoring forms are mandatory when judging the breed at Championship Certificate level, and Best of Breed winners must undergo a veterinary health check prior to competing for Best in Show. The points of concern reported are shown below in Table 3. Those marked with a * indicate newly reported points of concern.

Table 3: Judges' health monitoring reports for 2016 to 2019.

Point of concern	2016	2017	2018	2019
Excessive nasal folds	0.7%	1.3%	1.2%	0.9%
Excessively prominent eyes	0.4%	0.3%	0.4%	0.6%
Hair loss or scarring from previous dermatitis	0.0%	0.2%	0.0%	0.0%
Incomplete blink	0.1%	0.0%	0.0%	0.0%
Pinched nostrils	0.8%	2.4%	1.6%	1.4%
Showing respiratory distress including difficulty breathing	0.0%	0.0%	0.1%	0.1%
Significantly overweight	3.5%	2.6%	1.2%	5.0%
Signs of dermatitis in skin folds	0.0%	0.1%	0.0%	0.1%
Sore eyes	0.1%	0.2%	0.1%	0.1%
Unsound movement	1.3%	2.1%	0.7%	0.4%
* Difficulty breathing	0.3%	0.3%	0.0%	0.0%
* Heavy overnose wrinkle	0.0%	0.0%	0.0%	0.1%
*Obvious ear irritation	0.0%	0.0%	0.0%	0.1%
* Other	0.0%	0.0%	0.1%	0.0%
* Poor muscle tone	0.0%	0.2%	0.0%	0.0%
* Weak hindquarters	0.0%	0.0%	0.0%	0.2%
Total dogs shown	**3484**	**3102**	**3248**	**2362**

NB. Showing respiratory distress including difficulty breathing was introduced as a new point of concern in November 2017, and difficulty breathing was removed.

PERMISSION TO SHOW

As of the 1st January 2020 exhibits for which permission to show (PTS) following surgical intervention has been requested will no longer be published in the Breed Record Supplement and instead will be detailed in BHCPs, and a yearly report will be collated for the BHC. PTS granted to date are shown in Table 4 below (excluding PTS for neutering and caesarean sections).

Table 4: PTS surgeries granted to date for exhibits per year

	Year			
Surgery	2016	2017	2018	2019
Corneal graft for a perforated ulcer		1		1
Enucleation (eye removal)				1
Removal of testicle(s)	1			
Removal of tumour				1
Total ear canal ablation				1
Umbilical hernia	1			

ASSURED BREEDER SCHEME

Currently it is a requirement that all Assured Breeders complete the following health tests for all breeding stock:

- BOAS testing under the RFG Scheme

It is also recommended that dogs are tested for:

- Hemivertebrae testing of both parents by x-ray after 12 months of age
- Patella testing
- Participation in the 5 Star Health Scheme

BREED CLUB BREEDING RECOMMENDATIONS

It is currently recommended that that hemivertebrae checking of parents by X-ray at 12 months of age should be undertaken as should patella testing.

DNA TEST RESULTS

The following DNA tests are currently available and recognised for the breed:

- Pug Dog Encephalitis (PDE)

A list of laboratories that provide the test can be found through clicking here: https://www.thekennelclub.org.uk/worldwide-dna-tests/

Whilst other DNA tests may be available for the breed results from these will not be accepted by the Kennel Club until the test has been formally recognised; the process involves collaboration between the breed clubs and the Kennel Club in order to validate the test's accuracy.

No DNA test results for PDE have been received to date by the KC, however this is due to the test only having been formally recognised late November 2019.

CANINE HEALTH SCHEMES AND ESTIMATED BREEDING VALUES

All of the BVA/KC Canine Health Schemes are open to dogs of any breed with a summary given of dogs tested to date below. Estimated breeding values are not available for the breed at this time due to insufficient numbers of dogs that have participated in the current schemes. It is hoped EBVs may be accessible once a sufficient number of dogs have taken part in the University of Cambridge/ KC RFG Scheme.

HIPS

In total 67 Pugs have been hip scored as part of the BVA/KC Hip Dysplasia Scheme in the 15 years to 2019, the median hip score received was 17 (range 7 – 72). This does not differ hugely from the median score for the last five years which was 15.5 (range 7 – 60).

ELBOWS

Only six Pugs have been elbow scored as part of the BVA/KC Elbow Dysplasia Scheme since the scheme launched in 1998; with one scoring as 0, three grade 1, and two grade 2.

EYES

The Pug is not currently on the 'Known Inherited Ocular Diseases' list (previously Schedule A) under the BVA/KC/International Sheep Dog Society (ISDS) Eye Scheme. However, the BVA still records the results of dogs of other breeds which have participated in the scheme. The results of Eye Scheme examinations of Pugs which have taken place since 2012 are shown in Table 5.

