AGRICULTURAL RESEARCH ORGANIZATION
INSTITUTE OF FIELD AND GARDEN CROPS

A COMPARISON OF TWO SETS OF DATA ON THE ENERGY VALUES OF FEED FOR CATTLE

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A. GOLDMAN and A. GENIZI

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CONTENTS

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Nutritional data for cattle obtained from Rostock (East Germany) and from the Atlas of Nutritional Data (U.S. and Canadian Feeds) were analyzed as to the relationships between energy values and feed constituents (crude fiber, crude protein and ash), and as to feed characteristics (plant species, maturity degree, use, cut number, etc.). The investigation included about 300 feeds of 15-20 plant species relevant to Israel from the Rostock set of data, and about 500 feeds (of the same plants) from the Atlas.

Plant species and feed constituents accounted for about 92% of the variance in energy values of the Rostock set, but for only 52% with the Atlas data. The six characteristics studied accounted for about 97% of the variance with the Rostock set, while the 14 characteristics of the Atlas set accounted for only 48%. However, crude protein accounted for 95-99% of the variance in digestible protein values in both the Atlas and Rostock sets.

Possible reasons for the differences and some additional relationships and conclusions are discussed, as well as the applicability of the data (of either set) for farmers and research workers in Israel.

INTRODUCTION

The energy contribution of a feed is of major importance. The value of a table of energy values for the user depends greatly on the accuracy of the data. The National Academy of Sciences' Atlas (5) presents total digestible nutrients (TDN) values in units of 0.1% and energy values - digestible energy (DE), metabolizable energy (ME) and net energy gain (NE) - in units of 10 Kcal/kg dry matter. Nehring et al. (6), for the Rostock data, present values for energy digestibility in units of 1.0%, and for energy (DE, ME and NE) in Kcal/kg dry matter. Goldman (3) found that the TDN values in the Atlas for a specified feed for cattle often differ from those for sheep by more than 10 TDN units, whereas in general the digestibility by sheep and by cattle should be very similar; the differences were related to the complexity of a digestibility trial and to the fact that the Atlas combines data from a wide and variable range of sources. It was found also that the relationship between crude fiber content and digestibility of feeds in the data of Nehring et al. (6) was closer than in the data of the Atlas (5) or of Morrison (4).

In the present work we analyzed the data presented in the Atlas (5) and in Nehring et al. (6) for 15 forage plants which are pertinent to Israel (and probably to other countries), for the following purposes: (a) To study, for each of the two sources, the relationships between energy values and various characteristics of the feed - namely, plant species, use (fresh, hay and silage), maturity, etc., on the one hand, and between energy and feed constituents (crude fiber, ash and protein) on the other hand. (b) To determine the agreement (or lack of agreement) between the two sets of data. The analysis is intended to be of aid in deciding on the proper ways of evaluating feeds in Israel, for both cattlemen and research workers.

METHODS

Forage plants relevant to Israel were defined in Nehring et al. (6). All data for these plants (excluding mixtures) were included in our analysis (313 specified feeds in all) and are referred to herein as the Rostock data. All the characteristics applied by Nehring et al. were classified and coded (see Appendix I). Regression analyses and analyses of variance were carried out by the SAS package of computer programs (1), and in particular by the General Linear Models (GLM) procedure, which gives least squares' estimates and significance tests both for quantitative variables, which are continuous - like crude fiber (CF), and for qualitative or quantitatively orderable variables with discrete levels - like plant species or degree of maturity, to determine the relationships between certain energy or digestion parameters of the feed and various combinations of characteristics and/or constituents of the feed. Graphs were drawn to present such relationships; a few illustrations of these graphs are presented in Figures 1-4 and in Appendix III.

All the data available in the Atlas for the same plant species (522 specified feeds) were processed in the same way and are referred to herein as the Atlas data. The Atlas data contain more characteristics than these of Rostock (see Appendix I). An effort was made to code and set similar levels to those characteristics which appear in both sets of data. For only a few of the Atlas feeds were there definitions for more than two or three characteristics (out of 14); an undefined characteristic was classified (0) and thus included in the GLM analysis.

RESULTS AND DISCUSSION

1. Differences in the degree of explainability between the Rostock and Atlas data

In the Rostock set the major part of the variability in energy values of feeds could be explained by the characteristics and/or by the constituents of the feeds, whereas in the Atlas set the degree of explainability (that is, the percentage of variance explained by the model) was much lower. This is apparent both in the regression analyses and in the graphic presentations.

Summaries of the GLM outputs for the dependence of TDN and ME values on feed constituents - crude fiber (CF), crude protein (CP), digestible protein (DP) and ash (ASH)-and on plant species are presented in Table II-1 (Appendix II); Figures 1 and 2 show plots of the values of ME (as presented in the Rostock and Atlas sets, respectively), against those predicted by the model. The dependence of ME on the characteristics of the feeds for both sets is shown in Table II-2.

From Tables II-1 and II-2 and Figures 1 and 2 it is clear that the percentage of variance explained by the model (explainability) is much higher and the relationships between energy values and the possible explanatory factors (constituents and/or characteristics of feeds) are much closer for the Rostock data (R^2 = .92-.97) than for the Atlas data (R^2 = .48-.69); this superiority is apparent according to other criteria as well - coefficient of variation (c.v.), standard error (SE), the statistic F, and the probability of F (Pr (F)).

In Figure 3 the ME values for one species, as an example (alfalfa, in the Rostock set), are plotted against the degree of maturity (MAT); a clear resolution

