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DIET SELECTION BY OESOPHAGEAL-FISTULATED SHEEP GRAZING IN THE SEMI-ARID NORTHERN NEGEV (ISRAEL)

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in The Netherlands: Centre for Agro-biological Research (CABO), Agricultural University, Wageningen.

in Israel: The Hebrew University of Jerusalem, and the Agricultural Research Organization, Bet Dagan.

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1. INTRODUCTION

1.1. General considerations

The present study is part of a Dutch-Israeli joint project, the aim of which is to build a simulation model and to attempt to describe wheat and sheep meat production in a semi-arid area (250 mm average annual rainfall).

The need for a sound basis for the development of such an agro-pastoral system led to the study of plant-animal relationships such as selective grazing behavior, rumen fill and passage, etc. Such a study can help optimize management decisions such as the density of the livestock on the pasture area, the crop-land: pasture ratio, crop grazing, crop - pasture rotations, timing of grazing in relation to pasture growth, animal movements between pastures of different types, and levels of supplementary feeding.

Studying the diet selected by oesophageal fistulated (OF) sheep grazing an annual natural pasture, should provide a better understanding of feed intake and its conversion into meat by sheep grazing pastures that fluctuate between extremes of quality and of quantity. With OF sheep, a technique new to this area, we can determine more accurately the chemical and botanical composition, and the plant parts' proportions, of the herbage eaten. With such information, more precise estimates of the digestibility of the diet can be made allowing, in turn, better estimates of the intake-output relationships of the grazing sheep.

1.2. Techniques for estimating pasture selectivity by grazing animals

It has been long recognized that animals do not necessarily eat the plants in the same proportion they occur in the pasture (Heady and Torell, 1959). They graze selectively. Selectivity can be defined as the difference between the composition of the herbage selected by the grazing animal and the composition of the herbage on offer (Langlands and Samson, 1973). Cook et al. (1948), who recognized that animals can eat selectively, outlined the difficulty of finding out what species and portions of plants are actually consumed, and the difficulty of interpreting the nutritive content of the ingested forage; an adequate method had to be found in order to measure the diet selected by the animals. There are basically three such methods:

(i) Sampling the pasture on offer before and after grazing; method recommended by Cook et al. (1948).

(ii) Observing the sheep and plucking from the herbage on offer a sample similar to that assumed to have been grazed; this was considered as accurate but time consuming by Edlefsen et al. (1960).

(iii) Using animals with oesophageal fistulas as biological sampling agents to collect herbage actually grazed; this method was first presented by Torell (1954) and subsequently checked and refined further by others.

According to Heady and Torell (1959), the first two methods are not satisfactory, as the assumptions made cannot be defended. The third method should be more accurate. Lesperance et al. (1960) and Van Dyne and Torell (1964) found that the samples of OF sheep were different from hand-clipped samples and concluded that the former were more representative of the diet selected by animals. Arnold et al. (1964) found that the diet and grazing behavior of OF sheep are similar to those of normal sheep, provided that fistula size and care are adequate. Langlands (1967) and Bohman and Lesperance (1967) thought that the OF method was the best for obtaining unbiased samples of ingested forage: it is accurate for estimating both the botanical composition of the diet (Arnold et al., 1966; McManus, 1971) and its chemical characteristics (Arnold et al., 1964; Langlands, 1969).

1.3. Problems and objectives of the study

The annual cycle of pasture in a semi-arid winter rainfall area like Migda in the Negev Desert of Israel, can be divided into three main periods; in each period there is a different grazing situation, in the sense that sheep intake and selectivity are influenced by different factors:

a. The intake of sheep grazing annual pastures is restricted, after the first winter rains, to dead plant material of low nutritive value. In the period just after germination, sheep can graze either green herbage of low initial availability or dead plant material. The intake and performance of the sheep at this time of the year and its nutritive value will depend on the availability of each of these components and on the selective grazing of the sheep. In general, unsupplemented ewes are under nutritive stress at this time, when they are either in late pregnancy or lactating. Their performance for the whole season can be influenced to a large extent by the diet selected during this period of restricted feeding. An understanding of this relationship will be of aid in pasture and animal management by establishing levels of grazing of dead plant material in the late summer and early winter months and levels of supplements needed during these periods of restricted pasture availability.

b. During periods of high pasture availability, which may include the reproductive phase of the pasture, sheep can eat to satiation and have greater possibilities for selective grazing. To find out what species and what plant parts the sheep prefer is important in a study of the effect of grazing on botanical composition of the pasture.

c. Before and after seed formation and dispersal there may be a significant intake of seeds from the pasture. As the following year's pasture production may be strongly dependent on the amount of viable seeds available for germination, a study of the seeds ingested and a measure of the extent to which they are lost by digestion will help us to understand the effect of grazing animals on the seed dynamics of animal pastures.

One of the aims of this study was to adapt the OF technique for use in a semi-arid area in Israel. The second aim was to assess pasture selectivity by sheep in different seasons of the year and its implication on pasture - animal relationships. The period which covered the vegetative and the beginning of the generative growth of the pasture was studied in an experiment carried out in winter 1978 (January to March). The period which covered the late vegetative and the generative stage of the pasture was studied in a similar experiment in winter 1979 (end of January until end of February). In summer 1978 (July-August) an experiment was carried out on seed ingestion and disappearance in sheep digestion.

2. MATERIALS AND METHODS

2.1. General design

The winter experiments were carried out from January until March during two consecutive years at the Migda Experiment Farm (in the Negev Desert of

Israel): in 1978 in field 1 (F1), and in 1979 in fields 4 (F4) and 12 (F12) (see Map no. 1).

Field 1 is grazed continuously throughout the year at a low stocking rate (0.33 sheep/0.1 ha). Grazing began in fields 4 and 12 when the dry matter on offer was 110 kg/0.1 ha in F4 and 175 kg/0.1 ha in F12. Field 4 was grazed at a stocking rate of 0.67 sheep/0.1 ha and field 12 at a stocking rate of 1.5 sheep/0.1 ha.

Winter growth and changes in botanical composition and in nitrogen content of these pastures were measured during the experiment. Biomass measurements were carried out by the method of Tadmor et al. (1975) and botanical composition was estimated by the bayonet point technique at random of Poisonnet et al. (1972). Rainfall in those years is presented in Appendix Table 1.

2.2. Sheep

In winter 1978 two fistulated rams (one Awassi and one Awassi-Merino cross) were used for sampling, in summer 1978 three fistulated dry ewes, and in winter 1979 two fistulated dry ewes (all of them Awassi).

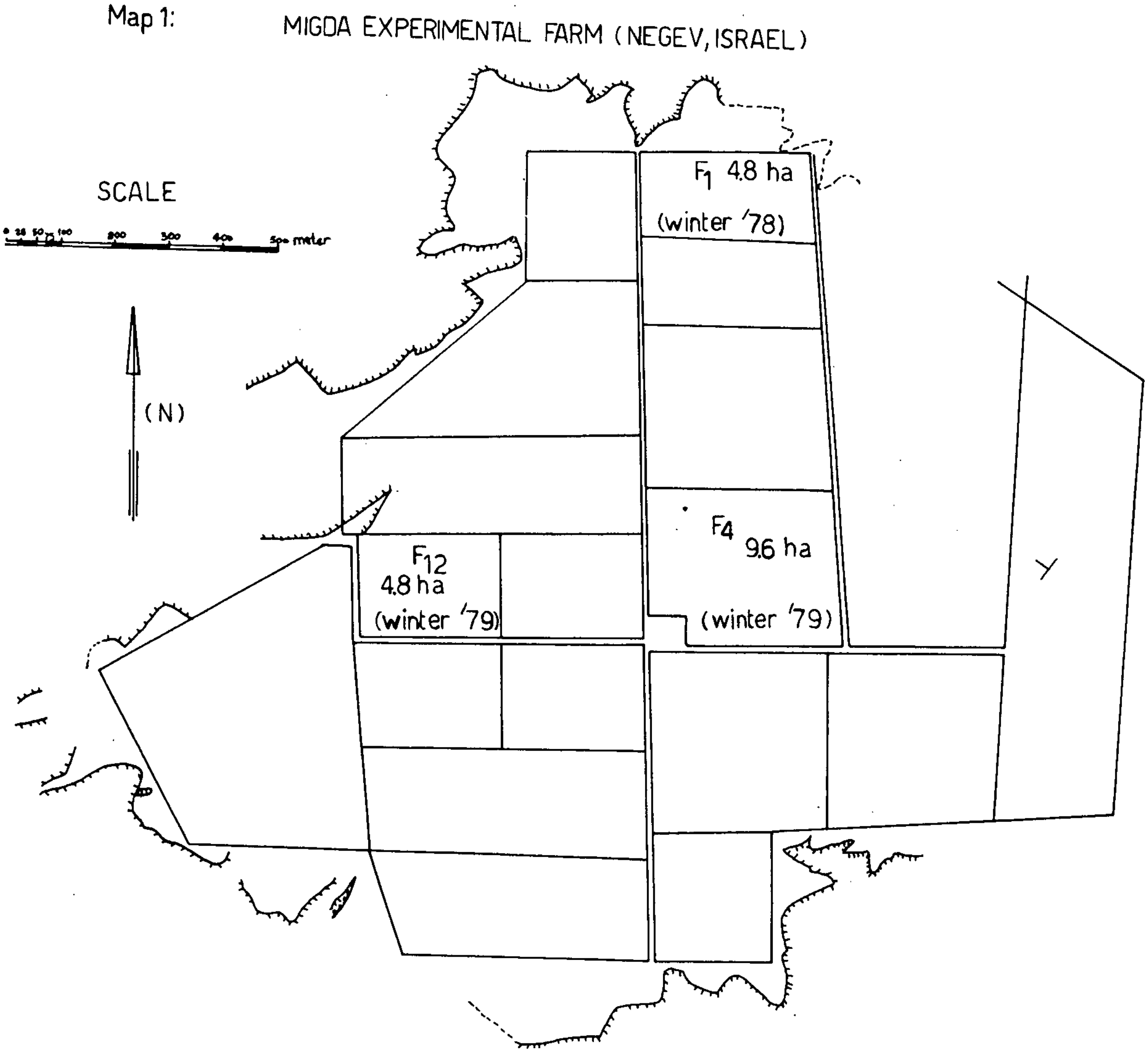
2.3. Recovery experiments through the fistula

In order to test the amount of feed ingested that was recovered through the fistula of each sheep, preliminary experiments were carried out in a pen, where the amount of ingested feed was known.

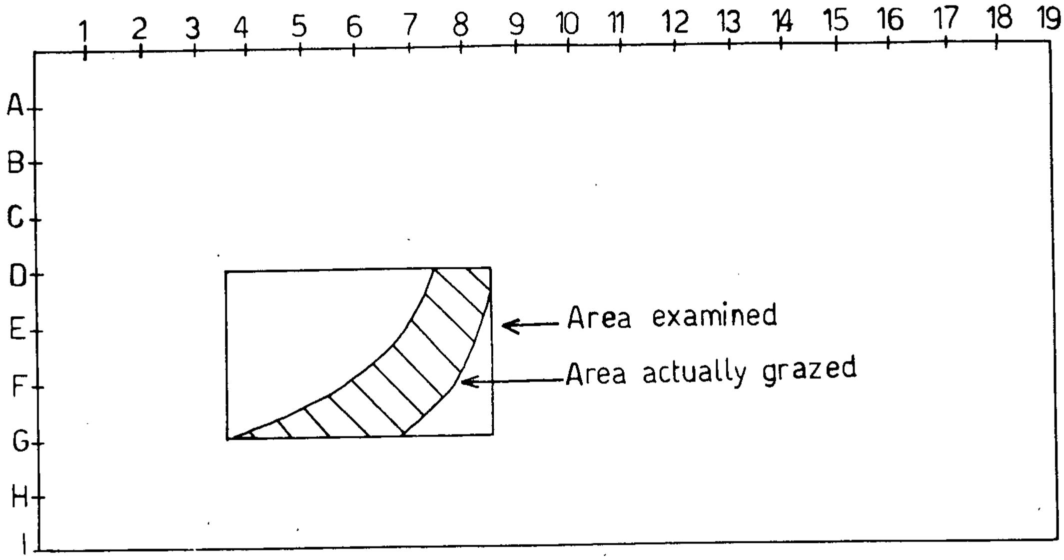
2.4. Care of the sheep

The state of health of the sheep was checked every 2 or 3 days. When fistulas were swollen and infected, they were treated with a penicillin ointment and penicillin was injected on three consecutive days as well. Plugs

Map 1:



Map 2: Field 1 (F1) labelled for pasture evaluation and showing area actually grazed, and area examined.



were removed - except for sampling - only when their position hindered the ingested food from passing through the oesophagus or when the size of the plug had to be adjusted because of changes in the size of the fistula. Harris et al. (1967) report that it is not desirable to remove the plug each day or to wash the fistula area. In the summer, plugs were treated with a fly repellent.

2.5. Sampling technique

2.5.1. Winter sampling The OF sheep grazed normally together with the rest of the flock. When samples had to be taken in different fields, the OF sheep were moved to the other pasture 3 or 4 days before sampling, as sheep diet immediately after moving into a new pasture can be atypical (Arnold et al., 1964).

Samples were taken usually early in the morning when the flock, which was always penned overnight, was turned out to the pasture. Sometimes, samples were taken also at noon (in 1978 and 1979) and in the afternoon (in 1978). Samples were taken every 8 to 10 days and in 1979 usually on two or three consecutive days in order to overcome between-days differences. When a sample had to be taken, the whole flock was gathered into the pen and canvas bags fitted inside with a labeled plastic bag were tied with strings around the neck of the OF sheep; then the whole flock was sent again to the pasture, for a 20-minute sampling period.

After sampling, again the whole flock was gathered into the pen and the OF sheep were fitted with a plug of the type described by McManus (1962). The plug was cut into two pieces to facilitate its use and to allow placing of spacers to adjust the size of the cannula to the size of the fistula (Nelson, 1962).

The field was labeled with letters in the breadth and with numbers in the length along the fence, so that the coordinates of the location where the OF sheep grazed during sampling could be read. After sampling, the botanical composition of the location was examined (see Map no. 2).

2.5.2. Summer sampling Eleven times between the beginning of July and the end of August, fistula samples were taken early in the morning at the moment the sheep were turned out to the pasture, for about 20 minutes (see procedure described in 2.5.1.). No examination of the pasture was made. Rectal faeces samples were grabbed from the OF sheep after sampling extrusa material on the pasture.

2.6. Botanical composition of the grazed pasture

In order to get comparable results, a point technique was used to analyze both the pasture and the extrusa samples (after Heady and Torell, 1959).

2.6.1. Description of the point technique The botanical composition of the area actually grazed during the sampling time was estimated by the bayonet (a stick with a very long needle) point technique at random of Poisonnet et al. (1972). Altogether, 400 to 800 points were recorded for each sampling time and coverage percent was then calculated.

2.6.2. Calibration of the point technique Calibration of the bayonet point technique was made by the methods described by Heady and Torell (1959), in the field and in the laboratory. The bayonet point technique at random in the field gave results closer to the manual separation of clipped squares than any of the other point techniques described by these authors (see Appendix - Table 2).

2.6.3. Correction for weight percentages Samples of each of the main species were collected, weighed, dried in the oven at 75°C for 24 hours, and then weighed again. Dry matter percentage was calculated and used to correct the figures obtained by the point technique.

2.7. Botanical analysis of extrusa samples

2.7.1. Dilution technique Whole extrusa samples were extracted through canvas: this removed most of the sand, saliva and plant juices. The material was then washed thoroughly with tap water through the cloth in a bucket, and spread and mixed evenly on the cloth on the bottom of the bucket (Grimes *et al*., 1967). The cloth was taken out flat, and excess water was removed by holding the cloth vertically before laying it on a table.

The material was covered with paper with ten holes (3 cm in diameter). A subsample from each of these holes was placed in a petri dish (10 cm in diameter). Each subsample was supposed to be approximately 0.1-0.2 g dry weight and if the sample was too small, the process was repeated until the added samples attained the weight mentioned above. Ten ml of a solution of 10% acetic acid (Harker *et al*., 1966; Molénat *et al*., 1976; Béchet and Loiseau, 1975) was added to each subsample. The acid helped to dissolve and spread the extrusa material evenly on the petri dish. The material should cover the whole surface of the petri dish but there should not be any overlapping of the plant pieces.

2.7.2. Classification of the material to be identified Identification of a number of species to the genera was impossible with the naked eye. Therefore, the material was classified into categories containing similar plants and representing the most common species available in the field (Molénat *et al*., 1976).

In 1978, as long as pasture availability was below 64 kg/0.1 ha, the material was classified into three categories:

1. "broad-leaf green grass" (over 0.1 mm), including *Hordeum murinum* and *Phalaris minor*.

2. "narrow-leaf green grass" (less than 0.1 mm), including *Schismus barbatus* and *Koeleria phloeides*.

3. "dead": dry stems remaining from the previous year.

When pasture availability was over 64 kg/0.1 ha, dicotyledons (forbs) appeared in the extrusa samples and were classified in a further category:

4. "forbs" with mainly *Plantago lagopus*, *Erucaria boveana*, *Diplotaxis erucoides*, *Anthemis pseudocotula* and *Fumaria densiflora*.

In 1979 plant parts as well as plant species were taken into consideration for the formation of the categories. The material was classified according to the following categories:

1. *Schismus* and *Koeleria*: leaves and stems
2. *Schismus* and *Koeleria*: inflorescences
3. *Hordeum* and *Phalaris*: leaves
4. *Hordeum* and *Phalaris*: stems
5. *Erucaria* (possibly including *Diplotaxis*): leaves
6. *Erucaria* (possibly including *Diplotaxis*): stems
7. *Erucaria* (possibly including *Diplotaxis*): inflorescences
8. "Forbs" including *Allium ampeloprasum*, *Malva nicaeensis*, *Anthemis pseudocotula*, *Trigonella arabica*, *Silene spp.*, *Glaucium corniculatum*, *Fumaria densiflora*, *Leontodon laciniatum*, *Isatis eusitanica*, *Bellevalia flexuosa*, *Linaria albifrons*.

Fig. 1: Calibration of the point cover technique against manual separation (subsample of the same sample).

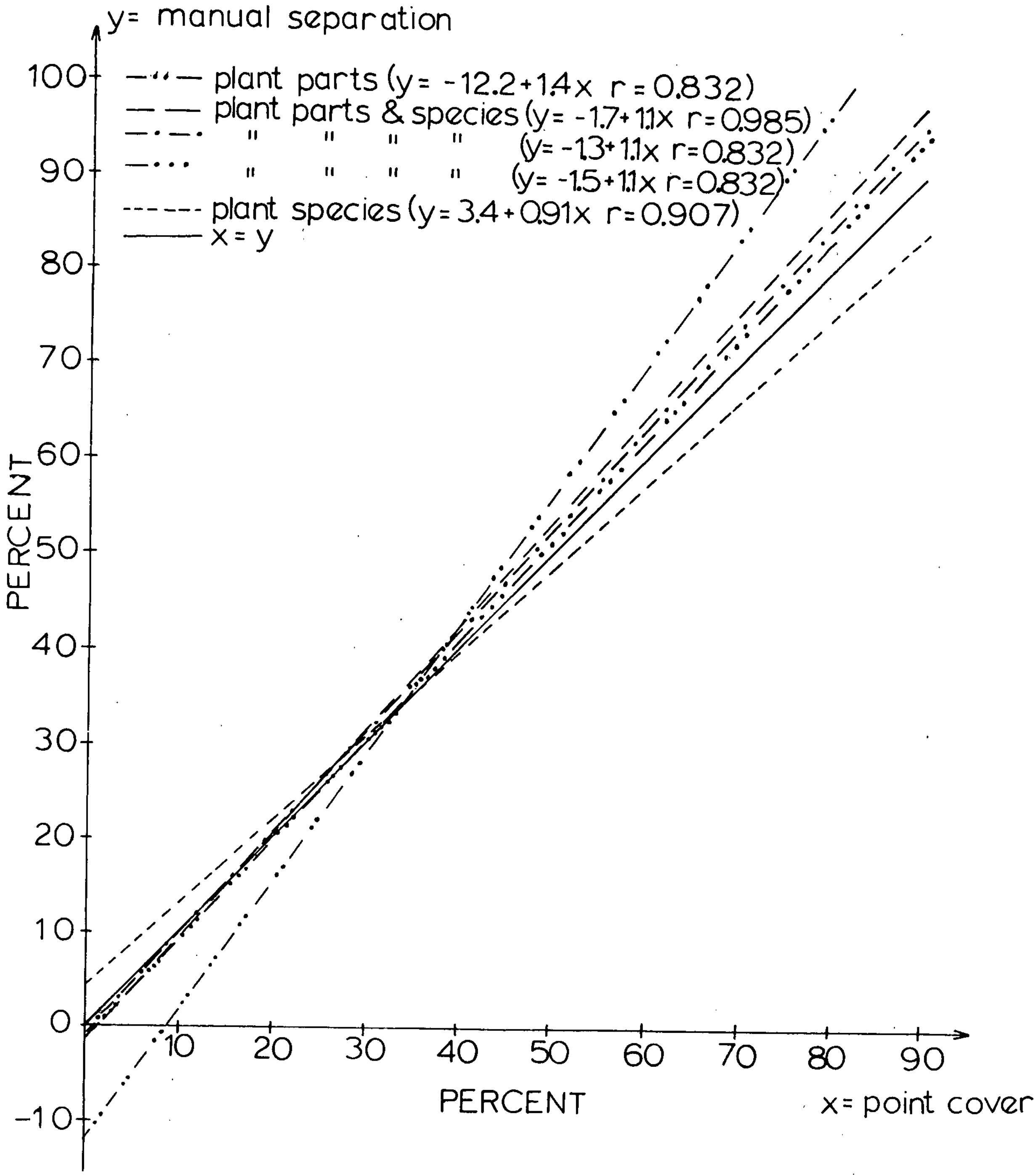
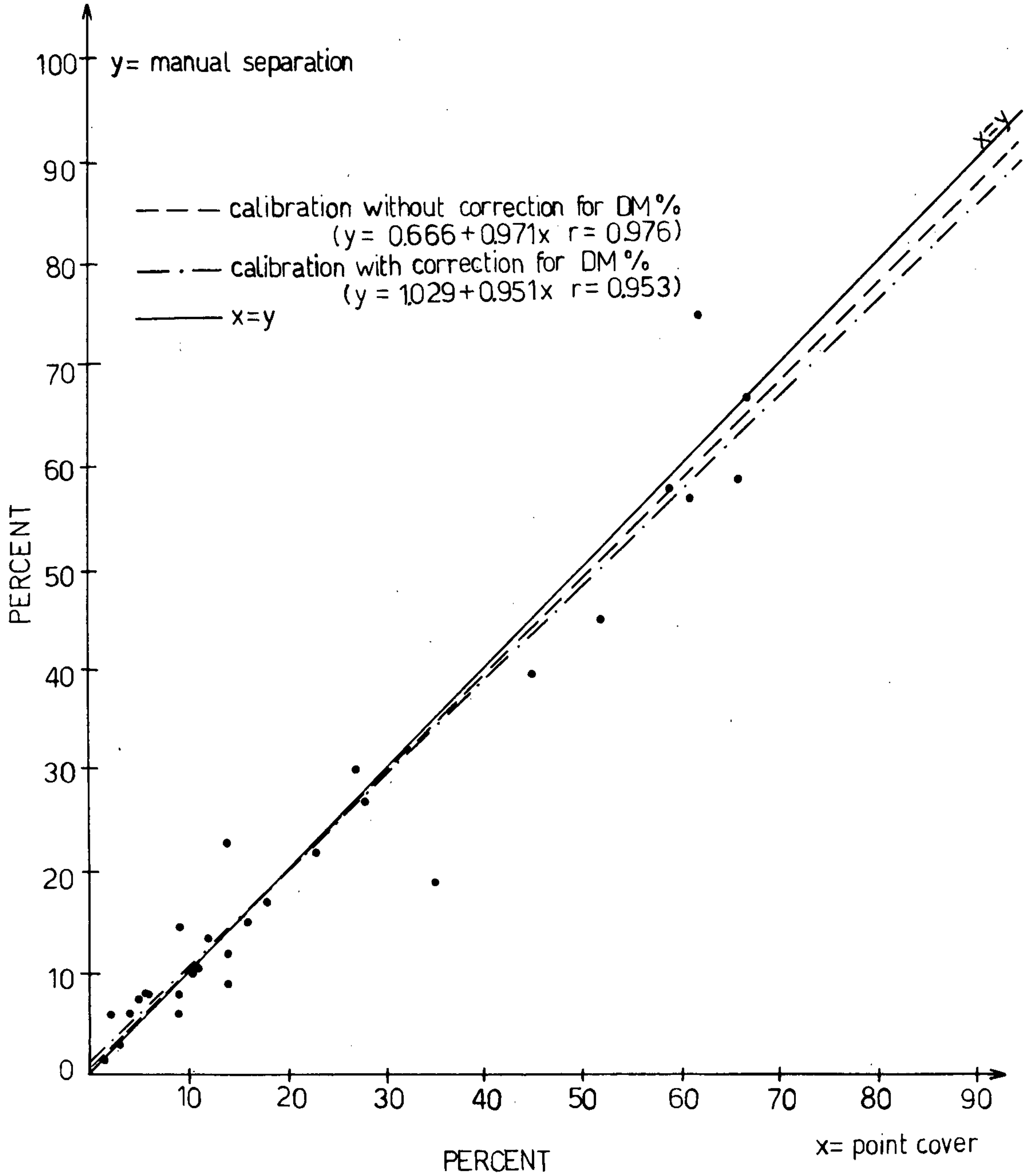


Fig. 2: Calibration of the point cover technique against manual separation (various samples).