Table 5: Reports on Pugs which have participated in the BVA/KC/ISDS Eye Scheme between 2012- 2017.

Year	Number seen	Comments
2012	15 adults 1 litter	10 – entropion 7 – corneal pigment 2 – ectopic cilia 1 – ectropion 1 – posterior polar sub-capsular cataract 1 – other cataract
2013	12 adults	9 – pigmentary keratitis 7 – entropion 1 – persistent pupillary membranes (PPM)

2014	10 adults 2 litters	5 – pigmentary keratitis 3 – entropion 2 – distichiasis No disorders noted for litters
2015	5 adults	3 – pigmentary keratitis 2 - entropion
2016	9 adults	5 – pigmentary keratitis 2 – entropion 1 – distichiasis 1 – persistent pupillary membranes
2017	5 adults 1 litter	No comments
2018	24 adults	5 – distichiasis 22 – entropion

In addition to the Sightings, a Pug Health Day was held in March 2018 and 19 Pugs were examined under the Eye Scheme by a single Eye Panellist. The results of those examinations are shown in Table 6.

Table 6: Results of examinations of 19 Pugs by a single Eye Panellist in March 2018.

Condition	**Number of dogs affected**
Entropion (medial aspect of lower eyelids and trichiasis)	18
Corneal pigmentation / fibrosis (medially)	12
Corneal pigmentation / fibrosis (other locations)	1
Notable macroblepharon	14
Distichiasis	4
Epiphora	2
PPM	2
Vitreal degeneration	2

American College of Veterinary Ophthalmologists (ACVO)

Results of examinations through AVCO are shown in Table 7 below. Between 2015 and 2019, 250 dogs of the breed were examined by the ACVO and prevalence data are shown in Table 8 alongside data from previous years. Overall, 29.4% (153 of 520) of the Pugs examined during this time had healthy eye conformation with no conditions diagnosed. It should be noted that the sample of dogs represents American Pugs solely.

Table 7: ACVO examination results for Pugs, 1991 - 2019

Disease Category/Name	Percentage of Dogs Affected

	1991-2014 (n=2,457)	2015-2019 (n=520)
Eyelids		
Entropion	19.1%	11.0%
Distichiasis	8.8%	8.3%
Macropalpebral fissure	2.7%	0.0%
Cornea		
Corneal pannus	3.3%	0.0%
Pigmentary keratitis	29.3%	51.7%
Uvea		
Persistent pupillary membranes, iris to iris	9.8%	16.0%
Lens		
Cataract (significant)	4.3%	2.9%
Vitreous		
Persistent hyaloid artery/remnant	0.4%	1.2%
Vitreal degeneration	1.1%	0.8%

Adapted from: https://www.ofa.org/diseases/eye-certification/blue-book

Respiratory Function Grading (RFG) Scheme

The University of Cambridge/ KC RFG Scheme was launched in February 2019 for the three most popular brachycephalic breeds, Pugs, French Bulldogs and Bulldogs. Breeders can take their dogs to an approved regional assessor who undertakes a simple and non-invasive trot test to establish a dog's airways before and after stress.

The results of dogs that have been graded under the scheme are shown in Table 8 below.

Table 8: University of Cambridge/KC RFG Scheme results for Pugs, 2016 - 2019

Respiratory Grade	Total Dogs	Male		Female	
Grade 0	40 (29.4%)	24 (30.8%)	61 (78.2%)	16 (27.6%)	53 (91.4%)
Grade 1	74 (54.4%)	37 (47.4%)		37 (63.8%)	
Grade 2	21 (15.4%)	16 (20.5%)	17 (21.8%)	5 (8.6%)	5 (8.6%)
Grade 3	1 (0.74%)	1 (1.28%)		0	
Total Graded	**136**	**78**		**58**	

REPORTED CAESAREAN SECTIONS

When breeders register a litter of puppies, they are asked to indicate whether the litter was delivered (in whole or in part) by caesarean section. In addition, veterinary surgeons are asked to report caesarean sections they perform on Kennel Club registered bitches. The consent of the Kennel Club registered dog owner releases the veterinary surgeon from the professional obligation to maintain confidentiality (vide the Kennel Club General Code of Ethics (2)).

There are some caveats to the associated data;

- It is doubtful that all caesarean sections are reported, so the number reported each year may not represent the true proportion of caesarean sections undertaken in each breed.
- These data do not indicate whether the caesarean sections were emergency or elective.

