

Historical control data on prenatal developmental toxicity studies in rabbits: Skeletal variations

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A Study Group for Historical Control Data on Prenatal Developmental Toxicity Studies in Rabbits

Historical control data for rabbits between 1994 and 2010 were collected, organized, and published in *Congenital Anomalies* 2012; 52 (3), 155-161 (DOI: 10.1111/j.1741-4520.2012.00365.x).

Data on skeletal variations of rabbit fetuses were obtained from 20 laboratories, including 11 pharmaceutical and chemical companies and 9 contract laboratories, in Japan. Data on skeletal variation were incorporated from all laboratories. The incidence of fetuses with skeletal variations was expressed as proportion of number of fetuses with skeletal variations to number of fetuses examined. The terminology used for skeletal variations was principally based on Horimoto *et al.* (1998) and Makris *et al.* (2009). Data on skeletal variations in Japanese White (JW) and New Zealand White (NZW) rabbit fetuses during 1994-2000 and during 2001-2010 is presented in Tables 1-4 as supplemental data.

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Table1a. Skeletal variations in Japanese White (JW) rabbits during 1994-2000

Laboratory #	10	12	20	8	17	3	15	6
Strain	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	JW-NIBS
No. of experiments	15	14	14	8	7	2	2	4
No. of dams	251	234	259	151	119	33	31	67
No. of dams/experiment (min-max)	12-20	6-20	17-20	17-22	14-20	16-17	13-18	15-19
Day of cesarean section	28	28	28	28	28	28	29	28
No. of fetuses examined	1937	1950	1997	1114	476	273	125	507
No. of fetuses with variations	761	623	658	356	190	8	63	34
Incidence (%)	39.29	31.95	32.95	31.96	39.92	2.93	50.4	6.71

Laboratory #: Refer to Congenital Anomalies DOI: 10.1111/j.1741-4520.2012.00365.x

Table1b. Skeletal variations in Japanese White (JW) rabbits during 1994-2000

Skull								
Basisphenoid	Incomplete ossification	4.0 (0-8.3) ¹⁷						
Hyoid	Incomplete ossification	5.0 (0-20.0) ¹⁷						
Interparietal	Incomplete ossification	0.4 (0-1.7) ¹⁷						
Sutural bone		1.3 (0-5.0) ¹⁷	2.96 (1.30-7.40) ⁶					
Thyrohyoid	Bent	0.8 (0-2.5) ¹⁷						
Cervical vertebra								
Arch	Split	0.03 (0-0.4) ¹⁰	0.09 (0-0.7) ²⁰					
Centrum	Misshapen (slightly)	0.05 (0-0.7) ²⁰	0.20 (0-0.80) ⁶					
	Split	0.04 (0-0.50) ¹²						
Thoracic vertebra								
Centrum	Bipartite	0.32 (0-1.3) ²⁰						
	Dumbbell ossification	5.92 (4.70-8.30) ⁶						
	Incomplete ossification	0.2 (0-1.4) ¹⁷						
	Slight deformity	0.05 (0.0-0.7) ²⁰						

