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Title EVALUATION OF SPECIES COMPOSITION BY FOUR METHODS ON TWO PERENNIAL GRASS PASTURES (FESTUCA ARUNDINACEA SCHREB. AND LOLIUM PERENNE L.) GRAZED LIGHTLY AND HEAVILY IN WESTERN OREGON

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The present study was undertaken to evaluate the seasonal botanical composition of two grass pastures, tall fescue (*Festuca arundinacea* Schreb.) and perennial ryegrass (*Lolium perenne* L.). Botanical composition was determined by four methods: dry-weight-rank, weight-estimate, hand separation, and the constituent differential, with cattle and sheep grazing at two intensities.

The pastures were sampled eight times during the growing season (March 23-July 8), taking 50, 25, 5, and 5 observations with the dry-weight-rank, weight-estimate, hand separation, and

constituent differential methods, respectively, using a 2.4-square-foot circular plot.

New sets of multipliers had to be determined for the dry-weight-rank method. Three different ways of grouping the data were tested. Best results were obtained in both pastures when all the data were grouped from all grazing treatments, because no significant differences were detected among the experimental errors in the analyses of variance used to test data arrangements. Consequently, the use of only one set of multipliers was found to be more practical.

The same ways of grouping the data were used to calculate the regression equations to give the most accurate correction for the weight-estimate method. Uncorrected data were also tested. It was determined that best results were obtained in the fescue pastures when all the data were grouped within each of the grazing treatments. In the ryegrass pastures, on the other hand, all data collected in each sampling period was found to be the best arrangement, provided that the number of observations is increased to compensate for greater pasture variability.

An analysis of variance was run on the information obtained with each method in both pastures. It was concluded that, in the fescue sections, the methods gave similar results regardless of the kind of livestock, grazing intensity, and sampling period. Units grazed by cattle showed a lower fescue percentage, especially those heavily grazed, than those grazed by sheep; grazing intensity did not affect the trend of the fescue percentages in the mixture which declined as the season progressed.

In ryegrass pastures, the ryegrass percentages obtained in each case were influenced by all four treatments: methods, kind of livestock, grazing intensity, and sampling periods.

It is apparent from this study that the constituent differential method is the most promising one, and more attention should be directed to it in the future. A study is proposed to explore some of the factors influencing the use of the constituent differential method for determining production and botanical composition on mixed grass-legume pastures.

EVALUATION OF SPECIES COMPOSITION BY FOUR METHODS ON TWO PERENNIAL GRASS PASTURES (*FESTUCA ARUNDINACEA* SCHREB. AND *LOLIUM PERENNE* L.) GRAZED LIGHTLY AND HEAVILY IN WESTERN OREGON

by

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INTRODUCTION

One of the purposes of the long-range forage improvement study, started in 1959 on the Adair land of the Oregon Agricultural Experiment Station, was to compare the value of two mixtures, perennial ryegrass (*Lolium perenne* L.) and subclover[1/] (*Trifolium subterraneum* L.) versus tall fescue (*Festuca arundinacea* Schreb.) with subclover, when grazed by both cattle and sheep. A study with esophageal fistulated sheep and cattle has been done to determine their dietary preferences on these pastures (Bedell, 1966).

Among the objectives of another study (Sanders, 1965) was one to provide botanical composition data on the two mixtures in support of a study on dietary preferences. Sanders' composition estimates were found to be unsatisfactory, because it was not feasible to hand separate the number of samples necessary to measure these highly variable stands of forages.

As a consequence of these conclusions and the fact that there

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1/ Subclover is used as synonym to subterranean clover.

is an obvious need for a quick and precise method for determining botanical composition, the present study was undertaken to select a faster method, which would give reliable estimates of species composition of these pastures. The objectives were two-fold:

(1) Compare four different methods to determine botanical composition. These methods were: dry-weight-rank (Mannetje and Haydock, 1963), weight estimate (Pechanec and Pickford, 1937), hand separation, and the constituent differential methods (Cooper et al., 1957).

(2) Compare the seasonal botanical composition of the fescue and ryegrass pastures grazed by sheep and cattle at two different intensities.

DESCRIPTION OF THE STUDY AREA

Climate

The study area is located at the eastern edge of the Coast Range foothills, 12 miles north of Corvallis on Soap Creek. The climate at Corvallis is described by the Oregon Agricultural Experiment Station (1965) as fairly representative of the Willamette Valley and may be designated as a mild subcoastal type, with moist open winters, a dry harvest period in late summer, and a relatively long growing season. There is comparative freedom from strong winds, hail, and electrical storms.

Coldest temperatures occur in December and January and warmest in August. During the 1931-1960 period, mean yearly temperature was 52.4°F with a mean maximum of 62.6°F and mean minimum of 42.1°F (Table 1).

Average yearly precipitation for the 1931-1960 period is 40 inches, which consists almost entirely of rainfall; snow seldom occurs. Extremes as high as 64 inches in 1937 and as low as 23 inches in 1944 have been recorded. Figure 1 shows monthly precipitation for the 30-year period and for 1964-1965.

During the 1965 spring growing season, mean maximum and minimum temperature were near or above the 30-year period, but precipitation was below normal.

Table 1. Mean maximum and minimum temperatures for 1964-65 and 30-year period. (Degrees F.)

Month	Mean Maximum		Mean Minimum	
	30-year	1964-1965	30-year	1964-1965
September	75.8	73.3	48.3	43.9
October	64.2	66.3	43.0	40.7
November	52.2	48.1	37.2	35.6
December	46.8	45.6	35.1	34.8
January	44.8	44.1	32.1	35.0
February	49.5	50.5	34.7	35.9
March	54.0	59.0	36.8	35.8
April	61.0	61.3	40.5	40.7
May	67.7	64.6	45.5	40.8
June	72.9	72.3	49.2	46.2
July	81.2	82.4	51.6	50.2
August	81.1	79.9	51.1	53.1

Establishment of Pastures

Sanders (1965) has described the soils, native vegetation, and establishment and management of the study area which lies on a gentle northwest slope. An Abiqua-like silt loam which is relatively shallow and well drained occurs upslope from a McAlpin-like silt loam that is deeper and moderately to imperfectly drained. Complete profile descriptions of these two series are given by Sanders (1965) and Bedell (1966). Chemical analysis for soil samples obtained in August, 1964, are shown in Table 2.

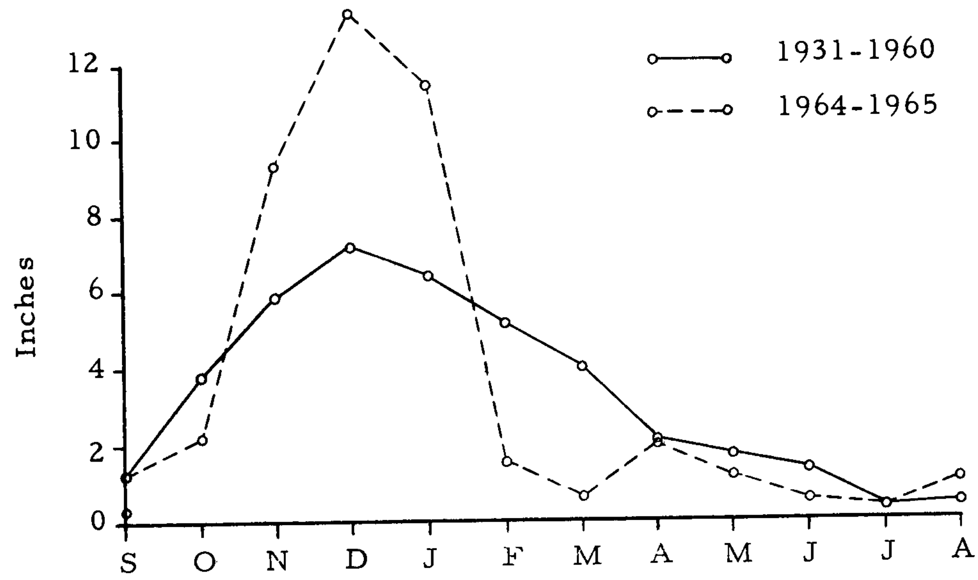

Figure 1. Monthly precipitation during 1964-1965 and the 30-year mean.

Table 2. Chemical analysis of surface soil. August, 1964.

Pasture	pH	P ppm	Organic Matter Percentage	Me/100 gr K	Me/100 gr Ca	Me/100 gr Mg
Tall Fescue-Subclover	6.0	4.3	6.26	.52	11.4	6.8
Perennial Ryegrass-Subclover	6.0	2.3	5.76	.45	11.4	5.8

Native vegetation on similar, but uncultivated areas, consists of Oregon white oak (Quercus garryana Dougl.) which as succession proceeds is replaced by Douglas-fir (Pseudotsuga menziesii (Mirb.)

Franco).

Understory and open areas consist of sweetbriar rose (*Rosa eglanteria* L.) and poison oak (*Rhus diversiloba* Buckl.), bracken fern (*Pteridium aquilinum* L.), velvet grass (*Holcus lanatus* L.) and others.

The study area was used to produce ryegrass seed until 1960. Seedbed preparation for the present pastures consisted of plowing and disking.

Inoculated subclover (Nangeela variety) was broadcast at the rate of five pounds per acre and fescue and ryegrass were drilled in at the rate of 15 and 10 pounds per acre, respectively. Good grass stands resulted, but subclover establishment was poor. Reseeding of subclover in fall 1961 resulted in satisfactory stands in both pasture mixtures.

Phosphorus, in the form of 11-48 fertilizer, and borated gypsum were each broadcast at 150 pounds per acre with the subclover seed, which was also treated with ammonium molybdate fertilizer. Each fall since 1960, 200 pounds of single superphosphate per acre have been applied.

A hay crop was harvested in July, 1961, in both pasture mixtures, but in 1962 an accidental fire destroyed the forage crop.

Seasonal Yield of Forage

Sanders (1965) reported that in 1964 growth was rapid in perennial ryegrass until anthesis occurred and its maximum production was reached in late June (milk stage) with 2180 pounds dry matter per acre. Production in the experimental area was variable. Tall fescue production reached a maximum of 6150 pounds dry matter per acre in late June. The maximum production of subclover occurred in early June during burr formation. Peak production in the ryegrass mixture was 5120 pounds dry matter per acre versus only 4390 pounds in the fescue mixture. Comparative production figures for 1964 and 1965 are given in Table 3. Low precipitation in the fall of 1964 delayed subclover germination until late November and mid-December temperatures killed nearly all the seedlings. The small population of subclover plants that survived the December freeze and those few that germinated in late winter, composed the very poor clover stand in 1965.

In 1965, each of the four pastures, namely, fescue-sheep, fescue-cattle, ryegrass-sheep, and ryegrass-cattle, were divided into halves. Bottom halves were stocked heavier than the upper ones from which seasonal forage production data were obtained. Maximum total production of the fescue mixture was reached in mid-June, when 4580 pounds dry matter per acre were obtained in the fescue-sheep pasture and 4830 pounds dry matter per acre on the fescue-cattle pasture. Maximum ryegrass production occurred in early June on the ryegrass sheep pasture, whereas in the ryegrass cattle pasture

Table 3. Mean seasonal production of tall fescue and perennial ryegrass pastures in 1964 and 1965.

