



THE KENNEL CLUB
DOG HEALTH

Breed Health and Conservation Plan

Norwich Terrier Evidence Base

CONTENTS

<u>INTRODUCTION</u>	3
<u>DEMOGRAPHICS</u>	3
<u>BREED HEALTH CO-ORDINATOR ANNUAL HEALTH REPORT</u>	4
<u>BREED CLUB HEALTH ACTIVITES</u>	5
<u>BREED SPECIFIC HEALTH SURVEYS</u>	5
<u>LITERATURE REVIEW</u>	6
<u>INSURANCE DATA</u>	10
<u>BREED WATCH</u>	12
<u>PERMISSION TO SHOW</u>	13
<u>ASSURED BREEDERS SCHEME</u>	13
<u>BREED CLUB BREEDING RECOMMENDATIONS</u>	13
<u>DNA TEST RESULTS</u>	13
<u>CANINE HEALTH SCHEMES</u>	14
<u>REPORTED CAESAREAN SECTIONS</u>	15
<u>GENETIC DIVERSITY MEASURES</u>	16
<u>CURRENT RESEARCH</u>	18
<u>PRIORITIES</u>	19
<u>ACTION PLAN</u>	19
<u>REFERENCES</u>	20



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 raise awareness of current health and welfare concerns in their breed, and support them in making balanced breeding decisions.

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 representatives where 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 are then monitored and reviewed on a regular basis.

DEMOGRAPHICS

The Norwich Terrier was first recognised by the Kennel Club in 1932. The number of Norwich Terriers registered by year of birth between 1990 and 2020 are shown in Figure 1.

The trend of registrations over year of birth (1990-2020) was -0.21 per year (with a 95% confidence interval of -1.32 to +0.89), reflecting the fluctuation of the breed's numbers during this time. It should be noted that the registered numbers have remained low, with no more than 200 dogs being registered during this time. The breed have been placed on the vulnerable native breed register, with this being designated for breeds with fewer than 300 dogs being registered per year.

[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.]

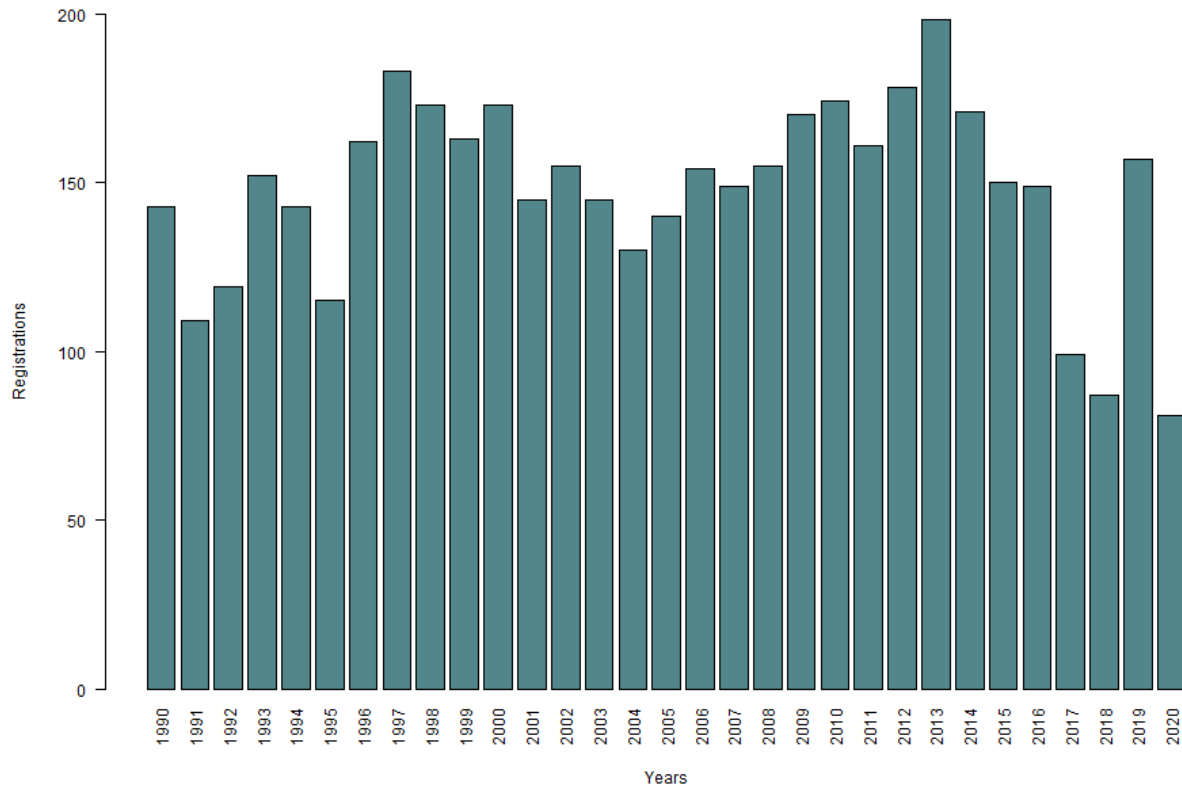


Figure 1: Registrations received per year for the Norwich Terrier, between 1990-2020.

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 2019, 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. Upper Airway Syndrome
2. Canine Epileptiform Cramping Syndrome (CECS)

In terms of what the breed have done to help tackle these listed health and welfare concerns, the breed continued to submit DNA samples to the Animal Health Trust (AHT) and cooperated with ongoing research where possible. They found that the inheritance of epilepsy in Norwich Terriers is extremely complex and therefore a single causative gene is unlikely. The AHT has been researching the Norwich Terrier's upper airway breathing problem for many years and recently secured a grant for further research. It is hoped that following the trust's closure in July 2020 this research will be reinstated at the University of Cambridge.

