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The Thorax in European Bison and other Ruminants

[With 19 Tables & 6 Figs.]

Examination of the structural elements of the thorax were made, using the skeletons of 93 European bison of both sexes. In addition 10 species of other ruminats, both domesticated and free-living, were studied (a total of 107 individuals). Measurements were made of the ribs, sternum and also the thorax as a whole. The angles of costal curves areas of cross-sections of ribs and growth coefficients of the values were defined. It was shown that there are differences in the structure of the thorax between European bison and the other species of ruminants, and that the angles of the curves of sternal ribs are smaller in the European bison than in other ruminants. In the latter there is a relation between the angle of curve of the sternal ribs and mass of the animal's body. The most intensive increase in the majority of dimensions is observed in European bison during the 1st year of life, after which it continues, but with decreasing intensity, up to the age of 12 years. Increase in the parameters examined during post-embryonal development depends on the degree to which growth had advanced during embryonic development. The weaker the development of a given character during embryonic development, the more intensive its growth during post-embryonic life.

I. INTRODUCTION

Although studies on the skeleton of European bison are more advanced than studies on soft parts of these animals, there has hitherto been no exhaustive elaboration of the skeletal framework of the thorax.

The studies so far made on this subject have either been based on very scanty material (Bojanus, 1827; Janicki, 1938; Juśko, 1953) or even when material was more representative, questions relating to the thorax have been treated as merely incidental (Koch, 1932, Sokolov, 1972).

Among the structures included in the skeletal framework of the thorax in the European bison it is only the thoracic spine which has been described in any great detail (Roskosz, 1962; Roskosz & Empel, 1963) and on this account the greatest emphasis has been laid on ribs and sternum, and the thorax as a whole in the morphological analysis contained in this study.

II. MATERIAL AND METHODS

Studies were made mainly on macerated bones of European bison (wisent) forming part of the osteological collection of the European Bison Anatomical Research Centre of the Veterinary Faculty of Warsaw Agricultural University.

Examination was made of a total of 93 individuals (56 males and 37 females) ranging from foeti immediately previous to birth to animals 22 years old. The material examined, taking into consideration earlier studies (Empel & Roskosz, 1963), was divided into 5 groups according to age (Table 1), which was defined on the basis of the European Bison Pedigree Book (Żabiński, 1947—1965; Żabiński & Raczyński, 1972).

Linear measurements of both ribs and sternum were made by means of the method, partly modified, given by Duerst (1926). Only bones which did not exhibit any pathological changes were taken for measurements, for which a linear slide-ruler and surveying tape measure were used. Each measurement was made twice and the average calculated. Ribs from the left side were always used for the observations. Measurements made on ribs and sternum are illustrated in figs. 1, 2 and 3.

The angles of the costal curves (α) were calculated by the method of vertical projection of the various ribs on to a plane. For this purpose the given rib was fixed firmly in a vice screwed to the table so that the middle of the shaft was held in the jaws of the vice. The vertebral extremity always pointed to the left and sternal extremity to the right. The concave side of the costal curve was directed towards the plane of the table top. After fixing the rib in position point A was marked halfway along its curve, while point B was the tubercle of the rib, and the sternal extremity point C (Fig. 4). These points were joined to form an isosceles triangle with sides a, b, c. Side a at the same time formed the chord of the arc. All three sides of this illusory triangle were measured in such a way that the jaws of the linear slide measure were direct vertically to the plane of the table and touched it. The value of the auxiliary angle α_1 was calculated using the modified equation of Carnot's cosines:

$$\cos\alpha_1 = \frac{a^2-b^2-c^2}{2\,bc}$$

Knowing the value of cos α_1, the size of angle α_1 was read from mathematical tables. The angle α required is the doubled angle α_1.

A knowledge of angle α was essential for calculating the length of the radius from which the arc was drawn on the basis of the following equation:

$$r = \frac{a}{2\sin - \frac{\alpha}{2}}$$

The value of the radius of the costal curve made it possible to calculate the coefficient of its curvature (Frindt, 1964).

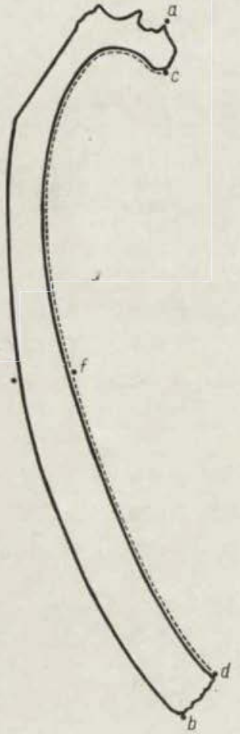
Table 1

List of material studied.

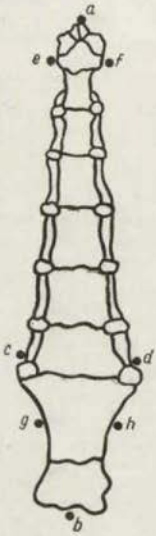
Species	Sex	Age, group	N	Age, years	Avg. age in group, yrs.
Wisent, *Bison bonasus* (L.)	♂♂	0	5	0— 1 *	0
		I	11	1— 3	1.6
		II	15	4— 7	5.6
		III	13	8—12	9.8
		IV	12	>12	16
	♀♀	0	3	0— 1	0
		I	8	1— 3	2.5
		II	6	4— 7	6.2
		III	7	8—12	10.3
		IV	13	>12	17
Bison, *Bison bison* (L.)	♂♂		1	> 5	
	♀♀		2	> 5	
Cattle, *Bos taurus* L.	♂♂		1	> 5	
	♀♀		13	> 5	
Watussi cattle, *B. taurus Watussi*	♂♂		1	> 5	
	♀♀		1	> 5	
Sheep, *Ovis aries* L.	♂♂		8	> 5	
	♀♀		9	> 5	
Goat, *Capra hircus* L.	♀♀		3	> 5	
Roe-deer, *Capreolus capreolus* L.	♂♂		21	> 5	
	♀♀		1	> 5	
Red-deer, *Cervus elaphus* (L.)	♂♂		16	> 5	
	♀♀		8	> 5	
Moose, *Alces alces* (L.)	♂♂		6	> 5	
	♂♂		4	> 5	
Rein deer, *Rangifer tarandus* (L.)	♂♂		6	> 5	
	♀♀		1	> 5	
Fallow deer, *Dama dama* (L.)	♂♂		2	> 5	
	♀♀		3	> 5	

* Age in days.

The areas of the cross-section of the sternal ribs (*I*, *V*) and two representatives of the asternal ribs (*IX*, *XIII*) were also defined, tracing in each of them the cross-section area below the tubercle (a), halfway along the shaft of the rib (b) and at the sternal extremity (c). For this purpose each of the ribs mentioned was surrounded at the places given above with strips of plasticine about 0.5 cm thick and



1



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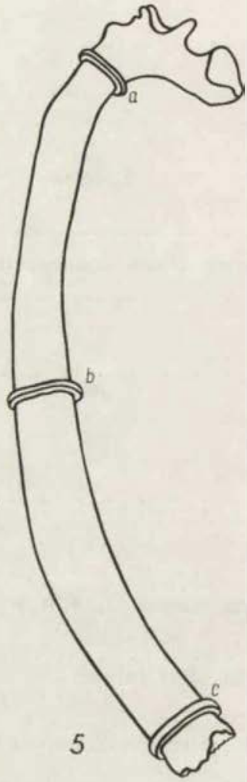

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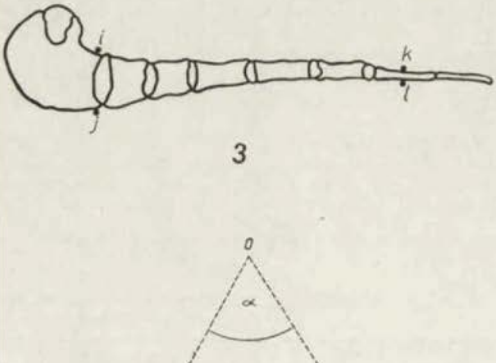

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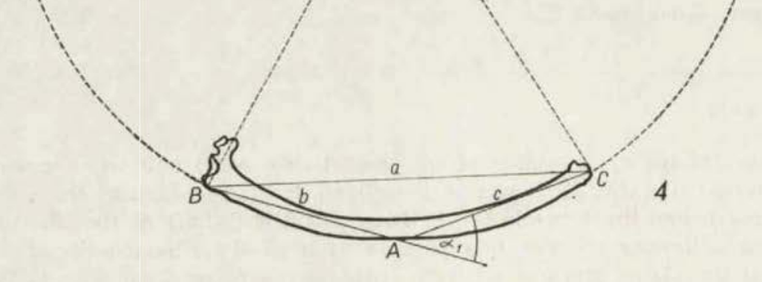

0.5 cm wide (Fig. 5). The plasticine was removed by cutting through the plasticine ring with a razor blade, then joining the ring up again, obtaining in this way the shape and size of the cross-section of the rib at a given place. These rings were next placed on photographic paper and contact photographs made, from which, using millimetre tracing-paper, the area of the cross-section of the rib was calculated (with accuracy to 1 mm^2).

The growth coefficients were defined for all the values examined in the European bison. They are the quotients of values in the oldest and youngest groups (Davletova, 1960).

For comparative anatomical purposes all the above examinations were carried out on the ribs and sternum or the adult individuals available of the related species of *Bovidae* and *Cervidae* (Table 1). Animals over 5 years old were considered as adult individuals.

The thorax as a whole was examined on the unfixed carcasses of 8 European bison, usually after anatomical and pathological dissection had been carried out. Two kinds of measurements were made in such cases: height and width. The first of these was measured halfway along the length of the shaft of different thoracic vertebrae vertically to the sternum, or (beginning from the eighth vertebra) to a line forming the extension of the sternum to the rear. Breadth was measured halfway along each of the bony parts of the ribs. The ratio of length of the bony parts of the ribs to length of the cartilaginous part of the ribs was calculated for these 8 European bison.

Use was made in this study of the arithmetical averages ($\bar{x}$) for the various groups, and in the case of groups of more than 5 individuals (in relation to the measurements of the four ribs chosen and the sternum) standard deviation (s) and ceofficients of variations (v) were given.

Fig. 1. Places in which ribs were measured. a—b Maximum length (direct measurement), c—d Length along curve, e—f Breadth half-way along shaft, b—d Breadth of sternal end, g—h Diameter of head of rib, i—j Thickness of shaft half-way along length.

Fig. 2. Places in which sternum was measured (seen from above). a—b Maximum length (direct measurement), c—d Maximum breadth before final pair of cartilaginous ribs, e—f Mximum breadth of manubrium, g—h Breadth of metasternum halfway along its length.

Fig. 3. Places in which sternum was measured (side-view), i—j Maximum height of manubrium before *II* pair of cartilaginous ribs, k—l Height of metasternum half-way along its length.

Fig. 4. Defining the angle of costal curve. A — Half the length of shalft of rib, B — Tubercle of the rib, C — Sternal end of rib, a, b, c — sides of triangle, α_1 — Auxiliary angle, α — Angle of costal curve, O — Middle of area, r — Radius of area.

Fig. 5. Places ringed with plasticene for calculating area of cross-section of rib. a — near tubercle, b — half the length of shaft, c — sternal end.

As only a very small number of original papers dealing with these elements of the skeletal system in other ruminants were found in the literature available, the author had therefore of necessity to refer to textbooks by the following authors: Ihle (1927), Kolda (1936), Martin (1938), Ellenberger (1943), Nickel (1960), Sisson (1960), Vokkken (1961), Koch (1963).

Latin nomenclature has been based on Nomina anatomica veterinaria (1968), and Polish nomenclature on the handbook by Poplewski (1948) and the translation of the handbook by Klimow (1960).

III RESULTS

1. *Costae*

The European bison possesses 14 pairs of ribs, although in the study material only 13 pairs were found in »Pluszcz«, aged 10 years, and »Plato« aged 17 years. In »Plotkarz« aged 6, »Pleśnianka«, aged 2, the final ribs are very short and there is no articulation with the final thoracic vertebra, but they fuse with it to form a stable whole.

Of the remaining ruminants it was only in the reindeer and American bison that 14 parts of ribs were present, the other species examined, whether domestic or wild animals possessing only 13 pairs. Two exceptions were, however, observed here, 14 pairs occurring in one female among 17 sheep examined, and in the only Watussi bull examined.

Os costale

Caput costae, which is flattened in an anterior-posterior direction, can be seen at the vertebral extremity of the rib in the European bison. This flattenning is distinct in the first pairs of ribs, up to and including ribs *VI,* but disappears in the following ribs. *Facies articularis capitis costae,* in the first three ribs is divided into two parts by a somewhat indistinct *crista capitis costae. Sulcus capitis costae* occurs in the other ribs on this surface, and deepens very slightly in a direction towards the posterior part of the ribs. Below the head there is a distinct *collum costae. Cartilago epiphysialis* occurs between the head and neck of the rib in European bison up to the age of 7, but this cartilage disappears earlier in the first ribs (at the age of 6 years). The neck of the rib gradually lengthens in a direction from the first to the final ribs. *Tuberculum costae,* fairly prominent and situated upwards on the first ribs, gradually decreases towards the rear and shifts slightly to the lateral surface. *Facies articularis tuberculi costae* changes from the spherical shape on the first ribs to oval in the lower ribs. The articular surface on the tubercles of the first three ribs is flat, but gradually becomes concave in further ribs up to rib *VIII,* and flattens again from

Table 2

Maximum length of ribs.