	Split	0.20 (0-0.60) ⁶	0.28 (0-1.82) ¹²						
Lumbar vertebra									
Centrum	Split	0.18 (0-1.05) ¹²							
Caudal vertebra									
6 lumbar vertebrae		0.30 (0-2.38) ⁸	0.50 (0-1.1) ¹⁰						
8 lumbar vertebrae		0.70 (0-1.39) ¹⁵	0.98 (0-4.07) ¹²	2.37 (0-3.10) ⁶	8.75 (4.51-18.78) ⁸	8.37 (2.2-13.3) ¹⁰			
Centrum	Misaligned (slightly)	0.2 (0-1.5) ¹⁷	0.87 (0-4.4) ¹⁰						
	Split	0.11 (0-1.1) ¹⁰							
Lumbarization		0.11 (0-1.95) ¹²	0.74 (0-1.47) ¹⁵	0.85 (0-2.51) ⁸	5.2 (0-10.6) ¹⁷				
Sacralization		0.2 (0-1.7) ¹⁷	0.85 (0-2.51) ⁸						
Vertebra	Variation in number	0.24 (0.0-1.1) ²⁰	0.83 (0-4.07) ¹²						
Rib									
12th rib	Short	0.16 (0-1.23) ¹²							
12th rib	Reduced	0.27 (0-2.8) ¹⁰							
Cervical rib		0.25 (0-0.50) ³	0.79 (0-3.40) ⁶	0.84 (0-1.67) ¹⁵	1.25 (0-4.7) ¹⁰	1.52 (0.56-3.33) ⁸	1.7 (0-7.1) ¹⁷	2.13 (0-5.79) ¹²	3.44 (0-8.90) ²⁰
Lumbar rib	Extra/Rudimentary	3.55 (0.60-6.60) ⁶	24.2 (0-43.1) ²⁰	27.39 (0-45.23) ¹²	27.9 (17.4-42.5) ⁸	30.6 (27.2-33.9) ¹⁵	31.2 (15.9-46.0) ¹⁰	39.7 (37.0-42.4) ³	
Rib	Asymmetric	0.59 (0-1.80) ⁶							
	Incomplete ossification	0.2 (0-1.1) ¹⁷							
	Nodulated	0.2 (0-1.3) ¹⁷							
	Short	0.35 (0.0-0.7) ³							
Supernumerary rib	Full	1.20 (0-9.60) ²⁰	14.8 (5.7-22.7) ¹⁷						
	Short	3.94 (0-32.5) ²⁰	19.9 (15.2-26.7) ¹⁷						
Sternebra									
Manubrium	Supernumerary ossification site	0.18 (0-0.79) ⁸							
Sternebra	Asymmetric	0.17 (0-1.1) ¹⁰	0.22 (0-0.80) ²⁰	0.30 (0-1.80) ¹⁷	0.39 (0-1.80) ⁶	0.46 (0-2.01) ¹²	0.60 (0-1.20) ³		

	Dumbbell ossification	0.20 (0-1.40) ¹⁷							
	Misaligned	0.24 (0-0.78) ⁸							
	Misaligned (slightly)	0.71 (0-1.90) ²⁰							
	Rudimentary	4.81 (4.61-5.00) ¹⁵							
	Short	7.29 (2.35-12.2) ¹⁵							
	Split	0.08 (0-0.53) ¹²	0.19 (0-1.49) ⁸	0.51 (0-3.00) ²⁰	0.76 (0-2.60) ¹⁰	0.80 (0-1.60) ³	1.78 (0.5-3.20) ⁶		
	Unossified	8.07 (6.96-9.17) ¹⁵							
Sternum	Supernumerary ossification site (Accessory?)	0.09 (0-1.00) ¹²	0.39 (0-1.00) ⁶	0.69 (0-3.90) ²⁰	0.74 (0-1.47) ¹⁵	1.25 (0.70-1.80) ³	3.30 (0-10.0) ¹⁷	6.26 (0-20.3) ¹⁰	
Pelvic girdle									
Pubis	Incomplete ossification	0.30 (0-1.50) ¹⁷							
Scapular/Forelimb/Hindlimb									
Forelimb phalanx (Middle)	Rudimentary	0.74 (0-1.47) ¹⁵							
	Unossified	0.84 (0-1.67) ¹⁵							
Forelimb phalanx (Proximal)	Unossified	0.70 (0-1.39) ¹⁵							
Metacarpus	Rudimentary	1.81 (0.84-2.78) ¹⁵							
	Short	3.54 (2.35-4.72) ¹⁵							
	Unossified	1.81 (0.84-2.78) ¹⁵							
Scapula (Acromion)	Hyperplastic	1.60 (0-5.20) ¹⁷							

Superscript: Laboratory #. Values are given as mean (min-max).

Table 2a. Skeletal variations in Japanese White (JW) rabbits during 2001-2010

Laboratory #	16	7	12	8	10	3	15	20	2	15
Strain	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW	Kbl:JW
No. of experiments	27	25	25	13	10	8	5	5	1	1
No. of dams	461	476	415	325	191	144	79	93	21	18
No. of dams/experiment (min-max)	5-20	16-24	5-20	25-25	17-23	14-20	10-24	18-19	21	18
Day of cesarean section	28	29	28	28	28	28	28	28	29	29

No. of fetuses examined	3638	3746	3210	2262	1524	1142	593	718	144	162
No. of fetuses with variations	869	1136	771	653	444	285	214	178	39	97
Incidence (%)	23.89	30.33	24.02	28.87	29.13	24.96	36.09	24.79	27.08	59.88

Laboratory #: Refer to Congenital Anomalies DOI: 10.1111/j.1741-4520.2012.00365.x