BREED CLUB HEALTH ACTIVITIES

The Norwich Terrier has an active Breed Health Co-ordinator and a webpage dedicated to health, which can be found at:

<https://www.norwichterrierclub.co.uk/>

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 collected for 182 live Norwich Terriers of which 114 (63%) were healthy and 68 (37%) had at least one reported health condition. The top categories of diagnosis were respiratory (20.7%, 24 of 116 reported conditions), reproductive (17.2%, 20 of 116 reported conditions), neurologic (14.7%, 17 of 116 reported conditions), ocular (11.2%, 13 of 116 reported conditions), and cardiac (4.3%, 5 of 116 reported conditions). The most frequently reported specific conditions were noisy breathing (17 cases), seizures/ fits/ idiopathic epilepsy (12 cases), cataracts (5 cases), dental disease (5 cases) and stuck puppy/ physical blockage (5 cases).

2004 Mortality results: A total of 56 deaths were reported for the Norwich Terrier. The median age at death was 13 years and 5 months (min = 1 year and 4 months, max = 16 years and 9 months). The most frequently reported causes of death by organ system or category were old age (30.4%, 17 of 56), cancer (21.4%, 12 of 56), cardiac (12.5%, 7 of 56), cerebral vascular (7.1%, 4 of 56), and neurologic (7.1%, 4 of 56).

2014 Morbidity results: Health information was collected for 42 live Norwich Terriers of which 32 (76.2%) had no reported conditions and 10 (23.8%) were reported to be affected by at least one condition. In total 13 conditions were reported and these were broken/ rotting teeth, CECS, chronic itching, conjunctivas, cryptorchidism, deafness (partial), hypersensitive (allergic) skin disorder, larynx disorder, oligospermia (low sperm count), otitis media, reproductive (unspecified), skin, urinary tract infection, and skin, ear or coat (unspecified). Each of these conditions were reported just once.

2014 Mortality results: Just one death was reported for the breed. The reported cause of death was road traffic accident and the age at death was one year.

Please note that caution should be taken when drawing meaningful conclusions from these data, given the relatively small number of reports for the breed.

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 was released relatively recently to try to reflect current publications and research relating to the breed.

Cardiac Conditions

Cardiomegaly: In 1995, Buchanan and Bücheler introduced a vertebral heart scale to objectively determine cardiomegaly (an abnormally enlarged heart) in dogs. They concluded that normal reference ranges for the vertebral heart scale were likely to vary depending on breed, and therefore breed-specific studies were necessary to determine precise values.

An American retrospective observational study investigated whether the Buchanan and Bücheler vertebral heart scale was applicable to the Norwich Terrier (Taylor et al, 2020) due to the hypothesis that dogs of the breed may be incorrectly diagnosed with cardiomegaly, when actually affected by respiratory disease (see below). Medical records of 61 Norwich Terriers that had no evidence of cardiac disease but had undergone thoracic radiographs between 2002-2018 were evaluated. Thirty of these dogs showed clinical signs of respiratory disease. The ranges for the vertebral heart scale in Norwich Terriers without cardiac disease (10.6 ± 0.6) was found to be significantly greater than Buchanan and Bücheler's initial reference ranges (9.7 ± 0.5). Norwich Terriers with a body condition score ≥ 6 had a significantly higher vertebral heart scale than those with a body condition score ≤ 5 . The authors found no significant correlation between clinical signs of respiratory disease, sex, or age and vertebral heart scale measurements in this breed.

Neoplastic Conditions

Cancer is a common problem in dogs and can affect any breed or crossbreed; however, some breeds appear to have a higher risk to certain types of cancer suggesting possible genetic predispositions. A cross-sectional study of purebred dogs in the UK listed the proportion of cancer-related mortality by breed (Adams et al, 2010). Cancer was the most frequently reported cause of death for all breeds (27%, 4,282 of 15,881 total deaths), and was the reason for 21.4% of deaths in the Norwich Terrier (12 of 56 total deaths). No specific cancer was reported at a greater risk in the breed.

Neurological Conditions

Paroxysmal Dyskinesia/ Canine Epileptoid Cramping Syndrome (CECS):

Paroxysmal dyskinesias are a group of neurological disorders characterised by sudden and unusual involuntary movements and have a varying range of causes. A study originating in the UK by Risio et al (2016) invited owners of Norwich Terriers to complete a questionnaire to identify dogs affected by paroxysmal dyskinesia. Of 198

Norwich Terriers, 26 (13%) were affected, all of which had no significant abnormalities detected on diagnostic investigations and were neurologically normal between episodes. The mean age when the affected dogs experienced their first episode was three years (range 0.8 - 5.4 years). Clinical signs of episodes were characterised by sustained muscular hypertonicity (muscle stiffness) and impaired posture and locomotion without loss of consciousness. Twelve (46%) of owners reported that their dog would attempt to seek reassurance prior to onset of an episode. The frequency of episodes varied, however stress, anxiety, excitement, and variation in daily routine were recognised as triggers in 13 dogs. The duration of episodes generally lasted between two and five minutes (range < 2 - 30 minutes). Owners mostly reported that the frequency of episodes remained unchanged overtime. Most of the affected dogs were related suggesting that this is potentially an inherited disorder in the breed.