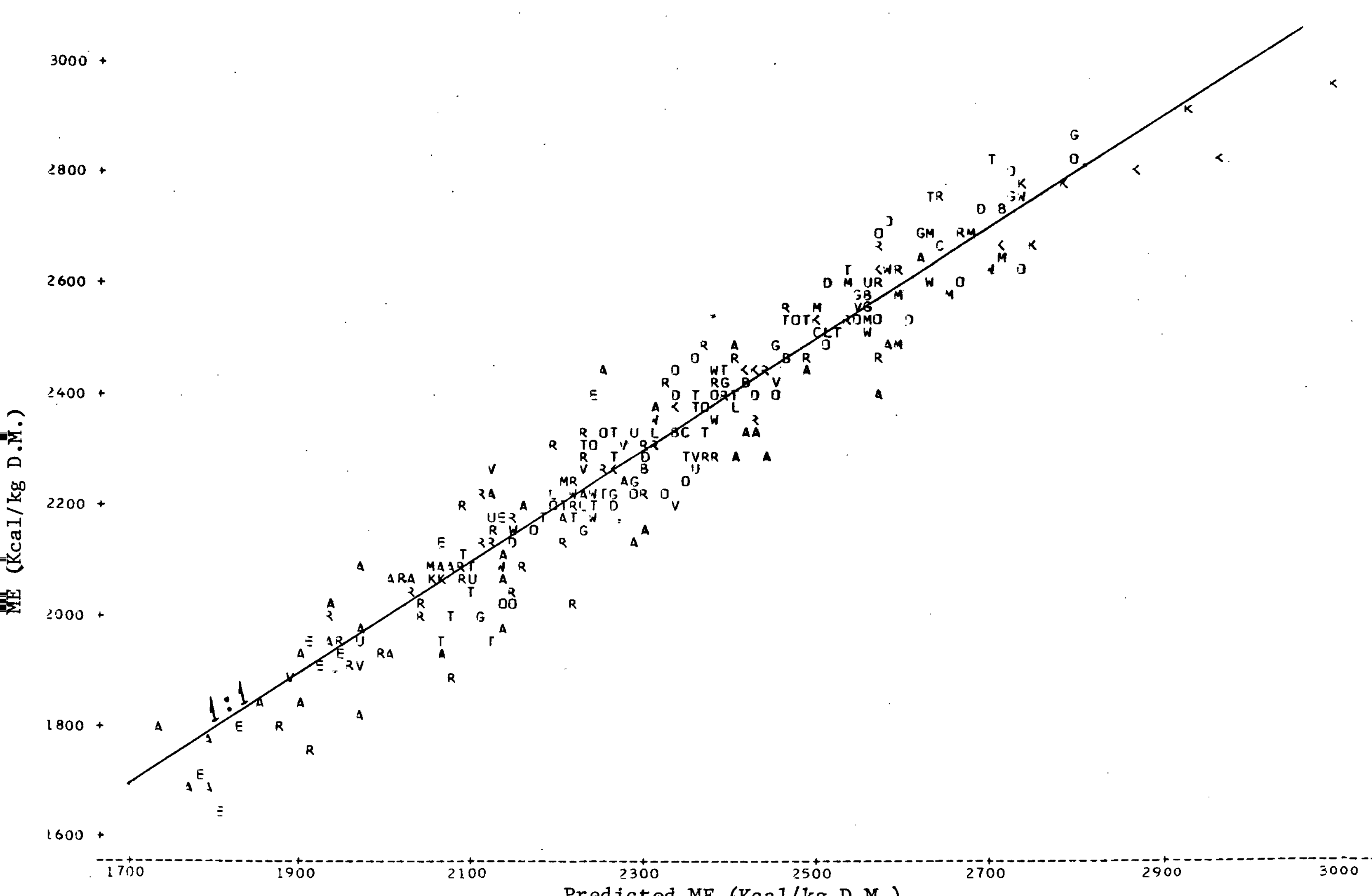
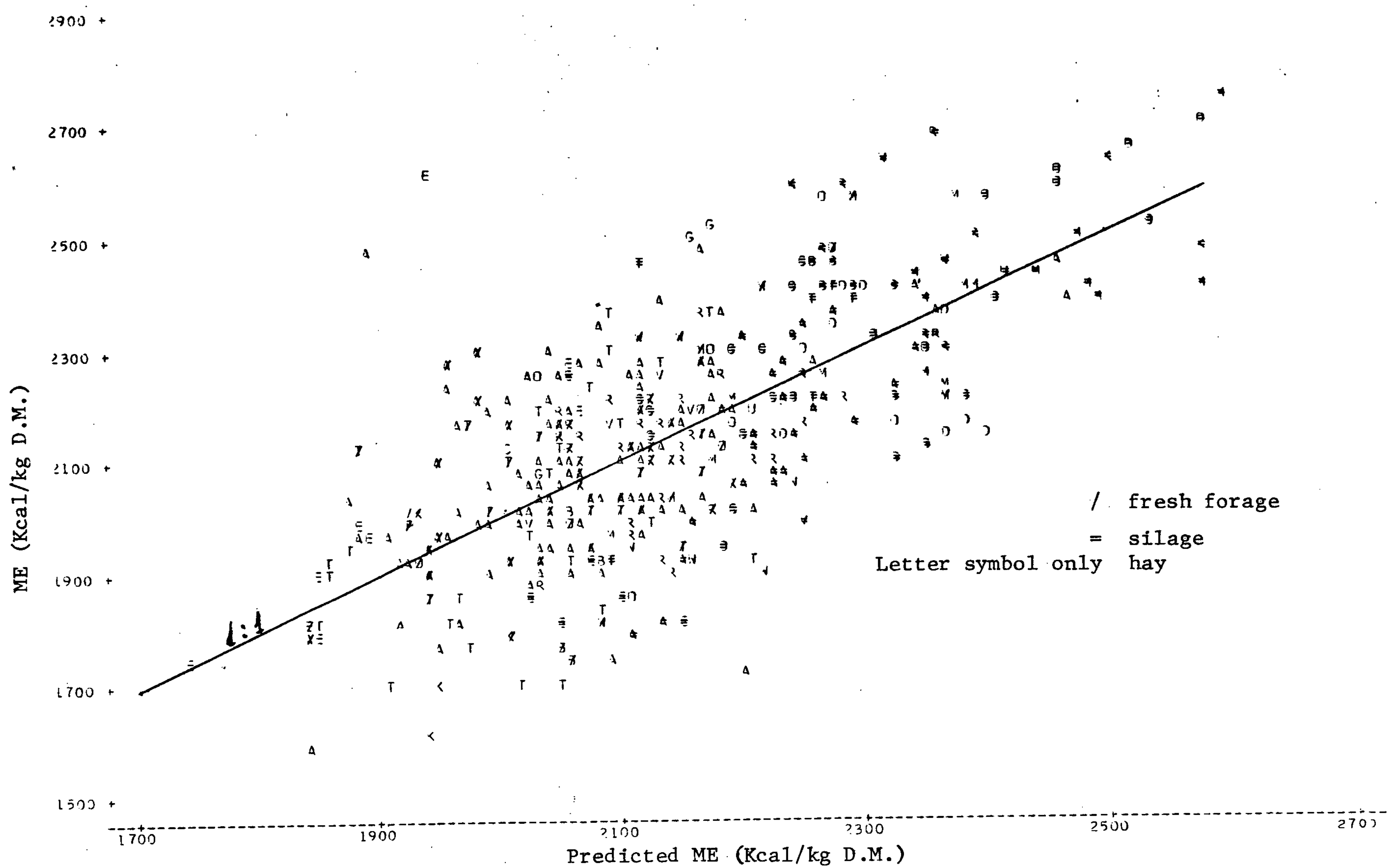


Fig. 1. Published metabolizable energy (ME) values plotted against predicted ME values (Rostock data)

Model: ME = CF, CP, ASH, DP, FD. (Letters represent plant species; see Appendix I)



<u>Fig. 2</u>. Published metabolizable energy (ME) values plotted against predicted ME values (Atlas data). Model: ME = CF, CP, ASH, DP, FD. (Letters represent plant species; see Appendix I).

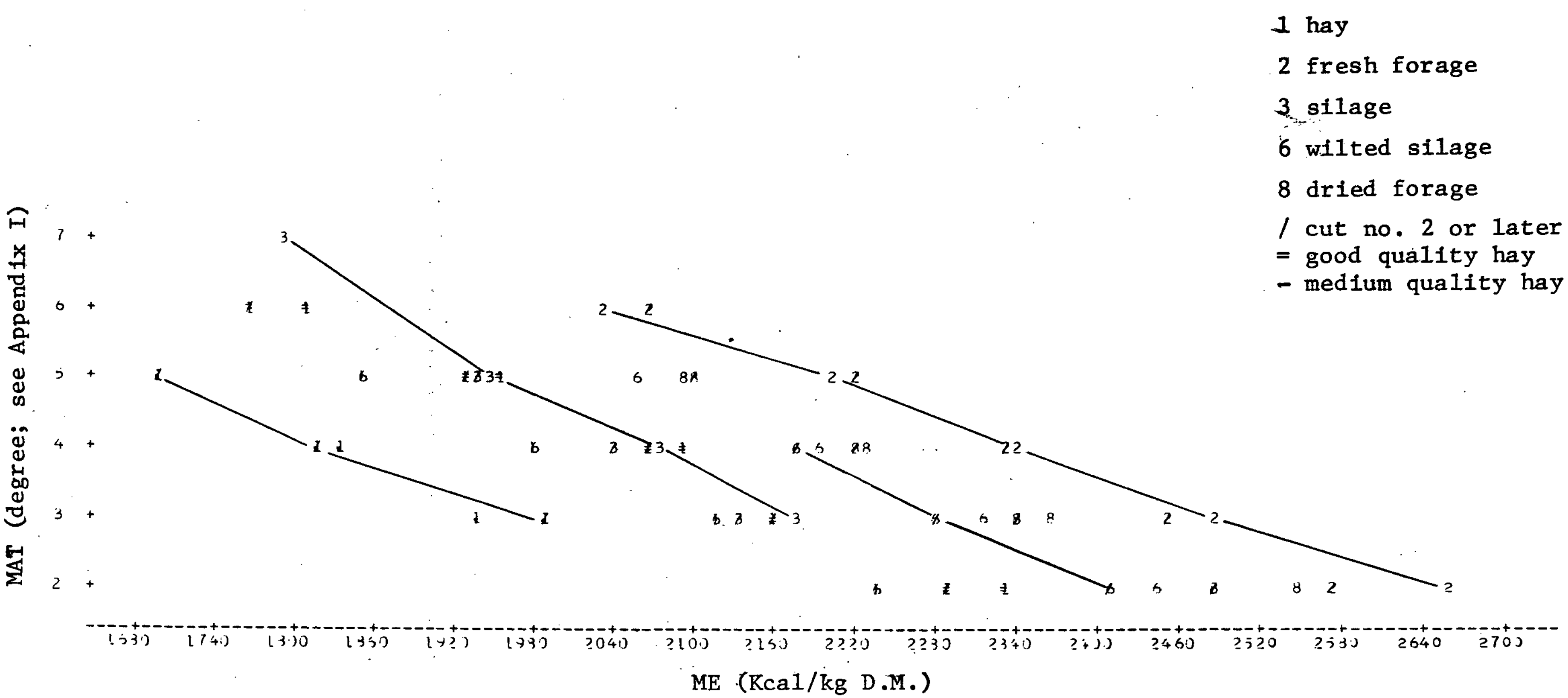


Fig. 3. Effects of feed characteristics on metabolizable energy (ME) values of alfalfa (Rostock data)

