Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 24, *Numbers* 1 *and* 2, *April,* 1950.

Printed in the Union of South Africa by the Government Printer, Pretoria.

Digestibility of Lucerne Hay with Special Reference to Experimental Technique in Digestion Trials.

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INTRODUCTION.

In determining the digestion coefficients of the various nutrients in any feedstuff as many replications of feeding trials as is possible are generally taken into consideration. Average values for coefficients of digestibility have been obtained without taking the possible influences of age in animals and level of feed intake into account. Morrison (1947) for instance, gives the digestibility coefficients of lucerne hay (alfalfa) as based on no less than 242 trials.

Insufficient data appear to be available on the influence of season, or the increasing maturity of experimental animals, on the digestibility of a particular feed. Watson *et al.* (1936) are of the opinion that digestibility coefficients of a feed may vary for different experimental periods. If the digestibility of a certain feed is, therefore, to be compared with that of another feed, the experiments should be so designed that all feeds which are to be compared, are tested in the same experimental period. Such a procedure would result in different animals having to be used in testing comparable feeds. However, this difficulty is overcome by repeating in more than one period and using different animals each time. The result is an average digestion coefficient for each feedstuff, for different animals and over different periods.

The experimental design advocated is that of the typical Latin Square or Randomized Block as evolved by Fisher (1925-1946). In the Latin Square, the number of feeds to be tested, the number of animals to be used and the number of periods of repetition would all have to be the same; a restriction which does not apply to the Randomized Block Layout. According to more recent work on the digestibility studies with swine, Watson *et al.* (1943) used an experimental technique which involved an 8×8 Latin Square. Their experimental layout must be regarded as quite remarkable for size and on this occasion there was no significant period influence.

The principles underlying these two experimental designs, the Randomized Block and Latin Square, are pre-eminently sound and as regards reducing any bias due to period influence which may be in favour of any particular feed, they cannot be improved upon. However, when unskilled assistants have to be employed in the feeding of experimental animals, mistakes may arise more easily when more than one feed has to be fed at the same time than would be the case if all animals were to receive the same feed or mixture. The advantages to be gained by eliminating the possibility of period effect may easily be appreciated. The object of this preliminary work was therefore, to study the period influence on digestibility.

Received for publication on 14th June, 1948.—Editor.

EXPERIMENTAL.

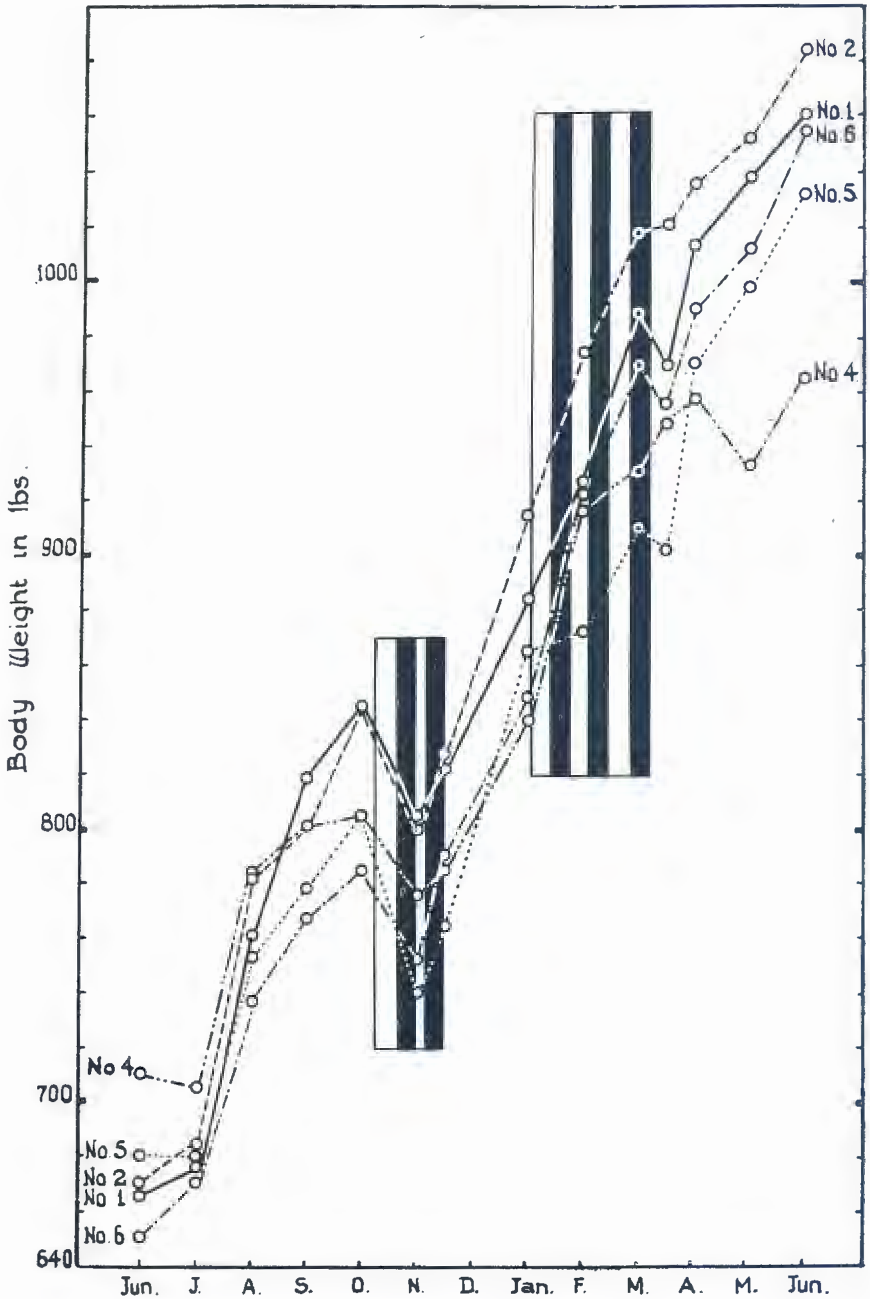
Six two-year-old Afrikaner steers that were trained to the wearing of digestion harness and the routine of the stalls, became available for this work. These animals consumed lucerne hay very readily and showed satisfactory gains on a ration of lucerne hay only as may be judged from the accompanying photographs and weight curves. As there is no doubt that unsupplemented good quality lucerne hay would supply the nutrient requirements of steers during the preliminary and experimental periods, it was decided that this feed be used during successive experimental periods in order to determine whether there is any significant difference in the digestion coefficients of lucerne hay from period to period. From October 1946 to March 1947 five 10-day experimental periods were completed. After a preliminary period of 10 days, the first two experimental periods were separated by a 5-day rest period only. The steers were then rested for two months during which they received a balanced concentrate in order to provide a complete change. The last three experimental periods were then completed after being preceded by a 10-day preliminary period and separated from each other by ten and elevenday rest periods, during which the lucerne ration remained constant.