Respiratory Conditions

Post-natal lung development: Post-natal lung development has been reported to be a major cause of death in Norwich Terrier puppies with a proposed hereditary basis. Anttila et al (2012) investigated the genetic background of post-natal lung development with the aim to develop a DNA test to eradicate the disease from the breed. Unfortunately, the full paper could not be accessed but has been referenced at the end of the BHCP. Given that the abstract was published in 2012 with no available DNA test it is likely the inheritance of this condition is complex.

Skull Conformation: Breeds are categorised into three subsets when considering skull morphology, with these being brachycephalic (short-muzzled), mesocephalic (medium) and dolichocephalic (long). However, caution must be taken when making this assumption due to inter-breed individual differences. Koch et al (2012), part of a Swiss research group, proposed a skull index (S-index), calculated using radiographs of living animals and giving insight into these inter-breed differences. The S-index is calculated as length of the facial skull/ length of the cerebrum, reflecting a length-to-length ratio. All breeds with an S-index < 1.25 were described as brachycephalic. Fourteen Norwich Terriers were examined, with an S-index mean of 0.93 (range 0.75 - 1.27).

Further to this study, the same research group (Koch et al, 2014) clinically examined 23 Norwich Terriers to investigate signs of BOAS and measured their skull dimensions to investigate if they could be classified as a brachycephalic breed. The breed showed several clinical brachycephalic characteristics, including narrowed nostrils and nasal airflow resistance, overlong soft palates and everted laryngeal pouches. However, the skull measurements were inconsistent, with some dogs having mesocephalic skull shapes and others having brachycephalic. The authors concluded that the breed shows some characteristics of brachycephaly and may be slowly transitioning towards becoming more brachycephalic.

Upper Airway Syndrome (UAS): Between 2010 and 2013, 12 Norwich Terriers affected by respiratory disease were presented to a veterinary teaching hospital in America to examine characteristics of their respiratory system (Johnson et al, 2013). Laryngoscopic examination was abnormal in 11 of these dogs, with nine showing each of the following respectively: enlarged tonsils, laryngeal collapse and severe redundancy in supra-arytenoid tissue. External nares, nasal airflow, and soft palate palpation were normal in all dogs. Four Norwich Terriers were subsequently presented for airway screening with no clinical signs of respiratory disease. All four of these dogs had a normal physical examination, however laryngeal abnormalities similar in appearance to dogs with clinical signs were seen in three, as well as four with enlarged tonsils, three with severe saccular swelling, and three with redundant supra-arytenoid folds. Grade 1-4 tracheal collapse was also seen in these dogs. The authors highlighted that the condition does differ to BOAS seen in brachycephalic breeds, but without owner or breeder awareness of the abnormalities found in this breed, the condition would have gone undiagnosed. Further, this should be taken into account when placing the breed under anaesthetic.

A subsequent review also noted that surgical intervention has a more minimal to moderate impact compared to similar pathology in larger breeds, and reiterated the care that should be taken when placing the breed under anaesthetic (Rozanski, 2015).

This condition in the breed has since been termed Upper Airway Syndrome (UAS). The closely related Norfolk Terrier is seemingly unaffected by UAS, suggesting a genetic predisposition in Norwich Terriers. As part of a PhD thesis 401 Norwich Terriers were examined and scored by laryngoscopy (Marchant et al, 2019). Of these, 65.8% were graded as mildly to severely affected. A genome-wide association analysis of a further 233 Norwich Terriers presenting with UAS revealed a genetic association on chromosome 13 and identified a missense variant, *ADAMTS3*. Of these dogs, everted saccules (35%) and elongated soft palates (14%) were the most commonly noted characteristics of disease. In the previous subset 32.9% were homozygous (affected) for the mutant allele, and 48.6% heterozygous (carriers), with an allele frequency of 57%. The homozygous dogs were significantly more likely to be graded a higher UAS score. However, whilst the cause of disease is likely polygenic (numerous genes interplaying to cause disease), the *ADAMTS3* variant was also highly prevalent in French Bulldogs and Bulldogs, and thought to lead to airway oedema and respiratory obstruction.

A recent American study released this year by Johnson et al (2021) noted that UAS in the Norwich Terrier appears clinically distinct enough from BOAS to be considered unique to the breed. The authors noted that the majority of affected Norwich Terriers had normal nares and soft palate, but often had abnormal tissue configuration within the supraglottic/ infra-glottic region, which increases resistance to airflow and soft tissue swelling.

The study group used a follow-up questionnaire to determine the outcome of Norwich Terriers that had previously undergone upper airway endoscopy. Owners were asked about respiratory noise, exercise tolerance and quality of life. A total of 34 Norwich Terriers were included in the study, of which 14 were female and 20 were male. No correlation was found between age at examination and UAS. Increased respiratory noise was reported on initial presentation in 20/34 dogs (59%), excessive panting in 14/34 dogs (41%), and owners of 15/34 (44%) dogs indicated that the dogs snored often or sometimes whilst asleep. Of five possible laryngeal abnormalities the median was 3.5 (range 1 – 5). The most common laryngeal abnormality found in all dogs examined was ventricular eversion (34/34), followed by excessive supraglottic tissue (28/34), which was moderate in 13 dogs and severe in 15. Despite the severity of UAS ranging from 0 to 31 out of 40, owners reported that the majority of Norwich Terriers examined had an excellent quality of life (16/31 scored as 0) and therefore there was no correlation noted between UAS and quality of life scores. Although a limitation of the study is that dogs were not re-examined, the results from the questionnaire are encouraging given the long-term survival and good scores for quality of life.

