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Hammond, G., Geary, M., Coleman, E., and Gunn Moore, D. (2011) *Radiographic measurements of the trachea in domestic short haired and Persian cats.* Journal of Feline Medicine and Surgery, 13 (12). pp. 881-884. ISSN 1098-612X

<http://eprints.gla.ac.uk/63667/>

Deposited on: 9th May 2012

Radiographic Measurements of the Trachea in Domestic Short Haired and Persian Cats

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48 **Radiographic Measurements of the Trachea in Domestic Short Haired and**
49 **Persian Cats**

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61 Dublin, Ireland.

62 **Abstract**

63 Tracheal diameter can be assessed from a thoracic radiograph, with assessment
64 of tracheal diameter in dogs based on ratios between tracheal diameter and a
65 skeletal measurement – however reference ranges are not available for the cat.
66 Tracheal narrowing may cause significant clinical problems, although tracheal
67 hypoplasia in dogs may be clinically silent, and is rarely reported in cats (both
68 mesati- and brachycephalic). The tracheal diameter and trachea:thoracic inlet
69 and trachea:rib ratios were calculated for populations of Domestic Short Haired
70 (DSH) (n=68) and Persian (n=40) cats. This gave reference ranges for
71 radiographic tracheal measurements in these breeds. It is proposed that the
72 tracheal diameter in a normal DSH cat should be 18% of the diameter of the
73 thoracic inlet, and compared to 20% in Persian cats.

74
75 **Introduction**

76
77 Tracheal hypoplasia is an underdevelopment of the trachea resulting in a
78 significantly narrowed tracheal diameter, which is commonly found in
79 brachycephalic dog breeds, most notably the English Bulldog and Boxer¹.
80 Changes that may be seen include close apposition or overlapping of the ends of
81 the tracheal cartilage rings and absence of the dorsal tracheal membrane.
82 Hypoplastic tracheas have a stable diameter that does not vary with the phase of
83 respiration¹. Tracheal hypoplasia may be regarded as a component of
84 brachycephalic syndrome (along with stenotic nares, everted laryngeal sacculles
85 and an elongated soft palate)². Although the condition may frequently be
86 clinically silent, the narrowing of the trachea may cause exacerbation of
87 cardiovascular or respiratory disease^{1,2}. Clinical presentations and conditions
88 associated with tracheal hypoplasia may include chronic coughing and recurrent
89 tracheitis¹.

90 In the cat dynamic tracheal collapse has been reported, both due to a
91 congenital malformation of the tracheal cartilages³ and as an acquired condition
92 associated with upper airway obstruction and neoplasms of the tracheal wall and

93 lumen^{3,4,5,6,7}. Acquired narrowing of the tracheal lumen may be seen following
94 trauma or associated with extraluminal compression or in association with
95 thickening of the wall of the trachea^{5,7}. However, tracheal hypoplasia has been
96 seldom reported in cats, where it has been reported in association with
97 mucopolysaccharoidosis⁸.

98 Diagnosis of tracheal narrowing (e.g. associated with collapse or
99 hypoplasia is most easily made through radiography. In dogs, the most
100 commonly used technique is to calculate the ratio between the diameter of the
101 trachea at the level of the thoracic inlet and the inner diameter of the thoracic
102 inlet⁹. In most dogs, this ratio will be greater than 0.2:1 – i.e. the tracheal
103 diameter will be at least 20% of the diameter of the thoracic inlet. In most
104 brachycephalic breeds, this ratio has been calculated as normal if it is greater
105 than 0.16:1, whilst in the English Bulldog, this measurement has been calculated
106 to be normal for the breed if greater than 11% of the diameter of the thoracic
107 inlet. Other ratios that have also been described for assessing tracheal diameter
108 in the dog include comparing the diameter of the mid-thoracic trachea to the
109 width of the 3rd rib, with normal ratios of trachea:3rd rib being reported as >2.0
110 and >3.0, with tracheal hypoplasia being defined as a ratio of less than 1.0¹⁰.
111 Although the diameter of the trachea can be assessed endoscopically, this
112 technique is potentially hazardous due to the risk of obstruction of the already
113 narrowed airway.