Sampling Period	Grazing Intensity	Pounds per Acre of Oven-dry Material					
		1964		1965			
		Fescue Pastures	Ryegrass Pastures	Fescue Pastures	Ryegrass Pastures	Fescue Pastures	Ryegrass Pastures
				------Cattle-------		------Sheep-------	
Early April	Heavy			1120		790	
	Light			1030		1150	
Mid-April	Light	2750	1500				
Late April	Light	4230	3550	1170	360	1280	380
	Heavy			720	520	790	510
Early May	Light	4790	4260	1450	800	1900	650
	Heavy			1000	730	1020	510
Mid-May	Light	5510	5560	2880	1160	2530	1200
	Heavy			910	870	1440	680
Early June	Light	7960	6690	3060	1950	3020	1700
	Heavy			980	1220	1220	890
Mid-June	Light			4830	2940	4580	1610
	Heavy			1000	1470	1550	800
Late June	Light	8080	6410				
Early July	Light			3730	2230	2830	1280
	Heavy			1760	470	1060	450
Late July	Light	5790	3890				
Early August	Light			3730	2160	2940	770
	Heavy			1120	470	1280	510

it occurred in mid-June with 1700 and 2940 pounds dry matter per acre, respectively.

In the heavily grazed pastures, maximum production was recorded in mid-June from the fescue-sheep pasture where 1550 pounds dry matter per acre were obtained, whereas on the fescue-cattle pasture, the highest production of 1760 pounds dry matter per acre occurred in early July.

In ryegrass, maximum production figures were recorded on the same dates indicated for light grazing intensity and these were 890 and 1470 pounds per acre for the ryegrass-sheep and ryegrass-cattle pastures, respectively.

Livestock Use of Pastures

Bedell (1966) reported that in 1963 only light cattle and sheep use occurred. In 1964, light use was continued with a total stocking rate of 258 Animal Days/Acre. This was increased by the addition of a heavy grazing treatment to a total of 884 Animal Days/Acre for 1965. Table 4 shows the animal use of the experimental pastures in 1964 and 1965.

Table 4. Animal use of experimental pastures in 1964 and 1965.

Pasture	Kind of Livestock	Grazing Intensity	Grazing Season	Animal Days	Stocking Rate Animal Days/Ac.
			1964		
Fescue	Sheep	Light	4/17 to 9/8	163	65
Fescue	Cattle	Light	do	155	62
Ryegrass	Sheep	Light	do	168	67
Ryegrass	Cattle	Light	do	160	64
			1965		
Fescue	Sheep	Light	3/26 to 8/10	92	74
Fescue	Sheep	Heavy	do	238	190
Fescue	Cattle	Light	4/17 to 8/10	45	36
Fescue	Cattle	Heavy	do	237	190
Ryegrass	Sheep	Light	do	50	40
Ryegrass	Sheep	Heavy	do	206	165
Ryegrass	Cattle	Light	do	53	42
Ryegrass	Cattle	Heavy	do	184	147

LITERATURE REVIEW

Considerable attention has been focused on the search for new methods that would replace hand separation when it is necessary to determine the vegetative composition of forage mixtures. As Cooper et al. (1957) indicate, this method, although it has been accepted as a standard, is objectionable not only because of the cost, but also because of the limited time for separation before species in the mixture become unidentifiable, and as a consequence, the sample numbers are drastically reduced and the accuracy of the method is lost (Mannetje and Haydock, 1963). Similar statements have been made by several other authors: Ahlgren (1947), Hunt (1964), Marten (1964), etc.

Brown (1954) indicates that many techniques have been devised, developed, and described for botanical analysis and that these methods may be fitted into four groups: (1) frequency of occurrence, (2) number of individuals, (3) area covered, and (4) weight. Those techniques belonging to groups (1), (2), and (3), according to Mannetje and Haydock (1964) are all quicker, but less accurate, since the estimation involved is highly subjective. Brown (1954) states that there are four general procedures for carrying out an analysis by weight: (1) A sample of the vegetation is cut, separated into species, and each species is weighed. (2) A sample of the vegetation is cut and the relative weight of each species estimated by eye in the laboratory. (3) The relative weights of each species in sampling units are estimated *in situ* in the field. (4) The weights are estimated in the field by means of plots.

Pechanec and Pickford (1937) developed the weight estimate[2/] method which has been evaluated by several investigators. Leasure (1949) found that when the weight estimate method was compared with the point quadrat method, the visual estimation by three persons seemed to be accurate within 10 percent. Also no differences were found in accuracy of determination due to species differences or to height of forage. Van Keuren and Ahlgren (1957a) working with 2 x 2-square-foot plots on legumes and grasses, determined that the weight estimate method for deriving percentage composition, had greater variation than the point quadrat methods, which gave reliable and objective estimates of botanical composition of pasture swards. The same authors (1957b) in another study concluded that the visual estimate of the standing forage appeared to be the more satisfactory, when compared to the estimate of the green harvested forage, although the reliability of both methods appeared to be influenced greatly by the experience of the estimator. Wagner (1952) reports that estimates based on standing forage were poorer than those based on

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2/ A more detailed description of this method and of others used in the present study are given in the methods section.

dried, clipped forage.

Tanner, Gamble and Tossell (1960) reporting on a two-component forage mixture, indicate that the weight estimate method can be superior to hand separation as a means of determining botanical composition. They also state that the visual estimation method was less variable than hand separation, and the precision per unit of cost was greater.

Similar conclusions were reported by Hunt (1964). He found in general that this method was extremely accurate and said that the precision of the estimates was increased after education or orientation of the estimators. Marten (1964), found that the visual estimation method has greater precision than hand separation, although the use of uncorrected estimates of percentage legume in two-component legume grass mixtures should be restricted to comparisons to treatments in which the same or very similar varieties are involved, as the degree and direction of bias may be influenced by variety and species growth habits.

Wilm, Costello and Klipple (1944) developed the double sampling method, which was primarily conceived to estimate production. This method consists of a combination of a quick method, such as the weight estimate, and clipping from which regression may be calculated. These authors found that the use of weight estimate in double sampling provided about 37 percent more information than could be obtained with straight clippings in an equivalent amount of time. If office compilation is considered the gain in information dropped to about 14 percent.

Van Keuren and Ahlgren (1957b) indicated that the use of regression equations to provide estimates of yield of forage did not give satisfactory results. Tiwari, Jacobs and Carmer (1963) also proposed a type of double sampling procedure for correcting visual estimates of botanical composition by establishing the relationship between these estimates and a limited number of hand separation measurements. Leasure (1949) cites that one way to improve the visual estimation method would be to use it in combination with the point quadrat method.

Cooper _et al_. (1957) presented the constituent differential method of estimating species composition by weight of a two-component forage mixture when the two components contain different concentrations of a given constituent. They investigated the use of dry matter, calcium and protein content to estimate botanical composition, and concluded that, at least where dry matter is the measured constituent, the method is more efficient than hand separation. Some of the disadvantages that this method has when dry matter is the measured constituent are: (1) Speed is essential to avoid error from moisture loss during sampling. (2) Other factors such as precipitation, time of day, and humidity may also introduce some errors. Both calcium and protein have distinct advantages over dry matter, in that speed is not a factor in handling the sample, and time of day and climatic conditions are not so likely to influence them.

De Vries (1933) introduced the idea of ranking the species by estimating the order of precedence in bulk of each of those components of the mixture occupying the first three ranks in a 1 dm^2 quadrat. Later, according to Mannetje and Haydock (1963), De Vries stated that "the modern way of calculation is to allocate three points to a first place, two points to a second place, and one point to a third place." These same authors in 1963 presented a method based on De Vries' rank method, which gives an estimate of botanical composition on a dry weight basis, without the necessity of cutting and hand separating. This method when compared to hand separation proved to be quite accurate if ranking is done correctly, and should be applicable over a wide range of pasture types. The maximum percent dry matter of a species that can be estimated is 70.2. Other sets of multipliers could be derived to suit higher percentages. Special care in training would be needed if a change were made to a completely different group of species. This method has the advantage that the pasture is not disturbed and large sample numbers are possible.

METHODS

During 1965, both fescue and ryegrass pastures were grazed by sheep and cattle and at two stocking rates, for a total of eight different treatments.

Botanical composition was determined at biweekly intervals, in each of the eight sections of the pastures using four different methods: dry-weight-rank, weight estimate, hand separation, and the constituent differential. The sampling dates were:

1. March 23 and 24
2. April 9 and 10
3. April 22 and 23
4. May 5 and 6
5. May 21 and 22
6. June 4 and 5
7. June 16 and 17
8. July 7 and 8.

Sheep and cattle grazing began in early and late April, respectively.

Sampling Procedure

All the methods were applied to each pasture simultaneously, and always in the same order:

1. Dry-weight-rank method (RM)
2. Weight-estimate (WE)
3. Hand separation (HS)
4. Constituent differential (CD).

A 2.4-square-foot plot was used to make the observations with each of the methods. The number of observations within each method were arbitrarily determined. When the RM was used, 50 observations were made with the circular plot in each of the 1.25-acre sections. Of these 50 objective sample locations, production per species (fescue, ryegrass, subclover, other annuals and other perennials) was estimated in every second throwing and five were clipped (every tenth). These figures were used to determine botanical composition by hand separation and the constituent differential methods.

Since little subclover was present in these experimental pastures at the end of June, additional sampling (20 observations in each pasture) was made with all four methods in some selected areas where there were fairly good fescue-subclover and ryegrass-subclover mixtures. The purpose of this special sampling was to get a comparison of these methods under a more normal composition of grass-legume mixtures.

The clipped material was placed in plastic bags and hand sorted in the laboratory. Each portion of a clipped plot was weighed to the nearest half-gram and dried in an oven at 105°C for 24 hours to determine dry matter and botanical composition on a dry-weight basis.

Methods Used to Determine Botanical Composition

Dry-Weight-Rank

This method has been proposed by Mannetje and Haydock (1963). It gives an estimate of the botanical composition, on a dry-weight basis, without the necessity of cutting and hand separating the samples. In 50 plots, in each pasture, it was estimated which species placed first, second, and third, in terms of dry weight after a short training period. The data were tabulated to give the proportion of plots in which each species received first, second, and third place. These proportions, according to the authors, should have been multiplied by 70.2, 21.1, and 8.7, respectively, and added to give the dry-weight percentages of each species, but it was soon observed that in the fescue mixture, the fescue percentage was much higher than 70.2 percent, which is the highest percentage obtainable with this set of multipliers. In the ryegrass mixture, it was also observed that the subclover percentage would hardly reach eight or a higher percentage because of the unfavorable climatic conditions during the fall of 1964. Therefore, for this study, another set or sets of multipliers had to be calculated. This was achieved through the application of the technique described by Mannetje and Haydock (1963), which is as follows:

Let X_{1i}, X_{2i}, X_{3i}, be the number of first, second, and third rankings, respectively, of the i^{th} component of a pasture. Multipliers k_1, k_2, and k_3 are sought such that:

$$k_1X_{1i} + k_2X_{2i} + k_3X_{3i} = p_i$$

where p_i is the dry-weight percentage of the i^{th} component. The number of rankings for any species is expressed as a proportion of the total number of observations in any set. As a consequence, the equation is transformed to:

$$k_1X_{1ij} + k_2X_{2ij} + k_3X_{3ij} = p_{ij}$$

where X_{1ij}, X_{2ij}, and X_{3ij} are the proportions of the first, second, and third rankings of the i^{th} component in the j^{th} set, respectively, and p_{ij} is the dry-weight percentage of the i^{th} component in the j^{th} set. Thus, a set of equations are obtained and are solved subject to the condition:

$$k_1 + k_2 + k_3 = 100$$

since it is required that the contributions from the three ranks add to 100 percent in any given set. The multipliers are obtained using the method of the least squares.