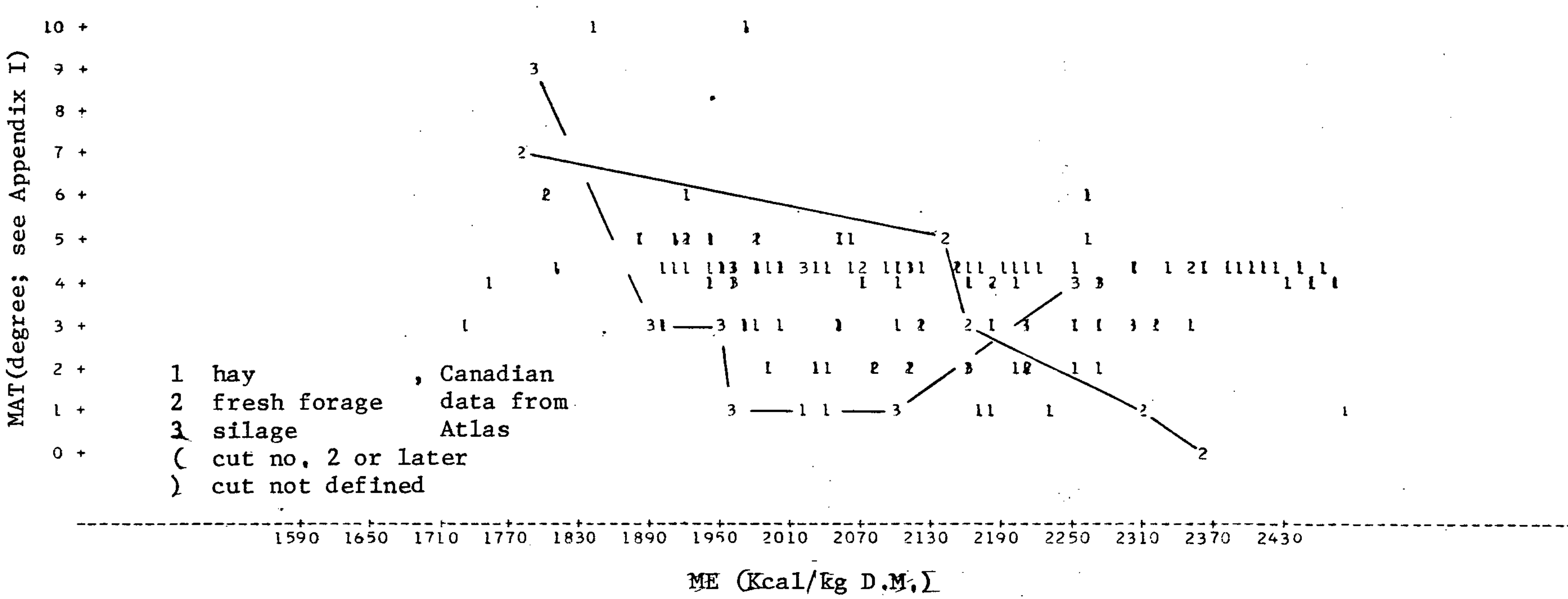


Fig. 4. Effects of feed characteristics on metabolizable energy (ME) values of alfalfa (Atlas data).

of the effects of various other characteristics on ME values is also apparent, further stressing the high degree of explainability and the clear relationships between factors in the Rostock set, including curvilinear relationships and minor interactions which are ignored by the GLM analyses in Tables II-1 and II-2. Figure 4 is a graphic presentation of the alfalfa data in the Atlas set. Here, the dependence of ME on MAT is apparent only for the first cut of fresh alfalfa (symbol 2); almost no order is apparent for the rest of the data. This is a typical example of the low resolution capacity of the graphs for effects of the various constituents on ME values in the Atlas set.

2. Effects of various factors on the energy values of feeds

a. Effects of feed constituents

Table II-1 shows that, according to both sets of data, crude fiber (CF) is the major factor in determining ME values of the various feeds, but the magnitude and even the order of importance of the influence of the other factors were different in the two sets of data. The correlation between the Rostock and Atlas estimates of 14 plant species was quite low: $r^2 = 0.19$. A very low correlation ($r^2 = 0.05$) was found between the coefficients of the effects of characteristics, including 14 plant species and five levels of characteristics common to the two sets in Table II-2.

b. Effects of feed characteristics

From Table II-2 (and other data which are not presented), it seems that the effects of the various characteristics in the Rostock set of data are quite different from those in the Atlas set. The coefficients of specific effects of feeds were also quite different, and correlations between the coefficients of the two sets were low ($r^2 > 0.1$). For example: an increase in one degree of maturity decreases ME values by 5.2% in the Rostock set, but by only 1.1% in the Atlas set. According to Rostock data, the coefficient for silage is 11% higher than that for hay, whereas in the Atlas set hay surpasses silage by 0.4%, etc.

3. Possible reasons for the differences in explainability

An attempt was made to clarify the reasons for the large differences in the results of the analyses between the two sets.

a. Differences in the contribution of characteristics

An important reason for the low degree of explainability of the Atlas characteristics is probably the large number - 14 - of characteristics, only a few of which are defined for each feed. The degree of maturity (MAT) was defined for only 324 and the variety for only 83 out of the 522 feeds; out of 204 feeds stemming from alfalfa, only 86 were defined as to cut no. (CUT); ten were defined only by "U.S. degree," six only by "% crude fiber," etc.

TABLE 1

SOME EFFECTS OF RANDOM EXCLUSION OF MATURITY DEGREE (MAT) DEFINITIONS IN GENERAL LINEAR MODEL RUNS (ROSTOCK DATA)

Parameter \ % of observations where MAT remains defined	100 (control)	75	50	25
R^2	.972	.830	.735	.653
C.V.%	1.99	4.89	6.1	6.99
Overall F value	289	39	22	15
Effect of CUT: F	20.	1.	1.	.4
Pr (F)	.0001	.3	.3	.5
Effect of MAT: F	616	58	25	11
Pr (F)	.0001	.0001	.0001	.0001
Range of MAT classes estimate %	37.5	37	34	32

In order to check the possible effect of the lack of definition on the results of an analysis, we carried out runs with Rostock data (for which MAT is defined for all feeds) where for 25, 50 or 75% of the feeds MAT definition was randomly omitted (placing them in class 0, as in the case of lack of definition in the Atlas data). A fully defined set was run as the control. A summary of outputs for the four runs (Table 1) shows that the explainability of variance by the model dropped from about 97% to 65% by omitting the definition in 75% of the observations for one variable only; the effect of CUT, which was very clear and significant in the control, was completely canceled with omission of the definition in 25% of the observations, which caused also a marked decrease in the significance (F values) of the effects of all factors in the model. In a regression of ME on MAT for the Rostock set (when all MAT values are defined), $r^2 = 0.212$ only; thus, in the full model (with all six characteristics, including MAT), the omission of MAT definition in 50% of the observations caused a decrease in the explainability of the full model from 97% to only 74% (while MAT alone seems to explain only 21% of the variance in ME values). Another interesting (and anticipated) effect of the omission is to moderate the effect of MAT (namely, to decrease the range of estimated values) with increasing percentage of undefined observations. The same tendencies were observed in the Atlas set analyses: when analyzing only the data where MAT was defined, R^2 increased from 0.477 to 0.542, F for MAT from 14 to 28, and the effect of MAT in the full model from -1.1% for each degree of maturity to -2.4% (as compared with -5.2% in the Rostock set, where MAT was defined for all observations).

Another difference between the two sets is the range of reference. The Rostock data were collected in a small ecological region, and most of them at one experiment station, where probably only one variety (or quite similar ones) prevails for each species. The Atlas set consists of data from practically an entire continent, with a wide range of ecological and cultivation conditions, as well as many methods of sampling, experimentation, and data processing by several different experiment stations. When such data are combined and processed according to the method applied by the Atlas - a condition may occur whereby entirely different feeds will be classified under the same code number. It is possible, for example, that the values of feed constituents (which are averages of all the contributing data) are greatly influenced by the data of certain stations or trials, whereas the data for digestibility and energy represent only one station or one trial with quite different conditions and values. Another reason for the higher explainability of the Rostock set may be found in Scheinmann _et al._'s (7) statement that data from the literature were included in the Rostock set selectively (representative, and not averages; see page 276 in ref. 7). No details are given as to the extent of this selection or the criteria followed for its implementation. For example, were data excluded only because of exceptional conditions, or also because of exceptional results? In the latter case, the data included may represent the opinions of the selector as to the effects of the various factors on, and the reasonable values of, the considered variable. Rostock data present only one value for each parameter in the specified feed. It is reasonable to assume that more than one determination was made for each parameter (especially in laboratory determinations of constituents). There is no information on the variability of the tests or on common SE values. The Atlas set, on the other hand, probably did not pass through such a critical (or "cosmetic") treatment, and includes data at their face value: For example, Kafir sorghum grain (feed 404428, p. 604 in the Atlas), with TDN values of 90.8% for sheep and only 51.3% for cattle. It is reasonable to assume that a thorough examination of the value for cattle will uncover an error or exceptional, unrepresentative, conditions.

b. Differences in the contribution of constituents

Tha gap between the explainability in the Rostock set (R^2 = 0.926) and in the Atlas set (R^2 = 0.545) as to the relationship between ME and the feed constituents which were included in the analysis, is smaller than in the analysis by characteristics (R^2 = 0.971 for Rostock, as compared with 0.477 for the Atlas). On the other hand, in an analysis of the relationship between TDN and the characteristics, the explainability was somewhat higher (R^2 = 0.573); hence, some part (small) of the gap may be assigned probably to the more precise calculations of energy changes between forms of energy (DE, ME and NE) in the Rostock set (see Table 3). An analysis including only those Atlas feeds for which TDN values were determined by digestion trials (and not calculated by a formula using the constituents) yielded R^2 = 0.688 (Table II-1). A check of residuals from the model in this analysis revealed that a great part of the remaining variance was further contributed by one species and one exceptional observation of another species. It is reasonable to assume that calculating TDN values of the Atlas by the Rostock formula would result in a better explainability in relating TDN values to constituents.

