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# **AN ANALYSIS OF THE DUTCH "MANUAL FOR THE CALCULATION OF THE NUTRITIVE VALUE OF ROUGHAGES"**

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AN ANALYSIS OF THE DUTCH "MANUAL FOR THE CALCULATION OF THE NUTRITIVE  
VALUE OF ROUGHAGES"

A. GOLDMAN\* and A. GENIZI\*\*

Dutch formulae for calculating energy and protein contribution of roughage feeds for cattle were analyzed and found to be quite regular. When compared with Rostock data, a considerable level of agreement was found between the two systems as to energy value of roughages, in contrast to negligible agreement between Rostock data and the American Atlas, the data of which presented a low level of regularity. Some systemic differences were found between Rostock and Dutch values. Rostock data were evaluated as more reliable than the Dutch in some cases of disagreement. The methods of presenting the data to the user are compared. Finally, possible benefits of the information for users in Israel are discussed.

### INTRODUCTION

An unbiased and accurate evaluation of the nutritive value of feeds, especially roughages, is of utmost importance to both farmers and research workers. Israel recently changed over (5) from the "Scandinavian Feed Unit" system of feed evaluation to that of the National Research Council (NRC) (6,7,8). Goldman (3) had pointed out some inaccuracies in using data of the NRC system as a basis for Israel's needs for feed evaluation. Goldman and Genizi (4) had found that the energy contribution of roughages was highly correlated ( $R^2 > .95$ ) with six characteristics of the feed or its main constituents ( $R^2 > .92$ ) for tabled values from Rostock, East Germany (9), while for tabled values from the Atlas of Nutritional Data for the USA and Canada (6) the correlation was much lower ( $R^2 = .48$ ), for as many as 14 characteristics or for main constituents ( $R^2 = .52$ ). The agreement between the two sets as to the magnitude of effects of characteristics or constituents on the energy values of feeds was quite low ( $r^2 < .2$ ). Nevertheless, a high correlation ( $r^2 > .95$ ) was found (4) in both sets (6,9) between digestible protein (DP) and crude protein (CP), with very similar regression coefficients for both sets. Goldman (3) and Goldman and Genizi (4) concluded that the determination of energy data

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for roughages is quite complicated and depends greatly on the appropriate characterization and processing of the data obtained in digestibility trials.

The user of data on the nutritive value of feeds is interested in a simple and reliable system which enables him to plan his diets accurately enough to meet both his zootechnical and economic goals. As feeds, and especially roughages, vary greatly in time and place, their classification and characterization (and even more so - the evaluation of a certain lot of a feed) impose a serious problem of balancing between accuracy (demanding the inclusion, measurement and processing of more data on more factors) and practicability (concerning costs, time factor and simplicity), which is essential for a widely used system .

In the present work we analyzed the Dutch Manual for the Calculation of the Nutritive Value of Roughage (2) in comparison with the Rostock data (9). Agreement in the evaluation of feeds by separate, independent systems gives promise of their being universal, and may enable their use in additional countries. Other aspects considered were the method of processing the data and of their presentation to the user.

## METHODS

### Classification and coding of Dutch and Rostock data

Data of the Dutch Manual (2) were classified and coded in order to enable their processing together with those of Rostock (9). Appendix I provides a description of and codes for the parameters in both sets. All the data of feeds appearing in both sets were included in our analysis (320 feeds in all). The Dutch data are presented to the user as a set of equations and/or tables, which enable the calculation of the digestible protein (FCP) from the relevant parameters. The second element of feed evaluation is the energy contribution of the feed. This is calculated in steps: first the percentage of digestible organic matter (D) is calculated from the relevant parameters (either constituents or characteristics) for each feed and then the energy forms are given by formulas using D and FCP. For green fodders and their derivatives (which are our concern in this work), the energy calculations are:

Gross Energy (GE) is fixed at 4400 kcal/kg D.M.

Metabolizable Energy (MEHES =  $3.4D + 1.4 \text{ FCP}$  if  $D/\text{FCP} \leq 7$ .

MEHES =  $3.6D$  if  $D/\text{FCP} > 7$ .

Net Energy, Dairy Cows (VEM) =  $0.6 [1 + 0.004 (q-57)] * 0.9752 * \frac{\text{MEHES}}{1.65}$

Net Energy, Beef Cattle (VEVI) =  $\frac{0.0078q + 0.006}{\frac{0.00493q - 0.548}{1.5 (0.00287q + 0.554)} + 1} * \frac{\text{MEHES}}{1.65}$

(where  $q = 100 \text{ MEHES/GE}$ ).

VEM and VEVI are the Dutch feed units, 1.65 being the net energy of 1 g of barley grain. In this work VEM and VEVI were remultiplied by 1.65 and could thus be expressed in kcal.

The Dutch formulae for calculating FCP (using CP and ash) and D (using CF and ash) are given in Appendix II, followed by the list of coefficients used in these formulae (Appendix III).

Rostock data consist of the tabulated results of laboratory tests and digestibility trials for feeds specified by main characteristics (see App. I) as well as the calculated energy contribution for each energy level and for each specified feed.

#### Data processing

The Dutch equations were applied to each feed of Rostock using its own values of constituents or specified characteristics to calculate the digestible protein to be compared later on with the measured digestible protein. Similarly, the digestibility was calculated as a Dutch parallel to the Rostock total digestible nutrients (TDN) value, MEHES to metabolizable energy (ME) and VEM or VEVI to net energy gain (NETG) in the Rostock set.

The agreement between the pairs of parallel values of the Dutch and Rostock parameters was tested in three ways:

- (i) Graphic presentation of Rostock values on the ordinate against Dutch values on the abscissa.
- (ii) Linear Regressions of Rostock values against those of the Dutch, by the Stepwise Regression Procedure (1).

The causes for the residual variance were studied by repetitive regressions in various groupings of the classified feeds, or graphically by

assigning each data point several symbol types simultaneously according to its levels in different classifications, which enables the tracing of deviations from the equality line ( $y=x$ ) and their connection with the levels of the classification.

(iii) Multiple regression analyses and analyses of variance were carried out by the General Linear Models (GLM) procedure of the SAS package of computer programs (1) to fit a linear model for the dependence of each of D, TDN, MEHES and ME on feed characteristics and on constituents. The coefficients (Least Squares Estimates) of the GLM analyses for each pair (D-TDN and MEHES-ME) were compared and the correlation between these sets of coefficients for both pairs was calculated to form an integrating index of agreement between the Dutch and the Rostock sets of data as to the effects of characteristics or constituents on energy values of roughage feeds.

## RESULTS AND DISCUSSION

### Overall level of agreement between Dutch and Rostock energy data

Figures 1-4 represent the overall agreement between the two sets of data for the different levels of energy. For full agreement, the symbols in the graph must coincide with the equality line. The deviations of points from the line represent differences between the Dutch and the Rostock data in the evaluation of individual feeds (the sources of these differences are discussed later); the general position of the line relative to the "cloud" of points represents the systematic difference, in the evaluation of roughages as a whole, between the two sets of data.

The least agreement between the Dutch and Rostock sets is on digestibility data (D and TDN, respectively). The nominal equality line in Fig. 1 (solid line) should be corrected by about 3 digestibility units (broken line), as the Rostock TDN data are calculated on a dry-matter basis and D is calculated on an organic-matter basis. For metabolizable energy (Fig. 2) and for net energy for lactating cows (Fig. 3), the agreement is best. The Dutch feed unit for beef cattle (VEVI, Fig. 4) tends to rank high-energy feeds higher than does Rostock, and low-energy feeds lower. This is also seen in Table 1, where the corresponding slope is considerably less than 1.

Fig. 1: Overall agreement between Rostock (TDN) and Dutch (D) digestibility values. (320 roughage feeds; for symbols, see Appendix I.)