The experimental duration as well as weight curves are illustrated in Graph. I.

An unaccountable depression in weight is evident in the case of all the steers during the first experimental period. Although the ration was not changed a marked recovery in weight is shown for the second period. During these periods all steers readily consumed 15 lb. of chaffed lucerne hay each per day. The sudden depression in weight apparently had no influence on the coefficients of digestibility. However, in view of the increased weights of the steers their lucerne ration was increased to 20 lb. each daily during the last three periods. Whilst assuring adequate nutrient intake this change in the daily allowance was taken not to have affected the results, in view of the conclusion reached by several investigators (c.f. Watson *et al.,* 1935) that variations within the normal plane of intake had no influence *per se* upon digestibility of roughages for ruminants. The feed consisted of sufficient chaffed lucerne hay to last the entire five experimental periods. This provision of a feed supply of uniform composition and adequate for all trials is of the utmost importance for this type of investigation in order that fluctuation of digestibility due to variations in chemical composition may be eliminated. The chaffed hay was well mixed and stored on a cement floor of a well ventilated room. The lucerne ration for each animal was weighed into large drums and samples taken for chemical analysis daily. Approximately half of the lucerne from each drum was fed at 9 a.m. and the balance at 2 p.m. This enabled the feed to be consumed at leisure and without wastage. The animals had free access to clean water at all times. While feed was being put into the mangers the animals were allowed out into an adjoining, concrete-floored paddock which measured 15 × 30 yards. In this way the animals were exercised for about an hour before each feed, during which time close observation was kept by an attendant in order to see that metabolism bags did not get out of place.

The collection of faeces commenced on the eleventh day and the trial lasted ten days, the bags being emptied into special bins with lids twice daily. Each 24-hour collection of faeces was weighed, well-mixed and sampled for analysis. The samples weighed 5 per cent. of the total and were dried on zinc pans in a Freas (air-circulated) oven at 80° C. About six hours was required for complete drying. The loss of weight was then obtained and the dry weight of faeces voided by each animal was recorded. The dry faeces of each animal were pooled

GRAPH I.—*The solid bands indicate the five 10-day experimental periods. The open bands show the preliminary and inter-periods of rest.*



separately, the 10-day collection then ground, well mixed and stored in well-stoppered jars. Analyses on these samples were generally undertaken immediately after the conclusion of each period. The following analyses were done: moisture, crude protein (Kjeldahl Method), crude fibre, ether extract, total ash, organic matter (calculated from ash content) and nitrogen-free extract (calculated by difference in the usual manner).

Digestion coefficients were calculated in the usual manner, and listed in the appendix.

All relevant data in detail are also given in the appendix. During the course of period No. 2, Bovine No. 3 became sick, developed diarrhoea and had to be withdrawn from the experiment. All other animals responded well and the trials proceeded without further mishap.