Urinary Conditions

Hepatorenal fibrocystic disorders (HRFCDs): Cilia are specialised cells involved in the movement of fluid and mucous throughout the body, and crucial for normal organ function. Defects in the cilia cause complex disorders known as ciliopathies, which can result in various defects including congenital disorders and progressive disorders. HRFCDs, including cystic renal dysplasia and hepatic fibrosis, can result from such ciliopathies. In the Norwich Terrier this disorder appears to present as a congenital disorder leading to neonatal death.

Dillard et al (2018) investigated the genetic background of congenital HRFCDs in a family of Finnish Norwich Terrier puppies. The pedigree of three affected puppies suggested an autosomal recessive mode of inheritance. Whole exome sequencing revealed a causative variant in a cilia-related gene, *INPP5E*. For further validation, the researchers genotyped the variant in a large cohort of Finnish Norwich Terriers with three cases and 480 controls, with a carrier frequency of 6%. However, no further literature could be found describing the condition in other populations.

Canine calcium oxalate urolithiasis: Calcium oxalate uroliths (stones) in dogs form within the renal system and can be differentiated into calcium oxalate monohydrate and calcium oxalate dihydrate. A retrospective Canadian study used epidemiological data to compare the two forms of calcium oxalate uroliths in dogs from 1979 to 2015. Of the 22,456 uroliths submitted, 6690 (29.8%) were composed of 70% calcium oxalate. The Norwich Terrier had the highest odds for calcium oxalate monohydrate uroliths compared to all other breeds combined (OR 6.51; 95% CI 3.67 – 11.36). Similarly the breed had the highest odds ratio for calcium oxalate dihydrate uroliths with an odds ratio of 8.42 (95% CI 4.68-14.89). Dogs with calcium oxalate

monohydrate uroliths were significantly older than the dogs with calcium oxalate dihydrate uroliths.

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 insured population
- Only clinical events that are not excluded and where the cost exceeds the deductible excess are included

However, insurance databases are too useful a resource to ignore as they fill certain gaps left by other types of research; in particular they can highlight common, expensive and severe conditions, especially in breeds of small population sizes, that may not be evident from teaching hospital caseloads.

Swedish Agria Data

Swedish morbidity insurance data were available from Agria for the Norwich Terrier. Reported rates are based on dog-years-at-risk (DYAR) which take into account the actual time each dog was insured during the period (2006-2011). The number of DYAR for Norwich Terriers in Sweden during this period was 1,000<2,500.

Swedish Agria insurance morbidity data

Specific causes for veterinary care episodes

The most common specific causes of veterinary care episodes (VCEs) for Agria-insured Norwich Terrier in Sweden between 2011 and 2016 are shown in Figure 2. The top five specific causes of VCEs were: vomiting/ diarrhoea/ gastroenteritis, cardiomyopathy/ endocardosis, clinical signs of tiredness, pain during locomotion and corneal ulcer.

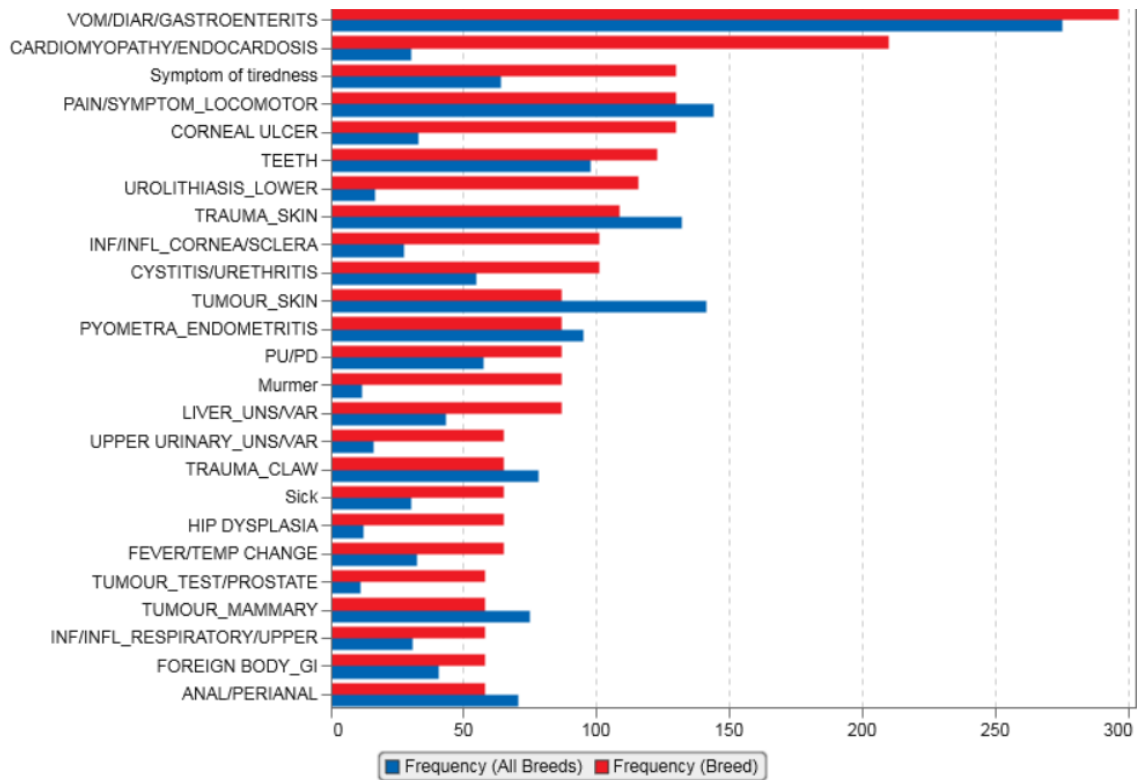


Figure 2: The most common specific causes of VCEs for the Norwich Terrier compared to all breeds in Sweden between 2011 and 2016, from Swedish Agria insurance data.