In both fescue and ryegrass pastures, three different ways of arranging the data were tested:

1. All available data obtained from one pasture through the growing season were used to calculate the multipliers (RM_1).

2. All available data obtained from each of the four fescue and ryegrass pastures were used to calculate the multipliers (RM_4). Thus, a set of multipliers for each fescue or ryegrass section was obtained.

3. All the available data collected in each of the eight sampling periods were used to calculate the multipliers (RM_8). A set of multipliers for each sampling period in each pasture was thus obtained.

An analysis of variance was run, using the composition percentages obtained with each of the groupings listed above, of the most important species in each pasture (fescue and ryegrass) and the two levels of grazing intensity were used as replicates. The way of calculating the different sets of multipliers showing the smallest experimental error mean square should indicate the most appropriate way of obtaining the multipliers.

Weight-Estimate

This method was presented by Pechanec and Pickford (1937). Yield is estimated in units of green or dry weight of the current growth. If recorded in grams, the weight is estimated to the nearest 10 grams, but for minor species, it is safer to estimate to the nearest 5 grams or even to 1 gram.

Before studying any area, each investigator spends several days in training. This is necessary at the beginning of each season and whenever proceeding to a new type of vegetation. A training period was undertaken in the present study, for three consecutive days, prior to the first sampling period (March 23).

As about 20 percent of the plots where production was estimated were clipped to hand separate, it was possible to develop a regression line for each species which was used as a correction factor for the actual estimates. This is what Wilm, Costello and Klipple (1944) have called double sampling.

The same criteria used in calculating multipliers in the dry-weight-rank method were applied to the weight estimate method:

1. All available data obtained from one pasture through the growing season were used to calculate the regression equations for each species (WE_1).

2. Similarly, all data obtained from each of the four sections within one pasture, were used to calculate the regression equations for each species (WE_4). Thus, four sets of equations were attained.

3. All available data collected in each of the eight sampling periods within each pasture were used to calculate the regression equations or one set for each sampling period (WE_8).

4. Likewise, all data collected in one pasture were used to obtain botanical composition without using any correction.

Botanical composition was calculated from the corrected estimates. The composition percentages, obtained with these four ways of grouping the data for calculating the regression equations were used to run an analysis of variance to determine the correction that showed the smallest experimental error mean square.

Hand Separation

Forty plots per sampling period were clipped in the field and the clippings of each plot were placed in a properly labeled plastic bag. These samples were kept in the freezer until they were hand separated into fescue or ryegrass, subclover and other species. This last group was composed mainly of annual grasses. Each species was weighed and dried at 105°C in an oven for 24 hours. Dry matter percentage was obtained by difference between green and dry weights. Percent composition was calculated on a dry-weight basis.

Constituent Differential

The same plots used in hand separation were used to calculate botanical composition with the constituent differential method.

This method was originally published in 1957 by Cooper *et al.* Basically, botanical composition may be obtained with this method if any constituent percentage, such as dry matter, protein, calcium, etc., is known in the mixture and in each of the species which are a component of the mixture. This method as reported was used in a two-component forage mixture.

As more than two species were found in the pastures used in this study, this method was used with some slight modifications. To calculate the grass percentage of the mixture, the dry matter content of fescue or ryegrass, mixture, and the mixture minus the grass portion, were obtained from the data recorded during the hand separation process, for each sampling period and each section of both pastures. An example of these is shown in Table 5.

Table 5. Data recorded during the hand-separation process in the fifth sampling-period from the fescue pasture lightly grazed by sheep.

Plot	Species (Weight in Grams per 2.4-sq.-ft.)					
	Fescue		Subclover		Other	
	Green	Dry	Green	Dry	Green	Dry
1	1.5	0.2	1.5	0.2	12.5	3.5
2	231.0	67.5	1.5	0.2	5.5	1.5
3	403.0	120.0	4.0	1.0	18.5	6.2
4	98.5	30.0	0.1	0.0	13.0	4.5
5	57.5	15.5	5.0	1.0	14.0	4.5
Total	791.5	233.2	12.1	2.4	63.5	20.2

In the formula proposed by Cooper *et al.* (1957):

$$X = \frac{100(H-G)L}{(L-G)H}$$

where X is the percent dry legume in the dry mixture, H the percent dry matter in the green mixture, G the percent dry matter in the grass, and L the percent dry matter in the green clover, the last three letters were replaced by M, P, and S, respectively, where M is the percent dry matter in the green mixture, P the pooled percent dry matter in the rest of the components of the mixture (or mixture minus species fraction of the total mixture), and S is the percent dry matter in the species whose percentage in the dry mixture is to be calculated. Table 6 presents the values for M, P, and S, obtained from the data shown in Table 5.

Table 6. Dry matter percentages obtained for M, P, and S with data of Table 5, when the percentage of fescue (X) in the mixture is to be determined.

Plot	Mixture (M)	Mixture-Fescue (P)	Fescue (S)
1	25.2	26.4	13.3
2	29.1	24.3	29.2
3	29.9	31.6	29.8
4	30.9	34.3	30.4
5	24.7	23.5	27.0
Mean	29.48	29.67	29.46

Once M, P, and S are known, their values are replaced in the formula:

$$X = \frac{100(M-P)S}{(S-P)M}$$

then $$X = \frac{100(0.2948-0.2967)0.2946}{(0.2946-0.2967)0.2948} = 90.4\%\ \text{fescue}$$

The same procedure was used to calculate the other species group percentages and the subclover percentage was obtained by difference, as the sum of the components should be 100.

Statistical Analysis

In order to decide which criteria to use for calculating the new sets of multipliers in the dry-weight-rank method and for correcting the estimates of the weight estimate method, the error mean squares were compared within each method. The formula:

$$F = \frac{\text{greater error mean square}}{\text{smaller error mean square}}$$

provided the final decision as to whether or not there were significant differences among the error mean squares (Steel and Torrie, 1960).

As the methods were sampled at different intensities, it was decided to set up a 4 x 8 x 2 factorial experiment with those groupings for calculating the sets of multipliers or correcting the estimates whose error mean square was statistically the same as those calculated for hand separation and the constituent differential methods, using as replicates the two levels of grazing intensities, which by using a functional (Appendices 10 and 11) factorial design were found not to be statistically different, at least in the fescue. In these calculations, the percent composition values obtained by the constituent differential method were not included, and the second and third order interactions were considered as error. In every case, all the ryegrass data were transformed by arc sin $\sqrt{\text{percentage}}$. This was not felt to be necessary in the calculations relative to fescue because of the narrow range in these percentages.

Percent composition as obtained with the constituent differential method was not available during the first two sampling periods; and because in the other six sampling periods there was a close agreement between those values obtained by hand separation and the constituent differential, these blanks were filled in with hand separation data.

RESULTS AND DISCUSSION

Fescue Pastures

Multipliers Derived for the Dry-Weight-Rank Method

The sets of multipliers calculated using three different ways of grouping the data are presented in Appendix 1. Mannetje and Haydock (1963) had already pointed out that other sets of multipliers, different from those proposed by them, could be derived to suit higher percentages, but at high levels of dominance, one species is likely to receive almost all the first rankings, therefore, the calculated dry-weight percentage would be very close to the value of the multiplier k_1 and the method would be insensitive. This statement is very well illustrated in Figure 2, where it can be observed that if the same set of multipliers is used throughout the season to calculate the dry matter percentage, then, the values obtained tend to follow a straight line, fairly close to the k_1 multiplier. On the other hand, when a different set of multipliers is used in each sampling period, the percentages obtained also follow very closely the distribution of the k_1 multipliers. As a consequence, in the first case variation among sampling periods is minimized and in the second is maximized. The analyses of variance presented in Table 7 also support this conclusion. Furthermore, these analyses of variance

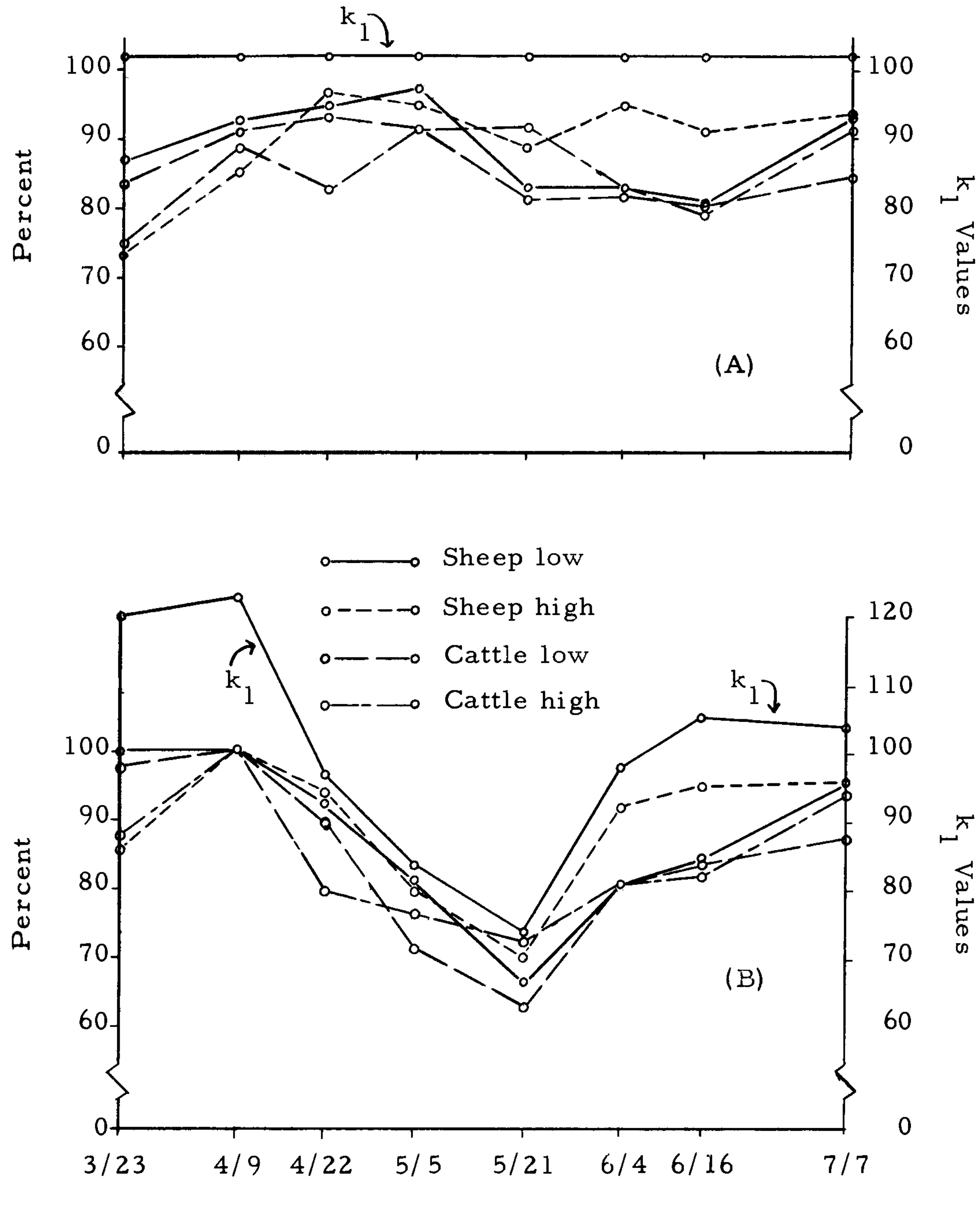

Figure 2. Relationship between the k_1 multipliers and fescue percent obtained with: (A) one set of multipliers, (B) eight sets of multipliers.