RESULTS.

(a) Crude Data:

TABLE 1.

Average Percentage Composition of the Lucerne Hay Expressed on dry basis.

Period.	Crude. Protein.	Crude. Fibre.	Ether. Extract.	Total Ash.	Organic Matter.	Nitrogen-free Extract.
1.............	17·47	30·70	2·43	9·82	90·18	39·68
2.............	17·65	30·70	2·42	8·80	91·20	40·43
3.............	17·76	30·50	2·49	8·80	91·20	40·45
4.............	18·25	29·40	2·57	7·87	92·13	41·91
5.............	17·05	29·20	2·38	10·20	89·80	41·17

The composition of the hay samples for the five periods is given in Table 1.

Since lucerne hay is somewhat difficult to sample, the composition may vary, but fortunately only within narrow limits as is shown. The value for ash, is merely given to arrive at a figure for organic matter and to enable a figure for nitrogen-free extract, to be calculated by difference in the conventional way.

TABLE 2.

Coefficients of Digestion of the Dry Matter of Lucerne Hay.

Bovine No.	PERIODS.					Totals	Means.
	1.	2.	3.	4.	5.		
1..............	57·4	56·7	58·5	55·3	55·9	283·8	56·8
2..............	56·4	59·6	59·6	60·0	58·5	294·1	58·8
4..............	57·8	56·6	60·0	57·4	54·8	286·6	57·3
5..............	56·6	58·7	58·6	56·7	56·4	287·0	57·4
6..............	56·7	60·7	60·0	58·4	56·0	291·8	58·4
TOTALS.....	284·9	292·3	296·7	287·8	281·6	1,443·3	—
MEANS.....	57·0	58·5	59·3	57·6	56·3	—	57·7

TABLE 3.

Coefficients of Digestion of the Crude Protein of Lucerne Hay.

Bovine No.	Periods.					Totals	Means.
	1.	2.	3.	4.	5.		
1	75·7	74·6	74·5	75·6	75·6	376·0	75·2
2	76·9	76·5	75·2	78·1	77·7	384·4	76·9
4	76·2	74·0	75·5	71·3	72·6	369·6	73·9
5	73·7	74·8	74·9	75·5	74·5	373·4	74·7
6	75·0	77·4	75·8	77·0	74·5	379·7	75·9
TOTALS	377·5	377·3	375·9	377·5	374·9	1,883·1	—
MEANS	75·5	75·5	75·2	75·5	75·0	—	75·3

TABLE 4.

Coefficients of Digestion of the Crude Fibre of Lucerne Hay.

Bovine No.	Periods.					Totals	Means.
	1.	2.	3.	4.	5.		
1	34·4	34·4	37·5	32·5	32·0	170·8	34·2
2	33·8	34·4	41·7	36·7	36·9	183·5	36·7
4	37·0	36·8	39·7	39·7	34·0	187·2	37·4
5	35·2	38·3	39·6	33·8	37·4	184·3	36·9
6	34·7	40·8	41·6	36·0	33·7	186·8	37·4
TOTALS	175·1	184·7	200·1	178·7	174·0	912·6	—
MEANS	35·0	36·9	40·0	35·7	34·8	—	36·5

(b) Analysis of Crude Data:

Fisher's (1925-1946) analysis of variance technique was carried out on the three sets of coefficients indicating dry matter, crude protein, and crude fibre in Tables 2, 3 and 4. The variation was split up into the following subdivisions with degrees of freedom as shown.

Variation due to animals	4	(D.F.)
Variation due to periods	4	
Variation due to error ...	16	
Total Variation	24	

From these analyses of variance tables it is possible to determine four different coefficients of variation. All four are a measure of the variability of the data but the first reflects the total variation; the second shows total variation minus that part due to the animals; the third reflects the total variation minus that part due to periods and the fourth coefficient of variation reflects the total variation when both animal and period variability have been removed. This final coefficient is a true measure of the experimental error.

Table 5, sets out these four coefficients.

TABLE 5.

Coefficients of Variation of Dry Matter, Crude Protein and Crude Fibre Digestibility Coefficients.

	Coefficients of Variation as Calculated from:			
	(1) Total Variation.	(2) Total Variation minus Bovine Variation.	(3) Total Variation minus Period Variation.	(4) Total Variation minus Bovine and Period Variation.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Dry Matter.....	2·87	2·78	2·34**	2·04
Crude Protein...	2·20	1·85*	2·32	1·93
Crude Fibre.....	7·72	7·61	6·11**	5·44

By use of the experimental error as exemplified by the No. 4 coefficient in Table 5 it is possible to determine significance levels which may be used in determining to what extent the average coefficients of digestion as determined for the different periods are significantly different. These significance criterions have been set out in Table 6 below, side by side with the period means rewritten from Tables 2, 3, and 4.

TABLE 6.

