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# **The remarkable vocal anatomy of the koala**

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***(Phascolarctos cinereus)***

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Supplemental Information

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8 **S-Tables**

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<b>S-Table 1. Koala specimens (<i>Phascolarctos cinereus</i>)</b>				
	<b>male 01</b>	<b>female 01</b>	<b>male 02</b>	<b>female 02</b>
<b>record number</b>	<b>A 44007</b>	<b>A 45147</b>	<b>A*</b>	<b>A52731</b>
<b>date of death</b>	25.10.2011	24.10.2011		11.02.2013
<b>body mass (kg)</b>	7.6	5.9		4.4
<b>body length (mm)</b>	750	680		700
<b>head length (mm)</b>	149	126		129
<b>neck length (mm)</b> (distance ear base : sternal manubrium, angled head position)	~ 140	~ 100		
<b>neck length (mm)</b> (distance ear base : sternal manubrium, head and neck extended)	~ 170	~ 115		

\* Unfortunately, the datasheet of male 02 was lost by the first author and could not be retrieved.

<b>S-Table 2. Cheek pouches in the koala (<i>Phascolarctos cinereus</i>)</b>		
	<b>male (n = 1)</b>	<b>female (n = 1)</b>
	Dimensions (mm)	
<b>rostrocaudal length</b>	~ 35	~ 28
<b>dorsoventral height</b>	~ 25	~ 20
<b>transverse width</b>	~ 20	~ 15

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**S-Table 3.** Soft palate dimensions (mm) in the koala (*Phascolarctos cinereus*)

	<b>male</b> (n = 1)	<b>female</b> (n = 1)
<b>resting length</b>	70	50
<b>extended length</b>	100	75
<b>dorsoventral thickness at the choanae</b>	20	15

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<b>S-Table 4.</b> Velar vocal fold dimensions (mm), resting and maximally extended, in koalas ( <i>Phascolarctos cinereus</i> )				
	<b>resting length</b>	<b>resting depth</b>	<b>resting width</b>	<b>extended length</b>
<b>female 01</b>	29	12	8	50
<b>female 02</b> (whole-body)	22	10	8.5	35
<b>female 03</b>	26	11	6.5	41
<b>female 04</b> (no data)				
<b>female 05</b>	27	10.5	7	45
<b>female 06</b>	26	12.5	8	39
<b>female 07</b>	29	12	8.5	49
<b>female 08</b>	29	12.5	7	48
<b>female 09</b>	25	12	8	45
<b>female 10</b>	23	13	7	40
<b>Mean</b>	26.2	11.7	7.6	43.6
<b>SD</b>	2.59	1.00	0.74	5.10
<b>male 01</b> (whole-body)	35	15	12	52
<b>male 02</b>	34	18	11	51
<b>male 03</b>	31.5	14.5	10	53
<b>male 04</b> (damaged)	30-35	12-16	10-12	45-50
<b>male 05</b>	31.5	18	11.5	50
<b>male 06</b>	35	13	12	53
<b>male 07</b>	36	15	8.5	56.5
<b>male 08</b>	31.5	16	12	53
<b>male 09</b>	31	12	9.5	58
<b>male 10</b> (incomplete)	27	13	9.5	36
<b>Mean</b>	32.5	14.9	10.7	51.4
<b>SD</b>	2.80	2.13	1.32	6.29

<b>S-Table 5. Hyoid ligaments in the koala (<i>Phascolarctos cinereus</i>)</b>			
	<b>male</b> (n = 1)	<b>female</b> (n = 1)	
<b>dorsal attachment</b>	skull base between auditory bulla and paracondylar process		
<b>remarks</b>	attachment supported by a small occipitohyoid muscle (S-Table 7)		
<b>ventral attachment</b>	lateral 'free' end of ceratohyoid		
<b>resting length (mm)</b>	~ 40	~ 30	
<b>maximally extended length (mm)</b>	~ 100	~ 60	
<b>extension (%)</b>	~ 150	~ 100	
<b>structure</b>	consists of several, fine, parallel-running sub-ligaments		