Table 7. Analyses of variance of fescue percentages as determined by the dry-weight-rank method using one, four, and eight sets of multipliers.

Source of Variation	d. f.	RM_1		RM_4		RM_8	
		Sum of Squares	Mean Square	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Replicates	1	0.03	0.03	28.13	28.13	0.01	0.01
(Treatments)	(15)	(851.22)	(56.75)	(1445.72)	(96.38*)	(2791.18)	(186.08**)
Kind of livestock	1	128.00	128.00	731.53	731.53**	110.64	110.64
Sampling period	7	644.47	97.07*	657.97	93.99*	2591.50	370.21**
Kind of livestock x sampling period	7	78.75	11.25	56.22	8.03	89.04	12.72
Error	15	443.43	29.56	509.37	33.96	382.13	25.47
Total	31	1294.72		1983.22		3173.32	

* Significant at the 5% level.
** Significant at the 1% level.

show that the variation due to kind of livestock is enhanced when four different sets of multipliers are used to determine botanical composition. This fact, in addition to the discussion already presented, seems to indicate that there is a relationship between the way of grouping the data and the treatment in which they are based. RM_4 was grouped taking into consideration kind of livestock and grazing intensities, therefore, the variation due to these treatments are the highest. RM_8 was grouped on a sampling period basis, and as a consequence, it shows the highest variation due to sampling period of all three ways of grouping the data. The F-test made to determine if there were significant differences among the error mean squares showed that these values, at a 5 percent level of significance, were not statistically different. The F determined was 1.333. It may be concluded that the best way to group the data was the RM_1 method, since the use of one set of multipliers is more practical. Fescue percentages as obtained by these three methods of grouping data are presented in Figures 3 and 4.

Equations Derived for the Weight-Estimate Method

The equations derived using the three ways of grouping the data (WE_1, WE_4, and WE_8) are shown in the Appendix 3. The values of a in the equation $Y' = a + bx$ of the fescue portion of the mixture became larger as the growing season progressed, indicating that the

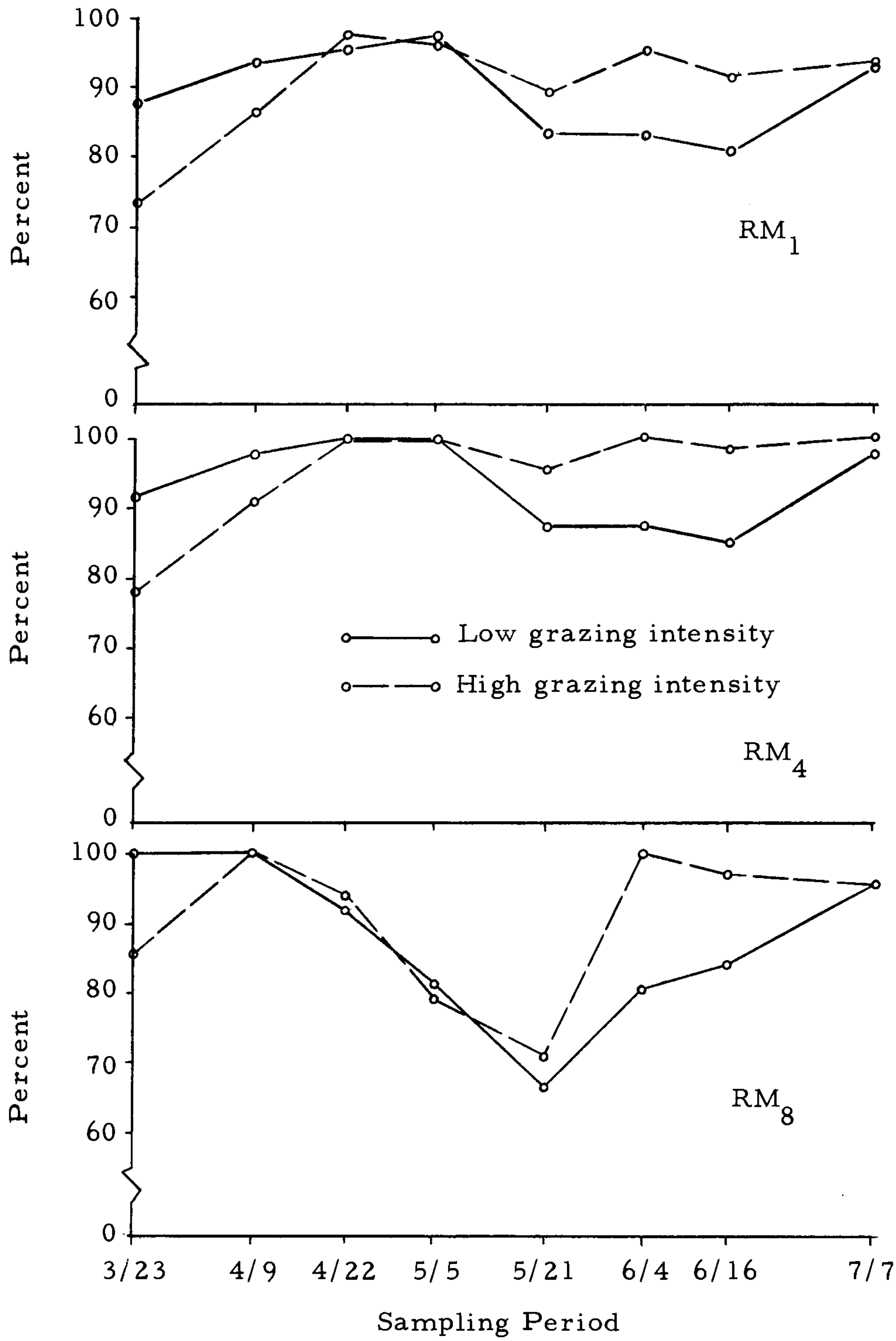

Figure 3. Fescue percentages obtained with three ways of grouping data on the pastures grazed by sheep: (RM_1) using one set of multipliers, (RM_4) using four sets of multipliers, one for each grazing treatment, and (RM_8) using eight sets of multipliers, one for each sampling period.

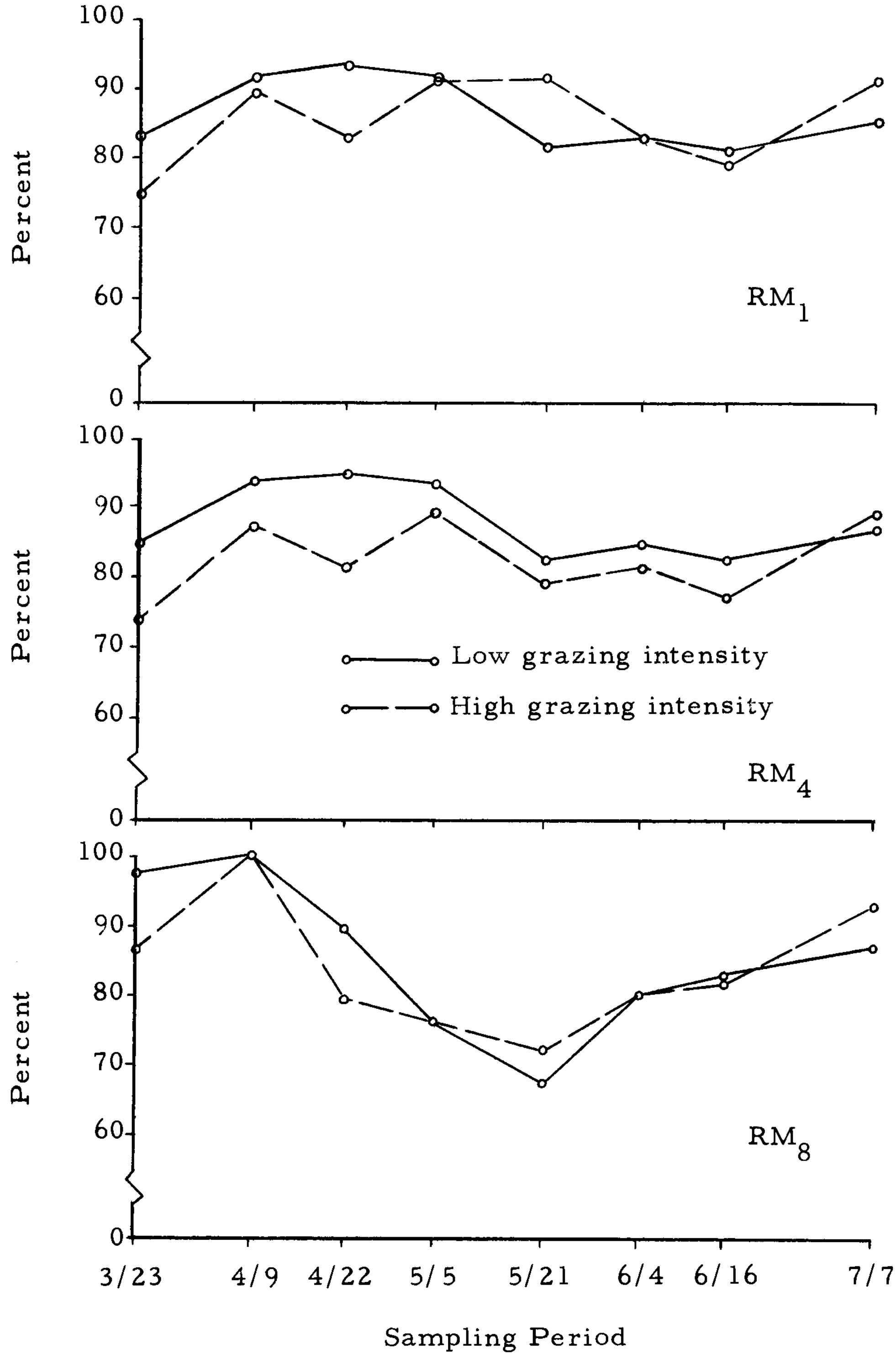

Figure 4. Fescue percentages obtained with three ways of grouping data on the pastures grazed by cattle: (RM_1) using one set of multipliers, (RM_4) using four sets of multipliers, one for each grazing treatment, and (RM_8) using eight sets of multipliers, one for each sampling period.

differences between the weight estimates and the actual weights increased as the yields were increasing along the season (Figure 5). However, the b values of this equation were not greatly affected, although they showed some variation. The rest of the species did not present any particular pattern of variation throughout the growing season, as they never showed marked tendencies to increase or decrease. This fact is demonstrated in Table 8, where the variation due to regression was highly significant for the first two sampling periods, and significant for the rest of them except the last one. Using the WE_1 and WE_4 criteria, a greater constancy was observed and it was determined that in these cases the variation due to regression was highly significant, except for that in the fescue pasture lightly grazed by cattle, where the variation due to regression was significant at the 5 percent level.