Means of the Dry Matter, Crude Protein and Crude Fibre Coefficients of Digestion as averaged over each period with significance levels.

	Averages of Periods.					Necessary Differences.	
	1.	2.	3.	4.	5.	P=·05	P=·01.
Dry Matter.....	57·0	58·5	59·3	57·6	56·3	1·55	2·14
Crude Protein...	75·5	76·3	75·2	75·5	75·0	1·83	2·52
Crude Fibre.....	35·0	36·9	40·0	35·7	34·8	2·44	3·36

According to the first row of the above table the largest average coefficient of digestion for dry matter is 59·3 per cent. as obtained in Period 3; the smallest is 56·3 per cent. as obtained in Period 5. The difference, 3 per cent. surpasses 2·14 and we may conclude that the dry matter coefficient of digestion as obtained from Period 3 was significantly larger than that obtained in Period 5 at the P= ·01 level of significance. Arguing on similar lines we may pick out all the other significant differences as follows:

For Dry Matter:

(*a*) Means of Periods 3 and 2 are greater than mean of Period 5 at P= ·01.

(*b*) Mean of Period 3 is greater than mean of Period 1 at P= ·01, and greater than mean of Period 4 at P= ·05.

(*c*) All other differences are insignificant.

(*d*) The descending order of magnitude is 3, 2, 4, 1, 5.

For Crude Protein:

(*a*) There are no significant differences between means.

(*b*) The descending order of magnitude is 2, 1, 4, 3, 5.

For Crude Fibre:

(*a*) Mean of Period 3 is greater than means of periods 5, 1, and 4 at P= ·01.

(*b*) All other differences are insignificant.

(*c*) The descending order of magnitude is 3, 2, 4, 1, 5.

Although not relevant to this discussion Table 7 is included for interest sake, since it gives the averages per animal with similar levels of significance.

TABLE 7.

Means of the Dry Matter, Crude Protein, and Crude Fibre Coefficients of digestion as averaged for each steer with significance levels.

	Averages for Steers.					Significance Levels at	
	1.	2.	4.	5.	6.	P= ·05.	P= ·01.
Dry Matter.....	56·8	58·8	57·3	57·4	58·4	1·58	2·18
Crude Protein...	75·2	76·9	73·9	74·7	75·9	1·96	2·70
Crude Fibre.....	34·2	36·7	37·4	36·9	37·4	2·66	3·66

DISCUSSION OF RESULTS.

The data in Table 1 show that as far as the chemical analysis is concerned the lucerne hay may be regarded as having been of uniform quality (approximately 17·5 per cent. crude protein and 30·0 per cent fibre) throughout the course of the experiment. The average coefficients of digestibility obtained for the various nutrients are in fairly good agreement with those reported for steers by Christensen and Hopper (1938) using a lucerne hay of essentially similar composition.

From the coefficients of variation in Table 5 it is evident that for dry matter and crude protein, there is very little variability in the coefficients of digestibility, the figures for total variation being only 2·87 per cent. and 2·20 per cent. respectively. Such low values are highly satisfactory pointing to uniformity of material and technique. The asterisks in the table show where the significance lies and it may be seen that period to period variation in the digestion coefficients is significant in the case of dry matter but quite insignificant in the case of crude protein. On removal of the appropriate portions of variability by means of the analysis of variance technique, the coefficient of total variation for dry matter drops from 2·87 per cent. to 2·34 per cent. In the case of crude protein the result is an increase from 2·20 per cent. to 2·32 per cent. which can be explained by the fact that the variability removed is so little that it cannot even off-set the loss of four degrees of freedom for periods. In both cases the changes are too small to warrant attention.

Although steer to steer variation does not interest us particularly, the same lack of variability is noticeable.

In the case of crude fibre, total variation in digestion coefficients is in general higher and the removal of period to period variation lowers the coefficient of variation by nearly 2 per cent. from 7·72 to 6·11 per cent.

A study of Table 6 confirms the conclusions arrived at from Table 5. No single significant difference is to be found among the crude protein period averages, but for dry matter and crude fibre, the coefficients of digestion are significantly higher in some periods than in others. For dry matter the range is only from 56·3 to 59·3 per cent and for practical purposes can be ignored; except Period 3, when the digestion coefficient rose to 40 per cent. the variability of the crude fibre coefficients is equally low.

If the determination of the digestion coefficient of the crude protein in a feedstuff may be regarded as the primary object of our digestion trials, then we have here a result which indicates that animals do not yield varying coefficients from period to period. In consequence it would be safe to determine the digestion coefficient of the crude protein of one feedstuff in one period and that of a second feedstuff in a second period without fear of introducing any period difference, provided an adequate level of intake is assured. The digestion coefficient of the crude protein of lucerne hay remained constant even though the daily consumption changed from 15 lb. per head per day in periods 1 and 2 to 20 lb. per head per day in Periods 3, 4 and 5.

