A C T A T H E R I O L O G I C A

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The Capacity and Weight of the Walls and Digesta of the Alimentary Tract in the European Bison

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[With 5 Tables]

In three adult male European bisons the maximum *post mortem* capacity of the alimentary canal fluctuated from 268 to 275 l., out of which the rumen + reticulum amounted to 99—120 l., omasum and abomasum — to 30.5—39, small intestine — 71.1—80, caecum 8.5—12.6, colon and rectum — 33.2—50 l. In 13 months old bull these values amounted to: 58.5 l., 10.0, 23.5, 3.3, and 11.0 l., respectively. In two males: adult one and 11 months old the capacity of the alimentary tract fixed in carcass immediately after the death was determined. These values should correspond with ones. For the adult animal they amounted to: 57.0, 11.7, 12.28, 0.97 and 3.25 l. — together to 85.2 l., while in the young individual: 19.2, 3.5, 8.5, 1.8 and 3.0 l. — altogether 36.0 l. The relative capacity of the stomach, and the ratio of the capacity of the small and large intestines to their length, as well as the ratio of the capacity of the large intestine to that of the small one were calculated. The weight of the walls of the total tract fluctuated from 23.55 up to 33.10 kg in adult bisons and 10.6 kg in the young one. The digesta weighed: in adults 64.1 — 78.6 kg, while in young — 29.8 kg. Besides, the active and nonactive sections in the small intestine of the European bison were examined. There were noted no changes in colour nor diameter which would indicate the vital existence of such sections in the bison's intestine.

I. INTRODUCTION

In the literature there are only few reports concerning measurements of the alimentary tract and its content in non-domesticated ruminants (Gill & Jaczewski, 1957; Gill & Korda, 1960; Gill, 1960; 1961; 1965). In relation to the alimentary tract of the European bison there are only fragmentary remarks. Wróblewski (1927) reported that the stomach of bison with body weight amounting to 16 hundredweights may contain 330 l. of water. Preliminary results of author's studies were published in two contributions (Gill, 1965; 1967).

Due to comparative aspects and future experiments on the physiology of digestion and nutrition of the European bison it seems purposeful to publish

further data concerning the capacity and weight of the alimentary tract of this animals, although the high casualness of material examined in not fully comparable manner and its low number makes it difficult to draw any far-reaching conclusions.

II. MATERIAL AND METHODS

Measurement was restricted mainly to the so-called maximal *post mortem* capacity of the alimentary tract after Kvasnicki's (1951) method. This method was used by the author since 1957 in all comparative experiments. All available corpuses of bisons, irrespectively to the cause of the death, size, and age of the animal, season of a year, and inhabited environment were used for measurements. Table 1 contains the characteristics of the whole material.

After dissection of the abdominal wall several ligatures were tied on the alimentary tract (as in material sampling for protozoan counts — Gill, 1954). Afterwards the digestive tract as removed from carcass, omentum and ligaments of the stomach were separated and stomach was severed from the intestine behind the pyloric sphincter and weighed as a whole. Then the small and large intestines were separated from the mesentery and weighed separately.

The contents of the omasum, abomasum, and intestine were washed out several times with current water. In order to remove the contents from rumen and reticulum the wall of the rumen was cut at the length of *ca* 15 cm and content was taken by hand and then whole rumen was turned and remnants of its content were washed out with tap water. For measurements this opening was closed with clamps.

The capacity measurements of the alimentary tract were made according to the techniques described by Kvasnicki, 1951. The stomach was divided into two parts — rumen with reticulum and omasum with abomasum. This procedure was used also previously (Gill & Jaczewski, 1957) due to the impossibility of closing of big openings: rumino-reticular and omaso-abomasal.

In the measurement of the capacity of the rumen and reticulum of 3 adult males the deviation from Kvasnicki's techniques was necessary due to the lack of a vessel which could house so big structure in water. Rumen and reticulum were filled with water on dissecting table or on a pavement. Water was poured until the tension of the walls of these compartments became identical with that in omasum and abomasum, which were placed besides in a vessel filled according to Kvasnicki's techniques. Such a procedure should not cause any significant errors. The rumen and reticulum of »Pluszcz«, »Pud«, and »Plon« were measured in water.

After the capacity measurement of the whole tract, its all parts were left to drip of water and then weighed. Weight of walls was obtained. By subtraction of the latter from the previous weight, the weight of digesta within each part of the tract was determined.