2.7.3. Description of the point technique. The petri dish containing a subsample of the extrusa (see 2.7.1) was placed on square FORTRAN paper and using a finely pointed needle 100 hits were recorded at the intersections of the lines (Malachek and Leinweber, 1972; Molénat et al., 1976; Loiseau and Bechet, 1975). A total of 1000 points were recorded for each extrusa sample. Percentage cover of each species was calculated.

2.7.4. Calibration of the point technique. On some of the sampling dates, results given by the point technique were checked and calibrated with a separation weighing technique. After the point readings were computed, the ten subsamples were manually separated into the same categories that were used for the point cover percentage. The category of the smallest pieces was left in the petri dish (usually *Schismus*, leaves and stems) and the other categories were placed on labeled microscope slides. The separated subsamples were dried for 24 hours at 75°C and weighed. Percentage by weight was calculated. A regression between percentage by cover and percentage by weight was made for all categories together.

Calibration of the various categories made within the subsamples of the same sample (1979: see Fig. 1) gave coefficients of regression between 0.83 and 0.98 and calibration of the various categories made with an average of ten subsamples of several samples (1978: see Fig. 2), gave a coefficient of regression of 0.97. In all cases but one, the intercept was close to 0 and the slope close to 1 (regression: x=y), showing that the two techniques gave similar results.

Correction of the point technique figures by dry matter percentage of field plants usually made the figures worse and was subsequently dropped (see Fig. 2).

2.8. A microscope technique

With the naked eye *Hordeum* and *Phalaris* had been classified in the category of "broad-leaf grasses" and *Schismus* and *Koeleria* in the category of "narrow-leaf grasses." An attempt was made to develop a technique which would enable us to distinguish between the species that were pooled in the same category and also to identify those leaf pieces that were too small to be pooled with certainty in either category, by a microscope method based on the characteristics of leaf epidermics.

Reference material (from the pasture) of the four species in the vegetative (3-5 leaves) stage (abaxial and adaxial sides of the leaf) and in the generative (merging of the inflorescence) stage (abaxial and adaxial sides of the leaf) was examined and compared. Anatomical characteristics of the cuticula of those species are presented in Appendix Tables 13 and 14, and a key for determination is given in Appendix Table 15. Appendix I presents various sketches of those anatomical characteristics.

2.9. Chemical analysis of the pasture and the fistula samples

2.9.1. Dry matter content (fistula samples). Each fistula sample (not washed) was mixed thoroughly in its bag and three subsamples were taken at random and placed on a preweighed petri dish; the samples were dried at 75^{o}C for 24 hours and weighed again. Dry matter percentage was then calculated.

2.9.2. Ash content (fistula samples). The samples that were dried in the oven were finely ground and thoroughly mixed in their bag. Of each sample, three subsamples (a total of about 1 g) were taken and placed in a preweighed porcelain dish. The samples were burned at 600^{o}C for 2-2.5 h, and weighed again. Ash percentage was then calculated.

2.9.3. Nitrogen content (pasture and fistula samples). Out of the samples that were dried and ground, 200 mg was weighed to measure organic-nitrogen and ammonium-nitrogen after Kjeldahl and 200 mg for analyzing nitrate-nitrogen. The analyzing methods (distillation) were those described by Black et al. (1965) of the American Society of Agronomy. Total nitrogen percentage was then calculated.

2.10. Preparation and analysis of samples taken in summer

Fistula samples were prepared by the method described in 2.8.1. Three or ten subsamples per sample (size:0.2 g dry weight) were examined under a binocular microscope. All seeds found in the samples were removed, placed on a microscope slide, identified, and counted.

For each faeces collection, 3 to 10 faeces balls (or 1/2-balls) (size: 0.3 g dry weight) were picked at random and crushed in a petri dish with a laboratory scalper in the same acid solution used for fistula subsamples. All seeds were removed, identified, and counted.

2.11. Statistical analysis

The statistical analysis for comparing the results consisted of an analysis of variance performed with the Statistical Analysis System (SAS) available in the computer of the Weizmann Institute of Science (Rehovot, Israel). Significance was determined with a F-test and defined as follows:

(*)	almost significant	($P<0.1$)
*	significant	($P<0.1$)
**	very significant	($P<0.05$)
***	highly significant	($P<0.001$)

Significance of the regression coefficients was tested with a statistical table prepared by Pearson and Hartley (1954).

3. RESULTS

3.1. Chemical data

3.1.1. Dry matter, ash and nitrogen content of pasture on offer. The composition of pasture vegetation in the various fields is presented in Appendix Table 3.

In F1 (1978), there was more than double the amount of dry matter on offer in the second period compared with the first period. In F4 and F12 (1979), there seemed to be a peak in dry matter on offer during the second period, followed by a decrease in the third period. Apparently, F12 offered more dry matter than F4. Dry matter on offer throughout the season is shown in Fig. 3 for F1 and in Fig. 4 for F4 and F12. Dry matter increase in F1 was rather irregular.

Dry matter content of plants varied between the various species but the ranking of the species remained constant throughout the season in all the fields (in 1978 and 1979): Schismus had the highest dry matter content, followed by Hordeum, with Erucaria having the lowest dry matter content. The dry matter content of the forbs was an average of several species, most of them with a low dry matter content. The increase of dry matter content for all the categories throughout the season, was significant or highly significant in all the fields (see Fig. 5 for F1 - only the second period, and Fig. 6 for F4 and F12, pooled together) except for Schismus in F1 and forbs in all the fields. Differences between periods, however, were significant only in F4 for Hordeum and Erucaria. No significant differences could be found between F4 and F12 for any of the categories.

Nitrogen content of the pasture generally decreased during the season;

Fig. 3: Dry matter on offer (kg/0.1 ha) and size (in grams) of extrusa samples in field 1 (1978).

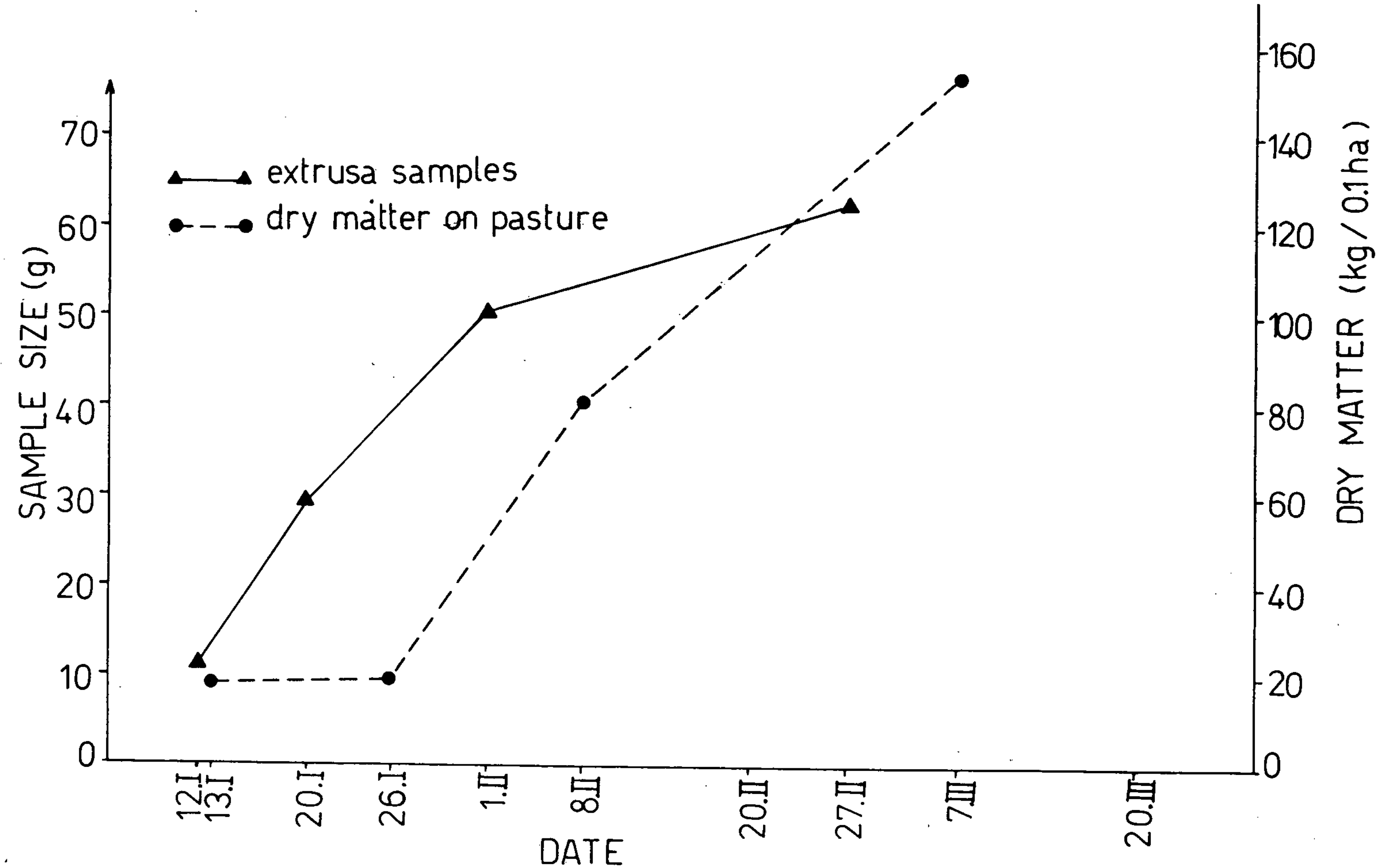


Fig. 4: Dry matter on offer (kg/0.1 ha) and size (in grams) of extrusa samples in field 4 and field 12 (1979).

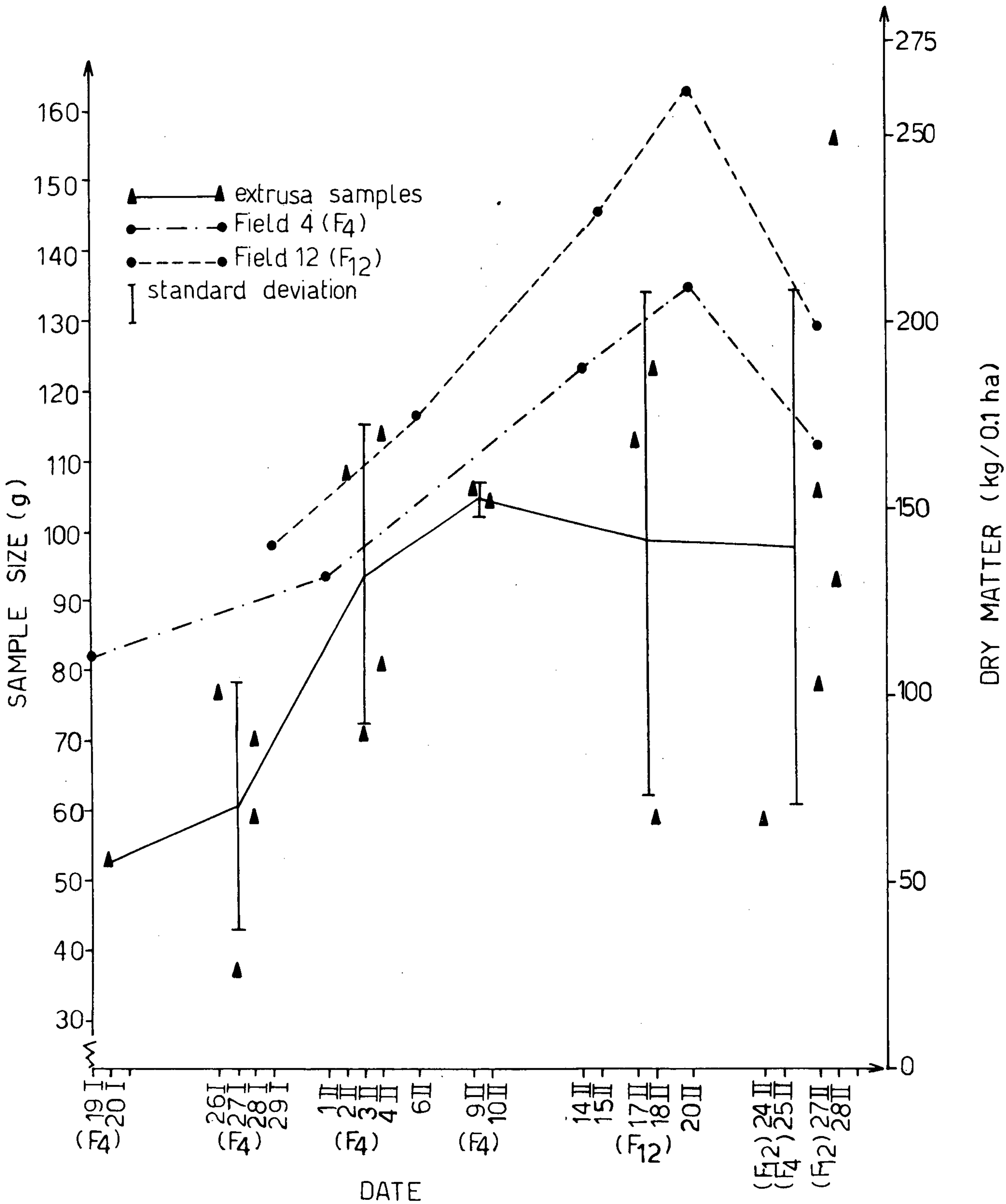


Fig. 5: Dry matter content (%) of extrusa samples and of the main pasture species and ash content (%) of extrusa samples in field 1 (1978).

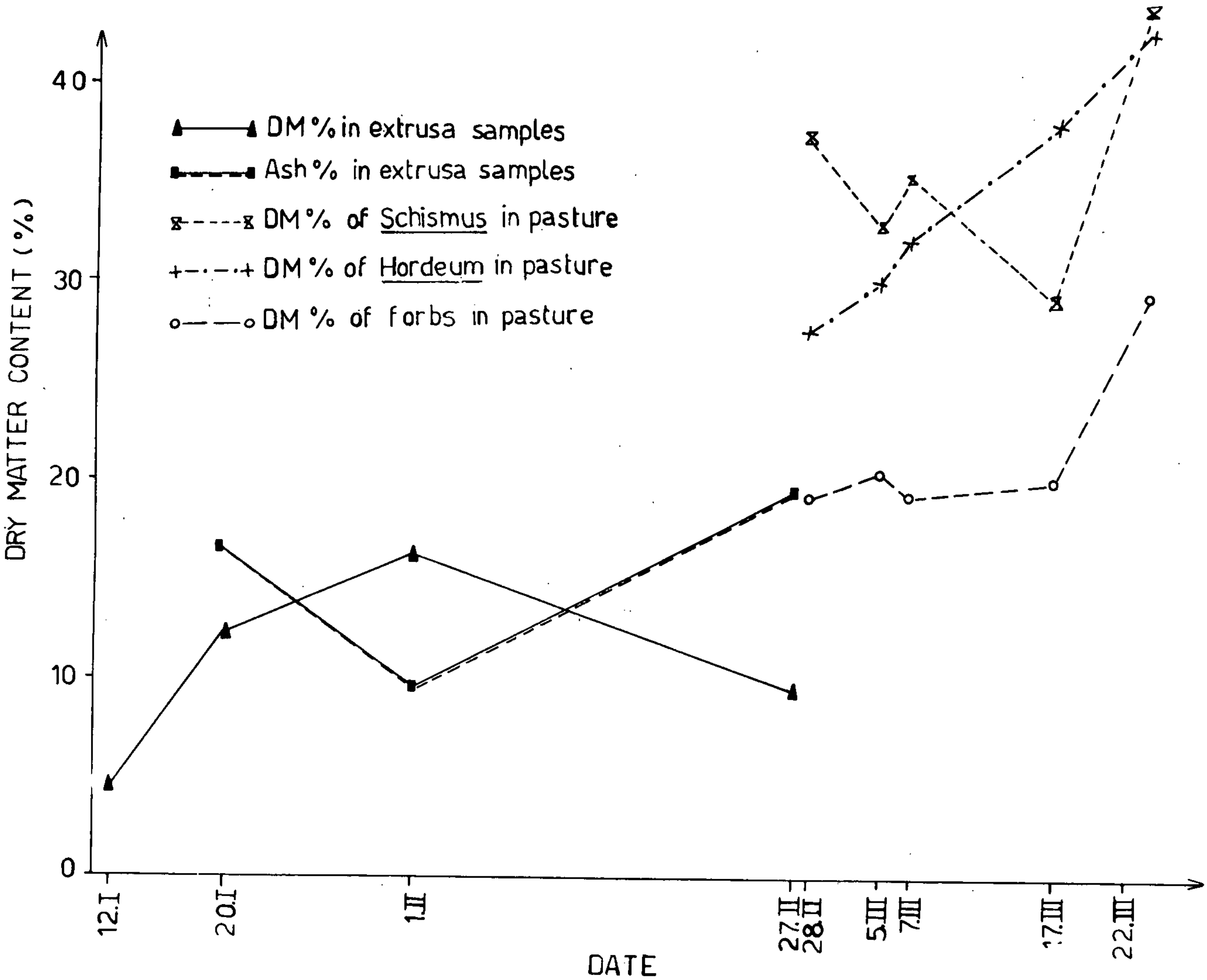
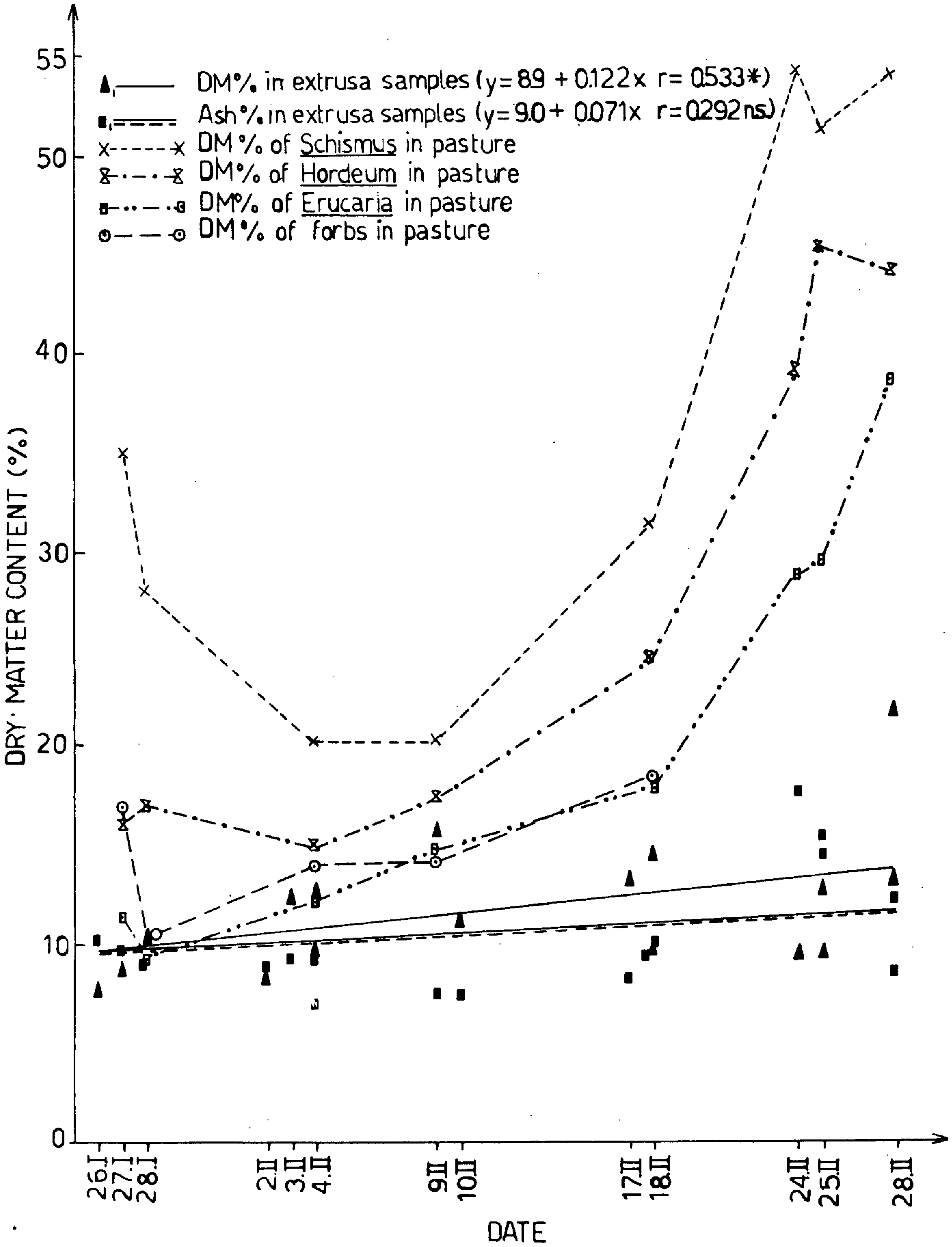


Fig. 6: Dry matter content (%) of extrusa samples and of the main pasture species and ash content (%) of extrusa samples in field 4 and field 12 (1979).



the decreasing trend was very significant where data of F4 and F12 were pooled (see Fig. 7), although differences between individual periods were usually not significant. Differences between the two fields were not significant. The lack of significant differences in chemical data justified the pooling of both fields (F4 and F12) in figures.

3.1.2. Dry matter, ash and nitrogen content of extrusa samples. Chemical data of extrusa samples are presented in Appendix Table 4.

In F1 (1978), the average size of the extrusa samples was three times as large in the second period as in the first period. The increase of the sample throughout the season was very significant (see Fig. 5), but variability between the samples was very high and the differences between periods was barely significant.