4. Comparison of the relationships between crude protein and digestible protein

Summaries of analyses of the relationship between CP and DP are presented in Table 2 (the inclusion of additional factors in the model did not increase the explainability of the variance of DP). Table 2 shows no gap whatsoever between the

Atlas and Rostock sets and the coefficients are quite similar as well. It seems that for a relatively simple relationship between two factors only (DP and CP), the Atlas method of treating the data was as effective as that of Rostock, and the agreed-upon relationship between crude protein and digestible protein is applicable in Israel (or elsewhere) too.

TABLE 2

REGRESSION OF DIGESTIBLE PROTEIN (DP) ON CRUDE PROTEIN (CP)

Data set	N	r^2	C.V.(%)	F value	Intercept	Slope
Rostock, all uses	288	.945	10.3	4915	-34.4	.892
Atlas* , all uses	100	.960	10.3	2344	-27.1	.837
Rostock, Fresh forage	91	.994	3.7	14087	-35.1	.934
Atlas, Fresh forage	113	.993	4.0	15896	-21.5	.857
Rostock, Hay	50	.980	5.3	2317	-49.3	.946
Atlas, Hay	297	.984	5.8	18431	-28.3	.851
Rostock, Silage	61	.993	3.9	7921	-34.8	.928
Atlas, Silage	297	.971	9.4	3574	-37.2	.890

*For feeds where TDN and DP were determined *in vivo*.

5. Some conclusions from the analyses of the Rostock data

The high explainability of the Rostock set as to the relationships between energy values of feeds and other factors enables us to draw some conclusions.

a. The explainability of various combinations of factors

Many combinations of factors were used as the independent variables in the GLM analyses. A few examples which demonstrate the relative importance of feed constituents in determining the energy values of feeds are presented in Table II-3 (Appendix II). The omission of CP (Run 2) makes almost no difference (R^2 decreased from 0.926 to 0.913). The further omission of FD (Run 3) decreases the explainability substantially (R^2 = 0.631). The omission of DP and ASH leads to only a small change, and with CF as the only independent variable, R^2 = 0.608, C.V. = 6.92%, and the increase of CF by 1 ‰ causes a decrease of 3.66 Kcal in the values of ME (an effect which is quite similar to the effect of CF in the other combinations of factors, in Runs 1 through 4). Blaxter and Boyne (2) suggest CF, USE and CUT as independent variables in the model determining the net energy gain (NETG) in growing cattle and sheep; the addition of USE and CUT to CF in the Rostock set contributed only a little to the explanatory capacity (over that of CF on ME): it resulted in $r^2 = 0.677$ and C.V. = 6.76%. In plotting NETG values in the Rostock set against the predicted NETG values in the model suggested by Blaxter and Boyne, it was quite clear that different species had specific effects: for example, all the values of rye and oats feeds were about 300 Kcal higher and those for vetch or yellow medic were lower than the regression line of the listed versus predicted NETG (in the range of 1200-1600 Kcal). It seems that additional factors exist, which are responsible for a further ca. 30% of the variability in the energy values of feeds, and which are expressed by specific effects of plant species.

Table II-4 (Appendix II) presents similar data for the examination of the relative importance of the characteristics in explaining differences in energy values of the feeds, and here also can be seen a specific effect of plant species which is responsible for about 30-40% of the variability.

b. A comparison between the energy forms (TDN, DE, ME and NETG)

A comparative analysis for all the forms of utilized energy was carried out for the Rostock set (excluding corn and without the interaction of plant species with maturity degree), i.e., a total of 288 feeds from 14 species. The relationship between each energy form and all the characteristics was tested. All the analyses yielded similar values of R^2 from 0.971 (ME) to 0.979 (TDN), and of C.V. % from 1.78 (TDN) to 2.02 (ME), etc. All the coefficients for effects of factors (including the specific effects of plant species) were very similar, as were the F values for the effect of each factor for the various energy forms. It seems that the main factor which determines the energy contribution of the different feeds is the degree of digestibility (this factor appears already in TDN). The gross energy (GE) contents of the feeds do not explain much of the variability in the utilized energy of various forms. The GE values in the different feeds ranged from 4086 to 4432 Kcal/kg dry matter (average = 4301). The lower GE values were generally associated with the lower degrees of maturity, in which ash % is higher (and thus the organic matter % is lower), but this was counterbalanced by the higher digestibility of the young plants. A second factor in the energy balance was the protein content of the feed, which contributes more gross energy according to the norms of Nehring et al. (6), but this was counterbalanced to a certain extent by the relatively lower efficiency of the transformation of protein energy into net energy by the same set of norms (see Table 3). The fat content of the feeds included in the analyses was generally low and the regularity of fat digestibility was lower than for other constituents, so we assumed that its inclusion in the analyses would not change materially the explainability level of the model or the coefficients.

TABLE 3

REGRESSION FUNCTIONS OF ENERGY LEVELS FOR CATTLE ON FEED CONSTITUENTS' CONTENTS AND THEIR DIGESTIBILITIES (in kcal)

(from Nehring et al. (6), page 261)

Constituent / Energy level		Crude protein	Crude fat	Crude fiber	N-free extract	S.E (%)
Gross energy (GE)	=	$5.72\ Z_1^{*}$	$+ 9.50\ Z_2 +$	$4.97\ Z_3$	$+ 4.17\ Z_4$	0.9
Digestible energy (DE)	=	$5.79\ X_1^{**}$	$+ 8.15\ X_2 +$	$4.42\ X_3$	$+ 4.06\ X_4$	1.0
Metabolizable energy (ME)	=	$4.32\ X_1$	$+ 7.73\ X_2 +$	$3.59\ X_3$	$+ 3.63\ X_4$	1.3
Net energy in fat (NETG)	=	$1.71\ X_1$	$+ 7.52\ X_2 +$	$2.01\ X_3$	$+ 2.01\ X_4$	4.7

$^*Z_1$-Z_4 = content (g/kg D.M.) of crude protein, crude fat, crude fiber and N-free extract, respectively.

$^{**}X_1$-X_4 = digestible matter (g/kg D.M.) of crude protein, crude fat, crude fiber and N-free extract, respectively.

c. Relationships between feed constituents and feed characteristics

Very marked and significant relationships were found between the CF content of the feed and the characteristics (plant species, use, cut no., fertilization, maturity degree, etc.) in the model (Table II-5, Appendix II); R^2 was 0.974 and C.V. = 3.85%. With CP the analysis yielded R^2 = 0.967 and C.V. = 6.57%, and with ASH, R^2 = 0.953 and C.V. = 6.82%. The major factor for all three constituents was the degree of maturity (MAT). With an increase of one degree in plant maturity, CF increased by 4.69%, CP decreased by 2.36% and ASH decreased by 2.09%. Large differences were found (up to two- or three-fold) between plant species, with legumes containing more ash and crude protein and less crude fiber than Gramineae, and with large differences among species in each group.

In Figure III-3 a marked difference is noticed between legumes and Gramineae as to crude protein content (CP) at each level of ME and differences between species in each group are obvious too; the relationships between CP and ME are generally slightly curvilinear. Some interactions can be noticed: for example, high fertilizer rates in oats (O) have a different effect than in rye (K); second cut in timothy (T) has a different effect than in red clover (R); very marked is the exception of corn (M).

In the relationships between ash (ASH) and ME too (Figure III-4), differences exist between Gramineae and legumes (the latter containing more ash) in some interactions (even though the order here seems less evident), and the outstanding position of corn (M).

d. Some examples of graphic presentations of Rostock data

Figures III 1-4 (Appendix III) represent a few examples of a graphic presentation of Rostock data, to check and accentuate certain effects in the complex model of factors affecting the energy values of fresh forage. The following are some examples of conclusions which can be drawn from these figures:

In Figure III-1 one can trace interactions between plant species and degree of maturity (MAT) in their effect on the metabolic energy (ME) contribution of the feed. In corn (M), the direction of the MAT effect is entirely different: there are marked differences in slopes (namely, the extent of the effect in change of MAT on ME); most of the species are quite close to each other, while reed canary grass (E) is much lower. Interactions exist between plant species and cut no. in their effect on ME value: in red clover (R) and alfalfa (A) there is only a small difference between the first and subsequent cuts, while in timothy the difference is large.

Figure III-2 reveals interactions between plant species and crude fiber content (CF) in their influence on the energy contribution of feeds: for most of the species the relationship between ME and CF is linear, while for oats (O) it is curvilinear. There are differences between species, and legumes generally contain less CF than Gramineae at the same level of ME; second cut alfalfa (A) and red clover (R) both contain less CF and are quite similar to Gramineae in this aspect; for timothy (T) the slope for the second cut is steeper than that for the first.

One can conclude from the above examples that the graphic presentations enable a considerable level of resolution as to the effects of various factors and the interactions between them, for data of the Rostock set.