If, however, dry matter or crude fibre coefficients of digestion are the primary objects of the digestion trials, there can be no certainty that coefficients will not change from period to period. Whether this be due to fibre digesting inefficiency of the animal body or variability in our methods of determination, the fact remains that the differences from period to period do occur and cannot be ignored.

We have arrived thus at an unfortunate result in that crude protein coefficients of digestion tell us one thing whilst dry matter and crude fibre coefficients of digestion point to a different conclusion, and we are as far as ever from being able to lay down a suitable experimental technique. The result of the impasse is that a continuation of the experiment has been decided upon and futher results will be reported in due course. An added advantage of this continuation will be that the experimental animals have aged by one year and it will be interesting to observe whether age exerts any influence on the digestion coefficients.

Conclusions.

Although there is some evidence of a period influence, this influence is so small that the temptation (in view of the importance of simplicity of technique) to ignore it is very great. The Latin Square or Randomized Block layout remains without doubt the correct unbiased technique and, where possible, it should be adopted, but where unskilled labour has to be used and may easily be the cause for error, the following simple technique is suggested:—

> Run digestion trials with 5 or 6 animals on feedstuff A. Then run digestion trials with feedstuff B; then, repeat the trials with feedstuff B and finally repeat digestion trials on feedstuff A, carrying out the usual precautionary preliminary periods between each series. Average the 10 or 12 (depending on whether 5 or 6 animals were used), results for each feedstuff. A technique of this kind will have the advantage of being simple, only one feedstuff being under consideration at one time. Period variation will be taken into account in that a repeat performance is carried out on the 5 or 6 animals during a second period. The reason for repeating the feedstuffs in the order A B B A instead of A B A B is merely a safeguard against residual effects. The rations to be tested should naturally meet the nutritional as well as physiological requirements of the animals.

Summary.

Five steers were used to determine the digestion coefficients of the Dry Matter, Crude Protein, and Crude Fibre of lucerne hay during five separate periods. The analysis of the resultant data shows that period has no influence on the coefficients of Crude Protein, but there is some evidence of a period influence on the coefficients of digestion of Dry Matter and Crude Fibre.

In consequence it is concluded that the Latin Square or Randomized Block Technique of Fisher should be adhered to wherever possible, but since period effects tend to be very small, an alternative technique is suggested in the interests of simplicity.

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APPENDIX.

Table 8.

Summary of Digestibility Coefficients.

Period.	Bovines.	Dry Weight Intake Daily.	Dry Matter.	Crude Protein.	Crude Fibre.	Ether Extract.	N-Free Extract.	Org. Matter.
1.—		lb.						
4 Nov. '46 to 14 Nov. '46........	1	13·90	57·4	75·7	34·4	25·2	73·6	59·2
	2	13·90	56·4	76·9	33·8	25·2	69·6	57·5
	4	13·90	57·8	76·2	37·0	22·6	70·8	59·1
	5	13·90	56·6	73·7	35·2	19·6	72·2	58·3
	6	13·90	56·7	75·0	34·7	19·3	71·8	58·1
Average 5 Bovines	—	—	57·0	75·5	35·2	22·8	71·6	58·4
2.—								
19 Nov. '46, to 29 Nov. '46........	1	13·70	56·7	74·6	34·4	25·3	70·7	57·9
	2	13·70	59·6	76·5	34·4	27·4	75·7	60·5
	4	13·70	56·6	74·0	36·8	32·2	68·7	57·7
	5	13·70	58·7	74·8	38·3	25·0	72·5	60·0
	6	13·70	60·7	77·4	40·8	28·6	72·7	61·5
Average 5 Bovines	—	—	58·5	75·5	36·9	27·7	72·1	59·5
3.—								
27 Jan. '47, to 6 Feb. '47.........	1	18·11	58·5	74·5	37·5	29·7	72·1	59·9
	2	18·11	59·6	75·2	41·7	37·3	70·4	61·2
	4	18·11	60·0	75·5	39·7	31·9	74·0	61·7
	5	18·11	58·6	74·9	39·6	35·7	69·0	59·3
	6	18·11	60·0	75·8	41·6	28·0	71·9	61·3
Average 5 Bovines	—	—	59·3	75·2	40·0	32·5	71·5	60·7
4.—								
17 Feb. '47, to 27 Feb. '47.........	1	17·76	55·3	75·6	32·5	28·7	68·0	57·0
	2	17·76	60·0	78·1	36·7	37·9	71·6	60·8
	4	17·76	57·4	71·3	39·7	29·7	67·0	58·5
	5	17·76	56·7	75·5	33·8	33·4	67·3	57·4
	6	17·76	58·4	77·0	36·0	32·8	69·6	59·4
Average 5 Bovines	—	—	57·6	75·5	35·7	32·5	68·7	58·6
5.—								
10 March '47, to 20 March, '47.......	1	18·07	55·9	75·6	32·0	29·0	68·1	56·8
	2	18·07	58·5	77·7	36·9	27·5	69·0	59·2
	4	18·07	54·8	72·6	34·0	17·0	66·0	55·5
	5	18·07	56·1	74·5	37·4	28·3	66·3	57·5
	6	18·07	56·0	74·5	33·7	27·0	65·8	56·7
Average 5 Bovines	—	—	56·3	75·0	34·8	25·8	67·0	57·1

TABLE 9.