Due to technical reasons the digestive tract remained usually for rather a long time in bison carcass, where slowly dropping internal temperature enabled still the activity of bacteria. Gases produced by them could extend walls of the tract. This is the reason why all the measurements (except of these for »Pluszcz« and »Plon«) were made not earlier than 24 hours after the death, *i. e.* when the tension and *rigor mortis* of smooth muscles were over. This permitted the determination of maximum *post mortem* capacity of the alimentary tract in the bison.

Table 1.
Characterictics of examined European bison.

Name and no. of pedigree book	Date of birth	Reserve	Date of death	Body weight (kg)	Notes
Pluvius II (546)	15.IX.1940	Pszczyna, Białowieża	20.XII.1957	920	Shot. Measurements some 20 hours after death.
Plato (575)	1.VI.1941	Pszczyna, Białowieża	5.X.1958	750 [1]	For 7 days stayed in Warsaw Zoo. Narcotized with chloralhydrate, 10 hours in narcosis. Measurements some 19 hours after bleeding.
Plater (825)	28.VII.1951	Pszczyna, Smardzewice, Warsaw Zoo	15.X.1958	530 [2]	Died after short scour. Measurements some 24 hours after death.
Pud (1089)	20.IX.1957	Borki	25.X.1958	318	Beaten by another bison, shot. Measurements *ca* 48 hours after death.
Pluszcz (785)	1.V.1950	Pszczyna, Smardzewice	10.X.1960	620 [1]	For 7 days stayed in Warsaw Zoo. Narcotized with chloralhydrate, died after 6 hours of anaesthesia. Fixed by Pilarski *et al.*, 1967. Measurements after 1 month.
Plon (1992)	1.VI.1960	Białowieża	20.IV.1961	—	Died, carcass fixed as above. Measurements after 14 weeks.

1) Weight of bison was determined during transportation; 2) Weight of bison was determined after dissection, on the base of the weight of body parts. Allowance for blood and fluid losses was 15%.

III. RESULTS

1. Capacity of the alimentary tract

As can be seen from table 2, the total capacity of the tract in two old bisons (»Pluvius II« and »Plato«) is almost identical. This capacity in »Plater«, and particularly in young »Pud«, is smaller, what undoubtedly results from the difference in the age and size of examined animals. The relative capacity of the different parts of the alimentary tract was expressed in per cents of the total capacity. In adult males

Table 2.
Capacity of different parts of the alimentary canal in the European bison.

		Rumen + reticulum	Omasum + abomasum	Small intestine	Caecum	Colon + rectum	Total
Pluvius II,	A	110	33	74	11	45	273
	B	40.29	12.09	27.11	4.03	16.48	100.00
	C	0.12:1	0.04:1	0.08:1	0.01:1	0.05:1	0.30:1
Plato,	A	120.0	39.0	71.1	12.6	33.2	275.9
	B	43.49	14.14	25.77	4.57	12.03	100.00
	C	0.16:1	0.05:1	0.09:1	0.02:1	0.04:1	0.36:1
Plater,	A	99.0	30.5	80.0	8.5	50.0	268.0
	B	36.94	11.38	29.85	3.17	18.66	100 00
Pud,	A	58.5	10.0	23.5	3.3	11.0	106.3
	B	55.03	9.41	22.11	3.10	10.35	100.00
	C	0.18:1	0.03:1	0.07:1	0.01:1	0.04:1	0.33:1
Pluszcz,	A	57.00	11.70	12.28	0.97	3.25	85.20
	B	66.90	13.73	14.41	1.14	3.82	100.00
	C	0.092:1	0.019:1	0.020:1	0.002:1	0.005:1	0.138:1
Plon'	A	19.2	3.5	8.5	1.8	3.0	36.0
	B	53.34	9.72	23.61	5.00	8.33	100.00

A — Absolute capacity in litres; B — Relative capacity in %%; C — Ratio of capacity to weight, litres: kilograms.

the capacity of the stomach only slightly exceeds the half of the capacity of the whole digestive tract and is quite similar in various individuals. The relative capacities of the small intestine also fail to reveal any greater differences. Divergencies between the minimum and maximum amount to some 30%. On the other hand higher variation is to be noted in the capacity of the caecum, colon and rectum in individual bisons.