Species	Sex & Age group	N	Consecutive numbers of ribs																					
			I			II	III	IV	V			VI	VII	VIII	IX			X	XI	XII	XIII			XIV
			$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$
Wisent	♂♂ 0	5	103.2	4.6	4.4	117.8	135.0	149.0	164.0	13.0	7.9	177.8	186.2	194.4	198.0	11.1	5.6	194.4	185.6	168.0	148.4	9.3	6.3	113.4
	I	11	204.8	7.9	3.8	237.9	269.2	301.2	336.3	41.8	12.4	367.2	396.4	412.4	424.4	61.7	14.5	412.9	403.2	368.4	341.0	37.4	10.1	274.6
	II	15	272.6	2.8	1.0	315.6	354.4	393.4	435.1	12.3	2.8	474.1	508.1	523.3	531.1	21.9	4.1	526.9	508.9	479.3	445.0	23.7	5.3	373.5
	III	13	291.8	7.5	2.5	340.3	380.5	420.6	465.8	22.6	4.8	497.0	528.1	547.5	555.5	24.7	4.4	541.3	532.1	486.9	449.0	33.4	7.1	374.1
	IV	12	293.1	15.4	5.2	346.1	387.4	423.0	470.2	19.9	4.2	508.2	538.4	551.8	552.4	20.5	3.7	549.5	529.0	499.9	467.4	31.8	6.8	375.7
	♀♀ 0	3	84.6	7.1	8.3	103.0	116.3	129.3	142.3	10.5	7.4	151.0	159.6	171.0	177.0	5.3	2.9	170.7	162.7	158.0	137.7	4.9	3.5	110.7
	I	8	193.2	19.8	10.2	219.9	248.0	278.9	308.2	30.6	8.0	332.9	356.8	371.4	376.8	42.0	11.1	368.1	342.4	335.6	309.4	28.5	9.2	257.2
	II	6	246.3	15.6	6.3	278.5	314.2	352.5	392.8	15.2	3.8	421.8	451.7	473.5	478.2	14.1	2.9	473.8	456.5	427.7	408.5	32.6	7.9	318.2
	III	7	259.0	6.8	2.6	301.0	341.7	372.0	408.4	3.7	9.0	446.3	470.4	487.8	498.2	19.4	3.8	495.7	479.8	458.7	425.0	13.4	3.1	323.8
	IV	13	262.5	9.3	3.5	307.0	345.1	381.7	417.4	3.8	9.1	448.0	480.2	501.7	509.3	14.3	2.8	508.5	497.5	472.6	443.8	10.0	2.2	335.8
Bison	♂♂	1	242.0	—	—	297.0	334.0	369.0	—	—	—	451.0	482.0	510.0	513.0	—	—	524.0	524.0	480.0	438.0	—	—	340.0
	♀♀	2	332.0	—	—	284.5	318.5	362.5	396.0	—	—	425.0	455.5	474.5	484.0	—	—	481.0	462.5	434.5	396.5	—	—	340.0
Cattle	♂♂	1	274.0	—	—	342.0	—	415.0	449.0	—	—	483.0	508.0	518.0	517.0	—	—	509.0	513.0	492.0	446.0	—	—	—
	♀♀	13	222.7	13.3	5.9	270.1	305.5	336.5	367.1	23.2	6.3	409.0	429.2	449.2	450.6	23.3	5.1	444.2	439.1	413.7	363.7	24.6	9.3	—
Watussi cattle	♂♂	1	247.0	—	—	306.0	352.0	381.0	416.0	—	—	458.0	485.0	510.0	511.0	—	—	512.0	500.0	500.0	480.0	—	—	432.0
	♀♀	1	212.0	—	—	258.0	300.0	343.0	387.0	—	—	416.0	461.0	464.0	451.0	—	—	463.0	450.0	461.0	361.0	—	—	—
Sheep	♂♂	8	105.0	21.0	20.0	123.0	133.5	159.5	175.0	19.0	10.8	184.5	191.5	195.5	200.0	24.0	12.0	200.5	191.5	184.0	168.5	28.3	16.8	—
	♀♀	9	90.0	9.4	10.4	119.6	139.0	153.7	162.0	12.6	7.8	174.0	182.6	190.6	191.6	10.7	5.6	185.3	173.6	157.3	136.3	9.9	7.3	77.0
Goat	♀♀	3	76.6	—	—	102.6	126.0	134.6	146.3	—	—	158.3	159.3	164.3	170.5	—	—	159.3	144.6	131.3	111.0	—	—	—
Red-deer	♂♂	21	82.5	7.8	9.4	108.7	129.0	146.1	155.3	8.9	5.7	170.2	182.9	190.6	189.1	12.5	6.6	178.4	167.0	148.2	128.9	8.8	6.8	—
	♀♀	1	63.0	—	—	85.0	97.0	108.0	112.0	—	—	123.0	135.0	140.0	139.0	—	—	129.0	122.0	109.0	92.0	—	—	—
Roe-deer	♂♂	16	185.0	18.0	9.7	232.6	266.3	294.6	298.5	16.5	5.5	338.0	364.3	376.3	376.6	26.9	7.1	361.3	340.0	308.6	266.0	18.2	6.8	—
	♀♀	8	160.5	14.0	8.7	203.0	232.0	258.0	276.5	19.6	7.1	293.5	315.5	323.0	321.0	29.4	9.2	309.0	291.5	265.0	225.0	17.9	8.0	—
Elk	♂♂	6	228.0	20.0	8.8	283.1	340.0	348.3	371.3	23.1	6.2	387.0	409.3	429.6	427.6	33.4	7.8	410.6	386.3	352.0	303.7	24.6	8.1	—
	♀♀	4	226.5	—	—	281.5	318.5	342.5	365.5	—	—	390.5	407.5	411.5	411.0	—	—	392.0	369.0	334.5	282.5	—	—	—
Reindeer	♂♂	6	125.0	11.0	8.8	159.0	208.5	234.0	254.5	19.5	7.7	278.5	297.0	302.0	311.0	17.6	5.6	311.5	297.0	274.5	245.5	13.5	5.5	195.5
	♀♀	1	123.0	—	—	158.0	187.0	212.0	236.0	—	—	256.0	237.0	282.0	291.0	—	—	288.0	271.0	247.0	213.0	—	—	176.0
Fallow deer	♂♂	2	104.5	—	—	130.5	155.5	172.0	184.0	—	—	194.5	208.5	217.5	218.0	—	—	209.0	196.5	180.0	152.5	—	—	—
	♀♀	3	101.3	—	—	133.3	155.3	169.6	184.6	—	—	197.3	204.0	220.0	218.6	—	—	213.3	204.0	194.3	160.3	—	—	—

Table 3

Length along costal curve (mm).

Species	Sex & Age group	N	Consecutive numbers of ribs																					
			I			II	III	IV	V			VI	VII	VIII	IX			X	XI	XII	XIII			XIV
			x̄	s	v	x̄	x̄	x̄	x̄	s	v	x̄	x̄	x̄	x̄	s	v	x̄	x̄	x̄	x̄	x̄	x̄	x̄
Wisent	♂♂ 0	5	97.6	8.8	9.0	115.4	138.8	155.2	176.6	13.4	7.6	190.6	203.6	214.2	219.4	11.6	5.3	210.0	208.4	194.6	168.8	8.3	4.9	132.2
	I	11	198.9	20.5	10.3	235.7	274.4	314.0	359.9	49.7	13.8	379.9	423.9	447.8	460.9	63.6	13.6	468.9	448.6	420.2	374.9	43.2	11.5	307.3
	II	15	263.7	10.4	3.9	310.1	359.6	406.4	460.1	28.0	6.1	504.3	543.4	571.3	585.9	20.9	3.6	593.6	588.8	552.4	504.1	26.9	5.3	406.2
	III	13	269.8	9.4	3.4	333.5	383.6	435.9	492.8	19.4	3.9	532.8	572.0	598.8	621.8	36.0	5.8	622.8	608.4	574.4	530.3	32.8	6.1	409.1
	IV	12	286.5	17.1	5.9	342.4	391.6	446.7	499.8	17.1	3.4	542.7	579.2	602.0	621.1	18.2	2.9	626.6	610.9	573.6	536.0	26.5	4.9	408.4
	♀♀ 0	3	81.7	6.9	8.4	101.3	117.3	130.0	147.3	4.9	3.3	157.0	174.7	187.0	194.3	6.9	3.5	193.0	186.0	172.0	162.7	4.0	2.4	134.0
	I	3	189.6	20.5	10.8	218.5	254.9	292.8	328.5	27.8	8.4	358.2	385.0	409.4	434.1	47.3	10.8	431.6	390.8	381.6	346.0	33.2	9.5	291.8
	II	6	241.2	11.2	4.6	274.5	321.8	368.7	421.4	12.8	3.0	456.2	495.8	523.5	532.8	18.8	3.5	533.2	516.2	488.5	446.2	19.2	4.3	344.8
	III	7	259.7	4.8	1.8	300.2	349.2	392.6	449.6	20.2	8.0	485.5	513.4	539.8	564.8	10.3	1.8	569.2	559.0	529.5	491.3	22.8	4.6	385.0
	IV	13	261.2	9.4	3.5	307.9	355.4	408.0	456.8	7.9	1.7	492.2	530.0	558.2	575.9	14.9	2.6	574.9	570.4	535.8	498.0	15.2	3.0	380.0
Bison	♂♂	5	241.0	—	—	296.0	350.0	402.0	—	—	—	495.0	530.0	569.0	561.0	—	—	576.0	575.0	524.0	476.0	—	—	356.0
	♀♀	2	227.0	—	—	282.5	322.0	381.5	422.5	—	—	471.0	508.5	537.0	542.5	—	—	540.0	520.5	490.0	445.0	—	—	383.0
Cattle	♂♂	1	249.0	—	—	334.0	—	417.0	462.0	—	—	514.0	552.0	591.0	594.0	—	—	575.0	582.0	551.0	488.0	—	—	—
	♀♀	13	216.6	11.6	5.3	267.5	309.3	350.6	393.1	24.4	6.2	444.7	507.3	510.0	510.8	22.6	4.4	507.2	506.5	470.1	405.8	44.2	10.8	—
Watussi cattle	♂♂	1	240.0	—	—	301.0	346.0	394.0	444.0	—	—	494.0	534.0	556.0	570.0	—	—	566.0	575.0	584.0	560.0	—	—	505.0
	♀♀	1	210.0	—	—	257.0	306.0	364.0	420.0	—	—	453.0	529.0	539.0	502.0	—	—	545.0	530.0	542.0	404.0	—	—	—
Sheep	♂♂	8	98.5	12.5	12.7	124.0	135.5	166.0	187.5	17.5	9.3	184.5	217.0	224.5	228.0	21.9	9.6	230.5	221.5	214.0	191.5	17.6	9.2	—
	♀♀	9	88.9	8.8	10.0	119.0	133.0	163.6	180.3	14.8	8.2	194.6	202.3	210.0	211.7	13.0	6.1	207.0	193.6	172.6	146.0	12.6	8.6	78.0
Goat	♀♀	3	73.0	—	—	103.3	126.0	144.3	174.0	—	—	181.5	184.2	186.3	185.0	—	—	179.6	160.3	145.0	117.3	—	—	—
Red-deer	♂♂	21	80.0	7.4	9.2	109.0	135.0	156.4	171.0	8.7	5.0	191.6	215.7	222.3	226.0	14.5	6.4	217.9	197.6	172.4	147.0	9.6	6.5	—
	♀♀	1	63.0	—	—	86.0	103.0	120.0	132.0	—	—	144.0	158.0	164.0	164.0	—	—	156.0	142.0	125.0	100.0	—	—	—
Red-deer	♂♂	13	179.3	21.3	11.8	235.6	279.0	321.3	335.0	19.0	5.6	385.3	417.6	440.0	445.3	31.0	6.9	426.0	402.4	356.6	293.0	23.6	8.0	—
	♀♀	8	160.5	18.3	11.4	207.5	244.0	282.5	313.5	27.4	8.7	339.6	362.8	378.4	384.0	38.0	9.9	370.3	348.6	311.2	257.5	20.9	8.1	—
Elk	♂♂	6	228.6	19.6	8.6	286.6	348.0	365.3	398.3	27.8	7.0	419.5	445.3	474.6	475.0	37.6	7.9	456.6	431.3	389.4	330.4	28.4	8.6	—
	♀♀	4	222.5	—	—	277.5	324.6	355.8	389.2	—	—	421.0	444.0	455.7	459.5	—	—	439.4	413.5	370.5	310.0	—	—	—
Reindeer	♂♂	6	126.0	7.0	5.6	160.0	211.4	241.6	273.0	19.0	7.0	300.0	329.5	332.6	358.5	32.1	9.0	358.0	341.4	311.8	271.0	23.8	8.8	209.5
	♀♀	1	133.0	—	—	—	230.0	260.0	292.0	—	—	321.0	351.0	370.0	380.0	—	—	380.0	360.0	330.0	290.0	—	—	230.0
Fallow deer	♂♂	2	101.5	—	—	132.5	158.5	185.0	207.0	—	—	222.0	242.0	252.5	258.0	—	—	249.0	233.0	213.0	176.0	—	—	—
	♀♀	3	101.0	—	—	134.6	161.6	187.3	210.3	—	—	235.0	240.6	256.3	259.0	—	—	250.4	237.6	228.6	182.0	—	—	—

Table 4

Breadth of sternal end of ribs (mm).

Species	Sex & Age group	N	I			II	III	IV	V			VI	VII	VIII	IX			X	XI	XII	XIII			XIV
			x̄	s	v	x̄	x̄	x̄	x̄	s	v	x̄	x̄	x̄	x̄	s	v	x̄	x̄	x̄	x̄	s	v	x̄
Wisent	♂♂ 0	5	8.0	0.3	3.6	7.8	8.4	9.0	8.4	1.5	2.2	8.6	9.4	9.0	8.0	1.1	13.7	7.2	6.8	6.8	7.0	1.0	14.2	6.6
	I	11	16.9	5.6	3.3	18.4	19.9	19.8	19.5	1.8	9.2	22.3	23.3	20.6	20.9	1.9	9.1	20.8	20.6	18.8	18.4	1.5	8.1	18.2
	II	15	28.6	1.5	5.2	26.5	27.2	29.1	32.0	2.1	6.5	34.6	37.3	35.7	37.2	1.7	4.5	34.0	28.7	29.1	30.3	2.0	6.6	26.0
	III	13	30.1	1.0	3.3	29.0	32.2	34.3	35.0	7.6	2.1	40.8	41.2	42.2	40.4	7.7	19.0	38.6	34.4	32.0	31.1	4.7	15.1	30.7
	IV	12	32.1	2.8	8.7	28.9	31.8	33.8	34.5	3.2	9.2	40.2	40.2	41.6	39.6	3.0	7.5	38.7	33.6	32.3	31.1	2.0	6.4	29.7
	♀♀ 0	3	8.6	1.0	11.6	6.0	7.0	9.0	9.0	0.8	8.8	9.0	8.7	8.6	7.0	0.8	11.4	7.0	6.1	6.2	6.0	0.8	13.3	6.0
	I	8	15.1	1.4	9.2	16.8	18.2	18.2	18.1	1.4	7.7	20.5	20.5	19.0	19.4	1.4	7.2	19.1	19.0	17.6	16.8	1.0	5.9	16.0
	II	6	24.3	2.4	9.8	24.0	24.5	25.3	28.0	1.4	5.0	28.0	29.3	29.5	29.2	2.2	7.5	28.2	26.3	23.7	23.8	1.7	7.1	23.4
	III	7	25.2	1.4	5.5	24.7	25.5	26.6	29.2	2.6	8.9	29.8	30.6	32.0	30.8	1.7	5.5	30.2	28.5	26.7	25.3	1.0	3.9	24.2
	IV	13	26.1	4.4	16.8	23.2	26.4	26.7	28.9	3.0	6.9	30.1	30.5	31.7	31.1	1.7	5.4	29.8	28.8	27.5	26.1	1.6	6.1	24.0
Bison	♂♂	1	24.0	—	—	21.0	22.0	24.0	23.0	—	—	25.0	28.0	29.0	26.0	—	—	28.0	28.0	21.0	22.0	—	—	23.0
	♀♀	2	24.0	—	—	21.5	21.0	23.5	24.5	—	—	27.0	29.5	27.0	24.0	—	—	23.5	20.0	19.5	21.0	—	—	22.5
Cattle	♂♂	1	33.0	—	—	32.0	—	50.0	52.0	—	—	55.0	55.0	56.0	50.0	—	—	44.0	50.0	45.0	28.0	—	—	—
	♀♀	13	23.0	2.8	12.1	23.8	29.1	34.4	38.5	4.6	11.9	42.7	43.1	38.6	39.5	3.5	8.8	35.6	32.7	26.7	22.1	2.7	12.2	—
Watussi cattle	♂♂	1	28.0	—	—	28.0	38.0	35.0	44.0	—	—	48.0	46.0	49.0	51.0	—	—	47.0	43.0	45.0	40.0	—	—	32.0
	♀♀	1	27.0	—	—	27.0	30.0	40.0	44.0	—	—	47.0	45.0	45.0	45.0	—	—	45.0	43.0	35.0	34.0	—	—	—
Sheep	♂♂	8	12.5	1.7	13.6	14.5	13.0	13.4	14.5	1.9	13.1	13.0	14.8	15.4	14.5	2.0	13.8	11.5	9.2	10.3	8.0	1.0	12.5	—
	♀♀	9	11.0	1.7	15.4	10.7	11.6	11.7	11.3	1.7	15.0	12.0	11.3	11.0	9.3	1.0	10.8	7.0	6.3	5.6	5.6	0.9	16.1	5.0
Goat	♀♀	3	9.7	—	—	8.6	10.3	9.3	9.7	—	—	9.7	10.0	10.0	8.6	—	—	6.7	6.0	5.7	5.0	—	—	—
Roe-deer	♂♂	21	9.0	0.6	6.6	10.3	12.8	12.9	12.0	1.3	10.8	11.7	12.4	9.5	6.0	0.5	8.3	7.1	7.0	7.0	7.0	1.0	14.2	—
	♀♀	1	8.0	—	—	10.0	8.0	9.0	9.0	—	—	8.0	7.0	7.0	6.0	—	—	7.0	7.0	6.0	6.0	—	—	—
Red-deer	♂♂	16	20.0	2.4	12.0	17.3	20.0	21.3	22.1	2.6	11.7	23.0	23.0	20.4	16.0	1.2	7.5	14.3	13.3	12.6	12.3	1.0	8.1	—
	♀♀	8	15.5	1.9	12.2	15.1	17.5	18.7	19.5	2.3	11.8	20.0	21.4	19.5	14.5	1.8	12.4	12.2	10.5	11.0	13.5	1.8	13.3	—
Elk	♂♂	6	21.3	2.4	11.3	21.3	24.3	23.6	24.3	2.5	10.3	23.0	23.0	20.6	15.6	1.6	10.2	15.7	12.6	15.2	14.0	2.0	14.3	—
	♀♀	4	20.2	—	—	20.5	22.5	22.0	22.5	—	—	22.0	21.5	20.4	18.6	—	—	15.0	11.5	14.4	13.2	—	—	—
Reindeer	♂♂	6	15.0	1.9	12.7	13.4	17.6	17.9	16.5	1.9	11.5	16.5	17.3	13.1	12.0	1.7	14.2	11.2	9.5	9.5	11.0	1.5	13.6	10.0
	♀♀	1	13.0	—	—	11.0	15.0	15.0	15.0	—	—	14.0	13.0	14.0	11.0	—	—	9.0	9.0	8.0	8.0	—	—	9.0
Fallow deer	♂♂	2	12.5	—	—	11.0	15.3	15.5	14.5	—	—	14.5	16.0	12.0	10.5	—	—	10.5	9.0	8.0	7.5	—	—	—
	♀♀	3	10.0	—	—	10.3	12.3	11.6	13.9	—	—	15.3	15.7	13.3	11.3	—	—	10.0	9.0	8.6	6.6	—	—	—

Consecutive numbers of ribs

Table 5

Breadth of sternal end of ribs (mm).