Relative risk for veterinary care episodes

The specific causes of VCEs ordered by relative risk are shown in Figure 3 for the Norwich Terrier. In this analysis, the top five specific causes of VCEs ordered by relative risk were: breathing problem, infection/ inflammation – mouth/throat, upper respiratory – various, lower urolithiasis and infection/ inflammation – eyelid/ conjunctiva.

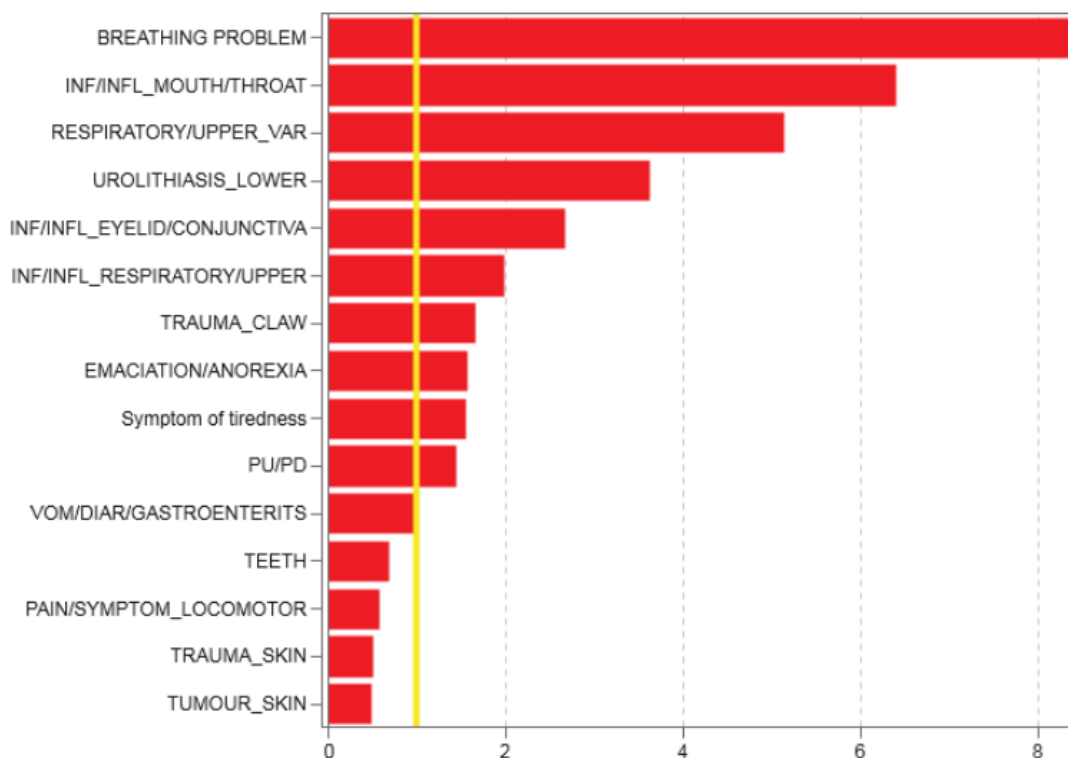


Figure 3: The specific causes of VCEs for the Norwich Terrier ordered by relative risk compared to all breeds in Sweden 2011 - 2016, from Swedish Agria insurance data.

BREED WATCH

The Norwich Terrier is a category two breed, meaning judges are required to complete mandatory monitoring forms following an appointment at championship certificate level. The points of concern reported are shown below in Table 3. Those marked with a * indicate newly reported points of concern.

Due to the lockdown implemented in March 2020 as a result of the COVID19 pandemic, no shows have been able to take place for the majority of 2020, and therefore these data have been excluded.

Table 3: Judges' health monitoring reports for 2017 to 2019.

Point of concern	2017	2018	2019
Showing respiratory distress including difficulty breathing	0.00%	0.96%	0.00%
* Other	1.25%	0.00%	0.99%
* Difficulty breathing	0.62%	0.00%	0.00%
* Weak hindquarters	0.00%	0.00%	0.99%
* Wet eyes	0.00%	1.27%	0.00%
Total dogs shown	321	314	203

NB. As of quarter 4 of 2019 judges are no longer sent reminders to complete their monitoring form, which has resulted in a drop in reports received breed-wide. This is reflected in the fall of total dogs shown in 2019.

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. In the past five years, one PTS has been granted for the Norwich Terrier (not including neutering or caesarean sections) and this was for the removal of teeth.

ASSURED BREEDERS SCHEME

There are currently no recommendations or requirements for the Norwich Terrier within the Kennel Club (KC)'s Assured Breeders Scheme.

BREED CLUB BREEDING RECOMMENDATIONS

There are not currently any Breed Club breeding recommendations listed on the Kennel Club's website for the breed.

DNA TEST RESULTS

There are currently no recognised DNA tests for this breed.

Whilst 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 of which involves collaboration between the breed clubs and the Kennel Club in order to validate the test's accuracy.