Digestibility of Lucerne Hay—Period 1.

Bovine.		Dry Matter.	Crude Protein.	Crude Fibre.	Ether Sol. Extract.	N-free Extractives.	Organic Matter.
		lb.	lb.	lb.	lb.	lb.	lb.
No. (1) 1529	Intake.......	13·90	2·47	4·27	0·337	5·52	12·55
	Excreted.....	5·93	0·60	2·80	0·242	1·46	5·11
	Digested.....	7·97	1·87	1·47	0·095	4·06	7·44
	Coefficient...	57·4	75·7	34·4	28·2	73·6	59·2
No. (2) 1608	Intake.......	13·90	2·47	4·27	0·337	5·52	12·55
	Excreted.....	6·07	0·57	2·83	0·252	1·68	5·33
	Digested.....	7·83	1·90	1·44	0·085	3·84	7·22
	Coefficient...	56·4	76·9	33·8	25·2	69·6	57·5
No. (4) 1484	Intake.......	13·90	2·47	4·27	0·337	5·52	12·55
	Excreted.....	5·87	0·59	2·69	0·261	1·61	5·14
	Digested.....	8·03	1·88	1·58	0·076	3·91	7·41
	Coefficient...	57·8	76·2	37·0	22·6	70·8	59·1
No. (5) 1554	Intake.......	13·90	2·47	4·27	0·337	5·52	12·55
	Excreted.....	6·03	0·65	2·77	0·271	1·54	5·23
	Digested.....	7·87	1·82	1·50	0·066	3·98	7·32
	Coefficient...	56·6	73·7	35·2	19·6	72·2	58·3
No. (6) 1640	Intake.......	13·90	2·47	4·27	0·337	5·52	12·55
	Excreted.....	6·01	0·62	2·79	0·272	1·56	5·27
	Digested	7·89	1·85	1·48	0·065	3·96	7·28
	Coefficient...	56·7	75·0	34·7	19·3	71·8	58·1
AVERAGE	COEFFICIENT...	57·0	75·5	35·2	22·8	71·6	58·4

TABLE 9. *(Contd.)*.

Digestibility of Lucerne Hay—Period 2.

Bovine.		Dry Matter.	Crude Protein.	Crude Fibre.	Ether Sol. Extract.	N-free Extractives.	Organic Matter.
		lb.	lb.	lb.	lb.	lb.	lb.
No. (1) 1529	Intake.......	13·70	2·42	4·21	0·332	5·62	12·50
	Excreted.....	5·94	0·62	2·76	0·248	1·65	5·27
	Digested.....	7·76	1·80	1·45	0·084	3·97	7·23
	Coefficient...	56·7	74·6	34·4	25·3	70·7	57·9
No. (2) 1608	Intake.......	13·70	2·42	4·21	0·332	5·62	12·50
	Excreted.....	5·52	0·57	2·75	0·241	1·37	4·93
	Digested.....	8·18	1·85	1·46	0·091	4·25	7·57
	Coefficient...	59·6	76·5	34·4	27·4	75·7	60·5
No. (4) 1484	Intake.......	13·70	2·42	4·21	0·332	5·62	12·50
	Excreted.....	5·94	0·63	2·66	0·225	1·76	5·28
	Digested.....	7·76	1·79	1·55	0·107	3·86	7·22
	Coefficient...	56·6	74·0	36·8	32·2	68·7	57·7
No. (5) 1554	Intake.......	13·70	2·42	4·21	0·332	5·62	12·50
	Excreted.....	5·66	0·61	2·60	0·249	1·55	5·01
	Digested.....	8·04	1·81	1·61	0·083	4·07	7·49
	Coefficient...	58·7	74·8	38·3	25·0	72·5	60·0
No. (6) 1640	Intake.......	13·70	2·42	4·21	0·332	5·62	12·50
	Excreted.....	5·83	0·55	2·49	0·237	1·54	4·78
	Digested.....	8·32	1·87	1·72	0·095	4·08	7·72
	Coefficient...	60·7	77·4	40·8	28·6	72·7	61·5
AVERAGE	COEFFICIENT...	58·5	75·5	36·9	27·7	72·1	59·5

TABLE 9. *(Contd.).*

Digestibility of Lucerne Hay—Period 3.