Species	Sex & Age group	N	Consecutive numbers of ribs I			II	III	IV	V			VI	VII	VIII	IX			X	XI	XII	XIII			XIV
			$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$
Wisent	♂♂ 0	5	26.0	4.0	15.3	12.2	13.8	18.1	18.4	2.4	13.0	18.0	18.2	17.6	16.2	1.5	9.2	14.6	13.2	11.4	9.0	2.1	23.3	8.2
	I	11	28.2	1.4	4.9	21.6	22.2	26.2	25.6	1.1	4.3	25.9	25.7	28.2	26.8	2.3	8.6	22.6	21.4	18.6	15.8	2.5	15.8	15.5
	II	15	53.9	3.7	6.9	27.6	28.5	30.8	32.4	4.6	14.1	39.1	39.1	39.7	35.7	2.5	7.0	28.9	25.1	22.0	21.5	1.7	7.9	21.9
	III	13	55.8	1.4	2.3	32.2	33.3	33.5	40.1	2.0	4.9	41.0	40.8	42.2	41.1	3.6	8.7	34.5	28.9	26.6	25.3	3.6	14.2	24.6
	IV	12	59.7	4.1	6.8	32.5	33.1	34.1	40.0	2.6	6.0	40.1	40.8	41.7	38.8	3.6	9.2	35.5	27.2	25.5	24.5	3.3	13.4	24.7
	♀♀ 0	3	23.0	1.4	6.0	12.0	14.1	15.4	17.0	1.6	9.4	15.2	15.3	15.6	17.0	1.6	9.4	13.5	10.4	9.2	8.0	0.8	10.0	8.0
	I	8	26.1	1.6	6.1	18.9	20.5	23.9	23.8	1.0	4.2	24.0	24.2	25.2	23.5	2.2	9.3	20.5	19.4	17.1	14.4	1.2	8.3	14.0
	II	6	45.7	1.4	3.0	26.0	26.0	27.3	28.2	2.2	7.8	28.7	29.0	29.3	28.3	2.0	7.0	27.1	23.8	21.3	19.0	1.7	8.9	17.6
	III	7	46.3	3.2	6.9	26.0	26.5	27.6	29.0	1.0	3.4	29.5	31.0	32.4	31.3	2.4	7.6	30.7	25.2	23.3	22.3	1.7	7.6	20.0
	IV	13	48.3	2.2	4.5	25.0	25.5	28.0	29.3	3.2	10.9	30.4	30.5	31.8	31.0	1.7	5.4	30.8	24.2	22.7	21.5	1.3	6.0	19.6
Bison	♂♂	1	51.0	—	—	30.0	25.0	29.0	30.0	—	—	30.0	33.0	32.0	22.0	—	—	25.0	30.0	20.0	17.0	—	—	12.0
	♀♀	2	49.5	—	—	24.0	25.0	28.0	30.0	—	—	28.5	32.5	36.0	29.5	—	—	24.5	20.5	18.5	15.0	—	—	11.5
Cattle	♂♂	1	69.0	—	—	41.0	—	51.0	55.0	—	—	58.0	61.0	63.0	54.0	—	—	38.0	48.0	30.0	32.0	—	—	
	♀♀	13	50.2	5.3	10.5	31.2	32.8	37.2	42.2	4.8	11.3	44.0	44.9	42.0	41.2	4.4	10.6	36.1	29.6	23.1	18.1	1.9	10.4	—
Watussi cattle	♂♂	1	55.0	—	—	41.0	35.0	38.0	41.0	—	—	44.0	48.0	56.0	39.0	—	—	53.0	32.0	38.0	32.0	—		28.0
	♀♀	1	52.0	—	—	29.0	30.0	36.0	40.0	—	—	40.0	33.0	34.0	42.0	—	—	26.0	27.0	25.0	17.0	—	—	—
Sheep	♂♂	8	27.5	3.1	11.3	16.2	20.4	15.0	16.5	2.0	12.1	17.2	15.5	15.8	14.0	1.8	12.8	12.4	9.5	10.5	8.5	1.0	11.8	
	♀♀	9	18.3	2.4	13.1	12.6	15.0	14.6	14.6	1.9	13.0	13.6	12.3	11.3	10.0	1.6	16.0	8.7	7.8	6.2	5.7	0.9	15.8	7.0
Goat	♀♀	3	15.6	—	—	11.0	11.6	12.4	11.3	—	—	12.2	11.0	8.7	7.7	—	—	8.6	6.0	5.7	5.3	—	—	
Roe-deer	♂♂	2	11.0	1.4	12.7	11.3	13.6	14.0	14.0	1.2	8.5	13.7	10.0	9.1	8.0	0.7	8.7	7.5	7.2	5.0	4.0	0.6	15.0	—
	♀♀	1	13.0	—	—	11.0	12.0	13.0	12.0	—	—	10.0	9.0	9.0	7.0	—	—	6.0	5.0	5.0	5.0	—	—	—
Red-deer	♂♂	16	35.0	3.7	10.5	17.3	21.0	23.7	23.5	2.8	11.9	23.6	20.6	15.3	14.6	1.8	12.3	11.3	11.0	10.0	10.3	1.0	9.7	—
	♀♀	8	28.0	3.3	11.8	16.5	19.5	22.5	23.5	2.8	11.9	24.8	22.5	17.5	13.5	1.6	11.8	12.5	10.0	10.2	9.5	1.3	13.7	—
Elk	♂♂	6	40.0	3.7	9.2	29.3	31.0	34.0	33.0	3.9	11.8	34.0	31.3	27.0	21.6	2.7	12.5	19.3	18.0	16.0	17.0	2.0	11.8	—
	♀♀	4	36.5	—	—	27.5	30.0	33.0	34.0	—	—	34.0	30.0	24.5	24.0	—	—	19.5	17.5	16.0	15.0	—	—	—
Reindeer	♂♂	6	26.0	2.9	11.2	18.2	20.4	22.0	18.5	2.1	11.4	24.4	20.5	19.5	14.0	1.6	11.4	15.0	12.3	11.6	13.5	1.6	11.8	13.5
	♀♀	1	22.0	—	—	14.0	18.0	20.0	19.0	—	—	20.0	18.0	17.0	13.0	—	—	12.0	10.0	10.0	12.0	—	—	12.0
Fallow deer	♂♂	2	19.5	—	—	13.0	12.5	15.5	15.0	—	—	14.0	11.5	11.0	8.0	—	—	7.5	6.5	6.5	5.5	—	—	—
	♀♀	3	18.3	—	—	13.3	16.3	15.3	16.0	—	—	13.0	13.6	9.7	8.0	—	—	7.7	6.0	5.7	5.3	—	—	—

Table 6

Diameter of head of ribs (mm).

Species	Sex & Age group	N	I			II	III	IV	V			VI	VII	VIII	IX			X	XI	XII	XIII			XIV
			$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$
Wisent	♂♂ 0	5	7.0	1.4	20.0	8.2	8.8	8.2	8.0	2.4	30.0	8.0	8.2	8.0	7.0	1.5	21.4	8.0	7.2	7.6	7.6	1.6	21.0	6.6
	I	11	16.8	1.7	1.2	15.8	15.7	14.8	14.6	1.2	8.2	16.4	16.7	16.7	15.9	1.7	10.6	15.8	15.6	13.4	15.0	2.1	14.0	14.0
	II	15	23.5	3.7	15.7	20.8	20.3	21.4	21.2	2.0	9.4	21.3	23.7	25.2	24.9	7.1	27.4	22.3	22.5	20.6	22.5	2.6	11.5	24.1
	III	13	27.8	2.9	1.0	23.6	22.4	22.7	22.4	2.0	8.9	22.2	24.3	25.5	25.1	2.3	9.1	24.2	23.3	22.6	22.6	1.4	6.1	24.6
	IV	12	27.9	3.3	11.8	23.0	22.8	21.7	22.2	3.0	13.5	21.7	22.8	24.9	26.1	1.4	5.3	23.8	25.0	23.7	23.0	1.0	4.3	25.6
	♀♀ 0	3	5.0	0.2	4.8	6.0	6.2	7.3	8.0	0.8	10.0	8.6	8.3	9.0	9.0	0.8	8.8	8.2	8.0	7.0	8.7	0.8	9.1	8.0
	I	8	14.9	1.2	8.0	15.0	14.9	13.8	13.9	1.0	7.1	15.1	15.2	15.1	14.5	1.3	8.9	14.6	14.6	12.6	13.9	1.2	8.6	13.0
	II	6	18.7	2.4	12.8	17.2	16.8	16.5	15.8	1.4	8.8	16.5	16.8	17.0	17.2	2.2	12.7	16.7	16.5	15.5	15.0	1.0	6.6	14.4
	III	7	19.2	2.6	13.5	18.5	17.8	18.2	18.0	1.4	7.7	18.0	18.6	19.0	19.0	1.4	7.3	18.5	18.0	17.7	17.8	1.7	9.5	18.9
	IV	13	19.7	2.8	14.2	18.6	18.4	18.7	18.6	1.7	9.1	18.0	18.4	19.3	19.6	1.0	5.1	18.7	17.9	17.5	17.7	1.9	10.7	19.5
Bison	♂♂	1	16.0	—	—	18.0	17.0	20.0	—	—	—	19.0	20.0	21.0	20.0	—	—	20.0	21.0	18.0	18.0	—	—	19.0
	♀♀	2	18.0	—	—	17.0	18.0	19.0	19.0	—	—	19.0	18.0	18.0	20.0	—	—	19.0	19.0	19.0	12.0	—	—	16.0
Cattle	♂♂	1	22.0	—	—	20.0	—	30.0	27.0	—	—	30.0	31.0	30.0	31.0	—	—	28.0	29.0	25.0	28.0	—	—	—
	♀♀	13	18.4	2.0	10.8	16.4	17.6	17.6	17.3	2.8	16.1	18.8	20.1	20.1	20.2	2.6	12.8	19.3	18.8	19.6	19.6	3.9	19.8	—
Watussi cattle	♂♂	1	23.0	—	—	19.0	21.0	22.0	23.0	—	—	24.0	24.0	25.0	23.0	—	—	24.0	23.0	22.0	23.0	—	—	25.0
	♀♀	1	19.0	—	—	18.0	17.0	22.0	20.0	—	—	21.0	21.0	20.0	20.0	—	—	19.0	20.0	21.0	21.0	—	—	—
Sheep	♂♂	8	11.0	1.8	16.4	12.2	12.5	9.0	8.5	1.0	11.8	9.4	8.5	8.6	8.5	0.9	10.6	8.5	10.0	10.0	10.0	1.4	14.0	—
	♀♀	9	8.0	1.0	12.5	6.6	7.3	7.3	7.3	0.9	12.3	7.6	7.3	7.7	7.7	1.0	13.0	8.3	9.3	8.3	9.3	1.0	10.8	9.0
Goat	♀♀	3	7.3	—	—	7.0	5.7	6.3	6.5	—	—	7.3	7.0	6.7	6.0	—	—	6.7	8.3	7.3	8.0	—	—	—
Roe-deer	♂♂	21	9.0	1.7	18.8	8.0	8.3	7.6	7.8	1.2	15.3	9.1	8.3	8.5	8.2	0.9	10.9	9.0	9.1	10.2	12.4	1.0	8.0	—
	♀♀	1	6.0	—	—	6.0	5.0	6.0	5.0	—	—	5.0	5.0	5.0	6.0	—	—	7.0	7.0	8.0	9.0	—	—	—
Red-deer	♂♂	16	17.6	2.4	13.6	15.6	15.0	14.6	13.5	1.4	10.4	15.3	16.3	15.0	14.0	1.0	7.1	14.6	15.0	14.3	17.0	2.4	14.1	—
	♀♀	8	14.0	2.0	14.3	13.2	12.0	12.5	12.5	1.7	13.6	12.5	12.6	13.0	12.0	1.4	11.7	12.0	12.5	12.5	15.0	2.0	13.3	—
Elk	♂♂	6	22.3	1.9	8.5	19.3	20.0	17.0	16.3	1.9	11.6	17.6	17.3	18.3	18.3	2.0	10.9	17.3	16.0	16.7	17.3	2.1	12.1	—
	♀♀	4	20.2	—	—	18.0	17.4	15.5	15.8	—	—	16.5	18.0	18.0	19.2	—	—	16.5	15.0	16.5	17.0	—	—	—
Reindeer	♂♂	6	13.0	1.8	13.8	11.2	10.5	10.8	11.5	1.4	12.2	12.0	12.5	12.5	11.5	1.8	15.6	11.0	11.5	11.5	12.0	1.8	15.0	11.5
	♀♀	1	10.0	—	—	10.0	10.0	10.0	10.0	—	—	11.0	11.0	10.0	10.0	—	—	10.0	10.0	11.0	11.0	—	—	12.0
Fallow deer	♂♂	2	12.5	—	—	8.0	9.0	8.0	9.0	—	—	6.5	10.0	10.0	9.5	—	—	9.0	10.0	11.0	11.0	—	—	—
	♀♀	3	12.2	—	—	10.6	9.6	9.6	9.8	—	—	10.3	10.0	9.3	9.3	—	—	9.3	10.3	10.1	11.0	—	—	—

Table 7

Thickness of shaft (halfway along its lenght) of ribs (mm).