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<b>S-Table 6. Thyrohyoid membrane length (mm) in the koala (<i>Phascolarctos cinereus</i>)</b>		<b>male</b> (n = 1)	<b>female</b> (n = 1)
<b>rostrocaudal length, laterally</b> (resting length)		3-4	2-3
<b>rostrocaudal length, ventrally</b> (resting length)		10-11	6-7
<b>rostrocaudal length, laterally</b> (maximal extension)		~ 5	~ 4
<b>rostrocaudal length, ventrally</b> (maximal extension)		12-13	8-9

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**S-Table 7.** Origin, termination and supposed function of those ventral neck muscles involved in pronounced laryngeal mobility, pharyngeal length changes and adopting the calling posture in the koala (*Phascolarctos cinereus*). Muscles listed in the approximate order, in which they are encountered during dissection.

Muscle	Portion	Origin	Termination	Function	Resting length (mm)		Remarks
					male	female	
<b>M. parotidoauricularis</b>		not only base of the ear, but also zygomatic and buccal region	sternal manubrium!	pulls auricle ventrally; assists in pulling the head ventrally	150	120	covered by cutaneous muscle of the head; strongly converging caudally; laminar muscle rostrally but ribbon-like towards termination
<b>M. sternocephalicus</b>	M. sternomastoideus	sternal manubrium, ventral to the M. sternooccipitalis	caudal to the external acoustic meatus, mastoid process	raises the head, pulls the head to one side	120	90	strong, prominent muscle that covers omohyoid and sternohyoid muscles laterally
	M. sternooccipitalis	sternal manubrium, dorsal to the M. sternomastoideus	occipital region		130	100	weak muscle at the dorsal edge of the sternomastoid muscle
<b>M. cleidocephalicus</b>	M. cleidooccipitalis	lateroventrally from clavícula	occipital crest of skull, caudal to cartilaginous part of external acoustic meatus, close to base of paracondylar process	advances forelimb or extends head and neck	120	105	additional tendinous attachment on the connective tissue extending between retroarticular process and angular process of mandibula
	M. cleidocervicalis	laterally adjacent to cleidooccipitalis portion	skull base, caudal to paracondylar process		110	95	very small, laterally covered by cleidooccipitalis portion
<b>M. digastricus</b>		paracondylar process	medial and ventral surface of molar part of mandibula	contributes to forming a muscular channel, in which the larynx moves down and up; anchor for sternohyoid, omohyoid and hyoglossus muscles	total length 100      80 rostral belly 60      55 caudal belly 50      35 10 mm overlap		two bellies separated by oblique tendinous intersection, not by an intercalated tendon; connected with omohyoid and sternohyoid muscle by Y-shaped tendinous intersection!
<b>M. mylohyoideus</b>		ventromedian raphe in intermandibular space	medial surface of mandibula	pushes the tongue dorsally, keeps initial portions of geniohyoid and genioglossolaryngeus muscles between the rami of the mandibula	rostrocaudal 35      30 transverse 20      16		no attachment to hyoid apparatus! (does not reach the basihyoid caudally)
<b>M. geniohyoideus</b>		inner angle of incisive part of mandibula, lateral to genioglossolaryngeal muscle	basihyoid and lateroventral half of thyrohyoid	protracts ventral hyoid parts and larynx, relaxes pharynx	120 10-15	95 7-8	in the relaxed state, the entire long, ribbon-like muscle is laid in 3-4 larger loops and its fibres show a narrowly spaced reserve undulation; the geniohyoid muscle passes through the arcade of the hyoglossus muscle