The analyses of variance of fescue percentages as determined by the weight-estimate method, using none, one, four, and eight sets of equations, are shown in Table 9. In general, almost the same conclusions were attained, regardless of the way of grouping the data. The most striking difference was that when WE_1 or WE_8 was applied, highly significant differences were obtained for replicates, whereas when WE_0 or WE_4 was used, the replicates were not statistically different. For these reasons, and the fact that it showed the smallest error mean square, which was significantly

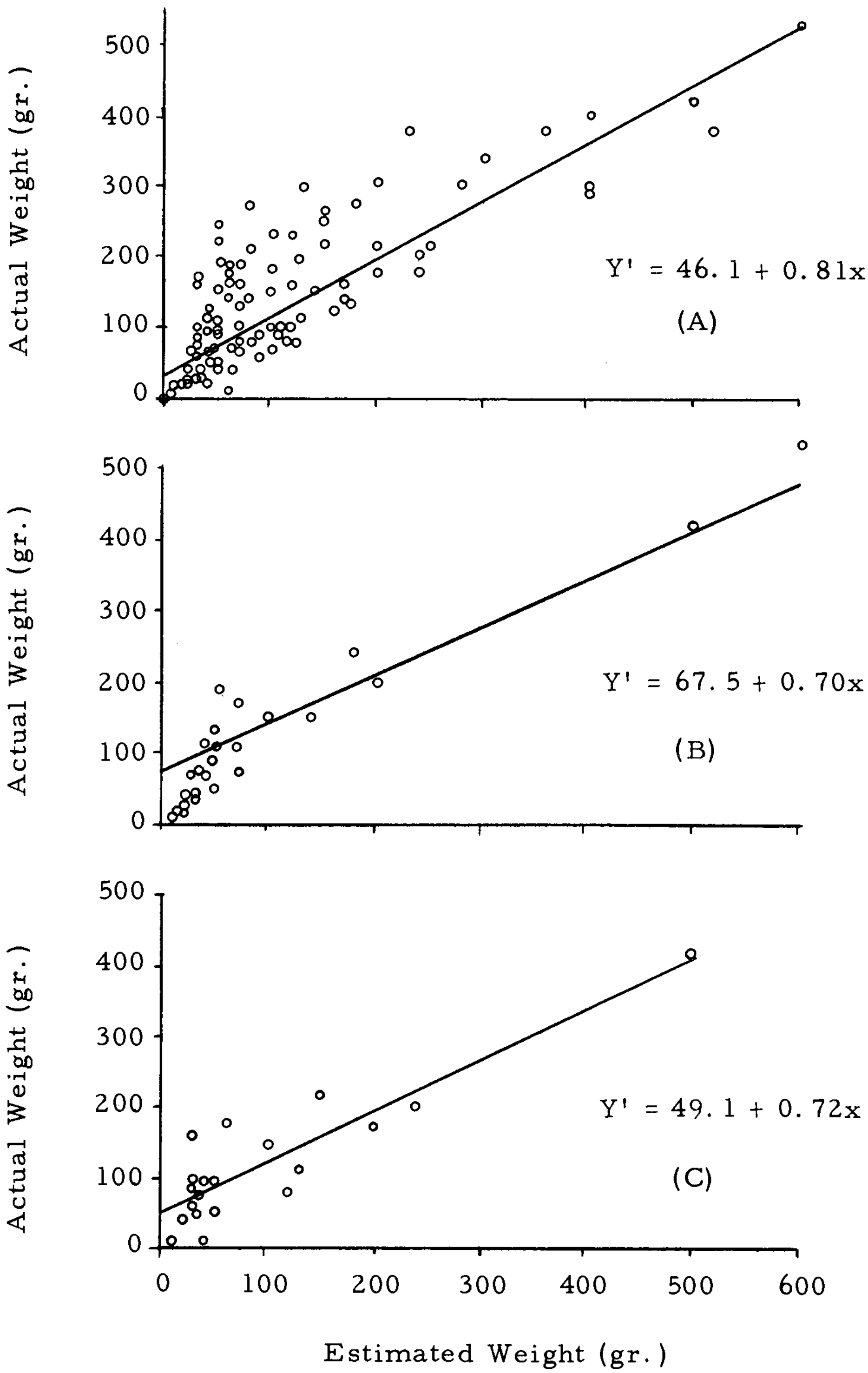

Figure 5. Regression equations for fescue: (A) a simple regression equation WE_1, (B) with four regression equations in the pasture grazed by sheep at a low intensity, and (C) with eight equations WE_8, but illustrated only in the fourth sampling period.

Table 8. Fescue regression sum of squares calculated using three ways of grouping the data.

Ways of Grouping	Regression Sum of Squares	s^2	n	Grazing Intensity	Pasture
WE_1	1,157,018.32**	16,602.95	160	Low and High	all
WE_4	158,218.67*	23,537.66	40	Low	Fescue-Cattle
WE_4	146,188.28**	6,862.45	40	High	Fescue-Cattle
WE_4	347,539.68**	32,383.03	40	Low	Fescue-Sheep
WE_4	403,093.00**	10,218.23	40	High	Fescue-Sheep
WE_8	75,270.29**	6,794.71	20	Low and High	all
WE_8	115,068.07**	4,132.33	20	Low and High	all
WE_8	75,860.66*	10,257.16	20	Low and High	all
WE_8	129,005.36*	17,290.97	20	Low and High	all
WE_8	225,815.89*	31,075.89	20	Low and High	all
WE_8	219,614.58*	27,277.40	20	Low and High	all
WE_8	244,036.17*	31,907.52	20	Low and High	all
WE_8	62,984.00	21,627.39	20	Low and High	all

* Significant at the 5% level.
** Significant at the 1% level.

Table 9. Analyses of variance of fescue percentages as determined by the weight-estimate method, using none, one, four, and eight sets of equations.

Source of Variation	d. f.	WE_0 Sum of Squares	WE_0 Mean Square	WE_1 Sum of Squares	WE_1 Mean Square
Replicates	1	46.32	46.32	175.19	175.19**
(Treatments)	(15)	(1589.22)	(105.95**)	(1159.13)	(77.27**)
Kind of livestock	1	524.07	524.07**	270.29	270.29**
Sampling period	7	587.41	83.92*	605.50	86.50**
Kind of livestock x sampling period	7	476.74	68.10*	283.34	40.48*
Error	15	310.82	20.72	192.46	12.83
Total	31	1946.34		1527.38	
		WE_4		WE_8	
Replicates	1	16.53	16.53	136.13	136.13**
(Treatments)	(15)	(1568.97)	(104.60**)	(898.72)	(59.91**)
Kind of livestock	1	780.13	780.13**	247.53	247.53**
Sampling period	7	483.59	69.08**	435.79	62.25**
Kind of livestock x sampling period	7	305.25	43.61**	215.60	30.80
Error	15	141.47	9.43	205.37	13.69
Total	31	1726.97		1240.22	

* Significant at the 5% level.
** Significant at the 1% level.

different from the WE_0 error mean square, it was concluded that the WE_4 method of grouping the data was the most suitable one. However, when botanical composition is the primary objective, there is no apparent need to correct the weight estimates, and the estimation of the percentage of each species in the mixture might be a better approach. Percent composition as obtained using none, one, four, and eight sets of equations per species is presented in Appendix 4.

Ryegrass Pastures

Multipliers Derived for the Dry-Weight-Rank Method

The multipliers obtained from the data collected from the ryegrass pastures are presented in Appendix 1. In these pastures, the ways of grouping the data did not affect the variation due to sampling period. In Figure 6, it can be observed that the shape of the curves are not particularly different, regardless of the method used for grouping the data. The analyses of variance in Table 10 show that the same conclusions are attained using one, four, or eight sets of multipliers. No significant differences were detected due to kind of livestock and the interaction of kind of livestock x sampling period. The variation due to sampling periods was significant at the 1 percent level in each case, because the botanical composition determined at each of the sampling periods showed a very definite trend

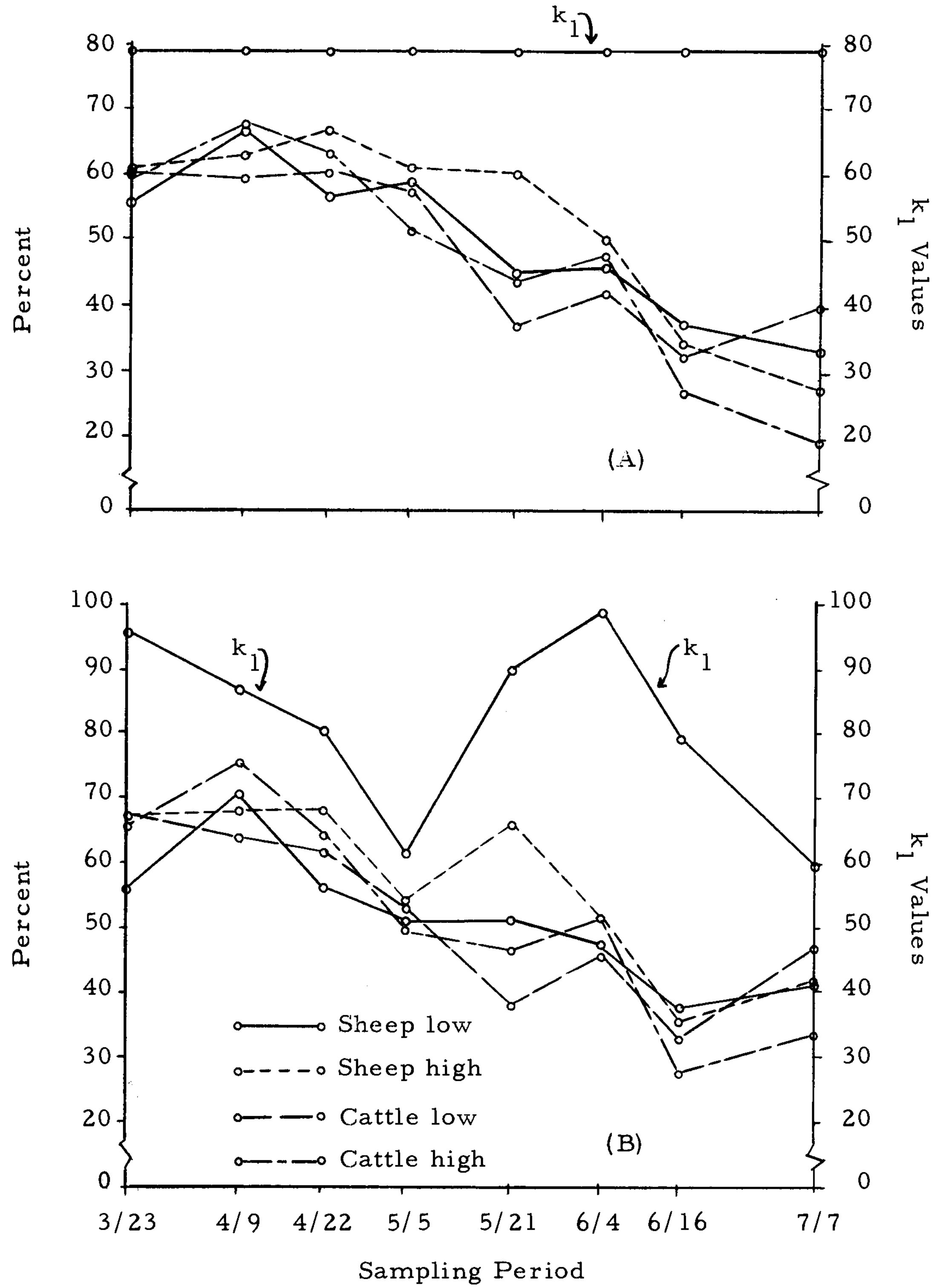

Figure 6. Relationship between the k_1 multipliers and ryegrass percent obtained with: (A) one set of multipliers, (B) eight sets of multipliers.