Bovine.		Dry Matter.	Crude Protein.	Crude Fibre.	Ether Sol. Extract.	N-free Extractives.	Organic Matter.
		lb.	lb.	lb.	lb.	lb.	lb.
No. (1) 1529	Intake.......	18·11	3·220	5·52	0·451	7·32	16·50
	Excreted.....	7·54	0·816	3·45	0·317	2·04	6·62
	Digested.....	10·57	2·404	2·07	0·134	5·28	9·88
	Coefficient...	58·5	74·5	37·5	29·7	72·1	59·9
No. (2) 1608	Intake.......	18·11	3·200	5·52	0·451	7·32	16·50
	Excreted.....	7·31	0·801	3·22	0·283	2·17	6·45
	Digested.....	10·80	2·419	2·30	0·168	5·15	10·05
	Coefficient...	59·6	75·2	41·7	37·3	70·4	61·2
No. (4) 1484	Intake.......	18·11	3·220	5·52	0·451	7·32	16·50
	Excreted.....	7·25	0·786	3·33	0·307	1·90	6·32
	Digested.....	10·86	2·434	2·19	0·144	5·42	10·18
	Coefficient...	60·0	75·5	39·7	31·9	74·0	61·7
No. (5) 1554	Intake.......	18·11	3·220	5·52	0·451	7·32	16·50
	Excreted.....	7·52	0·808	3·34	0·290	2·28	6·72
	Digested.....	10·59	2·412	2·18	0·161	5·04	9·78
	Coefficient...	58·6	74·9	39·6	35·7	69·0	59·3
No. (6) 1640	Intake.......	18·11	3·220	5·52	0·451	7·32	16·50
	Excreted.....	7·25	0·776	3·22	0·325	2·06	6·37
	Digested.....	10·86	2·444	2·30	0·126	5·26	10·13
	Coefficient...	60·0	75·8	41·6	28·0	71·9	61·3
AVERAGE	COEFFICIENT...	59·3	75·2	40·0	32·5	71·5	60·7

TABLE 9. *(Contd.).*

Digestibility of Lucerne Hay—Period 4.

Bovine.		Dry Matter.	Crude Protein.	Crude Fibre.	Ether Sol. Extract.	N-free Extractives.	Organic Matter.
		lb.	lb.	lb.	lb.	lb.	lb.
No. (1) 1529	Intake.......	17·76	3·240	5·220	0·457	7·44	16·36
	Excreted.....	7·94	0·790	3·530	0·326	2·39	7·05
	Digested.....	9·82	2·450	1·690	0·131	5·05	9·31
	Coefficient...	55·3	75·6	32·5	28·7	68·0	57·0
No. (2) 1608	Intake.......	17·76	3·240	5·220	0·457	7·44	16·36
	Excreted.....	7·09	0·708	3·300	0·281	2·11	6·40
	Digested.....	10·67	2·532	1·920	0·176	5·33	9·96
	Coefficient...	60·0	78·1	36·7	37·9	71·6	60·8
No. (4) 1484	Intake.......	17·54	2·710	5·160	0·457	7·34	16·15
	Excreted.....	7·47	0·780	3·110	0·321	2·44	6·70
	Digested.....	10·07	1·930	2·050	0·136	4·90	9·45
	Coefficient...	57·4	71·3	39·7	29·7	67·0	58·5
No. (5) 1554	Intake.......	17·76	3·240	5·220	0·457	7·44	16·36
	Excreted.....	7·69	0·798	3·460	0·304	2·40	6·97
	Digested.....	10·07	2·442	1·760	0·153	5·00	9·39
	Coefficient...	56·7	75·5	33·8	33·4	67·3	57·4
No. (6) 1640	Intake.......	17·76	3·240	5·220	0·457	7·44	16·36
	Excreted.....	7·38	0·750	3·340	0·307	2·26	6·64
	Digested.....	10·38	2·490	1·880	0·150	5·18	9·72
	Coefficient...	58·4	77·0	36·0	32·8	69·6	59·4
AVERAGE	COEFFICIENT...	57·6	75·5	35·7	32·5	68·7	58·6

TABLE 9. *(Contd.).*

Digestibility of Lucerne Hay—Period 5.