Species	Sex & Age group	N	Consecutive numbers of ribs																					
				I		II	III	V		V		VI	VII	VIII		IX		X	XI	XII		XIII		XIV
			x	s	v	x	s	v	x	s	v	x	x	x	x	s	v	x	x	x	x	s	v	x
Wisent	♂♂ 0	5	5.2	1.0	19.2	4.8	4.2	4.4	4.4	1.5	34.1	4.4	4.8	4.4	4.8	1.5	31.2	4.8	4.8	4.8	4.0	1.1	27.5	4.4
	I	11	10.8	1.0	9.2	7.8	7.7	6.9	7.7	1.4	18.2	7.7	9.1	8.6	8.8	1.8	20.4	7.7	7.9	6.9	7.3	2.4	32.7	7.2
	II	15	18.8	3.4	18.0	15.5	14.2	14.6	13.9	1.0	7.6	13.8	14.4	14.1	15.7	1.5	9.5	14.7	14.6	14.2	14.0	1.0	7.1	15.3
	III	13	20.0	2.4	1.2	17.2	15.8	15.9	15.2	0.8	5.2	14.8	15.3	15.5	16.5	1.4	8.4	16.9	15.4	16.1	15.2	1.4	9.2	15.5
	IV	12	19.6	2.0	10.2	17.4	16.3	15.9	16.0	1.3	8.1	15.1	16.2	16.8	17.5	1.4	8.0	17.8	16.8	16.5	16.0	2.4	15.0	16.0
	♀♀ 0	3	4.0	0.2	6.0	4.1	4.3	4.2	4.0	0.8	20.0	4.0	5.1	4.2	5.0	0.8	16.0	5.0	4.2	4.0	4.0	0.8	20.0	4.1
	I	8	9.5	1.0	10.5	6.6	6.8	6.4	6.8	1.0	14.7	6.6	8.0	7.5	7.8	1.1	14.1	6.8	7.0	6.5	6.8	1.0	14.8	6.5
	II	6	14.8	1.7	11.4	13.2	13.3	12.3	12.0	1.7	14.1	12.5	12.8	13.3	13.7	1.4	10.2	13.7	13.3	13.5	13.5	1.7	12.5	13.4
	III	7	16.0	1.7	10.6	15.5	14.2	14.0	13.8	1.0	7.2	13.7	14.0	14.2	14.7	1.0	6.8	15.0	14.2	14.5	14.5	1.0	6.8	14.0
	IV	13	15.4	1.6	10.3	15.3	14.8	13.9	13.8	1.4	11.0	13.8	14.0	14.3	15.1	0.9	5.9	15.4	14.8	14.3	14.2	0.8	5.6	13.6
Bison	♂♂	1	12.0	—	—	10.0	8.0	9.0	10.0	—	—	11.0	10.0	12.0	11.0	—	—	12.0	13.0	12.0	11.0	—	—	6.0
	♀♀	2	12.0	—	—	9.5	7.5	9.0	9.0	—	—	10.5	11.0	11.5	11.0	—	—	11.0	10.5	11.0	9.0	—	—	7.0
Cattle	♂♂	1	16.0	—	—	14.0	—	15.0	12.0	—	—	15.0	15.0	16.0	14.0	—	—	13.0	13.0	14.0	17.0	—	—	—
	♀♀	13	10.0	1.2	12.0	7.3	7.0	6.7	7.9	1.0	12.6	8.0	9.4	10.0	9.4	1.0	10.6	8.8	8.2	10.1	7.2	0.4	5.5	—
Watussi cattle	♂♂	1	16.0	—	—	11.0	10.0	11.0	11.0	—	—	12.0	12.0	13.0	14.0	—	—	15.0	12.0	15.0	14.0	—	—	15.0
	♀♀	1	12.0	—	—	11.0	10.0	9.0	12.0	—	—	13.0	14.0	12.0	14.0	—	—	10.0	13.0	10.0	9.0	—	—	—
Sheep	♂♂	8	6.5	0.7	10.8	4.5	5.5	5.0	5.5	0.5	9.1	6.0	6.0	6.0	5.5	0.7	12.7	6.0	6.0	6.0	6.5	0.9	13.8	—
	♀♀	9	5.0	0.8	16.0	4.0	3.3	3.6	4.3	0.7	16.3	4.0	4.0	4.3	4.0	0.8	20.0	4.3	4.3	4.0	4.0	0.8	20.0	3.0
Goat	♀♀	3	4.3	—	—	3.3	3.3	3.7	3.7	—	—	3.3	3.3	3.6	3.0	—	—	3.3	3.0	3.3	3.0	—	—	—
Roe-deer	♂♂	21	5.0	0.4	8.0	3.7	3.4	3.6	3.2	0.4	12.5	4.0	4.1	4.3	4.8	0.5	10.4	4.2	4.0	3.4	3.1	0.3	9.6	—
	♀♀	1	4.0	—	—	2.0	2.0	2.0	3.0	—	—	3.0	3.0	3.0	2.0	—	—	2.0	2.0	2.0	3.0	—	—	—
Red-deer	♂♂	16	10.0	1.0	10.0	8.0	8.7	8.7	8.5	0.6	7.0	8.7	8.7	7.7	8.7	0.5	5.7	7.3	7.6	7.3	7.0	0.3	4.2	—
	♀♀	8	6.5	0.9	13.8	5.0	5.5	5.4	6.5	0.8	12.3	7.2	7.0	6.0	5.5	0.8	14.5	5.5	5.0	5.0	5.0	0.4	8.0	—
Elk	♂♂	6	9.7	—	—	7.0	7.0	7.0	7.3	—	—	8.3	8.3	9.3	9.0	—	—	7.7	8.3	7.3	7.0	—	—	—
	♀♀	4	9.0	—	—	7.0	6.5	6.5	7.5	—	—	8.5	8.5	8.0	8.5	—	—	7.5	7.5	7.0	6.0	—	—	—
Reindeer	♂♂	6	7.0	0.7	10.0	5.0	5.6	4.5	5.0	0.6	12.0	6.2	6.0	6.0	5.5	0.9	16.4	5.0	5.0	5.2	4.0	0.6	15.0	3.5
	♀♀	1	6.0	—	—	4.0	4.0	4.0	4.0	—	—	5.0	5.0	5.0	5.0	—	—	5.0	5.0	6.0	4.0	—	—	4.0
Fallow deer	♂♂	2	6.0	—	—	4.0	4.5	4.5	4.5	—	—	5.5	5.0	5.5	4.5	—	—	4.0	4.0	3.5	4.5	—	—	—
	♀♀	3	5.3	—	—	4.3	4.3	4.7	5.3	—	—	5.3	5.7	5.3	4.7	—	—	5.0	4.0	4.0	4.7	—	—	—

Table 8

Angles of costal curves (degree).

Species	Sex & Age group	N	Consesutive numbers of ribs I			II	III	IV	V			VI	VII	VIII	IX			X	XI	XII	XIII			XIV
			$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	s	v	$\bar{x}$
Wisent	♂♂ 0	5	15.2	1.2	7.8	19.2	21.4	28.2	33.6	1.6	4.7	40.0	44.8	50.1	63.2	1.4	2.2	66.2	69.8	74.4	83.6	1.7	2.0	86.2
	I	11	21.1	3.9	18.4	25.0	28.5	36.4	45.6	4.5	9.9	51.4	54.9	61.0	67.1	3.8	5.7	75.8	84.0	84.6	86.2	3.4	3.9	92.6
	II	15	23.4	5.7	24.3	27.3	36.9	45.8	51.4	5.0	9.7	55.8	65.1	68.9	77.3	5.4	6.9	84.9	92.7	94.0	92.9	5.2	5.5	91.2
	III	13	24.1	4.9	20.3	30.5	39.4	50.8	53.6	4.6	8.5	58.0	64.0	70.1	80.2	6.0	7.4	86.3	90.0	93.0	91.4	6.6	7.2	89.4
	IV	12	23.6	3.7	15.6	32.8	42.4	52.8	56.3	2.0	3.5	59.4	66.0	74.4	84.8	8.2	9.7	90.5	94.3	95.5	94.8	6.0	6.3	86.9
	♀♀ 0	3	14.7	1.0	7.1	18.0	23.0	27.0	29.9	1.0	3.3	35.3	38.0	48.7	55.3	3.8	6.8	61.0	68.3	72.7	80.0	1.6	2.0	84.3
	I	8	20.5	3.6	17.5	24.0	35.2	45.8	50.5	3.2	6.3	54.8	61.5	67.7	73.3	6.2	8.4	75.3	77.8	84.2	86.7	11.0	12.6	83.7
	II	6	23.3	5.2	22.3	29.0	37.7	48.0	52.7	6.1	11.5	57.8	64.2	72.2	79.0	4.1	5.1	85.8	88.2	88.2	89.0	2.2	2.5	93.5
	III	7	21.0	2.6	12.3	28.0	35.6	51.0	57.1	6.3	11.0	62.5	67.0	72.4	82.1	6.3	7.6	88.8	92.9	92.1	94.2	5.4	5.9	91.0
	IV	13	24.8	3.3	13.3	32.6	46.4	57.4	60.9	5.8	9.5	63.8	66.8	72.5	80.8	5.4	6.6	85.2	88.0	88.0	90.0	5.9	6.7	86.1
Bison	♂♂	1	19.0	—	—	35.0	48.0	60.1	72.4	—	—	76.3	84.0	112.0	115.0	—	—	109.0	104.0	112.0	107.0	—	—	85.0
	♀♀	2	26.5	—	—	33.0	40.5	51.5	57.5	—	—	62.0	65.5	74.0	75.0	—	—	80.0	80.5	80.0	98.0	—	—	56.5
Cattle	♂♂	1	24.0	—	—	26.0	—	52.0	62.0	—	—	73.0	86.0	88.0	91.0	—	—	98.0	94.0	93.0	84.0	—	—	—
	♀♀	13	22.0	2.8	12.7	26.5	39.4	50.1	59.0	5.3	8.9	67.8	76.0	82.4	90.0	6.4	7.1	90.2	95.6	92.3	87.0	2.6	2.9	—
Watussi cattle	♂♂	1	25.0	—	—	33.0	44.0	56.0	64.0	—	—	74.0	84.0	91.0	97.0	—	—	98.0	100.0	100.0	97.0	—	—	94.0
	♀♀	1	27.0	—	—	38.0	58.0	66.0	76.0	—	—	86.0	98.0	104.0	106.0	—	—	108.0	118.0	118.0	—	—	—	—
Sheep	♂♂	8	37.0	4.0	10.8	37.0	37.6	44.8	66.0	5.7	8.6	74.5	80.1	84.4	90.0	6.0	6.7	96.2	98.6	99.0	96.0	7.1	7.4	—
	♀♀	9	29.0	3.1	10.7	32.8	48.2	55.2	66.0	6.4	9.7	70.6	77.0	77.9	77.0	5.9	7.7	77.0	82.0	87.0	87.0	5.6	6.4	38.0
Goat	♀♀	3	36.3	—	—	40.0	45.6	54.8	64.3	—	—	77.1	80.6	84.0	89.5	—	—	88.9	91.0	92.4	85.3	—	—	—
Roe-deer	♂♂	21	31.0	3.4	10.9	39.4	48.2	58.8	83.0	5.6	6.7	88.7	95.5	102.2	104.0	5.4	5.1	107.3	110.5	112.8	105.2	7.8	7.4	—
	♀♀	1	34.0	—	—	40.0	66.0	92.0	97.0		—	97.0	96.0	96.0	96.0	—	—	98.0	106.0	116.0	98.0	—	—	—
Red-deer	♂♂	16	24.0	1.6	6.6	34.6	49.2	67.5	73.0	3.4	4.6	83.4	86.3	95.4	101.0	6.6	6.5	106.7	109.0	100.5	96.0	5.8	6.0	—
	♀♀	8	24.0	2.0	8.3	26.6	51.9	71.8	82.0	6.1	7.4	90.2	94.3	100.5	105.0	8.2	7.8	108.5	109.3	106.2	102.0	7.6	7.4	—
Elk	♂♂	6	18.0	2.3	12.8	19.4	34.7	42.2	57.0	4.2	7.4	60.4	69.7	75.2	76.0	4.6	6.0	78.0	84.3	86.5	84.6	5.9	7.0	—
	♀♀	4	28.0	—	—	28.0	42.0	47.3	68.1	—	—	69.0	75.2	81.5	86.8	—	—	88.5	86.3	87.1	92.0	—	—	—
Reindeer	♂♂	6	23.0	3.0	13.0	37.4	41.8	52.7	62.0	6.0	9.7	71.4	79.5	81.3	94.2	7.1	7.6	94.2	93.1	90.3	73.0	6.0	8.2	60.0
	♀♀	1	28.0	—	—	33.0	35.0	53.0	64.0	—	—	76.0	80.0	88.0	86.0	—	—	88.0	88.0	86.0	70.0	—	—	61.0
Fallow deer	♂♂	2	33.5	—	—	38.6	48.5	60.0	74.5	—	—	89.5	91.0	102.0	102.5	—	—	113.5	114.0	115.5	107.0	—	—	—
	♀♀	3	27.6	—	—	27.4	41.9	62.6	76.8	—	—	85.6	87.9	95.4	98.4	—	—	101.0	105.6	106.0	104.2	—	—	—

rib *IX* onwards. The tubercle on rib *XIV* has no articular surface.

Angulus costae, faint in the first ribs and distinct in subsequent ribs, can be seen below the tubercle on the external surface of the shaft of the rib.

The shaft of rib *I* is similar in shape to a laterally flattened oval, and becomes increasingly flat in further ribs. The posterior margin of the shaft is always sharper than the anterior. *Sulcus muscularis* occurs on the external surface of the shaft, and is indistinct in the first two ribs, then in the following ribs up to rib *IX* gradually deepens and widens, to become shallower and narrower again in subsequent ribs. This sulcus is always deeper near the tubercle in all the ribs.

The sternal extremity of ribs *I* is decidedly wide and similar in shape to a laterally flattened oval. This flattening does not occur in the other ribs and the sternal extremity is of a distinct capital shape.

This part of the rib has a slightly concave surface which connects with the corresponding cartilaginous part of the rib, in the form of an articulation, with a fairly thick and taut joint capsule. In the oldest European bison (over 15 years old) the bony part of the rib joins the cartilaginous part by means of synchondrosis.

An exception to this rule is formed by rib *I,* in which even in the youngest individuals no traces of diarthrosis were observed between the cartilaginous and bony parts of the rib. A cartilaginous rib was in fact observed only in European bison up to the age of 8 (males) or 10 (females), after which time it completely ossifies, and thus forms a stable connection with the original bony part of the rib and together with it, one indivisible whole.

Cartilago costalis

Cartilago costalis of the initial pairs of ribs for an extension of the bony part of the ribs, and in a posterior direction connects with the bony parts of the ribs at an increasingly acute angle. In both sexes up to the age of 12 the connection between the cartilaginous part of the rib and the sternum takes the form of *diarthrosis,* to become a *synarthrosis* in older animals. This does not apply to rib *I,* in which at the age of 2 the connection between its cartilaginous part and the sternum takes the form of a *synchondrosis,* or even (some of the older males) *synostosis.*

Among the 14 pairs of ribs usually occurring in the European bison, the first 8, are *costae verae,* and the remaining 6 *costae spuriae.* The cartilaginous parts of the latter form *arcus costalis.* It was only in the 15-year old »Puls« that we found 9 pairs of *costae verae* and 5 pairs of *costae spuriae.*

In the American bison and reindeer there are 8 pairs of *costae verae* and 6 pairs of *costae spuriae*. Among the 13 pairs of ribs in the other ruminants 8 are true ribs and 5 false ribs.

Rib *I* is always the shortest in the European bison, length increasing in the following consecutive ribs to reach maximum length in rib *IX* (Table 2). As from rib *X* this measurement gradually decreases. Ribs are decidedly longer in males.

In the other species (Table 2) maximum length is attained by rib *VIII* or *IX* (domestic cattle, goats, red-deer. fallow-deer) *IX* or *X* (sheep, American bison, reindeer) or rib *VIII* (roe-deer, elk).

Length measured along the pericentral curve of the rib, like the previous measurement, is always greater in males, but the maximum value shifts in this case to rib *X* (Table 3). An exception to this in formed by group 0 of males and groups 0 and I of females, when this dimension is greatest in the case of rib *IX*. As in the case of the previous dimension, rib *I* is characterized by the lowest values.

Among the other ruminants examined (Table 3) the longest along the curve is either rib *IX* or *X* (sheep, American bison), rib *VIII* or *IX* (Watussi cattle) or rib *VIII* (remaining species).

The width of the shaft of the rib (Table 4) attains higher values in males than in females in almost all the European bison (except group 0). In groups 0 the results of measurements in both sexes are similar and there is even (rib *I*, *V*, *VI*) a certain predomination in this respect in females.

The shaft of rib *I* in the European bison is fairly narrow (Table 4), but becomes wider in the subsequent ribs up to *VII* or *VIII*, to narrow again in following ribs.

In American bison, domestic cattle and goats the widest shaft is found in rib *VII* or *VIII*, in fallow deer, roe-deer and red-deer — rib *VII*, in the elk — *V* and in the reindeer — *IV* (Table 4). All the ribs belonging to adult individuals of domestic and Watussi cattle are wider than the corresponding ribs in adult European bison.

Both in European bison and the other species it is always rib *I* which is decidedly the widest at its sternal extremity (Table 5) and the values of this dimension are greater in males. The width of the sternal extremity of rib *II* markedly decreases, but increases again in subsequent ribs.

