FACULTY OF SCIENCE
UNIVERSITY OF COPENHAGEN

Department of Large Animal Sciences – Reproduction,
Faculty of Life Sciences, University of Copenhagen

Veterinary master's thesis

Karen Singers Johansen BQN899

Investigation of dystocia in Scottish Terriers by means of radiographic pelvimetry

Academic advisor: Associate Professor, DVM, Dipl. ECAR Sandra Kathrin Goericke-Pesch.

Co-advisors: Veterinarian Kathrine Thejll Kirchhoff and veterinarian Alison Wilson.

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Preface

This master´s thesis concludes my Master of Science education in Veterinary Medicine at the Faculty of Health and Medical Science, University of Copenhagen. The project was carried out from February 2014 to August 2014.

The thesis is written for the use of the Health Committee within the Scottish Terrier Group in Denmark, which has requested this investigation of dystocia in the Danish population of Scottish Terriers. Veterinary students, veterinarians and other with an interest in the subject may also benefit from reading this assignment.

I would like to thank my main advisor, Associate Professor Sandra Kathrin Goericke-Pesch for her time and useful comments and my co-advisors veterinarian Kathrine Thejll Kirchhoff and veterinarian Alison Wilson for their invaluable help with obtaining the radiographs of the dogs. Furthermore, I would like to thank all members of the Health department within the Scottish Terrier group and Else Vigholt and Julie Hasselby in particular for their time and great effort with taking contact to the dog owners and for willingly answer my innumerable phone calls. I would like to express my gratitude to all the participating Scottish Terrier owners for supporting this project and for being so cooperative and to all the wonderful Scottish Terriers I have met along the way.

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Karen Singers Johansen bqn899

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Abstract

Around 60 percent of the Scottish Terrier litters in Denmark are today delivered by caesarean section. A number of these are elective caesarean sections performed for several reasons including single puppy syndrome and a previous history of dystocia. However, a large percentage of the caesarean sections is acute due to dystocia. This study aimed at investigating the causes of the high frequency of dystocia in the population of Scottish Terriers in Denmark with main focus on the size and shape of the pelvis. Furthermore, the study sought to describe mean pelvic dimensions of female and male Scottish Terriers. Therefore, radiographs were obtained of a total of 30 dogs in ventrodorsal and in laterolateral projection. 6 of these were male and 24 were female.

To investigate the impact of pelvic dimensions on dystocia the bitches that had given birth, 17 dogs in total, were divided into two groups: bitches that had given birth naturally (n=11) and bitches that had given birth solely by caesarean section (n=6). The study found that the pelves of bitches that had given birth naturally had significantly longer vertical diameters than the pelves of bitches that had given birth solely by caesarean section. These longer vertical diameters gave rise to a significant difference in the ratio between the vertical and horizontal diameter of the pelvis, *i.e.* bitches that had given birth by cesarean section had a more dorsoventrally compressed pelvis. Thus, a dorsoventral compression of the pelvis was identified as a cause of dystocia in the breed.

Apart from pelvic dimensions, the importance of the reproduction history of the bitches in relation to the dystocia frequency was investigated. The owners were asked to fill in a questionnaire concerning the reproduction history of the dog and the family of the dog. However no statistically significant correlations were found between dystocia and the mean size of the litters or the mean size of the puppies.

Finally, external measurements of all the dogs included in the study were obtained in order to depict the general size of the Danish male and female Scottish Terriers and to investigate if a correlation could be found between the external measurements of the bitches and dystocia. It was found that the height of the bitch at the withers was positively correlated with giving birth naturally *i.e.* the naturally whelping bitches were generally higher than the bitches that had given birth solely by caesarean section. Furthermore, a positive correlation was found between the height of the bitch and the vertical diameters of the pelvis. Thus, it was concluded that higher bitches are less prone to dystocia, most likely due to longer vertical diameters of the pelvis.

Resumé

Omkring 60 procent af de danske skotsk terrier kuld fødes i dag ved kejsersnit. En del af disse kejsersnit er elektive og udføres af forskellige grunde, eksempelvis grundet en historie om dystoki, eller hvis tæven er drægtig med kun en enkelt hvalp. En stor procentdel af de kejsersnit der udføres på skotsk terriere i Danmark er dog akutte grundet dystoki. Dette studie havde til formål at undersøge årsagen til den høje dystokifrekvens hos skotsk terriere i Danmark med fokus på størrelsen og formen på bækkenet. Desuden søgte studiet at beskrive gennemsnitsbækkenmål for både hanhunde og tæver af racen. Derfor blev der taget røntgenbilleder af i alt 30 hunde i ventrodorsal og i laterolateral projektion. Af disse var 6 hanhunde og 24 var tæver.

For at undersøge hvor stor en indflydelse bækkendimensionerne havde på dystokifrekvensen blev de 17 tæver, der havde fået hvalpe, opdelt i to grupper: Tæver, der havde født naturligt (n=11), og tæver, der havde fået hvalpe udelukkende ved kejsersnit (n=6). Det blev fundet at bækkenet hos tæver, der havde født naturligt, havde signifikant længere vertikale mål i forhold til tæver, der havde født udelukkende ved kejsersnit. Dette medførte en signifikant forskel i forholdet mellem bækkenets vertikale og horisontale diameter mellem de to grupper af tæver, hvilket pegede på et dorsoventralt fladtrykt bækken som en del af forklaringen på den høje dystokifrekvens hos skotsk terriere.

Ud over bækkendimensioner blev det undersøgt, om der i tævernes reproduktionshistorie kunne findes en forklaring på den høje dystokifrekvens. Ejerne blev bedt om at udfylde et spørgeskema omhandlende hundens og hundens families reproduktionshistorie. Der blev dog ikke fundet nogen signifikant sammenhæng mellem hverken størrelsen på kuldene eller vægten på hvalpene og dystoki.

Der blev desuden foretaget en opmåling og vejning af alle hunde inkluderet i studiet for at give en idé om størrelsen på de danske skotsk terrier tæver og hanhunde og for at undersøge om der var en sammenhæng mellem tævernes eksterne mål og dystoki. Der blev fundet en positiv korrelation mellem højden på tæverne og naturlig fødsel, hvilket vil sige, at de selvfødende tæver generelt var højere end de tæver, der udelukkende havde født ved kejsersnit. Der blev ydermere fundet en positiv korrelation mellem tævernes højde og deres vertikale bækkenmål, hvilket med al sandsynlighed betyder at grunden til, at højere tæver har mindre risiko for at lide af dystoki er, at de har længere vertikale bækkenmål.

Abbreviations

ACTH	Adrenocorticotropic hormone
BSAVA	British Small Animal Veterinary Association
CD	*Conjugata diagonalis* (the distance between the *promontorium* and the caudal extremity of *symphysis pelvis*)
CV	*Conjugata vera* (the distance between *promontorium* and *pecten ossis pubis*)
DKK	Dansk Kennel Klub
DT	*Diameter transversa* (the horizontal distance between the *corpus ossis ilii*)
DTK	Dansk Terrier Klub
DV	*Diameter verticalis* (the distance between the *pecten ossis pubis* and the sacrum orthogonal to the *symphysis pelvis*)
FCI	Federation Cynologique Internationale
KC	The British Kennel Club
KfT	German Terrier Club
mAs	Milliampere second
STCA	Scottish Terrier Club of America
SE	Standard Error
QTL	Quantitative Trait Loci
UKC	United Kennel Club

Introduction

Since the domestication of the wolf more than 10 000 years ago, the domestic dog has undergone intensive selection, that has resulted in over 400 different breeds, and today the domestic dog is the species with the greatest variation in behaviour and morphology. When the dogs entered the show rings in the 1900th century selective breeding was intensified and focus was shifted from functionality to appearance. Today numerous pure bred dogs suffer from compromised welfare as a direct or indirect result of selective breeding. This is due to the fact that selective breeding has resulted in high rates of heritable diseases and a number of physical conformations which can result in pain or disability and thereby cause unnecessary suffering. Treatment is one way to improve the welfare of these dogs suffering from heritable disorders or morphologic defects, but another option would be to improve the health through breeding. One of these heritable disorders is an inappropriate pelvis conformation of the bitch which leads to dystocia (Arendonk, Liinamo 2005, Arman 2007, Rooney, Sargan 2009, Bergstrom, Nodtvedt *et al.* 2006).

Dystocia

Normal parturition

An understanding of the endocrine and physiological mechanisms of normal parturition is essential in order to understand what goes wrong when a bitch suffers from dystocia. The parturition process can be divided into three stages: Uterine contractions and cervical dilation, delivery of the puppies and delivery of the placentas. (England, Heimendahl 2010).

Stage one: This stage lasts for approximately 6-12 hours and is characterised by intermittent myometrial contractions but with no signs of abdominal contractions. The stage may be associated with clinical signs of restlessness, panting and anorexia. The endocrinological mechanisms for parturition in the bitch remains unclear, but the contractions are a result of a hormonal cascade starting with the foetus getting stressed due to space limitations and producing Adrenocorticotropic hormone (ACTH) and cortisol, which triggers a number of events. These involve an increase in the prostaglandin concentration and a decrease in progesterone concentration in the circulatory system of the bitch. The contractions in the uterus propel the foetuses and the foetal membranes towards the cervix, which causes the cervix to dilate (England, Heimendahl 2010, Baan *et al.* 2008, Johnston, Kustritz *et al.* 2001, Senger 1997).

Stage two: The duration of this stage is usually 3 to 12 hours but may last for as long as 24 hours. The presence of a foetus or fluid-filled foetal membranes in the cervix causes a mechanical distension and thereby an activation of a neuroendocrine reflex, the Fergusons reflex, with a resulting rise in the oxytocin concentration. As the foetus passes through the birth canal, it becomes hypoxic and hypercapnic and sensitivity for chemoreceptors, that regulate respiration, increases. The cervical distension enhances the uterine contractions and initiates contraction of the abdominal musculature and as a result expulsion of the foetuses (England, Heimendahl 2010, Johnston, Kustritz *et al.* 2001, Senger 1997, Slatter 2003, Funkquist, Nyman *et al.* 1997).

Stage three: The placental membranes are usually expelled within 15 minutes of the expulsion of each foetus, but several foetuses may be born before the passage of their placentas. Because the expulsion of the placentas occur after each puppy, the bitch goes from stage two to stage three and back to stage two until all puppies are delivered (Slatter 2003).

The aetiology of dystocia

Dystocia in animals is defined as difficult parturition or inability to deliver foetuses without human intervention. (Blood, Studdert *et al.* 2007, Ettinger, Feldman 2004). Figure 1 outlines the aetiology of canine dystocia, dividing the causes into dystocia of maternal and of foetal origin, though often dystocia is due to a combination of maternal and foetal factors. Some of the most common maternal causes are uterine inertia and a narrow birth canal. When it comes to foetal causes, it is most often because of foetal oversize and malpresentation (Munnich, Kuchenmeister 2009, Ettinger, Feldman 2004). It is believed that the incidence of dystocia in bitches is around 5 percent, but that it in some breeds might be up to 100 percent (Eneroth, Linde-Forsberg *et al.* 1999, Linde-Forsberg 2003). Of the bitches suffering from dystocia, approximately 60 percent undergo caesarean section (Bergstrom, Nodtvedt *et al.* 2006).