<b>M. omohyoideus</b>		dorsocranial angle of scapula	not on basihyoid! but on Y-shaped tendinous intersection between digastric, sternohyoid and omohyoid muscles	contributes to forming a muscular channel, in which the larynx moves down and up	100	80	no attachment to hyoid apparatus!; at about half its length it has an additional attachment to the connective tissue ring around the large blood vessels to and from the thorax at the inner side of the first rib; this produces a sharp (tip-down) bend of the omohyoid muscle
<b>M. hyoglossus</b>	Pars rostralis	not from hyoid apparatus! contralateral muscle at ventromedian raphe	both portions: caudal quarter of tongue, medial to styloglossus muscle and lateral to genioglossolaryngeus muscle	guides geniohyoid muscle around the bend caused by Y-shaped tendinous intersection between digastric, omohyoid and sternohyoid muscles; pulls this tendinous intersection and the geniohyoid muscle dorsally towards the tongue or depresses the tongue	dorsoventral length		both portions are dorsally connected and form sort of an arcade through which the geniohyoid muscle passes; ventrally, the arcade is closed by the united left and right omo- and sternohyoid muscles (the Y-shaped tendinous intersection)
					rostrocaudal		
					25	15	
					15	12	
	Pars caudalis	common Y-shaped tendinous intersection between digastric, omohyoid and sternohyoid muscles, medially adjacent to caudal belly of digastric muscle					
<b>M. styloglossus</b>		skull base, medial to auditory bulla, lateral pharyngeal wall, rostral edge of hyoid ligament, dorsally, close to its attachment to skull base	lateral surface of tongue, lateral to hyoglossus muscle	retracts the tongue	up to lingual frenulum		very thin, weak muscle
					100	65	
					dorsoventral width at M4		
						10	
<b>M. genioglossolaryngeus</b>		inner angle of incisive part of mandibula, medial to the geniohyoid muscle	rostral fibres dorsally in the tongue	protrusion of tongue, protracts oropharynx and larynx	rostral portion		passes along dorsal surface of basihyoid without attaching to it; rostradorsal fibres to the tongue are less than half the length than ventrocaudal fibres to the larynx
					40		
			middle, caudally directed fibres on lateral wall of pharynx		100	80	
					maximally extended		
						135	
			ventral, caudally directed fibres on thyrohyoid, thyrohyoid membrane and rostral edge of thyroid cartilage				
<b>M. thyrohyoideus</b>		caudal horn and caudal edge of thyroid cartilage	caudal edge of basihyoid and lateroventrally on thyrohyoid, lateral to ventromedian line	pulls thyrohyoid caudally and larynx rostrally	25	15	short and weak muscle; origin contacts dorsal two thirds of the termination of sternothyroid muscle; termination caudally adjacent to termination of geniohyoid muscle
					dorsoventral width		
					12	8	



<b>M. sternohyoideus</b>		<u>male and female</u> : Y-shaped tendinous intersection between digastric, omohyoid and sternohyoid muscles; no attachment to hyoid apparatus!			145	110	no attachment to hyoid apparatus!; left and right sternohyoid muscles fused along c. 20 mm (male) and c. 30 mm (female) from termination; for the rest of their length separate but linked by a median connective tissue bridge; extrathoracically, it runs lateral to sternothyroid muscle but intrathoracically it runs ventral to this muscle and is covered by it; in the female, tendinous intersection 35 mm from termination
	<u>male</u> : manubrium, sternebra 1 and costal cartilages 2 + 3			contributes to forming a muscular channel, in which the larynx moves down and up;	max. dorsoventral width		
		<u>female</u> : sternebrae 1 + 2 and costal cartilages 2 + 3			15	12	
<b>M. sternothyroideus</b>			caudal edge of thyroid cartilage, contacting thyrohyoid muscle	retracts larynx towards the thoracic inlet, extends pharynx	115	90	left and right sternothyroid muscles fused along 50 mm from their origins up to a tendinous intersection; cranial portions not fused
	<u>male</u> : sternebra 2 and costal cartilages 3 + 4				max. dorsoventral width		
		<u>female</u> : sternebrae 2 + 3 and costal cartilages 3 + 4			18	15	
<b>M. occipitohyoideus</b>		base of paracondylar process	rostral and medial edge of dorsal part of hyoid ligament, close to its attachment to skull base	pulls dorsal end portion of hyoid ligament dorsally, towards the skull base	12	8	homology inferred from similar relative position within a complex system; tiny muscle, rostrally adjacent to dorsal end of hyoid ligament; its few fibres connect the dorsal end portion of the hyoid ligament to the base of the paracondylar process
<b>M. ceratohyoideus</b>		caudal edge of ceratohyoid	dorsorostral edge of thyrohyoid, dorsally adjacent to termination of geniohyoid muscle	pulls ceratohyoid and thyrohyoid towards each other	15	10	small, laminar muscle, spanning the trapezoid-shaped space between cerato- and thyrohyoid
					max. dorsoventral width		
					10	7	
<b>M. stylohyoideus<sup>1</sup></b>		dorsolateral pharyngeal wall, medial to attachment of hyoid ligament to skull base, perhaps partly from skull base	basi- and ceratohyoid, caudal to attachment of hyoid ligament	pulls cerato- and basihyoid dorsally	45	38	homology inferred from similar relative position within a complex system; shifted origin owing to lack of osseous hyoid suspension; weak muscle, covers two undulating nerves towards the rostral portion of the pharynx; closely connects to the caudal stylopharyngeal muscle caudally