The diameter of the head of rib *I* is smaller than that of rib *II* only in the youngest European bison of both sexes (Table 6), the reverse being the case in the other groups. In the following successive ribs of group 0 and *I* for males, and in all females it exhibits no great change, while in the other male European bison only small fluctuations are visible from rib *II* to *VI*. This dimension distinctly increases in ribs *VII* to *IX* in males, but returns to the previous dimension in the other ribs. Comparison of the diameter of the costal head in the European bison and I for males, and in all females, it exhibits no great change, while

The thickness of the shaft in the youngest European bison is almost uniform in relation to all the ribs (Table 7). Rib *I* is decidedly the thickest in both sexes, its predominance over the other ribs being very distinct in males, and less distinct in females. As is the case with European bison, the thickest shaft is that of rib *I* in all the other species examined (Table 7). It must also be emphasised that the thickness of the various ribs in the European bison is greater than this dimension in other ruminants.

The angles of the curves in the European bison are small in the true ribs, but gradually increase caudad until rib *XII* is reached (Table 8). A very slight decrease in the values of these angles in relation to the preceding ribs can be observed in the last two ribs (group II, III, IV of males and I, III and IV of females). The two last ribs are characterized by maximum individual variation in respect of length and also degree of curvature. No exact sex differences can be established in European bison on the basis of values of angles of the costal curves. The true ribs in ruminants with small body mass, such as sheep, goats, roe-deer or fallow-deer, are more curved than in red-deer, elk, reindeer, domestic cattle, Watussi cattle, American or European bison (Table 8).

False ribs are less curved in the European bison in domestic cattle, Watussi cattle, American bison, red-deer, roe-deer and fallow-deer (Table 8). The degree of their curvature is similar to that in sheep, goat, elk and reindeer.

The length of the radius defining the rib is changin reverse to the value of the angle of curve. Both in the European bison and the other species, the curved the rib, the longer its radius (Table 9). Thus radii are longer in true than in false ribs.

Coefficients of curvature of the ribs are small in the initial ribs, and increase successively caudad (Table 10). It can be seen from the table given that these coefficients are in reverse proportion to age. Coefficients of curvature are greater in females in the corresponding groups of males and females.

Coefficient of curvature of true ribs in sheep, goats, roe-deer and fallow-deer are correspondingly higher than in the other ruminants with greater body mass (Table 10). Coefficients of curvature for false ribs in American bison, domestic and Watussi cattle and elk are similar to the corresponding values for European bison.

The chord of the rib in European bison of both sexes gradually increases from rib *I* to rib *VIII* or *IX*, after with its value decreases up to the

Table 9

Length of radius of costal curves (mm).

Species	Sex Age group	N	Consecutive numbers of ribs I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Wisent	♂♂ 0	5	419.5	375.8	359.0	312.1	283.8	261.7	247.6	231.3	187.1	175.8	157.8	136.3	109.2	85.4
	I	11	613.3	592.6	584.6	514.8	459.6	442.3	441.6	419.4	395.5	341.0	307.4	276.4	247.2	199.8
	II	15	744.2	728.8	597.1	536.1	526.9	526.0	488.6	475.6	435.5	396.3	355.1	331.9	304.5	258.9
	III	13	757.6	700.9	603.1	543.8	534.8	518.9	518.6	493.2	439.7	408.4	379.6	346.0	323.4	272.3
	IV	12	777.7	657.1	569.5	536.1	526.4	511.4	509.4	468.4	423.1	391.5	369.7	343.4	315.0	272.0
	♀♀ 0	3	388.0	361.2	312.2	294.0	292.4	264.1	261.1	219.0	196.5	173.4	147.8	130.8	108.1	82.2
	I	8	623.2	596.4	470.9	406.1	403.8	396.7	389.2	370.5	343.3	325.8	296.8	260.9	227.9	212.2
	II	6	658.2	597.0	518.8	462.0	456.1	454.9	443.3	412.6	382.2	352.8	308.3	284.4	234.6	228.6
	III	7	655.4	662.0	598.0	456.4	450.0	448.8	439.9	424.6	386.3	358.2	335.0	317.5	294.5	225.5
	IV	13	667.6	589.0	568.5	456.6	449.2	437.4	435.0	421.4	402.9	367.4	360.8	340.8	315.8	241.6
Bison	♂♂	1	915.1	571.9	474.5	430.0	382.7	393.0	385.5	322.0	317.1	329.8	306.4	278.6	281.7	271.6
	♀♀	2	591.1	558.0	515.3	450.6	444.7	445.1	440.6	421.6	415.5	389.7	387.7	354.3	274.9	348.7
Cattle	♂♂	1	715.4	820.0	—	496.1	454.3	449.0	379.7	375.7	359.5	332.5	346.5	329.4	315.3	—
	♀♀	13	643.3	650.6	489.2	426.5	397.8	388.3	367.7	350.1	324.2	318.3	302.5	283.4	258.4	—
Watussi cattle	♂♂	1	644.6	595.0	511.2	441.9	423.6	403.7	385.5	368.7	343.1	339.2	326.3	324.4	321.0	296.0
	♀♀	1	509.8	442.2	337.2	335.1	329.7	318.9	314.0	302.0	291.7	280.5	260.7	270.6	—	—
Sheep	♂♂	8	175.7	204.0	221.3	223.6	168.4	159.5	154.4	151.3	142.8	135.9	126.5	120.6	111.3	—
	♀♀	9	192.8	224.2	177.4	175.0	157.5	156.0	153.8	152.6	150.4	146.6	130.5	111.3	99.0	119.7
Goat	♀♀	3	137.5	155.4	166.3	154.8	140.0	126.1	127.0	124.0	120.5	112.2	100.9	91.2	81.1	—
Roe-deer	♂♂	21	166.5	169.2	167.1	155.7	125.4	125.2	122.8	121.4	119.9	110.0	103.1	91.6	82.5	—
	♀♀	1	112.8	128.6	95.4	78.5	77.4	82.7	91.5	94.1	93.5	88.1	78.8	65.4	61.0	—
Red-deer	♂♂	16	488.9	420.6	337.1	279.0	262.6	264.5	269.9	257.9	244.0	224.3	205.9	197.5	171.7	—
	♀♀	8	419.6	475.5	282.8	232.9	219.4	213.9	220.1	213.7	203.2	190.6	178.4	163.4	140.5	—
Elk	♂♂	6	797.6	919.6	579.6	505.0	400.2	397.3	357.5	356.0	374.5	324.3	285.9	256.0	225.9	—
	♀♀	4	512.6	616.9	464.5	445.3	337.0	353.9	340.8	317.6	301.3	281.0	269.0	239.6	194.7	—
Reindeer	♂♂	6	364.3	295.6	313.3	278.2	259.0	245.9	238.5	237.0	213.5	208.5	204.3	192.5	200.0	185.6
	♀♀	1	276.9	295.7	327.5	248.7	231.1	212.7	216.2	207.2	217.0	208.7	194.3	177.4	177.8	161.5
Fallow deer	♂♂	2	198.0	217.5	196.7	177.5	158.2	149.6	142.3	140.2	139.6	124.1	116.5	106.1	93.6	—
	♀♀	3	237.7	301.1	230.7	173.3	156.7	154.8	154.7	150.7	144.1	138.8	128.1	122.2	99.0	—

Table 10

Coefficients of curvature of ribs.

Species	Sex & Age group	N	Consecutive numbers of ribs													
			I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*
Wisent	♂♂ 0	5	24	27	28	32	35	38	40	43	53	57	63	73	92	117
	I	13	16	17	17	19	22	23	23	24	25	29	32	36	40	50
	II	15	13	14	17	19	19	20	21	23	25	25	28	30	33	37
	III	13	13	14	16	18	19	19	19	20	23	24	26	29	31	37
	IV	12	13	15	18	19	19	20	20	21	24	26	27	29	32	37
	♀♀ 0	3	26	28	32	34	36	38	46	51	58	58	68	76	92	122
	I	8	16	18	21	25	25	25	26	29	29	31	34	38	44	47
	II	6	15	17	19	22	22	22	22	24	26	33	33	35	42	44
	III	7	15	15	17	22	22	22	23	24	26	28	30	31	34	44
	IV	13	15	17	21	22	22	23	23	24	27	27	28	29	32	41
Bison	♂♂	1	11	17	21	23	26	25	26	31	32	30	33	36	35	37
	♀♀	2	17	18	19	22	22	22	23	24	24	25	26	28	36	28
Cattle	♂♂	1	14	12	—	20	22	22	26	27	28	30	29	30	32	—
	♀♀	13	16	15	20	23	25	26	27	28	31	31	33	35	39	—
Watussi cattle	♂♂	1	16	17	20	23	24	25	26	27	29	29	30	30	31	34
	♀♀	1	19	22	29	30	30	31	32	33	34	35	38	73	—	—
Sheep	♂♂	8	57	49	45	44	59	62	64	66	70	73	79	82	89	—
	♀♀	9	53	44	56	57	63	64	65	65	66	68	77	90	101	83
Goat	♀♀	3	72	64	60	64	71	79	79	80	82	89	99	101	123	—
Roe-deer	♂♂	21	60	59	59	64	79	79	81	82	83	90	96	101	121	—
	♀♀	1	88	77	104	127	129	120	109	106	106	113	126	152	163	—
Roe-deer	♂♂	16	20	23	29	35	38	37	37	38	40	44	48	50	58	—
	♀♀	8	24	21	35	42	45	46	45	46	49	52	56	61	71	—
Elk	♂♂	6	12	10	17	19	24	25	27	28	28	31	35	39	44	—
	♀♀	4	19	16	19	22	30	28	29	31	33	36	37	42	51	—
Reindeer	♂♂	6	27	34	31	36	39	41	42	42	47	48	49	52	50	54
	♀♀	1	36	34	30	40	43	47	46	48	46	47	51	56	56	61
Fallow deer	♂♂	2	50	46	51	56	63	67	70	71	72	80	86	94	106	—
	♀♀	3	42	33	43	57	63	64	65	66	69	72	78	81	101	—

final rib (Table 11). The situation is the same in the case of sheep and goats, in which length of the chord increases up to rib *VIII* or *IX* (Table 11). In domestic cattle and Watussi cattle, roe-deer, red-deer and fallow-deer, the chord of rib *VIII* is the longest, in the elk *VII* or *VIII*, in the reindeer rib *IX* and in American bison *IX* or *X*.

The area of the tranvers section of ribs in both European bison and the other ruminants differs for differents ribs (Table 12). It also depends on the place in the rib in which it was defined, and this area is usually greater in true ribs in all the mammals examined. The area of the cross-section of ribs is one of the characters in which sex differences are most clearly evident.

In all the European bison the bony part on the rib is longer than the cartilaginous part. In the case of rib *I* the ratio of length of the bony part to the cartilaginous part is most favourable for the former (Table 13), but this ratio changes take place with increasing age.

In adult female domestic cattle the cartilaginous part lengthens with each succeeding rib (Table 13). Rib *I* in cattle has a relatively longer cartilaginous part than the corresponding rib in European bison.

2. *Sternum*

The sternum in European bison consists of 7 parts, *sternebrae*, 1 of which forms *manubrium sterni*, 5 form *corpus sterni* and 1 — *processus xiphoideus*.

Manubrium sterni in European bison is markedly flattened laterally and differs decidedly in this respect from *manubrium sterni* in domestic cattle, in which the flattening is dorso-ventral. Owing to the lateral flattening *crista sterni* is formed on the ventral surface of *manubrium sterni* in European bison. The anterior part of the *manubrium* ends in a distinct thickening, possessing articular surfaces serving for connection with the cartilages of the first pair of ribs. *Manubrium sterni* is connected with its shaft by means of an articulation.

The first two parts of the shaft are still flattened laterally, like the *manubrium*, while the others are flattened dorso-ventrally. The various parts composing the shaft are connected by synchondroses. In very old European bison (over 15 years old) these connections are replaced by synostoses. Ossification of these synchondroses always takes place in posterior-anterior direction, and thus the synchondrosis connection the final part of the shaft with *processus xiphoideus* is the first to ossify.

In the place where the various part of the shaft are connected *incisurae costales* occur on both the lateral margins and serve to connect with the corresponding pairs of cartilaginous ribs. Incisurae for the second

Table 11

Length of chord of ribs.

Species	Sex & Age group	N	I $\bar{x}$	I s	I v	II $\bar{x}$	III $\bar{x}$	IV $\bar{x}$	V s	V v	VI $\bar{x}$	VII $\bar{x}$	VIII $\bar{x}$	IX $\bar{x}$	IX s	IX v	X $\bar{x}$	XI $\bar{x}$	XII $\bar{x}$	XIII $\bar{x}$	XIII s	XIII v	XIV $\bar{x}$
Wisent	0	5	109.5	9.5	8.6	124.0	137.0	151.0	16.0	9.6	179.0	189.5	196.5	195.5	10.5	5.3	191.5	181.0	166.0	145.5	3.5	3.0	116.5
	I	11	223.5	27.4	12.2	256.5	289.5	321.0	41.0	11.5	382.5	410.8	425.7	436.6	52.1	11.9	416.8	411.4	373.5	338.2	26.4	7.8	289.8
	II	15	296.8	9.9	3.7	340.2	375.6	413.2	20.3	4.4	494.0	525.0	541.0	542.2	24.8	4.5	535.5	512.4	485.5	441.8	24.4	5.5	369.4
	III	13	315.0	15.7	4.9	362.8	405.9	443.9	23.3	4.7	518.6	550.0	565.8	567.2	25.5	4.4	557.0	536.9	502.0	461.4	30.4	6.5	382.8
	IV	12	314.5	16.8	5.3	369.6	411.3	449.3	19.9	4.0	530.8	557.0	566.0	562.6	16.6	2.9	555.3	536.5	507.7	463.3	18.8	4.0	373.3
	0	3	99.0	1.0	1.0	113.0	124.5	136.5	1.0	0.6	158.5	172.0	180.5	182.5	2.4	1.3	176.0	166.0	155.0	139.0	3.0	2.1	114.5
	I	8	220.0	18.0	8.1	248.0	283.2	313.0	23.1	6.7	346.3	397.0	410.8	410.0	34.3	8.3	398.2	372.3	349.2	312.8	27.5	8.7	282.0
	II	6	266.2	12.0	4.5	296.0	335.0	370.0	14.9	3.6	440.0	469.8	485.0	486.3	15.5	3.1	478.3	461.0	432.2	395.2	14.7	3.7	330.8
	III	7	282.3	8.8	3.1	320.3	363.0	393.0	5.4	1.3	465.8	485.6	501.2	507.0	5.9	1.2	500.7	484.7	459.5	420.2	14.2	3.3	330.0
	IV	13	285.2	9.5	3.3	328.0	368.6	404.3	23.6	5.3	471.7	499.6	516.2	519.8	11.1	2.1	515.1	501.3	473.4	434.9	18.3	4.2	329.6
Bison	♂♂	1	302.0	—	—	344.0	386.0	430.0	—	—	484.0	516.0	534.0	535.0	—	—	537.0	483.0	462.0	453.0	—	—	367.0
	♀♀	2	266.0	—	—	317.0	352.5	388.0	—	—	458.5	473.5	507.5	506.0	—	—	501.0	498.5	455.5	415.0	—	—	327.5
Cattle	♂♂	1	297.0	—	—	369.0	—	435.0	—	—	501.0	518.0	522.0	513.0	—	—	502.0	507.0	478.0	422.0	—	—	—
	♀♀	13	245.5	20.7	8.4	292.8	326.6	360.5	31.4	8.0	428.7	452.8	459.5	458.5	39.9	8.7	450.2	446.1	407.7	355.8	30.8	8.6	—
Watussi cattle	♂♂	1	279.0	—	—	338.0	383.0	415.0	—	—	486.0	516.0	526.0	514.0	—	—	512.0	500.0	497.0	481.0	—	—	433.0
	♀♀	1	288.0	—	—	298.0	327.0	365.0	—	—	435.0	474.0	476.0	466.0	—	—	454.0	447.0	464.0	—	—	—	—
Sheep	♂♂	8	111.5	9.4	8.4	129.5	140.5	167.5	16.7	9.1	192.0	198.5	202.5	202.0	18.4	9.1	202.0	191.0	183.5	165.5	14.8	8.9	—
	♀♀	9	96.6	7.9	8.2	123.6	144.3	161.6	16.2	9.4	179.0	187.3	190.0	191.6	18.0	9.4	182.6	171.3	153.3	136.3	10.1	7.4	78.0
Goat	♀♀	3	85.0	—	—	106.3	127.3	140.6	—	—	157.0	163.3	166.0	169.0	—	—	156.0	144.0	131.3	109.6	—	—	—
Red-deer	♂♂	21	89.0	7.4	8.3	113.6	136.2	151.9	18.4	11.4	174.3	185.0	191.6	189.0	13.2	6.9	177.0	169.5	152.2	131.0	4.7	3.5	—
	♀♀	1	66.7	—	—	88.2	104.0	113.6	—	—	124.5	136.0	140.7	139.1	—	—	133.2	126.0	111.0	92.3	—	—	—
Roe-deer	♂♂	16	203.3	18.4	9.0	246.0	279.6	308.0	28.7	9.1	350.6	371.6	380.3	376.6	36.4	9.6	358.3	335.3	302.6	255.3	23.6	9.2	—
	♀♀	8	174.5	15.6	8.9	214.0	243.5	270.2	25.4	8.8	302.6	322.0	327.5	322.5	28.1	8.7	308.5	290.4	261.0	218.5	17.8	8.1	—
Elk	♂♂	6	249.5	20.9	8.4	303.5	339.0	362.0	35.3	9.2	397.3	405.0	433.5	428.0	38.7	9.0	408.2	382.7	349.3	302.4	28.1	9.3	—
	♀♀	4	248.0	—	—	298.5	333.0	355.5	—	—	401.0	415.0	412.5	411.0	—	—	390.5	367.0	330.0	284.0	—	—	—
Reindeer	♂♂	6	145.3	13.0	8.9	187.6	219.5	244.0	23.9	9.0	285.7	303.5	307.9	312.4	27.2	8.7	305.0	296.5	272.3	238.0	20.3	8.5	185.6
	♀♀	1	134.0	—	—	168.0	197.0	222.0	—	—	262.0	278.0	288.0	296.0	—	—	290.0	270.0	242.0	204.0	—	—	164.0
Fallow deer	♂♂	2	112.5	—	—	141.5	160.0	177.5	—	—	199.5	213.5	218.0	217.0	—	—	207.0	195.5	179.0	150.5	—	—	—
	♀♀	3	111.2	—	—	140.6	161.6	178.3	—	—	209.3	213.0	222.3	217.6	—	—	214.3	203.3	195.3	156.0	—	—	—