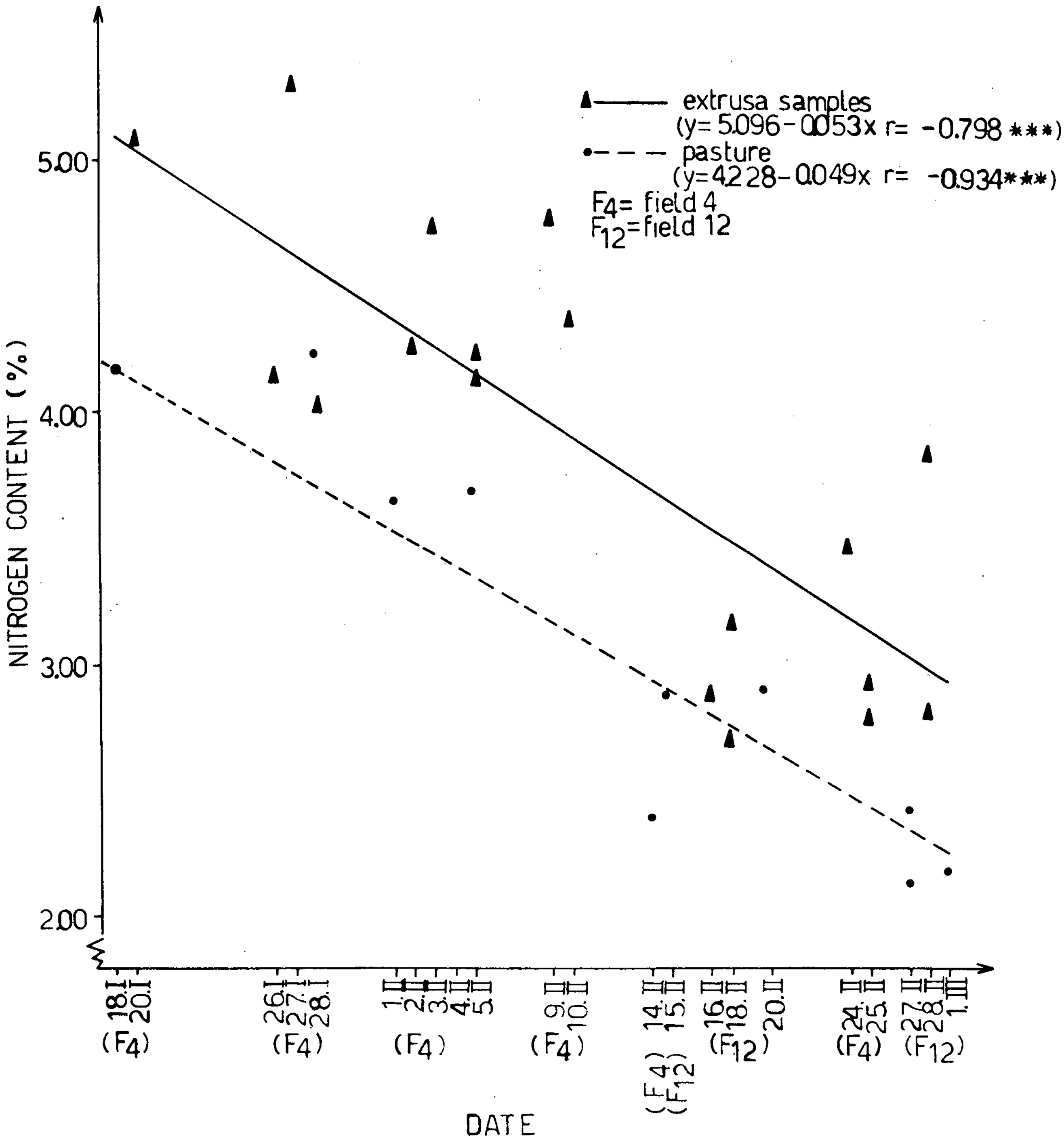
In F4 and F12 (1979), sample sizes were generally larger than in 1978, with high variability between the samples and no differences between periods or fields, and no changes throughout the season (see Fig. 6).

The seasonal trend of increased dry matter content of the extrusa samples was not significant in F1 (1978) (see Fig. 5), whereas it was significant in F4 and F12 (see Fig. 6). However, in neither year were differences between periods or fields significant.

In F1 (1978), no significant changes could be found between the periods or throughout the season (see Fig. 5). In F4 and F12 (1979), differences in ash content of the extrusa samples were very significant between the periods, although no significant trend could be found throughout the season (see Fig. 6). Differences between fields were not significant.

Differences in nitrogen content were significant between fields (generally

Fig. 7: Nitrogen content (%) of extrusa samples and pasture samples in field 4 and field 12 (1979).



feed with a higher nitrogen was ingested in F4 compared with F12) but not between periods, although there was a highly significant decrease in %N of extrusa samples throughout the season (see Fig. 7).

Differences between sheep were not significant for any of the chemical data; differences between days (of the same period) were highly significant during the first period in F1 for dry matter content and very significant for nitrogen content in F4 and F12 during the first and second periods. Differences within days (between morning and afternoon) were significant only for dry matter content in F4 and F12.

3.1.3. Content of extrusa samples and pasture nitrogen compared. The difference between extrusa samples and field (Appendix Table 3) was very significant, throughout all the periods. Figure 7 shows that the decrease of nitrogen content in extrusa samples and in the field is parallel and that extrusa samples contain always almost 1% more nitrogen than the field. In terms of crude protein, the difference would be about 6%.

3.2. Botanical composition

3.2.1. Areas grazed compared with a general survey. Appendix Table 6 presents the botanical composition of a general survey made in F4 (1979) during the first period, compared with the average of estimates of botanical composition of the areas actually grazed during the sampling in the same period. Differences were statistically non-significant.

Therefore, the botanical composition of extrusa samples in F1 (1978) that were taken during the first period were compared with general surveys made in the field during the same period; estimates of botanical composition of areas actually grazed during sampling were missing.

3.2.2. Botanical composition of areas actually grazed during sampling. Estimates of botanical composition (in percent) are presented in Appendix Table 7.

In F1 (1978), the proportion of Schismus and Hordeum did not increase significantly between the first and the second period; the decrease of the proportion of dead material and the increase of the proportion of forbs were significant. In F4 and F12 (1979), there were no significant differences between periods for any of the categories. Differences were significant between fields for Schismus and Hordeum only (there was more of Schismus and less of Hordeum in F12 than in F4). In the subsequent figures, however, both fields were pooled. The forbs could no longer be quantitatively estimated during the third period.

However, differences between F1 on the one hand, and F4 and F12 (1979) on the other hand, were highly significant for all the categories: F1 offered less Schismus and more Hordeum and more forbs than F4 and F12. Dead material could be found only in F1, and Erucaria appears to be an important species only in F4 and F12. It was observed that F1 was rather a short grass pasture and that F4 and F12 presented a taller herbage to the sheep.

3.2.3. Botanical composition of extrusa samples: Species. The botanical composition (in percent) of extrusa samples is presented in Appendix Table 6. For F4 and F12, proportions of the various species are presented, each split into plant parts. (No analysis of plant parts had been made in F1.) The material of the last samples taken in F12 was already so dry that identification of plant parts with the naked eye was difficult.

In F1 (1978) the increase of Hordeum and the decrease of Schismus between the first and the second periods were not significant. However, the disappearance of dead material and the appearance of forbs during the second period caused a highly significant change in the proportion of those categories between both periods.

In F4 and F12 (1979), among all the categories present, differences between periods were significant only for Schismus inflorescences and Hordeum leaves (increase between the first and the second period, and decrease between the second and the last period). However, trends throughout the season for plant parts of each species were never significant (see Fig. 8), nor were differences between fields. It should be pointed out that inflorescences of Hordeum, although they appeared in the pasture, could never be found in extrusa samples.

3.2.4. Botanical composition of extrusa samples: Plant parts. Appendix Table 9 summarizes the proportion of plant parts of all the species together in extrusa samples (1979).

Differences were very significant between periods for leaves and inflorescences and Figure 9 shows a significant increase of inflorescences and decrease of leaves throughout the season (F4 and F12, pooled together). Differences between fields were not significant.

3.2.5. Other factors influencing botanical composition of extrusa samples. Differences between sheep were significant in F1 for dry material, in F4 and F12 for Hordeum (leaves), very significant for Erucaria (inflorescences), and in general for inflorescences. Differences between days were significant to highly significant for dead material in F1 (first period), for Schismus (inflorescences), Erucaria (leaves) and forbs (F4 and F12, first period), and for Hordeum (leaves)(third period). No significant differences could be found within-days (between morning and afternoon).

Fig. 8: Proportion of plant parts (%) of each species in extrusa samples in field 4 and field 12 (1979).

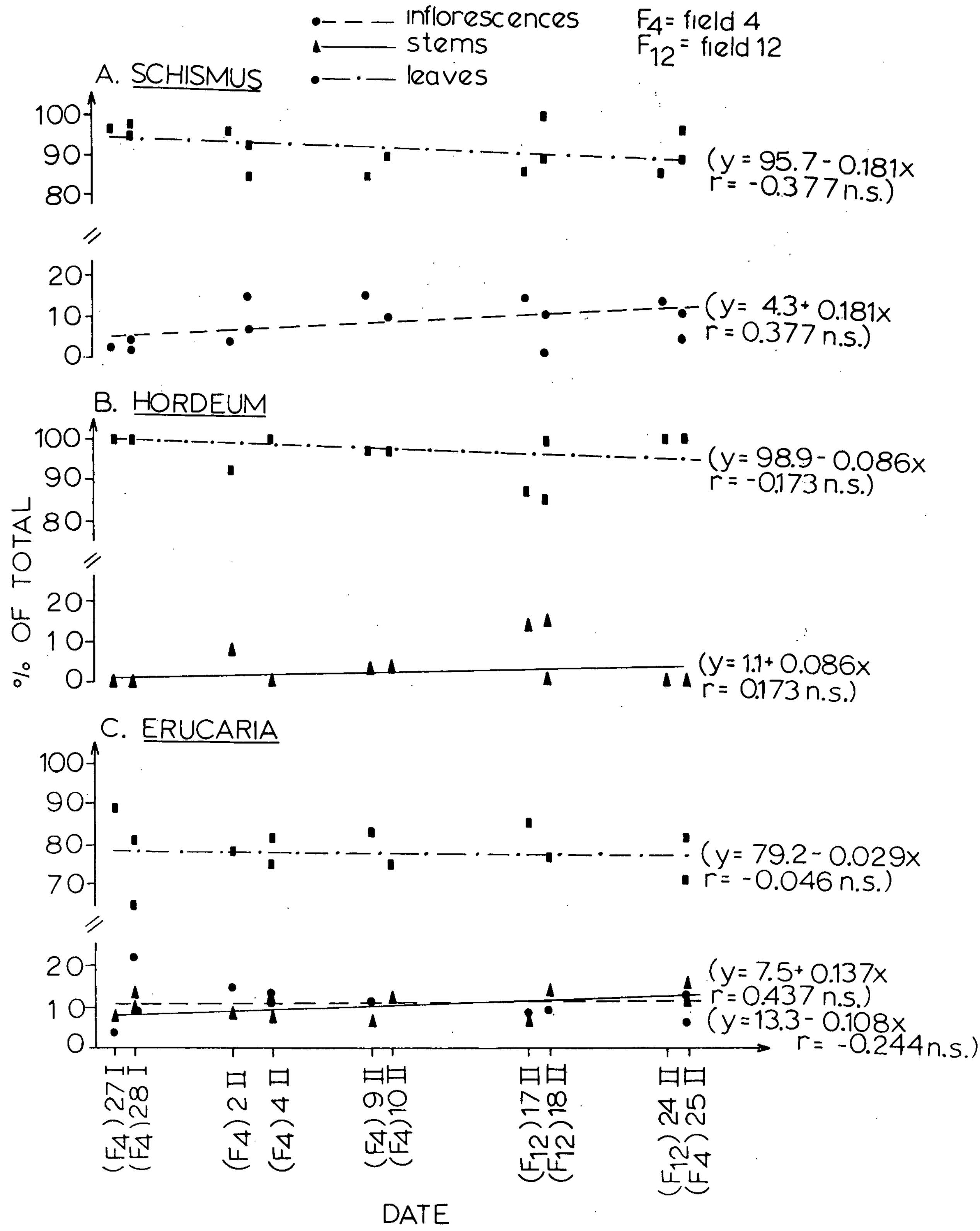
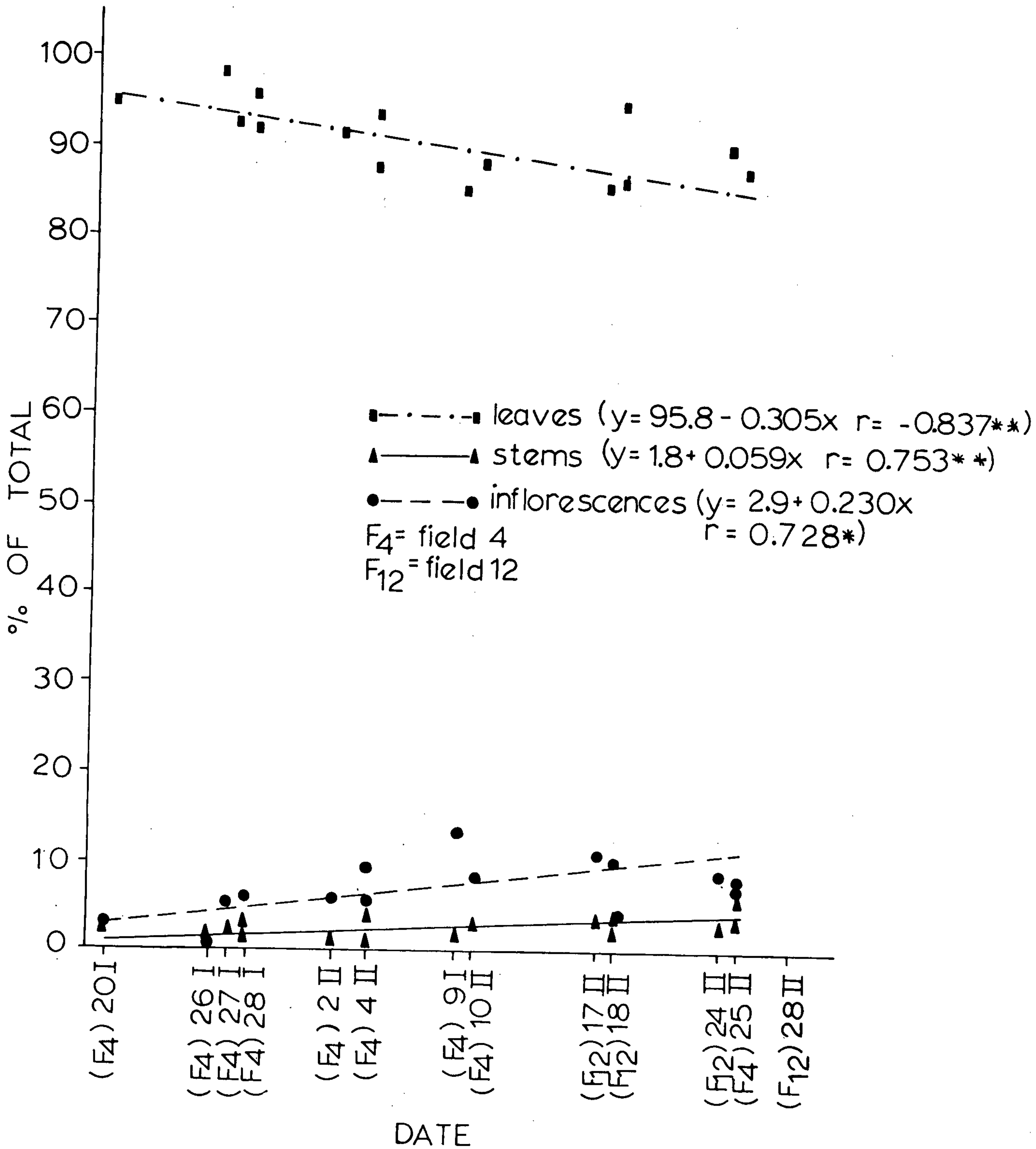


Fig. 9: Proportion of plant parts (%) of all species in extrusa samples in field 4 and field 12 (1979).



3.2.6. Botanical composition of extrusa and pasture compared.

3.2.6.1. General. Botanical composition of extrusa samples and of pasture are summarized in Appendix Table 10.

In F1 (1978), sheep ate in both periods a significantly greater proportion of *Schismus* than there was on offer, and correspondingly a smaller proportion of *Hordeum*. The forbs hardly appeared in the first period in extrusa samples, when they were already present in the field. In the second period they were consumed almost in the same proportion as they were on offer. Dead material was very much avoided during the first period and in the second period appeared in extrusa samples almost in the same (small) proportion as it was on offer.

In F4 and F12 (in all periods and fields except in the second period in F4), sheep atesignificantly less *Schismus* and *Hordeum* than there was on offer and significantly more *Erucaria*. There was sometimes more and sometimes less forbs in extrusa samples than on offer, and differences were not significant.

The preference for *Schismus* depended very much on the year (in 1978 it was chosen, in 1979 rejected), but did not change between the periods of the same year. In contrast to *Hordeum*, which was rejected in both years, *Erucaria* in 1979 was always chosen in all the periods, while the consumption of dead material in 1978 and of forbs in both years depended on the period.

For most of the categories, differences between pasture and extrusa samples were highly significant.

3.2.6.2. Selectivity throughout the season in 1978. Figures 10 and 11 present the proportions of the various categories found in each period (Fig. 10) in extrusa samples and in field surveys in F1, and for each sampling

Fig. 10: Proportion (%) of the various species in extrusa samples and in pasture in field 1 (1978; two periods).

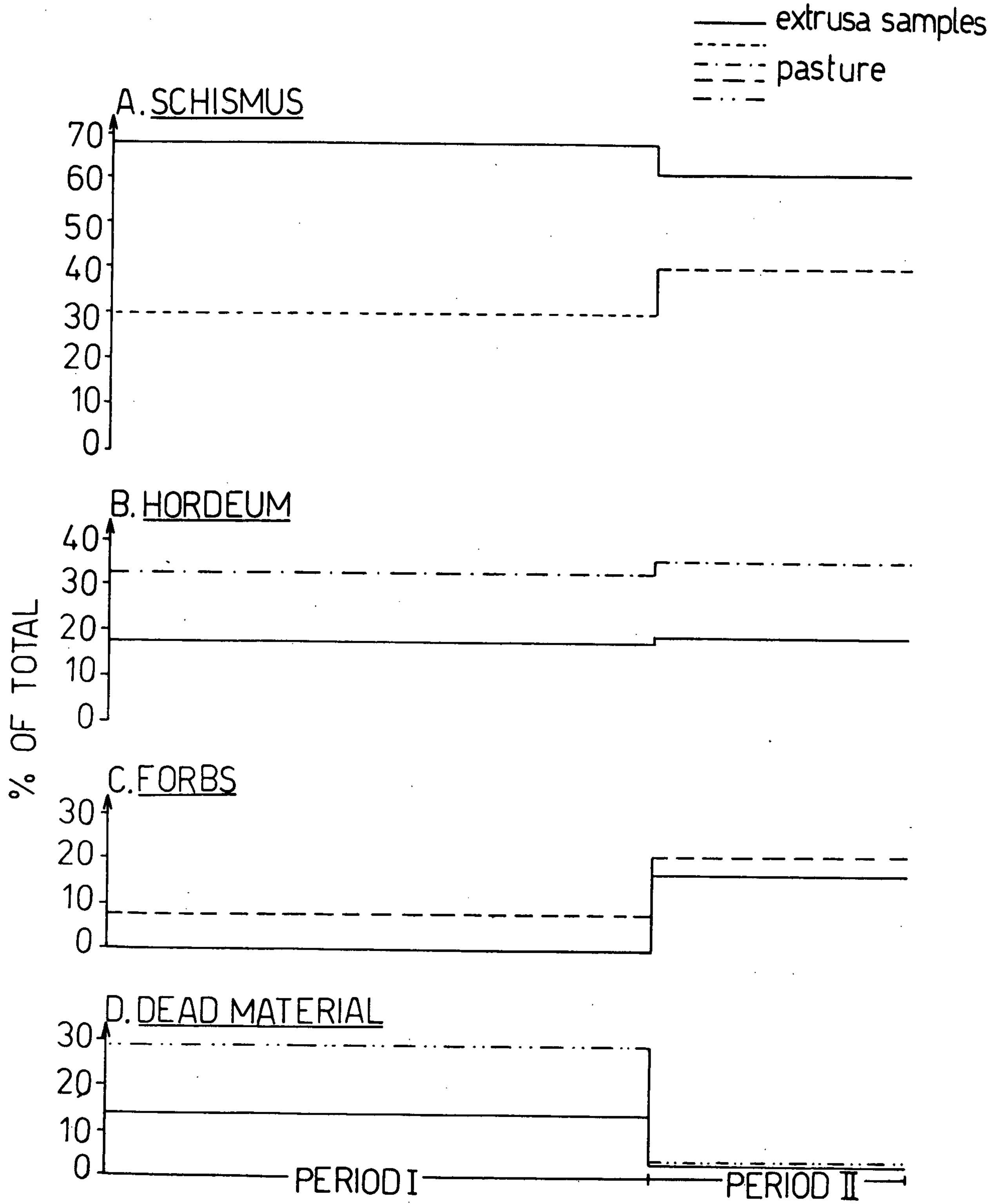
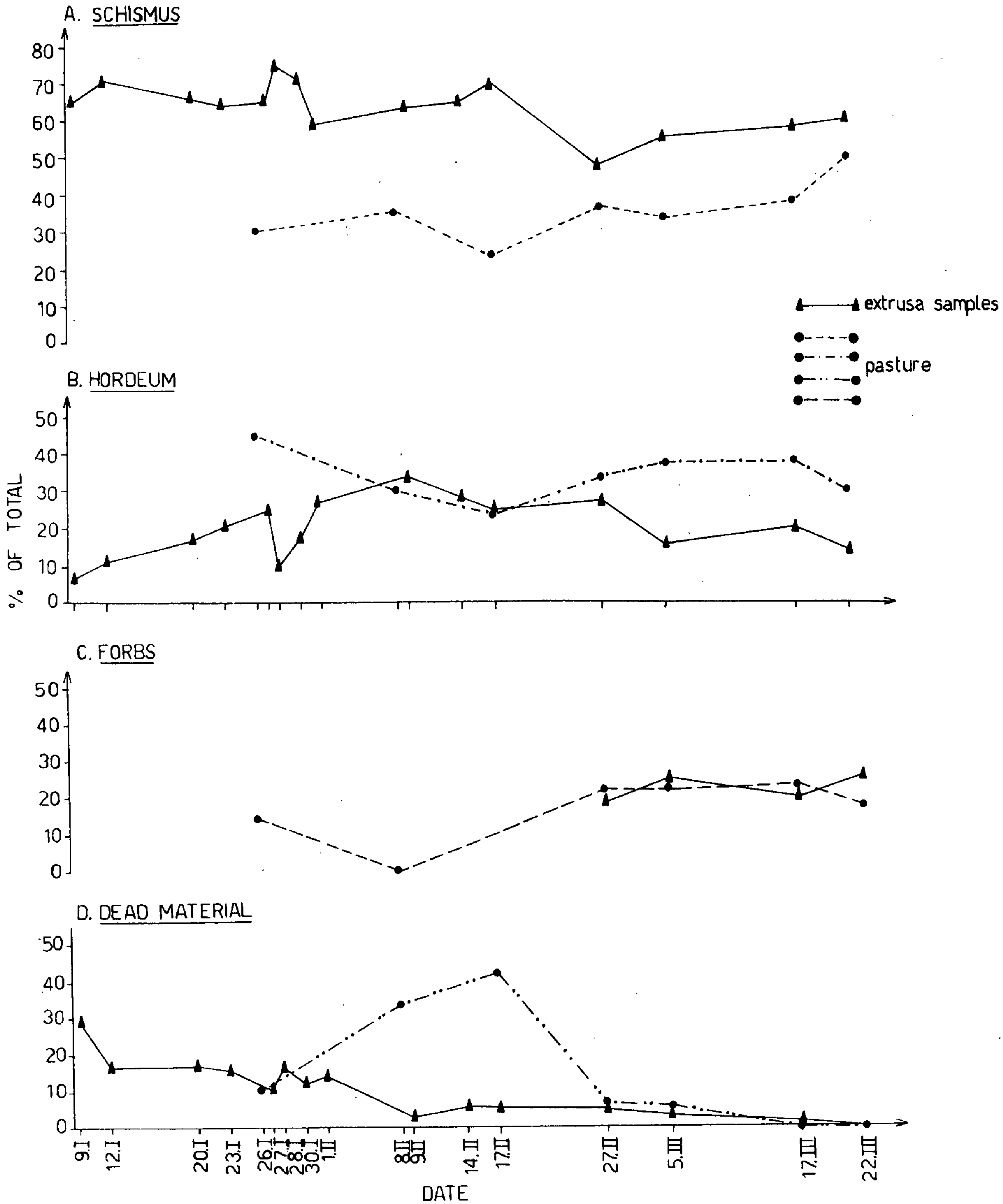


Fig. 11: Proportion (%) of the various species in extrusa samples and in pasture in field 1 (1978; each sampling date).



time (Fig. 11) . Comparisons cannot be made for the early January 1978 period, as field surveys were not made then.