114 Radiographic assessment of the tracheal diameter and calculation of
115 ratios to skeletal structures has not been reported in either Domestic Short
116 Haired or Persian cats. This study establishes reference ranges for these ratios
117 in domestic short haired cats (DSH) and Persians, and investigates for
118 differences in these ratios between the two breeds.

119 120 **Materials and methods**

121
122 The radiographic archives at the Small Animal Hospitals of the Royal
123 (Dick) School of Veterinary Studies, University of Edinburgh and the Faculty of
124 Veterinary Medicine, University of Glasgow were searched for thoracic
125 radiographs of DSH and Persian cats and the associated medical records. For
126 inclusion in the study, the patients had to be at least one year old and to have no
127 history of respiratory or cardiovascular disease, and had to have right lateral
128 thoracic radiographs of good diagnostic quality, including the entire thorax and
129 thoracic inlet in the collimated area, with the neck in a neutral position (i.e. not
130 excessively hyperextended or flexed), with the forelimbs extended cranially and
131 not superimposed on the thoracic cavity and with no axial rotation of the thorax.
132 Cases with radiographic evidence of thoracic disease were excluded. In addition,
133 cases with an endotracheal tube extending beyond the mid-cervical vertebrae
134 were also excluded.

135 Once the films were collected, measurements (in millimetres) were taken
136 from the films as follows (Figure 1):

- 137 i) Tracheal diameter at the level of the thoracic inlet (TD_{inlet}) – Figure
138 1a

Tracheal Diameter in Persian Cats

- 139 ii) Thoracic inlet diameter, from the dorsocranial aspect of the
140 manubrium to the cranioventral aspect of the body of the 7th
141 cervical vertebra (TInlet) – Figure 1a
142 iii) Tracheal diameter at the level of the 2nd intercostal space
143 (TDintercostal) – Figure 1b
144 iv) Width of the proximal third of the 3rd rib (Rib) – Figure 1b.
145

146 The means were calculated for each group of measurements. Ratios were
147 calculated between:

- 148 i) TDinlet divided by TInlet (Measurement points from Figure 1a)
149 ii) TDintercostal divided by Rib (Measurement points from Figure 1b)
150

151 The mean measurements and ratios were compared between the populations
152 (DSH and Persians) using a two-tailed t-test.
153

154 Results

155
156 Radiographs from 68 DSH and 40 Persians were included in the study. The
157 majority had undergone thoracic radiography for either oncological staging or
158 investigation of systemic disease. Measurements were subjectively simple to
159 obtain using a standard ruler. The mean measurements are presented in table 1.
160 The mean ratios and p-values are presented in table 2.
161

162 There was no significant difference in the mean tracheal diameter at either the
163 thoracic inlet or intercostal space locations, nor in the width of the 3rd rib between
164 the two populations. However there was a significant difference in the
165 measurements of the thoracic inlet, with the Persian cat population showing a
166 significantly narrowed thoracic inlet compared to the DSH population. There was
167 a significant difference in both of the ratios calculated, with the Persian
168 population showing significantly greater Trachea:Thoracic Inlet and Trachea:3rd
169 Rib ratios than the DSH population.
170

171

172

173 Discussion

174

175 Given the potential significance of tracheal hypoplasia or other causes of
176 tracheal narrowing, coupled with the lack of reference ranges for normal
177 radiographic tracheal measurements in the cat, the authors felt it valuable to
178 establish reference ranges for the trachea in mesaticephalic (DSH) and
179 brachycephalic (Persian) cat breeds.

180 When comparing the absolute size of the trachea between the DSH and
181 Persian populations, there was no significant difference between the mean
182 tracheal diameters (Table 1). However, when the trachea:thoracic inlet are
183 compared, that of the Persian population are significantly greater than that of the
184 DSH population. This is believed to be due to a proportional dorsoventral

185 compression of the thoracic inlet of the Persian cat when compared to that of the
186 DSH (demonstrated by the significant difference in absolute measurements of the
187 thoracic inlet shown in Table 1). This anatomic conformational difference is likely
188 of no clinical significance, but results in the alteration in the trachea:thoracic ratio,
189 and should be considered when assessing other structures using the thoracic
190 skeletal structure as a comparison (e.g. the height of the cardiac silhouette) as
191 this apparent flattening could result in a misinterpretation of the structure or organ
192 in question. The authors propose that the trachea in a DSH should be
193 considered of normal diameter if it is 18% of the diameter of the thoracic inlet,
194 and that of the Persian cat should be considered normal if it is 20% of the
195 thoracic inlet.