The number of litters registered per year for Pugs and the number and percentage of reported caesarean sections in the breed for the past 10 years are shown in Table 9.

Table 9: Number and percentage of litters of Pugs registered per year and number of caesarean sections reported per year, 2008 to 2018.

Year	**Number of Litters Registered**	**Number of C-sections**	**Percentage of C-sections**	***Percentage of C-sections out of all KC registered litters (all breeds)***
2008	1151	1	0.09%	0.05%
2009	1307	0	0.00%	0.15%
2010	1492	3	0.20%	0.35%
2011	1607	39	2.43%	1.64%
2012	1825	208	11.40%	8.69%

2013	2004	269	13.42%	9.96%
2014	2330	295	12.66%	10.63%
2015	2419	293	12.11%	11.68%
2016	2568	373	14.52%	13.89%
2017	2490	320	12.85%	15.00%
2018	2134	260	12.18%	17.21%

GENETIC DIVERSITY MEASURES

The effective population size is the number of breeding animals in an idealised, hypothetical population that would be expected to show the same rate of loss of genetic diversity (rate of inbreeding) as the population in question; it can be thought of as the size of the 'gene pool' of the breed. In the population analysis undertaken by the Kennel Club in 2015, an estimated effective population size of 133.9 was reported (estimated using the rate of inbreeding over the period 1980-2014). An effective population size of less than 100 (inbreeding rate of 0.50% per generation) leads to a dramatic increase in the rate of loss of genetic diversity in a breed/population (Food & Agriculture Organisation of the United Nations, "Monitoring animal genetic resources and criteria for prioritization of breeds", 1992).

Annual mean observed inbreeding coefficient (showing loss of genetic diversity) and mean expected inbreeding coefficient (from simulated 'random mating') over the period 1980-2014 are shown in Figure 5. As with most breeds, the rate of inbreeding was at its highest in this breed in the 1980s and 1990s. This represents a 'genetic bottleneck', with genetic variation lost from the population. However, since 2000 the rate of inbreeding has been negative, implying moderate restoration of genetic diversity (possibly through the use of imported animals). For full interpretation see Lewis et al, 2015 https://cgejournal.biomedcentral.com/articles/10.1186/s40575-015-0027-4.

The current annual breed average inbreeding coefficient is 5.2%.