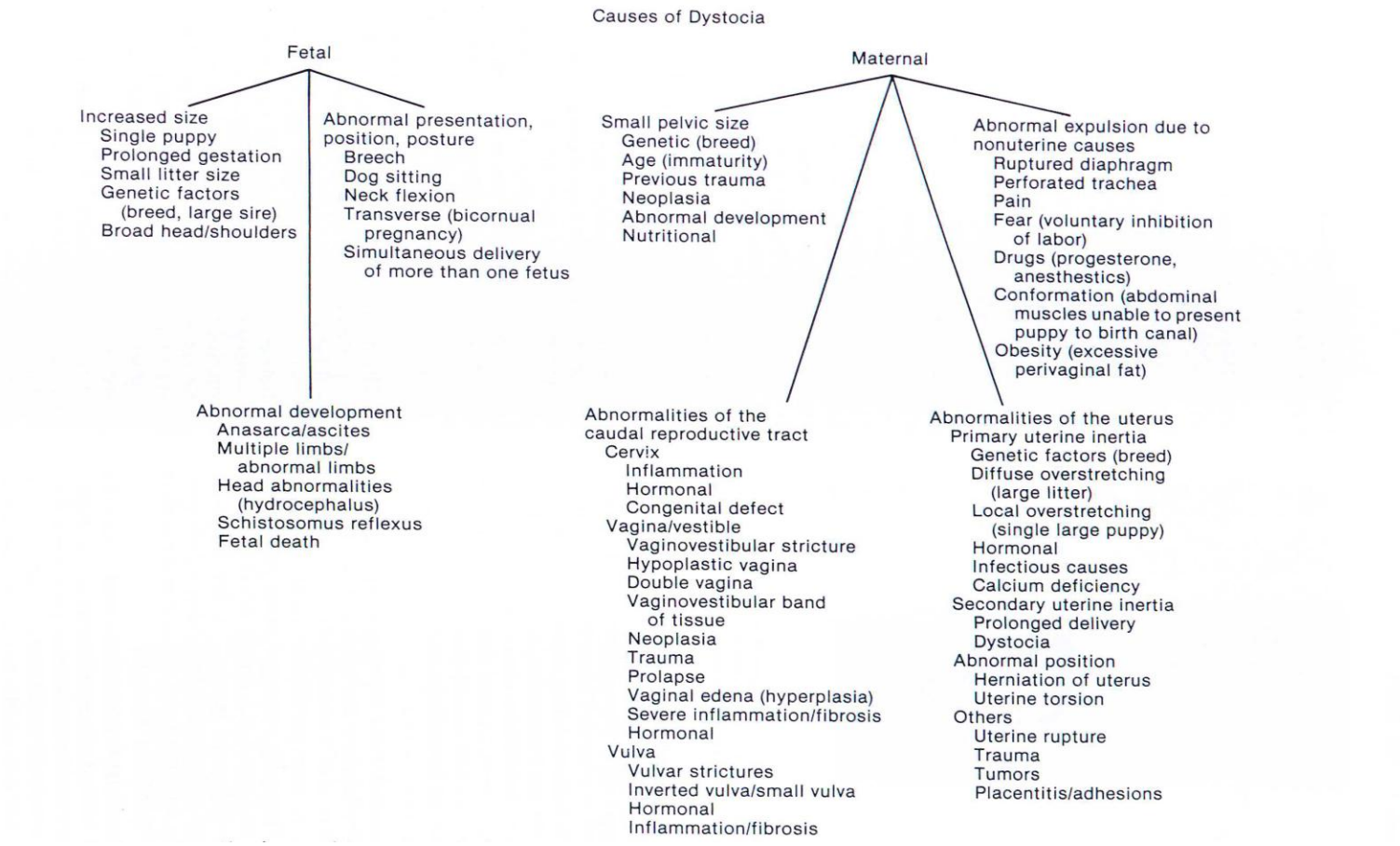

Figure 1 Causes of dystocia in bitches of foetal and of maternal origin respectively (Slatter 2003).

Caesarean section

Caesarean section is a surgical procedure where one or more foetuses are delivered by incision through the abdominal wall and the uterus (Blood, Studdert *et al.* 2007). Dystocia and subsequently caesarean section can cause distress and suffering to both the bitch and the puppies and is associated with potential operative complications including haemorrhage and hypovolemia (Slatter 2003, Rooney, Sargan 2009). Moreover, there is a risk of foetal mortality mainly because of a delayed parturition process, which can be fatal to the puppies due to detached placenta and following oxygen deficiency. But also because the puppies do not get the vital respiratory stimulation they normally get during their passage through the birth canal. Furthermore, puppies born by caesarean section are under the influence of drugs since most general anaesthetics cross the placental barrier, which causes a respiratory depression. However, for bitches undergoing elective caesarean sections, *i.e.* caesarean sections that are planned, the chances of giving birth to live puppies are larger than for bitches undergoing emergency caesarean sections (Funkquist, Nyman et al. 1997, Moon, Erb *et al.* 2000). Another issue, that may cause problems in relation to delivery by caesarean section, is the

risk of inappropriate maternal behaviour. During the surgical process the bitch is under the influence of stress, anaesthetic drugs, pain and excessive human interference that may have a negative impact on the maternal behaviour that is critical for neonatal survival (England, Heimendahl 2010).

Moreover, economy is an important aspect of caesarean section in dogs. The surgical procedure in itself is a considerable expense, and even more so if the caesarean section is acute and performed after opening hours of the clinic (Kirchhoff 2014). Although it has not been possible to find any records of the mortality rate of puppies in relation to natural birth in dogs, it can be assumed that caesarean sections cause an increased mortality rate of the puppies compared to puppies born naturally. Thus, caesarean section can result in a financial loss for the breeders, both due to the cost of the operation and due to increased mortality of the puppies, since especially purebred puppies bring in a considerable amount of money (Smith 2007).

Dystocia in Scottish Terriers

The Scottish Terrier

The Scottish Terrier is a sturdy little dog with a long head, short legs and a compact body. It was originally kept on Scottish households to hunt vermin and was later on selectively bred for hunting and going underground to flush and kill foxes, badgers and the like. Today, Scottish Terriers are mostly family companions and can be found in show rings around the world. Like other purebred dogs, the Scottish Terriers have a number of inherited disorders associated with the breed. Among these, Scotty Cramp, von Willebrands disease and Craniomandibular osteopathy are some of the most well-known. Another far more common disorder within the breed is dystocia (Agria Pet Insurance 2011, University of Cambridge 2013, UKC 1998 , Hedhammar, Olsson *et al.* 1979, DTK 2014)

Frequency of dystocia in Scottish Terriers

Dystocia with following caesarean section is a major issue in many breeds and in brachycephalic breeds in particular. One of the non-brachycephalic breeds, that has the highest frequency of caesarean section deliveries is the Scottish Terrier (Evans, Adams 2010). A statistical analysis from the Swedish insurance company Agria shows that among the insured dogs, Scottish Terriers had 9 times larger risk of having dystocia/labour problems compared to all breeds combined from 2006 to 2011 (Agria Pet Insurance 2011). In Dansk Kennel Club (DKK), when litters are being registered,

the owners inform if the birth was natural or by caesarean section. In 2012 and 2013, 38 Scottish Terrier litters were registered, 22 of these were born by caesarean section (58 percent) (DKK 2014). The issue of dystocia and as a consequence caesarean section is also well known in the population of Scottish Terriers in the United Kingdom with a caesarean section rate around 60 percent (Evans, Adams 2010). In Germany and USA the breed also has a problem with a high frequency of caesarean section, but to a far lesser extent. A health survey made by the Scottish Terrier Club of America (STCA) in 2005 reported a caesarean section rate of 34 percent (STCA 2005). The truthfulness of this number may however be questioned due to fact that data was collected by means of a questionnaire, which may have been answered untruthfully by the owners. The official studbook made by the German Terrier Club (KfT) reported a caesarean section rate of 38 percent in Scottish Terriers in 2012 (Scottish Terrier Föderverein 2013). This number is more reliable since a representative from the breed club inspects every newborn litter within 6 days after delivery and makes a note in the breeding protocol if the litter is born by caesarean section (Dr. Clieves 2014). It must be kept in mind that a number of these caesarean sections are elective and that the relation between acute and elective caesarean sections may vary between the populations of Scottish Terriers in the different countries. However it is estimated that the percentages mentioned above give a rough estimate of the frequency of dystocia in the Scottish Terrier populations in Denmark, UK, USA and in Germany.

Fetopelvic disproportion as a cause of dystocia

Fetopelvic disproportion can be due to either absolute or relative foetal oversize meaning that either the foetus is too large or the pelvis is too small for an uncomplicated birth. Abnormally large foetuses are often seen in miniature breeds with a small number of puppies in each litter. In cases where the pelvis is the cause it is not always the area of the pelvic inlet and outlet which causes problems, it may instead be the proportions of the pelvis (Blood, Studdert *et al.* 2007, Freak 1948, Jackson 2004). A Swedish study from 1999 has concluded, that the reason for the high dystocia rate among Scottish Terriers is most likely a dorsoventral flattening of the pelvis causing problems when the foetus is to pass through the birth canal (Eneroth, Linde-Forsberg *et al.* 1999). This pelvic disproportion in the breed has been known for many years. M. J. Freak states in her article from 1948 that the Scottish Terriers have *"a dorsoventrally compressed pelvis totally unsuited to the passage of the foetal head"* (Freak 1948).

Uterine inertia as a cause of dystocia

Another cause of dystocia recognized in the Scottish Terrier breed is uterine inertia (KC and BSAVA 2013). This cause is traditionally divided into primary- and secondary uterine inertia. Primary uterine inertia is defined as an absence or reduction of the forces of myometrial contractions. It may be complete where no foetuses are delivered or partial where some foetuses are expelled but contractions stops. Secondary uterine inertia is a result of another cause of dystocia, for instance obstruction where contractions declines and stops after a period of unproductive straining (Freak 1948, Jackson 2004, Slatter 2003).

The diagnosis of complete primary uterine inertia can be made if no progression from stage one labour occurs and other causes of dystocia have been ruled out by means of clinical examination and diagnostic imaging of the bitch. Alternatively uterine activity can be measured by means of tocodynamometry (Bergström, Fransson *et al*. 2010, Davidson 2011, Freak 1948, Jackson 2004, Slatter 2003).

The aetiology of primary uterine inertia is not well understood, but it is most likely multifactorial involving endocrine defects and may involve an inherited predisposition. One situation where primary uterine inertia is very likely to occur is in association with the so called single puppy syndrome, where the bitch is pregnant with only one puppy. The reason why this syndrome results in uterine inertia may be that the single puppy provides insufficient stimulation, *i.e.* produces too low concentrations of ACTH and cortisol, to initiate parturition (Ettinger, Feldman 2004, Jackson 2004)

Radiographic pelvimetry

One of the ways to investigate pelvic proportions is by means of radiographic pelvimetry, which is a method where the capacity and the diameters of the pelves are measured on radiographs (Blood, Studdert *et al.* 2007). Radiographic pelvimetry has been used in sheep to obtain estimates of pelvic dimensions in specific breeds and for selection of breeding sires and heifers (Cloete, Haughey 1990, Deutscher 1995). Moreover, the method has been used in humans to predict cephalopelvic disproportion (Lenhard, Johnson *et al.* 2010, Stark, Mccarthy *et al.* 1985). To the authors knowledge radiographic pelvimetry has mainly been used retrospectively in dogs and cats to look for correlations between pelvic measurements and dystocia (Celimli, Intas *et al*. 2008, Eneroth, Linde-Forsberg *et al.* 1999, Linde-Forsberg 2003).

When measuring the size of the pelvis one must take into account the degree of magnification, in order to be able to compare the measurements made on different objects. This is particularly important when pictures are taken with different distances between the object and the film, which can be the case when different apparatuses are used. One way to calculate the true length of an object is by applying the principle of similar triangles. Similar triangles are triangles that have the same corresponding angles but are different in size, which is the case with magnification on radiographs, since the triangle that holds the true length of the object is simply a smaller version of the triangle that holds the magnified length of the object. This is visualized in figure 2. Similar triangles have the same ratio between the length of corresponding sides and height. This ratio is the degree of magnification. When looking at figure 2, this means that $\frac{A}{a} = \frac{B}{b} = \frac{C}{c} = \frac{H}{h}$.