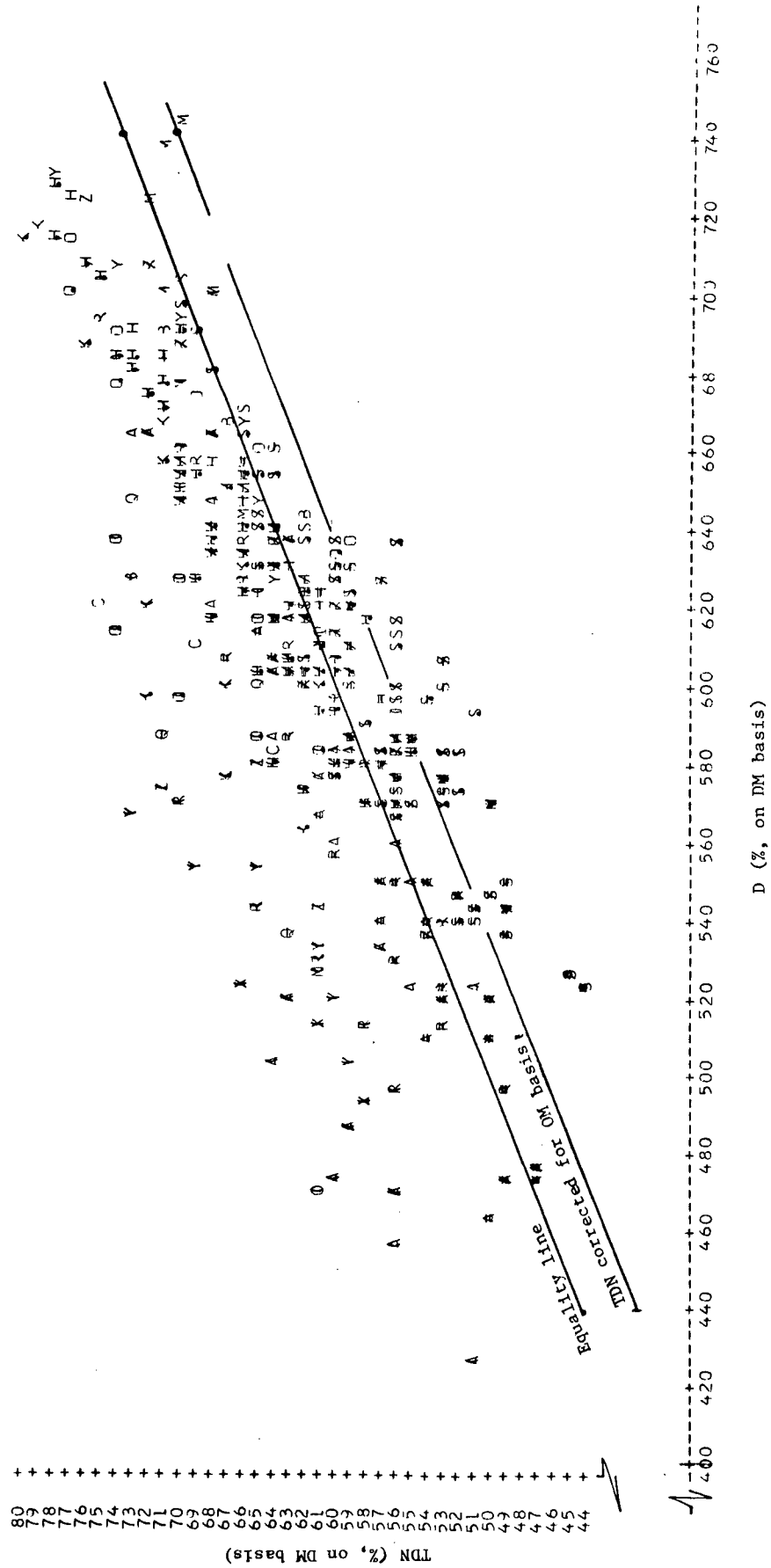


Fig. 2: Overall agreement between Rostock (ME) and Dutch (MEHES) metabolizable energy values. (320 roughage feeds; for symbols, see Appendix I.)

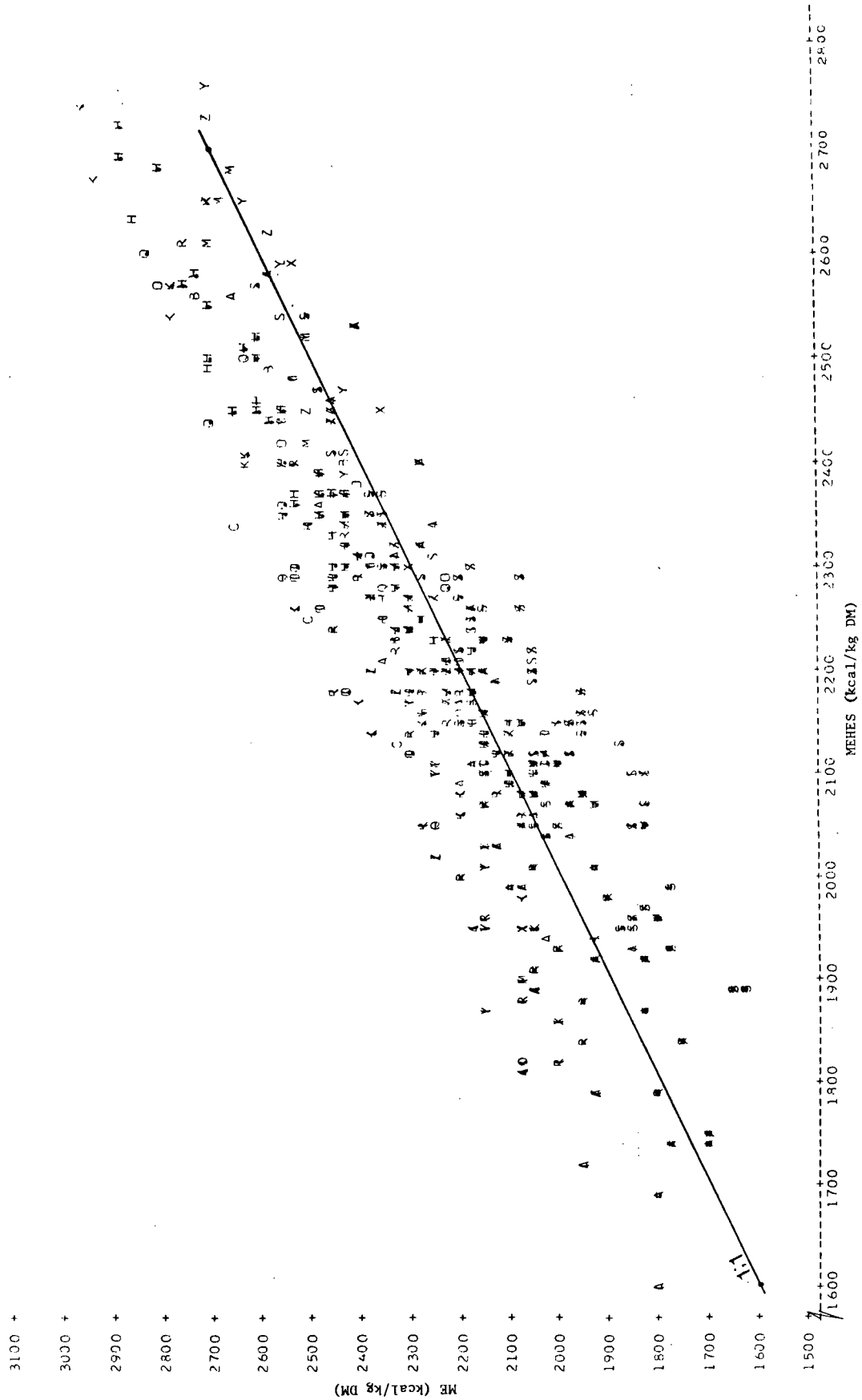




Fig. 3: Overall agreement between Rostock (NETG, net gain) and Dutch (VEM, net gain for dairy cows) values. (320 roughage feeds; for symbols, see Appendix I.)