On average, therefore, in 3 bisons the stomach comprises 52.78%, small intestine — 27.58%, and the whole large intestine — 19.65%.

Proportions recorded in the young bull »Pud« deviate from the state occurring in adult bulls (Table 2). The whole stomach comprises here 64.44% of the whole alimentary tract — when compared with 52.78% in adult individuals. In consequence of this fact the relative proportions of the small and large intestines are lower in »Pud«, than that in adult bisons. The proportions of the intestine, however, are very similar: in adults the small intestine is larger than the large one on average by 8.11%, while in »Pud« — by 8.66%.

Table 3.

Relative capacity of bisons' stomach.

Stomach part	Pluvius II	Plato	Plater	Pud	Pluszcz	Plon
Rumen + reticulum, %	76.92	75.47	76.48	85.40	82.97	81.78
Omasum + abomasum, %	23.08	24 53	23.52	14.60	17.03	18.22

Table 4.

Ratio of the capacity of the intestine to its length, and the ratio of the capacity of the large intestine to that of small intestine in bisons.

Bison's name	Ratio of capacity of the small intestine to its length, l. per current meters	Ratio of capacity of the large intestine to its length, l. per current meters	Ratio of capacity of the large: small intestine
Pluvius II	1.68	4.34	1:1.32
Plato	1.71	3.82	1:1.55
Plater	1.67	4.90	1:1.37
Pud	0.86	2.07	1:1.64
Pluszcz	0.47	0.67	1:2.91
Plon	0.49	1.05	1:1.77

The capacity of the digestive tract of »Pluszcz« and »Plon« fixed in carcass (Table 2) comprises about $^1/_3$ capacity of the tract discussed above of the adult bulls and 13 months old »Pud«. The relative proportions of the capacities of the different parts of the alimentary tracts of these two bisons are also different. The proportion of the stomach is remarkably higher here, when compared with intestine. The higher, however, proportion of the small and large intestine in »Plon« than in »Pluszcz«, would indicate the greater contribution of the intestine in

digestion in the young, about 1 year old calf, than in an adult bison, in which the bacterial digestion in the rumen and reticulum dominates.

In adult bulls the relative capacities of both parts of the stomach are similar. On the other hand in the young »Pud« the size of the rumen and reticulum comprises more than 85% of the total stomach and is very similar to proportions recorded both in the adult and young bisons fixed before measurements (Table 3).

The ratio of the capacity of the small and large intestines to their length was expressed in litres per 1 current meter of the intestine. More stable values were obtained for the small intestine, while variable ones — for the large intestine (Table 4). The mutual relation of the capacity of both segments of the intestine is rather balanced, with the exception of »Pluszcz« and »Plon« fixed before measurements.

The ratio of the *post mortem* capacity of the alimentary tract to the body weight in bisons examined without fixation amounts to more than 0.30:1. In the fixed »Pluszcz« this proportion is by some 2.5 times lower.

2. The weight of the walls of the alimentary tract and its contents

The weight of the walls of the rumen, reticulum, omasum, abomasum, and small intestine indicate high convergence in adult bulls, while the weight of the walls of the large intestine differs more (Table 5). Proportions in weight of different parts of the alimentary tract in the young »Pud« do not deviate from the relations found in adult bisons.

Due to a special diet of the bison »Plato« before the death absolute values of the content weight in this bull cannot be considered. Thus we were restricted to »Pluvius II«, »Plater«, and »Pud« only. All the relative values indicate that the division of the digesta inside the alimentary tract is similar in all bisons, irrespectively to their age and body size.

The ratio of the weight of the total alimentary tract with the digesta to the body weight (Table 5) amounts to 0.12:1, both in the adult »Pluvius II« and in one year old »Pud«. It is interesting the fact that the ratio for »Plater« amounts to 0.13:1, what could indicate that the determined *post mortem* body weight is close to the live one, or that losses of the digesta during the brief scour were marked here distinctly.

3. Functional conditions of intestine

In spite of the careful observation of the wall of the small intestine in none of examined bisons there was found the status indicating the

existence of active and nonactive sections. Total intestine had generally an uniform diameter, was congested and filled with the digesta to nearly the same extent.

»Plater's« intestine was partially in an inflammatory condition, »Plato« was subjected to anaesthesia for 10 hours. In both cases changes in digestion could occurred. On the other hand »Pluvius II« and »Pud«

Table 5.