Table 2b. Skeletal variations in Japanese White (JW) rabbits during 2001-2010

Skull										
Cranial	Extra ossification site	1.98 (0-12.30) ⁷								
Hyoid	Unossified	0.03 (0-0.70) ⁷								
	Single foramen hypoglossi	0.31 (0-1.9) ¹⁰								
Cervical vertebra										
Arch	Split	0.08 (0-0.8) ¹⁰								
Centrum	Split	0.15 (0-1.1) ¹⁰								
	Split (Bipartite ossification)	0.22 (0-1.1) ²⁰								
	Unilateral ossification	0.03 (0-0.60) ⁷								
	Incomplete ossification	0.14 (0-1.19) ⁸	0.31 (0-2.5) ³							
Thoracic vertebra										
Centrum	Bipartite ossification	0.10 (0-0.48) ⁸	0.13 (0-2.50) ⁷	0.22 (0-0.6) ²⁰						
	Dumbbell ossification	0.09 ± 0.22 ¹⁶	0.19 (0-1.55) ⁸							
	Split	0.13 (0-0.83) ¹²	0.13 ± 0.33 ¹⁶	0.16 (0-0.8) ³						
	Unilateral ossification	0.05 (0-1.20) ⁷								
Lumbar vertebra										
	6 lumbar vertebrae	0.22 (0-1.11) ¹⁵⁻²	0.26 (0-2.00) ⁸	0.34 (0-1.5) ¹⁰						
	8 lumbar vertebrae	2.09 (0-5.20) ¹⁵⁻²	2.68 ¹⁵⁻¹	2.69 ± 2.75 ¹⁶	5.07 (1.88-9.92) ⁸	5.07 (1.1-9.0) ¹⁰				
Centrum	Unilateral ossification	0.03 (0-0.70) ⁷								
	Lumbarization	0.51 (0-1.40) ⁷	0.98 (0-2.1) ²⁰	1.81 (0-4.00) ⁸	2.19 (1.11-2.98) ¹⁵⁻²	2.26 ¹⁵⁻¹				

Sacralization		0.03 (0-2.90) ⁷	0.22 (0-0.6) ²⁰	1.81 (0-4.00) ⁸						
Vertebra	Decreased	0.19 (0-1.60) ⁷								
	Supernumerary	1.76 (0-6.80) ¹²	3.68 (0-9.60) ⁷							
	Variation in number	3.9 ²	5.16 (2.3-8.4) ²⁰							
Sacral vertebra										
Centrum	Bipartite ossification	0.03 (0-0.60) ⁷								
Caudal vertebra										
Centrum	Bipartite ossification	0.03 (0-0.90) ⁷	0.07 (0-0.88) ⁸							
	Misaligned	0.05 (0-0.4) ³								
	Misaligned (slightly)	2.33 (0-4.4) ¹⁰								
	Split	0.03 ± 0.14 ¹⁶								
Vertebra										
	25 presacral vertebrae	0.09 (0-0.7) ³								
	27 presacral vertebrae	1.61 (0-10.5) ³								
Rib										
12th rib	Reduced	0.05 (0-0.5) ¹⁰								
	Short	0.15 ± 0.52 ¹⁶								
13th rib (Lumbar rib)		21.53 (9.50-42.70) ¹²	28.19 (18.7-34.8) ³							
	Extra / Rudimentary	17.75 (12.75-24.35) ¹⁵⁻²	25.39 (5.44-45.73)	41.02 ¹⁵⁻¹						
	Full	4.1 ²	6.22 (0-9.6) ²⁰	7.02 (1.3-11.6) ¹⁰	7.13 (3.00-14.10) ⁷	8.87 (1.80-19.74) ¹²	9.79 ± 5.19 ¹⁶			
	Full / Short	25.39 (5.44-45.73) ⁸								
	Short	15.43 (6.50-26.80) ⁷	15.73 (9.1-26.5) ¹⁰	16.09 ± 5.86 ¹⁶	16.63 (4.34-32.70) ¹²	17.26 (12.2-21.8) ²⁰	23.1 ²			
	Cervical rib	0.54 ± 0.74 ¹⁶	1.24 (0-3.90) ⁸	1.31 (0-4.0) ³	1.90 (0-3.4) ²⁰	1.94 (0-4.70) ¹²	1.97 ¹⁵⁻¹	2.21 (0-5.6) ¹⁰	2.70 (0-10.00) ¹⁵⁻²	4.14 (0-11.40) ⁷
Rib	Knobby	0.02 (0-0.30) ⁸	0.03 (0-0.90) ⁷	0.15 ± 0.30 ¹⁶						