Table 10. Analyses of variance of ryegrass percentages as determined by the dry-weight-rank method using one, four, and eight sets of multipliers.

Source of Variation	d. f.	RM_1 Sum of Squares	RM_1 Mean Square	RM_4 Sum of Squares	RM_4 Mean Square	RM_8 Sum of Squares	RM_8 Mean Square
Replicates	1	4.96	4.96	23.12	23.12	22.11	22.11
(Treatments)	(15)	(1747.03)	(116.47**)	(1446.10)	(96.41**)	(1509.24)	(100.62**)
Kind of livestock	1	24.75	24.75	4.06	4.06	17.11	17.11
Sampling period	7	1674.54	239.22**	1374.68	196.38**	1399.39	199.91**
Kind of livestock x sampling period	7	47.74	6.82	67.36	9.62	92.72	13.24
Error	15	213.33	14.22	197.85	13.19	149.88	9.99
Total	31	1965.32		1667.07		1681.23	

* Significant at the 5% level.
** Significant at the 1% level.

(Appendix 5). Ryegrass began to decline as the season progressed while the other-species group (primarily annual and a few perennial grasses) increased, regardless of the kind of livestock and grazing intensity applied. The error mean squares were found not to be statistically different and the F value determined in this case was 1. 423.

With these considerations, it is difficult to determine which is the best way of grouping the data, and from the point of view of the time spent in calculating the different sets of multipliers, although time was not recorded, it might be stated that there were not large differences among the ways of grouping the data. It is evident that the use of one set of multipliers would be much more practical, since the use of a different set for each sampling period involves extra calculations.

Equations Derived for the Weight-Estimate Method

The equations derived for the ryegrass pastures are presented in Appendix 6. In the ryegrass and other-annuals portion, the $\underline{a}$ values as well as the $\underline{b}$ values determined were variable, because of the difficulty in estimating weight of species at certain developmental stages, especially when ryegrass seed had shattered. Subclover and other perennial grasses did not show as much variation because they were present in lesser amounts. The variation due to regression, which is presented in Table 11 indicates that apparently when a high number of observations is made, the chances of obtaining significant values for regression sum of squares increase. Highly significant values were obtained when the number of observations were as high as 40 or 160, which corresponds to WE_4 and WE_1, respectively. When 20 observations were made, no significant differences were detected, and as a consequence, the WE_8 method of grouping the data shows the smallest variation and error mean square in the analyses of variance shown in Table 12. It seems probable that an increase in the number of observations or a more intense training in estimating production would be two possible ways of improving the weight-estimate approach.

In Figure 7, examples of scatter diagrams, in which regression equations are used to correct estimates, indicate that the poorest estimates are associated with the highest actual production.

Evaluation of Botanical Composition

Fescue Pastures

In these pastures, an analysis of variance was run only for the fescue component of the mixture, since percentages obtained by the four methods used in this study as presented in Table 13 were found generally to be in the range of 75 to 95 percent.

Table 11. Ryegrass regression sum of squares calculated using three ways of grouping the data.

Ways of Grouping	Regression Sum of Squares	s^2	n	Grazing Intensity	Pasture
WE_1	93,841.13**	1,190.22	160	Low and High	all
WE_4	13,679.34*	1,954.28	40	Low	Ryegrass-Cattle
WE_4	24,498.11**	1,574.42	40	High	Ryegrass-Cattle
WE_4	18,780.99**	1,045.96	40	High	Ryegrass-Sheep
WE_4	22,121.44**	1,282.85	40	Low	Ryegrass-Sheep
WE_8	850.43	324.97	20	Low and High	all
WE_8	936.93	269.63	20	Low and High	all
WE_8	5,378.27	1,309.56	20	Low and High	all
WE_8	2,763.57	1,052.83	20	Low and High	all
WE_8	12,448.17	3,760.67	20	Low and High	all
WE_8	33,796.50*	4,271.83	20	Low and High	all
WE_8	4,829.79	1,432.02	20	Low and High	all
WE_8	5,400.60*	722.64	20	Low and High	all

* Significant at the 5% level.
** Significant at the 1% level.

Table 12. Analyses of variance of ryegrass percentages as determined by the weight-estimate method, using none, one, four, and eight sets of equations.

Source of Variation	d. f.	WE_0 Sum of Squares	WE_0 Mean Square	WE_1 Sum of Squares	WE_1 Mean Square
Replicates	1	75.33	75.33	23.46	23.46
(Treatments)	(15)	(4908.44)	(327.23**)	(7191.46)	(479.43**)
Kind of livestock	1	7.70	7.70	23.65	23.65
Sampling period	7	4791.66	684.52**	6807.91	972.56**
Kind of livestock x sampling period	7	109.08	15.58	310.10	44.30
Error	15	422.42	28.16	1749.27	116.62
Total	31	5406.19		8964.19	
		WE_4		WE_8	
Replicates	1	49.01	49.01	51.77	51.77*
(Treatments)	(15)	(5854.10)	(390.27**)	(2747.69)	(183.18**)
Kind of livestock	1	205.04	205.04*	71.10	71.10**
Sampling period	7	5535.65	790.81**	2547.42	363.92**
Kind of livestock x sampling period	7	113.41	16.20	129.17	18.45
Error	15	369.01	24.60	114.90	7.66
Total	31	6272.12		2914.36	

* Significant at the 5% level.
** Significant at the 1% level.

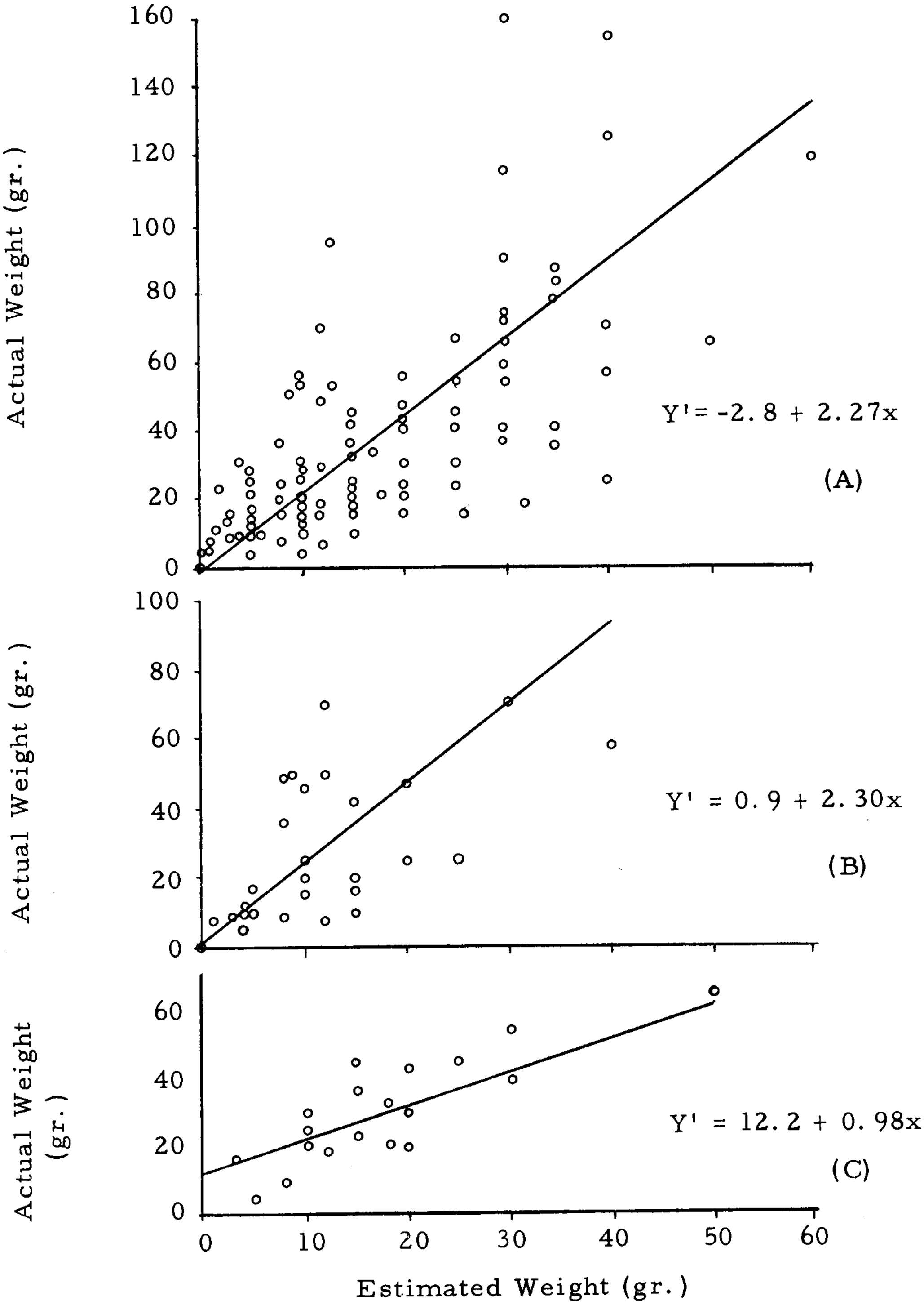

Figure 7. Regression equations for ryegrass: (A) with a single regression equation WE_1, (B) with four equations in the pasture grazed by sheep at a low intensity, and (C) with eight regression equations in the fourth sampling period.