196 The trachea:rib ratios demonstrated a similar (although less significant)
197 variation between the populations. Given the similarity in absolute size of the
198 tracheas, this is most suggestive of thicker ribs in the DSH population
199 demonstrated by the absolute measurements (although this was not statistically
200 significant). Although the weights and sizes of the patients included in the study
201 was not always available, subjectively there was no significant discrepancy in
202 body size between the two populations of adult cats (skeletally immature cats
203 were excluded from the study) and so this is not thought to be an influence on the
204 skeletal measurements. However, it was felt that the trachea:thoracic inlet ratio
205 was considerably easier to obtain, and it would be the authors' advice that the
206 trachea:thoracic ratio is used for assessing trachea diameter in preference to the
207 trachea:rib ratio.

208 In addition, given the fairly uniform nature of the body sizes in the study
209 population, it may be argued that a tracheal diameter of around 5.5mm is normal
210 for a cat (DSH or Persian) of average size, and this would forego the requirement
211 to calculate a ratio with a set skeletal measurement. However, it cannot be
212 guaranteed that the body sizes of the study population are typical of the
213 population as a whole, and in addition some cats will lie at the extremes of the
214 population range. It is therefore the authors' recommendation that the tracheal
215 diameter is assessed using a ratio with a skeletal measurement (such as those
216 described above) as this should minimise variations due to absolute body size.

217 Tracheal hypoplasia in the dog is frequently clinically silent, but as it can
218 significantly worsen the clinical effect of a respiratory disorder such as
219 pneumonia prior knowledge of its presence in a patient can be valuable¹.
220 Detection is most commonly through thoracic radiography, although computed
221 tomography or endoscopy may also be indicative of tracheal hypoplasia^{1,11}. On
222 the basis of the results of the study, it can be shown that there was no evidence
223 of clinically silent tracheal hypoplasia in the population of Persian cats studied. It
224 is possible that tracheal hypoplasia does exist in the Persian cat, but always
225 results in clinically significant respiratory disease (and as a result, such cases
226 would have been excluded from the population used in this study). However, this
227 is thought unlikely by the authors, considering the frequently silent nature of
228 tracheal hypoplasia in the dog. This would suggest that the brachycephalic
229 anatomic changes seen in Persian cats are restricted to the skull and upper
230 respiratory tract, such as the nasopharyngeal turbinates reported to be seen in

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231 about 20% of brachycephalic cats¹¹. There is the question of whether the study
232 population of Persian cats was truly representative of the population as a whole –
233 unfortunately, in part due to this being a retrospective study, the possibility of a
234 skewed population cannot be excluded. However, the authors feel that the wide
235 range of presentations, and the inclusion of cases from two different referral
236 hospitals reduces this possibility.

237 In conclusion, this study establishes reference ranges for the assessment
238 of tracheal diameter in Persian and Domestic Short Hair Cats: for DSH cats with
239 no evidence of cardiorespiratory disease, the tracheal diameter should be 18% of
240 the internal diameter of the thoracic inlet, and this measurement should increase
241 to 20% in normal Persian cats.

242

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284

285

286 **Figure Legend:**

287

288 **Figure 1a: Lateral feline thoracic radiograph showing measurement points**
289 **for Trachea:Thoracic Inlet Ratio: * = Level to measure tracheal diameter**
290 **(mm) at thoracic inlet (TDInlet); ◀...▶ = Thoracic inlet diameter (mm)**
291 **(TInlet).**

292

293 **Figure 1b: Lateral feline thoracic radiograph showing measurement points**
294 **for Trachea:3rd Rib Ratio: * = Point to measure tracheal diameter (mm) in 2nd**
295 **intercostal space (TDIntercostal); ▶◀ = Point to measure width of proximal**
296 **1/3 of 3rd rib (mm) (between arrow heads) (Rib).**