Weight of different parts of the alimentary canal in European bison.

			Rumen + reticulum	Omasum + abomasum	Small intestine	Large intestine	Total	Ratio of the weight of total canal with digesta to body weight
Pluvius II, 17 years old, 920 kg	Walls	kg	11.5	6.7	6.9	8.0	33.1	0.12:1
		%	34.74	20.24	20.85	24.17	100.0	
	Digesta	kg	61.5		11.1	6.0	78.6	
		%	78.25		14.12	7.63	100 0	
Plato, 17 years old. 750 kg	Walls	kg	9.35	4.50	5.55	4.15	23.55	(0.07:1)
		%	39.70	19.11	23.57	17.62	100.0	
Plater, 8 years old, 530 kg	Walls	kg	8.6	5.8	6.3	5.0	25.7	(0.13:1)
		%	33.46	22.57	24.51	19.46	100.0	
	Digesta	kg	56.1		2.8	5.2	64.1	
		%	87.52		4.37	8.11	100.0	
Pud, 13 months 318 kg	Walls	kg	4.2	2.0	2.5	1.9	10.6	0.12:1
		%	39.62	18.87	23.59	17.92	100.0	
	Digesta	kg	20.7	3.1	2.7	3.3	29.8	
		%	69.46	10.40	9.06	11.08	100.0	

were shot, and particularly the first of them failed to reveal any changes in feeding. One can suspect that gases accumulated after the death until dissection could cause the extension and equalization of the intestine lumen. Supravital differences in blood supply should not, however, disappear. Such differences were not found.

The small intestine of »Pluszcz« was well fixed, but differences in colours were not found. Intestine's lumen was of various size, but this

could result from starvation and, later, from narcotic action. In »Plon« also no differences in the colour nor in the diameter of the small intestine were found.

IV. DISCUSSION

The collected material comes from individuals died or killed and thus with fixed already functions of the alimentary canal. This fact does not affect negatively the value of obtained results, when measurements of the tract are concerned. On the other hand the material is still very scant for the characteristics of the size of the alimentary tract in European bison. It indicates rather what should receive further attention.

The obtained in this paper very scarce results could be compared with similar ones received with the use of the same procedure in wild ruminants or with results for domestic cattle measured with various methods.

The measurements of the maximum *post mortem* capacity of the alimentary canal in wild ruminants were taken thus far only for single individuals of 5 species, exclusively males (references cited in first section). When compared with those measurements in European bisons one can note the lower capacity of the rumen and reticulum, while higher one for the omasum and abomasum. Also the relative capacity of the small intestine is in bisons slightly greater than in other ruminants (with some exceptions).

The ratio of the total capacity of the alimentary canal to the body weight indicates the existence of two groups, namely the Red Deer and European bisons have this ratio similar in spite of the fact that they most differ in the size of the rumen and reticulum. Remaining ruminants inticate the higher this ratio to the body weight. Due to scant and diverse material no further conclusions could be drawn here.

The comparison of the alimentary canal capacity in European bison and cattle is not a simple matter due to the existence of a large number of data for cattle obtained with various methods. First accurate data were provided by Schmaltz (1894). Later there were done many studies from which it resulted that the alimentary canal in cattle has a greater capacity, then that of bisons examined. In cattle the rumen and reticulum have especially high capacity. In bisons it comprises on average 76.29%, while in cattle — 80 to 88% of the whole stomach (Schmaltz, 1894). In relation to the total alimentary canal stomach comprises in cattle 70.8% (Colin, 1955), while in bisons — 52.78%. The capacity of the whole stomach in one year old »Pud« was smaller, than in $^1/_2$ year old steer.

It is possible that the feeding of the bisons in reserves rearing with the first quality fodder with predominance of the concentrated food resulted in some reduction in their alimentary canal.

On the other hand the cited by Blamire (1952) so-called actual capacity of 77 stomachs of the cattle amounted to: the highest capacity 77.28 l., while the lowest one — 13.64 l. The determined here stomach capacity for adult bison »Pluszcz« is close to the highest one for cattle. Perhaps these too methods reflect the vital capacity with rough approximation.

The ratio of the capacity of the small intestine to its length is similar in bisons and cattle (Schmaltz, 1894). In »Pud« these values were considerably lower, what would indicate that his intestine had a smaller diameter than in adult bisons. In »Pluszcz« and »Plon« corresponding indices were still lower what could result from the existence of the tonus of the muscular coat of the intestine before the death.