During the second period, for Schismus the difference between sheep diet and pasture was smaller than during the first period: the proportion of this category increased in the field and decreased in extrusa samples.

The proportion of Hordeum increased slightly between the first and the second period in the field, and this increase was followed in extrusa samples. In the middle of February, sheep seem to have consumed slightly more Hordeum than on offer.

The forbs were not consumed during the first period although a few of them had already appeared in the field (less than 10% of the botanical composition). When the proportion of forbs reached about 20% in the field, they were consumed almost in the same proportion as they were on offer; the forbs consisted mainly of Erucaria, Anthemis, Fumaria, Bellevalia, Diplotaxis and Plantago.

The dead material was obviously rejected when it appeared in large proportions during the first period (except on January 26, when sheep ate the same proportion as on offer). It was consumed by sheep more or less at the same level when very small quantities of it remained in the field during the second period.

Although no significant changes throughout the season could be found in the botanical composition of the field, in the extrusa samples the increase of the proportion of forbs, and the decrease of Schismus and of dry material, were quite significant. No significant changes could be found for Hordeum.

3.2.6.3. Selectivity throughout the season in 1979. Figures 12 and 13 present the proportions of the various categories as they were found in the field and in extrusa samples for each period (Fig. 12) and for each sampling date (Fig. 13) in 1979 for F4 and F12 pooled together.

For all the categories the differences between the field and the sheep diet were the smallest during the second period and the greatest during the third period.

Except on two occasions, in the middle of February, *Schismus* was always rejected to some extent and more so during the first and third periods. During all the periods, *Hordeum* was rejected and *Erucaria* was selected. Furthermore, for both species, the irregularities in the botanical composition of the field between the sampling dates could be found also in the extrusa samples.

The forbs were selected during the first and the third periods and slightly rejected during the second period. The category of forbs contained a number of species that were not always the same between the periods: during the first period it was mainly *Allium*, *Anthemis*, *Trigonella* and *Silene*; during the second period *Glaucium*, *Allium*, *Leontodon* and *Fumaria*; and in the third period *Isatis*, *Fumaria*, *Allium*, *Bellevalia* and *Linaria*.

On January 26, sheep grazed an area the botanical composition of which was completely different from that of the rest of the field, and which contained mainly *Malva*. Therefore, the botanical composition of extrusa samples was also completely different from what it usually was. The selective behavior of the sheep was also different: they rejected *Erucaria* and selected *Schismus*. For the statistical analysis and in the figures (except for Fig.11), this sample has been discarded.

Fig. 12: Proportion (%) of the various species in extrusa samples and in pasture in field 4 and field 12 (1979; three periods).

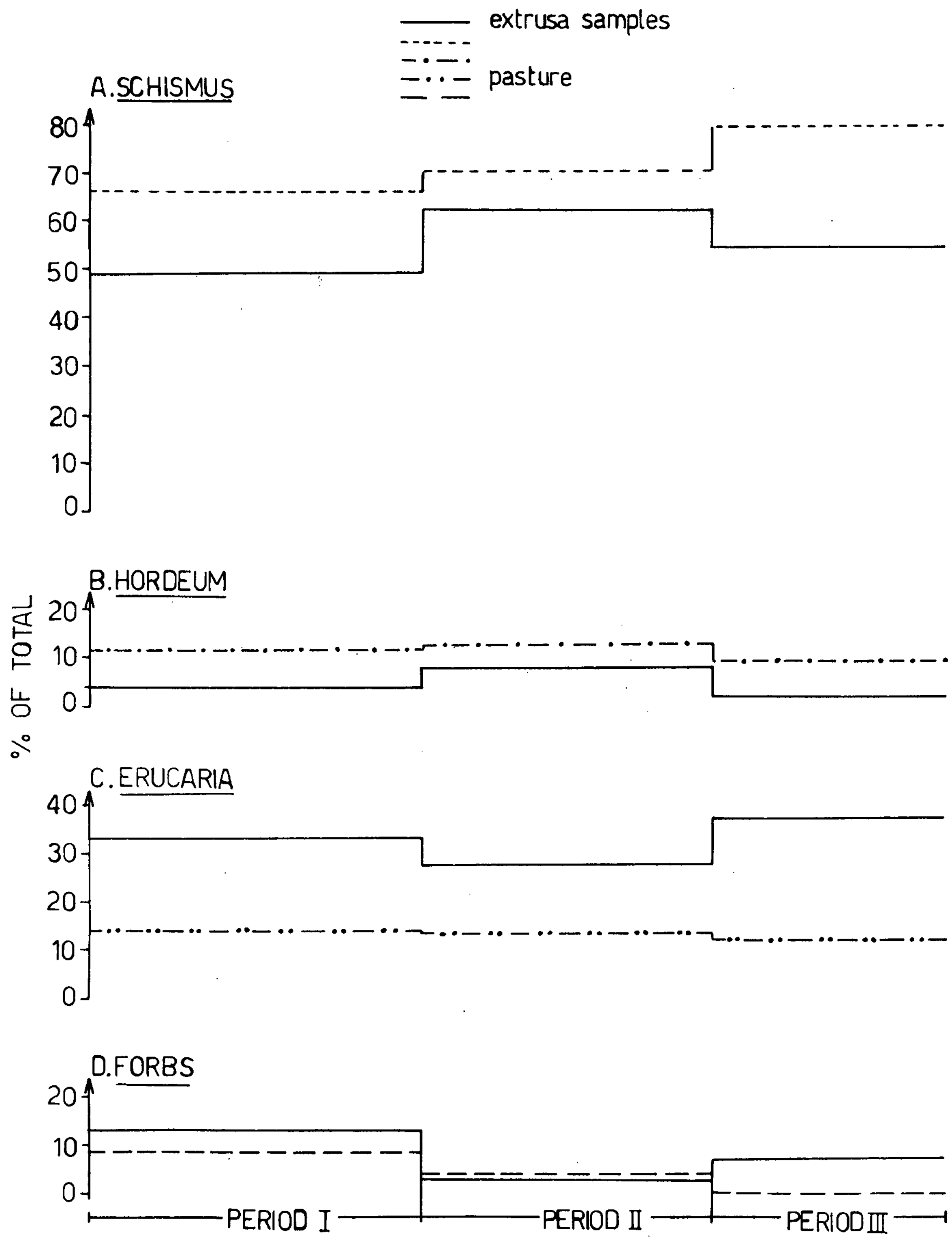
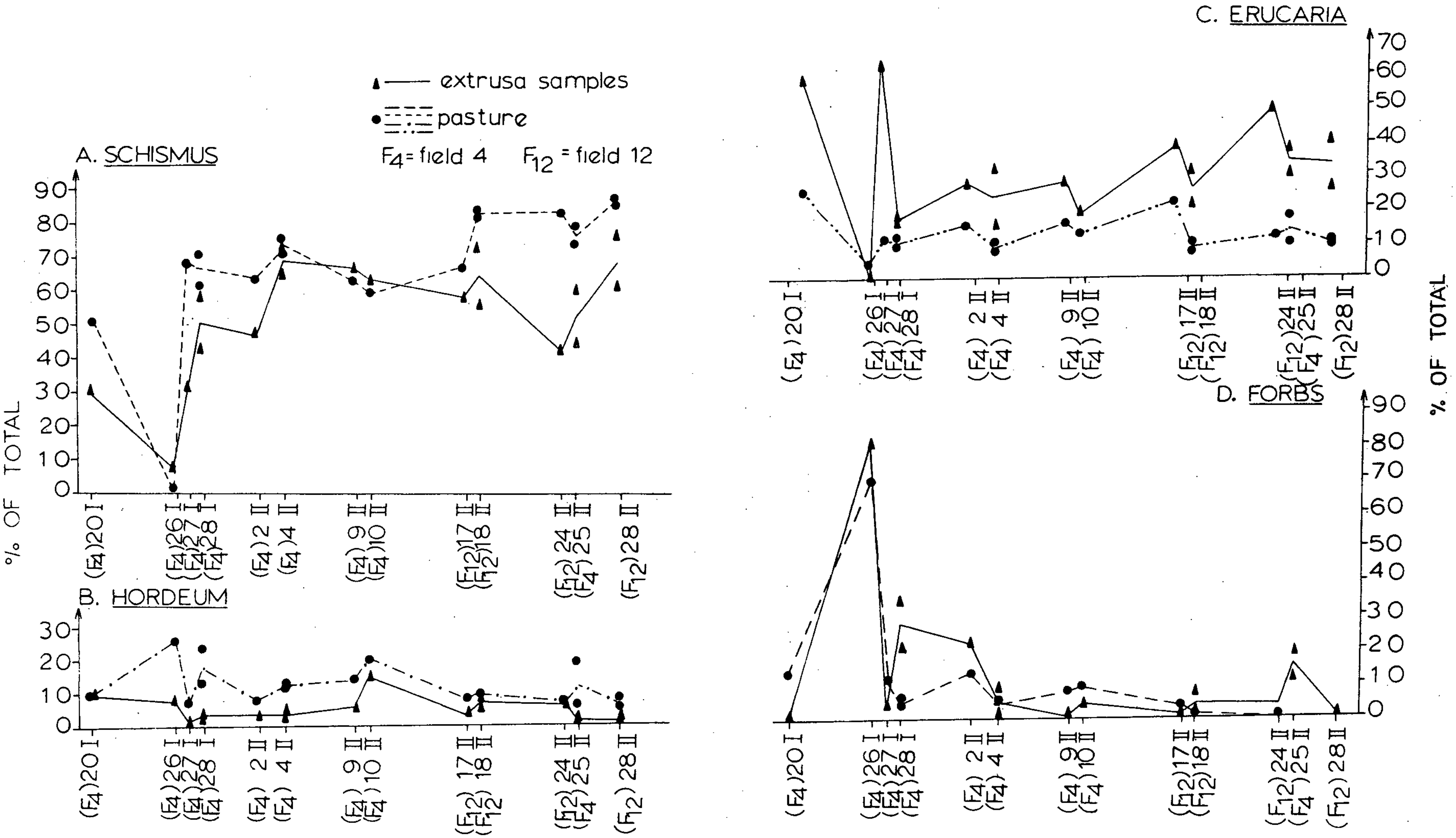


Fig. 13: Proportion (%) of the various species in extrusa samples and in pasture in field 4 and field 12 (1979; each sampling date).



In the field there was quite a significant increase of Schismus and decrease of Erucaria throughout the season. No changes could be found in the other categories, or in any of the categories of extrusa samples.

3.2.6.4. Electivity in 1978 and 1979. Figures 14 and 15 show the electivity coefficient E for the various categories throughout the season, for F1 (Fig. 14) and F4 and F12 (pooled in Fig. 15). The electivity coefficient E was calculated with the formula used by Ivlev (1961): $E = \frac{e-c}{e+c}$, where e is the proportion of eaten and c the proportion on offer. If a category of feed is selected, its electivity will be between 0 and +1.0; if it is rejected, its electivity will be between -1.0 and 0. The less a category is selected or rejected, the closer its electivity is to 0.

In 1978 electivity of Schismus was always positive but closer to 0 at the end of March than at the end of January. Electivity of Hordeum was negative at the end of January and in March, and close to 0 during February. The electivity of forbs was -1.0 until the end of February and then it was close to 0. The electivity of dead material was always negative in February and early March. It was close to 0 only at the end of January.

In 1979, in both F4 and F12, the electivity of Schismus was negative except on two occasions in the middle of February, when it was close to 0. The electivity was more negative at the end of January and at the end of February than at the beginning of February. The electivity of Hordeum was always negative (except at the first date), and more so at the end of January and beginning of February than in the middle of February. The electivity of Erucaria was always positive and more so at the end of January and February than in the middle of February. The electivity of the forbs varied greatly: it was very negative at the end of January and in the

Fig. 14: Electivity of the various species in field 1 (1978; each sampling date).

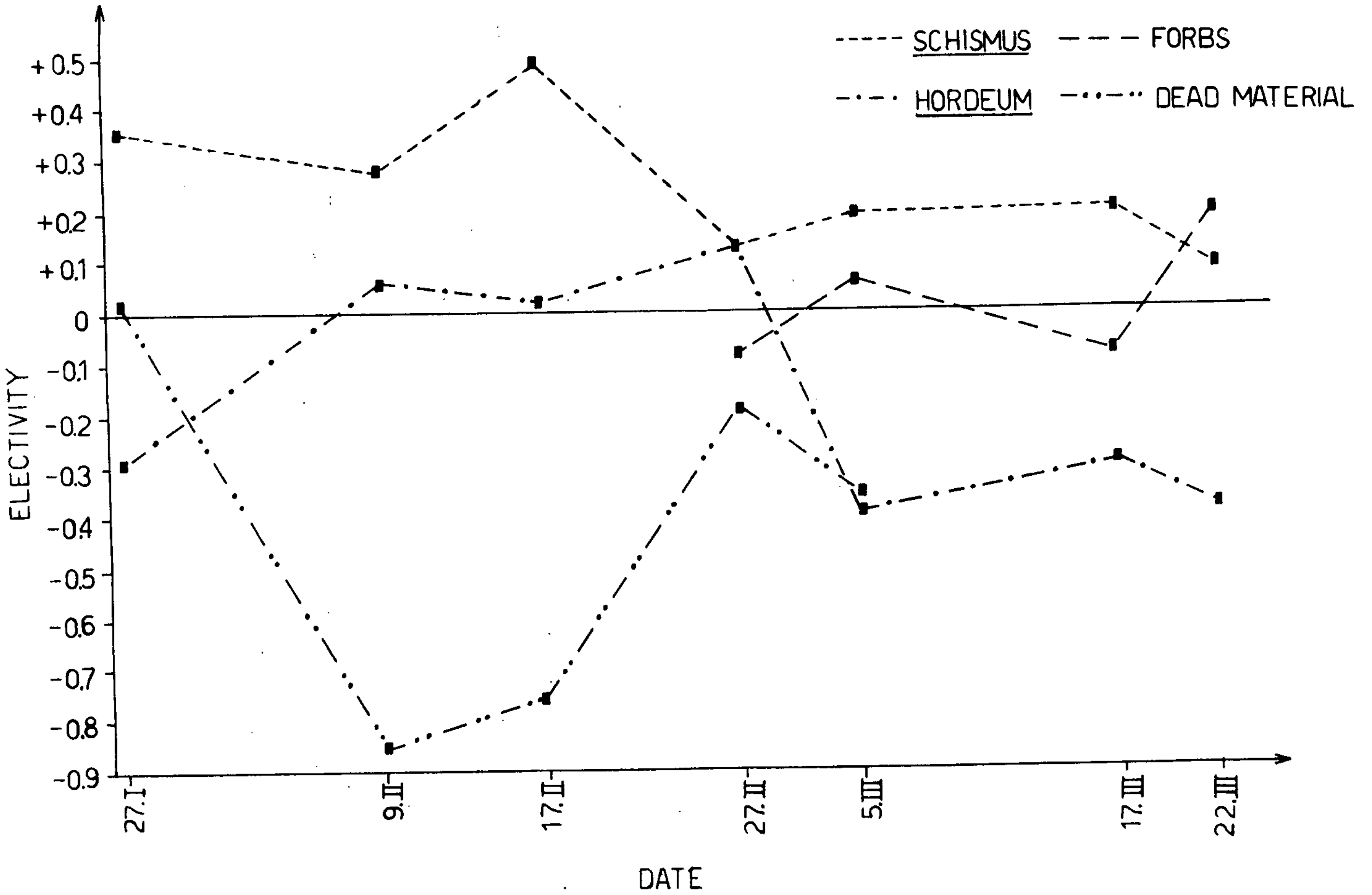


Fig. 15: Electivity of the various species in field 4 and field 12 (1978; each sampling date).

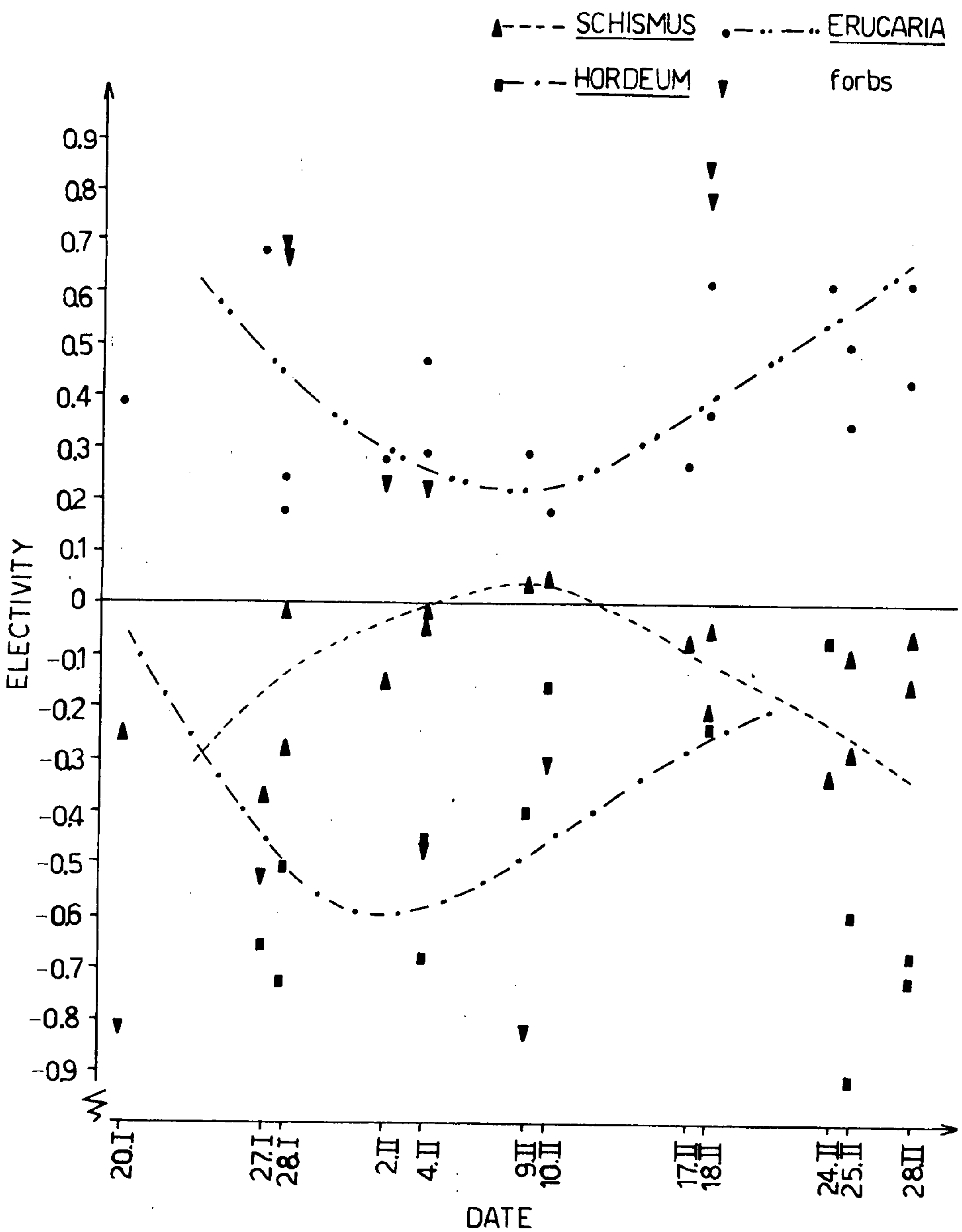


Fig. 16: Relationship between proportion (%) of the various species on offer and proportions of the same species found in extrusa samples in field 1 (1978; each sampling date).

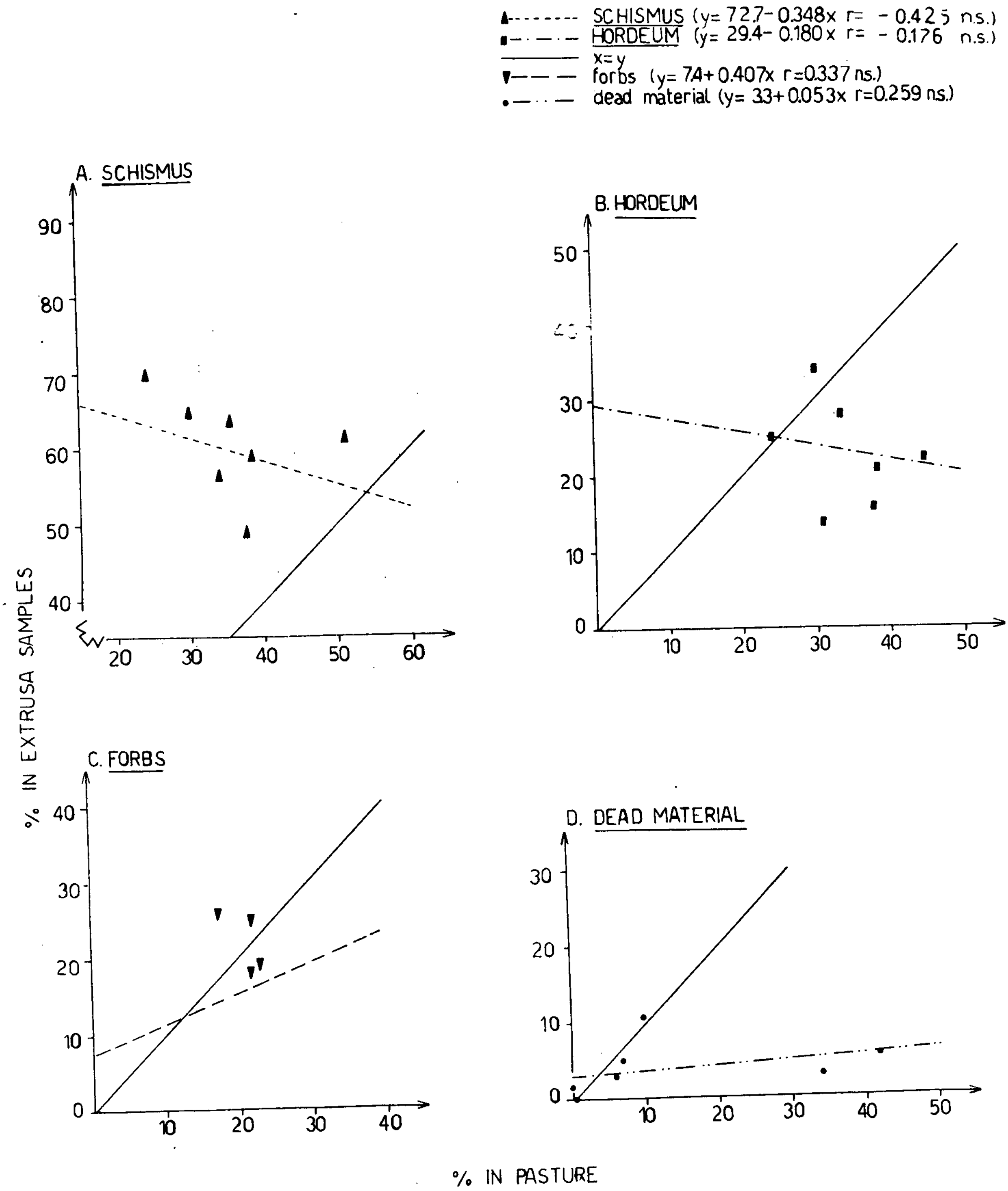


Fig. 17: Relationship between proportions (%) of the various species on offer and proportions of the same species found in extrusa samples in field 4 and field 12 (1979; each sampling date).