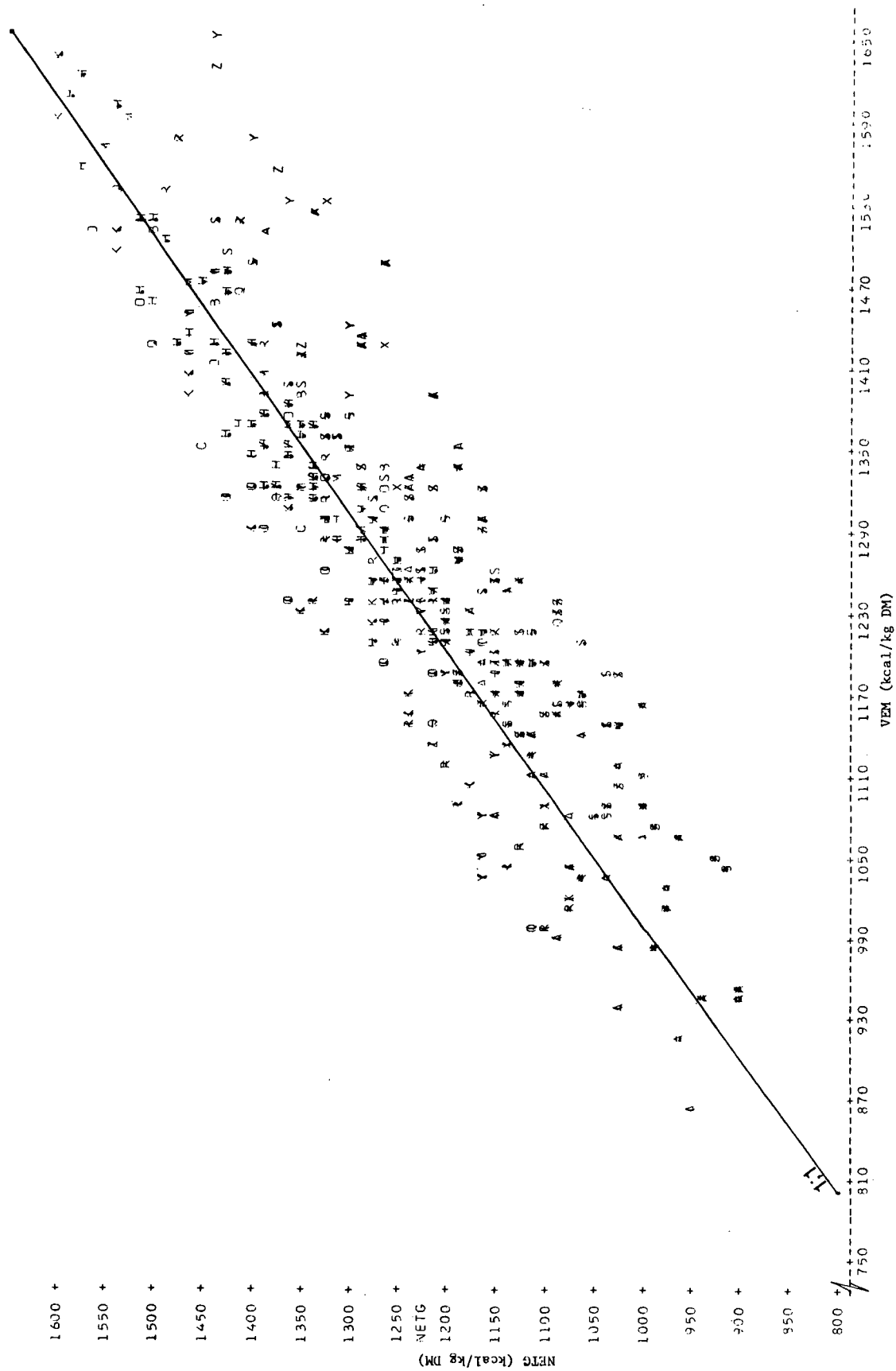


Fig. 4: Overall agreement between Rostock (NEIG, net gain) and Dutch (VEVI, net gain for beef cattle) values. (320 roughage feeds; for symbols, see Appendix I.)

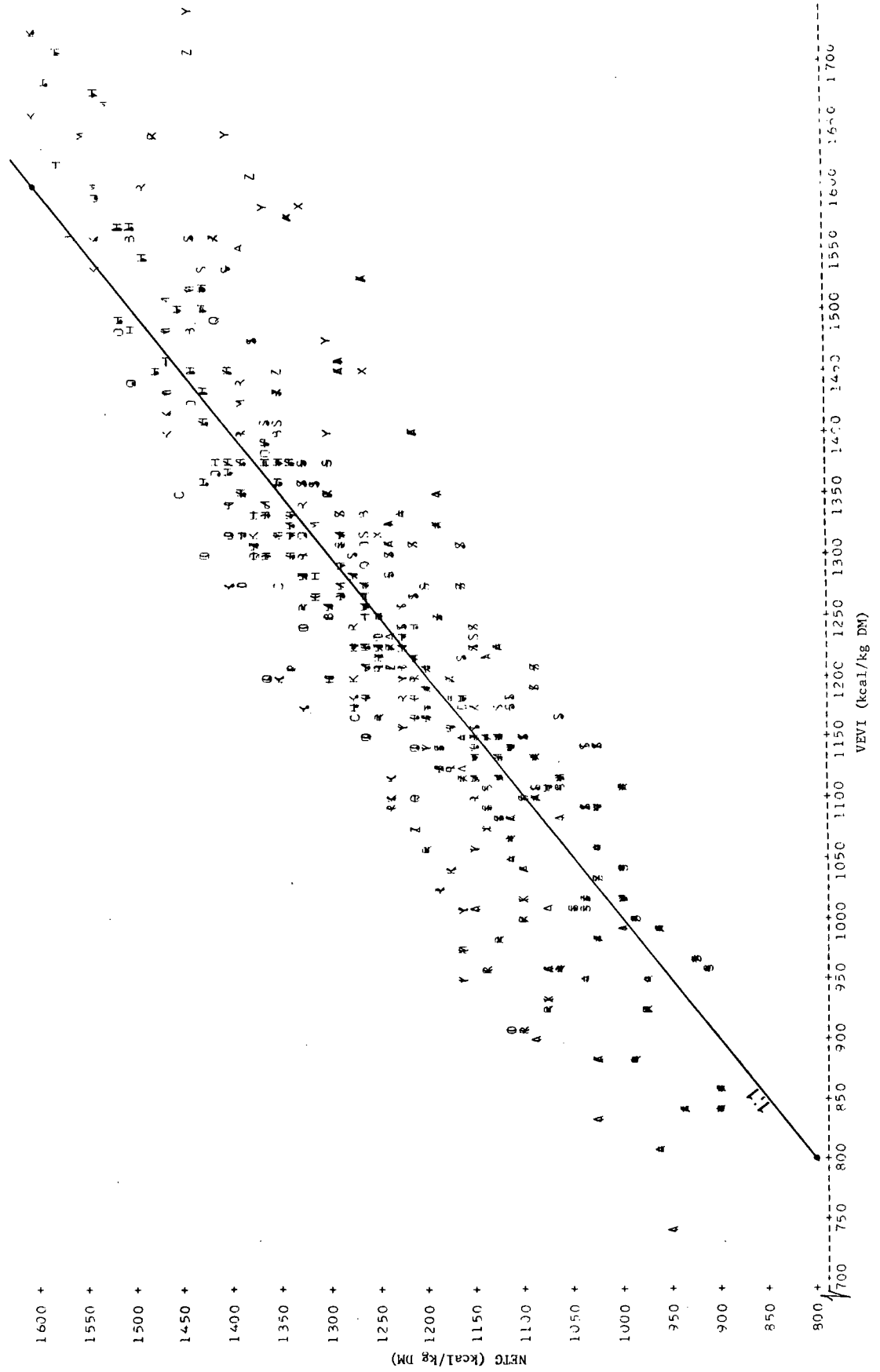


Table 1: Overall correlations between Rostock (Y) and Dutch (X) energy data (all feeds = 320)

Unit	Y	X	$r^2$	Intercept	Slope (B)	S.E. of B	Mean difference % $\pm$ S.D.*
%	TDN	D	.60	50	.95	.04	3 $\pm$ 7
kcal	ME	MEHES	.79	-155	1.09	.031	2 $\pm$ 5
kcal	NETG	VEM	.79	114	.89	.026	
kcal	NETG	VEVI	.79	375	.67	.020	

\* Standard deviation of differences in percentage.

Another measure of agreement between the two sets of data is the mean Rostock-Dutch difference as a percentage of the Rostock average and its standard deviation (S.D.). We obtained from the 320 pairs TDN-D = 3.0% with S.D. = 7.3%, and ME-MEHES = 2.0% with S.D. = 5.4%. The respective ranges are -13% to +26% for TDN-D, and -12% to +14% for ME-MEHES. These values, like the Figures, show a small systematic overall deviation of 2-3% and also a perceptible skewness to the positive values in the TDN-D difference.

#### Differences in agreement between the energy data for main uses

There seem to exist some systematic differences in agreement between the two systems which are related to the use of the feeds. For example: For hays (except for clover; Fig. 5) and fresh-cut feeds (Fig. 6), the Dutch evaluation for metabolizable energy (MEHES) tends to be higher than that of Rostock (ME), while for silages - except for second-grade meadow grass (Fig. 7) - that of Rostock is higher. Systematic differences between the two sets could also be found for other energy levels and other uses. Table 2 presents the detailed regressions of Rostock (Y) on Dutch (X) data for each energy level and for each of the five uses, showing systematic differences between the two sets in both the slopes' difference from 1 and the intercepts' deviation from zero of the regression lines.

Fig. 5: The agreement between Rostock (NETG, net gain) and Dutch (VEM, net gain for dairy cows) values for hays. (73 feeds; for symbols, see Appendix I.)

