Quantitative Anatomy of the Trachea of the Giraffe (*Giraffa camelopardalis rothschildi*)

Anatomía Cuantitativa de la Tráquea de la Jirafa (*Giraffa camelopardalis rothschildi*)

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SUMMARY: We described the macroscopic and quantitative anatomy of the trachea of the Giraffe (*Giraffa camelopardalis rothschildi*). The trachea of one juvenile male giraffe (25 months of age) weighing 754 kg was used in this study. The length of the neck was 125 cm. The trachea had 107 cm in length on its cervical part and 18 cm on its thoracic part. The total number of cartilage was 87.74 at the neck and 13 at the thorax. The general shape of the duct was mostly circular. The separation of the dorsal ends of the tracheal cartilages was pronounced in the first half of the cervical trachea, reducing caudally and overlapping in the thoracic trachea. In the caudal part the trachea had a tracheal bronchus for the cranial lobe of the right lung and the end of the trachea was divided into two main bronchi, where the left was larger in diameter.

KEY WORDS: Anatomy; Respiratory apparatus; Trachea; Wild animal; Quantitative study.

INTRODUCTION

The giraffe (*Giraffa camelopardalis*) is the largest extant ruminant (Owen-Smith 1988). Giraffes live in open woodland and wooded grassland areas in Africa south of the Sahara Desert.

To our knowledge the anatomy of the giraffe is scarcely studied in comparison with domestic animals and camelids. According to the textbook of Barone (1997) the trachea of the giraffe has more of 200 cartilages.

The trachea in the domestic mammals was studied quantitatively: in the dog (Dabanoglu *et al.*, 2001), in the horse (Freitas *et al.*, 2001), in the indian buffalo (Peshin & Prakash, 1975), and in camels (Kumar *et al.*, 1992). Harrison (1980) studied the biomechanics of the giraffe's larynx and trachea and reported for a male animal a total length of 2.3m for the trachea, with a maximum width of 51 mm, and a minimum width of 35 mm. He did not specify to which parts of the trachea these measurements belonged to. He stated that the trachea is oval in cross-section.

To our knowledge, quantitative studies of the trachea of the giraffe have not been published so far, and therefore,

we wanted to make the most of the opportunity of the one giraffe dissection to carry out this study.

MATERIAL AND METHOD

The trachea of one giraffe was used in this study. At a Zoological Garden of Uruguay, a juvenile male giraffe (25 months of age) weighing 754 kg died because of acute traumatic pericarditis. The animal was dissected at the Veterinary Faculty of the University of Montevideo. After removal of the trachea from the neck and thoracic cavity the trachea was studied and documented by digital photography (Nikon D200).

After dissection of all fasciae, the length of the trachea (from the cranial border of the first tracheal ring up to the bifurcation) was measured with a standard measuring tape and the tracheal rings counted. After fixation in formalin the inner transverse (IT), outer transverse (OT), inner vertical (IV) and outer vertical (OV) diameters were measured at the level of each tracheal ring with the aid of a calliper in