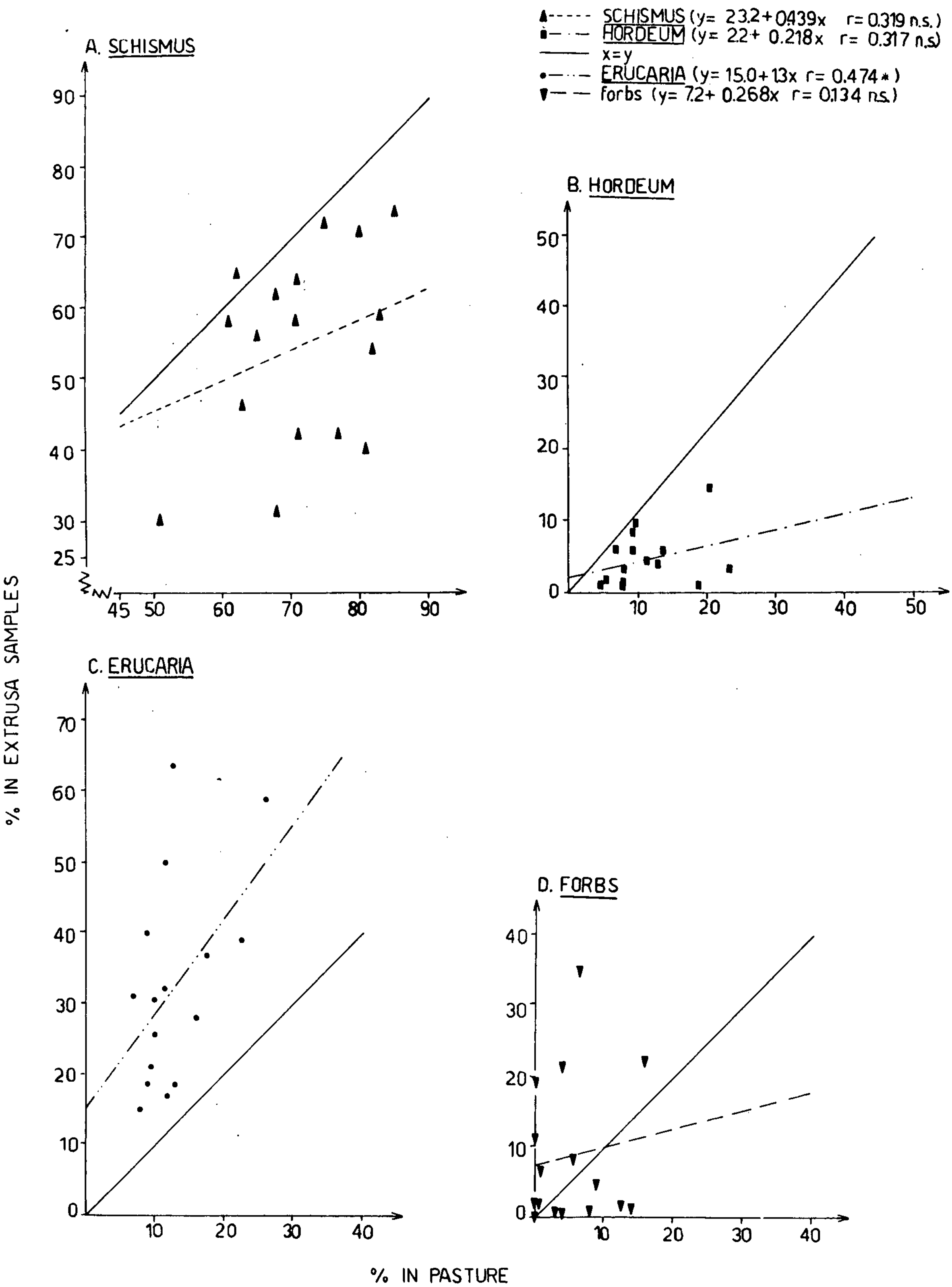


Fig. 18: Electivity of the various species compared with their availability (%) in field 1 (1978; each sampling date).

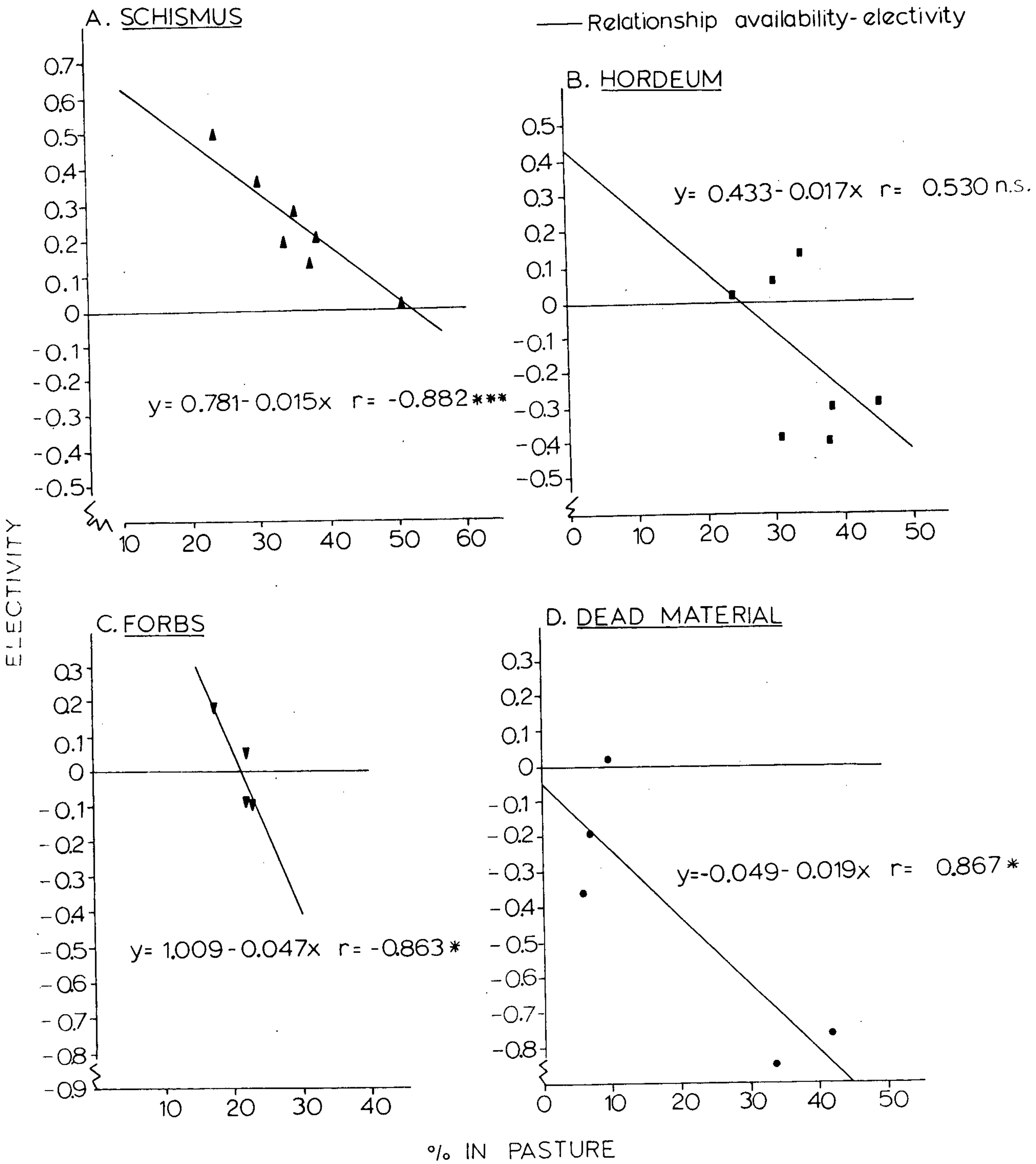
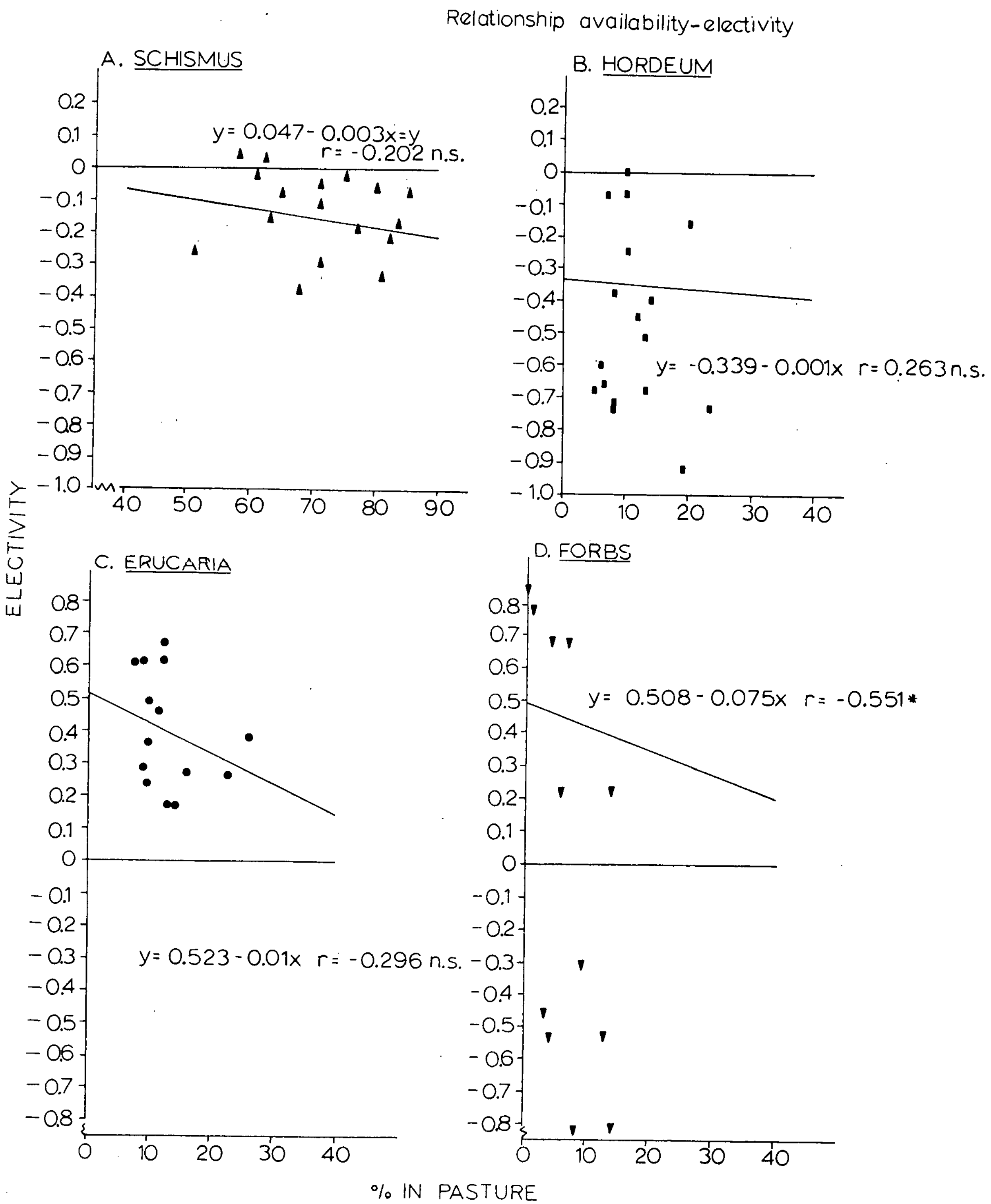


Fig. 19: Electivity of the various species compared with their availability (%) in field 4 and field 12 (1979; each sampling date).



middle of February and very positive at the beginning and end of February. The electivity coefficient is an attempt to express the differences between the field and sheep diet in one number and Figures 12 and 13 summarize Figures 8 to 11.

3.2.6.5. Electivity and availability in the pasture. In Figures 16 and 17, the proportion of each category available is plotted against the proportion consumed by sheep for each sampling date in F1 (Fig. 6) and F4 and F12 (pooled together in Fig. 7).

In F1, the effect of the availability on the consumption by sheep was not significant for all the categories. However, a trend for *Schismus* consumption to decrease was seen as availability increased. In F4 and F12 (1979), the more *Erucaria* was available, the more it was chosen. No significant effect of availability on the consumption could be found for other categories.

In Figures 18 and 19, the proportion of each category available was plotted against the electivity of this category at each sampling date in F1 (Fig. 18) and F4 and F12 (pooled together in Fig. 19).

In F1 (1978), the electivity of *Schismus* in extrusa samples decreased highly significantly as the availability of it increased in the field. The decrease of electivity of forbs and dead material (but not of *Hordeum*) as their availability increased in the field, was significant.

In F4 and F12 (1979), the electivity was not significantly influenced by availability in the field, except for forbs, which were chosen less - the more they appeared in the field.

3.3. Ingestion and disappearance of seeds in sheep digestion during summer grazing

The presence of seeds of various species in extrusa and in faeces samples is presented in Appendix Table 11. At the beginning of July there seemed to be more species represented both in extrusa and in faeces than at the end of August. Koeleria and Hordeum seeds appeared in extrusa and faeces and then they tended to disappear from faeces samples. Schismus and Erucaria seeds were always present both in extrusa and in faeces samples. Except for the beginning of July, Anthemis seeds appeared in faeces samples only. Phalaris seeds appeared in extrusa and in faeces, but only at the beginning of July and Trigonella seeds appeared only at the end of August and only in faeces. Both in extrusa and in faeces, quantities did not vary from the beginning to the end of the experiment.

Appendix Table 12 presents the number of seeds per gram of extrusa sample (ci), and per gram of faeces (ca) for each species, concentration ratio of seeds in faeces compared with seeds in extrusa (ca/ci),and digestibility of seeds. Benjamin et al. (1977) reported that the digestibility of dry pasture (medic) is 53%. The sheep may have chosen material more digestible than the average of the feed available in the field. Disappearance of seeds was calculated using the figure of 60% digestibility of feed. For some species disappearance of seeds was high (Koeleria, Hordeum, Phalaris), whereas for others it was low (Schismus, Erucaria). When the calculated disappearance of seeds is below 0, it shows that sampling was not done correctly (Erucaria, Anthemis). The digestibility coefficient should be considered as an estimate as the number of seeds was very small.

4. DISCUSSION

4.1. Evaluation of the technique

4.1.1. Number of sheep. There is much variability between individuals (Heady and Torell, 1959; Arnold et al., 1964; and others) and Van Dyne and Heady (1965) found that the individual variations are so great that conclusions drawn from single-animal studies are of limited value. For examination of the botanical composition, they recommend to use at least five OF sheep and preferably ten or more. Harniss et al. (1975) reported that a minimum of six OF sheep was necessary for their studies on a sagebush grass range. The number of OF sheep necessary for examination of the chemical composition of the diet should be smaller than for the botanical composition. Individual differences in the present experiment were not significant for most of the categories. However, a minimum of four OF sheep had been recommended for this present investigation (Sachs, Thériez, personal communications); this number could never be reached.

4.1.2. Kind of sheep. No experiment was made to compare sheep of different kinds, as Langlands (1969) had indicated that individual differences should be more important than the differences between ages, breeds, sexes, strains and previous histories,in an experiment using 120 OF sheep on a lucerne diet. McManus et al. (1968), who compared ewes in various physiological states (pregnant, lactating, dry) in an annual pasture, found no difference in botanical composition and only small differences in chemical composition of the diet.

4.1.3. Sampling dates. A number of authors found great within-day variations in the extrusa samples, both in botanical and in chemical composition

(Edlefsen *et al*., 1960; Arnold *et al*., 1964; Heady and Van Dyne, 1965; Arnold *et al*., 1966). Thériez (personal communication) suggested that the diet of sheep that were penned overnight will have a lower nitrogen content in the morning than later in the day, as sheep are hungrier and thus less selective early in the morning. Heady and Van Dyne (1965) mentioned also other factors, such as changes in moisture content of herbage during the day, temperature changes, or a combination of factors. Therefore, they recommended to take samples several times throughout the same day rather than at the same time every day. In the present experiment, no significant differences could be found within-days except for dry matter content - which corresponds with the results of Langlands (1967). Many other authors sampled once daily, in the early morning.

Contrary to the results of Heady and Van Dyne (1965), who found minor differences between days, a number of authors found great variations between samples taken on different days (Arnold *et al*., 1964; McManus *et al*., 1968), and pooled the examination of samples taken on a few consecutive days. In this experiment, for a number of categories, differences between days pooled in the same period were significant.

4.1.4 Sampling periods. Bath *et al*. (1956) recommended that collection periods should not exceed 30 minutes or the sample may be lost by regurgitation and contamination by the rumen content. In addition, McManus (1967) reported that too long sampling periods can lead to rumen dysfunction. In the present experiment 20 minutes was sufficient to collect a sample of between 50 and 150 g dry weight, when the sheep were willing to graze. In case the sheep grazed very little, or not at all, the sampling was stopped after 30 minutes anyway: the chances of getting a bigger sample by extending the sampling period seemed to be very small.

4.1.5. Recovery experiments through the fistula. Usually more than 80% of the ingested feed was collected through the fistula, but sometimes less than 30%, or way above 100%: such high recoveries could not be explained only by the dry weight of the saliva added to the sample - even in small extrusa samples. Variations between sheep and between samplings of the same sheep were large. Percentage recovery, as shown by Arnold et al. (1964), is usually, but not always , higher from a larger fistula. The position of the fistula is also important (it must be sufficiently central). McManus (1961) found that recovery usually exceeded 35% even with small fistulas, the leakage of which is easier to control.

Experiments carried out to test whether certain categories of feed have a tendency to be represented in the extrusa samples disproportionately to their rate of ingestion, failed for technical reasons. Lesperance et al. (1960) showed that more fibrous material could bypass the fistula during sampling, but Arnold et al. (1964) demonstrated that for chemical components (nitrogen and fiber) there was no evidence that low recovery is associated with unrepresentative diet samples.

4.1.6. Success of maintaining OF sheep. In the present study, the number of sheep was limited and the experiments came to an abrupt end because of the difficulties of maintaining OF sheep.

The fistula itself presented two types of problems:

1. The fistula wound healed well after the operation, and the fistula grew so large that it was difficult to close it, probably because of oesophageal fistulas being in a region where muscles are scarce and movement cannot be avoided (Van Dyne and Torell, 1964). Most of the saliva and the

water drunk leaked through the fistula and the sheep would die of digestive disorders (lack of appetite, possible ulceration of the rumen and reticulum [Nelson, 1962]).

2. The fistula wound did not heal but remained swollen and bleeding. If the cannula fell (probably because of pressure necrosis [Nelson, 1962]), and was not replaced immediately, the fistula would close and heal.

Other sheep with adequate fistulas died either immediately or a few weeks after the operation because of digestive disorders or other sicknesses. Van Dyne and Torell (1964) report that the success rate is usually rather low; McManus (1962) reported around 30%. Bath et al. (1956) reported that their main problem in the experiments was to keep their sheep alive. However, some authors reported exceptionally good survival periods in some cases: 8 months (Cook et al., 1958), 20 months (Bath et al., 1956) or even several years (Heady and Torell, 1959). The condition of those sheep was satisfactory. According to McManus (1962), a satisfactory oesophageal fistula must remain functional for at least three months so that the establishment of gregarious habits of the sheep is assured and they become accustomed to the environment and the handling.

4.1.7. Conclusions on the point technique used for analysis of extrusa samples.

A. The dilution technique. The dilution technique is adequate for large categories, but small categories are irregularly represented in the subsamples and thus coefficients of variation of their average can be over 100%. The fistula technique is useful primarily for studying abundant and constant elements in the diets of freely grazing animals (Heady and Van Dyne, 1965).

B. The point cover technique. The point cover technique for analyzing the extrusa sample was developed because it enabled comparison of the composition of the extrusa samples with the field botanical composition estimated by the Poisonnet et al. (1972) method, which was used at the Migda Experiment Farm. The point cover technique gives the same degree of accuracy as manual separation but is quicker and allows the planning of larger experiments with more repetitions.

However, for field botanical composition, a correction for weight percentages is necessary because the purpose of the present project was to relate all results to biomass. Heady and Van Dyne (1965) found that botanical composition based on percentage of points usually underestimated the dry weight contribution of grasses and overestimated the dry weight contribution of forbs.

For extrusa samples, the calibrations show that the point technique can be used for estimated weight percentages. Harker et al. (1964) found a linear regression when plotting percentages directly against points and percentages against dry weight of the various categories.

Hamilton and Hall (1975) compared a known composition of ingesta with an analysis of the extrusa material made by manual separation and with a microscope point technique, with adjustments made per area constants. They found that the point technique gave results closer to the actual composition of the ingesta than did manual separation. The relationship could be expressed by a linear regression close to x=y.

Usually, research workers used between 400 and 600 points for each extrusa sample but they either worked on sown pastures with only a few species

(Hamilton and Hall, 1975; Hall and Hamilton, 1975; Grimes and Watkin, 1975; Arnold, 1960; Arnold et al., 1964; Arnold et al., 1966 [Exps. 3,4]; Hamilton et al, 1972; Langlands, 1967; Langlands and Samson, 1976), or on natural pastures with more species but classified them into categories (Arnold et al., 1966 [Exp. 1]; Harniss et al., 1975; Molenat et al., 1976).

In the present experiment, there were up to eight categories in the same analysis, so that it was considered necessary to use 1000 points per extrusa sample, although Heady and Torell (1959), who had 12 categories, recorded only 400 points per sample. The accuracy of the analysis (i.e., the size of the coefficients of variation) depends not on the number of sub-samples but on the number of points recorded per sample. Using 2000 points instead of 1000, however, improved the results only very little.

4.1.8. A microscope technique for analysis of extrusa. The categories of the classification of the extrusa material were made in order to allow rapid easy identification and separation. However, important findings might have been missed because the categories were not suitable or not fine enough to describe them. It thus seems important to find a technique which will allow the identification of fistula material down to the level of genus of the plant species.

The anatomical characteristics of the epidermis of a species can change when the plant reaches the generative stage (see Sparks and Malacheck, 1968, and their reference list). At Migda, all species usually germinate within one month and reach the generative stage at the same time. Therefore, up to that stage, all the extrusa material should be of the vegetative type. When the pasture reaches the generative stage and the young inflorescence emerges from the axil of the flag leaf, the sheep may tend to eat this young upper part of the plant (especially of Schismus and Koeleria) and to neglect older parts (vegetative leaves) (Arnold et al., 1966; Hamilton et al., 1972). Therefore, at this stage most of the extrusa leaf material could consist of leaves associated with generative parts. Differentiation between species has been limited to the same stage of growth, which simplifies their identification.

Anatomical differences between genera can be summarized briefly as follows:

Schismus is the most easily recognizable species because of its sinuous longitudinal cell walls.

Phalaris can be distinguished by its special form of prickles on leaf margins and sometimes by the disposition of its stomata, alternating in a double row.

Koeleria has very long cells and in the vegetative stage, with Schismus, is the only species that has a hairy leaf. Phalaris is the only species without any hairs in the generative stage.

Especially difficult is the differentiation between Hordeum and Phalaris in the vegetative stage, and between Hordeum and Koeleria as well as between Phalaris and Schismus (adaxial side) in the generative stage. When the leaf margins are missing on a piece of epidermis that has to be identified, or if the piece does not show all the characteristics of the species, differentiation can be very difficult or impossible. Species then have to be pooled in new categories. A more detailed discussion about the epidermis characteristics of these species is presented in Appendix II.

A quick examination of some extrusa material of January 1978, showed that most of the material belonged to Schismus, as it had been already identified with the naked eye. Generally, if a species belonging to the same category, like Phalaris or Koeleria, is much less available in the pasture than another (Schismus or Hordeum), then one can expect that the chance of finding this species in extrusa samples is also low. However, in pasture showing a totally different botanical composition, the microscope identification method could be used, provided that preparation, examination and quantification of the samples are mastered.

Another aspect of this method is the microscopic examination of material other than oesophageal extrusa samples. The handling of oesophageal fistulas is both difficult and cruel to the animal.