<b>M. stylopharyngeus caudalis</b> <sup>2</sup>		paracondylar process medial to attachment of hyoid ligament to skull base, caudal edge of dorsal end of hyoid ligament	dorsal half of thyrohyoid, tip of thyrohyoid, rostral horn of thyroid cartilage	protracts the larynx and hyoid, relaxes pharynx	55	35	shifted origin owing to lack of osseous hyoid suspension; in the resting position, fibres arranged in an undulating pattern; fibres diverge towards termination; termination partly covered by ceratohyoid muscle; dorsally accompanied by two strongly undulating nerves towards the caudal pharyngeal constrictor muscles
<b>M. hyopharyngeus</b> <sup>3</sup>		caudodorsal edge of thyrohyoid, lateral to caudal stylopharyngeal muscle	dorsally on pharyngeal wall up to pharyngeal raphe	constricts pharynx, assists in protracting the hyoid	45	30	small, narrow muscle, covers caudal part of termination of caudal stylopharyngeal muscle, traversed by cranial laryngeal nerve; closely connects to the caudal stylopharyngeal muscle rostrally
<p><sup>1 2 3</sup> These three muscles are difficult to homologize with the corresponding muscles of placental mammals because an osseous suspension of the hyoid apparatus to the skull is lacking in the koala. MacAlister (1872) and Young (1882) realised this and combined them as the 'styloid group', 'consisting of a single sheet, the hinder fibres of which pass to the pharynx, the middle to the ceratohyal, under the stylohyoid ligament, and the anterior to the side of the tongue.' We suggest to unite these three muscles under the new name 'M. hyocephalicus'.</p>							
<b>Mm. constrictores pharyngis caudales</b>	M. thyropharyngeus	dorsal edge of thyroid cartilage including dorsal edge of its caudal horn	dorsally on pharyngeal wall up to pharyngeal raphe	constricts pharynx, protracts larynx	30	22	caudally adjacent to hyopharyngeal muscle
	M. cricopharyngeus	dorsocaudal edge of cricoid cartilage	dorsally on pharyngeal wall towards pharyngeal raphe	assists in pharynx constriction and larynx protraction	20	16	small narrow muscle, caudally adjacent and fused to thyropharyngeal muscle
thyropharyngeal and cricopharyngeal muscle are laterally flanking the vestibulum of the oesophagus							
<b>M. palatopharyngeus</b>		caudal edge of palatine bone	pharyngeal raphe	constricts pharynx, shortens soft palate	70	50	surrounds the intra-pharyngeal ostium on both sides