Cartilage	OV	IT	OV	OT	CCL1	CCL2	CCL3	CCL4	DS
Cervical part of the trachea									
1	36	37	40	43	24	11	12	15	12
2	37	37	44	44	17	14	14	14	20
3	38	37	45.5	45	15	18.5	15	17	19
4	39	36.5	46	44.5	11	15	14	13	19
5	37	36	44	43	8	12	13	13	16
6	36	34	43.5	42	12	11	15	16	14.5
7	35	34	43	42	16	18	19	19	13
8	36	34	43	41	17	20	19	21	14
9	33.5	33	40	39	14	16	17	15	11
10	33	31	41	40	15	15	15	15	11
11	34	31	41	39	8	15	13	12	10
12	33	33	41	40	12	16	17	16	11
13	33	33	40	40	12	15	16	16	10
14	33	32	39	40	12	14	16	17	11
15	32	33	40	41	8	14	14	15	11
16	32	34	39	41	12	17	16	19	10
17	33	33	40	40	13	15	19	17	13
18	33	32	40	39	11	14	16	14	9
19	33	31	39	39	13	13	15	15	10
20	33	32	39	39	12	17	16	18	11
21	33	32	40	38	12	17	16	15	7
22	33	32	40	38	11	16	17	15	9
23	32	32	39	39	11	13	12	15	8
24	32	33	39	40	6	12	12	12	11
25	33	32	39	38	9	11	12	10	7
26	32	33	39	40	11	16	12	11	7
27	33	32	40	39	17	18	19	22	11
28	33	33	40	39	11	14	16	16	9
29	33	33	39	40	12	15	15	14	10
30	34	32	40	38	9	13	14	11	7
31	34	32	40	39	12	14	14	14	8
32	34	32	41	38	7	9	15	15	15
33	34	32	40	39	11	14	14	14	10
34	35	30	40	38	9	15	13	15	7
35	33	33	41	39	13	16	17	15	8
36	34	33	40	39	11	15	16	16	6
37	34	32	41	38	13	16	16	16	6
38	35	32	39	39	12	17	17	17	5
39	34	32	40	40	15	15	14	16	8
40	35	32	40	39	7	14	15	12	7
41	34	33	39	40	11	13	14	12	7
42	34	33	40	40	8	14	13	14	9
43	33	33	40	39	12	15	15	16	7
44	34	33	40	39	9	13	12	15	8
45	34	32	41	40	14	16	16	15	5
46	34	32	40	39	10	17	16	19	7
47	35	32	41	39	13	17	13	16	7
48	35	32	43	39	15	19	20	20	7
49	36	31	42	39	10	17	15	15	6
50	34	32	41	41	14	18	14	17	9
51	34	33	41	40	11	16	18	20	6
52	34	34	40	40	15	15	15	16	6
53	34	32	41	40	14	16	15	18	6
54	35	33	42	40	10	16	12	13	4
55	33	34	39	41	12	18	20	19	4
56	33	33	39	41	12	15	15	15	5
57	32	33	39	39	11	13	14	15	4
58	31	34	37	40	11	14	14	16	4
59	33	33	39	40	8	15	12	16	7
60	32	32	40	40	15	13	16	14	3
61	34	32	42	40	11	14	13	14	1
62	34	31	45	38	13	16	13	17	3
63	35	28	45	35	15	15	17	18	7
64	35	28	45	34	13	18	14	17	2
65	36	29	43	35	11	12	16	12	2
66	36	29	44	36	13	11	10	10	1
67	35	28	43	35	12	16	14	7	1
68	35	29	45	35	9	18	19	12	0
69	36	29	41	35	22	18	19	21	2
70	35	29	40	34	13	17	15	18	0
71	36	30	40	35	19	14	13	17	2
72	34	30	40	35	10	13	13	14	3
73	34	30	40	35	10	14	14	16	3
74	33	30	40	36	15	15	17	15	0

similar form to the previous study of the trachea of the dog by Dabanoglu et al. Furthermore, the distance between the dorsal ends of each ring was measured dorsally (DS), as was the cranio-caudal length of each ring (CCL). CCL 1 was measured in the dorsal part of the rings, CCL 2 in the ventral part, CCL 3 in the left side and CCL 4 in the right side.

Terms are used in agreement with the Nomina Anatomica Veterinaria (2005)

RESULTS

The length of the neck was 125 cm. The trachea was 107 cm in length on its cervical part and 18 cm on its thoracic part. The total number of cartilages was 87.74 belonged to the cervical portion and 13 to the thoracic part.

Table I shows the measurements described in Material and Method section at the each tracheal ring. The figure 1 (Fig. 1) shows the tracheal ring diameters at all levels in the giraffe.

The general shape of the duct was mostly circular. The thickness of the cartilage rings (Fig. 2) was constant throughout the trachea. In several places the cartilages were fused. The separation of the dorsal ends of the tracheal cartilages was pronounced in the first half of the cervical trachea, decreasing caudally and overlapped in the thoracic trachea (Fig. 3).

On the right side, at the level of cartilage number 83 emerged a tracheal bronchus for the cranial lobe of the right lung (Fig. 3). The emergence of the tracheal bronchus was 7 cm from the end of the trachea. The diameter of

Table I. Diameters of each tracheal rings: inner transverse (IT), outer transverse (OT), inner vertical (IV) and outer vertical (OV). Distance between the dorsal ends of each ring (DS), and cranio-caudal length of each ring (CCL). CCL 1 was measured in the dorsal part of the rings, CCL 2 in the ventral part, CCL 3 in the left side and CCL 4 in the right side.