	Nodulated	0.05 ± 0.21 ¹⁶										
Sternebra												
Manubrium	Supernumerary ossification site	0.12 (0-1.59) ⁸										
Sternebra	Accessory	0.06 (0-0.83) ¹²	0.38 (0-1.9) ²⁰	0.95 (0-5.5) ¹⁰	2.33 (0-6.5) ³	5.09 (2.54-7.86) ¹⁵⁻²						
	Asymmetric	0.08 (0-0.71) ¹²	0.23 ± 0.42 ¹⁶	0.26 (0-0.7) ²⁰	0.36 (0-1.16) ¹⁵⁻²	0.38 (0-2.1) ¹⁰	0.56 ¹⁵⁻¹	0.60 (0-2.6) ³				
	Asymmetric fusion	0.15 ± 0.43 ¹⁶										
	Bipartite ossification site	0.19 (0-1.39) ⁸	0.85 (0-2.70) ⁷									
	Misaligned	0.27 (0-2.60) ⁷	0.49 (0-1.41) ⁸									
	Misaligned (slightly)	0.48 (0-1.8) ²⁰										
	Rudimentary	1.57 (0-5.93) ¹⁵⁻²	2.59 ¹⁵⁻¹									
	Split	0.67 (0-1.69) ¹⁵⁻²	2.42 (0.6-6.0) ¹⁰	2.71 (0-6.3) ³								
	Supernumerary	0.91 (0-7.3) ⁸										
	Supernumerary ossification site	0.05 (0-0.90) ⁷	0.38 (0-1.9) ²⁰									
	Supernumerary (split)	1.21 (0-9.0) ³										
	Thready fusion	0.32 ± 0.45 ¹⁶	0.33 (0-10.82) ¹²	0.48 (0-1.8) ²⁰								
	Unossified	11.83 (0-16.47) ¹⁵⁻²	15.69 ¹⁵⁻¹									
Hindlimb												
Talus	Unossified	0.06 (0-0.5) ³										

Superscript: Laboratory #. Values are given as mean (min-max) or mean ±S.D.

Table 3a. Skeletal variations in New Zealand White (NZW) rabbits during 1994-2000

Laboratory #	3	14	2	13	12	18	19	1	9	11	1	6
Strain	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW
No. of experiments	31	28	17	15	10	10	9	7	7	7	2	1
No. of dams	511	319	216	170	216	88	109	122	132	142	33	4
No. of dams/experiment (min-max)	10-21	4-19	3-22	4-20	17-20	3-18	5-19	15-19	17-20	14-20	15-18	4
Day of cesarean section	28	28	29	29	28	28	28	29	28	29	29	29

No. of fetuses examined	3801	2669	1737	1368	1678	653	648	989	1059	1027	199	30
No. of fetuses with variations	92	2094	1283		1361		217	698	747	786	0	0
Incidence (%)	2.42	78.46	73.86		81.11		33.49	70.58	70.54	76.53	0	0

Laboratory #: Refer to Congenital Anomalies DOI: 10.1111/j.1741-4520.2012.00365.x

Table 3b. Skeletal variations in New Zealand White (NZW) rabbits during 1994-2000