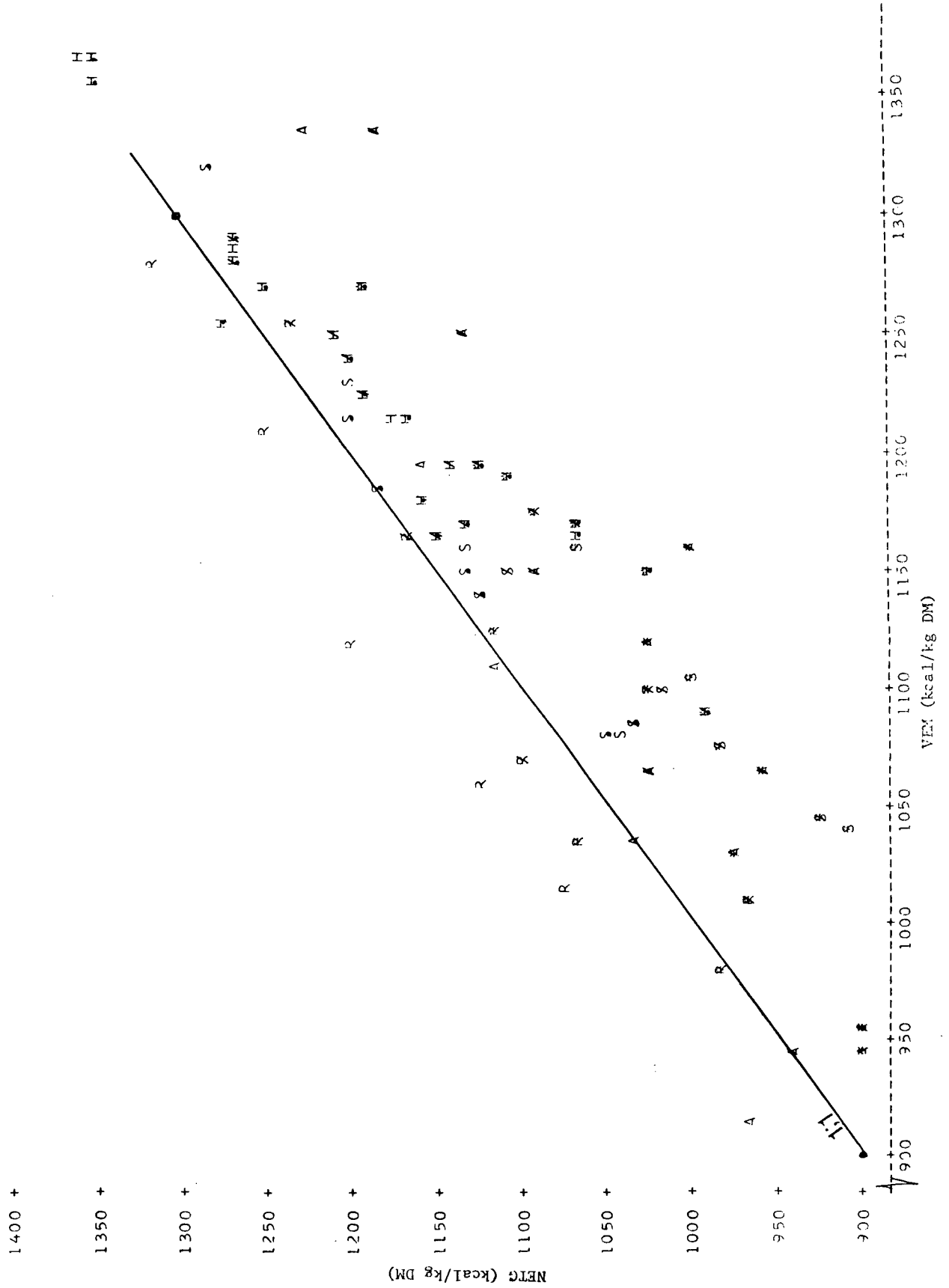


Fig. 6: The agreement on metabolizable energy of fresh cut roughages between Rostock (ME) and Dutch (MEHES) values. (103 feeds; for symbols, see Appendix I.)

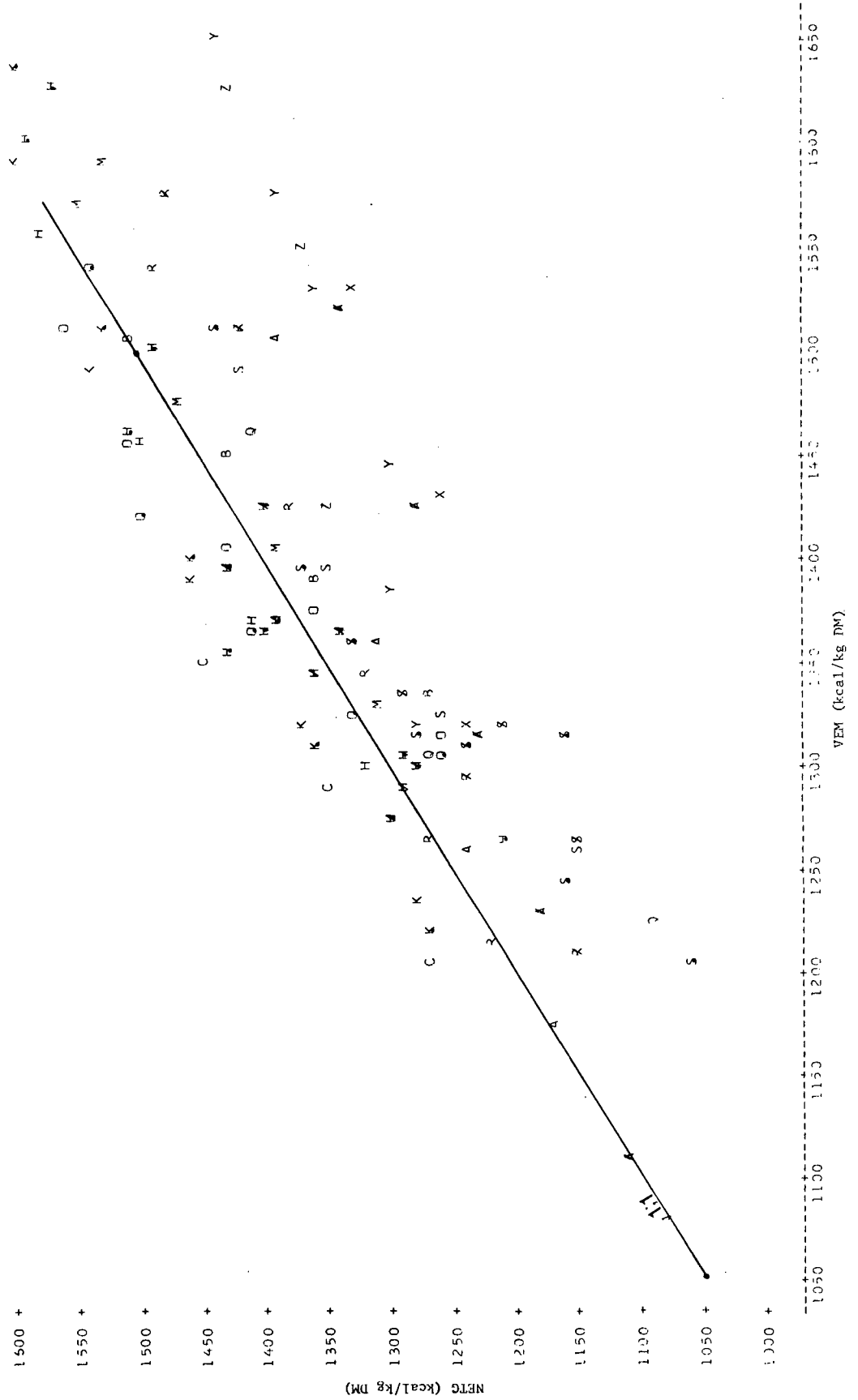


Fig. 7: The agreement between Rostock (ME) and Dutch (MEHES) values for silages. (76 feeds; for symbols, see Appendix I.)

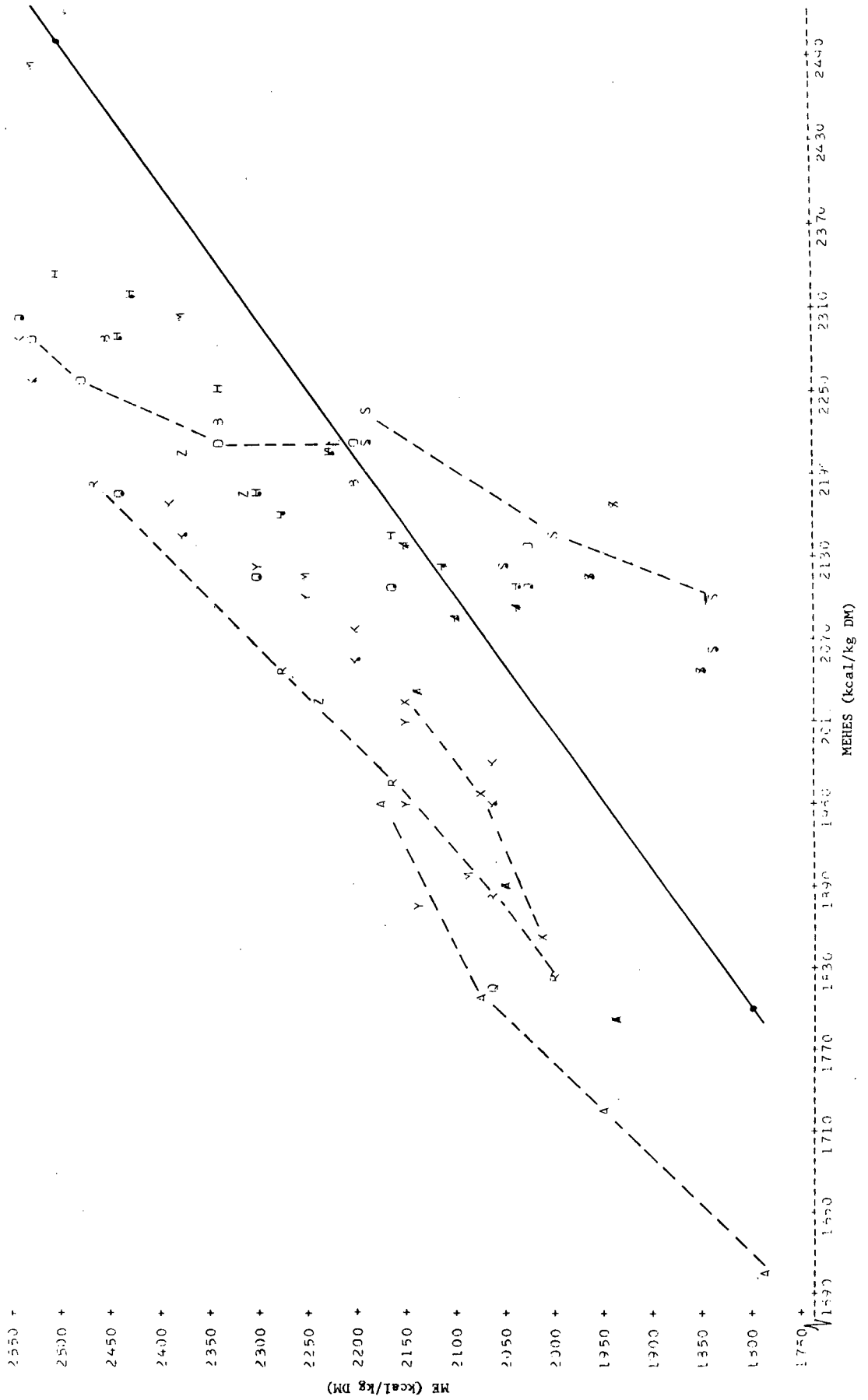


Table 2: Detailed correlations (by uses) between Rostock (Y) and Dutch (X) energy data