Vavra et al. (1978) compared the results of microhistological examination of oesophageal fistula and faeces samples of the same animal and came to the conclusion that the two methods gave similar results and could be used at least for ranking the species according to animal preferences and their importance in the animal's diet. If faeces examination could give sufficient information on sheep diet, this method would allow unlimited sampling from animals without affecting their health or behavior.

4.2. Chemical composition of extrusa

The size of the collected samples varied considerably between sampling dates, between sheep, within days, and between days, and differences between periods and fields were usually not significant. However, between the first and the second period in F1, the size of the sample increased significantly; this could be due to the fact that intake during the sampling period was limited by the low availability of pasture feed (in January below 20 kg/0.1 ha), as well as low dry matter content of the ingested herbage (Arnold, 1962). In F4 and F12, low availability was not the case and variations in the size of the collected samples was probably due to other factors.

Cook (1962) found that intake can be influenced by the species available in the pasture and that it was larger on "good" pasture than on "poor" pasture. Arnold and Dudzinksi (1967) suggested that intake is influenced by the physical characteristics of the pasture (leaf lengths, density of herbage), as well as its chemical composition, and that measuring total yield can give only a crude assessment of the pasture condition for the grazing sheep. In the present experiment, it seems that intake usually depended also on factors other than quantity and structure of the herbage on offer, such as appetite of the animal at the moment. The measured samole was collected during a short period compared with the total grazing time, and in any case, extrusa samples cannot be used to estimate the intake of the sheep (Heady, 1964).

In all fields, moisture content of the collected sample seems to decrease with the size of the sample: the longer time spent grazing as opposed to eating harvested food, the greater the quantity of saliva added to the feed and thus the lower the dry matter content of extrusa samples.

Extrusa samples always contain more moisture than the pasture plants (cf. Grimes et al., 1967). Furthermore, the dry matter content of extrusa samples increases throughout the season much less than that of the pasture plants (Blackstone, 1965). Drier, more mature forage had a greater absorbing capacity for saliva than less mature or green forage (Wallace et al., 1972), and salivary flow increases with the consumption of dry forage (Wilson, 1963).

There is, in general, more ash in extrusa samples of F1 than of F4 or F12. Wallace et al. (1972) reported that soil intake is greater on short grass pasture than on tall pasture. Langlands (1969) notes that when herbage availability is low, then intake of soil is higher. This also explains the difference between 1978 and 1979 but is in contradiction to the fact that in 1978 there was more ash in the second period (higher availability) than in the first period (lower availability).

In general, the ash content of extrusa samples increases throughout the season and is usually inversely related to the dry matter content. Many authors report that saliva contamination influences significantly the ash content of extrusa samples (Scales et al., 1974: 37 to 51%; Wallace et al., 1972: 12 to 27%; McManus, 1961: 20%; Edlefsen et al., 1960: 16.5%); the more saliva there is in extrusa, the greater the contamination with ash. This might explain the higher content of ash in extrusa samples at the end of the experiment, when drier plant material induced a greater flow of saliva. The higher dry matter content of the samples during the second period in F4 - that indicates a more rapid rate of ingestion - may explain its lower saliva contamination, and thus the low ash content.

Because of saliva contamination, it is generally recommended to express organic chemical components of extrusa samples on an organic matter basis rather than on a dry matter basis. In this experiment, nitrogen content of extrusa is expressed on a dry matter basis because this was also the basis used for pasture samples: soil (ash) contamination can occur on pasture plants before they are ingested (Meyer et al., 1957). Edlefsen et al. (1960) are of the opinion that ash contamination of extrusa is due partly to saliva and partly to the soil ingested during the grazing process. Contamination is reported to depend on the type of feed (Cook et al., 1962) and the season (Wilson, 1963); in the present experiment sheep grazed the same type of feed during the same season.

Certain authors found that nitrogen content of extrusa can be biased by nitrogen content of saliva (Scales et al., 1974, with steers), and Hogan (1963) found that a lower percentage of nitrogen is associated with a more rapid rate of eating. Grimes et al. (1967) tried to correct the nitrogen and organic content of extrusa samples by means of analysis of the saliva collected per fistula.

However, a number of authors found that saliva did not influence the measured nitrogen content of extrusa (Bath et al., 1956; McManus, 1961), or influenced it only a little (Langlands, 1966).

4.3. Selection for nitrogen content. Many authors found that, as in this experiment, protein (or nitrogen) content of the diet selected by grazing animals is higher than that of the field. Weir and Torell (1959) found that, over a wide variety of range and pasture conditions at various seasons of the year, the diet selected was higher in protein and lower in crude fiber than pasture on offer (clipped samples). Arnold (1960) showed that sheep preference was always directed to material with the highest level of available nitrogen. High nitrogen content is correlated with low crude fiber content in plants and selection could have been influenced by either one or both of the chemical characteristics.

Molenat et al. (1976) found that nitrogen content of extrusa samples decreased during the season even though it remains fairly constant in clipped pasture samples. They suggested that decrease of quantity and changes in pasture structure reduce the possibility of choice for the animals. In the present experiment, however, the decrease of %N in extrusa and in field samples was parallel.

4.4. Botanical composition

The differences in nitrogen content between field samples and extrusa samples indicate that animals exhibit preferences when grazing. This selection has been demonstrated experimentally by numerous workers. Preferences are not restricted to the selection of certain species over others but also operate within a species: within a particular plant some plant parts will be eaten in preference to others.

4.4.1. Selection for species. This experiment presents two distinct grazing situations: in F1 (1978), where sheep grazed continuously throughout the year, the botanical composition consisted mainly of two Gramineae, Schismus and Hordeum. Sheep selected Schismus, and this species represented 60 to 70% of their diet during the first period and between 50 and 60% during the second period. Before dead material almost disappeared from the diet and the field, it was strongly rejected during the first period. The fact that Schismus tended clearly to be less selected in the second period, when more of it was available in the field, may be explained by the appearance of an alternative feed (the forbs), which was more attractive than those previously available (dead material and Hordeum).

Selection against dead material has been reported by Grimes et al. (1967), where sheep grazed a mixture of grass and clover, and by Arnold et al. (1966), where sheep grazed all kinds of sown and natural pasture. The consumption of a certain quantity of dead material during the first period has been explained by Hamilton et al. (1972) and Arnold et al. (1966), who suggested that when the availability of green herbage in the pasture is low, sheep have to ingest a certain quantity of dead material to fill their stomach, although it does not contribute much to their nutrition (Hamilton et al., 1972). Molenat et al. (1976) and Loiseau and Bechet (1975) found a similar grazing pattern in European mountain range (Auvergne, France): thin-leaf grasses were preferred to broadleaves, and tended to be overgrazed. When the availability of thin-leaf grasses was restricted, consumption of broadleaves increased, but this could not be verified in the present experiment, where thin-leaf grasses (Schismus) were apparently always available in great quantities and the main broadleaf grass was rejected.

In the experiment of Molenat et al. (1976), also, dead material was rejected when there was a lot of it available in the field, and eaten almost in the same proportion as it appeared in the field when its availability decreased. Forbs were consumed in the same proportion as they were available.

Although sheep might consume more of a category when more of it was available, they did not necessarily do so in the same proportion as it was available. Therefore, electivity of a category can decrease when its availability increases as well as its consumption, as was the case with forbs and dead material in 1978, and with all the categories except Erucaria in 1979.

In 1979, Schismus dominated the pasture (botanical composition) and Hordeum remained a small component. Forbs, especially Erucaria, appeared in large quantities. No dead material was present in the field.

Schismus still represented about 50% of the diet during the first and last period, and 60% during the second period. However, this species was rejected by the sheep, which preferred eating *Erucaria*: that species formed 30% of the diet in the first and third periods and 35% in the second period. The continuous selection of *Erucaria* can be explained by its low dry matter (*i.e.*, high moisture) content and its high nitrogen content, the highest of all examined species (including legumes) at Migda (Seligman *et al.*, 1976). These characteristics are constant throughout the season and were confirmed in a summer experiment in 1979 at Migda, where sheep consumed first all *Erucaria* leaves (E. Eyal, personal communication). The slight changes in the proportion eaten of *Hordeum* (the species always rejected) and of *Erucaria* (the species always preferred) follow, in most cases, the same slight changes in the pasture's botanical composition. Sheep did not seem to choose grazing on certain areas on the field - during sampling - for reasons related to the botanical composition of the site, but to select species in any area of the field in the same manner. The consumption of the various species is then influenced also by the structure of the vegetation; with dense vegetation it can be difficult for the sheep to avoid eating unwanted species in favor of wanted ones (Molénat *et al.*, 1976).

Dry matter content of *Schismus* and *Hordeum* was significantly higher at the end of January and beginning of February than in the middle of February, while dry matter content of the forbs and *Erucaria* remained relatively low. After the middle of February, all species dried out very quickly, but the grasses more so than *Erucaria*. This was accompanied by a general decrease in the nitrogen content of the pasture. Both of these factors, more than changes in the availability of the various categories, could explain variations in the selectivity of sheep: they would select for high nitrogen content and for low dry matter content (high moisture content) and even more so as moisture content decreased (first and third period) and nitrogen content decreased (third period). Arnold et al. (1966) found that selectivity became more and more pronounced as the herbage offer increased in age and maturity. Furthermore, with a general decrease in nitrogen content of the pasture, sheep tended to select more and more vigorously species with a high N-content. Edlefsen et al. (1960) noted that on a mixed sward, sheep can shift grazing from one species to another and so are better able to maintain the nutritive level of their diet.

As the forbs constituted a small category containing a number of species with variable dry matter and nitrogen contents, no conclusion can be drawn about sheep selectivity for this category. The presence of Trigonella (legume), with its relatively high nitrogen content (Seligman et al., 1976), might have influenced positively the selection of this category during the first period. Although no data are available for this category, it may be assumed that a relatively low dry matter content of most of the species can be responsible for selection of them during the last period.

Legumes (Trigonella) appeared in very small quantities in the experimental plots, so no information is available for animal nutrition on sheep behavior toward this important family. Leigh and Holgate (1978) showed that sheep strongly selected clover and a certain forb when available. Grimes et al. (1967) suggested that sheep may select some legumes in preference to grasses, while Arnold et al. (1966) could not find any preference between grass and clover in a mixed sward.

4.5. Selection for plant parts

Selection for plant parts within the same plants may be, in many cases, more important than selection for species (Arnold et al., 1966). Heady and Torell (1959) found in mixed swards that sheep selected for clover leaves at a certain season and for clover seeds at another season.

When the pasture is flowering and the greatest bulk of herbage is available, sheep are the most selective (Arnold, 1966) and eat leaf tips. This is due partly to greater availability and partly to greater variability between the plant parts (Meyer et al., 1957). All the authors report that sheep prefer leaves to stems (Arnold, 1960; Cook and Harris, 1950; Hamilton et al., 1973; Buchanan et al., 1972; Malacheck and Leinweber, 1972, for goats). In fact, sheep always ate the material with the highest available nitrogen, so that selection took place within the leaf category as well, for younger against older leaves (Arnold et al., 1966; Hamilton et al., 1972). In the present experiment, no data were available about proportions of the various parts of plants in the pasture. In extrusa samples, leaves represented 85 to 90% of the diet. This proportion may be an overestimate, as all plant parts in the category of forbs were pooled together and added to the leaf category. Buchanan et al. (1972) reported that leaves represent 75% of the sheep diet on a tall forb range.

With the advance of the season, the proportion of inflorescences increased and the proportion of leaves decreased significantly in the extrusa (cf. Buchanan et al., 1972), partly because more inflorescences appeared in the field and partly also because sheep, looking for the youngest leaves, picked deliberately the top of the plant, in particular of grasses (Schismus), and could not avoid eating inflorescences because of the anatomy of the plant, which plays a role in the selective behavior of sheep (Arnold *et al.*, 1966). It is important to note that inflorescences of *Hordeum* were never consumed. The reason why the proportion of stems remained small throughout the season is given by Cook and Harris (1950), who suggested that there is an increased selectivity for leaves because of the increased lignification of stems.

4.6. Other factors affecting selection by sheep

Some authors (Pieper *et al.*, 1959, on pure swards) found that higher grazing intensity (=higher stocking rate) led to a decrease in the protein content of the diet, some not (Arnold *et al.*, 1966). Malacheck and Leinweber (1972) found that goat's extrusa samples contained more leaves at a lower than at a higher stocking rate. In the present experiment, although no difference in consumption for any of the categories could be found, the diet of sheep had a higher nitrogen content at the lower stocking rate (F4).

The nitrogen content of the diet selected by sheep depends probably on a combination of the effect of the season and the stocking rate.

4.7. General outlook for diet selection

The composition of the diet of an animal is a combination of the animal's true preferences and the opportunities given to express them (Molénat *et al.*, 1976). Palatability of a species is defined as plant characteristics or conditions which stimulate a selective response by animals (Heady, 1964). Loiseau *et al.* (1975) divided the pasture species into three categories according to their palatability: those that are always rejected; those that are always selected; and those that are selected or rejected according to the availability of those that are always selected. The experiments that were carried out at Migda show that in the studied grazing situations Hordeum and dead material belong to the first category, Erucaria to the second, and Schismus to the third.

Pastures have been given indexes of pastoral value using a formula combining abundance in the pasture, palatability, and forage value of the various species represented in the pasture. It is clear in the present case that for a very important pasture species (Schismus), the palatability depends on the grazing situation more than on the specific properties of the species. Therefore, one should refrain from using such indexes of pastoral value when one of the parameters is not constant (Loiseau et al., 1975).

Heady (1964) tried to summarize the reasons why species are selected or rejected by grazing animals. Some reasons can be physical properties of the plants (presence of unavoidable spines, awns, hairiness, stickiness, texture) or chemical properties (nitrogen content, fiber content, sugars, extracts, salt, repellent substances), or probably a combination of these components that form the nutritive value of the plant (Cook et al., 1956). Westoby (1974) suggested an optimization model (in a linear program) for an ideal diet for a given pasture species. This model is based on the fact that diet selection is dominated by the need to meet the nutritional criteria of the grazing animal. However, the question arises whether animals exhibit natural nutritional wisdom and select an adequate diet (for instance, species or plant parts with a high protein content) because they instinctively "know" their physiological needs. Arnold (1965) showed that sheep use smell, taste and touch combined to select their diet. The properties of the plant that are detectable by the animal before ingestion, and which determine its selection or rejection, might not be connected with its nutritional properties. Therefore, they cannot be chosen in accordance with the nutritional benefits they eventually bring, unless there is a mechanism of a long delay in learning on the side of the animal (Westoby, 1974). Langlands (1969), who studied the diet of ewes in various physiological stages (lactating, pregnant, dry) found no evidence of the sheep selecting a diet with varying nutritional values to meet their various physiological needs, and Arnold (1964) doubts whether sheep show any nutritional wisdom in feeding. However, Westoby (1974) believes that herbivores do optimize the nutrient content of their diets but there are various distortions due to the animal's imperfect selectivity; he terms this "fallible nutritional wisdom."

4.8. Seed ingestion, differential disappearance and digestion

The literature available on the subject states that some of the seeds are digested. Of those that pass whole through the digestive tract, subsequent germination can be reduced, enhanced, or not affected. The proportion of the seeds that are not digested depends on the characteristics of the plant species (Heady, 1954; Lehrer and Tisdale, 1956, and their references). Another effect of seed ingestion is the spreading of seeds that were not digested to areas where these species were not present previously (Lehrer and Tisdale, 1956). In the present experiment, it can be stated only that a greater proportion of certain species (*Koeleria*, *Hordeum* and *Phalaris*) is digested than of other species (Schismus, Erucaria, Anthemis). On the whole, very few seeds were available and consumed by the sheep during the period of measurements. Furthermore, the viability of recovered seeds has not been tested.

5. CONCLUSIONS

With the oesophageal fistula technique, the chemical composition and the main species categories in the extrusa of sheep grazing a natural range freely can be estimated and compared with their availability in the pasture. Using a similar analytical method (i.e., the point cover technique) allows a direct comparison between the botanical composition of the pasture and that of extrusa samples. However, the mortality of OF sheep is high, not always enough OF sheep are available for the experiments, and experiments are interrupted by the death of the OF sheep. Thus, it would be worthwhile to search for other techniques of measuring the selective behavior of sheep. Especially interesting could be the development of a microscope analysis method of plant cuticula pieces found in faeces collected from the sheep: it would allow unlimited sampling without harming the animal.

The results of the present experiments are in agreement with those of various authors who studied the selective behavior of sheep in semi-arid Mediterranean-climate ranges in Australia and California and in temperate mountain ranges in France. Consumption of certain species or categories, but not all, depends on their availability in the pasture. For instance, during the winter seasons of 1978 and 1979 at Migda, Hordeum was always rejected in both years because Erucaria appeared in great quantities (mainly in 1979) and was strongly selected. It would be interesting to study sheep selectivity during the summer and in the early winter just after seed germination in the pasture. In addition, it would be of value to learn about sheep selective behavior in pastures, the botanical composition of which is dominated by species other than *Schismus*, *Hordeum* and *Erucaria*.

During the period when the seed digestion experiment was carried out, in July-August 1978, very few seeds were available in the pasture, and thus for ingestion by the sheep. A similar experiment should be repeated earlier in the season. In addition, the viability of seeds that passed whole through the digestive tract should be compared with that of seeds found in the pasture.

6. SUMMARY

Sheep selective behavior, *i.e.*, the chemical and botanical composition of their diet, compared with that of the pasture, was studied in a semi-arid Mediterranean range in the Negev Desert of Israel, with the oesophageal fistulation (OF) technique, during two consecutive years (1978 and 1979).

A point cover technique - calibrated by manual separation - was used both in the pasture and on extrusa subsamples placed in petri dishes after the material was washed and diluted, to estimate the proportion (in %) of the various categories or species. Recovery of ingested feed, number of sheep and size of fistula, sampling date and period, preparation, classification and analysis of the extrusa material are discussed, as well as the possibility of using a microscope analysis technique that would allow examination of cuticula pieces found in faeces samples. This last possibility would obviate the need for the OF technique, which is difficult to maintain and with which sheep mortality is very high.

The present experiments show that sheep selectivity can vary between years: Schismus was selected in 1978 and rejected in 1979, according to the grazing situation; Erucaria was available in great quantities only in 1979 and strongly selected; dead material was present only at the beginning of 1978 and strongly rejected. Hordeum was usually rejected in both years. The selectivity (i.e., the intensity of selection) can vary between periods within the same year, and the category of forb was even selected or rejected during the same year. Sheep do not seem to select specific sites in the field; the structure of the herbage appears to influence their selective behavior. In 1979, the major part of the sheep diet consisted of leaves, but a certain amount of inflorescences (Erucaria and Schismus, but never Hordeum) appeared in extrusa samples toward the end of the studied period. Sheep selected continuously a diet about 1% richer in nitrogen than the average of the pasture on offer (1979). It is suggested that Erucaria was strongly selected because of its high nitrogen content, and possibly also because of its high moisture content. No differences could be found between fields, except in nitrogen content. There were no differences between data of the same day for any of the categories. Between data obtained on different days within the same period, there were differences for a number of categories. Differences between sheep appeared in some categories.

Seed availability and consumption in summer 1978 were very low, and the disappearance of seeds in the sheep's digestive tract varied between the species (higher for Hordeum, Koeleria and Phalaris than for Schismus, Erucaria and Anthemis).

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Appendix

Table 1 - Rainfall (in mm) at Migda - winter 1977/78 and winter 1978/79

Month	Day	1977/78	Monthly total	1978/79	Monthly total
October	18	3.0			
	20	10.0			
			13.0		
November	9			15.0	
	12	3.0		4.0	
			3.0		19.0
December	2			2.0	
	3			8.0	
	9			8.0	
	11			2.0	
	13			18.0	
	15	27.0			
	16	3.0			
	22	5.5			
	23	20.0			
	24	19.5			
			75.0		38.0
January	3	2.0			
	4	20.0			
	9			29.0	
	10			4.0	
	21			3.0	
	22			5.0	
	23			15.0	
			22.0		56.0
February	8			3.5	
	9			1.5	
	10			5.0	
	11			5.0	
	23	15.5			
			15.5		15.0
March	12	8.0		No data available	
	13	13.0			
	23	9.0			
			30.0		
Yearly total			158.5		> 128.0

Appendix

Table 2 - Botanical composition (in % ± S.E.) of Field 1 by various methods of estimation (January 1979)

Species	20 squares of 0.04 m^2 by a point technique*: Standing in the field – Estimator A	20 squares of 0.04 m^2 by a point technique*: Standing in the field – Estimator B	20 squares of 0.04 m^2 by a point technique*: Lying in the laboratory	20 squares hand-separated and weighed* (dry)	Step point** technique corrected for dry matter %
Hordeum	10.6 ± 4.5	10.6 ± 4.5	13.4 ± 5.4	17.0 ± 5.4	25.3
Phalaris	9.8 ± 2.6	8.8 ± 5.9	9.3 ± 3.4	8.1 ± 2.7	8.1
Schismus & *Koeleria*	59.2 ± 5.9	61.5 ± 5.4	55.6 ± 6.5	45.1 ± 6.8	47.1
Erucaria	3.2 ± 1.6	2.9 ± 1.2	3.2 ± 1.9	5.3 ± 2.8	3.8
Diplotaxis	3.7 ± 1.5	3.8 ± 1.7	5.2 ± 2.4	10.0 ± 4.3	4.6
Allium	6.3 ± 3.8	6.3 ± 3.7	5.0 ± 2.9	7.6 ± 5.1	2.7

* From Heady and Torell (1959).

** From Poissonnet *et al*. (1972).

Appendix

Table 3 - Dry matter on offer, dry matter content, and nitrogen content of pasture plants

Period	Dry matter (kg/0.1 ha)		Dry matter (%) Schismus		Dry matter (%) Hordeum		Dry matter (%) Erucaria		Dry matter (%) Forbs+		Dry matter (%) Dead material++	Nitrogen (%)	
(1978)	F1		F1		F1				F1		F1		
9.I -17.II	45.5												
27.II-22.III	118.5		36.0 ± 5.6		33.6 ± 5.4				21.6 ± 4.8		88.3 ± 2.0		
(1979)	F4	F12	F4	F12	F4	F12	F4	F12	F4	F12		F4	F12
19.I - 4.II	121.6	158.1	27.6 ±7.3		16.2 ±1.2		11.0 ±1.5		13.7 ±3.4			3.847 ±0.290	
9.II-20.II	188.0	262.8	20.3*	31.4*	17.6*	24.5*	14.8*	18.0*	14.2*	18.6*		2.412*	2.890 ±0.021
24.II-1.III	166.8	197.3	51.2*	54.0 ±0.4	45.2*	41.5 ±3.6	29.5*	33.8 ±7.0	-	-		2.427*	2.265 ±0.168

* Only one figure available; otherwise, standard deviations are given.

+ In F1 *Erucaria* included, in F4 and F12 *Erucaria* not included.

++ Dry material of the previous year.

F1 = field 1;

F4 = field 4;

F12 = field 12.

Appendix

Table 4 - Size and dry matter, ash and nitrogen contents of extrusa samples

Period	Size of sample (g)		Dry matter (%)		Ash (%)		Nitrogen (%)	
(1978)	F1		F1		F1		F1	
9.I -17.II	21.0 ± 26.9		8.2 ± 5.7		12.4 ± 5.0		--	
27.II-22.III	62.2 ± 16.3		9.6*		19.5*		--	
(1979)	F4	F12	F4	F12	F4	F12	F4	F12
20.I - 4.II	74.2 ±33.5		10.4 ±1.6		9.3 ±2.3		4.493 ±0.525	
9.II-18.II	105.3 ±39.6	98.5 ±43.1	13.5 ±2.8	12.0 ±2.4	7.5 ±1.9	9.1 ±1.8	4.579 ±0.444	2.958 ±0.267
24.II-28.II	92.0 ±19.5	102.6 ±49.4	11.2 ±2.7	14.9 ±6.3	15.0 ±1.6	12.9 ±4.6	2.856 ±0.098	3.354 ±0.551

* Only one figure available; otherwise, standard deviations are given.