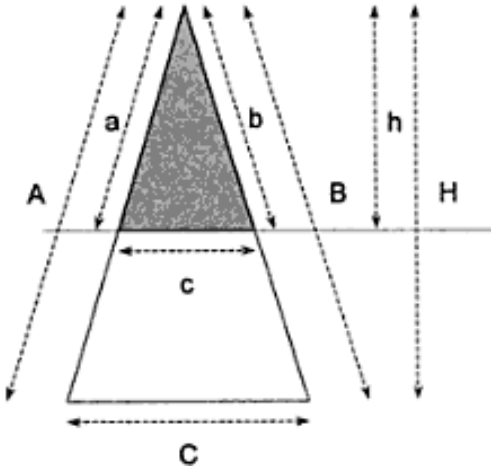

Figure 2 Illustration of magnification on radiographic images. h = distance between focus and object, H = distance between focus and film, c = the true length of the object, C = length of the object as it appears on the image (Bushberg, Seibert *et al.* 2003)

The following formula can be used to determine the degree of magnification when the distance between the focus and object (h) and the distance between the focus and film (H) is known (Bushberg, Seibert *et al.* 2003, Haughey, Gray 1982).

$$Magnification = \frac{H}{h}$$

Heritability

In this study both bitches and male dogs were included. This was done due to the theory, that there is a degree of heritability of pelvic shape from both the father and the mother, in which case it is important to include male dogs in a possible breeding program. A genetic study concludes, that the shape of the canine pelvis is regulated by several so called Quantitative Trait Loci (QTL), which are a number of genes that influences a phenotypic trait, which is quantitative *i.e.* can be measured on a scale (Carrier, Chase *et al.* 2005, Grisel 2000). Furthermore, a number of studies have looked into the concept of heritability, which is defined as the phenotypic variance of a certain trait, for instance pelvic shape, that can be ascribed to a genetic variance. It adopts a value between 0 and 1 with a

value of 1 meaning that all variation in a particular trait is of genetic origin (Visscher, Hill *et al.* 2008). A Swedish study from 2003 concerning heritability of the pelvic shape in Boston Terriers found that the heritability was 0.26, which means that there is a "*strong tendency that the pelvic shape in Boston Terriers is inherited from both the father and the mother in that 26 % of the pelvic shape in the offspring could be explained by the pelvic shape of the parents*" (Linde-Forsberg 2003). Heritability of the pelvic shape has also been investigated in cattle, since the shape of the pelvis is one of the measurements used for selection of breeding sires and heifers. Articles report of heritability values of pelvic shape in cattle between 0.24 and 0.92, which indicates that pelvic shape is indeed a trait, that can be altered through selective breeding (Benyshek, Little 1982, Deutscher 1995, Morrison, Williamson *et al.* 1986). Even though the Scottish Terrier is not a Boston Terrier and certainly not a cow, the fact that these studies have shown, that the shape of the pelvis is a heritable trait, along with the study that has found specific QTLs that regulates the shape of the canine pelvis, makes it very likely to the point of certainty, that the pelvic shape is a heritable trait in Scottish Terriers.

Aim

The high percentage of Scottish Terrier litters in Denmark born by caesarean section has given cause for concern among the owners and among the members of the Health Committee within the Scottish Terrier Group in particular. To the author's knowledge, a number of the caesarean sections performed on Scottish Terriers in Denmark are elective, but the majority of the caesarean sections are acute due to dystocia. It has been stated, that dystocia in Scottish Terriers mainly is due to a dorsoventral compression of the pelvis, which leads to fetopelvic disproportion. Thus, the main task of this project was to investigate whether or not a pelvic conformation issue could be found in a section of Danish Scottish Terriers and to identify a possible correlation between pelvic measurements and dystocia.

This master thesis consists of two parts: a descriptive study and an analytical study.

The descriptive study aimed at determining mean pelvic- and external measurements of male and female Scottish Terriers.

The analytical study was intended to investigate the importance of pelvic dimensions and external body parameters of Scottish Terrier bitches in relation to dystocia. Moreover, the study sought to investigate the impact of the reproduction history of the bitches on the dystocia rate in the breed and finally investigate, if correlations between external measurements and pelvic diameters of Scottish Terrier bitches could be found.

Materials and methods

In order to look into the matter of how different factors including pelvic dimensions and the size of the dog, the litters and the puppies affect the risk of dystocia in Scottish Terriers and to obtain mean pelvic and external dimensions, a number of bitches and male Scottish Terriers were measured and radiographed and reproduction history was obtained.

Animals

The dogs were selected within the population of Scottish Terriers in Denmark. The contact to the owners was arranged by the Health Committee within the Scottish Terrier Group. All members of Dansk Terrier Klub (DTK) with a Scottish Terrier received an e-mail explaining the problem with dystocia in the breed and inviting people to participate in the project (appendix A page 47) An article describing the project was brought in the newsletter "Hunden" from DKK and the newsletter "Terrier Nyt" from DTK (appendix B page 49) Furthermore, to reach out to as many Scottish Terrier owners as possible, the project was advertised on a number of Facebook groups and owners were contacted at dog shows. Moreover, the larger Scottish Terrier breeders that were members of DKK were contacted by phone and urged to participate.

In cases where there was doubt about the reason why a bitch had undergone caesarean section, the attending veterinarian was contacted.

Radiographs were taken of a total of 30 dogs. 6 of these were male and 24 were female. The bitches were divided into three groups:

1) Nulliparous bitches (n=7).

2) Bitches that had given birth naturally (n=11). Several bitches in the study had given birth to a number of puppies naturally, but were forced to undergo caesarean section in order to conceive the last puppies. These were placed in group 2 since the pelvic dimensions had proven adequate for a foetus to pass by.

3) Bitches that had given birth to all puppies by caesarean section (n=6).

The males were not divided as they were included solely for mean pelvic dimensions.

To obtain as much data as possible, 13 dogs were included in the study with only their external measurements and their reproduction history. The owner of these dogs were willing to participate in

the project but were unwilling to let their dog undergo radiographic pelvimetry for various reasons. Of these dogs 10 were females and 3 were males. The female dogs were divided according to the classification above, 3 were nulliparous, 2 had given birth naturally and 5 had given birth solely by caesarean section.

Table 1 Survey of all dogs included in the study Table 1 visualizes the division of the dogs into the different groups.

	Male dogs	**Nulliparous female dogs**	**Female dogs that had given birth naturally**	**Female dogs that had given birth solely by caesarean section**	**Total**
Contributing with pelvic measurements, external measurements and reproduction history	6	7	11	6	**30**
Contributing with external measurements and reproduction history	3	3	2	5	**13**
Total	**9**	**10**	**13**	**11**	**43**

Taking all dogs into account the age of the dogs at the time of examination was ranging from two years and two months to 12 years and 10 months with an average age at of five years and eight months

To ensure that the pelvis was fully developed and that it was not under the influence of hormones all dogs were at least 2 years old at the time of examination and the bitches were in anoestrus and at least 60 days postpartum. The limit of 2 years was set due to fusion of the ossification centres of the pelvis, which takes place in dogs at the age of 1½ to 2 years (König, Liebich 2009, Eneroth, Linde-Forsberg *et al.* 1999).

External body parameters:

All dogs that were radiographed were examined at either one of two Danish clinics. At Dyrlægehuset in Ballerup with aid from veterinarian Alison Wilson or at Hadsten dyreklinik with aid from veterinarian Kathrine Thejll Kirchhoff. The dogs that only contributed to the study with their external measurements and reproduction history were measured at their respective homes. No food or water restriction was made in advance. The dogs were weighted using a digital scale with an accuracy of 0.1 kg. Furthermore, the following external measurements were made on the dogs standing in show stack position with the hind legs placed behind the level of the tail, illustrated in figure 3 (Brown 2012): Height at the withers was measured from the ground to the dorsum of the *processus spinosus* of the first thoracic vertebrae. Body length was measured from the most cranial point of the *articuli humeroscapularis* to the *tuber isciadicum*. Height at the withers was measured with a measuring rod with an accuracy of 0.1 cm. The body length was assessed using a measuring tape also with 0.1 cm accuracy.

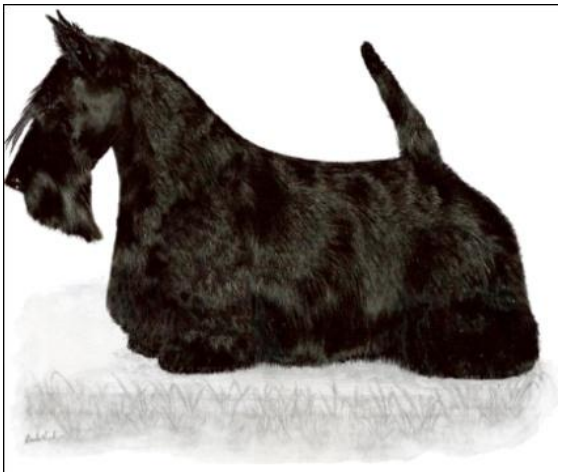

Figure 3 A Scottish Terrier in show stack position (Brown 2012)

Radiographic parameters

At Hadsten dyreklinik the radiographs were obtained digitally with a Toshiba Rotanode E-7242X (Japan), using a Fuji IP Cassette type CC size 24×30 cm. All dogs were radiographed with a focus-film distance of 100 cm, at 65 Kilovolts (kV) and 6 milliampere-seconds (mAs) with the use of a Potter-Bucky diaphragm. Minor adjustments were made on kV depending on the size of the dog. The images were processed on a Fuji CR-IR 357.

At dyrlægehuset Balleup the radiographs were also obtained by digital radiography using a Ralco TOP100G (Lissone, Italy) and an ABS CR Cassette size 24×30 cm. The images were generated at 55-65 kV depending on the size of the dog with a fixed mAs at 6.25 using table top technique with a grid placed on top of the cassette and with a focus-film distance of 100 cm. The image processor used was a Dürr medical CR 35 VET image plate scanner.

The radiographs were taken without the use of anaesthetics with the dogs in left lateral and in dorsal recumbency. In dorsal recumbency, where radiographs in ventrodorsal projection were obtained, the dogs were placed in frog-leg position and the central beam was focused on a midline between the two *trochanter major*. In the laterolateral projection the legs were pulled caudally to expose the *pecten ossis pubis* and the focus of the central beam was positioned at the *trochanter major* (Waibl, Mayrhofer *et al.* 2005). To make sure that the dogs were lying in a straight position, a comparative evaluation of the size and shape of various pelvic structures on the radiographs of the pelvis in ventrodorsal projection was made. These structures were the right and left *foramen obturatorium*, the *alla ossis ilii* and the *tabula ossis ischii*. On the laterolateral projection it was made sure that the *caput femoris*, the *ala ossis ilii* and the *tuber isciadicum* were as superimposed as possible (König, Liebich 2009).

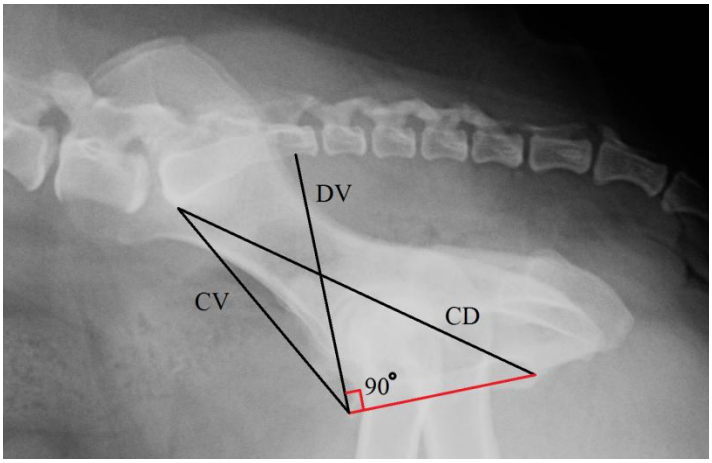

Figure 4 Measurements on the laterolateral radiograph. CV = *conjugata vera*, DV = *diameter verticalis*, CD = *conjugata diagonalis.*

The pictures were analysed and measurements were made using the computer software RemotEye at Veterinary Imaging, Department of Veterinary Clinical and Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen.