Skull												
Hyoid	Bent	0.92 (0-4.2) ¹⁸										
	Incomplete ossification	3.22 (0-9.7) ¹⁸										
Thyrohyoid	Crooked	0.58 (0-3.30) ¹⁴										
Cervical vertebra												
6 cervical vertebrae		0.02 (0-0.60) ¹⁴										
Arch	Split	0.10 (0-0.69) ¹¹										
Articulation cervical rib and manubrium sterni		0.02 (0-0.50) ¹⁴										
Centrum	Split	0.21 (0-3.30) ³	0.29 (0-0.74) ¹¹									
Hemicentrum	Unossified	0.04 (0-1.20) ¹⁴										
Thoracic vertebra												
Arch	Bifurcated	0.05 (0-0.58) ¹²										
Centrum	Asymmetric	0.02 (0-0.60) ³										
	Split	0.03 (0-0.70) ¹⁴	0.05 (0.0-1.70) ³	0.07 (0-0.7) ¹³	0.09 (0-0.66) ⁹	0.10 (0-0.70) ¹	4.10 (0-10.4) ¹⁹					
Hemicentrum	Unossified	0.34 (0-7.10) ¹⁴	0.15 (0-0.80) ¹⁸									
Lumbar vertebra												
6 lumbar vertebrae		0.05 (0-0.70) ¹⁴	0.09 (0-0.60) ¹	0.19 (0-0.74) ¹¹	28.6 (0-50.0) ¹⁹							
7 lumbar vertebrae		0.95 (0-16.1) ²										
8 lumbar vertebrae		0.10 (0-0.70) ¹	0.10 (0-0.88) ¹¹	2.19 (0-22.0) ¹³	4.60 (0-11.8) ¹⁹	20.6 (0-42.8) ¹⁴						
Centrum	Split	0.02 (0-0.60) ¹⁴										

Lumbarization		0.07 (0-0.70) ¹³	4.50 (0-10.0) ¹⁹	4.73 (0-10.7) ¹⁴					
Sacralization		0.02 (0-0.60) ¹⁴	1.32 (0-4.90) ²	1.70 (0-4.50) ¹⁹					
Vertebra	Variation in number	0.10 (0-0.58) ¹²	0.87 (0-2.01) ⁹	11.7 (0-25.30) ¹⁹					
Presacral vertebra									
Vertebra	Decreased	0.15 (0-2.30) ¹³							
	Increased	18.7 (0-47.1) ¹³							
25 presacral vertebrae		0.46 (0-5.0) ¹⁸							
27 presacral vertebrae		3.22 (0-15.9) ¹⁸							
Sacral vertebra									
Hemicentrum	Unossified	1.07 (0-5.6) ¹⁸							
Caudal vertebra									
Arch	Bifurcated	0.04 (0-1.10) ¹⁴							
Centrum	Misaligned (slightly)	0.20 (0-2.50) ¹⁴							
Vertebrae	Misaligned	0.11 (0-1.21) ¹²							
Rib									
12th rib	Short	0.06 (0 -0.60) ²							
13th rib	Short	0.39 (0-6.70) ²							
Cervical rib		0.06 (0-1.00) ²	0.07 (0-1.20) ¹³	0.31 (0-2.60) ³	0.39 (0-1.34) ⁹	0.66 (0-2.48) ¹²	0.85 (0-5.40) ¹⁴	1.17 (0-4.29) ¹¹	1.41 (0-5.10) ¹
Costal cartilage	Intercostal	4.35 (0-16.9) ¹⁴							
Lumbar rib	Extra	53.4 (40.2-80.6) ¹⁴	55.6 (44.2-63.9) ⁹						
	Extra / Rudimentary	43.3 (0-63.8) ¹⁹	69.8 (0-90.2) ³	71.4 (38.9-95.0) ¹⁸	71.8 (0-93.2) ¹³	73.29 (68.83-76.68) ¹²	74.3 (57.1-91.1) ²	74.4 (52.1-94.4) ¹⁴	75.5 (64.6-84.1) ¹¹
	Rudimentary	13.4 (10.9-18.6) ⁹	14.6 (6.90-25.1) ¹⁴						
Rib	Asymmetric	0.10 (0-0.70) ¹							
	Nodulated	0.04 (0-1.10) ¹⁴							
	Short	0.09 (0-0.65) ⁹	0.10 (0-0.74) ¹¹	6.80 (0-12.1) ¹⁹					