Bovine.		Dry Matter.	Crude Protein.	Crude Fibre.	Ether Sol. Extract.	N-free Extractives.	Organic Matter.
		lb.	lb.	lb.	lb.	lb.	lb.
No. (1) 1529	Intake.....	18·07	3·080	5·280	0·430	7·44	16·22
	Excreted.....	7·97	0·747	3·590	0·305	2·38	7·02
	Digested.....	10·10	2·333	1·690	0·125	5·06	9·20
	Coefficient...	55·9	75·6	32·0	29·0	68·1	56·8
No. (2) 1608	Intake.......	18·07	3·080	5·280	0·430	7·44	16·22
	Excreted.....	7·49	0·690	3·330	0·312	2·31	6·93
	Digested.....	10·58	2·390	1·950	0·118	5·13	9·59
	Coefficient...	58·5	77·7	36·9	27·5	69·0	59·2
No. (4) 1484	Intake.......	18·07	3·080	5·280	0·430	7·44	16·22
	Excreted.....	·8·17	0·846	3·480	0·357	2·53	7·22
	Digested.....	9·90	2·234	1·800	0·073	4·91	9·00
	Coefficient...	54·8	72·6	34·0	17·0	66·0	55·5
No. (5) 1554	Intake.......	18·07	3·080	5·280	0·430	7·44	16·22
	Excreted.....	7·83	0·783	3·300	0·308	2·51	6·90
	Digested.....	10·24	2·297	1·980	0·122	4·93	9·32
	Coefficient...	56·4	74·5	37·4	28·3	66·3	57·5
No. (6) 1640	Intake.......	18·07	3·080	5·280	0·430	7·44	16·22
	Excreted.....	7·95	0·784	3·500	0·314	2·55	7·03
	Digested.....	10·12	2·296	1·780	0·116	4·89	9·19
	Coefficient...	56·0	74·5	33·7	27·0	65·8	56·7
AVERAGE	COEFFICIENT...	56·3	75·0	34·8	25·8	67·0	57·1

TABLE 10.

Percentage Composition of the Faeces Expressed on absolute dry basis.

Period.	Bovine.	Crude Protein.	Crude Fibre.	Ether Sol. Extract.	Total Ash.	N-free Extractives.	Organic Matter.
1.............	1	10·18	47·20	4·08	13·80	24·74	86·20
	2	9·35	46·70	4·14	12·16	27·65	87·84
	4	10·04	45·80	4·44	12·36	27·36	87·64
	5	10·79	45·90	4·50	13·30	25·51	86·70
	6	10·38	46·50	4·52	12·30	26·30	87·70
2.............	1	10·43	46·40	4·17	11·15	27·84	88·85
	2	10·23	49·90	4·36	10·74	24·77	89·25
	4	10·60	44·80	3·78	11·08	29·74	88·92
	5	10·76	46·00	4·40	11·40	27·44	88·60
	6	10·20	46·30	4·40	10·37	28·73	88·63
3.............	1	10·82	45·80	4·21	12·16	27·01	87·84
	2	10·96	43·90	3·87	11·66	29·61	88·34
	4	10·85	46·00	4·24	12·82	26·09	87·18
	5	10·75	44·40	3·86	10·64	30·35	89·36
	6	10·70	44·30	4·49	12·15	28·36	87·85
4.............	1	9·96	44·50	4·11	11·20	30·23	88·80
	2	9·98	46·60	3·96	9·70	29·76	90·30
	4	10·42	47·40	4·30	10·26	33·42	89·74
	5	10·38	45·00	3·95	9·50	31·17	90·50
	6	10·16	45·20	4·16	9·90	30·58	90·10
5.............	1	9·37	45·00	3·83	11·90	29·90	88·10
	2	9·22	44·40	4·17	11·36	30·85	88·64
	4	10·36	42·60	4·37	11·68	30·99	88·32
	5	10·00	42·20	3·95	11·72	32·13	88·28
	6	9·86	44·00	3·95	11·60	30·59	88·40

FIG. 1.—Steers in concrete floored exercising paddock.

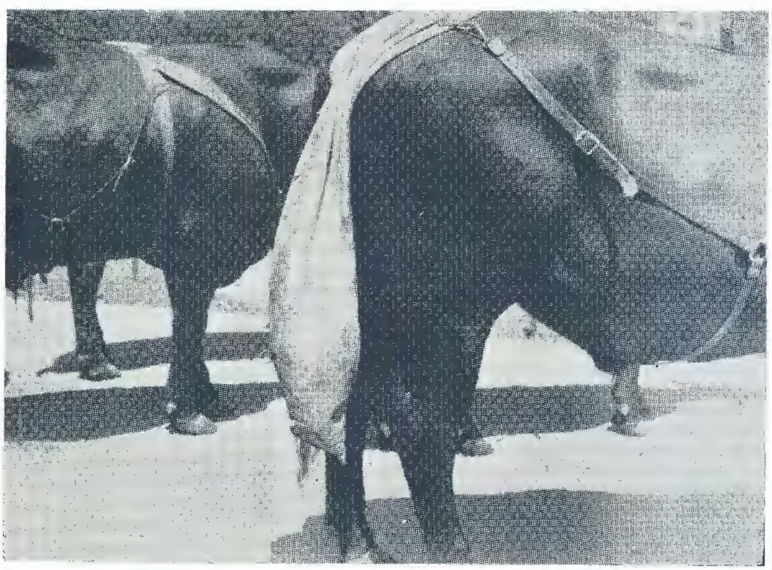

FIG. 2.—Side view of metabolism harness.

FIG. 3.—Rear view of metabolism harness

FIG. 4.—Animals in metabolism stalls.

FIG. 5.—Metabolism stalls.

FIG. 6.—The metabolism stall and equipment.

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