297

298

299 **Table Legends:**

300

301 Table 1: Mean measurements and p-values for DSH and Persian study
302 populations

303

304 Table 2: Mean Ratios and p values for DSH and Persian study populations.

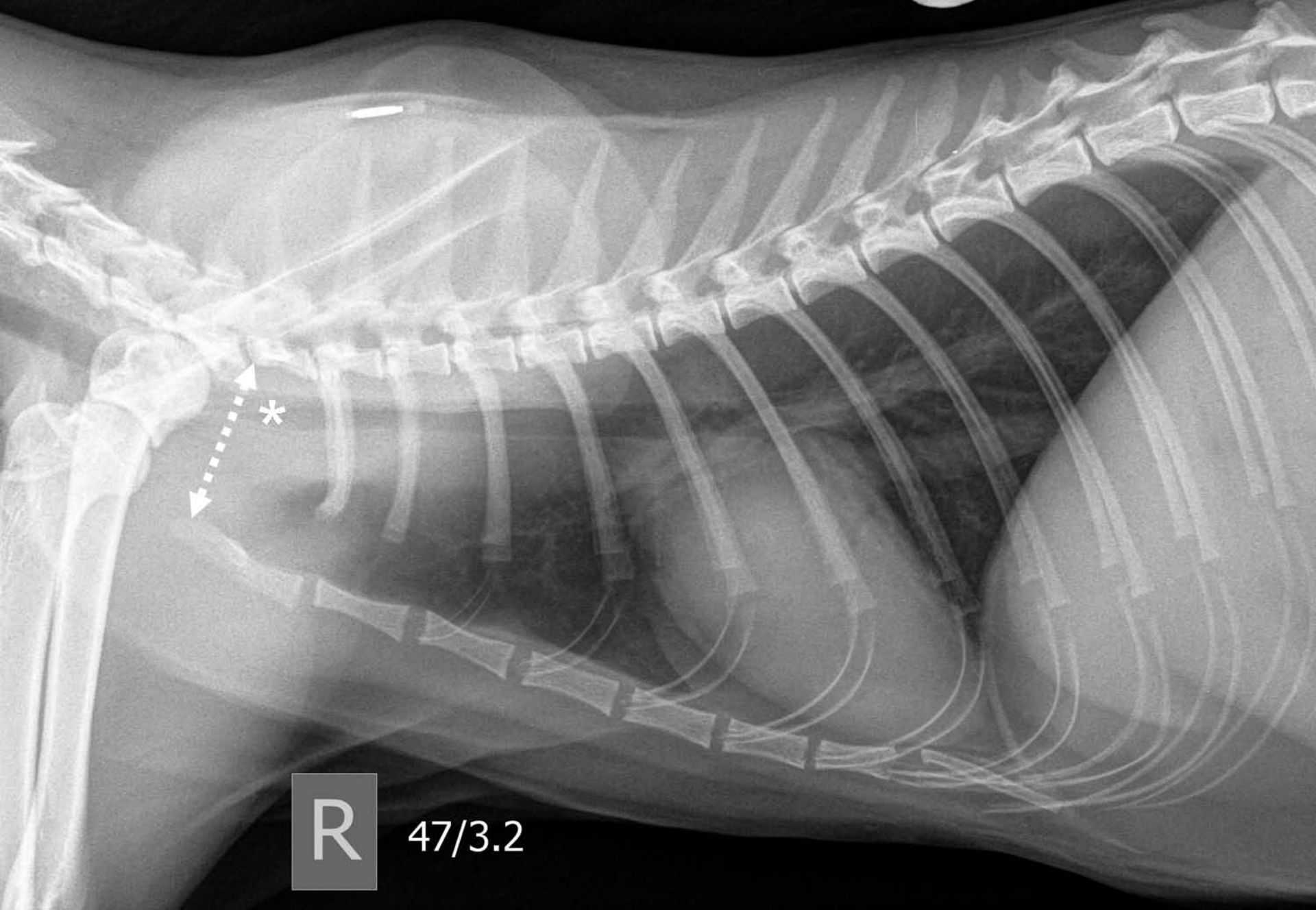
305

	Mean Measurements		P value
	DSH	Persian	
Trachea - Thoracic Inlet	5.4mm	5.6mm	0.37
Trachea - Mid-Thoracic	5.4mm	5.6mm	0.42
Thoracic Inlet	32.5mm	28.7mm	<0.005
Proximal 3rd Rib	3.5mm	3.3mm	0.05