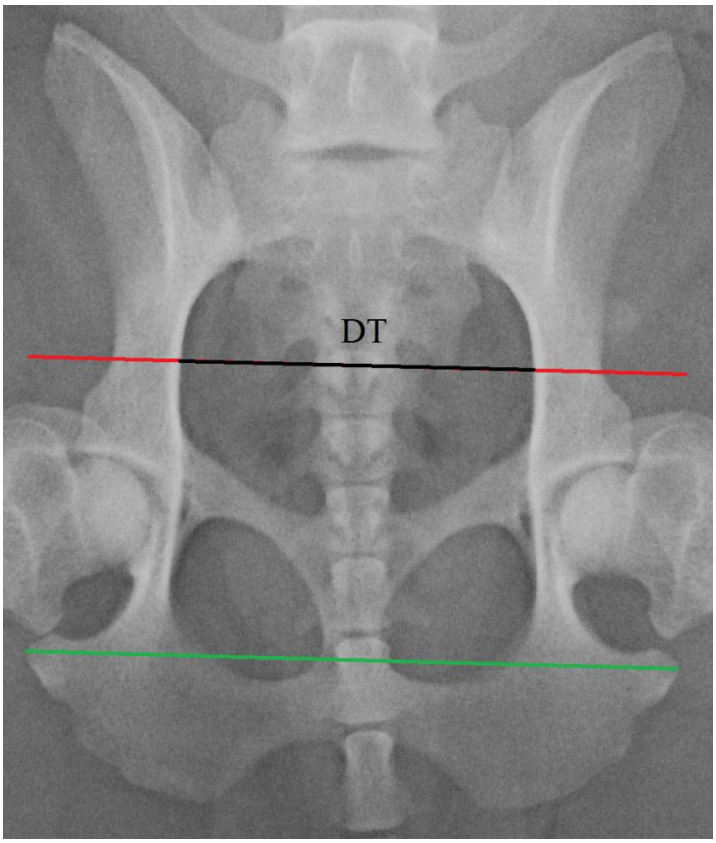

Figure 5 Measurement on the ventrodorsal radiograph. DT = *diameter transversa*

Figure 4 and 5 illustrates the measurements made on the pelvis in laterolateral and in ventrodorsal projection respectively. Due to the relative ease of manipulating the vertical diameters on the

pelvis in ventrodorsal projection by tilting the dog along the medial axis, only the horizontal diameter of the pelvic inlet was measured on the ventrodorsal radiographs. *Conjugata vera* (CV) is the distance between *promontorium* (craniovental extremity of sacrum) and *pecten ossis pubis* (cranial end of *symphysis pubica*) CV is the vertical diameter of the pelvic inlet. *Diameter verticalis* (DV) is the vertical distance between the *pecten ossis pubis* and the sacrum orthogonal to the *symphysis pelvis*. The line through *symphysis pelvis* is illustrated by the red line on figure 4. *Conjugata diagonalis* (CD) is the distance between the *promontorium* and the caudal extremity of the *symphysis pelvis. Diameter transversa* (DT) is the horizontal distance between the *corpus ossis ilii*. DT is the horizontal diameter of the pelvic inlet. (König, Liebich 2009) To make sure that the horizontal distance was found when measuring DT a line was drawn between two distinct bony landmarks on the pelvis, namely the two lateral *tuber ischiadica*. This is illustrated by the green line in figure 5. The distance DT was measured parallel to the green line. This is illustrated by the red line in figure 5. Furthermore, the relationship between the vertical and the horizontal diameter of the pelvic inlet was calculated (CV/DT) together with the area of the pelvic inlet. It was estimated that the geometric figure that the pelvic inlet resembled the best was an ellipse. Therefore, the area of the pelvic inlet was calculated by using the formula $\pi \times CV/2 \times DT/2$ (UC San Diego 2014).

Correction of magnification

The radiographs of the dogs were taken on two different devices. The radiographs taken at Hadsten dyreklinik were obtained with the film in the table while the radiographs taken at Dyrlægehuset Ballerup were obtained with film on top of the table with only the grid between the film and the dog. This means that there was a considerable difference in the distance between the object and the film, which resulted in different degrees of magnification. To correct for this, the principle of similar triangles was applied. Referring to figure 2 at page 13 the degree of magnification on the radiographs was calculated by use of the formula:

$$Magnification = \frac{H}{h}$$

The bony landmarks of interest and thereby the base of the smaller triangle was assumed to lie in the horizontal plane halfway through the thickness of dog. Thickness was measured at the level of trochanter major in lateral and in dorsal recumbency with measuring tape with an accuracy of 0.1 cm (Haughey, Gray 1982).

Due to inconsistency in the protocol, the thickness was only measured on eight dogs. Based on the measurement from the eight dogs, an average value for the thickness of the dogs in lateral and in dorsal recumbency was calculated.

Mean thickness of dogs in lateral recumbency: 12.7 cm

Base of the smaller triangle in lateral recumbency: 12.7 cm/2 = 6.35 cm

Mean thickness of the dogs in dorsal recumbency: 6.5 cm

Base of the smaller triangle in dorsal recumbency: 6.5 cm/2 = 3.25 cm

Besides the thickness of the dog, in order to calculate the magnification, the focus-film distance and the distance between the dog and the film was measured.

At Hadsten dyreklinik the focus-film distance was 100 cm. and the distance between the dog and the film was 8.5 cm.

At dyrlægehuset Ballerup the focus-film distance was also 100 cm. and the distance between the dog and the film was 0.6 cm (the thickness of the grid)

This means that the degree of magnification on the radiographs obtained on the apparatus at Hadsten dyreklinik was:

In laterolateral projection: $\frac{100}{100-(8.5+6.35)} = 1.174$

And in ventrodorsal projection: $\frac{100}{100-(8.5+3.25)} = 1.133$

The degree of mmagnification on the radiographs obtained on the apparatus at Dyrlægehuset Ballerup was:

In laterolateral projection: $\frac{100}{100-(0.6+6.35)} = 1.075$

And in ventrodorsal projection: $\frac{100}{100-(0.6+3.25)} = 1.04$

All radiographs were corrected for magnification by dividing the measurements on the radiographs with the corresponding magnification value.

Reproduction history

Before the visit to the clinic the owners received an e-mail with a questionnaire about the reproduction history of the dog including questions about date of birth, caesarean section rate in the family, litter size and weight of the new-born puppies (appendix C page 52). In case the owners had problems filling out the questionnaire it was done in relation to the examination of the dog with aid from the undersigned.

Statistical analysis

All data was analysed using the Statistical Analysis System (SAS).

For the descriptive study mean values and standard deviations were calculated for both male dogs and bitches.

For the analytical study Students T-test was used to test for differences between means of pelvic and external measurements of bitches that had given birth naturally and bitches that had given birth solely by caesarean section. All measurements analyzed by means of students t-test were tested for normality using the Shapiro-Wilk test. Furthermore, by means of a Chi-square test it was tested if bitches born by caesarean section had a higher risk of giving birth by caesarean section than bitches born naturally and finally it was investigated whether height, weight and length of the dogs were correlated with three different measurements on the pelvis using pearsons correlation coefficient. A p-value below 0.05 was considered significant for all tests. For the Shapiro-Wilk test a p-value above 0.05 indicated that the data were normally distributed.

Results

The results are divided into two main sections; a descriptive part where mean pelvic and external measurements for all male dogs and bitches included in the project are listed, and an analytical part.

Descriptive study

Pelvic- and external measurements of the male Scottish Terriers

To assess the composition of the pelves of the male Scottish Terriers, radiographs were taken in left lateral and in dorsal recumbency. In table 2 are listed the mean values for each of the pelvic measurements made on the radiographs of the six male dogs.

Table 2 Table 1 Mean pelvic values for male Scottish Terriers (mean ± Standard error (SE)). N = number of dogs, CV = *conjugata vera*, DV = *diameter verticalis*, CD = *conjugata diagonalis*, DT = *diameter transversa*. CV/DT = the relation between the vertical and horizontal diameter of the pelvic inlet. Assuming that the pelvic inlet is the shape of an ellipse the area can be calculated by using the formula $\pi \times CV/2 \times DT/2$ (UC San Diego 2014).

Measurement	Male dogs (n=6)
CV (cm)	4.12 ± 0.07
DV (cm)	4.24 ± 0.18
CD (cm)	6.27 ± 0.09
DT (cm)	4.03 ± 0.05
CV/DT	1.02 ± 0.02
Area pelvic inlet (cm)	13.05 ± 0.31

To get an idea of the size of the Danish male Scottish Terriers, all male dogs included in this study were weighted and measured. Table 3 is a list of mean values of all external measurements made on the nine male dogs.

Table 3 External measurements of the male dogs (mean ± SE). N = number of dogs.

Measurement	Male dogs (n=9)
Length (cm)	42.0 ± 0.44
Height (cm)	26.7 ± 0.54
Weight (kg)	11.1 ± 0.34

Pelvic- and external measurements of the female Scottish Terriers

All bitches that contributed to the radiographic study, both nulliparious bitches, bitches that had given birth by caesarean section and naturally whelping bitches are included in the table 4, where mean pelvic measurements for the female Scottish Terriers are listed.

Table 4 Mean pelvic values for female Scottish Terriers (mean ± SE). N = number of dogs, CV = *conjugata vera*, DV = *diameter verticalis*, CD = *conjugata diagonalis*, DT = *diameter transversa*. CV/DT = the relation between the vertical and horizontal diameter of the pelvic inlet. Assuming that the pelvic inlet is the shape of an ellipse the area can be calculated by using the formula π×CV/2×DT/2 (UC San Diego 2014)

Measurement	Bitches (n=24)
CV (cm)	4.23 ± 0.06
DV (cm)	4.22 ± 0.05
CD (cm)	6.21 ± 0.06
DT (cm)	4.12 ± 0.03
CV/DT	1.03 ± 0.02
Area pelvic inlet (cm)	13.72 ± 0.22

To find the general size of the Danish female Scottish Terriers, all bitches included in the radiographic study and all bitches that only contributed with external measurements and reproduction history were weighted and measured, a total of 34 bitches. Table 5 lists the mean external measurements of Scottish Terrier bitches included in the study.

Table 4. External body measurements of the Scottish Terrier bitches (mean ± SE). N = number of dogs.

Measurement	Bitches (n=34)
Length (cm)	40.2 ± 0.34
Height (cm)	26.3 ± 0.18
Weight (kg)	10.9 ± 0.20

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Analytical study

It has previously been demonstrated that dystocia is a common issue during the parturition process in the Scottish Terrier breed (Bergstrom, Nodtvedt *et al.* 2006). The main purpose of this analytical study was to investigate the causes of the high frequency of dystocia in the Scottish Terriers in Denmark, with the main focus on the pelvic size and composition. By means of inferential statistics, this part of the study sought to analyse the data obtained from the pelvic measurements made on the radiographs, data acquired from the external measurements of the dogs and the data obtained from the questionnaire handed in to the owners. The results are listed below.

The Shapiro-Wilk test was used to test for normality. All data which was tested by means of students t-test in the following were normally distributed with a p-value above 0.05.

Correlation between pelvic measurements and external measurements of the bitches

In table 7 is listed the coefficients for the correlation between the pelvic measurements CV, CD and DT and the length, height and weight of the bitches. In this analysis, all bitches that were radiographed are included, a total of 24 dogs. The table shows a significant positive correlation between height of the dog and the pelvic measurements CV and CD with a p-value of 0,004 and 0.005 respectively. The fact that the correlation coefficients are positive (0.561 and 0.541) goes to show that an increase in CV and CD corresponds to an increase in height of the dog. The scatter plot in figure 6 shows the distribution of data and if looking closely one can sense a linear relationship between the variable “height” and the variables “CV” and “CD”.

Table 5 Correlation between pelvic- and external measurements evaluated by means of Pearsons Correlation Coefficient with values ranging from -1 to 1 (SAS Tutorials 2007). CV = *conjugata vera*, CD = *conjugata diagonalis*, DT = *diameter transversa*.

Pearson Correlation Coefficients n = 24			
	CV	**CD**	**DT**
Length (cm)	0.063 P=0.764	0.027 P =0.896	0.389 P=0.060
Height (cm)	0.561 P=0.004	0.541 P=0.005	0.292 P=0.166
Weight (kg)	0.202 P=0.333	0.266 P=0.199	0.242 P=0.255

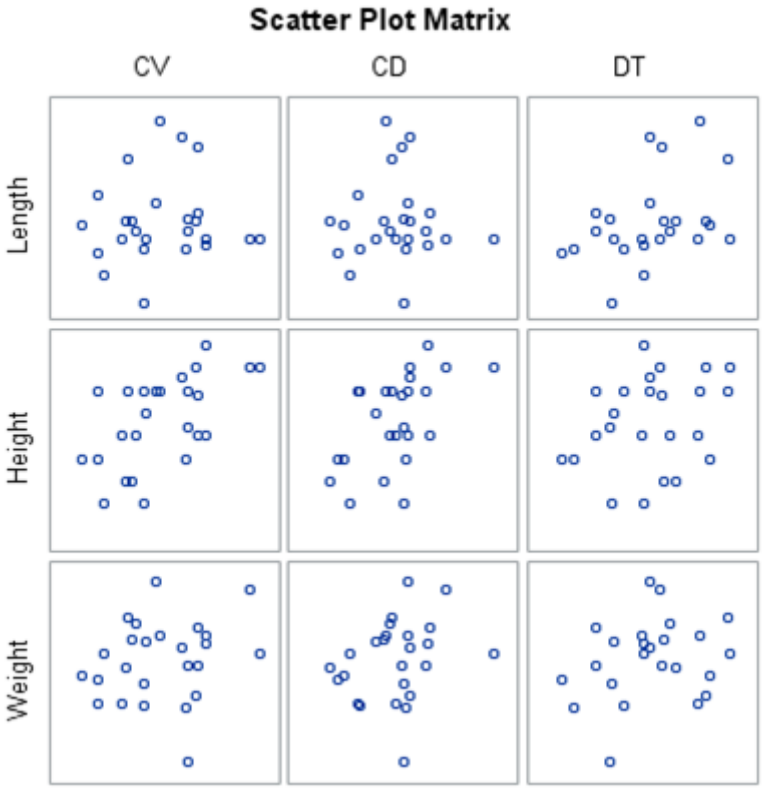

Figure 6 A scatter plot where values of the pelvic- and the external variables are displayed.