The ratio of the capacity of the large intestine to that of the small one is remarkably higher in cattle than in bisons. It stressed not only greater length of the large intestine in the bison, when compared with cattle (Pięknoś *et al.*, 1958), but also its greater capacity. In »Pud« this ratio is somewhat greater, than in adult animals. In »Pluszcz« and »Plon« it is situated already within limits found for cattle.

On the basis of the material collected here one cannot say, if in a bison there are some functional or seasonal changes in the total capacity of their alimentary tracts. Each bison was examined in different season of a year and under different conditions. »Pluvius II« was shot during winter feeding. »Plato« was euthanized during summer feeding with a slight addition of concentrated food, before the operation was starved and strongly dehydrated, while in the day of operation it drunk 20 l. of water with chloralhydrate. It is difficult to say if the anaesthesia caused some permanent and considerable decrease in the tension of muscular membrane of the alimentary canal. On the basis of the action of acetylcholine used during the anaesthesia it seems that there was no such decrease and the anasthesia should not result in any changes in the capacity of the alimentary canal.

The weight of the wall and digesta of the alimentary tract in bisons could be compared with Blamire's (1952) data, but exclusively for cattle stomachs.

In bisons the weight of the walls is lower than in cattle. On the other hand the weight of the stomach content was rather higher in bisons than in cattle. It is possible that the quality of the food is responsible for this fact.

The ratio of the weight of the total tract with digesta to the body weight is almost as high as in other non-domesticated ruminants, considerably differing in size, but similarly fed. The feeding of ruminants in breeding enclosures is, in general, quite similar. On the other hand the same ratio in cattle is distinctly higher.

Although the measurements of the intestine lenght were taken by other laboratory, still the attention was paid to the presence of active and nonactive sections of the small intestine. This way of the intestine work was for the first time indicated by Kvasnicki (1951) in swine. Later the active and nonactive sections were found in non-domesticated ruminants (Gill & Jaczewski, 1957; Gill & Korda, 1960) and in cattle (Gill, 1963). The described here lack of active and nonactive sections in the small intestine of the bisons is not the biological property of the European bison, rather, but most probably the result of too late approaching the alimentary canal, when the activity of bacteria and their gases changed already the vital status. On the other hand in bisons fixed immediately after the death there also were lacking changes in colour and size of the intestine diameter. This problem requires a keen examination whenever it is possible.

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POJEMNOŚĆ ORAZ CIĘŻAR ŚCIAN I ZAWARTOŚCI PRZEWODU POKARMOWEGO ŻUBRA

Streszczenie

U 3 dorosłych żubrów — samców maksymalna pośmiertna pojemność przewodu pokarmowego waha się od 268 do 275 l, w czym żwacz + czepiec stanowiły 99—120 l, księgi + trawieniec 30,5—39, jelito cienkie 71,1—80, jelito ślepe 8,5—12,6, okrężnica i jelito proste 33,2—50 l. U 13-miesięcznego byczka te same wartości wynosiły: 58,5 l, 10,0, 23,5, 3,3 i 11,0 l (Tabela 2).

U 2 samców: dorosłego i 11-miesięcznego oznaczono pojemność przewodu pokarmowego utrwalonego w zwłokach tuż po śmierci. Wielkości te mają odpowiadać wielkościom przyżyciowym. Dla dorosłego wynoszą kolejno: 57,0, 11,7, 12,28, 0,97 i 3,25 l — razem 85,2 l, u młodego: 19,2, 3,5, 1,8 i 3,0 l — razem 36,0 l.

Wyliczono względną pojemność żołądka (Tabela 3) oraz stosunek pojemności jelita cienkiego i grubego do jego długości oraz stosunek pojemności jelita grubego do cienkiego (Tabela 4).

Ciężar ścian całego przewodu wahał się od 23,55 do 33,10 kg u dorosłych żubrów i 10,6 kg u młodego (Tabela 5). Treść pokarmowa ważyła: u dorosłych 64,1—78,6 kg, u młodego 29,8 kg.

Ponadto badano stan czynny i spoczynkowy w jelicie cienkim żubrów. Nie zaobserwowano zmiany barwy, ani średnicy, które wskazywałyby na istnienie przyżyciowo takich odcinków w jelicie żubra.