Supernumerary rib	Full	0.05 (0-1.30) ¹⁴	17.8 (14.2-20.5) ¹												
	Short	51.0 (35.1-66.2) ¹													
Sternebra															
Manubrium	Supernumerary ossification site	0.10 (0-2.40) ¹⁴													
Sternebra	Asymmetric	0.10 (0-0.69) ¹¹	0.15 (0-0.8) ¹⁸	0.21 (0-2.00) ¹⁴	0.46 (0-1.92) ⁹	0.49 (0-2.29) ¹²	0.55 (0-3.90) ³	0.72 (0-5.30) ²	0.88 (0-3.7) ¹³						
	Bifurcated	0.07 (0-0.70) ¹³													
	Dumbbell ossification	2.22 (0-3.90) ⁹	7.60 (0-13.20) ¹⁹												
	Fused	2.64 (0-12.0) ¹⁴													
	Fused (Junctura)	1.50 (0-5.30) ²													
	Fused (Junction)	1.09 (0-2.50) ¹													
	Fused (Peduncular?)	0.12 (0-1.32) ¹²													
	Split	0.14 (0-0.51) ¹²	0.20 (0-0.80) ¹	0.74 (0-4.70) ¹⁴	0.77 (0-3.6) ¹⁸	1.12 (0-3.50) ³	1.17 (0-3.09) ¹¹	2.12 (0-5.00) ¹³	2.40 (0-5.60) ¹⁹						
Sternum	Supernumerary ossification site (Accessory?)	0.15 (0-0.8) ¹⁸	0.19 (0-0.88) ¹¹	0.20 (0-2.00) ³	0.22 (0-3.70) ¹³										
Xiphoid process	Bifurcated	0.10 (0-2.20) ¹⁴													
Pelvic girdle															
Pubis	Unossified	0.31 (0-0.9) ¹⁸													
Forelimb/ Hindlimb															
Forepaw middle phalanx	Unossified	0.15 (0-0.8) ¹⁸													
Hindpaw middle phalanx	Unossified	0.31 (0-0.9) ¹⁸													
Metacarpal	Unossified	1.38 (0-5.5) ¹⁸													
Talus	Unossified	0.46 (0-6.3) ¹⁸													

Superscript: Laboratory #. Values are given as mean (min-max).

Table 4a. Skeletal variations in New Zealand White (NZW) rabbits during 2001-2010

Laboratory #	16	3	11	7	14	10	4	6	12	2	18	1	9	19	5
Strain	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW	Kbl:NZW

No. of experiments	40	37	30	27	20	19	13	13	12	11	10	7	4	4	3
No. of dams	639	686	560	498	245	342	237	205	206	161	118	134	60	58	51
No. of dams/experiment (min-max)	5-22	9-22	13-20	15-25	4-19	14-21	16-19	5-19	5-20	4-22	3-23	18-20	5-20	4-20	16-18
Day of cesarean section	28	28	29	29	28	28	28	29	28	29	28	29	28	28	29
No. of fetuses examined	5033	5580	4093	4028	1964	2763	1962	1501	1661	1311	885	1096	474	414	366
No. of fetuses with variations	3564	306	2999	2818	1394	1971	1433	1031	1149	838	-	743	346	24	273
Incidence (%)	70.81	5.48	73.27	69.96	70.98	71.34	73.04	68.69	69.18	63.92	-	67.79	73	5.8	74.59

Laboratory #: Refer to Congenital Anomalies DOI: 10.1111/j.1741-4520.2012.00365.x

Table 4b. Skeletal variations in New Zealand White (NZW) rabbits during 2001-2010

Skull															
Cranium	Extra ossification site	0.50 (0-2.10) ⁷													
Hyoid	Incomplete ossification	1.61 (0-7.3) ^{18*}													
Thyrohyoid	Crooked	1.84 (0-11.40) ¹⁴													
	Single foramen hypoglossi	0.20 (0-3.8) ¹⁰													
	Sutural bone	0.47 (0-1.90) ⁶													
Cervial vertebra															
	6 cervical vertebrae	0.03 (0-0.50) ¹⁴													
Arch	Incomplete ossification	0.10 (0-0.70) ¹													
	Split	0.03 (0-0.50) ¹⁴	0.70 (0-2.8) ¹⁹												
Centrum	Incomplete ossification	0.02 (0-0.6) ³	0.08 (0-1.10) ⁴												
	Unilateral ossification	0.13 (0-2.80) ⁶	0.11 (0-0.8) ¹⁸												
	Unossified	0.06 (0-1.6) ³													
	Split	0.02 (0-0.6) ³													
	Split (Bipartite ossification)	0.06 (0-1.10) ¹⁴													
Thoracic vertebra															
Arch	Asymmetric	0.02 (0-0.9) ³													