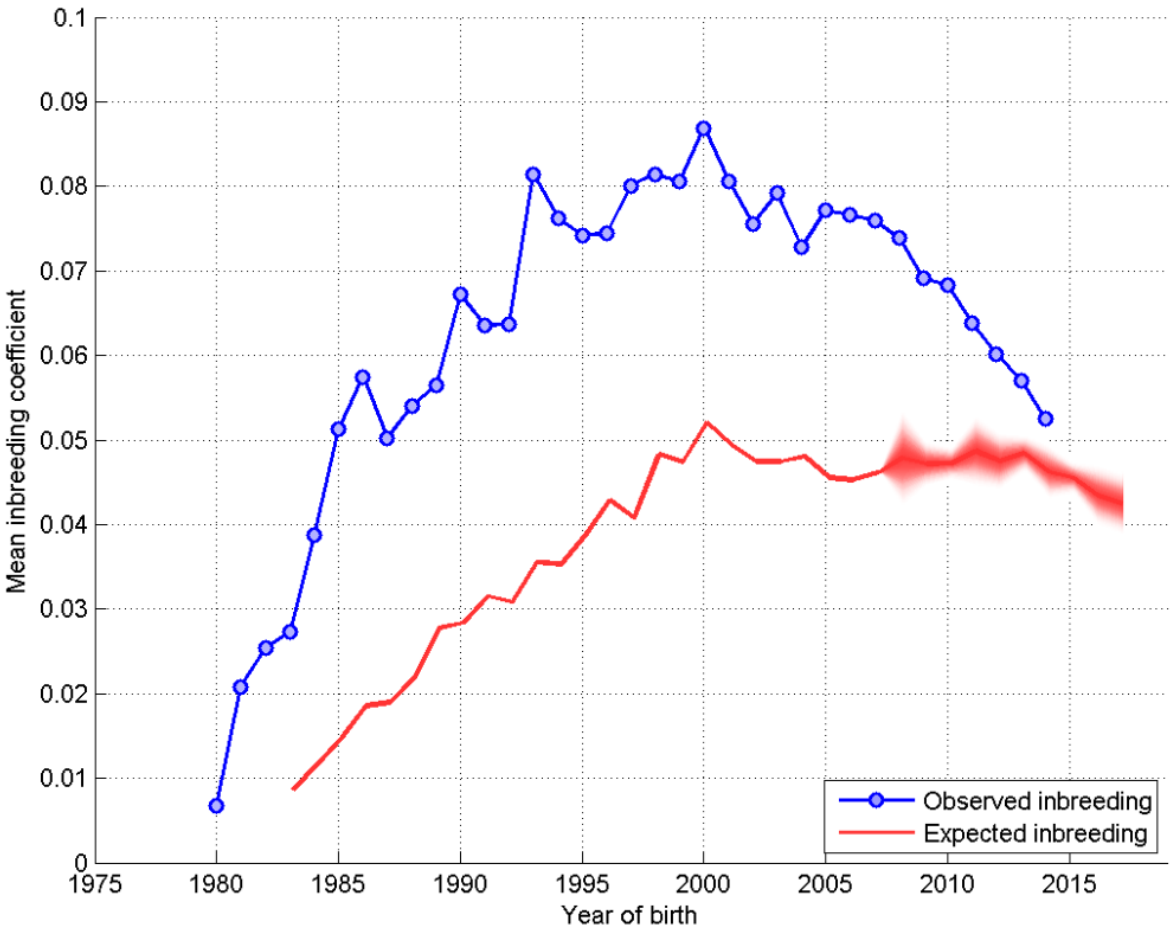

Figure 5: Annual mean observed and expected inbreeding coefficients.

[The blurring around the expected inbreeding line indicates an approximate standard deviation around the estimate, in breeds with more than 2000 individuals born in a given year.]

Below is a histogram (‘tally’ distribution) of number of progeny per sire and dam over each of seven five-year blocks (Figure 6). A longer ‘tail’ on the distribution of progeny per sire is indicative of ‘popular sires’ (few sires with a very large number of offspring, known to be a major contributor to a high rate of inbreeding). There appears to be extensive use of popular dogs as sires in this breed (the 'tail' of the blue distribution in Figure 6).