CANINE HEALTH SCHEMES

All of the British Veterinary Association (BVA)/Kennel Club (KC) Canine Health Schemes are open to dogs of any breed with a summary given of dogs tested to date below.

EYES

The breed is not currently on the BVA/KC/ISDS Known Inherited Ocular Disease (KIOD) list (formally Schedule A) or Schedule B for any condition under the BVA/KC/International Sheep Dog Society (ISDS) Eye Scheme.

KIOD lists the known inherited eye conditions in the breeds where there is enough scientific information to show that the condition is inherited in the breed, often including the actual mode of inheritance and in some cases even a DNA test.

As well as the KIOD list, the BVA record any other conditions affecting a dog at the time of examination, which is incorporated into an annual sightings report. Since 2012, no Norwich Terriers have been eye tested under the BVA/KC/ISDS Eye Scheme.

AMERICAN COLLEGE OF VETERINARY OPHTHALMOLOGISTS (ACVO)

Results of examinations through ACVO are shown in Table 1 below. Between 2015 and 2019, 680 Norwich Terriers were examined, of which 88.8% (604 of 680 dogs) were found to be unaffected by any eye condition.

Whilst it is important to note that these data represent dogs in America, the organisation tend to examine a higher number of dogs than that in the UK, and therefore are a valuable source of information.

Table 1: ACVO examination results for Norwich Terrier, 1991 – 2019.

Disease Category/Name	Percentage of Dogs Affected	
	1991-2014 (n=2,911)	2015-2019 (n=680)
Eyelids		
Distichiasis	0.6%	1.6%
Uvea		
Persistent pupillary membranes, iris to iris	5.9%	3.1%
Lens		
Cataract, suspect not inherited/ significance unknown	2.4%	1.6%
Significant cataracts (summary)	3.8%	3.5%

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

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.
- In all breeds, there was an increase in the number of caesarean sections reported from 2012 onwards, as the Kennel Club publicised the procedure to vets.

The number of litters registered per year for the breed and the number and percentage of reported caesarean sections in the breed for the past 10 years are shown in Table 2.

Table 2: Number of Norwich Terrier litters registered per year, and number and percentage of caesarean sections reported per year, 2009 to 2019.

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)
2009	61	0	0.0%	0.15%
2010	64	0	0.0%	0.35%
2011	65	1	1.5%	1.64%
2012	55	11	20.0%	8.69%
2013	69	16	23.2%	9.96%
2014	58	10	17.2%	10.63%
2015	61	9	14.8%	11.68%
2016	54	6	11.1%	13.89%
2017	41	9	22.0%	15.00%
2018	32	6	18.8%	17.21%
2019	48	9	18.8%	15.70%

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 2020, an estimated effective population size of **N/A** was reported (estimated using the rate of inbreeding over the period 1990-2019).

Where the rate of inbreeding is negative the effective population size is denoted 'N/A'. This indicates that at this time, the effective population size for the Norwich Terrier is increasing. However, it is important to note that given the small population of the breed this will be constantly fluctuating, and breeders should take care to preserve genetic diversity when making breeding decisions.

Annual mean observed inbreeding coefficient (showing loss of genetic diversity) and mean expected inbreeding coefficient (from simulated 'random mating') over the period 1990-2019 are shown in Figure 4. Following a peak in 1999, the observed inbreeding coefficient declined and since then has remained relatively consistent, although is predicted to begin to rise again.

It should be noted that, while animals imported from overseas may appear completely unrelated, this is not always the case. Often the pedigree available to the Kennel Club is limited in the number of generations, hampering the ability to detect true, albeit distant, relationships.