Use	N	Y	X	$r^2$	Intercept	Slope (B)	S.E. of B
Hays	73			.74	- 70	1.11	.08
Fresh	103	TDN	D	.66	- 74	1.14	.08
Silages	76	%	%	.26	-310	0.55	.10
Artificially dried	38			.85	-187	1.32	.09
Wilted silages	29			.42	- 67	1.11	.25
Hays	73			.82	-324	1.15	.07
Fresh	103			.77	-233	1.13	.06
Silages	76	ME	MEHES	.53	425	.84	.09
Artificially dried	38	kcal	kcal	.82	-429	1.20	.09
Wilted silages	29			.70	-812	1.36	.18
Hays	73			.83	6	.96	.05
Fresh	103	NETG	VEM	.70	161	.86	.06
Silages	76	kcal	kcal	.68	192	.86	.07
Artificially dried	38			.72	56	.92	.10
Wilted silages	29			.70	- 93	1.05	.13
Hays	73			.83	274	.76	.04
Fresh	103	NETG	VEVI	.70	425	.66	.04
Silages	76	kcal	kcal	.69	431	.69	.05
Artificially dried	38			.72	328	.72	.08
Wilted silages	29			.70	225	.81	.10

Differences between the energy evaluations of specific feeds

Systematic differences were traced between feeds within each use, and could be related to their characteristics, as plant species, cut number, etc. This can be seen in Figs. 5 - 7, and a more detailed example in Figs. 8 and 9, where feeds stemming from two species have different evaluations for effects of use and degree of maturity for different energy levels.

Fig. 8: The agreement between Rostock (along the ordinate) and Dutch (along the abscissa) values for white lupine roughages.  
(For symbols, see Appendix I.)

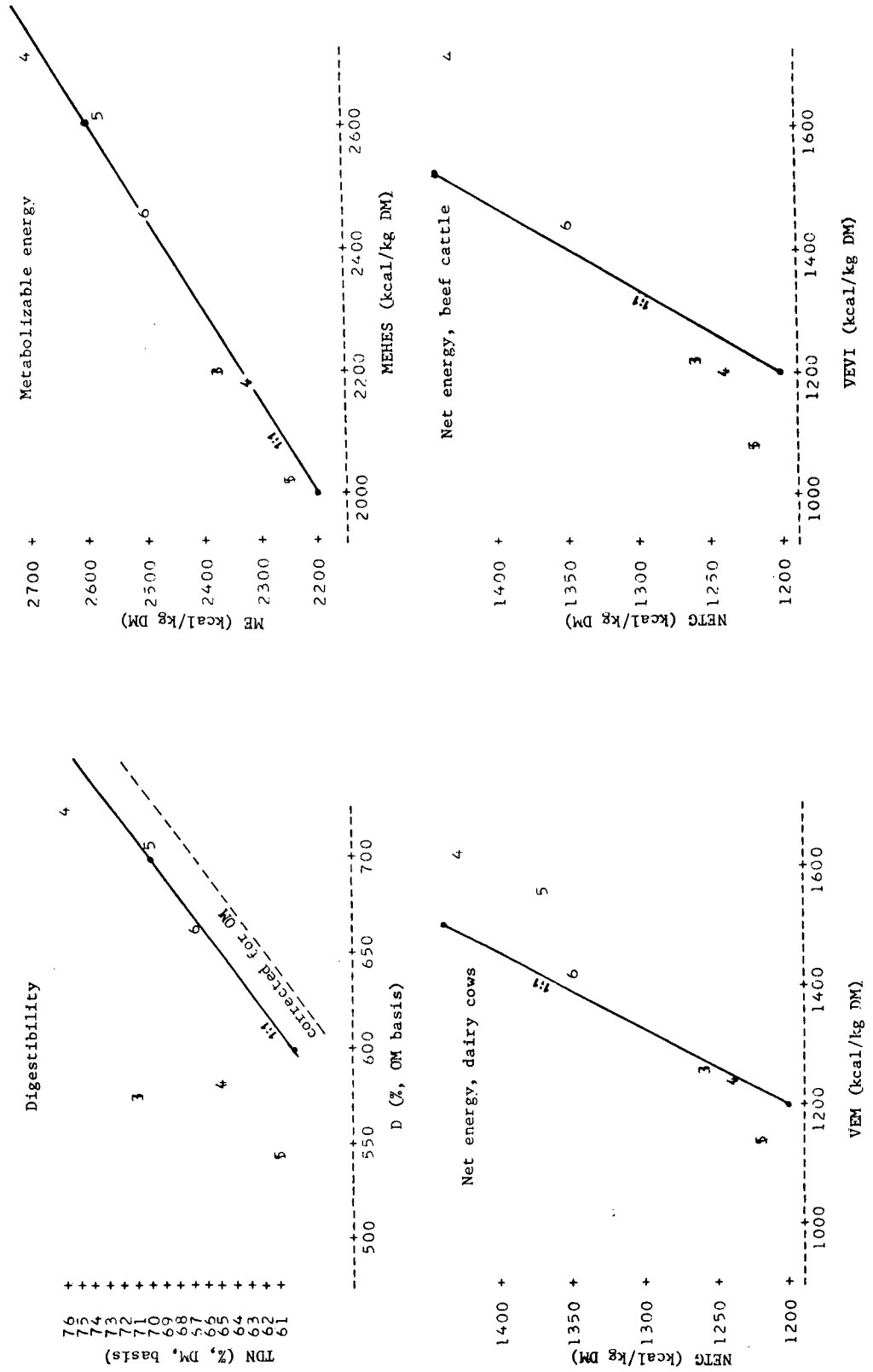
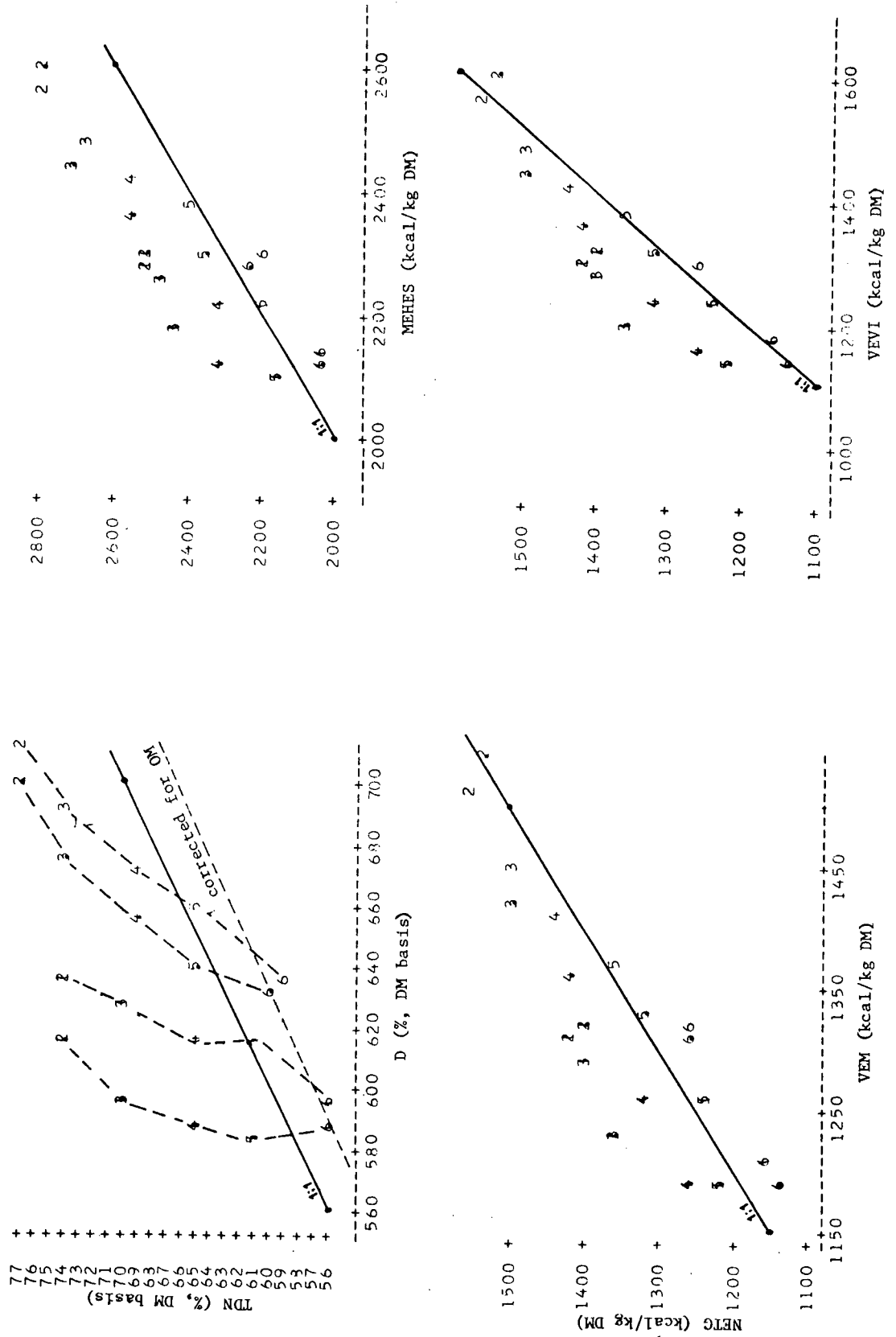




Fig. 9: The agreement between Rostock (along the ordinate) and Dutch (along the abscissa) values for oat roughages. (For symbols, see Appendix I.)