Table 12

Area of cross-section of ribs.

Species	Sex & Age group	N	Rib I a $\bar{x}$	s	v	b $\bar{x}$	s	v	c $\bar{x}$	s	v	Rib V a $\bar{x}$	s	v	b $\bar{x}$	s	v	c $\bar{x}$	s	v	Rib IX a $\bar{x}$	s	v	b $\bar{x}$	s	v	c $\bar{x}$	s	v	Rib XIII a $\bar{x}$	s	v	b $\bar{x}$	s	v	c $\bar{x}$	s	v
Wisent	♂♂ 0	5	30.6	1.7	5.3	37.2	3.3	8.8	38.8	6.3	16.2	29.8	3.9	13.0	32.4	4.0	12.3	103.6	6.3	6.1	34.8	3.5	10.0	25.0	3.5	14.0	44.0	7.2	16.3	21.6	3.3	15.2	23.8	1.0	4.2	16.2	1.7	10.4
	I	11	118.4	30.6	25.8	144.9	29.4	20.2	312.6	77.0	24.6	122.9	27.4	22.2	131.9	17.2	13.0	242.2	42.0	17.3	117.4	24.0	13.5	154.1	28.1	18.2	163.2	25.1	15.3	98.4	20.6	20.9	117.9	23.4	19.8	85.6	10.1	11.7
	II	15	282.9	41.4	14.6	368.3	34.6	9.3	737.9	128.9	17.4	269.0	25.4	9.4	282.5	30.7	10.8	418.1	26.9	6.4	259.7	24.7	9.5	346.9	47.7	13.7	404.4	38.8	9.5	235.7	25.1	10.6	284.4	26.2	9.2	150.9	19.6	12.9
	III	13	344.8	43.8	12.7	438.7	35.9	8.1	1016.4	132.1	12.9	319.1	27.9	8.7	321.2	32.5	10.1	492.0	38.4	7.8	294.9	26.4	8.9	389.5	39.0	10.0	423.9	37.2	8.8	271.3	26.5	9.6	313.8	29.7	9.4	182.7	19.9	10.8
	IV	12	351.7	40.8	11.6	499.7	45.2	9.0	1126.8	121.3	10.7	327.2	30.4	9.2	328.1	32.5	9.9	558.8	50.9	9.1	301.7	31.3	10.3	457.0	46.1	10.0	394.2	36.7	9.3	278.3	28.2	10.1	344.9	37.1	10.7	160.6	18.9	11.7
	♀♀ 0	3	21.0	3.6	17.1	22.7	2.2	9.6	70.0	5.3	7.5	17.7	2.4	13.5	18.7	2.2	11.7	44.0	3.2	7.2	18.3	2.5	13.6	24.3	3.7	15.2	70.3	11.6	16.5	16.0	1.3	8.1	13.0	2.8	21.5	15.3	2.2	14.3
	I	8	117.2	23.0	19.6	191.9	31.5	19.4	311.6	39.7	12.7	114.8	15.5	13.5	136.6	13.9	10.1	199.9	23.8	11.9	130.0	20.0	15.3	148.5	17.9	12.0	145.2	19.4	13.3	101.5	14.6	14.3	129.5	16.3	12.5	69.9	9.1	13.0
	II	6	171.2	25.9	15.1	233.5	29.3	12.5	514.7	54.8	10.6	181.3	20.7	11.4	187.8	11.3	6.0	288.7	24.9	8.6	174.3	27.0	15.4	232.6	19.9	8.5	229.3	24.7	10.7	149.2	17.3	11.7	187.5	22.6	12.0	87.8	10.2	11.6
	III	7	195.9	17.2	8.7	249.9	23.2	9.2	532.0	54.1	10.1	212.1	22.4	10.5	223.0	28.0	15.2	311.5	27.5	8.8	211.1	26.4	12.5	307.1	28.5	9.2	276.4	29.1	10.5	189.7	21.2	11.1	250.7	29.3	11.6	119.8	24.6	18.0
	IV	13	205.3	8.5	4.1	292.3	22.7	7.7	577.4	50.1	8.6	223.7	14.8	6.6	223.9	17.6	7.8	364.9	31.5	8.6	215.5	17.3	8.0	300.6	26.1	8.6	257.0	20.2	7.8	199.0	24.3	12.2	262.4	23.1	8.8	107.6	8.3	7.7
Bison	♂♂	1	139.0	—	—	197.0	—	—	114.0	—	—	187.0	—	—	242.0	—	—	121.0	—	—	198.0	—	—	236.0	—	—	572.0	—	—	190.0	—	—	198.0	—	—	238.0	—	—
	♀♀	2	180.5	—	—	210.0	—	—	185.3	—	—	121.0	—	—	162.0	—	—	61.5	—	—	188.5	—	—	240.0	—	—	387.5	—	—	190.0	—	—	185.0	—	—	232.5	—	—
Cattle	♂♂	1	409.0	—	—	582.0	—	—	640.0	—	—	319.0	—	—	295.0	—	—	192.0	—	—	362.0	—	—	369.0	—	—	920.0	—	—	483.0	—	—	591.0	—	—	519.0	—	—
	♀♀	13	226.4	18.1	8.0	303.8	26.4	8.7	334.2	24.2	7.2	168.4	14.9	8.8	154.6	14.7	9.5	85.0	7.0	8.2	198.0	27.0	13.6	217.4	23.4	10.7	452.1	41.3	9.1	219.0	23.1	10.5	252.0	22.0	8.7	335.3	29.7	8.8
Watussi cattle	♂♂	1	274.0	—	—	258.0	—	—	229.0	—	—	341.0	—	—	453.0	—	—	519.0	—	—	274.0	—	—	258.0	—	—	949.0	—	—	297.0	—	—	404.0	—	—	499.0	—	—
	♀♀	1	249.0	—	—	446.0	—	—	344.0	—	—	126.0	—	—	127.0	—	—	122.0	—	—	193.0	—	—	253.0	—	—	626.0	—	—	224.0	—	—	417.0	—	—	464.0	—	—
Sheep	♂♂	8	53.2	5.0	9.4	69.0	5.4	7.8	49.6	3.7	7.6	40.0	3.5	8.8	44.1	4.0	9.1	25.6	2.4	9.6	69.0	5.7	8.3	66.2	6.4	9.7	146.1	13.7	9.4	43.4	4.1	9.5	42.1	3.9	9.3	84.0	7.3	11.5
	♀♀	9	30.1	4.1	11.4	25.6	2.1	8.4	16.5	2.0	12.5	15.3	1.7	11.3	17.3	2.0	11.8	6.0	0.9	15.0	30.0	4.1	13.7	33.2	3.6	10.9	46.0	3.9	8.5	28.0	3.2	11.4	32.1	2.9	9.1	44.2	3.6	8.2
Goat	♀♀	3	15.6	—	—	16.5	—	—	8.6	—	—	13.0	—	—	10.7	—	—	6.6	—	—	34.9	—	—	34.1	—	—	60.0	—	—	27.7	—	—	33.6	—	—	27.4	—	—
Roe-deer	♂♂	21	23.7	1.8	7.8	27.4	2.4	8.8	11.2	1.0	9.0	19.0	1.9	10.0	24.2	1.9	7.9	6.1	0.7	11.6	29.3	3.0	10.3	36.6	2.9	8.0	37.2	3.9	10.5	33.0	2.4	7.2	45.5	3.0	6.6	37.6	4.3	11.5
	♀♀	1	8.0	—	—	10.0	—	—	9.0	—	—	11.0	—	—	11.0	—	—	7.0	—	—	29.0	—	—	17.0	—	—	37.0	—	—	12.0	—	—	19.0	—	—	23.0	—	—
Red-deer	♂♂	16	94.5	6.7	7.1	93.7	7.5	8.0	52.1	3.0	5.7	80.3	5.1	6.3	68.8	4.0	5.8	25.2	2.0	8.0	150.2	12.1	8.0	138.7	13.0	9.4	238.4	18.0	7.5	132.8	8.7	6.5	137.0	9.4	6.8	124.2	7.1	5.7
	♀♀	8	48.2	3.9	8.1	52.5	4.7	9.0	26.4	3.0	11.5	40.4	4.2	10.5	33.0	3.5	10.6	12.4	1.3	10.8	74.6	7.2	9.7	58.1	4.7	8.1	100.0	9.1	9.1	88.8	7.9	9.0	88.4	7.1	8.1	88.3	7.4	8.4
Elk	♂♂	6	112.4	10.2	8.4	94.2	7.5	8.0	123.0	9.6	7.8	86.3	6.7	7.8	78.6	6.9	8.8	77.0	5.0	6.5	186.1	16.5	8.6	185.4	16.0	8.6	309.5	27.4	8.9	135.4	10.3	7.6	111.0	8.7	7.8	161.4	14.1	8.8
	♀♀	4	105.2	—	—	121.7	—	—	74.0	—	—	66.5	—	—	66.3	—	—	46.0	—	—	133.5	—	—	132.2	—	—	204.0	—	—	120.2	—	—	134.7	—	—	163.3	—	—
Reindeer	♂♂	6	51.7	4.1	8.0	52.0	4.0	7.7	40.7	4.0	10.0	56.6	4.7	8.4	41.0	3.5	8.5	24.8	3.0	12.5	78.3	6.1	7.8	74.2	5.8	7.8	118.4	9.3	7.9	68.0	5.2	7.6	70.1	5.0	7.1	84.6	6.3	7.5
	♀♀	1	53.0	—	—	39.0	—	—	46.0	—	—	44.0	—	—	28.0	—	—	31.0	—	—	57.0	—	—	50.0	—	—	97.0	—	—	58.0	—	—	52.0	—	—	76.0	—	—
Fallow deer	♂♂	2	29.0	—	—	34.5	—	—	15.0	—	—	28.5	—	—	27.0	—	—	6.0	—	—	44.5	—	—	50.5	—	—	70.0	—	—	49.5	—	—	51.0	—	—	30.0	—	—
	♀♀	3	29.3	—	—	33.1	—	—	12.7	—	—	19.0	—	—	18.6	—	—	4.0	—	—	37.8	—	—	36.2	—	—	45.9	—	—	35.7	—	—	51.9	—	—	32.0	—	—

Table 14

Dimensions of sternum.

Species	Sex & Age group	N	Maximum length			Maximum breadth			Breadth of manubrium			Breadth of metasternum			Height of manubrium			Height of metasternum		
			$\bar{x}$	s	v	$\bar{x}$	s	v	$\bar{x}$	s	v	$\bar{x}$	s	v	$\bar{x}$	s	v	$\bar{x}$	s	v
Wisent	♂♂ 0	5	188.2	10.4	5.5	43.0	2.0	4.6	18.4	1.6	8.6	11.6	1.4	12.0	28.0	1.6	5.7	6.0	1.0	16.6
	I	11	392.9	10.5	2.7	66.9	11.8	17.6	35.2	6.0	17.0	38.7	9.0	23.2	51.1	4.1	8.0	10.7	1,7	15.8
	II	15	509.4	28.2	5.5	102.4	11.6	11.3	49.7	13.7	27.5	48.3	9.8	20.2	64.5	11.2	17.3	13.9	2.2	15.8
	III	13	543.2	33.4	6.1	111.8	9.7	8.6	55.8	4.5	8.0	52.7	10.7	20.3	74.2	10.9	14.6	16.9	2.4	14.2
	IV	12	558.8	44.3	7.9	116.3	7.9	6.7	57.7	5.7	9.8	54.5	8.4	15.4	77.3	10.5	13.5	19.2	3.6	18.7
	♀♀ 0	3	175.0	10.1	5.7	37.0	3.0	8.1	10.0	0.6	6.0	9.0	0.5	5,5	17.0	1.4	8.2	3.3	0.4	12.1
	I	8	385.3	28.7	7.4	62.0	7.6	12.2	30.0	3.0	10.0	38.1	2.0	5.2	46.5	6.5	13.9	9.0	1.2	13.3
	II	6	446.3	20.8	4.7	98.7	11.0	11.1	40.8	3.5	8.5	42.7	8.2	19.2	55.3	7.2	13.0	11.2	1.4	12.5
	III	7	478.6	30.5	6.3	99.2	10.3	10.4	42.5	3.0	7.0	44.0	2.8	6.3	59.8	3.3	5.5	11.8	2.0	16.9
	IV	13	481.0	36.4	7.5	99.5	7.3	7.4	42.7	3.3	7.7	44.5	6.2	13.9	60.9	4.8	7.8	11.8	1.4	11.8
Bison	♂♂	1	468.0	—	—	78.0	—	—	38.0	—	—	26.0	—	—	66.0	—	—	14.0	—	—
	♀♀	2	407.5	—	—	69.0	—	—	37.0	—	—	19.5	—	—	58.0	—	—	13.0	—	—
Cattle	♂♂	1	567.0	—	—	105.0	—	—	74.0	—	—	48.0	—	—	87.0	—	—	19.0	—	—
	♀♀	13	420.3	24.4	5.8	86.4	12.8	14.8	49.8	7.2	14.4	35.4	3.9	11.0	55.3	6.1	11.0	10.8	1.3	12.0
Watussi cattle	♂♂	1	516.0	—	—	112.0	—	—	56.0	—	—	70.0	—	—	72.0	—	—	20.0	—	—
	♀♀	1	409.0	—	—	78.0	—	—	50.0	—	—	44.0	—	—	57.0	—	—	17.0	—	—
Sheep	♂♂	8	224.7	23.1	10.3	41.5	4.0	9.6	24.0	2.6	10.8	15.5	1.7	11.0	16.0	1.8	11.2	8.5	0.9	10.6
	♀♀	9	204.3	22.9	11.2	34.0	3.9	11.5	13.0	2.0	15.4	12.5	1.6	13.3	15.7	1.9	12.2	6.5	0.9	13.8
Goat	♀♀	3	201.9	—	—	29.6	—	—	14.3	—	—	11.6	—	—	12.6	—	—	5.3	—	—
Roe-deer	♂♂	21	258.7	24.7	9.5	38.4	4.0	10.4	15.2	2.1	14.0	10.0	1.0	10.0	15.6	1.8	11.5	5.1	0.8	15.4
	♀♀	1	201.0	—	—	28.0	—	—	11.0	—	—	8.0	—	—	11.0	—	—	3.0	—	—
Red-deer	♂♂	16	424.0	31.2	7.3	68.6	6.9	10.0	33.3	2.6	11.4	27.3	2.9	10.6	33.3	3.8	11.4	8.0	0.5	6.2
	♀♀	8	392.2	21.0	5.4	65.0	6.0	9.2	27.0	2.0	7.4	22.0	2.9	13.2	24.5	2.7	11.0	5.5	0.7	12.7
Elk	♂♂	6	459.0	32.0	7.0	86.3	13.2	15.3	39.0	4.0	10.2	40.0	2.2	5.5	49.6	5.9	11.9	8.3	0.9	10.8
	♀♀	4	439.6	—	—	73.8	—	—	38.0	—	—	36.0	—	—	39.5	—	—	8.0	—	—
Reindeer	♂♂	6	348.4	32.0	0.2	60.5	7.2	11.1	30.0	4.0	13.3	17.5	2.1	12.0	22.5	2.0	11.2	7.0	1.0	14.3
	♀♀	1	309.0	—	—	58.0	—	—	24.0	—	—	12.0	—	—	20.0	—	—	8.0	—	—
Fallow deer	♂♂	2	292.0	—	—	42.5	—	—	21.5	—	—	18.5	—	—	18.0	—	—	5.5	—	—
	♀♀	3	288.6	—	—	37.3	—	—	17.6	—	—	19.3	—	—	19.0	—	—	6.3	—	—

Table 13

Ratio of length of bony part to cartilaginous part of ribs in European bison and domestic cows.