F1 = field 1;
F4 = field 4;
F12= field 12.

Appendix

Table 5 - Nitrogen content (in % ± S.D.) of extrusa samples compared with that of the pasture

Period	Field 4		Field 12	
(1979)	Extrusa	Pasture	Extrusa	Pasture
19.I - 5.II	4.493 ± 0.525	3.847 ± 0.290		
9.II-20.II	4.579 ± 0.444	2.412*	2.958 ± 0.267	2.890 ± 0.021
24.II- 1.III	2.856 ± 0.098	2.427*	3.354 ± 0.551	2.265 ± 0.168

* Only one figure available.

Table 6 - Botanical composition (in %) of areas actually grazed during sampling (A), as compared with that of a general pasture survey (B) in Field 4

Period	Schismus		Hordeum		Erucaria		Forbs	
(1979)	A	B	A	B	A	B	A	B
20.I-4.II	65.7 ±8.1	53.2*	12.3 ±9.5	12.2*	13.6 ±5.9	21.6*	8.4 ±4.8	13.0*

* Only one figure available; otherwise, standard deviations are given.

Appendix

Table 7 - Botanical composition (in % ± S.D.) of areas grazed during sampling

Period	Schismus		Hordeum		Erucaria		Forbs		Dead material
(1978)	F1		F1				F1		F1
9.I -17.II	30.0 ± 5.8		33.1 ± 11.0				8.1 ± 7.3		28.8 ± 16.6
27.II-22.III	40.2 ± 7.6		35.4 ± 3.4				21.1 ± 2.4		3.3 ± 3.8
(1979)	F4	F12	F4	F12	F4	F12	F4	F12	
20.I - 4.II	65.7 ±8.1		12.3 ±9.5		13.6 ±5.9		8.4 ±4.8		
9.II-18.II	59.9 ±2.9	76.0 ±9.2	17.2 ±4.5	9.2 ±0.8	14.4 ±2.1	13.1 ±4.7	8.5 ±0.5	1.7 ±1.2	
24.II-28.II	73.8 ±4.0	83.0 ±2.0	12.3 ±9.5	6.6 ±1.6	13.9 ±5.4	10.4 ±1.2	+	+	

\+ Present but not quantified

F1 = field 1;
F4 = field 4;
F12 = field 12.

Appendix

Table 8 - Botanical composition (in %) of extrusa samples: Plant species and parts summarized

Period (1978)	Schismus F1	Hordeum F1	Erucaria	Forbs F1	Dead material F1
9.I -17.II	67.7 ± 7.2	17.7 ± 9.8		0.3 ± 1.1	14.2 ± 6.9
27.II-22.III	61.2 ± 6.0	18.9 ± 3.8		17.1 ± 10.4	2.8 ± 2.7

(1979)	SCHLV		SCHINF		HORLV		HORSTEM		ERULV		ERUSTEM		ERUINF		FORBS	
	F4	F12	F4	F12	F4	F12	F4	F12	F4	F12	F4	F12	F4	F12	F4	F12
20.I - 4.II	46.9 ±18.1		2.1 ±1.5		4.2 ±3.7		0.1 ±0.2		28.1 ±20.8		2.4 ±2.1		2.8 ±1.8			
9.II-18.II	55.8 ±6.1	53.5 ±13.6	7.9 ±4.3	6.8 ±3.6	10.0 ±5.3	5.5 ±6.1	0.3 ±0.3	0.5 ±0.8	18.5 ±9.2	25.5 ±9.8	1.9 ±0.8	2.4 ±1.9	2.8 ±1.3	2.4 ±0.6	2.8 ±2.7	3.4 ±3.3
24.II-28.II	45.1 ±7.6	34.3 ±19.8	4.0 ±3.0	5.6*	1.1 ±0.4	6.2*	0	0	25.6 ±0.8	45.4*	4.6 ±1.6	1.8*	3.4 ±2.1	2.8*	15.4 ±5.7	3.9 ±2.3

* Only one figure available; otherwise, standard deviations are indicated.

SCHLV - *Schismus* leaves + stems
SCHINF - " inflorescences
HORLV - *Hordeum* leaves
HORSTEM - " stems
FORBS - In F1 with *Erucaria*, in F4 + F12 without *Erucaria*.

ERULV - *Erucaria* leaves
ERUSTEM - " stems
ERUINF - " inflorescences

F1 = field 1
F4 = field 4
F12 = field 12

Appendix

Table 9 - Botanical composition (in %) of extrusa samples: Plant parts summarized

Period	Leaves		Stems		Inflorescences	
(1979)	F4	F12	F4	F12	F4	F12
20.I - 4.II	92.7 ± 3.7		2.5 ± 2.1		4.9 ± 2.4	
9.II-18.II	87.1 ± 3.2	88.0 ± 3.7	2.3 ± 1.2	2.8 ± 2.7	10.7 ± 3.8	9.2 ± 3.8
24.II-28.II	88.0 ± 0.6	89.8*	4.7 ± 1.6	1.8*	7.4 ± 1.0	8.4*

* Only one figure available; otherwise, standard deviations are indicated.

F4 = field 4;

F12 = field 12.

Appendix

Table 10 - Botanical composition (in % ± S.D.) of extrusa samples, compared with that of the pasture

Period (1978)	Schismus F1 EX	Schismus F1 PA	Hordeum F1 EX	Hordeum F1 PA	Dead material F1 EX	Dead material F1 PA	Forbs F1 EX	Forbs F1 PA
9.I -17.II	67.7 ± 7.2	30.0 ± 5.8	17.7 ± 9.8	33.1 ± 11.0	14.3 ± 6.9	28.8 ± 16.6	0.3 ± 1.1	8.1 ± 7.3
27.II-22.III	61.2 ± 6.0	40.2 ± 7.6	18.9 ± 3.8	35.4 ± 3.4	2.8 ± 2.7	3.3 ± 3.8	17.1 ± 10.4	21.1 ± 2.4

Period (1979)	Schismus F4 EX	Schismus F4 PA	Schismus F12 EX	Schismus F12 PA	Hordeum F4 EX	Hordeum F4 PA	Hordeum F12 EX	Hordeum F12 PA	Erucaria F4 EX	Erucaria F4 PA	Erucaria F12 EX	Erucaria F12 PA	Forbs F4 EX	Forbs F4 PA	Forbs F12 EX	Forbs F12 PA
20.I - 4.II	49.0 ±19.3	65.7 ±8.1			4.3 ±3.7	12.3 ±5.5			33.3 ±21.9	13.6 ±5.9			13.4 ±13.6	8.4 ±4.8		
9.II-18.II	63.7 ± 9.9	59.9 ±2.9	60.3 ±16.5	76.0 ±9.2	10.3 ±5.5	17.2 ±4.5	6.0 ±6.1	9.2 ±0.8	23.2 ±10.5	14.4 ±2.1	30.3 ±10.9	13.1 ±4.7	2.8 ± 2.7	8.5 ±0.5	3.4 ±3.3	1.7 ±1.2
24.II-28.II	49.9 ±10.7	73.9 ±4.0	57.3 ±16.9	82.9 ±2.0	1.1 ±0.4	6.6 ±1.6	2.8 ±3.0	12.3 ±9.5	33.6 ± 4.5	10.4 ±1.2	38.6 ±12.3	13.9 ±5.4	15.4 ± 5.7	+	1.3 ±2.3	+

+ Present but not quantified

F1 = field 1; EX = extrusa

F4 = field 4; PA = pasture

F12 = field 12;

Appendix

Table 11 - Presence (+) of seeds in extrusa (Fi) and faeces (fa) samples

Species	JULY														AUGUST							
	5		19		21		26		27		30		31		1		4		20		30	
	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa	Fi	fa
Schismus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Erucaria	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+			
Anthemis	+	+						+		+		+		+				+		+		
Hordeum	+	+		+	+		+				+	+	+	+					+			
Koeleria	+	+			+		+		+		+									+		
Phalaris	+	+																				
Trigonella																		+		+		
?	+	+																				

Appendix

Table 12 - Number of seeds in 1 gram of extrusa (ci) and faeces (ca), concentration ratio of seeds in faeces compared with that of seeds in extrusa (ci/ca), and disappearance rate of seeds (in %)

Species	Seeds/extrusa (ci)	Seeds/faeces (ca)	Concentration ratio of seeds in faeces ÷ seeds in extrusa (ca/ci)	Disappearance rate (%) of seeds (digestibility of feed =0.6*)
Schismus	3.527	7.725	2.190	12.4
Koeleria	0.581	0.053	0.091	96.4
Hordeum	0.775	0.079	0.104	95.8
Phalaris	0.116	0.026	0.224	91.0
Erucaria	1.163	3.175	2.730	-9.2
Anthemis	0.233	3.439	14.760	-4.904
Trigonella	0.0	0.053	--	--
?	0.116	0.053	0.457	81.7

Formula used for calculating digestibility of seeds = $d_s = 1 - \frac{ca}{ci}(1-d_b)$ d_s = digestibility of seeds

d_b = digestibility of feed

Comments on digestibility: if all seeds are digested, digestibility = 100%
" " " " <u>not</u> " , " = 0%
if some of the seeds are digested, " =<100%
if there is an error in sampling, " =<0%

Appendix

Table 13 - Leaf characters used for identification of *Hordeum murinum* and *Phalaris minor* in the vegetative and generative stages of growth (abaxial and adaxial sides of the leaf)

Type and side of leaf		Species \ Characteristics:	Microhairs	Macrohairs	Prickles	Stomata	Long cells	Shortened "long cells"	Short cells with silica bodies
Vegetative	Abaxial	Hordeum	-	-	base flattened, tip short and broad on leaf margins	elongated-oval separated by 1 long cell	walls straight	-	no visible granulas
Vegetative	Abaxial	Phalaris	-	-	base rounded, tip long, tapered on leaf margins	slightly longer than Hord.veg. ab. separated by 1 long cell, sometimes alternating in double rows	see Hord. veg. ab.	-	see Hord. veg. ab.
Vegetative	Adaxial	Hordeum	-	above veins	see Hord. veg. ab.	see Hord. veg. ab.	see Hord. veg. ab.	-	?
Vegetative	Adaxial	Phalaris	-	-	see Phal. veg. ab.	see Phal. veg. ab.	see Hord. veg. ab.	-	?

Hord = *Hordeum* veg = vegetative ab = abaxial
Phal = *Phalaris* gen = generative ad = adaxial

Table 13 - continued

Type and side of leaf		Characteristics: / Species	Microhairs	Macrohairs	Prickles	Stomata	Long cells	Shortened "long cells"	Short cells with silica bodies
Generative	Abaxial	Hordeum	-	Long on leaf margins and between veins	see Hord. veg. ab. on leaf margins and above veins	see Hord. veg. ab.	see Hord. veg. ab.	-	see Hord. veg. ab.
		Phalaris	-	-	see Phal. veg. ab.	see Phal. veg. ab. - slightly rounder	see Hord. veg. ab.	-	see Hord. veg. ab.
	Adaxial	Hordeum	-	Long, on leaf margins and above veins	see Hord. veg. ab.	see Hord. veg. ab., long cells between stomata slightly shorter	slightly shorter than in Hord. veg. ab.	-	see Hord. veg. ab.
		Phalaris	-	-	see Phal. veg. ab.	see Phal. veg. ab.	see Hord. veg. ab.	-	see Hord. veg. ab.

Hord = Hordeum veg = vegetative ab = abaxial
Phal = Phalaris gen = generative ad = adaxial

Appendix

Table 14 - Leaf characters used for identification of *Schismus barbatus* and *Koeleria phloeides* in the vegetative and generative stages of growth (abaxial and adaxial sides of the leaf)

Type and side of leaf		Characteristics; Species	Microhairs	Macrohairs	Prickles	Stomata	Long cells	Shortened "long cells"	Short cells with silica bodies
Vegetative	Abaxial	Schismus	between veins	-	base flattened, tip short and broad on leaf margins (see Hord. veg. ab.)	subsidiary cells form ± half a circle separated usually by 1 long cell, sometimes by 2 long cells and 1 shortened long cell	longitudinal walls sinuous	between long cells	conspicuous granulas
		Koeleria	-	mostly very long, on leaf margins above and between veins (see Hord. veg.ad.)	see Hord. veg. ad. on leaf margins and above beins		walls straight and thin, cells very long, cross walls much shorter than middle of all	-	no visible granulas
	Adaxial	Schismus	could not be found	rare, long between the veins	see Hord. veg. ad.	slightly longer than Schis. veg. ab., separated by 1 long cell, sometimes alternating in a double row	longitudinal cell walls not sinuous, only close to leaf margins	-	?
		Koeleria	-	see Hord. veg.ad.	see Hord. veg. ad.	see Koel. veg. ab.	see Koel. veg. ab.	-	?

Hord = Hordeum   Phal = Phalaris   Schis = Schismus   Koel = Koeleria   veg = vegetative   gen = generative
ab = abaxial   ad = adaxial

Table 14 - continued

Type and side of leaf		Characteristics; Species	Microhairs	Macrohairs	Prickles	Stomata	Long cells	Shortened "long cells"	Short cells with silica bodies
Generative	Abaxial	Schismus	see Schis. veg. ab.	-	see Schis. veg. ab. & Hord. veg. ab.	see Schis. veg. ab.	longitudinal cell walls sinuous, sometimes not sinuous	see Schis. veg. ab.	see Schis. veg. ab.
		Koeleria	-	see Koel. veg. ab, Hord. gen. ad., relatively shorter	see Koel. veg. ab. & Hord. veg. ab.	see Koel. veg. ab.	see Koel. veg. ab.	-	see Koel. veg. ab.
	Adaxial	Schismus	-	-	see Koel. veg. ab. & Hord. gen. ab.	slightly larger than Schis. veg. ab., separated only by one long cell (see Schis. veg. ad.)	walls generally not sinuous (see Hord. veg. ab.)	-	see Koel. veg. ab.
		Koeleria	-	see Koel. veg. ab. Only on leaf margins and above veins (see Hord. gen. ab.)	see Koel. veg. ab.	see Koel. veg. ab. Sometimes alternate in a double row	see Koel. veg. ab.	-	see Koel. veg. ab.

Hord = Hordeum Phal = Phalaris Schis = Schismus Koel = Koeleria veg = vegetative gen = generative
ab = abaxial ad = adaxial

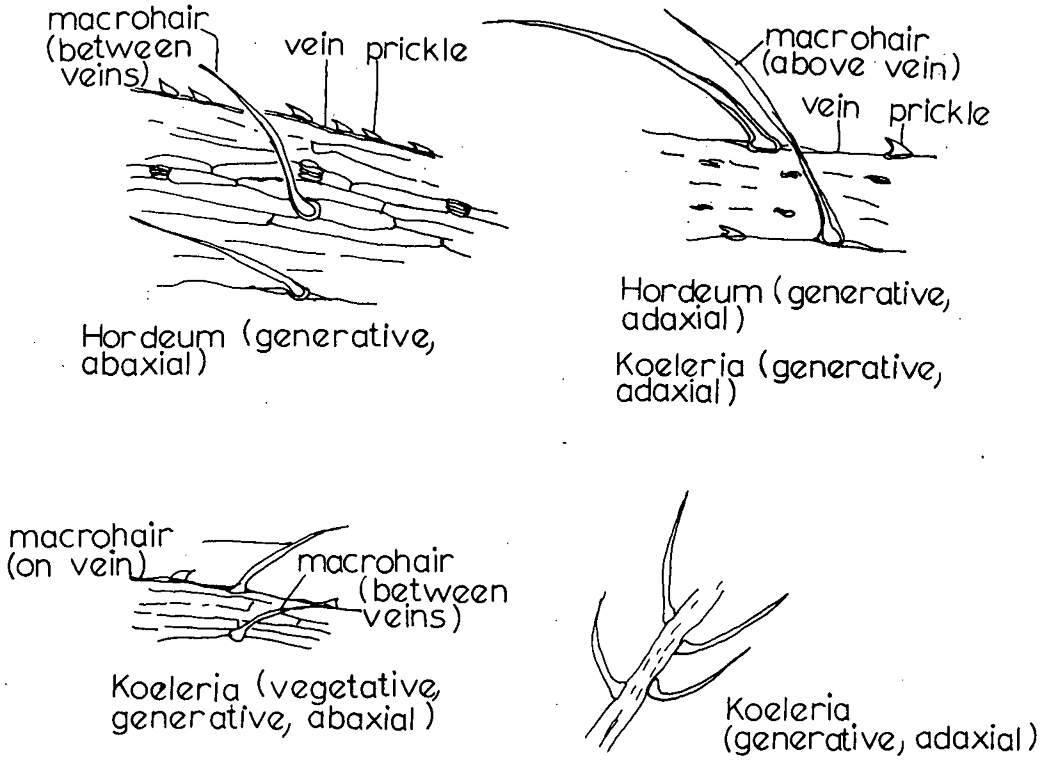
Appendix

Table 15 - Identification key for leaves of Hordeum murinum, Phalaris minor, Schismus barbatus and Koeleria phloeides at the vegetative stage of growth and at the generative stage of growth (abaxial and adaxial sides).

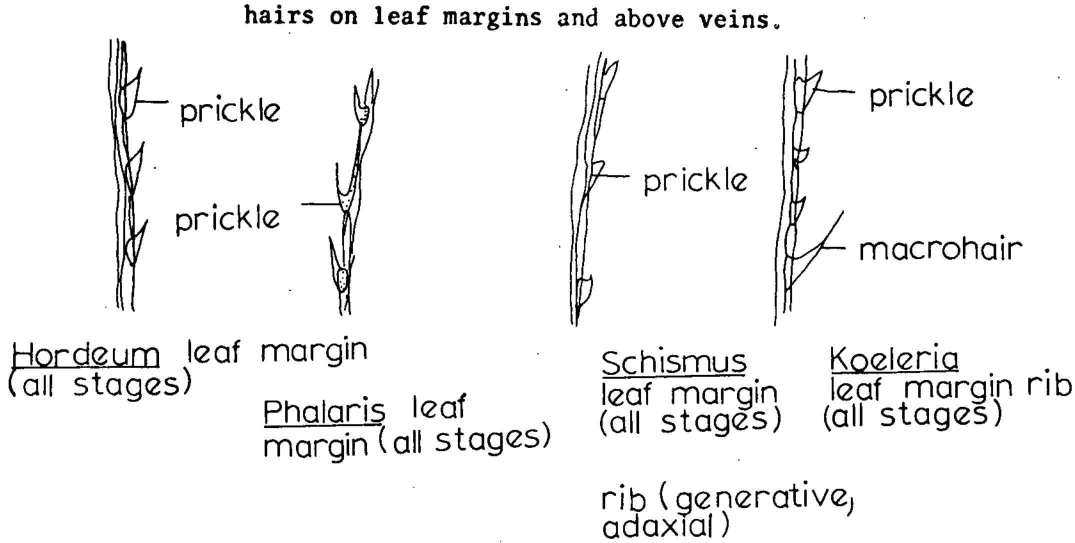
0. Longitudinal cell walls of long cells sinuous and/or shape of stomata subsidiary cells is a half-circle	Schismus (veg. ab. and gen. ab.)
- cell walls of long cells not sinuous	1.
1. Silica cells above veins, granulas conspicuous, microhairs and shortened long cells between veins	Schismus (veg. ab. and gen. ab.)
- Not as above	2.
2. Macrohairs present	5.
- Macrohairs absent	3.
3. Prickles only on leaf margins: base rounded, tip long tapered. Stomata may appear alternating in a double row	Phalaris
- Prickles on the leaf margins shorter and broader, with a flat base. Stomata in a single row	4.
4. Prickles also above veins	7.
- No prickles above veins	Hordeum (veg.)
5. Macrohairs present between veins	6.
- Macrohairs only above veins	Hordeum (gen. ad.)
- Macrohairs present only above veins. Stomata may appear alternating in a double row	Koeleria (gen. ad.)
6. Macrohairs present also above veins; long cells about 6 times longer than their width; on each side of the vein one row of stomata	Koeleria (gen. ab.)
- No macrohairs above veins. Long cells not longer than 3 times their width. Stomata in a few rows between veins	Hordeum (gen. ab.)
- No macrohairs above veins, stomata may appear alternating in a double row	Schismus (veg. ad.)
7. Long cells about 6 times longer than their width	Koeleria (veg.)
- Long cells not longer than 3 times their width	Schismus (gen. ad.)

gen. = generative stage　　veg. = vegetative stage
ab. = abaxial side　　ad. = adaxial side

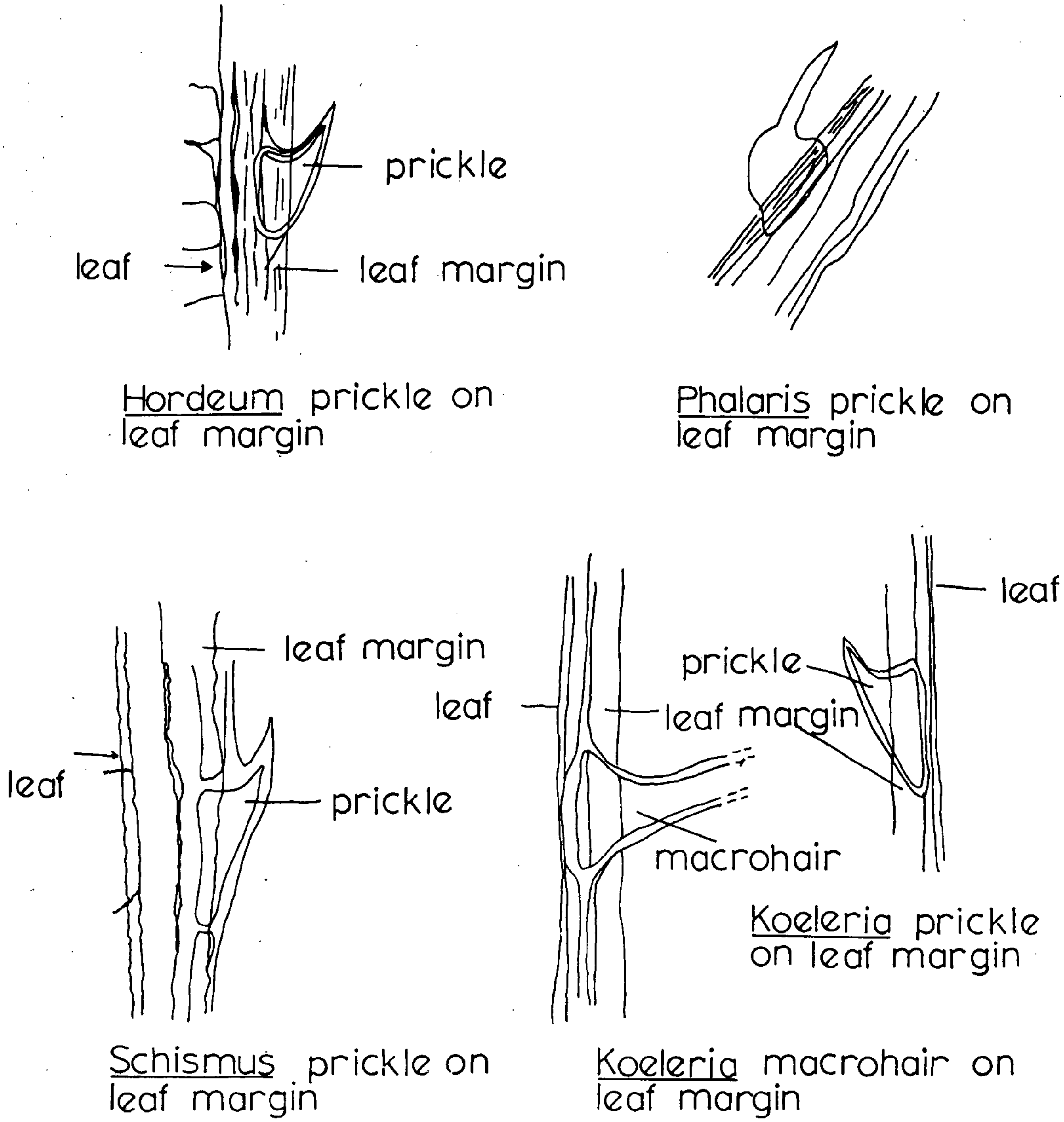
Appendix Fig. 1: Anatomical features of four grass species: macrohairs and prickles between veins and above veins.