For full interpretation see Lewis et al, 2015

<https://cgjournal.biomedcentral.com/articles/10.1186/s40575-015-0027-4>

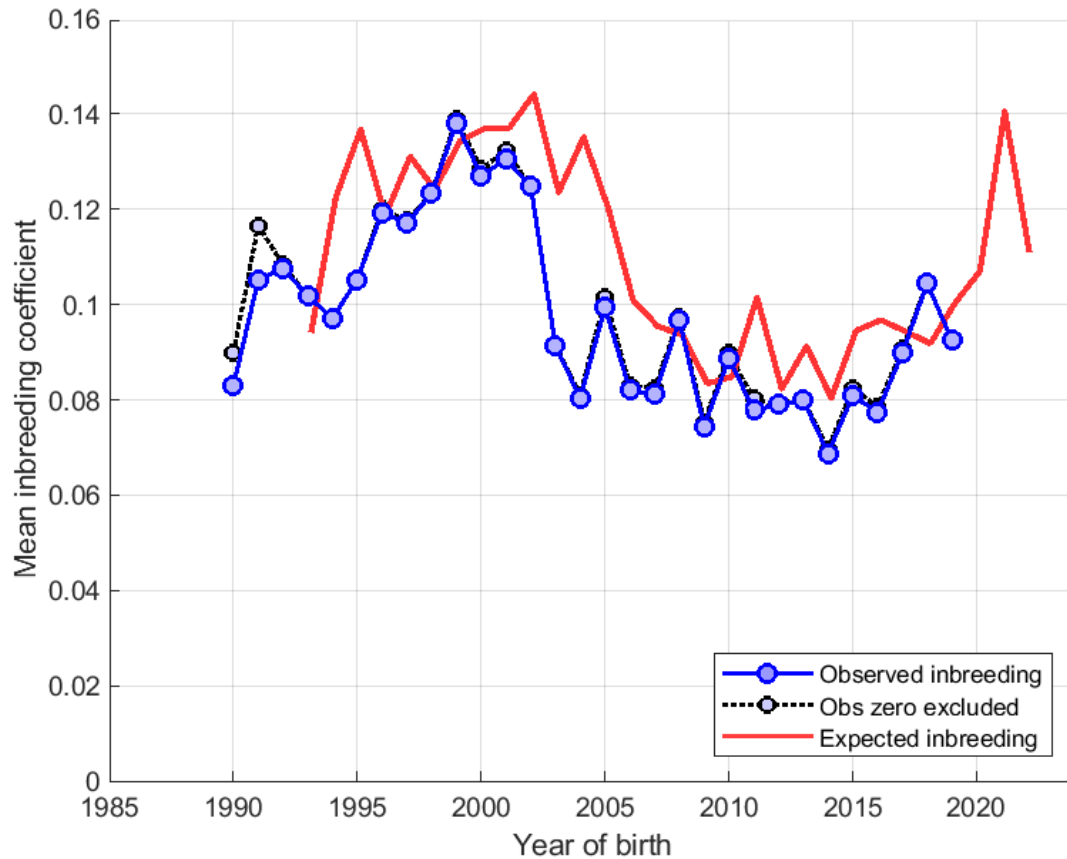


Figure 4: Annual mean observed and expected inbreeding coefficients.

The current breed average inbreeding coefficient for the Norwich Terrier is **9.3%**

Below is a histogram ('tally' distribution) of number of progeny per sire and dam over each of six 5-year blocks (Figure 5). 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 is evidence of several popular sires being used in the breed, with one sire responsible for 11.1% of all registered progeny during 1995-1999 and, more recently, two sires responsible for approximately 16% of all registered progeny during 2015-2019.

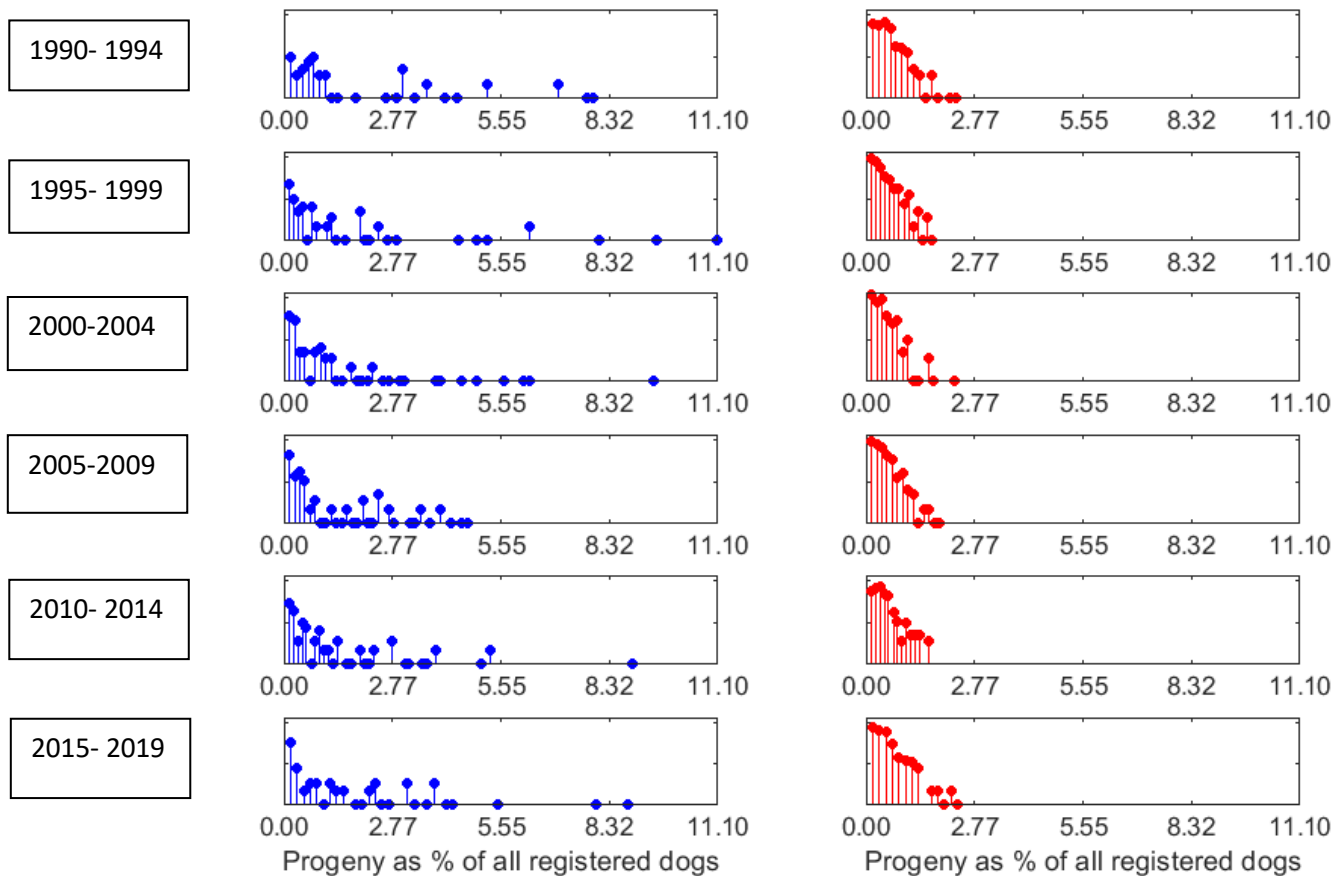


Figure 5: Distribution of the number of progeny per sire (blue) and per dam (red) over 5-year blocks (1990-4 top, 2015-19 bottom). Vertical axis is a logarithmic scale.