Name	Sex	Age years	Consecutive numbers of ribs													
			I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*
Plagtur	♂♂	1	4.7	3.2	3.4	3.2	2.8	2.8	2.7	2.4	2.0	1.8	1.7	1.5	1.4	1.2
Zor		2	5.1	3.4	3.7	3.3	3.0	3.0	3.1	2.5	2.8	2.5	2.2	1.9	1.8	1.2
Anon.*		12	9.7	4.2	3.4	3.8	3.9	3.3	3.1	2.9	1.9	2.1	1.9	1.7	1.9	1.4
Anon.*		12	13.3	3.9	4.1	3.8	4.0	4.1	3.6	2.9	2.8	2.4	2.0	1.8	1.9	1.3
Puls		14	13.9	4.8	3.9	3.9	4.1	4.3	3.7	3.3	2.9	2.8	2.8	1.9	1.9	1.5
Polga	♀♀	3	5.3	3.3	3.7	3.3	3.0	2.8	2.7	2.4	2.6	2.4	2.3	1.7	1.6	1.4
Puszkotka		8	7.2	3.4	3.8	3.6	3.3	3.0	2.9	2.6	2.7	2.5	2.5	1.9	1.7	1.5
Podwika		22	11.4	3.6	4.1	4.4	4.8	4.5	4.2	3.3	2.2	2.6	2.4	2.2	2.1	1.5
Cattle	♀♀	5	16.3	3.7	4.0	4.1	4.0	3.2	2.8	2.0	1.9	1.6	1.6	1.6	1.6	—

* Animals coming from free-living herd in Białowieża Forest.

Table 15

Growth coefficients of ribs in European bison.

Measurement	Sex	Consecutive numbers of ribs													
		I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*
Maximum length	♂♂	2.8	2.9	2.9	2.8	2.9	2.9	2.9	2.8	2.8	2.8	2.8	3.0	3.2	3.3
	♀♀	3.1	3.0	3.0	3.0	2.9	3.0	3.0	2.9	2.9	3.0	3.1	3.0	3.2	3.0
Length along curve	♂♂	2.9	3.0	2.8	2.9	2.8	2.8	2.8	2.8	2.8	3.0	2.9	3.0	3.0	3.1
	♀♀	3.2	3.0	3.0	3.1	3.1	3.1	3.0	3.0	3.0	3.0	3.0	3.1	3.1	3.1
Breadth of shaft halfway	♂♂	4.0	3.9	3.8	3.8	4.1	4.2	4.3	4.6	5.0	5.4	4.9	4.8	4.4	4.5
along length	♀♀	3.0	3.7	3.8	3.0	3.2	3.3	3.4	4.0	4.4	4.2	4.8	4.6	4.4	4.0
Breadth of sternal end	♂♂	2.3	2.7	2.4	1.9	2.2	2.2	2.2	2.4	2.4	2.4	2.1	2.2	2.7	3.0
	♀♀	2.1	2.1	1.8	1.9	1.7	2.0	2.0	2.1	1.8	2.4	2.4	2.5	2.7	2.4
Diameter of head of rib	♂♂	3.9	2.8	2.6	2.6	2.6	2.8	2.7	2.8	3.1	3.1	3.0	3.5	3.1	3.0
	♀♀	3.9	3.1	3.1	2.7	2.3	2.2	2.3	2.2	2.2	2.3	2.2	2.5	2.0	2.4
Thickness of shaft halfway	♂♂	3.8	3.6	3.9	3.6	3.6	3.4	3.4	3.8	3.6	3.7	3.5	3.4	4.0	3.6
along length	♀♀	3.8	3.8	3.7	3.5	3.4	3.4	3.4	3.6	3.0	3.1	3.7	3.6	3.6	3.4
Angle of curve	♂♂	1.6	1.7	2.0	1.9	1.7	1.5	1.5	1.5	1.3	1.4	1.3	1.3	1.1	1.0
	♀♀	1.7	1.8	2.0	2.1	2.0	1.8	1.8	1.5	1.5	1.4	1.3	1.2	1.1	1.0
Length of radius of curve	♂♂	1.9	1.8	1.6	1.7	1.8	2.0	2.0	2.0	2.3	2.2	2.3	2.5	2.9	3.2
	♀♀	1.7	1.6	1.5	1.6	1.5	1.6	1.7	1.9	2.0	2.1	2.4	2.6	2.9	2.9
Length of chord	♂♂	2.9	3.0	3.0	3.0	3.0	3.0	2.9	2.9	2.9	2.9	3.0	3.0	3.2	3.2
	♀♀	2.9	2.9	3.0	3.0	2.9	3.0	2.9	2.9	2.8	2.9	3.0	3.0	3.1	2.9

pair of ribs are situated near where the *manubrium* joins the shaft. The *VII* and *VIII* pairs of ribs, however, have one common and appropriately wider incisura situated on the boundary line between shaft and *processus xiphoideus*.

The *metasternum* forms the final, flattest part of the *sternum* and narrows caudad. It ends in a xiphoid cartilage widening caudad, which does not exhibit a tendency to ossification in even the oldest European bison.

The majority of the sternal measurements in the European bison have higher values than the corresponding measurements in other large ruminants (Table 14).

Growth coefficients for the majority of the rib measurements are similar in European bison of both sexes (Table 15), although these coefficients for width of shaft, width of the sternal extremity and diameter of the head of the rib are slightly higher in males. The reverse situation applies, however, in the case of maximum length and length measured along the curve of the rib.

Table 16

Growth coefficients of sternum in Europen bison.

Measurement	Males	Females
Maximum length	3.0	2.8
Maximum breadth	2.7	2.7
Bredth of manubrium	3.1	4.3
Breadth of metasternum	4.7	4.9
Hight of manubrium	2.8	3.6
Hight of metasternum	3.2	3.6

Growth coefficients for sternal measurements are slightly higher in female European bison in the majority of cases (Table 16).

3. *Thorax*

The *thorax* in the European bison is similar in shape to a cone with the apex directed forwards. It gradually widens caudad immediately after the place of attachment of the scapulae.

Apertura thoracis cranialis seen from the front is similar in shape to an isosceles triangle with the apex directed downwards. The base of this triangle is formed by the ventral surface of thoracic vertebra in *I*, the sides are formed by the first pair of ribs, and the apex is *manubrium sterni*. The height of the aperture increases with age (Table 17).

The height of the *thorax* gradually increases caudad up to the level of the final thoracic vertebra, and is always greater in males.

Table 17

Dimensions of thorax in European bison (mm).

Name	Sex	Age, years	Consecutive numbers of thoracic vertebrae													
			I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*
						Height										
Plagtur	♂♂	1	155	228	249	269	299	318	242	360	392	395	398	392	381	378
Zor	♂♂	2	179	238	254	300	331	369	400	432	431	449	467	473	496	512
Anon.*	♂♂	12	225	267	351	388	430	454	496	510	552	602	620	625	631	643
Anon.	♂♂	12	227	251	262	389	416	459	490	500	543	583	613	607	622	629
Puls	♂♂	15	221	350	384	392	420	454	492	503	528	571	592	603	620	635
Polga	♀♀	3	185	256	335	352	365	392	398	412	426	446	451	457	456	455
Puszkotka	♀♀	8	235	321	358	390	430	462	512	556	509	531	550	535	545	576
Podwika	♀♀	22	230	282	330	341	408	421	442	511	525	513	476	491	496	500
						Breadth										
Plagtur	♂♂	1	68	90	106	140	169	190	225	255	292	320	340	349	355	320
Zor	♂♂	2	[illegible]4	87	111	115	170	206	256	293	321	356	359	367	378	388
Anon.	♂♂	12	100	126	163	198	259	314	358	392	440	516	566	583	587	587
Anon.	♂♂	12	97	118	169	168	249	307	342	399	451	509	560	598	587	582
Plus	♂♂	15	95	125	170	205	255	290	340	400	460	505	576	597	594	590
Polga	♀♀	3	80	106	157	184	237	275	318	342	375	385	370	360	345	343
Puszkotka	♀♀	8	105	124	179	226	261	290	325	336	367	426	445	455	450	451
Podwika	♀♀	22	82	118	156	210	257	300	339	394	450	475	542	512	500	450

* Animals from free-living herd.

Table 18

Ratio of height to breadth of thorax in European bison and domestic cows.

Name	Sex	Age, years	Consecutive numbers of thoracic vertebrae													
			I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*
Plagtur	♂♂	1	2.3	2.5	2.4	1.9	1.8	1.7	1.5	1.4	1.3	1.2	1.2	1.1	1.1	1.2
Zor	♂♂	2	2.8	2.7	2.3	2.6	2.0	1.8	1.6	1.5	1.3	1.3	1.3	1.3	1.3	1.3
Anon.*	♂♂	12	2.2	2.1	2.2	2.0	1.7	1.4	1.4	1.3	1.2	1.2	1.1	1.1	1.1	1.1
Anon.	♂♂	12	2.3	2.1	2.1	2.0	1.7	1.5	1.4	1.2	1.2	1.1	1.1	1.0	1.1	1.1
Puls	♂♂	15	2.3	2.8	2.3	1.9	1.6	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.0	1.1
Polga	♀♀	3	2.3	2.4	2.1	1.9	1.5	1.4	1.2	1.2	1.1	1.2	1.2	1.3	1.3	1.3
Puszkotka	♀♀	8	2.2	2.6	2.0	1.7	1.6	1.6	1.6	1.6	1.4	1.2	1.2	1.2	1.2	1.3
Podwika	♀♀	22	2.8	2.4	2.2	1.7	1.6	1.4	1.3	1.3	1.2	1.1	0.9	1.0	1.0	1.1
Cattle	♀♀	5	2.6	2.4	1.6	1.6	1.3	1.2	1.2	1.1	1.0	1.1	1.2	1.2	1.2	—

* Animals from free-living herd.

The breadth of the aperture in both males and females reveals individual variation (Table 17). At the height of the other ribs the width of the *thorax* increases caudad. This increase takes place in the males examined up to rib *XIII* or *XIV*, but in females up to rib *XI* or *XII*.

The *thorax* in males in comparable age classes is wider than in females. The ratio of height to width of the *thorax* decreases in a direction from front to back (Table 18).

Apertura thoracis caudalis, bounded by the last thoracis vertebra, the last pair of ribs, the costal arch and the xiphoid procces of the *sternum*, seen from the rear, is similar to a lateraly flattened oval in European bison.

IV. DISCUSSION

The typical number of ribs for European bison (wisent) must be considered as 14, since the number occurs in the majority of the individuals examined (95.7%) and this statement is borne out by the observations made by Bojanus (1827), Koch (1932), Janicki (1938), Juśko (1953) and Roskosz (1962). In a few cases only 13 pairs of ribs were observed (4.3%). Bojanus (1827) and Janicki (1938) found similar relations in female European bison.

The relations found in »Plotkarz« and »Pleśnianka« must be considered as lumbalisation of the final thoracic vertebra and the final pair of ribs connected with it. The situation found in one of all the sheep examined and in the only male individual of Watussi cattle examined must be classified as thoracalisation of the first lumbar vertebra.

Pilarski & Roskosz (1957) and Roskosz (1962) have drawn attention to the possibility of vertebra reciprocally becoming similar to each other in neighbouring parts of the spine in the European bison, and the consequent shifts in numbers of given vertebrae. Similar shifts have also been observed in other ruminants, for instance Allen (cited after Roskosz, *l.c.)* found 14 thoracic and 5 lumbar vertebrae in the American bison, and simultaneously referred to the possibility of occurrence of both cervical and lumbar ribs. Vokken (1961) draws attention to the fact that in domestic cattle (in 1.6% of cases) and sheep (in as many as 3.5% of cases) deviation can be observed from the normal number of 13 pairs of ribs. Pilarski & Roskosz (1959) observed thoracalisation, lumbalisation and sacralisation in the elk. These same authors observed unilateral metamorphosis of the arched rib into the floating rib in one individual of this species. Szaniawski (1966) and Roskosz & Pytel (1966) refer to similar shifts in the red-deer.

Quantitative changes connected with occurrence of cervical ribs or with vertebrae becoming similar in neighbouring parts of the vertebral column were also observed in other species of animals such as: the horse (Mobilio, 1910; Drahn, 1926; Favilli, 1928; Zietzschmann, 1943; Krysiak, 1950), domestic cattle (Drahn, *l.c.*; Cloete, 1941), the dog (Fiebiger, 1917; Ivanoff, 1934. 1935), the donkey (Barpi, 1909; Curson & Neitz, 1927). It may therefore be concluded that quantitative deviations in this respect do not constitute a rare phenomenon.

Our observations of the division into true and false ribs in the European bison provide confirmation of the opinions given by Bojanus (1827) and Koch (1932). In one case (»Puls«) we found 9 pairs of true and 5 pairs of false ribs, which must be regarded as an exceptional case, although in Janicki's (1938) opinion the European bison has 9 true and 5 false ribs. This latter author analysed only 3 skeletons of this species and therefore his material was not adequately representative. It must also be added here that the qualification itself of a rib for one of these two groups, depending on the way they are connected with the sternum, may prove very difficult in many cases.

In situation in which there were 13 pairs of ribs the number of false ribs was always reduced to 5, but the number of true ribs, *i.e.* 8, remained unchanged.

Division into true and false ribs is analogical in this respect in all the other species examined possessing 13 pairs of ribs. This confirms the data contained in textbooks by such authors as: Kolda (1936), Martin (1938), Ellenberger (1943), Nickel (1960) and Vokken (1961).

Olbrycht (1934), on the other hand, in his studies on ossification of the sternum in domestic cattle found in as many as 20.4% of cases no trace of the insertion of the eighth pair of ribs, which would indirectly point to the presence of 7 pairs only of sternal ribs.