### Comparative multiple regression analyses of energy data

The combined effects of feed constituents on digestibility (TDN) of Rostock, measured; and D of the Dutch Manual, calculated), as well as on the metabolizable energy (ME and MEHES for the Rostock and Dutch data, respectively) were studied in the multiple regression analyses by the GLM Procedure (1). The summaries of the analyses are given in Table 3, and those for the effects of characteristics in Table 4. Tables 5 and 6 give the coefficients of each pair of analyses (of Tables 3 and 4, respectively) as a measure of agreement between the Dutch and Rostock sets, on the dependence of either digestibility or metabolizable energy of roughages on either constituents or characteristics of the feed.

Table 3: Regressions\* of energy parameters on main constituents  
(15 DF for Model, 304 DF for Error)

	%				kcal/kg DM			
Dependent variable	D		TDN		MEHES		ME	
Mean and CV	608	3.04	62	4.00	2228	2.98	2273	4.07
R <sup>2</sup>	.904		.883		.909		.883	
F value and PR F	191	.0001	153	.0001	204	.0001	153	.0001
Source variables	F value	PF	F value	PF	F value	PF	F value	PF
FD	69	.0001	52	.0001	65	.0001	56	.0001
CF	816	.0001	413	.0001	818	.0001	412	.0001
ASH	388	.0001	7	.01	385	.0001	128	.0001
DP	9.7	.002	37	.0001	55	.0001	71	.0001
Dependence function **	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Intercept	1023	16	944	21	3627	56	3620	78
FD	121	-94	12	-78	16	-335	42	-295
	131	-91	6	-115	08	-328	20	-426
	141	-3	9	-70	12	-86	32	-293
	143	-28	7	-51	10	-82	25	-232
	145	-26	9	-51	12	-80	32	-224
	151	-81	5	-144	7	-266	19	-448
	155	-84	9	-95	12	-263	32	-355
	239	-22	5	-55	7	-80	18	-188
	240	-25	6	-86	8	-82	20	-317
	251	6	9	-10	12	17	32	-65
	255	7	6	-03	9	28	23	-10
	269	-33	9	-41	12	-104	32	-146
	275	0	-	0	--	0	--	0
CF	-	.95	.03	-0.92	0.045	-3.44	.12	-3.40
ASH	-	1.03	.05	-0.18	0.071	-3.70	.19	-2.96
DP	-	.17	.06	0.45	0.075	-1.47	.20	2.33

\* Summaries of General Linear Model Program Outputs (1).

\*\* For codes of source variables, see Appendix I.

Table 4: Regressions of energy parameters on main characteristics  
(22 DF for Model, 297 DF for Error)

Dependent variable	%				kcal/kg DM			
	D		TDN		MEHES		ME	
Mean and % CV	607	4.89	627	4.92	2228	5.14	2273	5.28
R <sup>2</sup>	.757		.827		.737		.808	
F value and PR. F	42	.0001	65	.0001	38	.0001	57	.0001
Source variables	F value	PF	F value	PF	F value	PF	F value	PF
FD	22	.0001	26	.0001	16	.0001	24	.0001
USE	103	.0001	73	.0001	96	.0001	91	.0001
CUT	15	.0002	68	.0001	12	.0005	56	.0001
FRT	2	.023	8	.0001	4	.0019	7	.0001
MAT	148	.0001	583	.0001	209	.0001	384	.0001
Dependence function*	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Intercept	671	12	73	13	2520	47	2723	49
FD 121	- 46	19	10	20	-140	73	- 49	77
131	- 18	10	-15	10	- 57	39	- 87	41
141	- 11	15	14	15	38	57	- 66	59
143	7	12	26	12	85	46	9	48
145	31	15	39	15	169	56	93	59
151	- 45	10	-30	10	-101	39	-169	40
155	- 43	15	17	15	- 52	57	- 31	60
239	7	9	0	10	58	36	- 1	38
240	- 13	11	-59	11	- 17	42	-235	44
251	30	14	21	14	91	53	3	56
255	31	10	22	10	93	37	47	39
269	103	13	107	13	369	48	343	50
275	0	--	0	--	0	--	0	--
USE 1	- 43	7	-58	7	-174	26	-220	28
2	27	7	27	7	105	26	111	28
3	- 54	7	-17	7	-186	27	-151	28
6	- 4	8	-17	8	- 4	30	- 61	32
8	0	-	0	-	0	--	0	--
CUT 1	19	5	43	5	67	19	150	20
2	0	-	0	-	0	--		
FRT 0	-	-	-	-	-	-		
1	- 11	11	-48	11	-131	43	-181	45
2	3	8	-22	8	- 64	30	- 84	32
3	- 6	8	-25	8	- 51	29	- 86	31
4	18	8	4	8	13	31	4	32
6	0	-	0	-	0	-	0	-
MAT	- 17	1	-35	1	- 78	5	-110	6

\*) For codes of source variables, see Appendix I.

Table 5: Regressions of Rostock (Y) on Dutch (X) coefficients in the linear fits of TDN, D, ME and MEHES on feeds and constituents (from Table 3)

Coefficients for the effects of:	N	Y	X	$r^2$	Intercept	Slope
Plant species (FD)	13	TDN	D	.871	- 23	.93
CF + ASH + DP	3			.809	.03	.08
All	16	%	%	.620	- 33	.50
Plant species (FD)	13			.834	-108	.96
CF + ASH + DP	3	ME	MEHES	.993	71	1.09
All	16	kcal	kcal	.840	- 80	.96

Table 6: Regressions of Rostock (Y) on Dutch (X) coefficients in the linear fits of TDN, D, ME and MEHES on feeds and characteristics\* (from Table 4)

Coefficients for the effects of:	N	Y	X	$r^2$	Intercept	Slope
Plant species (FD)	13			.57	10	.72
USE	5	TDN	D	.58	- 4	.99
FRT	5	%	%	.66	-19	1.56
USE + FRT + CUT + MAT	13			.50	- 7	.86
ALL	26			.52	1	.78
Plant species (FD)	13			.71	-36	.88
USE	5	ME	MEHES	.91	-13	.99
FRT	5	kcal	kcal	.99	- 8	1.32
USE + FRT + CUT + MAT	13			.89	- 3	1.17
ALL	26			.76	-31	.91

\* See Appendix I.

The agreement between the coefficients of the two sets for ME on MEHES is better than that for TDN on D ( $r^2$  values in Tables 5 and 6), and for the effects of constituents (Table 5) better than for that of characteristics (Table 6). The two sets agree well on the effects of use (USE) and N fertilization (FRT), and less well on the effects of plant species (FD). As to the effect of date of harvest (CUT), there is an agreement that first cut is the best, but the Rostock coefficients are much higher; in the Dutch set there is a decline in both D and FCP for each month of delay, while the Rostock set differentiates only the first cut.

The effect of maturity (MAT) is also greater in the Rostock set. This tendency can be seen also in the figures, and especially in Fig. 10, where the degrees of maturity are numbered, and the gap between the two sets often decreases with maturity.

As to the effects of the constituents (Table 3), the two sets agree quite well as to CF: the Rostock set accentuates a little the effect of DP, and the Dutch set that of ASH. The agreement on the specific effects of plant species (FD) is also quite good, with the range of the Rostock coefficients tending to be larger.

#### Relation between Dutch net energy values for dairy cattle (VEM) and beef cattle (VEVI)

On regressing VEM on VEV I for all 320 feeds (in kcal/kg DM):

$$\text{VEM} = 241 + 0.783 \text{ VEV I } (r^2 > .9999, F > 9999, \text{S.E. of slope} = 0.001).$$

On regressing by use groups, the intercepts ranged from 279 to 306 kcal, and the slopes ranged from 0.773 to 0.794, with similar high values of  $r^2$  and F and low values of the S.E. of slope. On regressing VEM on VEV I graphically, the relationship was not absolutely linear, being slightly convex, as can be derived from their respective formulae in the Methods section.