Table 13. Fescue percentages[1/] as obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

Kind of Live-stock	Sam-pling Period	Replicates (Grazing Intensity)								Total	Mean
		I (Low)				II (High)					
		RM_4	WE_0	HS	CD	RM_4	WE_0	HS	CD		
Sheep	1	91.5	84.5	89.0	89.0	78.0	89.0	97.0	97.0	715.0	89.4
	2	98.5	99.5	99.5	99.5	91.0	99.0	98.0	98.0	783.0	97.9
	3	100.0	99.0	98.0	98.0	100.0	99.5	97.5	97.5	789.5	98.7
	4	100.0	95.0	98.5	98.5	100.0	96.5	97.5	98.5	784.5	98.1
	5	87.5	92.0	91.0	92.0	95.5	97.0	99.0	99.0	753.0	94.1
	6	87.5	93.0	97.5	95.0	100.0	92.5	96.5	96.5	758.5	94.8
	7	85.0	92.5	92.0	92.0	98.5	96.0	98.5	98.5	753.0	94.1
	8	98.0	81.5	93.5	93.5	100.0	96.5	98.5	98.5	760.0	95.0
Cattle	1	84.5	95.0	95.0	95.0	73.5	89.5	92.0	92.0	716.5	89.6
	2	93.0	95.0	93.0	93.0	87.0	97.5	94.5	94.5	747.5	93.4
	3	95.0	90.5	92.5	92.5	81.0	89.0	85.0	85.5	711.0	88.9
	4	93.0	81.0	93.5	94.0	89.0	89.0	74.5	74.0	688.5	86.1
	5	82.5	78.5	81.5	81.5	79.0	84.5	87.0	87.0	661.0	82.6
	6	84.5	74.5	78.5	78.5	81.0	76.0	68.5	69.0	610.0	76.3
	7	82.5	80.0	85.5	85.5	77.0	71.0	71.0	71.0	623.5	77.9
	8	86.5	87.5	87.0	87.0	89.0	95.0	93.0	93.0	718.5	89.7
	Mean	90.6	88.7	91.6	91.5	88.7	91.1	90.5	90.6		

1/ Rounded off to the nearest 0.5 percent.

The analysis of variance presented in Appendix 7 indicates that there were not significant differences due to methods. Therefore, the selection of any of these methods should be based on some of their inherent characteristics, such as: (1) time involved in collecting the data, (2) personal ability to use some of these methods, (3) kind of data needed, and (4) whether the main interest is precision within sampling dates or over the mean seasonal botanical composition (Figure 8).

Although time spend in sampling with each method was not recorded, because the methods were being applied simultaneously, it can be said that the dry-weight-rank was the fastest method, weight-estimate was the second, the constituent differential was the third, and hand separation was the most time consuming method.

Some of these methods, such as the dry-weight-rank, which might be referred to as subjective ones, require previous training for efficient application. This fact makes this method strongly dependent upon the person who is using them.

Also, if production as well as species composition data are needed, the dry-weight-rank method is inadequate and another method becomes essential.

The decision as to which method to use also depends on how precise a measurement of percent composition within any sampling period is required. As shown in Figure 8, although analysis of variance did not indicate significant variation due to the interaction of sampling x methods, it is apparent that there are some sampling periods such as March 23, April 9, and May 7 in which the dry-weight-rank method showed the largest differences.

The variation of the fescue percentages due to sampling periods was found to be highly significant ($LSD_{0.01}$ = 4.2 percent). As the season progressed, annual and perennial grasses, and clover to some extent, began to grow and, thus, the fescue percentage began to decrease until late June; when the annual species dried, it started to increase again. The trend of the average fescue percentages are presented in Figure 9.

Kind of livestock was found to be one of the major sources of variation in this analysis of variance. It was shown that sheep and cattle graze different species, thus, each of these kind of livestock affects in a particular way the botanical composition of the fescue pastures. Cattle grazed preferentially the fescue plants and some of the "other species" thus decreasing fescue percentage. Sheep, on the contrary, heavily grazed the annual grasses, the little clover that was present, and the fescue only lightly except after seed formation and the green leaves in summer.

Figure 10 shows the mean fescue percentages as determined in the sheep and cattle pastures. The $LSD_{0.01}$ for the mean seasonal fescue percentage was 3.4 percent.

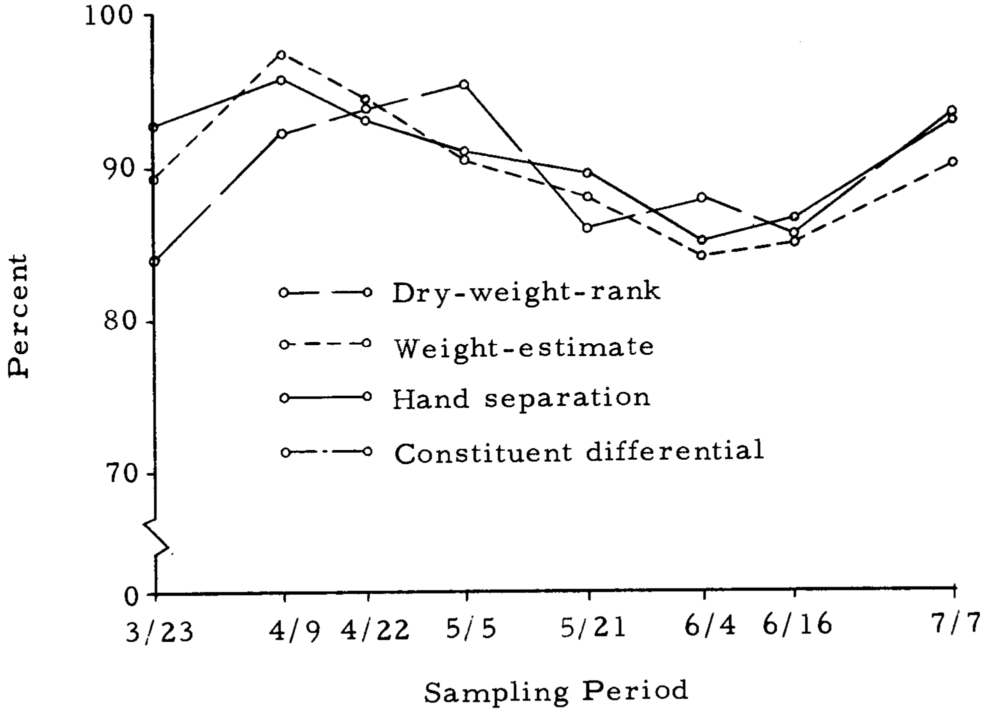

Figure 8. Average fescue percentages as determined by dry-weight-rank, weight-estimate, hand separation, and constituent differential methods. These last two methods are shown in the same line in this figure, as their values were very close together.

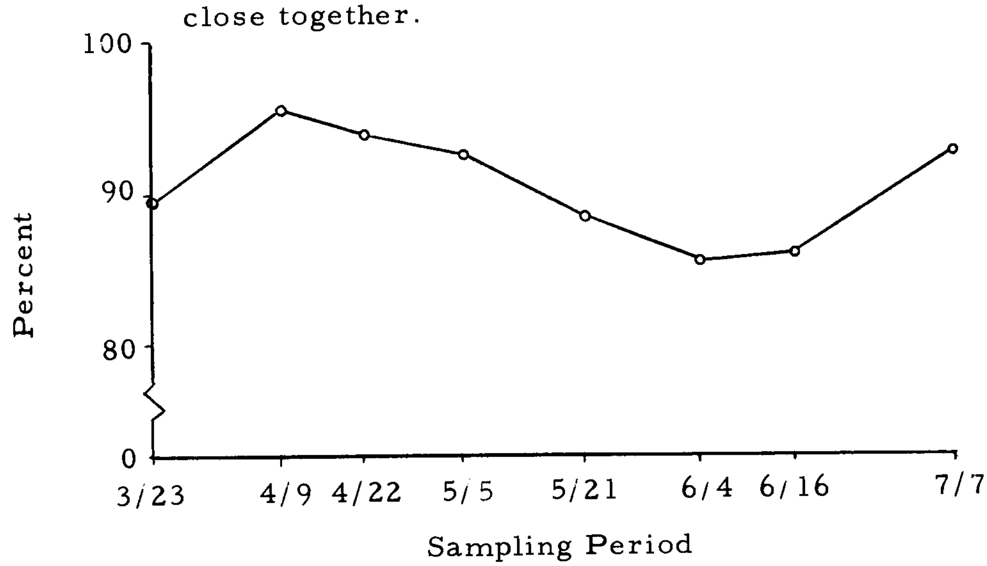

Figure 9. Seasonal trend of the average fescue percentage.

Replicates (or grazing intensity) were not statistically different on a seasonal mean basis, that is, the influence of a heavy stocking rate in the fescue percentage was the same as the influence of a lighter stocking rate (Table 4), but as will be discussed later, some differences were found within sampling periods. Figure 11 presents the mean fescue percentages under heavy and light grazing intensity.

There were no significant variations with the methods used. This fact supports the contention that any method was equally effective in determining botanical composition in the fescue pastures.

Sampling period showed a significant interaction with kind of livestock ($LSD_{0.01}$ = 6.0 percent). The reason for the significance may well be explained on the basis of the differential influence of sheep and cattle on the fescue percentage which has already been discussed. An interaction between sampling period and grazing intensity was also detected at a 5 percent level ($LSD_{0.05}$ = 4.6 percent), which is shown in Figure 11. In this figure, the low grazing intensity data follow very close those of Figure 9, indicating that there is little effect of grazing intensity on the fescue percentage. High intensity grazing produced some differences in botanical composition early and late in the season.

Another interaction that deserves some attention is grazing intensity x kind of livestock, which was significant at the 1 percent level ($LSD_{0.01}$ = 3.4 percent), and is presented in Table 14.

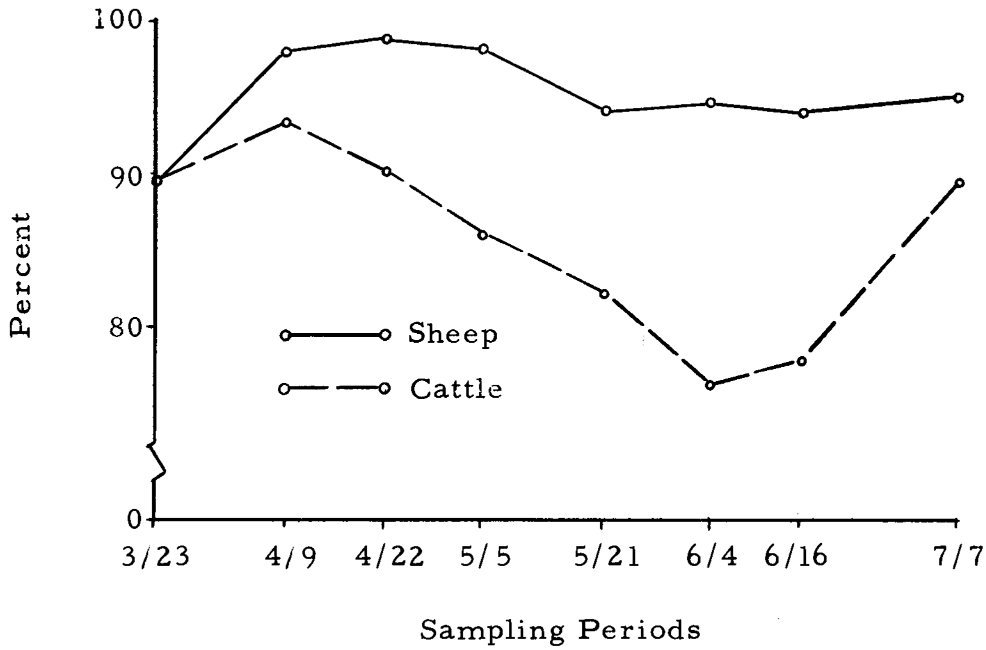

Figure 10. Mean fescue percentages in sheep and cattle pastures.