Table 1: Mean measurements and p-values for DSH and Persian study populations

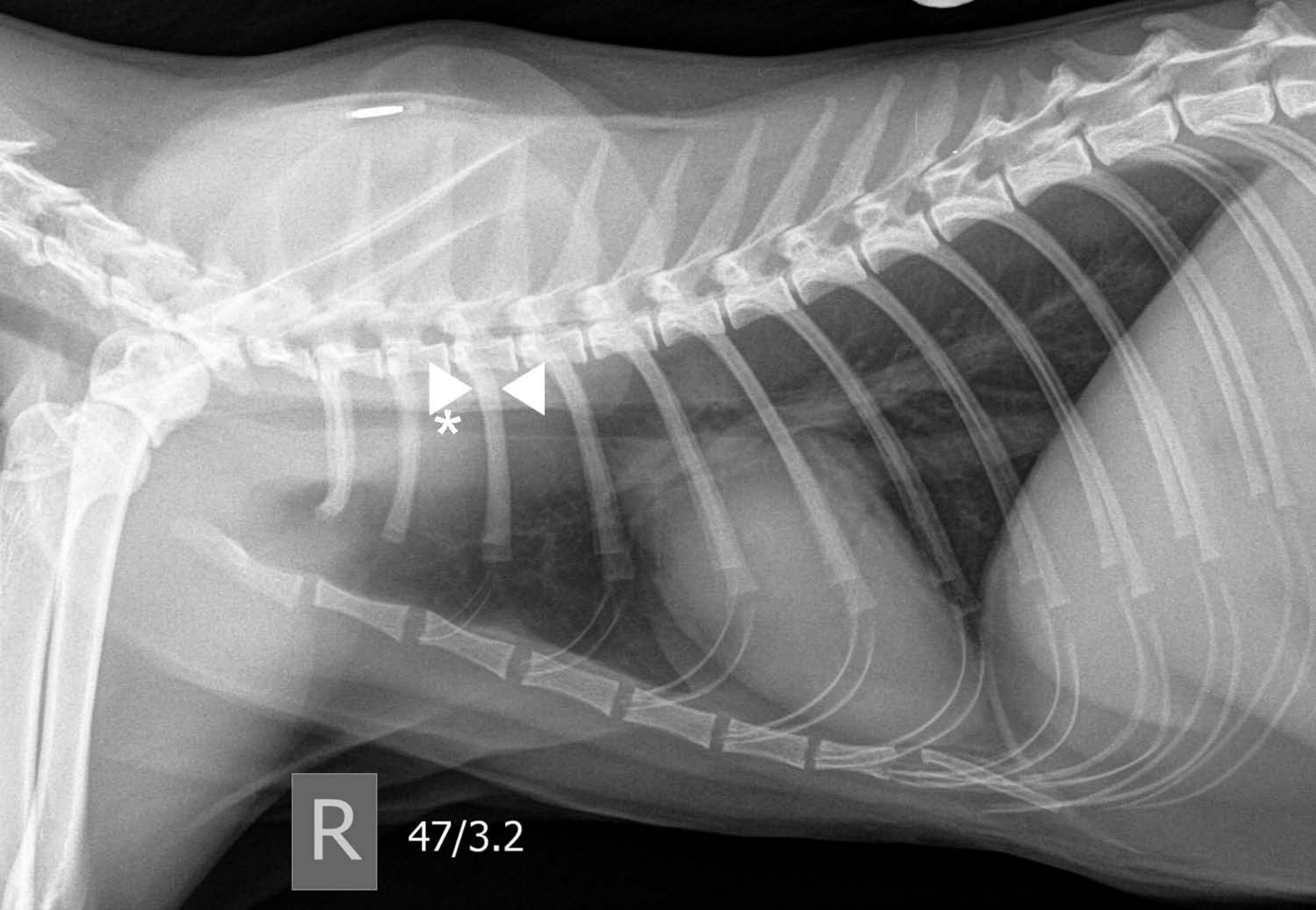
	Mean Ratios		P value
	DSH	Persian	
Trachea:Thoracic Inlet	0.18 (Range 0.13-0.23)	0.20 (Range 0.13-0.28)	<0.005
Trachea:3rd Rib	1.59 (Range 1.20-2.33)	1.71 (Range 1.25-2.33)	<0.05

Table 2: Mean Ratios and p values for DSH and Persian study populations.



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47/3.2



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47/3.2