6. Some conclusions from partial analyses of the Atlas data

A partial study of several feeds, belonging to a close definition group, may sometimes yield more encouraging results than the analyses of all data (in GLM or graphic presentation). For example, Figure 5 shows a clear connection between TDN and PERF values (% crude fiber values, which is one of the characteristics in the Atlas), while in the general analysis PERF was found to have no effect on TDN. In a graphic presentation of data for three species of those included in the Atlas and for which details were given for varieties, a marked difference was found between varieties of timothy, that accentuated also the effect of MAT. Testing small groups of data, with consecutive code numbers in the Atlas, often reveals clearer effects of other characteristics as well; it is reasonable to assume that each such small group comes from one source of information, representing a better defined set of data. Better and more complete information on the source and a more homogeneous grouping of the data would probably improve the accuracy of energy data in subsequent editions of the Atlas and render them more meaningful for users.

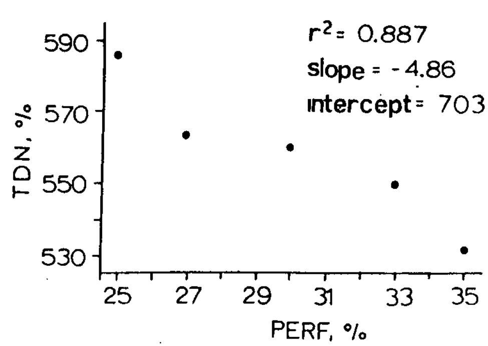


Fig. 5. Regression of TDN on PERF (Atlas data set)

7. Applicability of the Atlas and/or the Rostock data for Israel

In the Atlas (5) it is stated: "The committees hope that these tables will be useful to feed manufacturers, feed dealers, nutrition consultants, research specialists, government agencies, teachers, students, county agricultural agencies and farmers." (p. IV). Nehring et al. (6) also directed their information more or less to the same public (p. 6). The farmer needs the data to assist him in selecting the most suitable feeds (out of a huge variety of possibilities) to balance the daily ration according to his production goals, and considering his specific economic and managerial conditions. A set of data on the contents of main constituents of feeds is one of the two bases of a nutrition system used by the farmer; animals' demands for the same constituents in the ration (or their responses to different compositions of the ration) constitute the second basis. An overestimation of the energy content of a certain feed will lead - in the realm of decision making - to a preference for a certain feed and a greater demand for it, which will be expressed in a price higher than proper; in the realm of production, a lower output than the anticipated will ensue. An underestimation of the energy content reduces the demand and the utilization of the feed in favor of less valuable feeds, or will result in a too-rich ration, which may sometimes have a negative physiological effect, and will most often be wasteful, from the economic aspect.

The research worker may need the data of the energy values of feeds for many and varied purposes, and every error in feed values will lead to a distortion in the conclusions of the research and/or an increased statistical error, and reduce the explainability of the research.

How can research workers and farmers in Israel make use of the Rostock and Atlas sets of data? Some people think that conditions in Israel resemble those in the U.S.A. and suggest the utilization of the Atlas data for a certain feed as a basis - to test the contents of the local feed (which satisfies, more or less, the same definition) and to correct the energy values assigned to the local feed according to the differences in its crude fiber, crude protein and ash content, etc., as compared with those of the Atlas feed. However, owing to the great variability in energy data in the Atlas (even in the model based on feed constituents), this method can hardly assure substantial contribution to improved evaluation of the energy value of local feeds. If a high correlation had been found between energy values (of more or less identical feeds) in the Rostock and Atlas sets of data, it might have indicated a generality of the values and their applicability in Israel too. Unfortunately, only an intermediate correlation was found, and only for the effect of crude fiber content of feeds, explaining about 60% of the variability in energy values of roughages. The Rostock data set is apparently more accurate, but these data represent botanical, ecological, agro-technical systems quite different from those of Israel. It does not seem reasonable to adopt the Rostock data for use in Israel without checking first the degree of similarity (or difference) of at least a few major factors.

SUMMARY AND CONCLUSIONS

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 method of grouping, processing and presentation of the Rostock data enables their direct utilization by the farmer or the research worker in the region where they were determined; energy values in the Atlas set do not seem applicable by those for whom an error of ten TDN units is considered meaningful. The method of grouping and presentation does not enable the ordinary user to check the data of the Atlas and to "debug" those with the bigger errors.

Our analysis points to the possibility of further advances in explaining variance of energy values of feeds (including roughages and others) by additional investigation into Rostock data: the inclusion of more feeds (out of about 1400 feeds presented), as well as additional factors out of the constituents presented by Nehring *et al.* (6). Analyses of the original data, from which the Atlas data were determined (changing the grouping method, etc.), might improve the accuracy of information from this source. A comparative study of additional sets of data from all over the world might yield some general conclusions as to the effects of various factors (feed constituents and characteristics, including specific effects of feeds) and to enable the utilization of Rostock and/or other sets of data with a high explainability, as bases for the *indirect* determination of more accurate estimates of the energy values of feeds in Israel.

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APPENDIX I: CODES OF CHARACTERISTICS COMMON TO THE ROSTOCK AND ATLAS SETS OF DATA

Degree of maturity

Atlas	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 "
5 - Full bloom		- Blüte	- Vol "
6 - Late bloom		- Nach, Blüte	- Ende der Blüte
Milk		Milch	
7 - "		- Milchwachs	- Hülsenansatz
8 - Dough		- Wachs	- Kornans
9 - Mature		- Begin Kornreif	
10 - Overripe			

USE	CUT No.	OTHER
1 - hay	1 - first cut	1 - good quality hay
2 - fresh	2 - 2nd and later cuts	2 - medium quality hay
3 - silage		3 - dried too much

contd.

Plant species

Rostock code no.	Name	Graphic code
121	Egyptian clover	C
123	Yellow medic	L
131	Red clover	R
137	White clover	D
151	Alfalfa	A
161	Common vetch	V
163	Hairy vetch	U
217	Reed canary grass	E
229	Timothy	T
235	Italian ryegrass	G
251	Barley	B
255	Oat	O
269	Maize (corn)	M
275	Rye	K
281	Common wheat	W

APPENDIX II. SUMMARIES OF GENERAL LINEAR MODEL PROGRAM OUTPUTS

TABLE II-1. REGRESSION OF METABOLIZABLE ENERGY (ME) AND TOTAL DIGESTIBLE NUTRIENTS (TDN) ON ALL CONSTITUENTS

Parameter \ Data set	Rostock		Atlas		Atlas for measured TDN only	
Dependent variable	ME		ME		TDN	
Mean and % C.V.[a]	2311	3.13	2139	6.76	601	5.29
R^2	.926		.545		.689	
Overall F value and Pr (F)[b]	186	.0001	27	.0001	28	.0001
DF for Model and error	18	269	17	386	13	164
Source (of variation):	F value	Pr(F)	F value	Pr(F)	F value	Pr(F)
Plant species (FD)	56	.0001	10	.0001	13	.0001
Crude fiber (CF)	441	.0001	61	.0001	26	.0001
Crude protein (CP)	19	.0001	32	.0001	53	.0001
Ash (ASH)	98	.0001	0.2	.6	.01	.9
Digestible protein (DP)	78	.0001	48	.0001	80	.0001
Dependence function	Est.[c]	S.E.	Est.	S.E.	Est.	S.E.
Intercept	3342	100	2591	110	702	40
FD: 121 - Egyptian clover	119	46	- 146	57	0	22
123 - Yellow medic	13	35				
131 - Red clover	22	20	108	28	55	10
137 - White clover	68	31	109	48	35	18
161 - Common vetch	- 33	26	8	60	72	13
163 - Hairy vetch	- 108	38	107	85		
217 - Canary reed grass	- 28	29	- 94	41		
229 - Timothy	196	29	162	31	60	11
235 - Italian ryegrass	212	33	147	54		
251 - Barley	310	41	93	51		
255 - Oat	341	31	231	39	94	13
269 - Corn	205	46	336	43	115	16
275 - Rye	382	21	138	58	128	19
281 - Common wheat	275	33	184	51	90	25
151 - Alfalfa	0	-	0	-	0	-
CF	- 3.49	.16	- 1.63	.21	- .40	.08
CP	- 2.19	.50	- 5.63	1.00	-1.75	.24
ASH	- 2.43	.25	0.19	.43	.02	.17
DP	4.03	.45	7.72	1.11	2.40	.27

[a] Coefficient of variation (standard deviation as % of the mean).
[b] Probability of F being random.
[c] The (least squares) "estimates" for the different FD levels are actually estimates of the differences between the specified plant and alfalfa, and the "standard errors" are also related to these differences.