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<b>S-Table 8. Larynx size (mm) in koalas (<i>Phascolarctos cinereus</i>)</b>			
	<b>max. overall length (rostrocaudal)</b>	<b>max. overall width (transverse)</b>	<b>max. overall height (dorsoventral)</b>
<b>female 01</b>	26.8	23.2	17.1
<b>female 02</b> (whole-body)	25	22	18
<b>female 03</b>	23.2	19.5	15.7
<b>female 04</b>	24.4	22.3	16.9
<b>female 05</b>	24.7	21.9	17.1
<b>female 06</b>	23.7	20.3	15.9
<b>female 07</b>	28.7	26.6	16.3
<b>female 08</b> (no data)			
<b>female 09</b>	25.3	22.6	15.8
<b>female 10</b>	25.2	20	17.2
<b>Mean</b>	25.2	22.0	16.7
<b>SD</b>	1.66	2.13	0.78
<b>male 01</b> (whole-body)	30	25.8	20.8
<b>male 02</b>	29.6	27.2	20.6
<b>male 03</b>	28.1	24	19.1
<b>male 04</b>	24.8	23.8	17.7
<b>male 05</b>	29.9	26.4	21.6
<b>male 06</b>	30.5	26.7	18.5
<b>male 07</b>	30	27.4	20
<b>male 08</b>	31	27.2	21.4
<b>male 09</b>	25	22.6	17.5
<b>male 10</b>	23.9	21.2	17.5
<b>Mean</b>	28.3	25.2	19.5
<b>SD</b>	2.68	2.19	1.62

<b>S-Table 9. Epiglottis dimensions (mm) in koalas (<i>Phascolarctos cinereus</i>)</b>			
		<b>rostrocaudal length</b>	<b>transverse width</b>
<b>female 01</b>		11.6	13.7
<b>female 02</b> (whole-body)		10.5	12.7
<b>female 03</b>		8.9	11.5
<b>female 04</b> (no data)		11	
<b>female 05</b>		9.7	11.4
<b>female 06</b>		10	10.9
<b>female 07</b>		9.3	13.5
<b>female 08</b> (no data)			
<b>female 09</b> (no data)			
<b>female 10</b>		9.4	12
<b>Mean</b>		10.1	12.2
<b>SD</b>		0.92	1.08
<b>male 01</b> (whole-body)		11.6	15.7
<b>male 02</b>		10.6	16.1
<b>male 03</b>		10.8	12.5
<b>male 04</b>		11.3	14.6
<b>male 05</b>		11.4	15.3
<b>male 06</b>		12	15.1
<b>male 07</b>		10.7	15.4
<b>male 08</b>		11.1	17.2
<b>male 09</b>		9.3	11.2
<b>male 10</b> (no data)			
<b>Mean</b>		11.0	14.8
<b>SD</b>		0.77	1.85

<b>S-Table 10.</b> Laryngeal vocal fold dimensions (mm), resting and maximally extended, in koalas ( <i>Phascolarctos cinereus</i> )				
	<b>resting length (dorsoventral)</b>	<b>resting length (rostrocaudal)</b>	<b>resting width (transverse)</b>	<b>extended length (dorsoventral)</b>
<b>female 01</b>	8.5	0.85	0.6	9.8
<b>female 02</b> (whole-body)	8.2	0.9	0.6	10.2
<b>female 03</b>	7.4	0.7	0.4	9.5
<b>female 04</b> (incomplete)	8.5	0.8		
<b>female 05</b>	8.7	0.9	0.5	10.3
<b>female 06</b>	7.7	0.7	0.6	9.2
<b>female 07</b>	8.3	0.7	0.4	10.1
<b>female 08</b> (no data)				
<b>female 09</b>	7	0.95	0.3	10
<b>female 10</b>	7.8	0.9	0.4	9.5
<b>Mean</b>	8.0	0.8	0.5	9.8
<b>SD</b>	0.57	0.10	0.12	0.39
<b>male 01</b> (whole-body)	10.6	1.1	0.85	12.7
<b>male 02</b>	10.7	1.05	0.8	12.2
<b>male 03</b>	10.4	0.9	0.8	12.6
<b>male 04</b>	8.5	0.8	0.8	10.6
<b>male 05</b>	10	1.2	0.9	12.2
<b>male 06</b>	10.1	0.9	0.75	12.2
<b>male 07</b>	10	0.8	0.95	12.3
<b>male 08</b>	10.5	1	1.2	12.4
<b>male 09</b>	9	1	0.7	10.3
<b>male 10</b>	8.3	0.9	0.6	10.5
<b>Mean</b>	9.8	1.0	0.8	11.8
<b>SD</b>	0.88	0.13	0.16	0.94