Reproduction history of the bitches

Birth way of bitches and progeny

From the information given by the owners about the bitches´ reproduction history, data about whether or not the bitches, the mother of the bitches and the litter of the bitches were born by caesarean section were extracted. The results are presented in the 2×2 tables A and B in table 8. The association between the data was tested by means of chi-square tests resulting in a p-value of 0.0006 for table A and a p-value of 0.0001 for table B. These p-values indicate that the association is statistically significant implying that for this population, if a bitch is born by caesarean section its progeny will most likely be born by caesarean section.

Table 6 2×2 tables to show how the way of birth of the mother influences the way of birth of the progeny for the bitches included in the study.

A

Born by caesarean section	Giving birth by caesarean section		
	Yes	No	Total
Yes	11	1	12
No	1	13	14
Total	12	14	26

B

Born by caesarean section	Mother born by caesarean section		
	Yes	No	Total
Yes	11	2	13
No	1	13	14
Total	12	15	27

Litter size and puppy weight

For all the bitches included in the study, both the ones that only contributed with external measurements and reproduction history and the ones that also contributed to the radiographic study, data about litter size, number of litters and puppy weight was collected, the data are shown in table 9. The p-values reveal that no significant correlation between the litter data and way of birth could be found for this study population, which may lead to the conclusion that no correlation between dystocia and litter size or puppy weight exists for this study population.

Table 7 Information about litter size and puppy weight and a comparison of data from bitches that had given birth naturally to bitches that had given birth solely by caesarean section by means of Students t-test (mean ± SE). N = number of dogs. Mean puppy weight (%) = the relation between the mean weight of the puppies and the weight of the mother in terms of percentage.

	Natural birth (n=13)	Caesarean section (n=11)	p-value
Mean age at first litter (months)	38.8 ± 2.66	40.5 ± 2.05	0.62
Mean litter size	4.7 ± 0.38	4.4 ± 0.55	0.58
mean puppy weight (g)	234 ± 5.13	247 ± 5.44	0.09
mean puppy weight (%)	2.2 ± 0.11	2.2 ± 0.08	0.69
Mean weight of heaviest puppy (g)	254 ± 6.53	270 ± 7.56	0.11

Pelvic measurements of the bitches that had given birth at the time of examination

The main purpose of this assignment was to investigate whether or not differences in pelvic measurements of naturally whelping bitches and bitches that had given birth solely by caesarean section could be found. In table 10 mean values for the pelvic measurements are shown together with p-values indicating that significant differences between the two groups of bitches exist for the following measurements: CV, DV, CD, CV/DT and area pelvic inlet were 0.0006, 0.0008, 0.0149, 0, 0002 and 0,00326 respectively, which means that the vertical diameters of pelvis together with the length of the pelvis were significantly shorter in the group of caesarean section bitches compared to the group of normally whelping bitches. This was reflected in the area of the pelvic inlet and in the relation between the vertical and the horizontal diameter that became significantly different between the two groups of bitches due to the difference in CV.

Table 10 Comparison of pelvic measurements of bitches that had given birth naturally and bitches that had given birth solely by caesarean section by means of students t-test (mean ± SEM). N =number of dogs, CV = *conjugata vera,* DV = *diameter verticalis,* CD = *conjugata diagonalis,* DT = *diameter transversa.* CV/DT = the relation between the vertical and the horizontal diameter of the pelvic inlet. Assuming that the pelvic inlet is the shape of an ellipse the area can be calculated by using the formula π×CV/2×DT/2 (UC San Diego 2014).

Measurement	Natural birth (n=11)	C-section (n=6)	P-value
CV (cm)	4.37 ± 0.06	3.97 ± 0.04	0.0006
DV (cm)	4.39 ± 0.06	3.98 ± 0.07	0.0008
CD (cm)	6,33 ± 0.08	5,97 ± 0.09	0.0149
DT (cm)	4.08 ± 0.04	4.13 ± 0.07	0.5855
CV/DT	1.07 ± 0.02	0.96 ± 0.01	0.0002
Area pelvic inlet (cm)	14.02 ± 0.30	12.91 ± 0.32	0.0326

External measurements of the bitches that had given birth at the time of examination

A total of 24 bitches included in the radiographic study had given birth either naturally or solely by caesarean section. The mean external measurements of the two groups of bitches are listed in table 9. The p-value for height at 0.0133 reveals a significant difference in height between the naturally whelping bitches and the bitches that has given birth solely by caesarean section. This p-value indicates that naturally whelping bitches as a group are higher at the withers than the bitches whelping solely by means of caesarean section.

Table 9 shows the mean external measurements of naturally whelping bitches and bitches that had given birth solely by caesarean section and a comparison by means of students t-test (mean ± SE). N = number of bitches.

Measurement	Natural birth (n=13)	Caesarean section (n=11)	P-value
Length (cm)	40.3 ± 0.63	39.9 ± 0.56	0.6650
Height (cm)	26.7 ± 0.24	25.7 ± 0.29	0.0133
Weight (kg)	10.9 ± 0.34	10.8 ± 0.28	0.8327

Discussion

This study of dystocia and pelvic proportions in Scottish Terriers was requested by the Health Committee within the Scottish Terrier Group in Denmark. Since the publication of the Swedish study by Eneroth and others in 1999, the Health Committee has been interested in looking into the matter of dystocia due to fetopelvic disproportion in the population of Scottish Terriers in Denmark, in order to lay the first stone in reducing the percentage of Scottish Terrier bitches undergoing caesarean section (Eneroth, Linde-Forsberg *et al.* 1999, Hasselby 2014).

It was the intention of this study to investigate whether the causes for the high dystocia rate found by Eneroth and others in the study from 1999 could be found in the population of Scottish Terriers in Denmark. The main aim of this study was therefore to investigate the impact of pelvic size and proportions on dystocia in Scottish Terriers in Denmark.

To make sure that the study population was as representative as possible for the population of Scottish Terriers in Denmark and that not only a few breed lines were represented, the radiographic examination was preformed at two clinics in Denmark, one in Jutland and one on Zealand.

Descriptive study

Pelvic- and external measurements of the male and female Scottish Terriers

Besides bitches that had given birth, nulliparious bitches and male dogs were included in this study to get an idea of the general pelvic size, height at the withers, weight and length of the Danish Scottish Terriers.

The idea of this section was to create reference values as a tool for Scottish Terrier owners to evaluate their own dog. It was the intention also to subdivide the male dogs according to the reproduction performance of their female progeny. Unfortunately, due to the small number of males included in the study and the fact that only two of the dogs included had female progeny that had given birth, this idea was rejected.

One thing that can be deduced from table 2 and 4 page 24 and 25 is that the mean size and proportion of the pelves of male and female Scottish terriers is virtually the same with only minor differences. The area of the pelvic inlet was slightly larger in females than in males. In order to minimize the number of T-tests and thereby decrease the number of false positives it was not calculated whether or not these differences were statistically significant. An article by Ocal and

others about pelvic measurements in German Shepherd Dogs found that *"there was no significant statistical difference between male and female dogs"*. Furthermore, in agreement with this study, the article by Ocal and others found that the area of the pelvic inlet was larger in females than in males, though not significantly (Ocal, Dabanoglu *et al.* 2003).

An interesting observation when looking at table table 2 and 4 is that the ratio between the vertical and horizontal diameter of the pelvic inlet in both female and male Scottish Terriers almost equals 1 (Mean and standard error of 1.03 ± 0.02 and 1.02 ± 0.02 respectively). The normal pelvic inlet in dogs has a vertical diameter that is longer than the horizontal (Eneroth, Linde-Forsberg *et al.* 1999). In the article by Ocal and others it was found that the ratio between the vertical and horizontal diameter was 1.33 and 1.25 for female and male German Shepherd Dogs respectively. The fact that the mean ratio for both males and females in this study is so low suggests that the dorsoventral flattening of the pelvis is not only the case in bitches that suffers from dystocia, but instead a general issue in the Scottish Terrier population in Denmark.

From table 3 and 5 page 24 and 25 it is seen that the male Scottish Terriers are slightly larger and heavier than the female Scottish Terriers. The Federation Cynologique Internationale (FCI), which is an international organization of kennel clubs, has created a standard for every sanctioned breed as regards to appearance, temper and movement together with the "owner" country of the breed (FCI 2014). The FCI standard of the Scottish Terrier dictates that the height at the withers must be between 25 and 28 cm. and that the dog must weigh between 8.5 and 10.5 kg.(FCI 2011) In this study the average height of female and male Scottish terriers were 26.3 cm and 26.7 cm respectively, which is within the limits of the FCI standard. The weight of the dogs on the other hand were on average 10.9 kg and 11.1 kg for female and male Scottish Terriers respectively, which is above the limit of 10.5 kg. A possible reason for this discrepancy is that a considerable share of the dogs participating in this study were not show-dogs and it is therefore likely, that these dogs were allowed a less strict diet than dogs attending shows. Moreover, two important sources of error in connection with the weight of the dogs are at stake. First of all several of the dogs were weighted with their leash. Second of all a number of the dogs were measured on bathroom scales, which is a source of error due to lack of calibration of the scales. This inaccuracy presents a problem in every test that involves the weight of the dogs. Therefore, these results should be evaluated with caution.

Analytical study

Caesarean section

Due to the fact that around 60 percent of the cases of dystocia result in caesarean section and that elective caesarean section may be an alternative to dystocia, the relevance of this study depends on the fact that cesarean section is, in fact, an undesired and potentially harmful procedure. An acute caesarean section is associated with a number of risk factors including maternal stress and a delayed parturition process that can be fatal to the puppies due to oxygen deficiency. Even though the risk factors involving a delayed parturition are eliminated when performing elective caesarean section there is still reason to believe that the mortality rate of the bitch and the puppies is higher when birth is by caesarean section compared to a natural, uncomplicated birth. Furthermore, when Scottish Terriers in Denmark deliver 60 percent of their litters by caesarean section it is not only a problem concerning the health of the bitch and puppies but also an ethical problem. DKK has made a set of ethical recommendations for breeding. Here it is stated that "*it is the responsibility of the breeders only to use dogs for breeding that are able to mate, give birth and raise puppies in a natural way*" (DKK 2012). Thus, it can be concluded that cesarean section is indeed an unwanted event in dogs, and should be prevented.

External measurements and correlation between pelvic measurements and external measurements of the bitches

In the Swedish study by Eneroth and others it was investigated if there were correlations between external measurements and pelvic measurements and if there was a connection between suffering from dystocia and external measurements of Scottish Terrier bitches. The study found a tendency of *"a lighter, lower and shorter body type in bitches experiencing dystocia"*. Furthermore the study found a significant positive correlation between weight, body length and height at the withers and vertical diameters of the pelvis (Eneroth, Linde-Forsberg *et al.* 1999).

These results are in tally with the results found in this study where a significant correlation between height at the withers and giving birth by caesarean section was found in that bitches that had given birth solely by caesarean section generally were shorter than bitches that had given birth naturally ($p = 0.013$). Furthermore, by means of Pearsons correlation coefficient this study revealed a significant correlation between the height at the withers and the *conjugata vera* and *conjugata diagonalis* of the pelves of the Scottish Terrier bitches with p-values of 0.004 and 0.005

respectively. These results reveal that in all probability the reason why higher bitches have a lower frequency of dystocia is that higher dogs have longer vertical pelvic diameters.

The above mentioned results may lead to the conclusion that breeding for larger dogs will decrease the dystocia rate. One of the things that one must consider is whether the size of the bitch affects the size of the puppies. This study reveals that puppies from litters born solely by caesarean section were not significantly heavier than puppies born naturally ($p=0.09$) even though the bitches were significantly higher in the latter group. In tally with these results, the study by Eneroth and others found no significant difference in the weight of the puppies between the two groups of bitches in spite the fact that the naturally whelping bitches were larger (Eneroth, Linde-Forsberg *et al.* 1999). Even though it cannot be predicted if breeding for larger bitches would result in larger puppies in the long run and thereby counterbalance the positive effect of a larger pelvis it might have a positive effect on the dystocia rate in Scottish Terriers to breed for larger dogs.