TABLE II-2: REGRESSIONS OF METABOLIZABLE ENERGY (ME) ON ALL CHARACTERISTICS

Parameter \ Data set	Rostock		Atlas, all data		Atlas only for MAT defined	
Dependent variable	ME		ME		ME	
Mean and % C.V.	2138	2.02	2138	7.97	2134	7.43
R^2	.971		.477		.542	
F value and Pr (F)	213	.0001	4.3	.0001	4.97	.0001
DF for Model and error	39	248	72	339	50	210
Source (of variation):	F value	Pr (F)	F value	Pr (F)	F value	Pr (F)
Place (PLC)			.01	.9	1.	.3
Plant species (FD)	30	.0001	1.7	.05	1.9	.03
Additives (ADD)			.6	.7	.6	.8
Treatment (TRT)			2.5	.008	.7	.7
Use (USE)	307	.0001	41	.0001	14.9	.0001
Type (TYP)			.7	.6	.2	.8
Cut no. (CUT)	25	.0001	.5	.8	.6	.6
U.S. degree (USD)			.3	.8		
Calculated data (CAL)			17	.0001	2.6	.1
Other (OTHR)	171	.0001	4.2	.02	9.7	.0001
Percent N (PERN)			2.3	.02		
Percent fiber (PERF)			.2	.9		
Maturity degree (MAT)[a]	2735	.0001	14	.0002	28.4	.0001
(interaction)						
MAT * FD	64	.0001	1.6	.09	1.9	.04
N fertilizer (FRT)	49	.0001				
Dependence function[b]	Est.	S.E.	Est.	S.E.		
Intercept	2335	25	2154	49		
FD: 121 - Egyptian clover	330	137	- 28	148		
217 - Canary reed grass	- 241	47	-107	89		
269 - Corn	- 679	53	148	133		
275 - Rye	283	32	-460	206		
151 - Alfalfa	0	-	0	-		
Use 2 - Fresh	498	15	207	25		
3 - Silage	261	16	- 8	27		
1 - Hay	0	-	0	-		
MAT	- 121.5	5.1	- 24.7	9.3		
MAT * FD						
121	- 46	33	- 3	40		
217	- 52	16	.3	20		
269	191	9	33	20		
275	- 40	9	100	36		
151	0	-	0	-		

[a]MAT was entered as a continuous variable.

[b]Only a few illustrations are presented.

TABLE II-3: REGRESSIONS OF METABOLIZABLE ENERGY (ME) ON CERTAIN COMBINATIONS OF FEED CONSTITUENTS (DATA SET - ROSTOCK)

Parameter \ Source variables included in Run	1) ALL		2) FD, CF, ASH and DP		3) CF, ASH and DP		4) CF and ASH		5) CF	
Mean and % C.V.	2312	3.13	2312	3.36	2312	6.74	2312	6.74	2312	6.92
R^2	.926		.913		.631		.629		.608	
F value and Pr (F)	186	.0001	166	.0001	162	.0001	242	.0001	444	.0001
DF for Model and error	18	269	17	270	3	284	2	285	1	286
Source (of variation):	F value	Pr(F)	F value	Pr(F)	F value	Pr(F)	F value	Pr(F)	F value	Pr(F)
Crude protein (CP)	19	.0001								
Plant species (FD)	56	.0001	62	.0001						
Digestible protein (DP)	78	.0001	64	.0001	1.3	.25				
Ash (ASH)	98	.0001	82	.0001	6.9	.009	16	.0001		
Crude fiber (CF)	441	.0001	426	.0001	419	.0001	476	.0001	444	.0001
Dependence function[a]	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Intercept	3342	100	3071	75	3603	77	3575	73	2356	50
CF	- 3.49	.16	-3.2	.15	- 3.95	.19	- 3.86	.18	- 3.64	.17
ASH	- 2.43	.25	-2.3	.25	- 1.19	.45	- 1.49	.37		
DP	4.03	.45	2.2	.28	- 0.33	.28				
CP	- 2.19	.50								
FD: 121 - Egyptian clover	119	46	141	48						
161 - Common vetch	- 33	26	7	27						
217 - Canary reed grass	- 28	29	- 22	30						
269 - Corn	205	46	287	40						
151 - Alfalfa	0	-	0	-						

[a] Only a few illustrations of plant species' effects (FD) are presented.

TABLE II-4: REGRESSIONS OF METABOLIZABLE ENERGY (ME) ON CERTAIN COMBINATIONS OF FEED CHARACTERISTICS (DATA SET - ROSTOCK)

Parameter / Source variables included in Run	1) ALL		2) USE, FRT, OTHR and MAT		3) USE and MAT		4) MAT	
Dependent variable	ME		ME		ME		ME	
Mean and % C.V.	2312	2.02	2312	7.23	2312	7.83	2312	9.82
R^2	.971		.588		.506		.212	
F value and Pr (F)	213	.0001	36	.0001	58	.0001	77	.0001
DF for Model and error	39	248	11	276	5	282	1	286
Source (of variation):	F value	Pr (F)	F value	Pr (F)	F value	Pr (F)	F value	Pr (F)
Plant species (FD)	30	.0001						
Cut no. (CUT)	25	.0001						
N fertilizer (FRT)	50	.0001	3.5	.008				
Other (OTHR)	171	.0001	19.3	.0001				
Use of the feed (USE)	307	.0001	19.9	.0001	42	.0001		
Maturity degree (MAT)	2735	.0001	112	.0001	117	.0001	77	.0001
Interaction (MAT * FD)	64	.0001						
Dependence function[a]	Est.	S.E.	Est.	S.E.	Est.	S.E.	Est.	S.E.
Intercept	2335	25	2171	56	2349	37	2599	35
MAT	-121.5	5.1	-75.3	7.1	- 76.8	7.1	-76.6	8.7
USE 2 - fresh	498	15	562	53	402	32		
3 - silage	261	16	348	54	191	35		
1 - hay	0	-	0	-	0	-		
OTHR 1- good quality hay	245	16	241	56				
3- dried too much	- 222	16	- 309	68				
0- undefined	0	-	0	-				

[a] Only a few illustrations are presented.

TABLE II-5: REGRESSIONS OF FEED CONSTITUENTS ON CHARACTERISTICS

(DATA SET - ROSTOCK)

Constituent / Parameter	CP %		CF %		ASH %	
Mean and % C.V.	154	6.57	285	3.85	107	6.82
R^2	967		.974		.953	
F value and Pr (F)	152	.0001	194	.0001	105	.0001
DF for Model and error	51	261	51	261	51	261
Source (of variation):	F value	Pr (F)	F value	Pr (F)	F value	Pr (F)
Plant species (FD)	33	.0001	41	.0001	18	.0001
Use of the feed (USE)	12	.0001	91	.0001	420	.0001
Cut no. (CUT)	29	.0001	20	.0001	5	.009
N-fertilizer (FRT)	94	.0001	138	.0001	11	.0001
Maturity degree (MAT)	2113	.0001	3441	.0001	1242	.0001
Other (OTHR)	18	.0001	56	.0001	2.6	.05
(interaction) MAT * FD	9	.0001	71	.0001	5	.0001
Dependence function	Est.	S.E.	Est.	S.E.	Est.	S.E.
Intercept	266	23	- 78	25	214	
FD: 121 - Egyptian clover	141	31	- 87	33	51	17
123 - Yellow medic	167	25	- 68	27	52	22
131 - Red clover	73	10	- 32	11	- 42	7
137 - White clover	172	21	-108	23	21	15
151 - Alfalfa	116	10	- 16	11	- 29	7
161 - Common vetch	88	12	- 31	13	7	9
163 - Hairy vetch	85	16	- 36	17	10	12
217 - Reed canary grass	15	13	104	14	- 42	9
229 - Timothy	17	14	7	16	- 61	10
235 - Italian ryegrass	50	16	- 16	17	- 53	11
251 - barley	- 69	18	332	20	- 48	13
255 - Oat	- 81	18	348	19	- 44	13
269 - Corn	- 31	19	230	14	- 34	9
275 - Rye	- 34	13	357	19	- 70	13
281 - Common wheat	-108	18	359	19	- 63	13
USE: 1 - Hay	- 13	13	- 47	14	- 11	9
2 - Fresh	- 4	3	- 25	3	- 6	2
3 - Silage	- 5	3	6	3	40	2
8 - Artificially dried	0	-	0	-	0	-
CUT: 0 - Not relevant	- 20	6	12	6	- 11	4
1 - 1-st	- 15	2	14	2	- 3	1
2 - 2-nd and later	0	-	0	0	0	-
FRT: 0 - 0	-113	16	332	17	- 34	11
2 - 50 kg N/ha	-150	18	392	20	- 29	13
3 - 75 kg N/ha	- 36	2	- 1	2	- 10	2
4 - 100 kg N/ha	- 99	18	317	19	- 24	13
6 - 150 kg N/ha	0	-	0		0	-
MAT	-23.6	4.2	46.9	4.5	- 20.9	3
OTHR: 0	53	12	- 7	13	2	9
1 - good quality hay	18	4	- 9	4	5	3
2 - medium " hay	0	-	0	-	0	-
MAT * FD[a]: 123	- 15	7				
137	- 16	6				
269	14	4	- 69	5	11	3
161			18	5		
217			23	6		
131					11	3
151					11	3

[a]Only a few illustrations are presented.