**S-Table 11.** Vocal tract lengths (mm) in the koala (*Phascolarctos cinereus*)

classical definition	male	female	new definition 1	male	new definition 2	male
(from nostrils and lips to laryngeal vocal folds)			(from nostrils and lips to tracheal bifurcation)		(from nostrils and lips to velar vocal folds)	
<b>nasal vocal tract length (resting length, head angled, pharynx intact)</b>	185-190	160-165				
<b>nasal vocal tract length (maximal extension, head angled)</b>	230-240	185-190				
<b>nasal vocal tract length (maximal extension, head and neck extended)</b>	255-260		<b>nasal vocal tract length (maximal extension, head and neck extended)</b>	~ 295	<b>nasal vocal tract length (maximal extension, head and neck extended)</b>	~ 220
<b>oral vocal tract length (resting length, head angled, pharynx intact)</b>	150-155	120-125				
<b>oral vocal tract length (maximal extension, head and neck extended, cerato-/basihyoid close to thoracic inlet)</b>	210-220		<b>oral vocal tract length (maximal extension, head and neck extended, cerato-/basihyoid close to thoracic inlet)</b>	~ 270	<b>oral vocal tract length (maximal extension, head and neck extended, cerato-/basihyoid close to thoracic inlet)</b>	~ 190
<b>oral vocal tract length (resting length, head angled, pharynx opened)</b>	160-170	140-145				
<b>oral vocal tract length (resting length, head angled, pharynx opened)</b>	210-220					
<b>oral vocal tract length (resting length, head and neck extended, pharynx opened)</b>	230-240					

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## ***Supplemental Abbreviations***

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Ang. or. = mouth angle

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Basih. = basihyoid

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Burs. bucc. = cheek pouch

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Cart. aryt. = arytenoid cartilage

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Cart. cric. = cricoid cartilage

56

Cart. proaryt. = proarytenoid cartilage

57

Cart. thy. = thyroid cartilage

58

Cart. trach. IV = 4<sup>th</sup> tracheal cartilage

59

Ceratoh. = ceratohyoid

60

Corn. caud. = caudal horn of thyroid cartilage

61

Corn. rostr. = rostral horn of thyroid cartilage

62

Cost. I = 1<sup>st</sup> rib

63

Gll. subling. = sublingual salivary glands

64

I<sub>low</sub> = lower incisor

65

Lab. sup. or. = upper lip

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Lig. hyo. = hyoid ligament

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Ling. = tongue

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Mand. = mandible, lower jaw (dentary)

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Man. sterni = sternal manubrium

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Muc. bucc = buccal mucosa

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72	M. digastr.	=	digastric muscle
73	M. geniogllar.	=	genioglossolaryngeal muscle
74	M. genioh.	=	geniohyoid muscle
75	M. hyoceph.	=	hyocephalic muscle
76	M. hyogl.	=	hyoglossus muscle
77	M. hyophar.	=	hyopharyngeus muscle
78	M. myloh.	=	mylohyoid muscle
79	M. omoh.	=	omohyoid muscle
80	M. sternoh.	=	sternohyoid muscle
81	M. sternthyr.	=	sternothyroid muscle
82	M. stylogl.	=	styloglossus muscle
83	M. thyroh.	=	thyrohyoid muscle
84	N. hypogl.	=	hypoglossal nerve
85	Oesoph.	=	oesophagus
86	Proc. parac.	=	paracondylar process
87	Thyroh.	=	thyrohyoid
88	Trach.	=	trachea
89	T3	=	3 <sup>rd</sup> thoracic vertebra