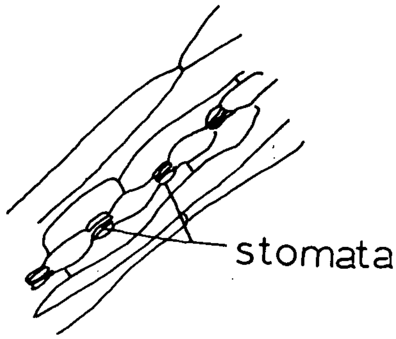
Appendix Fig. 2: Anatomical features of four grass species: prickles and macro-hairs on leaf margins and above veins.

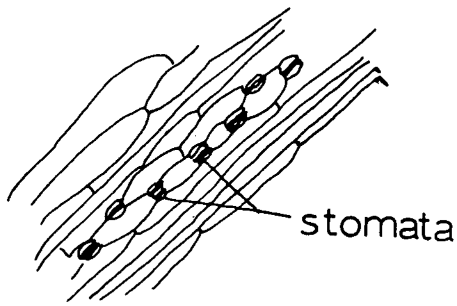


Appendix Fig. 3: Anatomical features of four grass species: prickles and macrohairs on leaf margins.



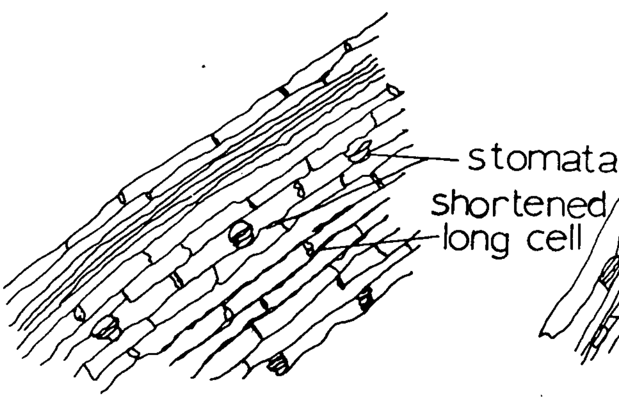
Appendix Fig. 4: Anatomical features of four grass species: stomata and epidermal cells.



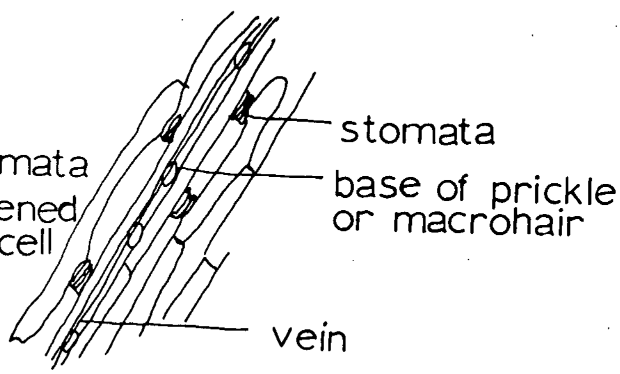


Hordeum: stomata and epidermis cells (all stages)
Schismus: idem (generative, adaxial)

Phalaris: stomata epidermis cells (all stages)
Koeleria: idem (generative, adaxial)

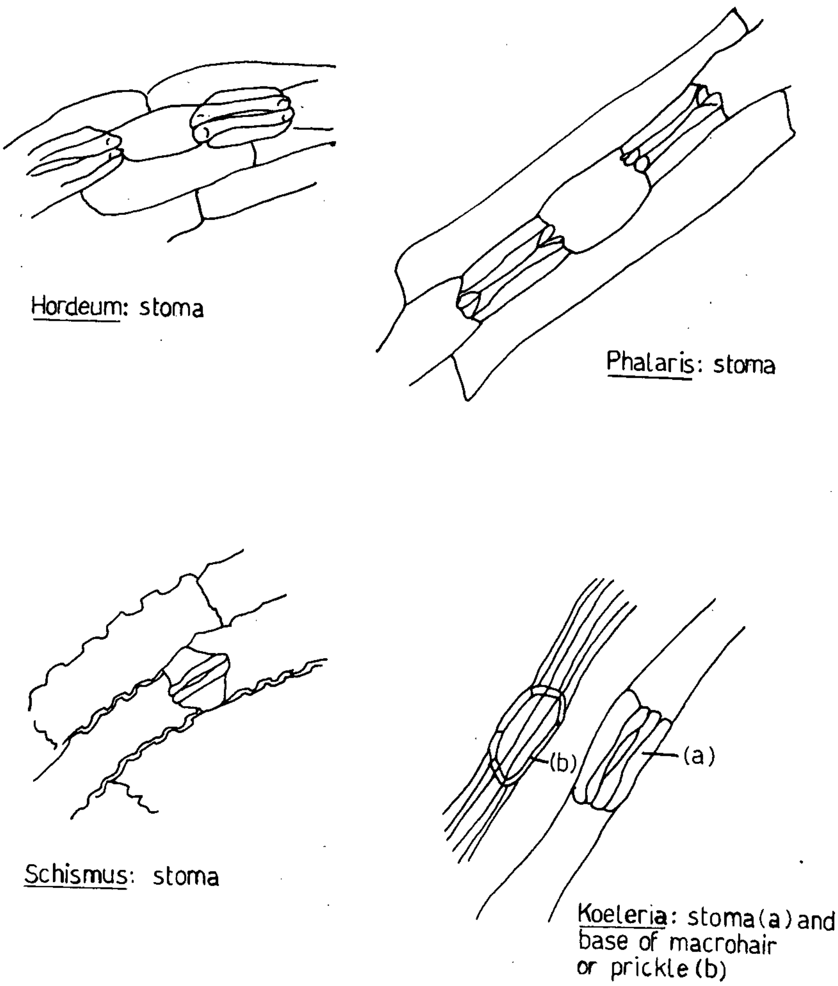


Schismus stomata and epidermis cells (vegetative, generative, abaxial)

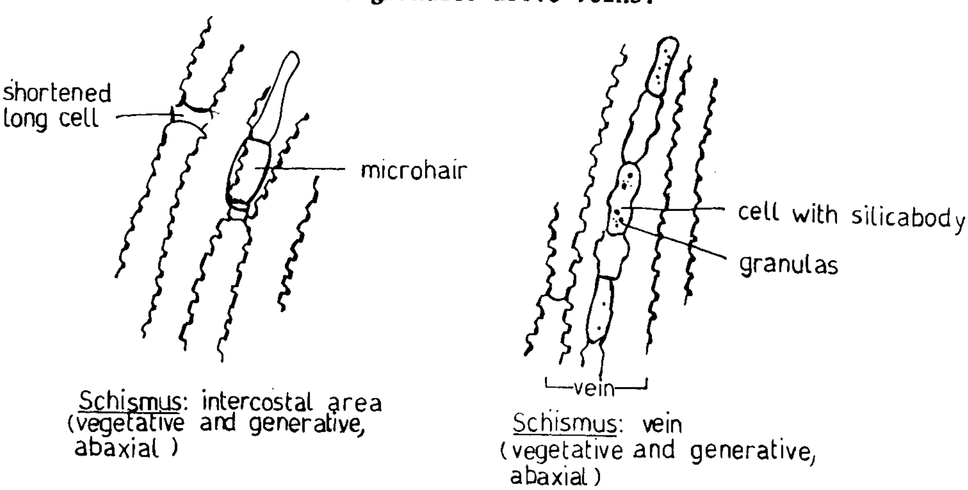


Koeleria: stomata and epidermis cells, rib (all stages)

Appendix Fig. 5: Anatomical features of four grass species: stomata and base of macrohair or prickle above vein.



Appendix Fig. 6: Anatomical features of four grass species: microhair and shortened long cell between veins, and cells with silica bodies and granules above veins.



Appendix II

- A microscope point technique to distinguish between some grass species found in sheep oesophageal extrusa samples

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1. Materials and Methods

1.1. Preparation of reference material

As soon as the seedlings were recognizable in the pasture, i.e., at the beginning of the growing season (3- to 5-leaf stage, "vegetative stage"), samples of each species were collected. Of these plants, the abaxial and adaxial sides of the leaves were examined. Once again, when the inflorescence was emerging out of the flag leaf ("generative stage"), samples of each species were collected; of these plants, the flag leaf was examined also on both sides.

Pieces of the epidermal tissue were torn off the leaf and laid on a microscope slide in a glycerin solution. The slides were viewed a minimum of three days after preparation, to allow the material to become clear under the action of the glycerin.

1.2. Preparation of extrusa samples

The main problem is to present the extrusa material in a form that will make it recognizable (pieces should not be too small) and that will allow the use of a practical point technique (pieces should not be too large), so that several meaningful data can be recorded from the same microscope slide.

Actually, two methods were tested:

(i) Maceration in an acid solution (a mixture of chromic acid and nitric acid), a method described by Storr (1961) and other authors: the pieces that remained after filtration are mainly fragments of lignified walls or are otherwise too small to be recognized (often isolated cells).

(ii) Preparation with lactic acid heated over a flame, a clearing technique commonly used in plant anatomy; pieces remain whole and epidermal characters can only to a certain extent be distinguished on the leaf.

It is necessary to investigate the possibilities of and the refinements for both methods.

2. Results and Discussion

2.1. General characteristics of the Gramineae (Metcalf, 1960)

In most grasses the epidermis is made up of cells of two distinct sizes. The larger cells of the two categories ("long cells") are elongated. Cells in the smaller category are commonly known as "short cells." Short cells are generally classified as "silica cells" which contain silica bodies and "cork cells," the walls of which give the reactions of cork. Some types of long cells are very small and thus called shortened "long cells." Variations between genera can be in the length and the shape of the various types of cells, in the thickness and shape of their cell walls, in the shape of the silica bodies within the silica cells, and in the presence of granulas in these silica bodies.

The epidermis may bear hairs of various types. They are classified as "macrohairs," which are usually unicellular, forming an indumentum on the grass leaf; "micro-hairs," which are much smaller and commonly two-celled; and "prickle-hairs," which are sharply pointed but short structures with swollen bases. Within each type, the hairs can vary in shape and size between different genera.

Stomata are confined to the intercostal areas (between veins), and generally occur in horizontal bands. The guard cells of the stomata are elongated and bone-shaped. There may be variations in size and manner of arrangement of the stomata, and in shape of their subsidiary cells, between different genera.

The characters of leaf used for identification of Hordeum and Phalaris are presented in Appendix Table 13, and those for identification of Schismus and Koeleria in Appendix Table 14. Identification among all four genera is presented in Appendix Table 15.

2.3. Differences between Hordeum and Phalaris (see Appendix Table 13)

In the vegetative stage:

Differences between Hordeum and Phalaris in the vegetative stage seem to be very few: the prickles which are found in both species on the leaf margins are short and with a flat base in Hordeum, while they are longer and with a rounder base in Phalaris (see Appendix I, Fig. 3a,b). However, the chances of finding a piece with a leaf margin are small because of mastication by the sheep.

Phalaris (stomata are arranged sometimes, but not always, in two alternate rows, which is not the case with Hordeum (see Appendix I, Fig. 4). The adaxial side of Phalaris is similar to its abaxial side. Hordeum shows macrohairs above the veins on the adaxial side but not on the abaxial side.

In the generative stage:

The striking difference between the epidermis of the flag leaf of Hordeum and Phalaris is that Hordeum bears very long and abundant macrohairs on both leaf margins and on the leaf itself, on the abaxial side in the intercostal areas and on the adaxial side in the costal areas, above the veins (see Appendix I) as well as prickles also above the veins, while Phalaris remains completely bare except on the margins. Differences between the form of the prickles on leaf margins and the disposition of the stomata of Hordeum and Phalaris are the same as in the vegetative stage.

2.3. Differences between Schismus and Koeleria (see Appendix Table 14)

In the vegetative stage:

There are noticeable differences in the epidermis characteristics between the two species: first of all, Schismus long cells have very characteristic sinuous longitudinal cell walls, while Koeleria long cells are very long, with straight walls (see Appendix I, Fig. 5). Furthermore, Schismus has microhairs and shortened "long cells" between the veins;and on the veins cells containing silica bodies with conspicuous granula (see Appendix I, Fig. 6). All these characteristics could not be found on the epidermis of Koeleria.

The Koeleria epidermis is covered by macrohairs between the veins, above the veins, as well as on the leaf margin (see Appendix Fig. 1). Prickles, short and with a flat base, can be found above the veins and on the leaf margins. Schismus has no macrohairs and shows prickles only on the leaf margin (see Appendix Fig. 2).

Stomata of Schismus are sometimes separated by two long cells and one shortened long cell and have a relatively round shape due to the subsidiary cells forming a half-circle in Schismus, while stomata of Koeleria are longer and always separated by one long cell only (see Appendix Fig. 4). While the adaxial side of Koeleria is similar to its abaxial side, Schismus' adaxial side shows some differences from its abaxial side: some macrohairs are to be found between the veins, the stomata are slightly longer than on the abaxial side, are separated only by one long cell, appear sometimes as alternating in a double row; longitudinal walls of the long cells are sinuous only close to the leaf margins.

In the generative stage:

The abaxial side of Schismus and Koeleria shows the same characteristics in the generative stage as in the vegetative stage, except that Schismus "long cells" do not always have sinuous longitudinal walls; it is then necessary to rely on the other characteristics described above to distinguish between the species.

Quite to the contrary of the abaxial side of the flag leaf, the adaxial side of Schismus is very similar to both leaf sides of Koeleria; longitudinal cell walls of long cells of Schismus are usually not sinuous. Both species have no microhairs, no shortened long cells, and between the long cells there are no conspicuous granulas in the silica bodies of the silica cells. Stomata are more elongated and are always separated only by one long cell in Schismus. They appear sometimes alternating in a double row on the adaxial side of Koeleria. Schismus and Koeleria both have short prickles, with a flat base, set on leaf margins and above the veins. Schismus does not have any macrohairs, while they can be found in Koeleria on leaf margins, above veins in the adaxial side, and between the veins on the abaxial side (See Appendix I, Figs. 1, 2).

3. General Discussion

The anatomical characteristics of the epidermis of a species can change when it reaches the generative stage (cf. Sparks and Malachek, 1968, and their references).

Usually all species germinate within one month, and together reach the generative stage. Therefore, up to that stage, all the extrusa material is of the vegetative type. When the pasture reaches the generative stage and the young inflorescence emerges from the axil of the flag leaf, it could be that the sheep tend to eat this young upper part of the plant (especially of Schismus and Koeleria) and to neglect older parts (vegetative leaves) (cf. Arnold et al., 1966; Hamilton et al., 1973). Therefore, at this stage most of the extrusa material could consist of generative parts.

Differentiation between species will consequently be limited to the same stage of growth, which simplifies their identification.

The identification key (see Appendix Table 15) was planned so that plant species can be identified at both stages of growth (vegetative and generative). If one or more of the characteristics fail to appear (because of its small size or because of damage due to mastication) on the piece of epidermis that has to be identified, definition down to the level of genera will be impossible and certain species will have to be pooled into new categories.

In the extrusa material, leaf pieces which consist of the entire leaf width can be easily classified into one of the two categories, i.e., Hordeum and Phalaris, or Schismus and Koeleria. Further identification of these species within a category can be achieved by comparing their anatomical characteristics. Pieces that do not show the entire leaf width will have to be identified by the anatomical characteristics of all four species.

Anatomical differences between genera can be briefly summarized as follows:

In the vegetative stage:

Schismus is recognizable by the round shape of the stomata together with the subsidiary cells and its sinuous longitudinal cell walls, but only on the abaxial side (i.e., theoretically in 50% of the cases). The adaxial side of Schismus has characteristics close to those of Hordeum and Phalaris; it can be differentiated from them by its macrohairs between veins, and - if a leaf margin is visible - by the sinuous shape of the longitudinal cell walls of the long cells. Koeleria is recognizable by the length of its long cells, its hairy epidermis, its prickles on the veins (in case no hairs appear on the epidermis piece), and less clearly by the disposition of its stomata, in one row on each side of the vein - on both sides of the leaf.

Differentiation between Hordeum and Phalaris is not possible without the prickles on the leaf edge, unless Phalaris shows alternate rows of stomata, or Hordeum macrohairs above veins (adaxial side).

In the generative stage:

Only the abaxial side of the Schismus leaf shows its sinuous cell walls and its other characteristics, so that Schismus will be easily recognizable, theoretically, in only 50% of the cases. The adaxial side of Schismus is very similar to both leaf sides of Phalaris and Hordeum. It is similar to Phalaris when its stomata happen to be arranged alternately in a double row; the only difference between the two is the presence of prickles above the veins of Schismus. When a piece of Hordeum does not show the macrohairs, it is very similar to Schismus (see below).

Phalaris is easily distinguishable from *Hordeum* and *Koeleria* by the shape of its prickles on leaf margins - when the examined piece has a leaf margin, and by its complete lack of macrohairs. However, if a piece of *Hordeum* does not show macrohairs or at least their base, it will hardly be possible to distinguish between *Koeleria* and *Hordeum* (see description of vegetative stage). The only characteristics which enable us to distinguish between *Koeleria* and *Hordeum* (and *Phalaris* in the case mentioned above) are the very long cells and the disposition of the stomata in one row on each side of the vein in *Koeleria*; and on the adaxial side of *Koeleria*, but not of *Hordeum*, macrohairs that appear also above the veins.

It is usually possible to see the abaxial side of *Schismus* leaf in the appropriate depth of focus, so the number of pieces of *Schismus* that remains unidentified is rather small.

החלק העיקרי במזון הכבשים, אולם לקראת תום תקופת העבודה המעקב הופיעה כמות מסויימת של תפרחות שלח ושסיע (אך אף פעם לא של שעורת העכבר). נמצא, כי הכבשים בחרו בקביעות בתפריט שהיה עשיר בחנקן, בכ-1% יותר משיעור החנקן הממוצע במרעה (1979). סיבה אפשרית לכך ששלח הועדף במידה בולטת יוחסה לתכולת החנקן הגבוהה שבו, ואולי גם לתכולה הנמוכה של חומר יבש. להוציא את תכולת החנקן, לא נמצאו סיבות אחרות להעדפת חלקות-שדה אלו או אחרות על-ידי הכבשים. כמו כן, לא נמצאו הבדלים בין תוצאות בדיקות אקסטרוזה שנעשו בשעות שונות באותו היום לגבי מינים שונים של צמחי מרעה. אולם,בנתונים שנלקחו בימים שונים באותה התקופה נמצאו הבדלים לגבי כמה מינים; כמו כן נמצאו הבדלים בין הכבשים מבחינת ההעדפה של מינים מסויימים במרעה. זמינותם וצריכתם של זרעים היו נמוכות בקיץ 1978 ושיעור העלמות הזרעים במערכת העיכול של הכבשים היתה שונה לגבי המינים השונים; הוא היה גדול יותר בשעורת העכבר, בדגנין ובחפורית מאשר בשסיע, בשלח ובקחון.

ת ק צ י ר

ברירת המזון על-ידי כבשים נבחנה במשך שנתיים (1979-1978) על-ידי השוואת ההרכב הכימי והבוטאני של מזונם לזה של הצמחים בשלוש חלקות מרעה טבעי צחיח למחצה. חלקה אחת היתה ברעייה קבועה מתונה (0.33 כבשה לדונם) ושתיים היו ברעייה חזקה יותר (0.67 ו-1.5 כבשה לדונם), שהתחילה רק כאשר הצמיחה הגיעה לכמות הסף הרצויה של חומר יבש. ההרכב הכימי של המזון נבדק בטכניקת הפיסטולה. בשיטה זו נפתח פתח בוושט ודרכו מוצאות דוגמאות מזון לבדיקה (אקסטרוזה). להערכת שיעורי המינים במזון הבהמה (הרכב בוטאני, באחוזים) שימשה טכניקת ה-Point Cover, מכוילת על-ידי הפרדה ידנית, הן לגבי הצומח בשדה והן במעבדה לגבי האקסטרוזה, לאחר שהחומר נשטף ודולל.

מלבד הבדיקות באמצעות הפיסטולה נבחנה גם אפשרות השימוש באנאליזה מיקרוסקופית. השפעת הגורמים הבאים על הבדיקות בשיטת הפיסטולה נדונה תוך השוואה עם הידוע מהספרות: שיעור הדוגמא מתוך כלל המזון שנבלע (Recovery); מספר הכבשים שנבדק; גודל הפיסטולה; מועד ומשך הדגימה; הכנה, מיון ואנאליזה של חומר האקסטרוזה. באנאליזה מיקרוסקופית של פיסות קוטיקולה הנמצאות בדוגמאות צואה אפשר היה להבדיל בין המינים החשובים, ונראה שבדרך זו ניתן להימנע מהשימוש בפיסטולה, שהוא קשה לביצוע וגורם לתמותה רבה של כבשים.

תוצאות הניסויים שנערכו בעבודה זו מראות שהעדפת מיני מזונות על-ידי הכבשים עשויה להשתנות משנה לשנה. ב-1978 הועדף שסיע, אך הוא נדחה ב-1979, בשל שינוי בטיב המרעה; שלח נמצא במרעה בכמויות גדולות רק ב-1979 והוא הועדף בשנה זו במידה בולטת; קמל נמצא בשטח רק בתחילת 1978 והוא נדחה במידה בולטת. שעורת העכבר נדחתה בדרך כלל בשתי השנים.

עצמת הסלקציה עשויה להשתנות גם בתקופות שונות באותה השנה, עד כדי שינוי בהעדפה; למשל, רחבי-עלים שהועדפו בחלק מהעונה נדחו בחלק אחר שלה. נראה שהכבשים לא בחרו מקומות מסויימים בשדה לרעייה. מבנה העשבייה השפיע על התנהגותם הסלקטיבית: ב-1979 היתה העלווה

מינהל המחקר החקלאי
המכון לגידולי שדה וגן

האוניברסיטה העברית
בירושלים

האוניברסיטה החקלאית ואכנינגן
המרכז למחקר אגרו-ביולוגי

ברירת צמחי מרעה על-ידי כבשים המצוידות בפיסטולה של הוושט בנגב הצפוני

אליזאבת ארנולד

בולטין מס' 225

המחלקה לפירסומים מדעיים
מרכז וולקני, בית-דגן

תש"ם - 1980

ברירת צמחי מרעה על-ידי כבשים המצוידות
בפיסטולה של הוושט, בנגב הצפוני

אליזבט ארנולד

עבודה זו הינה חלק מתוכנית מחקר הולנדית-ישראלית: ייצור ממשי ופוטנציאלי ממרעה ארידי-למחצה, שלב בי. תוכנית זו מומנה על-ידי המחלקה לסיוע טכני של המשרד לפיתוח ולשיתוף פעולה של ממשלת הולנד. המחקר התנהל תוך שיתוף פעולה בין המוסדות הבאים:

בישראל - האוניברסיטה העברית בירושלים
- מינהל המחקר החקלאי, מרכז וולקני בית-דגן
בהולנד - האוניברסיטה החקלאית ואכנינגן, המרכז למחקר אגרו-ביולוגי (CABO)

* המחלקה למרעה, מינהל המחקר החקלאי, מרכז וולקני בית-דגן.

29-12-80

עבודה זו נעשתה בהדרכתם של

פרופ' עמנואל נוי-מאיר

וד"ר עזרא איל

ה ב ע ת   ת ו ד ה

תודתי העמוקה מובעת בזה למורי, פרופ' עמנואל נוי-מאיר וד"ר עזרא אייל, וכן לד"ר נעם זליגמן ולמר רוג'ר בנימין, על הדרכתם, עזרתם, התענייננותם ועידודם. כמו כן, חובה נעימה היא לי להודות לכל חברי באוניברסיטה העברית ובמחלקה למרעה של מינהל המחקר החקלאי בגילת ובבית-דגן, על עזרתם ושיתוף פעולתם.

תוכן העניינים

עמוד

עמוד