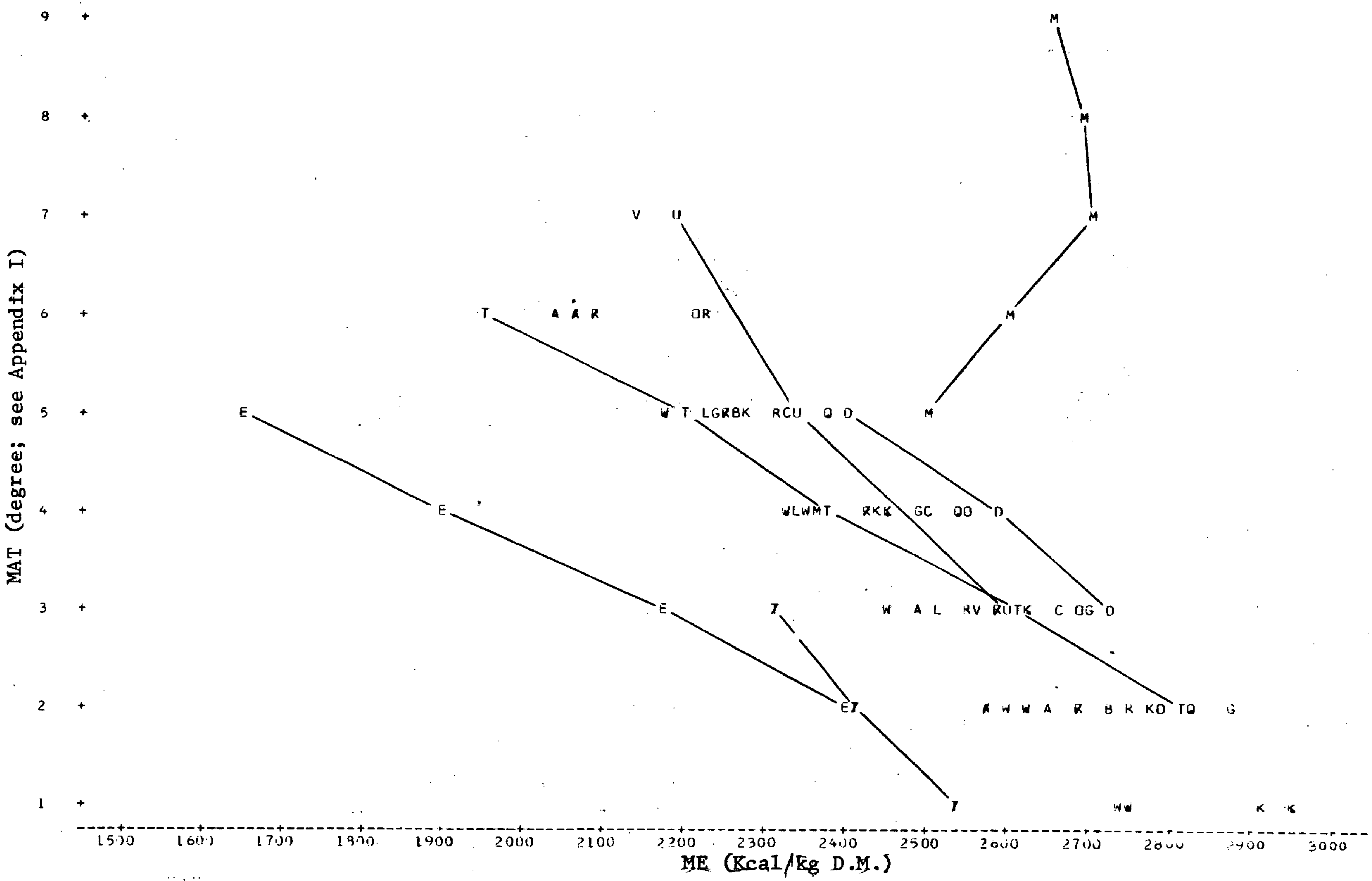

Fig. III-1: Effects of FD, CUT and FRI on the relationships between ME and MAT (fresh forage, Rostock data)
(Letters represent plant species; see Appendix I)

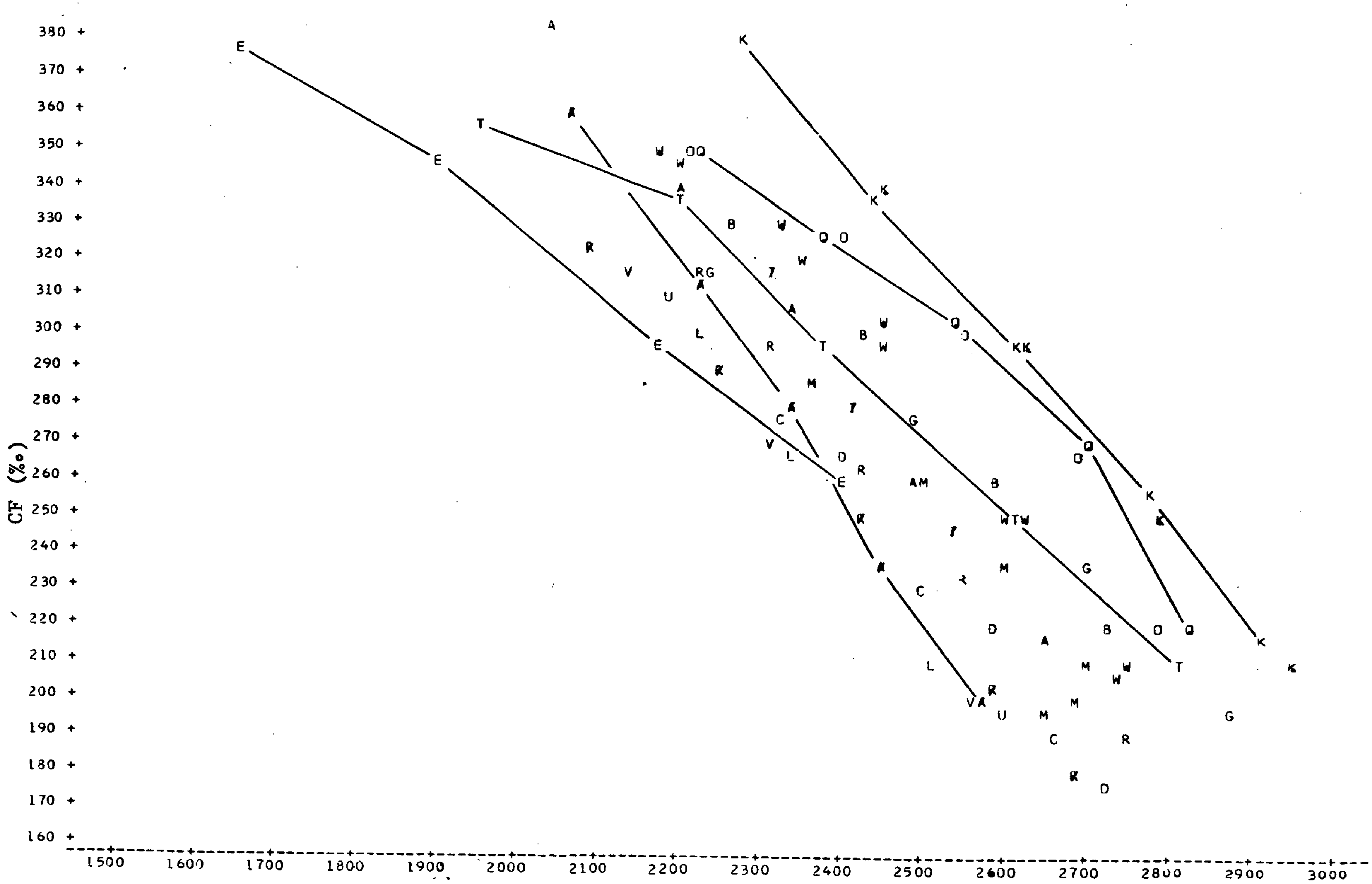

Fig. III-2: Effects of FD, CUT and FRT on the relationships between ME and CF (fresh forage, Rostock data)

(Letters represent plant species; see Appendix I)