Thoracic part of the trachea									
75	35	30	42	36	11	15	15	16	2
76	32	30	40	35	13	16	18	17	1
77	30	30	39	36	14	15	15	14	0
78	32	31	39	36	12	14	14	17	1
79	34	29	40	35	14	18	20	18	1
80	35	30	40	36	14	17	15	14	0
81	36	33	42	36	17	17	24	21	0
82	35	35	45	40	15	16	15	15	0
83	37	31	49	41	15	24	15	14	0
84	34	26	47	33	12	14	14	9	0
85	33	26	46	36	14	11	25	17	0
86	32	29	45	37	9	10	5	11	0
87	34	28	41	34	13	10	7	9	0

the tracheal bronchus was 20 mm dorso-ventrally and measured 13 mm transversally.

The right main bronchus had a dorso-ventral diameter of 23 mm and 19 mm transversally. The left main bronchus had a dorso-ventral diameter of 31 mm and 23 mm transversally. The tracheal carina had a thickness of 8 mm.

Fig. 1. Tracheal ring diameters at all levels in the giraffe. IT: inner transverse; OT: Outer transverse; IV: Inner vertical and OV: Outer vertical.

Fig. 2. Caudal view of the first tracheal ring of the giraffe.

Fig. 3 Dorsal view of the thoracic part of the trachea of the giraffe. 1. Tracheal bronchus; 2. Right bronchus; 3. Left bronchus.

DISCUSSION

The total number of cartilages was less than was reported by Barone (1997) and strikingly low, as is the length of the thoracic part. Most of the trachea was in the neck. The bovine and equine trachea consists of 48-60 cartilages. However, the number of the tracheal cartilages is not constant in all species and varies even in animals of the same species. Occasionally, adjacent cartilages become partly or completely fused. This is seen most often in the pig and least often in the ruminants. The giraffe studied despite being ruminant had coalescence of several cartilages.

Equally variable is the cross sectional appearance of the trachea (Nickel *et al.*, 1979). In the horse, the internal diameters of the tracheal rings measured indicated a predominance of an elliptic shape of the trachea (Freitas *et al.*), unlike the circular shape of the giraffe studied. Notwithstanding Harrison indicated that the trachea had an oval section but we observed this only on a few parts of the duct.

The trachea of the ox displays marked differences in shape in live and in dead animals, due principally to changes in tension of the trachealis and the annular ligaments. In the live animal, the trachea is more or less oval, but after death it becomes compressed laterally. (Nickel *et al.*). Probably the same thing happens in the giraffe, but also our material was studied after fixation in formalin.

In the caudal part of the trachea of the horse, small overlapping cartilaginous plates form part of the dorsal wall where the ends of the tracheal cartilages do not meet. (Nickel *et al.*).

Because only one animal was studied, we can not know whether there are differences in the trachea between sexes. In male horses there is more cartilage than in mares (Freitas *et al.*).

The main limitation of our study was that we used one animal, but this work is a further contribution to the study of the anatomy of this animal, which must be continued with other works of the anatomy of the respiratory apparatus.

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RESUMEN: Describimos la anatomía macroscópica y cuantitativa de la tráquea de la jirafa (*Giraffa camelopardalis rothschildi*). La tráquea de una jirafa macho joven (25 meses de edad), con un peso 754 kg fue utilizada en este estudio. La longitud del cuello era de 125 cm. La tráquea tuvo 107 cm de longitud en su parte cervical y 18 cm en su parte torácica. El número total de cartílagos fue de 87,74 en el cuello y 13 en el tórax. La forma general de la vía fue principalmente circular. La separación de los extremos dorsales de los cartílagos traqueales se pronunció en la primera mitad de la tráquea cervical, reduciéndose caudalmente y superponiéndose en la tráquea torácica. En la parte caudal la tráquea tenía un bronquio traqueal para el lobo craneal del pulmón derecho y el final de la tráquea se dividió en dos bronquios principales, donde el izquierdo fue de mayor diámetro.

PALABRASCLAVE: Anatomía; Aparato respiratorio; Tráquea; Animal salvaje; Estudio cuantitativo.

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