#### Agreement between Dutch and Rostock data on digestible protein

Almost complete agreement was found between the calculated Dutch (FCP) and measured Rostock (DP) values for digestible protein. However, equally high correlation coefficients were obtained by simply regressing DP on CP for all data, or even more so by use groups (Table 7).

Table 7: Regressions of measured digestible protein (DP, Rostock) on either calculated digestible protein (FCP, Dutch) or measured crude protein (CP, Rostock)

Use	N	Y	X	$r^2$	F	Intercept	Slope (B)	S.E. of B
Hays	73			.989	7024	- 5.84	1.08	.012
Fresh	103	DP	FCP	.994	9999	- 2.84	0.98	.008
Silages	76	Rostock	Dutch	.996	9999	- 2.84	1.08	.008
Artificially dried	38	%	%	.933	501	0.89	0.98	.004
Wilted silages	29			.992	3378	- 0.38	1.04	.018
All	320			.980	9999	- 0.97	1.01	.008
Hays	73			.984	4267	-48.2	.938	.014
Fresh	103	DP	CP	.989	9420	-39.7	.955	.010
Silages	76	Rostock	Rostock	.990	7292	-40.3	.962	.011
Artificially dried	38	%	%	.957	836	-50.2	.911	.032
Wilted silages	29			.990	2699	-44.0	.951	.012
All	320			.966	9065	-42.4	.940	.010

#### DISCUSSION

##### Agreement between Rostock and Dutch energy values in contrast to that between Rostock and the American Atlas

The agreement between the Rostock and Dutch values of coefficients for the effect of CF was quite high (Table 3), as found by Goldman and Genizi (4) in comparing the Rostock data (9) with those of the Atlas of Nutritional Data on United States and Canadian Feeds (6). The Dutch and the Rostock sets agree completely on the signs of the effects of other constituents and common characteristics, and agree quite well on the magnitudes of the coefficients (Tables 3-6), whereas when comparing the Rostock values with the Atlas data, very little agreement was found (4). As to the specific effects of plant species too, the agreement between the Rostock and the Dutch values was considerable (albeit a little less than for other factors), while that between the Rostock and the Atlas was negligible. The higher overall level of agreement in the present work

than in the comparison between the Rostock and the Atlas data (4), may be attributed to the greater environmental similarity between East Germany and Holland, and perhaps also to some extent to the fact that the Dutch data have been "smoothed." The latter are formulae expressing net effects of factors with no measure of the experimental error, while the Atlas data consist of detailed documentation of digestibility trials, similar to the Rostock work. Goldman and Genizi (4) concluded that "...The Rostock data represent a system with a high level of regularity in explaining energy values of feeds by their constituents and/or characteristics; in the Atlas set the explainability is much lower, probably to a great extent due to insufficient characterization under conditions of highly variable sources of information." The Dutch characterization is probably more adequate than that of the Atlas, and is quite similar to that of Rostock (see Appendix I). The differences will be discussed below.

Possible explanations for differences between Rostock and Dutch energy values

In evaluating the level of agreement between the two sets of feed energy values, one should bear in mind that the residual differences between two specific feeds may still amount to more than 20%. As an example we point out a few extreme values of net energy for dairy cows, assigned by the two sets to the same feeds (in kcal/kg DM, from Fig. 3):

<u>System</u>	<u>Alfalfa silage</u>		<u>Artificially dried grass</u>		<u>Oats silage</u>
Rostock, NETG	1091	=	1091	<	1360
Dutch, VEM	991	<	1237	=	1235

The figures in this example imply that if we wish to use, in Israel, either the Dutch or the Rostock set of values, we should first try to understand the sources of the differences in order to obtain reasonable estimates for specific situations.

Differences due to varieties may account for some of the differences between feeds, even though neither system differentiates between varieties. The Dutch set even combines three small grains (barley, oats and rye),

while the Rostock set considers each of these species separately, and also three lupines separately. "Meadow grass;" too, may differ greatly between the two countries. As shown in Tables 3 and 4 and in Appendix II, the coefficients for the specific effects of plant species contribute considerably to the differences between the two sets of energy values.

The two sets differ somewhat in the coefficients used to calculate the energy contribution of the different constituents for different energy levels. For example, Rostock Gross Energy (GE) and Metabolizable Energy (ME) are calculated as follows (9):

	<u>Protein</u>	<u>Fat</u>	<u>Crude Fiber</u>	<u>N-free extract</u>
GE =	$5.72_{z1}$	$+ 9.5_{z2}$	$+ 4.79_{z3}$	$+ 4.17_{z4}$
ME =	$4.32_{x1}$	$+ 7.73_{x2}$	$+ 3.59_{x3}$	$+ 3.63_{x4}$

where  $z_i$  = g/kg DM and  $x_i$  = digestible g/kg DM ( $i=1,2,3,4$ ).

The Dutch set fixes GE at 4400 kcal/kg DM (for roughages, as dealt with in this work) and simplifies as well the calculation of ME (see Methods section). This may account, for example, for the higher values assigned by Rostock to silages, if fatty acids are given their higher specific energy value. The Dutch set also considers in more detail than the Rostock set, feeds prepared improperly (see Appendices I and II for parameters and their effects), such as the role of protein degradation to  $\text{NH}_3$  in silages, effects of overheating, overdrying, etc., but most of these effects were not dealt with in this work, as they were not present in the plant species analyzed.

The degree of maturity (MAT) is a main characteristic for all plant species (where protein and digestibility decline gradually with age, except in corn - which has an optimum at the milk stage) in the Rostock set, whereas in the Dutch set only small grains (barley, oats, rye) are affected in a stepwise manner, namely, digestibility drops 150 units after heading. Considering the high correlation which exists among MAT, CF and CP (4), much of the effect of maturity is expressed in the Dutch



formulae through CF and CP values. This can be seen from the highly significant coefficient (-12) for the effect of Mat on D (Table 4). The higher value for the effect of MAT on TDN (-24) may indicate the special effect of MAT which is not accounted for in the Dutch formulae.

The effect of cut no. (CUT) is dealt with in more detail by the Dutch set, but the range of cut effects is small (less than 10 units for FCP and up to 20 units for D; see Appendices II and III).

The Dutch set assigns much importance to ash, including it in the basic functions and as a specific additional effect for both FCP and D (see Appendices II and III). In the GLM analyses (Table 3), the coefficient for the effect of ash on MEHES (-3.70) is higher than that for ME (-2.96). The ash values upon which the Dutch regressions are based are quite extreme occasionally, ranging from 5% to 400% (Appendix III). It seems easier to accept the Rostock approach in this matter.

#### Reliability of the Dutch and the Rostock data

The unexplained part of the disagreement between the two sets of data may raise the question of their relative degree of reliability. The Dutch set gives no statistical measures of confidence in the regression coefficients; this is especially critical for those based on fewer than ten trials (see Appendix III). The Dutch document (ref. 2, p. 14) notes that "Formulae for calculating FCP and D can only be considered as being reasonably reliable for the range formed by a mean  $\pm 2$ x the standard deviation of the explanatory variable." This range is shown for each variable in Appendix III). Some of these ranges are too narrow to be applicable - for example: CP 137-152 (line 11 in Appendix III), ash 138-150 (line 19), CF 322-366 (line 5).

The Rostock document (9) likewise does not include any statistical measure of the experimental error for the data presented. Scheinman et al. (ref. 10, p. 86) state that energy digestibility (TDN in our work) was determined with the deviation of  $\pm 1.3$  units at most, for feeds in the range of 36-74 units. Goldman and Genizi (4) found a high degree of regularity in the changes in all parameters of all feeds with changing

physiological age of the plants. Other characteristics also showed a high degree of regularity. This may strengthen our confidence in the single-datum observations. The ranges of constituent values referred to in the Rostock work are also more common than those of the Dutch. In conclusion, one is inclined to prefer the Rostock value over the Dutch value in most cases of unexplained disagreement.

#### Presentation of the information

Both the Rostock and the Dutch books are intended to be users' manuals. The Dutch manual implies the execution of several laboratory tests accompanied by some calculations. The Rostock set handles all the information as normative data classified only by some informative characteristics (use, plant species, degree of maturity, cut no., level of N fertilization) and some quality evaluations (second-grade hay, overheated silage, etc.). From the point of view of the user - the normative set of Rostock is much more convenient, and for fresh-cut roughages it is actually the only practical way. The advantage of an exact determination of D and FCP of a certain lot of hay or silage on the farm is clear: if it is sufficiently homogeneous, if sampling is adequate, if the characterization of the feed fits that of the Manual, and if the correlation between laboratory tests and animal performance is high. If, on the other hand, a simple characterization exists which is applicable by farmers, and if a high correlation exists between digestibility calculated by the characteristics and that determined experimentally (4) - then the errors in feed evaluation in the Rostock manual may be even smaller and the need for laboratory tests for specific lots may be restricted to unusual feeds only.