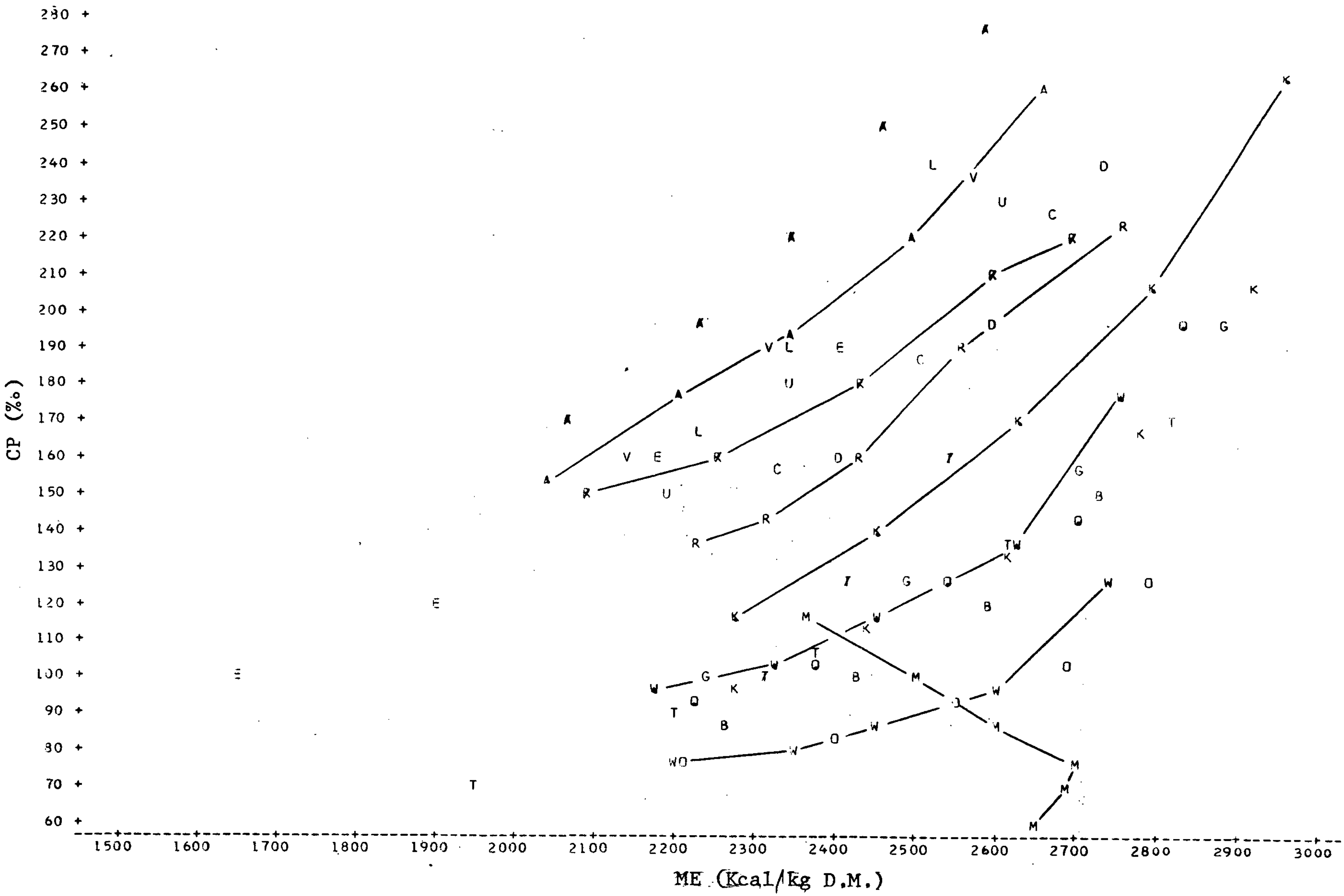

Fig III-3; Effects of FD, CUT and FRT on the relationships between ME and CP (fresh forage, Rostock data) (Letters represent plant species; see Appendix I)

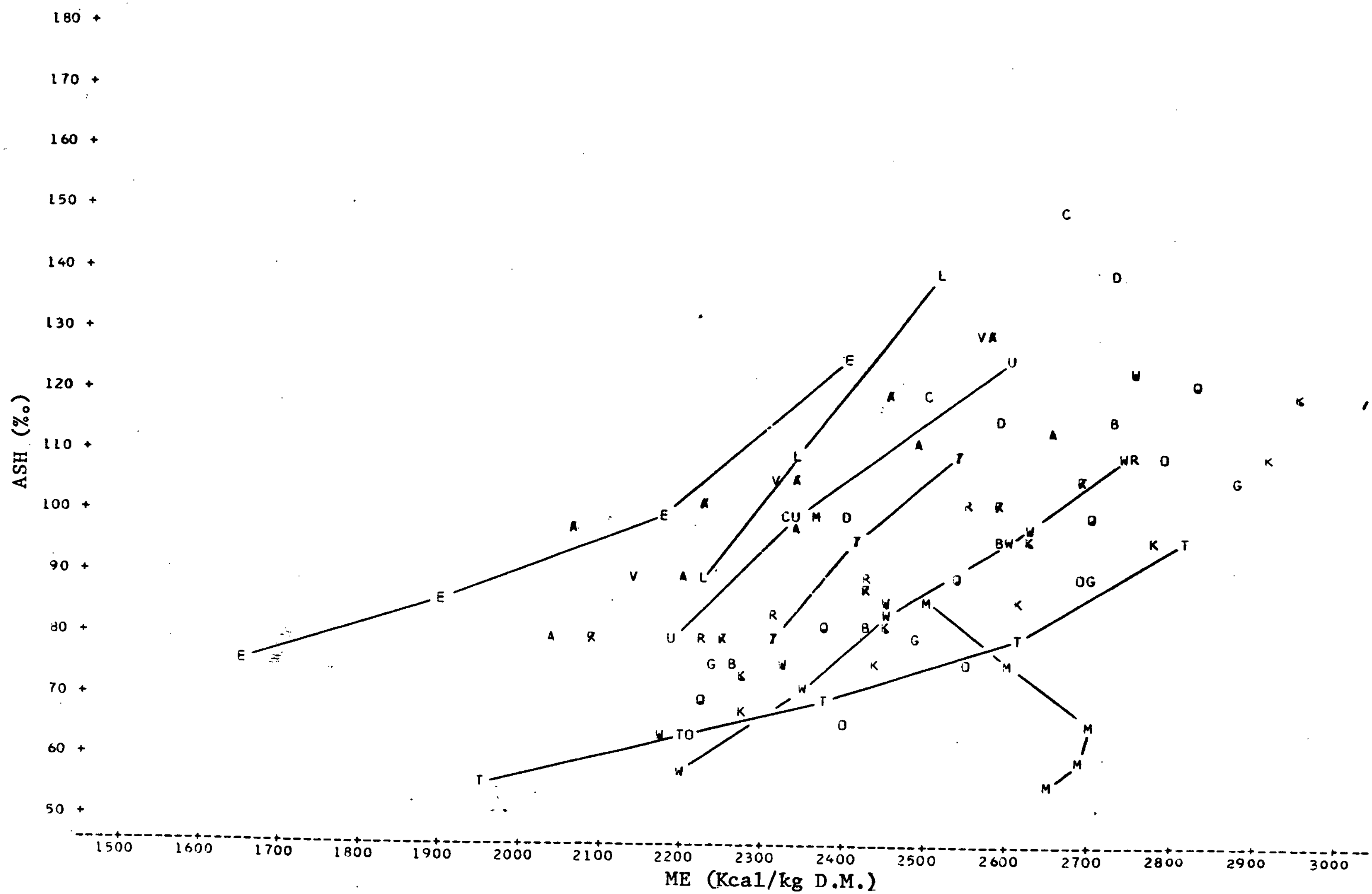

Fig. III-4: Effects of FD, CUT and FRT on the relationships between ME and ASH (fresh forage, Rostock data) (Letters represent plant species; see Appendix I)

השוואה של שתי מערכות נתונים של ערכי מזונות גסים
לפרות ומשמעותה לבוקר ולחוקר

מ א ת

ע' גולדמן* וא' גניזי**

תקציר

נתונים של הערך התזונתי של מזונות גסים מרוסטוק (מזרח גרמניה), מארה"ב וקנדה (אטלס המזונות) נותחו מבחינת הקשרים בין ערכי האנרגיה לבין רכיבי המזון (תאית גסה, חלבון ואפר), ו/או מאפייני המזון (מין הצמח, שלב ההבשלה, צורת השימוש, מספר הקציר וכו'). כ-300 מזונות מ-15-20 מינים המתאימים לישראל שנלקחו מנתוני רוסטוק, וכ-500 מזונות (מאותם מינים) מהאטלס הוכללו בניתוח.

מין הצמח והרכיבים הסבירו כ-92% מהשונות בערכי האנרגיה של נתוני רוסטוק, אך רק 54% מזו של נתוני האטלס. ששת המאפיינים של מערכת נתוני רוסטוק הסבירו כ-97% מהשונות בערכי האנרגיה של המזונות, בעוד ש-14 המאפיינים של נתוני האטלס הסבירו רק 48% ממנה. לעומת זאת, נמצא כי תכולת החלבון הכללי הסבירה כ-95%-99% מהשונות בערכי חלבון נעכל, בשתי מערכות הנתונים, ללא הבדל ביניהן.

במסגרת זו נדונו סיבות אפשריות להבדלים בין שתי המערכות, וכן קשרים נוספים בין הגורמים. הוערכה ונדונה אפשרות השימוש בנתונים של האטלס ושל רוסטוק על-ידי בוקרים וחוקרים בישראל.

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* מינהל המחקר החקלאי, המחלקה למרעה ומספוא

** מינהל המחקר החקלאי, המחלקה לסטטיסטיקה ועיבוד נתונים

24.10.80

מינהל המחקר החקלאי
המכון לגידולי שדה וגן

השוואת שתי מערכות של נתוני ערך אנרגטי של מזון לבקר

מאת

ע' גולדמן , א' גניזי

פירסום מיוחד מס' 170

המחלקה לפירסומים מדעיים
מרכז וולקני, בית-דגן

תש"ם-1980