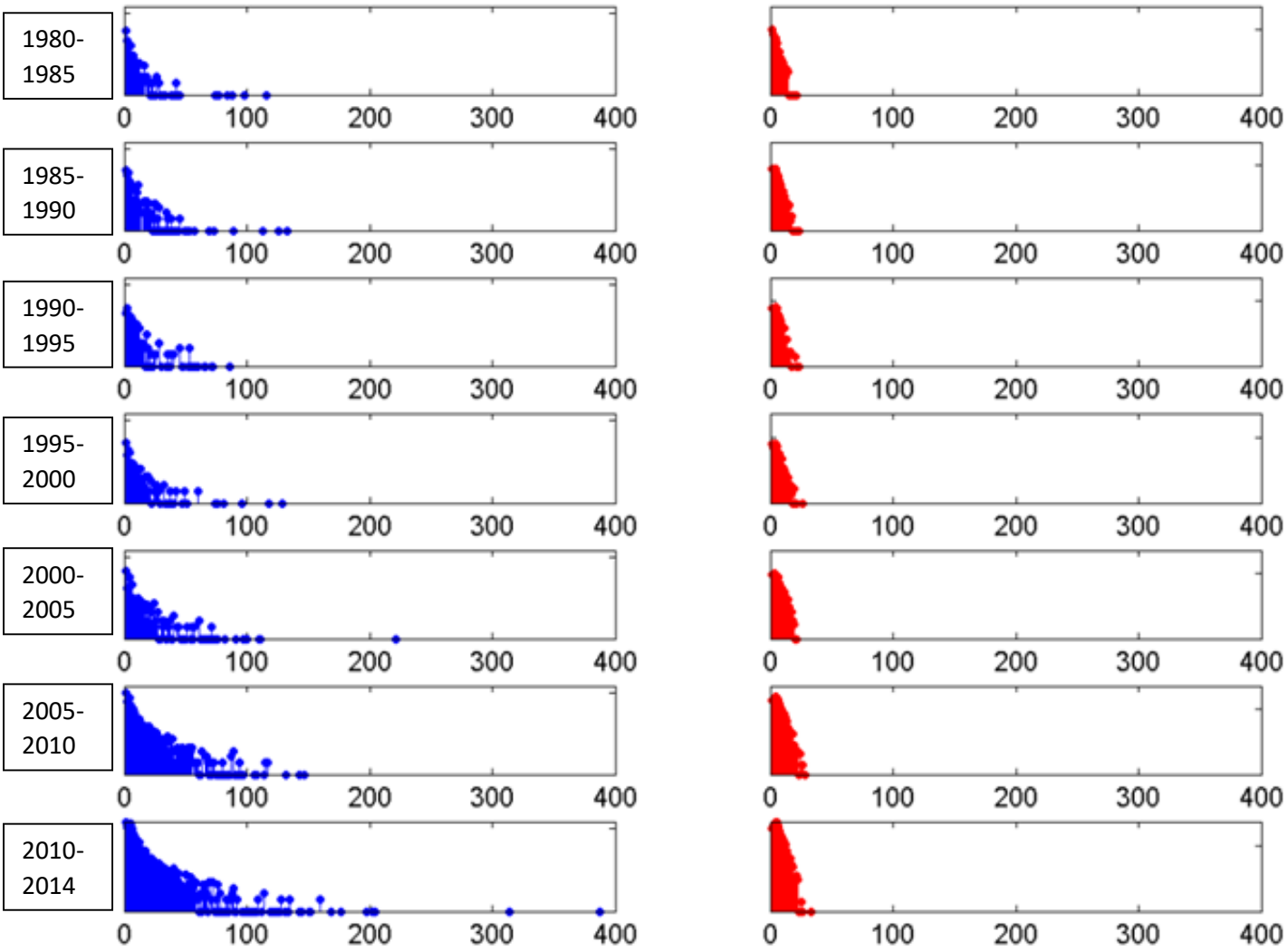

Figure 6: Distribution of progeny per sire (blue) and per dam (red) over 5-year blocks (1980-4 top, 2010-14 bottom). Vertical axis is a logarithmic scale.

CURRENT RESEARCH

The Pug is one of the 77 breeds in the AHT’s Give a Dog a Genome project; the health condition given as a concern for the breed was BOAS. A Pug affected with BOAS has been sequenced, and the sequence has been passed onto Dr Sargan at the University of Cambridge for his work into the genetics of the condition.

In addition to the research into the genetics of BOAS, research into the condition's aetiology and treatment is ongoing at the University of Cambridge.

Research into hemivertebrae and a grading scheme for the condition is ongoing at Dick White Referrals.

There is research into 'Pug myelopathy' underway at Michigan State University with Dr K Smiler.

The breed are working with Dr M Dunning and Willows Veterinary Surgery, who are holding a Pug Day open to owners, which will allow the research group to establish areas of the breed's health to direct research to.

PRIORITIES

A review meeting was held with the Pug Dog Council Breed Health Sub-committee on 6th September 2018. The group agreed that the priorities for the Pug were:

- BOAS
- Epilepsy
- Eye conditions
- Obesity
- PDE
- Skin conditions
- Spinal problems

ACTION PLAN

Following the meeting between the Kennel Club and the breed, the following actions were agreed to improve the health of the Pug.

Breed Club actions include:

- The breed council and breed clubs to consider comparative analysis of participation in the available health schemes and how they can work together to ensure they encourage owners to uptake health testing with Pugs without creating confusion.

- The Breed Council and Clubs to work together in holding BVA/KC/ISDS Eye testing sessions to gain valuable information on Pug eye health, and continue to distribute husbandry information to owners to educate on preventative measures

- The breed council and clubs to work together to continue to support the University of Cambridge/ Kennel Club Respiratory Function Grading Scheme and hold testing sessions throughout 2020 and continue to promote use of the scheme on websites and social channels were feasible – **ONGOING**

- The breed council and clubs to send dates for any upcoming health events to the Kennel Club Health Team, so that these can be added to the 2020 Health Calendar

- A Pug Dog Council breed health sub-committee member to continue to participate in the Brachycephalic Working Group – **ONGOING**

- The Breed Council, Northern Pug Dog Club and Pug Dog Welfare & Rescue Association to share data from their visual health assessments/ schemes to the Kennel Club for central collation and review of all schemes

Kennel Club actions include:

- The Kennel Club to raise at the next Eye Panel Working Party the possibility of moving the breed onto the Known Inherited Ocular Disease list (formally Schedule A) with relevant breeding advice, following published research of prevalent conditions - **ONGOING**

- The Kennel Club to request update on the outcomes of the Give a Dog a Genome project at the AHT for the Pug and provide written update to the breed- **ONGOING**

- The Kennel Club to develop a Pug Health Survey, as well as disseminate to all Kennel Club registered owners and analyse results, with particular emphasis on spinal disorders, which will feed into the neurology development group.

- The Kennel Club to encourage uptake of Respiratory Function Grading scheme by contacting regional approved assessors and asking them to advertise to owners within their practises.

- The Kennel Club to investigate the current status of the breed standard changes, and to support the breed with progressing breed standard changes via appropriate Kennel Club committees.

- The Kennel Club to incorporate the body condition score kit into judges' education and vet training.

- The Kennel Club to liaise with the ABS sub-group for methods of recording and accepting health schemes and provide written response on this for the breed.

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