	Incomplete ossification	0.06 (0-0.90) ⁶												
	Split	0.04 (0-1.4) ³												
	Supernumerary	0.05 ± 0.20 ¹⁶												
Centrum	Bipartite ossification	0.04 (0-0.50) ⁴	0.07 (0-0.90) ⁷	0.11 (0-0.7) ¹⁸										
	Deformed (slightly)	0.70 (0-2.8) ¹⁹												
	Dumbbell ossification	0.06 ± 0.32 ¹⁶	2.32 (0-6.60) ⁶											
	Hemicentric	0.15 (0-1.40) ⁶												
	Split	0.03 (0-0.6) ³	0.12 (0-0.82) ¹¹	1.25 (0-5) ¹⁹										
	Split (Bipertite ossification)	0.27 (0-1.90) ¹												
	Supernumerary	0.05 ± 0.20 ¹⁶												
	Unilateral ossification	0.02 (0-1.50) ⁷	0.23 (0-1.5) ¹⁸											
Hemicentrum	Unossified	0.20 (0-2.80) ⁶	0.10 (0-1.30) ¹⁴											
Lumbar vertebra														
Lumbar vertebra	Unilateral ossification	0.05 (0-0.70) ⁶												
6 lumbar vertebrae		0.06 (0-0.60) ¹⁴	0.19 (0-2.80) ⁶	0.20 (0-1.89) ¹¹	0.25 (0-2.4) ¹⁰									
8 lumbar vertebrae		0.09 (0-0.60) ¹	0.10 (0-1.03) ¹¹	8.90 ± 6.42 ¹⁶	11.86 (0-35.80) ⁶	15.87 (1.80-33.20) ¹⁴	21.58 (3.9-34.8) ¹⁰	23.50 (22.41-25.20) ⁵						
Centrum	Bipartite ossification	0.02 (0-0.80) ⁷												
	Hemicentric	0.05 (0-0.70) ⁶												
	Unilateral ossification	0.11 (0-0.8) ¹⁸												
Lumbarization		0.03 (0-0.40) ²	0.50 (0-2) ¹⁹	2.16 (0-8.00) ⁷	3.49 (0-6.70) ¹⁴	17.20 (10.60-26.30) ⁴								
Sacralization		0.05 (0-0.60) ⁷	0.20 (0-2.20) ²	0.25 (0-1.00) ⁴										
Vertebra	Decreased	0.17 (0-2.90) ⁷												
	Supernumerary	15.81 (0-29.38) ¹²	19.07 (5.30-30.30) ⁷											
	Variation in number	1.05 (0-3.01) ⁹	17.62 (6.10-29.20) ²											

Sacral vertebra														
Centrum	Bipartite ossification	0.11 (0-0.8) ¹⁸												
	Unilateral ossification	0.79 (0-3.7) ¹⁸												
Caudal vertebra														
Centrum	Deformed (slightly)	0.70 (0-2.8) ¹⁹												
	Misaligned	0.02 (0-0.6) ³												
	Misaligned (slightly)	0.03 (0-1.0) ³	0.20 (0-2.50) ¹⁴	0.68 (0-2.9) ¹⁰										
	Split	0.03 (0-0.6) ¹⁰												
Vertebra	Misaligned	0.03 (0-1.2) ³												
Vertebra														
25 presacral vertebrae		0.06 (0-0.8) ³	0.45 (0-1.1) ¹⁸											
27 presacral vertebrae		2.17 (0-25.8) ³	0.68 (0-7.1) ¹⁸											
Rib														
12th rib	Reduced	0.06 (0-1.2) ¹⁰												
	Short	0.27 (0-0.80) ²												
13th rib (Lumbar rib)	Extra	53.71 (0-81.00) ¹	54.91 (36.60-84.20) ¹⁴	56.14 (0-86.80) ⁶	59.49 (55.00-66.01) ⁹	63.11 (53.66-71.55) ⁵								
	Full	0.38 (0-1.70) ²	51.41 (35.50-67.78) ¹²	51.93 (30.9-70.3) ¹⁰	52.01 (36.10-70.90) ⁷	52.28 (42.40-63.90) ⁴	52.55 ± 9.18 ¹⁶	65.70 (41.67-86.11) ¹¹						
	Rudimentary	9.84 (6.03-11.81) ⁵	11.96 (0-21.10) ¹	12.78 (0-30.70) ¹⁴	12.87 (11.11-15.00) ⁹									
	Short	9.53 (0-35.07) ¹¹	19.63 (14.00-24.90) ⁴	23.71 (14.50-33.00) ⁷	26.18 ± 6.55 ¹⁶	26.81 (16.9-32.5) ¹⁰	27.48 (20.95-36.27) ¹²	64.30 (50.00-91.70) ²						
	Supernumerary	3.00 (0-6.20) ¹⁹	39.79 (0-81.6) ³	42.53 (40.90-86.70) ²	67.89 (49.07-84.44) ¹²	67.48 (46.30-86.20) ¹⁴	75.37 (68.6-100) ¹⁸							
Cervical rib		0.09 (0-1.5) ³	0.34 (0-0.8) ¹⁸	0.42 (0-3.80) ²	0.44 (0-2.6) ¹⁰	0.44 (0-3.07) ¹¹	0.56 ± 0.96 ¹⁶	0.69 (0-3.90) ⁶	1.03 (0-4.70) ¹⁴	1.09 (0-2.36) ⁵	1.11 (0-4.20) ¹	1.15 (0-3.80) ⁴	1.40 (0-1.50) ¹²	2.53 (0-8.80) ⁷
Costal cartilage	Discontinuous	0.87 (0-5.00) ⁶												
Costal cartilage (7th)	Non-articulated	2.40 (0-10.80) ¹⁴												
Extra true ribs		0.03 (0-0.50) ¹⁴												