Rib *I* is always shortest in the European bison. This fact was recorded by Bojanus (1827) and confirmed by other researchers (Koch, 1932; Janicki, 1938; Juśko, 1953). There are, however, certain differences of opinion as to the longest rib. In our material rib *IX* is always the longest in European bison of both sexes. This agrees with the observation made by Bojanus (1827) and Juśko (1953), whereas Janicki (1938) considers rib *IX* as the longest in an adult male and female, and rib *VIII* in a young male. Koch (1932) states the rib *IX* or *X* is the longest in the European bison.

Increase in the dimensions of the ribs and sternum connected with age continues in European bison almost up to the end of their lives, although it is most intensive during the first year of life, and its dynamics distinctly decrease in later years. Marked increase is still observed in the majority of the dimensions in group III (up to 12 years old). In older European bison the increases observed were either small or else, in some cases, they were even observed to decrease in relation to the preceding group.

Koch (1934/1935) states that growth in the European bison in all parts of the body, most intensive during the first year of life, is completed at the end of the 7th year. Furthermore this author states that there is only very slight growth in females over the age of 3 years, although in males growth continues to be fairly intensive between the 4th and 6th year of life. It can be seen from this that the results of our studies only partly confirm the observations of the author in question.

The shaft of ribs *VII* or *VIII* is broadest in European bison (apart from foeti and newborn animals). Janicki (1938) reached similar conclusions, bu Koch (1932) considers rib *VII* as the widest.

The rib which attains the highest values in respect of the sternal extremity dimension in both European bison and the other species compared is always rib *I*. This is due to the fact that among the true ribs it is this rib which plays a special part. Being the rib stituated most vertically it bears a considerable part of the weight of the beam-like structure of the thoracic part of the vertebral column. Its role may be compared to a column which on the one side supports the vertebral column and on the other is supported on the sternum, connecting in a practically immovable manner with its manubrium. This kind of function cannot fail to influence the shape of this rib. Its sternal end must be suitably developed to be able to form a sufficiently sturdy base for this type of column.

This must also be the explanation of the fact that rib *I*, which is practically immovable, connects with the costal cartilage by means of synchondrosis and not by means of diarthrosis, which is the case with the other ribs in European bison up to the age of 15. In order to make the almost vertical position of rib *I* even more stable its cartilaginous part in 8-year old males or 10year old females changes into a bony structure.

The majority of researchers draw attention to the different degree of the arch-shaped curve of the various ribs and the consequent shape of the thorax in the European bison (Bojanus, 1827; Wróblewski, 1927; Koch, 1932; Janicki, 1938).

No objective data were found in the literature available on the European bison or other mammals dealing with the degree of this curve. Some researchers (Janicki, *l.c.;* Szaniawski, 1966) in the osteometry of ribs, using the diagram of measurements suggested by Duerst (1926), in addition along the curve. The values of this second measurement obviously always exceed similar values obtained by the first measurement. It was only possible to arrive indirectly and approximately at the degree of this curve on this basis.

The method used in our studies on the curve of ribs is ressonably simple and at the same time sufficiently accurate. It may be mentioned in passing that it was also used for calculating the degree of convexity or concavity of the articular surface in arthrological studies now being carried out on the European bison. The behaviour of the angles of curves in the different ribs is one of the convincing proofs of the interrelation between the shape of a given structure and the function it carries out.

True ribs, which limit the anterior and most flattened part of the thorax, are far less mobile than the false ribs. They form as it were columns of which the beam-like structure of the thoracic part of the vertebral column is supported. At the same time they serve as the place of insertion for the strongly developed muscles of the shoulder girdle, such as *musculus serratus ventralis* and *musculus pectoralis profundus* (Świeżyński, 1962). In this way they create a situation in which the corpus is, as it were, suspended by means of these muscles between the two thoracic limbs. The necessity for carrying out the functions referred to above result in the true ribs being situated almost vertically in relation to the spine, and the degree to which they move during respiration is slight, and therefore the term proposed by Krysiak (1950) for this group of ribs »supporting ribs« or »bearing ribs« is very apt, since it conveys the significance of their function.

The function of the initial pairs of ribs fully justifies the behaviour of the angles of their curves, and is in this particular group of ribs that they come closest to straight lines.

Comparison of these angles in the European bison and other ruminants shows that the degree of curvature of true ribs depends on the size of the animals, and therefore on their mass which these ribs must carry. Thus in European bison the »bearing« or true ribs are less curved than in all the other ruminants examined. This is conditioned by the greater mass of this animal (the average weight of an adult male is 683.2 kg, Pytel, 1969), and also the strongly developed »hump« in this region, formed from the spinous processes of the thoracic vertebrae and corresponding muscles — Roskosz & Empel (1961), whereas the average weight of an adult red-deer is approximately 140 kg (Mystkowska, 1966; Dzięciołowski, 1970).

The false ribs play a completely differents part, and are situated diagonally to the vertebral column, and are very flexibly connected with it. Another factor which additionally facilitates their movements is the connection of the final pair of ribs with the spine by the head only. Similarly the relatively longer cartilages of these ribs, forming the costal arch, ensure a more flexible connection with the sternum.

The false ribs also serve as places of insertions of the corresponding muscles (Świeżyński, 1962), but their chief role is evident in their participation in respiratory movements, and it is on account of this important function that the false ribs have been termed »respiratory« (Krysiak, 1950). The functions referred to and the necessity for ensuring the largest possible capacity of the thoracic cavity result in these ribs being curved to a greater degree than the ones preceding them their behaviour is the chief factor determining the considerable breadth of the thorax in the European bison.

Analysis of the area of cross-sections of ribs once again provides evidence, in both the European bison and the other species, that the behaviour of the different kinds of ribs depends on the function which they are called upon to perform. The area of the cross-section, like the shape, determines their capacity for taking strain. It is not therefore suprising that this area, irrespective of the place for which it is defined, is as a rule greater in the true ribs, whereas it is considerably reduced in the false ribs.

The ratio of length of they bony part of the rib to the cartilaginous part is the exponent of the degree of elasticity of the thorax. The more cartilaginous elements there are, the greater the elasticity of the thorax and accordingly in the first pairs of ribs the ratio of length of the bony part to the cartilaginous part is more favourable to the former. The following ribs, on account of the function they perform, have relatively longer cartilaginous parts, and they also, joined in the costal arch, ensure the most favourable connection, from the biomechanical point of view, with the sternum.

The cartilaginous parts of the rib should be treated as the residue of the cartilaginous stage in the development of the skeleton which (except for rib *I*) persists throughout the animal's whole life, although with more advanced age the cartilaginous parts of the ribs become increasingly shorter. There is in fact a general tendency for the cartilaginous elements slowly to recede with age and to be replaced by bony elements, and therefore *cartilago epiphysialis* undergoes liquidation and *cartilago articularis* becomes far more slender, as is the case with the cartilaginous parts of the ribs. These changes, however, do not fail to exert an influence of the mechanics of the thorax.

Our observations showing that the sternum in the European bison consists of 7 segments, agree with the observations made by Janicki (1938). An analogical situation occurs in the other ruminants examined, proving confirmation of the studies by Akajevskij (1939) and Szaniawski (1966) and of the data contained in textbooks by such authors as: Kolda (1936), Martin (1939), Ellenberger (1943), Koch (1960) and Vokken (1961).

Olbrycht (1934) showed that *manubrium sterni* has two centres of ossification during the embryonic development of domestic cattle, and there consists of two parts, proof of which is the location of *articulus intersternalis* on the line connecting the second pair of ribs. The above author considers that line forms the most posterior boundary of the second intercostal part. In the light of the foregoing, 8 segments should be distinguished in the *sternum* in domestic cattle. As, however, in postembryonal life the appearance of the manubrium does not betray the slightest traces of having consisted of two parts, regarding it as a single formation and consequently distinguishing 7 segments in the *sternum* of this species cannot be considered an error.

Attention has been drawn by Janicki (1938) to the lateral flattening of *manubrium sterni* characteristic of the European bison, and our observations have fully confirmed the above finding. It is only necessary to add that due to this flattening, the appearance of *manubrium sterni* is significantly different in European bison from the corresponding formation in domestic cattle and the other ruminants. *Manubrium sterni* is connected with its shaft by an articulation in both European bison and the other species we examined. Olbrycht 1934) observed the rudiments of this articulation in domestic cattle during embryonic development in foeti only 11—12 weeks old. Connection of the various segments of the *mesosternum* by synchondroses in the European bison, in which ossification takes place in a direction progressing from the most caudad segments when the animal is over 15 years old, provides confirmation of Olbrycht's (*l.c.*) observations on ossification processes of the sternum in domestic cattle.

The dimensions of the sternum in both European bison and the other species point clearly to sex differences. Mohr (1952), in considering differences between the European and American bison, states that the sternum is shorter in the latter than in the former, and this is confirmed by our studies. The breadth of the sternum in domestic and Watussi cattle is smaller than the average measurement for adult European bison. The sternum is far narrower in American bison than in adult European bison. The absolute dimensions of *manubrium sterni* in adult European bison are narrower than in domestic and Watussi cattle.

Manubrium sterni is decidedly broader in European bison than this part of the sternum in American bison. The breadth of the *metasternum* in adult European bison is far greater than the corresponding measurement in American bison and domestic cattle, but smaller than in Watussi cattle. The average values for height of *manubrium sterni* in adult European bison are far greater than those in American bison, domestic cows and representatives of Watussi cattle. The height of the *metasternum* is the least characteristic dimension of European bison, and the values obtained for domestic cattle, American bison and Watussi cattle come within the limits of extreme values for this measurement in adult European bison. Among all the ruminants examined the *mesosternum* is relatively the broadest in European bison. A relatively narrow shaft occurs in roe-deer, red-deer and fallow-deer (Table 19).

Table 19

Ratio of sternal length to its maximum breadth in adult European bison and other ruminants.

Species	Males	Females
Wisent	4.8	4.8
Bison	6.0	5.9
Cattle	5.4	4.9
Watussi cattle	4.6	5.2
Sheep	5.4	6.0
Goat	—	6.8
Roe-deer	6.7	7.2
Red-deer	6.2	6.0
Elk	5.4	6.3
Reindeer	5.7	5.3
Fallow deer	6.9	7.1

Increase of the characters examined of ribs and sternum in European bison during postnatal life depends on the degree to which their growth progressed during embryonic life. If we take the dimensions of the ribs and sternum in the group of oldest European bison as 100%, we can calculate what percentage of this value is formed by these dimensions in group 0. Such calculation indicates what part of growth of the given character occurs during embryonic and postembryonic development. On this principle the different characters of the ribs and sternum were arranged in order of least advanced to most advanced during embryonic development and presented in the form of diagrams (Fig. 6). It can be seen from these diagrams that the lower the values attained by the given dimension during embryonic life, the greater its growth during postembryonic life. It is also clear that the characters of the ribs and sternum in the European bison arranged in this order are interchanged. The sequence of these characters in males and females coincides in four cases only (breadth of the *metasternum*, height of the *metasternum*, breadth of the sternal extremity of the ribs and sternum has in a certain sense its own predetermined line of development.

The thorax in the European bison, in respect of both height and breadth, increases caudad. The anterior heigh of the thorax defined by B o j a n u s (1827) as 10 inches and 3 lines (246 mm) is greater than

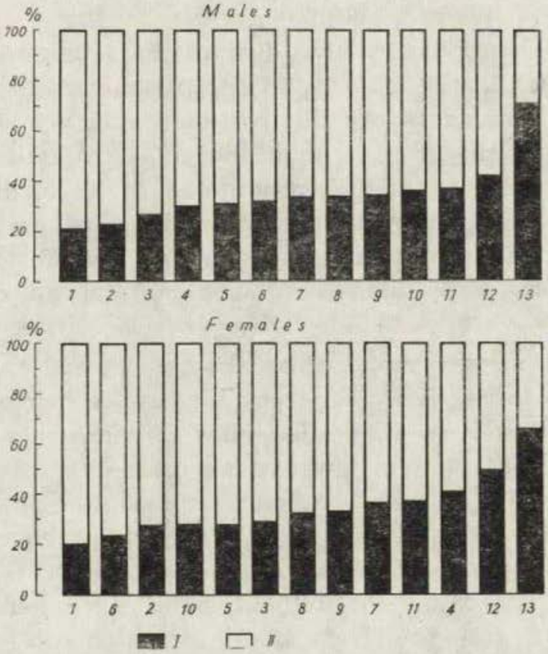

Fig. 6. Increase in dimensions of ribs and sternum in the European bison during embryonic (I) and postembryonic (II) development.

1. Breadth of metasternum, 2. Breadth of shaft of rib, 3. Thickness of shaft of rib, 4. Diameter of head of rib, 5. Height of metasternum, 6. Breadth of *manubrium sterni*, 7. Maximum length of sternum, 8. Length along costal curve, 9. Maximum length of rib, 10. Height of *manubrium sterni*, 11. Breadth of sternum before final pair of cartilaginous ribs, 12. Breadth of sternal end of rib, 13. Angles of costal curves.

that which we obtained for the anterior aperture of the thorax. This predominance is due to the different method used making the measurement. The posterior height of the thorax defined by the above author as 1 foot, 11 inches and 6 lines (544 mm) is not a record value, even if allowance is made for the different method of measurement. None of the authors studying the European bison, apart from W r ó b l e w s k i (1927), gives the breadth of the thorax, and Wróblewski gives »width of withers« as 52.5 cm. It must be assumed that he made this measurement on the skin of a carcass. In our case higher values were obtained when we measured breadth of the thorax from the pericentral surface of the bony parts of the ribs.

Comparison of absolute figures expressing the ration of thorax height to its breadth in European bison and domestic cows shows that the thorax in the latter is proportionately broader, particularly in its middle and posterior part, whereas in the European bison it is appropriately higher but proportionately narrower.

It must also be emphasised that distinct characters of sex dimorphism were encountered in the majority of the parameters for European bison and the other ruminants. As the posterior aperture of the thorax is simultaneosly the posterior limit of the epigastrium it was anticipated that sex differences would be encountered in its formation. Attention has already been drawn (Wróblewski, *l.c.;* Świeżyński, 1962) to the fact that gestation in European bison is not manifested by a lowering of the floor of the abdominal cavity such as occurs in, *e.g.* the domestic cow.

Our observations did not confirm the assumption that the posterior aperture of the thorax has a different appearance in males and females. It is possible that it is a question here of increase in the degree of convexity of the diaphragm towards the interior of the thoracic cavity in pregnant females, which permits of accomodating the contents of the abdominal cavity without increasing its circumference. The powerful development of the deep fascia of the abdomen in European bison (Świeżyński, *l.c.*) is not without significance here, as it is consequently able to take the strain of the increased contents of the abdominal cavity during gestation. Further studies should provide more information on this problem, of which mention only is made in the present study.

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KLATKA PIERSIOWA ŻUBRA I INNYCH PRZEŻUWACZY

Streszczenie

Badania elementów strukturalnych klatki piersiowej przeprowadzono na kośćcach 93 żubrów obu płci. Przebadano także 10 gatunków innych przeżuwaczy zarówno udomowionych jak i wolnożyjących (łącznie 107 osobników). Wykonano pomiary żeber, mostka a także klatki piersiowej w całości. Określono także kąty krzywizn żebrowych, powierzchnie przekrojów poprzecznych żeber oraz współczynniki wzrostu uzyskanych wartości. Wykazano różnice w budowie klatki piersiowej żubra i pozostałych gatunków. Udowodniono, że kąty krzywizn żeber prawdziwych żubra są mniejsze w porównaniu z pozostałymi przeżuwaczami. Wśród innych przeżuwaczy istnieje zależność kąta krzywizny żeber prawdziwych od masy ciała zwierzęcia. Najbardziej intensywny wzrost większości wymiarów obserwowano u żubrów do 1 roku życia. Wzrost ten ze zmniejszającym się natężeniem trwa do lat 12. Wzrost badanych parametrów w rozwoju pozapłodowym zależy od stopnia jego zaawansowania w rozwoju płodowym. Im w rozwoju płodowym dana cecha jest słabiej rozwinięta tym jej wzrost w życiu pozapłodowym odbywa się bardziej intensywnie.

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