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91 **S-Figure Legends**

92 **S - Fig. 1:** Left cheek pouch in an adult female koala: stuffed with paper to show maximal dimensions  
93 in a lateral view (A); excised, opening to the empty cheek pouch from the oral cavity, dorsocaudal  
94 to the mouth angle, medial view (B). Scale bar 10 mm

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96 **S - Fig. 2:** Pharynx inflation in a bellowing adult male koala, ventral view: resting state (A), inflated  
97 (expanded) state (B). The white arrows indicate the location of the pharyngeal inflation (single  
98 frames taken from S - Video 1)

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100 **S - Fig. 3:** A typical mammalian IPO in an adult male goitred gazelle (*Gazella subgutturosa*, Bovidae)  
101 (A) and the specialised IPO of an adult male koala (*Phascolarctos cinereus*) (B). In other mammals,  
102 the IPO is a simple oval opening in the soft palate (white ellipse in A) whereas in the koala the edges  
103 of this opening have specialised into the thickened VVFs (white ellipse in B). Ventral view, Scale  
104 bars 10 mm, respectively

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106 **S - Fig. 4:** The ventral hyoid parts of an adult male (A, B) and an adult female koala (C, D); A, C:  
107 ventral view; B, D: dorsal view. \* \* attachment sites of the hyoid ligaments; # # connections to the  
108 rostral horns of the thyroid cartilage.

109 Scale bars 10 mm, respectively

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111 **S - Fig. 5:** The geniohyoid muscle of an adult male (A, C) and adult female koala (B). This muscle  
112 has been evolutionarily elongated to accommodate the low larynx and hyoid position and the  
113 extensive movements of hyoid and larynx. As a consequence, in the resting position of the head,

114 the hyoid and the larynx, the geniohyoid muscle of koala is considerably curved. The geniohyoid  
115 muscle courses through a guiding arch, which is formed by the weak hyoglossus muscle; its two  
116 portions surround the geniohyoid muscle and keep it in place during movements of the head, the  
117 hyoid and the larynx. The two circles in A mark the cut lateral portion of the hyoglossus arch (The  
118 N. hypoglossus does not pass through this arch but courses lateral to the hyoglossus muscle.); the  
119 two asterisks mark the lateral retropharyngeal lymph nodes. The asterisk in B marks the tendinous  
120 intersection where the digastric muscle (removed) connects to the omo- and sternohyoid muscles  
121 (cf. Fig. 8). In (C) the hyoglossal guiding arch for the geniohyoid muscle is exposed. Scale bar 10  
122 mm

123

124 **S - Fig. 6:** CT-based 3D reconstruction of the ventral parts of the hyoid apparatus, laryngeal  
125 cartilages, and rostral end of the trachea of an adult male koala. Left lateral view. Single large  
126 asterisk: cartilaginous thyrohyoid connection; two small asterisks: cartilaginous longitudinal ventral  
127 fusion of thyroid and cricoid cartilage, typical for marsupials; cross: additional ossification centre of  
128 thyroid cartilage (A). Oblique left dorsolateral view to expose the proarytenoid cartilage (B).

129

130 **S - Fig. 7:** Double connective tissue gliding layer intercalated between the hypaxial neck  
131 musculature dorsally and the pharynx, larynx and oesophagus ventrally (2 arrows). This connective  
132 tissue sheet is very pronounced in the koala and facilitates movements of the ventral hyoid parts  
133 and the larynx down and up the ventral neck region. Here, the larynx has been pushed ventrally for  
134 better demonstration of the whitish gliding layer (asterisk). Scale bar 10 mm

135

136

137

138 **S-Videos**



Pharyngeal sac.wmv

139

140 **S – Video 1:** Repeated artificial inflation of the pharynx in an adult male koala during simulated  
141 inhalation. Airway tightly closed by plastic strap. Experimenter: BDC

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