However, when looking at the numbers from USA from 2005, only approximately 35 percent of the American Scottish Terrier litters were born by caesarean section compared to a frequency of approximately 60 percent in Denmark (STCA 2005). Furthermore, the breed standard of height dictated by the American Kennel Club (AKC) is 10 inches (25.4 cm), which means that the American Scottish Terriers are most likely significantly shorter than the Danish Scottish Terriers (AKC 1993). If the numbers from America are representative it goes to show that a population of relatively short Scottish Terriers can have a low dystocia rate compared to the dystocia rate in the breed in Denmark. One explanation could be that these shorter bitches give birth to smaller puppies that are able to pass through the birth canal in spite of a smaller pelvis. It could have been interesting to have more recent data from USA, but the reproduction survey is only conducted every 10^{th} year, which means that new data will be available in 2015. Alternatively it would have been an advantage to have a caesarean section frequency for Danish Scottish Terriers from 2005 to have more comparable data. However, no data about the way of birth of the litters is available in DKKs database before 2010 due to a change in the protocol.

Reproduction history of the bitches

In order to investigate if other factors influenced the risk of dystocia besides pelvic size and shape, the owners filled in a questionnaire about the reproduction history of the dog.

One of the most important sources of error regarding the reproduction history of the dogs is that the data are based entirely upon information given by the owners and breeders of the family of the dogs. It is however estimated that the owners in general were very thorough in gathering information about their dogs and that the questionnaires were answered truthfully.

Results from this study and the study by Eneroth and others point at fetopelvic disproportion due to inappropriate pelvis conformations as the main reason for the high dystocia rate in the Scottish Terrier breed (Eneroth, Linde-Forsberg *et al.* 1999). To investigate if the fetopelvic disproportion found in this study was only due to a relative foetal oversize or if an absolute foetal oversize also played a part, the weight of the puppies was examined. The mean weight of the puppies in litters born naturally and in litters born solely by caesarean section was calculated but no significant difference was found ($p = 0.69$). In Welch Corgis dystocia is often due to fetopelvic disproportion due to a considerable variation in the size of the foetuses (Jackson 2004). To exclude this as a cause of dystocia in the Scottish Terriers the mean weight for the heaviest puppy in each litter was calculated for the two groups of bitches. In normally whelping bitches the mean weight of the heaviest puppies was 254 g, while the mean weight of the heaviest puppies was 270 g. in litters born solely by caesarean section. The p-value of 0.11 reveals that no significant difference exists, which means that in all probability the high dystocia rate in Scottish Terriers is not due to isolated cases of oversize puppies. A source of error to these numbers is that several of the puppies that were stillborn were not weighted. Since puppies that gets stuck are in great risk of dying due to hypoxia, the stillborn puppies may very well be the oversized ones (Senger 1997).

It is estimated that the upper limit for the weight of the puppy relative to the weight of the bitch for an uncomplicated birth is 4 to 5 percent in smaller breeds (Ettinger, Feldman 2004, Eneroth, Linde-Forsberg *et al.* 1999). In this study it was shown that the mean puppy weight compared to the weight of the bitch in both the “caesarean section group” and in the “naturally whelping group” were 2.2. In the study by Eneroth and others the values were 2.5 for the dystocia bitches and 2.1 for the naturally whelping bitches (Eneroth, Linde-Forsberg *et al.* 1999). These numbers goes to show that it is not the size of the puppies that is the reason for the high dystocia rate in the breed. The fact that such a low puppy weight relative to the weight of the bitch gives cause for dystocia in the Scottish Terriers underlines the seriousness of the problem with the shape and size of the pelvis in the breed.

In order to look into the heritability of dystocia in general in Scottish Terriers, it was investigated whether bitches born by caesarean section had a higher risk of giving birth by caesarean section than bitches born naturally. A statistically significant association between being born by caesarean section and giving birth by caesarean section was found (p=0.0006). This suggests that there is a degree of heritability in pelvic shape in Scottish Terriers. However, other factors apart from heritability are likely to affect these numbers. For instance many Scottish Terrier owners included in this study own a breed line of dogs. It is likely that certain owners have a tendency to let their dogs undergo caesarean section either electively or very early in the parturition process and thereby will dogs born by caesarean section also give birth by caesarean section despite the fact that their pelves may by fit for giving birth naturally.

Pelvic measurements of the bitches that had given birth at the time of examination

The primary task of this project was to investigate the pelvis conformations of the Scottish Terriers and thereby focus on the obstructive dystocia. However, from the reproduction history given by the owners and the information obtained from the attending veterinarians it was not possible to rule out other causes than pelvis conformation, for instance uterine inertia and foetal maldisposition, as the cause of dystocia in the bitches that had given birth solely by caesarean section. All 11 dogs included in the radiographic study that had given birth solely by caesarean section were clinically examined before the procedure. Furthermore, five of the 11 dogs had undergone an ultrasonic examination prior to the operation to check for foetal viability. However, in none of the cases were radiologic examination conducted to check for foetal maldispostion and fetopelvic disproportion. Moreover two of the 11 dogs had undergone elective caesarean section due to a family history of dystocia. Therefore, the bitches were grouped into 1) bitches that had given birth solely by caesarean section and 2) bitches that had given birth naturally. However, when looking at the data obtained from the radiographic examination of the bitches and the mean values and p-values listed in table 10 page 30 it is clear that the vertical pelvic diameters of the bitches that had given birth naturally were significantly longer than for bitches that had given birth solely by caesarean section. Furthermore, for the pelvic measurement CV, there were no overlapping measurements between the two groups of bitches *i.e.* the lowest value of the bitches in the "naturally whelping group" were higher than the highest value in the "caesarean section group". For these reasons it seems reasonable to assume that in this study, caesarean section can be used as an indicator for dystocia due to a dorsoventral flattening of the pelvis.

In the study by Eneroth and others from 1999 it was found that all measurements made on the laterolateral projection of Scottish Terrier bitches were significantly larger in normally whelping bitches compared to bitches suffering from dystocia. This includes the *conjugata vera* with a p-value of 0.021. In general the study found that the pelvic canal was significantly shorter and lower in bitches suffering from dystocia compared to naturally whelping bitches (Eneroth, Linde-Forsberg *et al.* 1999). In tally with the results found by Eneroth and others, this study found that the mean diameters on the pelves in laterolateral projection were significantly longer in bitches that had given birth naturally compared to bitches that had given birth solely by caesarean section. Both this project and the project by Eneroth and others found no significant difference in the *diameter transversa* between the two groups of bitches. These results indicate that the main problem with the pelves of the Scottish Terriers is a dorsoventral flattening of the pelvic inlet. It would have been interesting to compare the mean pelvic measurements in this study with the measurements made by Eneroth and others, but due to lack of correction for magnification in the Swedish study, this was not possible (Eneroth, Linde-Forsberg *et al.* 1999).

Pelvic measurements and statistics

Due to inexperience of the undersigned in measuring on radiographs and minor imperfections in the positioning of the dog on a number of the radiographs, an inaccuracy of 0.1 cm from the values listed in the results section was estimated. However, due to the differences in the mean pelvic measurements between the naturally whelping bitches and bitches that had given birth solely by caesarean section listed in table 10 page 30, it is highly unlikely that the inaccuracy would change the results concerning the vertical diameters of the pelvis. If a similar study should be made in the future this measurement inaccuracy could be excluded by having highly experienced people in charge of the radiographic examination and to obtain the measurements on the radiographs. Furthermore, even though the majority of the dogs were very calm and easy to manipulate during the radiographic examination, a few of the dogs were nervous and restless which affected the quality of the pictures. Therefore, it may be an idea to use sedatives or anesthesia in future projects.

In this study it was chosen to correct for magnification of the measurements made on the pelves by means of the principle of similar triangles. By applying this method it was assumed that all bony landmarks of interest lay in the same horizontal plane, which was not the case on the ventrodorsal and on the laterolateral radiographs. Thus, this is a source of error. This source of error was the same for all measurements made in this study, but it creates a problem when comparing the results

of this study to results of other studies that may have corrected for magnification in other ways. The fact that the thickness of the dogs in laterolateral and in ventrodorsal projection was calculated as a mean value of eight dogs is another source of error. Instead the thickness of all the dogs should have been measured and the magnification value calculated for each individual.

Even though a considerable number of measurements made on the pelves and externally on the dogs were sorted out, this study still tested 25 hypothesis on the same dataset. The problem with testing multiple hypothesis on a set of data is that it increases the risk of rejecting the null-hypothesis *i.e.* the hypothesis that there is no difference, when it is in fact true. In other words there is a great risk of finding differences even though no difference exist. One way to address this issue is to apply the Bonferroni correction to the data set. Here the chosen p-value (in this case 0.05) is divided by the number of tested hypothesis.

0.05/25 = 0.002. This means that the null-hypothesis can only be rejected if the p-value is below 0.002 (Abdi 2007).

If we assume that all measurements made on the pelves are correct, the diameters CV ($p = 0.0006$), DV ($p=0.0008$) and the ratio between the vertical and horizontal diameter CV/DT (0.0002) are statistically different between bitches that has given birth solely by caesarean section and bitches that has given birth naturally even when the rather conservative Bonferroni correction is applied (Abdi 2007).

One of the problems with the Bonferroni correction is that it increases the risk of false negative results. In this case the height at the withers is no longer statistically different between the two groups of bitches ($p = 0.013$), which may be the case or it may be a false negative (Abdi 2007)

Uterine inertia

The British Kennel Club (KC) reports, that dystocia in Scottish Terriers is more often due to uterine inertia than physical blockage (KC and BSAVA 2013). Due to the focus of this study it was not investigated if uterine inertia could be a part of the explanation of the high frequency of dystocia in the population of Scottish Terriers in Denmark. However, when looking at the information about the reproduction history of the bitches obtained from the owners, there is a tendency that single puppy litters makes out a disproportionately large amount of the total number of litters. Since single puppies presumably gives rise to primary uterine inertia this could be a part of the explanation of the high dystocia frequency. Furthermore, a number of the bitches included in this study had given

birth to a number of puppies on their own, but were forced to undergo caesarean section because one or more foetuses still remained in the uterus. These bitches were placed in the group of naturally whelping bitches in this study since their pelves were big enough for a foetus to pass through. However, in the statistics these births are listed as births by caesarean section. It may be that these cases of dystocia were due to primary partial uterine inertia, though other causes such as foetal maldisposition cannot be excluded.

Future perspectives

This study and the study by Eneroth and others from 1999 suggest that pelves with a dorsoventrally compressed conformation can be considered one of the most important causes of dystocia in Scottish Terriers (Eneroth, Linde-Forsberg *et al.* 1999).

When looking at the results from this study and the study by Eneroth and others together with the fact that there is a degree of heritability in the shape of the pelvis in dogs, it would be obvious to suggest that bitches that had given birth by acute caesarean section should be excluded from breeding in order to prevent passing on unwanted alleles. However, several problems with this proposal are at stake. First of all, if unwanted alleles should be excluded, the litter of the bitches that had given birth by acute caesarean section should also be prohibited from giving birth. Second of all, one could fear that owners would go too far in trying to get a litter delivered naturally in order to get more litters from a highly awarded bitch. Third of all due to the high frequency of caesarean sections in the Scottish Terrier breed and the relatively low number of individuals in the population, only letting bitches that has given birth naturally give birth again would decrease the genetic pool considerably. This would mean a decrease of the genetic polymorphism and thereby higher rates of homozygosity, which may result in expression of deleterious recessive traits (Arendonk, Liinamo 2005). Finally if the only initiative to reduce the frequency of caesarean section would be to exclude bitches that had given birth by caesarean section from breeding, one would not take the influence of the pelvic measurements of the male dogs into consideration.

Another way to address the issue of dystocia be to increase the number of elective caesarean sections performed on Scottish Terriers in Denmark. This would increase the of number of caesarean sections performed but would decrease the number of prolonged and painful parturitions within the breed. Furthermore, caesarean section within the opening hour of the clinics are considerably cheaper than acute caesarean sections performed after hours (Kirchhoff 2014).

The main problem with increasing the number of elective caesarean sections is of ethical character. Is it okay produce a breed that is unable to give birth on its own? According to DKK the answer is no, since DKK has made ethical recommendations against breeding bitches that are unable to give birth on their own (DKK 2012).

A different way to handle the problem would be to initiate a breeding program with the focus on increasing the pelvic size and improving the pelvic proportions in the breed. Several challenges are

present when initiating and designing a breeding program. First of all, for a breeding program to have optimal effect it should be an international rather than a Danish initiative. This means that it may very well be a distant project and only be a reality if a large organization such as the FCI could be convinced of the severity of the problem. Second of all, it must be kept in mind that the size and shape of the pelvis may be correlated with diseases and undesired phenotypical traits.