#### Possible benefits of the information for users in Israel

The direct use in Israel of data from northern Europe is a possibility, if the environmental and technological differences are believed to have only small effects on energy values of roughages. This assumption is still to be proved, as there are indications of differences in varieties, or as a result of climatic factors, etc. The mere existence of sets of energy data with a high degree of regularity should encourage one to improve the degree of regularity of his own set. A prerequisite for a

reliable set of energy functions is that it be based on adequate characterization and classification of the data. The effects of specific factors in regular sets of tabulated data can serve as guidelines: the conformity of one's data to them can affirm the data's validity; the sources of disagreement should be sought. Unfortunately, energy calculations nowadays in Israel follow those of the NRC (6,7,8), which possess a low degree of regularity (3,4). The execution of simple local tests of feed, to amend these data, was suggested by Goldman and Genizi (4). Taking into consideration the conclusions obtained from the regular sets of nutritional data at the planning, data processing and calibration stages, may further improve the results.

APPENDIX I: CODES OF CHARACTERISTICS

Degree of maturity (MAT)

Degree	Rostock		
	Vegetative stage	Gramineae	Legumes
1 Immature	früh	Begin Schossen	Für Knopse
2 Pre-bloom	mittel	Für Rispen- schieben	Knopse
3 Early bloom	spät	Begin "	Für Blüte
4 Midbloom		Ende "	Begin Blüte
5 Full bloom		Blüte	Vol Blüte
6 Late bloom		Nach, Blüte	Ende der Blüte
Milk		Milch	
7 -		Milchwachs	Hülsenansatz
8 Dough		Wachs	Kornans
9 Mature		Begin Kornreif	
10 Overripe			

Use (USE)	Graphic code	OTHER	Graphic code
1 hay	=	good quality hay	
2 fresh		2 medium quality hay	
3 silage	(		
6 artificially dried	)	<u>N fertilization (FRT)</u>	
8 wilted silage	-	0 no N applied	
		25 kg N/ha	
		2 50 kg N/ha	
<u>Cut no. (CUT)</u>		3 75 kg N/ha	
first cut		4 100 kg N/ha	
2nd and later cuts	/	6 150 kg N/ha	

Plant species (FD)

<u>Rostock code no.</u>	<u>Name</u>	<u>Graphic code</u>
121	Egyptian clover	C
131	Red clover	R
141	Blue lupine	X
143	Yellow lupine	Y
145	White lupine	Z
151	Alfalfa	A
155	Serradella	Q
239	Meadow grass, high value	H
240	Meadow grass, poor value	S
25	Barley	B
255	Oat	O
269	Maize (corn)	M
275	Rye	K

APPENDIX II: FUNCTIONS AND PARAMETERS USED FOR CALCULATIONS OF FCP AND DParameters used to calculate digestible protein (FCP)

ZXP - coefficient of effect of CP on FCP } pertain to all feeds  
 ZP - fixed effect of CP on FCP } in basic function:

$$\text{FCP} = \text{ZXP} * \text{CP} - (\text{ZP}/1000) * \text{ASH} + \text{ZP}$$

Additional parameters for selected feeds:

TASH - threshold of special effect of ASH on FCP (100-150)

PASH - coefficient of special effect of ASH on FCP (100)

AGUT - reduction in FCP for 15.VII - 15.VIII cut (2-5)

SCUT - reduction in FCP for 16.VIII - 15.IX cut (2-10)

FCUT - reduction in FCP for after 15.IX cut (4-10)

PCUT - reduction in FCP for cutting date to be applied actually

FASH - fixed reduction in FCP over ASH threshold (150) in corn silage

TRIF - specific coefficient for Egyptian clover (\*.9) in calculating FCP

$$D = -Z Y D * C F - (Z D / 1000) * A S H + Z D$$

FHOT - effect of overheating grass silage on FCP (-30)  
 DHOT - effect of overheating grass silage on D (-25)  
 DMSF - special effect of DM on D (in the range of 25-35% DM) in grass silage (up to +17)  
 $\text{ZH}_3$  - effect of  $\text{NH}_3\%$  (a) in total N on D, in grass silage (-2.77a; up to -70)  
 $\text{FH}_3$  - effect of  $\text{NH}_3\%$  (a) in total N on FCP, in grass silage (from -5 for a > 15 to +5 for a < 8).

### Complete functions for calculating FCP and D

where  $QASH = PASH * (ASH - TASH) / 1000$        $YDRY = DERY * (DAYS - DRYB)$   
 $YASH = DASH * (ASH - EASH) / 1000$        $SPEC = (TRID + CORN) - 1000$

APPENDIX III: COEFFICIENTS FOR BASIC DIGESTIBILITY FUNCTIONS (APPENDIX II)  
AND DATA ON DUTCH TRIALS FROM WHICH THEY WERE DERIVED

Coefficients relevant to: *		Coefficients based on values of:						Coefficients for the calculation of:					
		Number of digestion trials	Crude protein (CP)		Ash (ASH)		Crude fiber (CF)		Digestible protein (FCP)	Digestible organic matter (D)			
			Avg.	Range	Avg.	Range	Avg.	Range					
Plant *	Uses									ZXP *	ZP *	ZYD *	ZD *
species													
239,240	2	50	159	72-246	112	81-143	248	182-315	959	40	1100	1068	
239,240	3,8	110	139	84-192	134	85-212	267	204-330	895	40	1100	1114	
239,240	1	221	135	75-196	102	71-133	300	242-358	868	40	1100	1094	
239,240	6	48	190	141-240	143	64-221	247	206-288	836	40	1100	1061	
121,131	1	4	182	173-191	100	84-116	344	322-366	789	36	972	926	
121,131	2	7	208	161-256	116	103-129	218	179-257	978	40	1023	996	
121,131	3	5	165	135-194	187	92-281	231	153-308	900	40	1023	962	
121,131	6	13	169	122-216	122	34-210	251	166-337	798	36	972	946	
151	1	9	174	142-207	109	81-137	381	302-459	877	40	1023	975	
151	2	12	220	168-272	114	94-133	264	171-356	978	40	1023	996	
151	3	2	145	137-152	168	78-258	297	224-370	900	40	1023	962	
151	6	30	183	133-233	109	68-149	316	236-396	887	40	1023	996	
155	2	5	145	123-167	154	113-195	232	190-274	978	40	1023	996	
155	3	3	168	145-191	300	200-400	160	200-400	900	40	1023	962	
251,255,275	2	26	154	61-247	111	5-217	297	137-337	981	40	950	1036	
251,255,275	3	8	89	38-139	183	72-293	317	234-400	932	40	950	1051	
269	2	60	109	79-139	80	54-106	246	193-300	1040	40	650	900	
269	3	26	88	73-103	73	42-104	250	202-298	969	40	650	891	
141,143,145	2	3	203	196-210	144	138-150	208	181-235	987	40	1125	1096	
141,143,145	3	3	162	115-209	225	173-277	222	202-242	900	40	1125	1058	

\* For codes, see Appendix I.

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# ניתוח נתונים לחישוב הערך התזונתי של מזונות גסים

מ א ת

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הנוסחאות ההולנדיות (2) לחישוב תרומת האנרגיה והחלבון של מזונות גסים לבקר הופעלו על נתונים (הרכב המזון ואפיונו) מרוסטוק שבמזרח גרמניה (9). נמצאה חוקיות ניכרת: מעל 80% מההבדלים בערכי האנרגיה של מזונות גסים הוסברו על-ידי המאפיינים, ו/או מרכיבי המזון. הערכים שהתקבלו מהחישובים הושוו לערכי המזונות שנמצאו ברוסטוק (9) ונמצאה התאמה ברמת בינונית ( $r^2=60\%$  כ-). בין ערכי ההעכלות המחושבים לפי הנוסחאות ההולנדיות לבין הערכים שנמדדו ברוסטוק. רמת התאמה גבוהה למדי ( $r^2=80\%$ ) נמצאה בין ערכי האנרגיה המחושבים בשתי המערכות ורמת התאמה בינונית עד גבוהה מאוד ( $r^2=60-99\%$ ) נמצאה בין מקדמי ההשפעות של גורמים שונים (כגון: גיל הצמח, מס' הקציר, מין הצמח, שיעור התאית וכו') שהתקבלו בשני מודלים שהותאמו לנתונים משני המקורות. לעומת זאת, בניתוח שהשווה את נתוני רוסטוק לאולו של האטלס האמריקאי (6) נמצאה בדרך כלל מידת התאמה נמוכה מאוד.

נמצאו ונדונו מספר הבדלים שיטתיים בין המערכות, כגון: נטייה לערכים גבוהים יותר לתחמיץ בנתוני רוסטוק, ולירק ולשחת - בנתונים ההולנדיים. בכמה מקרים של אי-התאמה הוערכו נתוני רוסטוק כקבילים יותר מבחינת ההתאמה לאיפיון המזון, להרכבו, לערכים של מזונות אחרים.

נדונו שיטות הצגת הנתונים ותרומתם האפשרית למשתמש בישראל.

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מינהל המחקר החקלאי

המחלקה לסטטיסטיקה  
ותכנון ניסויים

המכון לגידולי שדה וגן  
המחלקה למרעה ומסבוא

## ניתוח נתונים לחישוב הערך התזונתי של מזונות גסים

ע' גולדמן, א' גניזי

פירסום מיוחד מס' 188

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מכון  
לחקר  
המחלקה  
לסטטיסטיקה  
ותכנון ניסויים

המחלקה לפירסומים מדעיים  
מרכז וולקני, בית-דגו  
התשמ"א - 1981