Rib	Asymmetric	0.09 (0-0.60) ¹	0.24 (0-1.64) ¹¹										
	Knobby	0.12 (0-1.20) ⁷	0.26 ± 0.62 ¹⁶										
	Nodulated	0.04 (0-0.80) ¹⁴											
	Short	5.70 (0-10.4) ¹⁹											
	Wavy	0.06 ± 0.31 ¹⁶											
Sternebra													
Manubrium	Extra ossification site	0.05 (0-1.00) ¹⁴											
Sternebra	Accessory	0.04 (0-0.80) ¹⁴	0.06 (0-0.6) ¹⁰	0.09 (0-1.1) ³	0.21 (0-0.87) ⁹	0.39 (0-6.25) ¹¹	0.55 (0-1.57) ⁵	0.83 (0-5.00) ²	0.83 (0-8.60) ⁶				
	Asymmetric	0.04 (0-0.50) ²	0.09 (0-1.2) ³	0.11 (0-0.7) ¹⁸	0.21 (0-0.65) ⁹	0.22 (0-1.9) ¹⁰	0.28 (0-1.80) ⁶	0.35 ± 0.66 ¹⁶	0.38 (0-2.78) ¹²	0.47 (0-2.80) ¹⁴			
	Asymmetric fusion	0.08 ± 0.23 ¹⁶											
	Bipartite and asymmetric ossification	0.10 (0-1.40) ¹⁴											
	Dissymmetric	0.04 (0-1.3) ³											
	Extra ossification site	0.05 (0-1.50) ⁷											
	Fused (Junction)	1.15 (0-5.10) ¹⁴	1.49 (0-3.60) ¹										
	Misaligned	0.25 (0-2.30) ⁷											
	Split (bipartite ossification)	0.59 (0-2.00) ¹⁴	1.29 (0-5.00) ⁶	1.34 (0-6.19) ¹¹	1.48 (0.60-5.00) ⁹	1.66 (0-4.8) ³	1.98 (0-5.0) ¹⁰	2.18 (0-4.80) ⁷	2.37 (0-7.4) ¹⁸				
	Supernumerary	0.02 (0-0.6) ³	0.94 (0-1.30) ¹										
	Thready fusion	1.07 (0-2.78) ¹²	1.40 ± 1.43 ¹⁶										
Pelvic girdle													
Pubis	Incomplete ossification	0.16 (0-1.1) ¹											
	Unossified	0.35 (0-2.70) ⁴	2.03 (0-21.7) ¹⁸										
Forelimb													
Carpal bone	Fused	0.13 (0-1.2) ⁶											
	Misshapen	0.20 (0-1.7) ⁶											

Metacarpal	Unossified	5.08(0-30.4) ¹⁸												
Proximal phalanx	Unossified	0.34 (0-4.3) ¹⁸												
Hindlimb														
Middle phalanx	Unossified	1.36 (0-14.3) ¹⁸												
Proximal phalanx	Unossified	0.23 (0-4.3) ¹⁸												
Talus	Unossified	0.96 (0-4.5) ³	1.36 (0-7.1) ¹⁸											
	Unossified (left)	0.01 (0-0.5) ³												
	Unossified (right and left)	0.10 (0-1.7) ³												

Superscript: Laboratory #. Values are given as mean (min-max) or mean ±S.D.