Last, but not least, before a breeding program could be carried out more information about causes of dystocia in Scottish Terriers must be obtained. Both the study by Eneroth and others from 1999 and this study includes a very limited study population. To investigate further the causes of dystocia in the breed, the heritance of pelvic shape and to make specific cut off values for certain pelvic measurements an extensive radiographic project should be launched with a considerably larger study population lasting for a sizable period of time. This makes the improvement of the dystocia frequency in Scottish Terriers an even more distant project and would require a substantial amount of money.

Apart from pelvic size and conformation, it has been suggested that uterine inertia plays an important part in the high frequency of dystocia in Scottish Terriers (KC and BSAVA 2013). Furthermore, the reproduction history of the bitches included in this study implies that primary uterine inertia due to litters consisting of only one puppy and primary partial uterine inertia where a number of puppies are born but contraction stops may be a part of the explanation of the high dystocia frequency in the breed. These factors makes an investigation of the matter of uterine inertia as a cause of dystocia highly relevant.

Conclusion

The aim of this study was to investigate the reason for the high frequency of dystocia in the population of Scottish Terriers in Denmark with main focus on pelvic size and conformation.

It was found, that the vertical diameters of the pelvis were significantly shorter in Scottish Terrier bitches, that had given birth solely by caesarean section compared to naturally whelping bitches. No significant difference was found in the horizontal diameter of the pelvic canal between the two groups of bitches. This goes to show, that the pelves of the Scottish Terriers that underwent caesarean section were more dorsoventrally compressed than the pelves of the Scottish Terriers that were able to give birth naturally. Due to the significant differences found in vertical pelvic measurements between the two groups of bitches it seems reasonable to assume that one of the main reasons for dystocia in the Scottish Terrier breed is a dorsoventral flattening of the pelvis. However, the ratio between the vertical and horizontal diameter of the pelvic inlet in general in both male and female Scottish Terriers was close to one which suggests, that a dorsoventral compression of the pelvis is a problem in the entire breed and not just in cases of dystocia.

Apart from the pelvic dimensions, a correlation between height of the bitches at the withers and way of birth of the litters was found revealing, that the naturally whelping bitches in general were higher than bitches that had given birth solely by caesarean section. Furthermore, it was found, that a correlation between height of the bitches and vertical diameters of the pelvis existed. This implies, that shorter bitches were more prone to dystocia due to shorter vertical diameters.

No statistically significant correlations were found between the way of birth of the litters and the mean size of the litters or the mean weight of the puppies which indicates, that litter size and puppy weight are not causes of dystocia in Scottish Terriers in Denmark

In conclusion, a dorsoventrally compressed pelvis is considered to be the main reason for the high dystocia rate in Scottish Terriers in Denmark. However, the impact of uterine inertia on the dystocia frequency in the breed should be investigated. In addition more investigations should be made in order to establish specific cut off values for pelvic diameters and reduce the problem of dystocia through breeding.

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Appendix A

Kære Skotteejer

Din race har et problem. Skottebestanden i Danmark og i resten af verden står over for en udfordring, som aldrig har været større end den er i dag. De har problemer med at føde naturligt.
En dansk opgørelse har vist, at kejsersnitsraten for Skotsk Terrier er helt op til 70 %, hvor gennemsnittet for hunde ligger på ca. 5 %. Der kan være forskellige årsager til at en tæve kan få problemer med at føde, eksempelvis et misdannet foster eller for store hvalpe.
En undersøgelse fra Sverige har imidlertid vist, at det for Skotsk Terrierens vedkomne med stor sandsynlighed skyldes, at tævens bækken er "fladtrykt". Hos andre hunderacer er fødselskanalen pæreformet dvs, at den lodrette akse er længere end den vandrette. Hos Skotsk Terrier er det omvendt, hvorfor fosteret kan få problemer med at passere.

Grundet den foruroligende høje procentdel af Skotte-tæverne, der får foretaget kejsersnit, har sundhedsudvalget i skottegruppen taget kontakt til fagdyrlæge Kathrine Thejll Kirchhoff, som har sendt forespørgslen videre. Da det haster med at få problematikken undersøgt, opstartes per 25/2-2014 et specialeprojekt, der har til formål at undersøge nærmere, hvorledes Skotsk Terrierens bækken er udformet, med henblik på udregne konkrete mål for det optimale forhold mellem størrelsen på tæven og dennes bækken.
Dette gøres i samarbejde med professor Sandra Kathrin Goericke-Pesch, der er vejleder på projektet samt dyrlæge Alison Wilson og dyrlæge Kathrine Thejll Kirchhoff. Alison og Kathrine står for opmåling og røntgenbilledtagning af hundene. Projektet planlægges, koordineres og skrives af mig, Karen Singers. Jeg er dyrlægestuderende ved Københavnsuniversitet med speciale i smådyr.

Når et studie som dette søsættes, er den vigtigste forudsætning for succes, at der er nok materiale at arbejde med. Jo flere data, der er samlet sammen, jo mere nøjagtige bliver resultaterne i sidste ende.

Derfor beder vi jer skotteejere om at støtte op om projektet og lade jeres hund indgå i studiet. Vi håber på at kunne bruge alle de data, vi med jeres hjælp får indsamlet, til at forudse risikoen for at en tæve får fødselsproblemer og dermed bliver nødsaget til at undergå kejsersnit. Vores mål er at vi i sidste ende skal få udviklet et værktøj til jer opdrættere, som kan hjælpe jer til udvælgelse af bestemte avlshanner og -tæver ud fra deres reproduktionshistorie og forholdet mellem hundens og dens bækkens størrelse.

Undersøgelserne udføres i perioden 10/3-14 til 10/6-14 og der kan bookes tid allerede i dag. Afhængig af, hvor du bor i landet og hvad der er nemmest for dig, kan du besøge en klinik enten i Hadsten eller i Ballerup.
Alt du skal gøre er at ringe til en af nedenstående klinikker og booke en tid, nummeret står under adresserne længere nede. Når du ringer beder vi dig meddele, at det drejer sig om skotte-projektet. Hvis du ønsker mere information inden du melder dig, er du velkommen til at kontakte mig (se nederst i brevet) eller en repræsentant for Skottegruppens sundhedsudvalg.
Bor du på sjælland kan du kontakte Julie Hasselby på telefon 4139 8543.
Bor du i jylland kan du kontakte Else Vigholt på telefon 4042 8994.

Adressen på klinikkerne er følgende:

Dyrlæge Kathrine Thejll Kirchhoff
Dyrlægegruppen Frijsenborg A/S
Søndergade 36
8370 Hadsten
Tlf. 86962300
post@frijsenborgvet.dk

Dyrlæge Alison Wilson
Dyrlægehuset i Ballerup
Centrumgaden 13
2750 Ballerup
Tlf. 44661800
dyrlaegehuset@gmail.com

Lidt mere information

Fødselsproblemer er et velfærdsmæssigt problem for tæven og bliver der ikke handlet hurtigt, kan det have alvorlige konsekvenser. Selv med den rette behandling medfører fødselsproblemer øget hvalpedødelighed og kan i værste fald være fatalt for tæven. Den eneste løsning er i langt de fleste tilfælde at foretage et kejsersnit, hvilket er stressfuldt for både hvalpe og tæve, og selv om dette udføres korrekt og med den rigtige behandling efterfølgende, kan det ikke undgås at indgrebet og den efterfølgende helingsperiode er forbundet med en vis grad af smerte og utilpashed.

Dyrlægerne, der har meldt sig til at tage billederne, er efter nogen forhandling kommet op med en rigtig god pris. Det kommer til at koste 1000 kr/hund inkl. Moms, men fordi Dansk Kennel Klub støtter op og har valgt at give en sum penge til projektet her der har til formål at forbedre sundheden for Skotsk Terrier i Danmark, gives der en rabat på 200 kr/hund, således at du som ejer kun skal betale 800 kr/hund.

Besøget på klinikken kommer til at forløbe på følgende måde: Der vil blive udleveret et spørgeskema angående hundens fødsels- og parringshistorie, som I som hundeejere bedes besvare efter bedste evne. Herefter bliver der taget mål af hunden, og til sidst vil der blive taget

røntgenbilleder af hundens bækken. For at sikre os de bedst mulige billeder og dermed et mere pålideligt resultat i sidste ende, vil hunden få noget beroligende medicin i forbindelse med røntgenbilledtagningen.
Dette kan gøre dem en smule trætte i en tid efter besøget, hvorefter hunden vil være helt sig selv igen.

Ud over data på tæver kunne det være interessant at få mål og røntgenbilleder fra avlshanner, idet der er en vis grad af arvelighed i bækkenstørrelse. Desuden ønsker vi data både fra tæver, der har fået hvalpe og fra tæver, der ikke har. Dette skyldes, at der skal oprettes en hoveddatabase med gennemsnitsmål for racen, hvorudfra afvigelser kan udregnes. De mål og billeder, der bliver taget af tæver, der endnu ikke har fået hvalpe, håber vi på sigt at kunne bruge til at klarlægge disses avlspotentiale. Det eneste krav til hundene er, at de opfylder følgende:

Tæverne, der skal undersøges, skal være i anøstus (dvs. minimum 90 dage efter sidste løbetid) eller minimum 60 dage efter fødsel. Hundene skal desuden være mindst 1½ år gamle og veje mindst 8 kg, hvis det er en tæve og mindst 8,5 kg hvis det er en hanhund.
Disse begrænsninger skyldes, at hundens bækken skal være fuldt udvokset og for at udelukke slappe bækkenligamenter som en fejlkilde.

Har I spørgsmål, er I velkomne til at kontakte en af dyrlægerne på ovenstående telefonnummer eller mail, eller I kan kontakte mig, Karens Singers, på mail: bqn899@alumni.ku.dk.

Med ønske om et godt samarbejde.

Med venlig hilsen

Professor Sandra Kathrin Goericke-Pesch, dyrlæge Alison Wilson, dyrlæge Kathrine Thejll Kirchhoff og Stud. Med. Vet. Karen Singers.

Appendix B

Nyt projekt skal undersøge årsager til fødselsproblemer

Karen Singers Johansen, dyrlægestuderende

En robust hund med kraftige knogler og korte ben, som i sin tid blev fremavlet til gravjagt på blandt andet grævling og ræv. Af sind som udgangspunkt reserveret, med en stor portion selvstændighed og stædighed, men har man først vundet dens kærlighed, har man en ven for livet. Det er selvfølgelig den skotske terrier – eller bare skotten - der her er tale om. Skotten er en relativt lille race i Danmark med 60 – 90 nye registreringer pr. år. Dog er den kendt af de fleste - ikke mindst på grund af pladsen i DKKs (og Nettos!) logo.[1,2]

Blandt opdrættere af Skotter har det længe været en kendt sag, at en relativt stor procentdel af fødslerne ender med et kejsersnit. Ud fra de tal, danske opdrættere selv har meldt ind til DKK, var procentdelen af skotsk terrier-kuld, der kom til verden ved kejsersnit, helt oppe på 70 % i 2013, hvor gennemsnittet for hunde formentlig ligger omkring 5 % [2]

Der kan være en lang række årsager til fødselsproblemer, og i langt de fleste tilfælde kan denne findes enten hos moderen (maternelle) eller hos hvalpene (føtale). En lille procentdel af fødselsproblemerne kan tilskrives fejlbehandling og fejlbedømmelse af situationen af dyrlægen og hundeejeren. Den hyppigste maternelle årsag til at en tæve ikke kan føde selv er vesvækkelse, hvor livmoderens sammentrækninger ikke er kraftige nok til at få hvalpene ud. Hvis problemet ligger hos hvalpene, er det som oftest, fordi en eller flere af hvalpene er for store, eller fordi de ligger forkert i fødselskanalen. I mange tilfælde er det ikke muligt at placere problemet udelukkende hos moderen eller hvalpene, fordi en kombination af flere problemer kan give fødselsbesvær. For eksempel kan det være svært at afgøre om fødselsbesvær hos en tæve skyldes et for snævert bækken eller for store hvalpe.[3]

Hos skotsk terrier har man imidlertid fundet ud af, at den høje procentdel af tæver med fødselsbesvær med stor sandsynlighed skyldes, at tævens bækken er mere "fladtrykt". Hos andre hunderacer er fødselskanalen pæreformet dvs, at den lodrette akse er længere end den vandrette. Hos skotsk terrier er det omvendt, og det kan betyde, at hvalpene kan få problemer med at passere. Dette er illustreret i figur 1.[4,5] Fødselsproblemerne er blevet drøftet i mange år på racemøderne og har givet anledning til megen spekulation og hovedpine blandt de danske Skotteopdrættere og i særdelshed blandt medlemmerne af skottegruppens Sundhedsudvalg (SUS). De tog derfor kontakt til dyrlæge Kathrine Kirchhoff fra Dyrlægegruppen Frijsenborg A/S, som er en af de få dyrlæger herhjemme, der næsten udelukkende beskæftiger sig med reproduktion hos familiedyr. Herfra tog tingene hurtigt fart, og i februar i år stod et hold klar til at undersøge omstændighederne bag den høje kejsersnitsfrekvens hos Skotsk Terrier. Udover Kathrine Kirchhoff er den nyansatte lektor i reproduktion på KU/SUND, Sandra Kathrin Goericke-Pesch samt dyrlæge Alison Wilson involveret. Jeg er som dyrlægestuderende blevet koblet på projektet i forbindelse med mit speciale, og det er fantastisk på denne måde at få lov til at medvirke til at kaste lys over en relevant problemstilling for de danske opdrættere. DKK har valgt

Figur 7: Billederne her er fra en svensk undersøgelse fra 1999. Billede A er fra en Skotsk Terrier tæve der har født naturligt, mens billede B er af en Skotsk Terrier tæve der har fået hvalpe ved kejsersnit. Med det blotte øje kan man se at fødselsåbningen hos tæven der ikke selv har kunnet føde er mere fladtrykt end fødselsåbningen på billede A[4].

at yde økonomisk støtte til projektet, og det er vi meget glade for, fordi det understreger vigtigheden i at få problematikken undersøgt.