CURRENT RESEARCH

Prior to the AHTs closure, there were a number of research projects which the breed had contributed DNA samples towards. This includes research on the Norwich Terrier's Upper Airway Syndrome and CECS. It is hoped that this work will be continued at the University of Cambridge.

PRIORITIES

Correspondence between the breed representatives and the Kennel Club was undertaken in July 2021 to discuss the evidence base of the BHCP and agree the priority issues for the health of the breed. The group agreed from the evidence base that the priorities for the Norwich Terrier were:

Priorities:

1. Upper Airway Syndrome
2. Epileptoid Cramping Syndrome (CECS)

At watch:

3. Urolithiasis

ACTION PLAN

Following the correspondence between the Kennel Club and the breed regarding the evidence base of the Breed Health & Conservation Plans, the following actions were agreed to improve the health of the Norwich Terrier. Both partners are expected to begin to action these points prior to the next review.

Breed Club actions include:

- The Breed Club to undertake a breed health survey, with the Kennel Club to assist in development and dissemination
- The Breed Club to monitor the use of popular sires and raise awareness of the importance of considering genetic diversity when breeding
- The Breed Club to continue to engage in CECS research

Kennel Club actions include:

- The Kennel Club to assist with the development and dissemination of a breed health survey
- The Kennel Club to produce a piece on the importance of considering genetic diversity and popular sires when breeding, specifically for numerically small breeds
- The Kennel Club to provide analysis for UK insurance data for the breed

REFERENCES

- Adams, V.J., Evans, K.M., Sampson, J., Wood, J.L.N. (2010) Method and mortality results of a health survey of purebred dogs in the UK. *Journal of Small Animal Practice*. **51(10)**: 512-524
- Anttila, M., Dillard, K., Vainio-Siukola, K. (2012) Disturbance of post-natal lung development in Norwich terriers. *The FASEB Journal*. **26(1)**: 658
- Buchanan, J.W. and Bucheler, J. (1995) Vertebral scale system to measure canine heart size in radiographs. *Journal of the American Veterinary Medical Association*. **206(2)**: 194-199
- Dillard, K.J., Hytönen, M.K., Fischer, D., Tanhuanpää, K., Lehti, M.S., Vainio-Siukola, K., Sironen, A., Anttila, M. (2018) A splice site variant in INPP5E causes diffuse cystic renal dysplasia and hepatic fibrosis in dogs. *PLoS ONE* **13(9)**
- Ekenstedt, K.J., Crosse, K.R., Risselada, M. (2020) Canine Brachycephaly: Anatomy, Pathology, Genetics and Welfare. *J Comp Pathol* **176**: 109-115
- Hesse, A., Frick, M., Orzekowsky, H., Failing, K., Neiger, R. (2018) Canine calcium oxalate urolithiasis: Frequency of Whewellite and Weddellite stones from 1979 to 2015. *Can Vet J* **59**: 1305-1310
- Johnson, L.R., Matthew, P.D., Steffey, M.A., Hunt, G.B., Carr, A.H., McKiernan, B.C. (2013) Upper Airway Obstruction in Norwich Terriers: 16 Cases. *J Vet Intern Med*. **27**: 1409-1415
- Johnson, L.R., Mayhew, P.D., Culp, W.T.N., Stanley, B.J. (2021) Results of owner questionnaires describing long-term outcome in Norwich terriers with upper airway syndrome: 2011- 2018. *Journal of Veterinary Internal Medicine*: 1-7
- Koch, D.A., Wiestner, T., Balli, A., Montavon, P.M., Michel, E., Scharf, G., Arnold, S. (2012) Proposal for a new radiological index to determine skull conformation in the dog. *Schweiz Arch Tierheilk* **154(5)**: 217-220
- Koch, D.A., Rosaspina, M., Wiestner, T., Arnold, S., Montavon, P.M. (2014) Comparative investigations on the upper respiratory tract in Norwich terriers, brachycephalic and mesaticephalic dogs. *Schweizer Archiv für Tierheilkunde*. **156(3)**: 119-124
- Marchant, T.W. (2019) Detection and characterisation of genetic associations with canine skull shape and disease. *College of Medicine and Veterinary Medicine, The University of Edinburgh*.
- Marchant, T.W., Dietschi, E., Rytz, U., Schawalder, P., Jagannathan, V., Rasouliha, S.H., Gurtner, C., Waldvogel, A.S., Harrington, R.S., Drögemüller, M., Kidd, J., Ostrander, E.A., Warr, A., Watson, M., Argyle, D., Haar, G.T., Clements, D.N., Leed, T., Schoenebeck, J.J. (2019) An ADAMTS3 missense variant is associated with Norwich Terrier upper airway syndrome. *PLoS Genet* **15(5)**

Taylor, C.J., Simon, B.T., Stanley, B.J., Lai, G.P., Thieman Mankin, K.M. (2020) Norwich terriers possess a greater vertebral heart scale than the canine reference value. *American College of Veterinary Radiology*. **61**: 10-15

Risio, L. D., Forman, O.P., Mellersh, C.S., Freeman, J. (2016) Paroxysmal Dyskinesia in Norwich Terrier Dogs. *International Parkinson and Movement Disorder Society* **3(6)**: 573-579

Rozanski, E. (2015) Breed-Specific Respiratory Disease in Dogs. *Today's Veterinary Practice*: 28-33