Den praktiske del af projektet går ud på, at et antal skotteejere får taget mål og røntgenbilleder af deres hunde, enten hos Kathrine på Hadsten Dyreklinik eller hos Alison i Dyrlægehuset i Ballerup. Ejerne udfylder desuden et skema omkring hundens reproduktionshistorie (har hunden haft kuld tidligere, blev disse født naturligt eller ved kejsersnit osv.), som skal indgå som en væsentlig del af studiet. Det overordnede formål med projektet er at undersøge, om der er en direkte sammenhæng mellem fødselsbesvær og bækkenmål opmålt på røntgenbilleder af Skotsk Terriere i Danmark. Hvis en sådan sammenhæng kan findes, er målet at udvikle et værktøj til opdrætterne, så de kan udvælge deres avlshanner og -tæver på baggrund af en kombination af bækkendimensioner og eventuel tidligere reproduktionshistorie.

Studiet er godt i gang, de første 12 hunde er blevet målt, vejet og røntgenfotograferet på klinikkerne i Jylland og på Sjælland, og vi forventer mange flere tilmeldinger til projektet i løbet af de næste par måneder. Skottegruppens sundhedsudvalg lægger megen tid og arbejde i projektet, idet de står for kontakten til den enkelte skotteejer. Efter planen skal projektet være færdigt i starten af august, hvor vi forventer at stå med en masse ny viden omkring bækkendimensioner hos Skotsk Terrier i Danmark.

Vil du også være med?
* Alle skotteejere i Danmark har mulighed for at hjælpe racen og på sigt give en større procentdel af tæverne mulighed for at føde selv.
* Tæverne, der skal undersøges, skal være i anøstus (dvs. minimum 90 dage efter sidste løbetid) eller minimum 60 dage efter fødsel. De skal være minimum 1½ år gamle og veje mindst 8 kg, hvis det er en tæve og mindst 8,5 kg hvis det er en hanhund.
* Det koster 800 kroner per hund at deltage, pengene dækker røntgenfotograferingen.
* Er du interesseret i at deltage, så kontakt Karen Singers Johansen på bqn899@alumni.ku.dk

Kilder:

1. Hasselby J. Skotsk terrier. http://www.dansk-terrier-klub.dk/Default.asp?PageID=80&Lang=Dk. Accessed April 8, 2014.

2. Dansk kennel klub, reproduktionsstatistik, skotsk terrier, 2013.

3. Munnich A, Kuchenmeister U. Dystocia in numbers - evidence-based parameters for intervention in the dog: Causes for dystocia and treatment recommendations.

4. Eneroth A, Linde-Forsberg C, Uhlhorn M, Hall M. Radiographic pelvimetry for assessment of dystocia in bitches: A clinical study in two terrier breeds.

5. Jones E, Joshua JO. Some problems of partuition. In: *Reproductive clinical problems in the dog.*

Appendix C

Kære hundeejer,

Vi beder dig udfylde nedenstående spørgeark og stamtavle efter bedste evne. Er der spørgsmål du ikke har mulighed for at svare på, skriver du blot *ved ikke*.

Tak for hjælpen og tak for din tid.

Spørgeark til udlevering

Navn og telefonnummer og e-mail adresse på ejer……
……

Jeg har ikke noget imod at blive ringet op og få stillet yderligere spørgsmål angående min hunds avlshistorie (sæt kryds)*……

Navn på hund……

Hundens stambogsnummer……

Tæve eller hanhund.....

Hundens fødselsdato……

Sæt kryds på denne linje, hvis hunden ikke indgår i avl……

HVIS HUNDEN ER EN TÆVE, DER HAR FÅET HVALPE SKAL FØLGENDE UDFYLDES:

Tævens alder ved første kuld?.....

Har tæven fået foretaget kejsersnit?.....

Årsag til kejsersnit/kejsersnittene?.....

Hvis ja til ovenstående, hvad var navnet på dyrlægen der udførte kejsersnittet/kejsersnittene? (eller navnet på klinikken, hvorpå indgrebet blev udført) **.....

……

Medicinsk behandling af fødselsbesvær med efterfølgende kejsersnit? Hvilken form for behandling var der tale om? (Eks. oxytocin eller andet), og i forbindelse med hvilke kejsersnit.....
……

Medicinsk behandling af fødselsbesvær UDEN efterfølgende kejsersnit? Hvilken form for behandling var der tale om? (Eks. oxytocin eller andet)……
……

*Har du problemer med at udfylde nogle af felterne, er du meget velkommen til at sætte kryds i feltet, så guider jeg dig igennem udfyldningen over telefon. Du er altid velkommen til at ringe til mig på telefon 28935087, hvis du har spørgsmål.

**Det er naturligvis kun, hvis det er i orden med klinikken og den pågældende dyrlæge, at dette skal oplyses, men det kunne være en stor hjælp at have mulighed for at kontakte klinikken og få flere detaljer angående årsagen til kejsersnittet, idet vi i det pågældende projekt koncentrerer os om kejsersnit som følge af misforhold mellem størrelsen tæven og fosteret, og det ville derfor være en stor fejlkilde, hvis vi ikke får frasorteret kejsersnit som følge af misdannede fostre og fejlplacerede fostre.

Vejledning til stamtavle:

Vi har interesse i at vide så meget som muligt om din hunds avlshistorie. Derfor beder vi jer udfylde stamtavlen efter bedste evne. Det er klart at du med stor sandsynlighed ikke ligger inde med alle de informationer om din hunds forældre og bedsteforældre – er der er felt man ikke kan svare på, skriver man blot *ved ikke*.

I feltet "navn", skrives hundens fulde navn.

I feltet "Hvalpe i kuldet", skrives det antal hvalpe, der var i den pågældende hunds kuld, se eksempler nedenfor.

I feltet "Kejsersnit", skrives, om den pågældende hund er født ved kejsersnit, det kan besvares med enten *ja*, *nej* eller *ved ikke*. Hvis årsagen til kejsersnittet kendes, skrives dette i samme rubrik. Er der ikke plads i rubrikken, sættes en lille stjerne og der skrives under eller ud for rubrikken. Der kan eksempelvis skrives *foster lå forkert i fødelskanalen* eller *fødslen var gået i stå.*

Eksempel 1:

Din hunds farfar hedder Vaks den tredje. Han er født i et kuld med 5 hvalpe, som er kommet til verden ved kejsersnit.

Så skrives følgende i skemaet:

Farfar

Navn	Vaks den tredje
Hvalpe i kuldet	5
Kejsernit	ja

Eksempel 2:

Din hunds mor hedder Ingrid Black. Hun er født i et kuld med 5 hvalpe og de er født naturligt. Hundens mor har fået tre kuld. I første kuld fik hun 4 hvalpe, men du ved ikke, om de blev født ved kejsersnit eller ej. I andet kuld fik hun 3 hvalpe, der blev født ved kejsersnit. I tredje kuld fik hun 4 hvalpe, der blev født ved kejsersnit.

Så skrives følgende i skemaet:

Mor

Navn	Ingrid Black
Hvalpe i kuldet	5
Kejsernit	nej

	Antal hvalpe	Kejsersnit
Kuld 1	4	Ved ikke
Kuld 2	3	ja
Kuld 3	4	ja
Kuld 4	-	
Kuld 5	-	
Kuld 6	-	

Eksempel 3:

Din hanhund hedder Oskar Black. Han er selv født i et kuld med 5 hvalpe og kuldet kom til verden ved kejsersnit. Oskar er far til 2 kuld. Moderen til første kuld hedder Angelina Sophia og kuldet består af 5 hvalpe der blev født naturligt. Lige efter fødslen vejede hvalpene hhv. 120 g, 134 g, 184 g, 153 g. og 204 g. Moderen til det andet kuld hedder Molly Mini. Kuldet består af 2 levendefødte og 1 dødfødt hvalp (læg mærke til, at der så skrives 3 i feltet "antal hvalpe"), som blev født ved kejsersnit. Du ved ikke, hvad hvalpene vejede lige efter fødslen.

Så skrives følgende i skemaet:

Din hund

Navn	Oskar Black
Hvalpe i kuldet	5
Kejsernit	ja

	Antal hvalpe	Kejsersnit	Vægt på hvalpene	Mage
Kuld 1	5	nej	120,134,184,153,204	Angelina Sophia
Kuld 2	3	ja	-	Molly Mini
Kuld 3	-			
Kuld 4	-			
Kuld 5	-			
Kuld 6	-			

Hvis din hund har fået hvalpe, der selv har fået hvalpe, og ligger du inde med informationer om de pågældende kuld, er vi også meget interesserede i dem. Vi vil gerne vide, hvor mange kuld din hunds afkom hver især har fået, hvor mange hvalpe der var i hvert kuld om kuldene er født ved kejsersnit og vægten på hvalpene lige efter fødslen.

Drejer det sig om få hvalpe, bedes du lave et skema på et stykke blankt papir og udfylde det. Det kunne eksempelvis se således ud:

Eksempel 4:

Din hanhund Oskar Black er far til Trille Black. Hun har selv fået 3 kuld hvalpe, alle kuld er kommet til verden naturligt. I kuld et var der 4 hvalpe, som vejede hhv. 154, 132, 205 og 174 g.. I kuld to var der 5 hvalpe og i kuld tre var der 3 hvalpe. Du ved desværre ikke hvad hvalpene vejdede i de to sidste kuld.

Navn Trille Black

	Antal hvalpe	Kejsersnit	Vægt på hvalpene
Kuld 1	4	nej	154, 132, 205 og 174
Kuld 2	5	nej	-
Kuld 3	3	nej	-

Drejer det sig om mange kuld, og har du ikke noget imod at blive ringet op, beder vi dig sætte kryds i feltet "jeg har ikke noget imod at blive ringet op…." på første side.

Reproduktionsstamtavle

Farmor

Navn	
Hvalpe i kuldet	
Kejsernit	

Farfar

Navn	
Hvalpe i kuldet	
Kejsernit	

Mormor

Navn	
Hvalpe i kuldet	
Kejsernit	

Morfar

Navn	
Hvalpe i kuldet	
Kejsernit	

Far

Navn	
Hvalpe i kuldet	
Kejsernit	

Mor

Navn	
Hvalpe i kuldet	
Kejsernit	

	Antal hvalpe	Kejsersnit
Kuld 1		
Kuld 2		
Kuld 3		
Kuld 4		
Kuld 5		
Kuld 6		

Din hund

Navn	
Hvalpe i kuldet	
Kejsernit	

	Antal hvalpe	Kejsersnit	Vægt på hvalpene	Mage
Kuld 1				
Kuld 2				
Kuld 3				
Kuld 4				
Kuld 5				
Kuld 6				