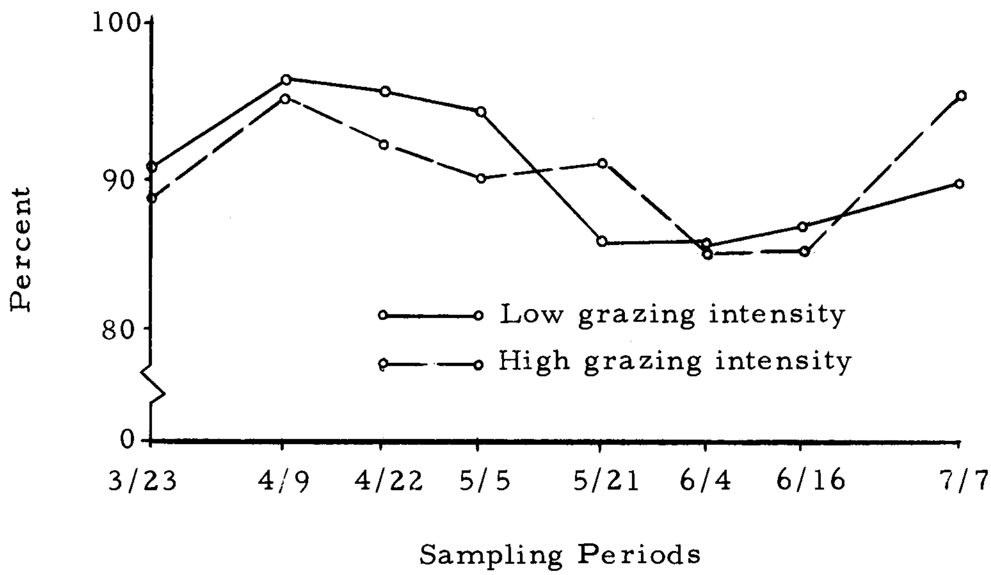

Figure 11. Mean fescue percentages obtained for the high and low grazing intensity treatments.

Table 14. Mean fescue percentages[1/] as affected by the grazing intensity x kind of livestock interaction.

Kind of Livestock	Grazing Intensity	
	Low	High
Sheep	94.0	96.5
Cattle	87.5	83.0

1/ Rounded off to the nearest 0.5 percent.

On basis of these results, it appears that as grazing intensity is increased, sheep cause an increase in fescue percentage whereas cattle stocking results in a decrease (Figure 12).

The second order interaction, kind of livestock x sampling period x method, did not show any influence in the fescue percentage.

The subclover portion of these pastures remained fairly constant but unusually low throughout the season (Table 15). Since this species was present in such low percentages (in the range of 0 to 4 percent), no definite statements can be made regarding the influence of some of the factors studied. It is apparent that any of the methods could be used to determine subclover percentage and, also, that sheep seem to graze this species more heavily than cattle, (Figure 13).

The other species (Table 16), because of the low amounts of subclover, could be considered as the reciprocal of fescue percentage.

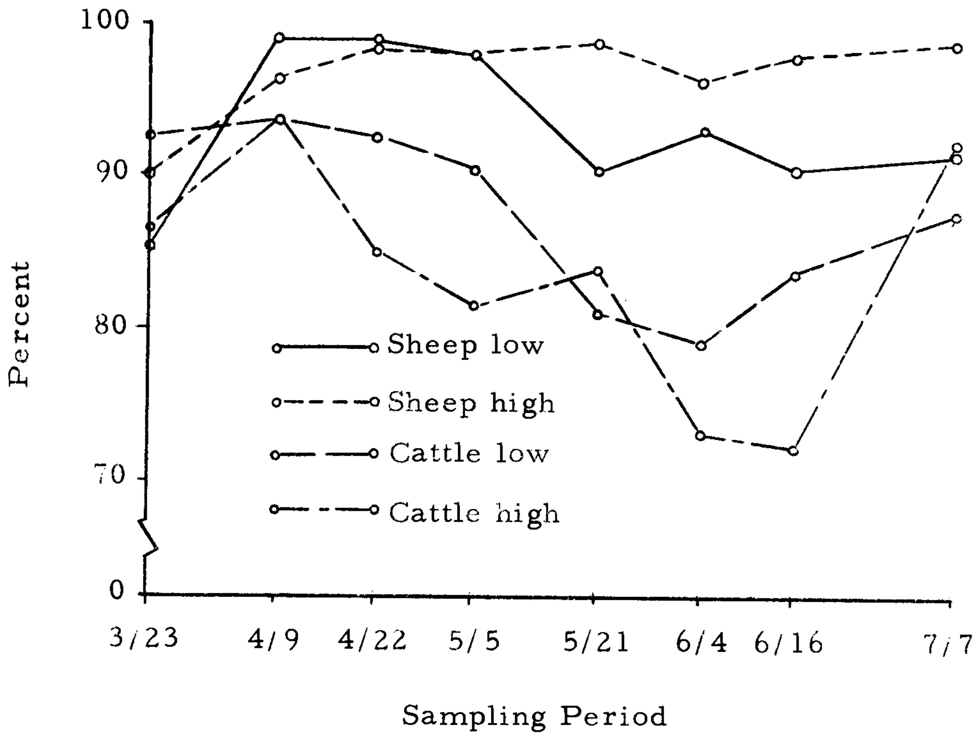

Figure 12. Mean fescue percentages resulting from sheep and cattle grazing at high and low intensities.

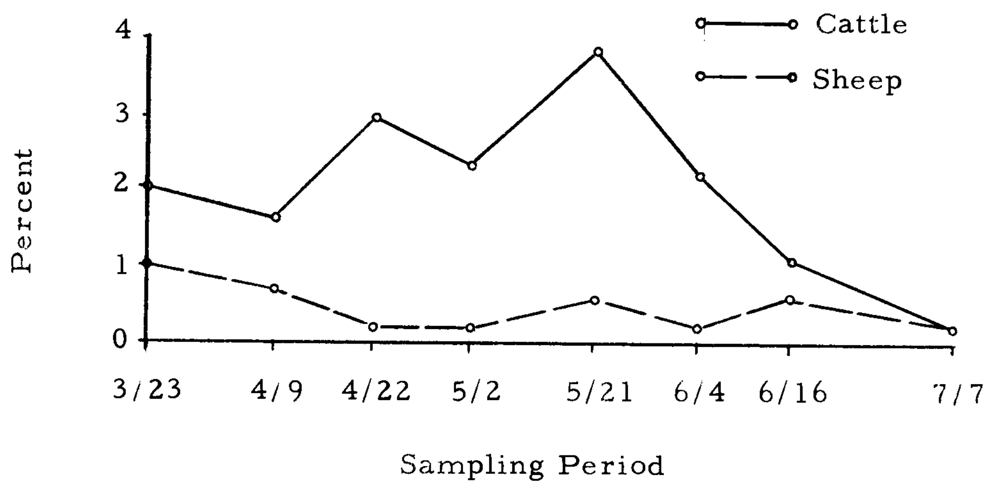

Figure 13. Mean subclover percentage in the fescue pastures as influenced by cattle and sheep grazing.

Table 15. Subclover percentages[1/] in the fescue pastures as obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

Kind of Live-stock	Sam-pling Period	Replicates (Grazing Intensity)								Total	Mean
		I (Low)				II (High)					
		RM_4	WE_0	HS	CD	RM_4	WE_0	HS	CD		
	1	2.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	8.0	1.0
	2	0.0	0.5	0.5	0.5	1.5	0.5	1.0	1.0	5.5	0.7
	3	0.0	0.5	0.0	0.0	0.0	0.5	0.5	0.5	2.0	0.2
Sheep	4	0.0	0.5	0.5	0.0	0.0	0.5	0.0	0.5	2.0	0.2
	5	0.0	2.0	1.0	0.5	0.5	0.5	0.0	0.0	4.5	0.6
	6	0.5	1.0	0.0	0.0	0.0	0.5	0.0	0.0	2.0	0.2
	7	1.5	0.5	0.5	0.5	1.5	0.5	0.0	0.0	5.0	0.6
	8	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.5	1.5	0.2
	1	1.0	2.5	2.5	2.5	1.0	2.5	2.0	2.0	16.0	2.0
	2	3.0	1.0	0.5	0.5	5.0	0.5	1.0	1.0	12.5	1.6
	3	5.0	2.0	1.5	1.5	3.0	1.5	4.5	4.0	23.0	2.9
Cattle	4	2.5	5.5	1.5	0.5	2.5	2.0	2.0	2.0	18.5	2.3
	5	0.0	7.5	3.5	3.5	1.0	6.0	4.5	4.5	30.5	3.8
	6	0.0	3.0	2.0	2.0	1.0	3.5	3.0	3.0	17.5	2.2
	7	0.0	2.0	0.5	0.5	1.0	2.0	1.5	1.5	9.0	1.1
	8	0.0	0.0	0.0	0.5	0.5	0.5	0.0	0.0	1.5	0.2
	Mean	1.0	1.6	1.0	0.9	1.2	1.4	1.3	1.4		

1/ Rounded off to the nearest 0.5 percent.

Table 16. Other species percentages[1/] (annual and perennial grasses) in the fescue pastures as obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

Kind of Livestock	Sampling Period	Replicates (Grazing Intensity)								Total	Mean
		I (Low)				II (High)					
		RM_4	WE_0	HS	CD	RM_4	WE_0	HS	CD		
Sheep	1	6.5	14.5	10.0	10.0	22.0	10.0	6.5	6.5	86.0	10.7
	2	1.5	0.0	0.5	0.5	7.5	0.5	1.0	1.0	12.5	1.6
	3	0.0	0.5	2.0	2.0	0.0	0.0	2.0	2.5	9.0	1.1
	4	0.0	4.5	2.0	1.0	0.0	3.0	1.0	1.0	12.5	1.6
	5	12.5	6.0	8.0	8.0	4.0	2.5	1.0	0.5	42.5	5.3
	6	12.0	6.0	4.5	4.5	0.0	7.0	3.5	3.5	41.0	5.1
	7	13.5	7.0	7.5	7.5	0.0	3.5	1.5	1.5	42.0	5.2
	8	1.5	18.5	6.0	5.5	0.0	3.5	1.0	1.5	37.5	4.7
Cattle	1	14.5	2.5	2.5	2.5	25.5	8.0	7.0	7.0	69.5	8.7
	2	3.5	4.0	6.5	6.5	8.0	2.0	4.5	4.5	39.5	4.9
	3	0.0	4.0	6.0	6.0	16.0	9.5	10.5	10.5	62.5	7.8
	4	4.0	13.5	5.5	5.0	8.5	9.0	24.0	23.5	93.0	11.6
	5	17.5	14.0	15.0	15.0	20.0	9.5	8.0	8.0	107.0	13.4
	6	15.5	22.5	19.5	19.5	18.0	20.5	28.0	28.5	172.0	21.5
	7	17.5	18.5	14.0	14.0	22.0	27.0	27.5	27.5	168.0	21.0
	8	13.5	12.5	12.5	13.0	10.5	4.5	7.0	7.0	80.5	10.1
	Mean	8.3	9.3	7.6	7.5	10.1	7.5	8.4	8.4		

1/ Rounded off to the nearest 0.5 percent.

Therefore, the analysis of variance for fescue should be applicable to this portion of the mixture. The methods mean, shown in Table 16, were not strikingly different, and as a consequence, any of the methods studied would give comparable results. The only important effect observed was the way in which sheep and cattle utilize this fraction of the mixture. As shown in Figure 14, sheep did graze much heavier than cattle, thus, reducing its percentage in a manner similar to subclover.

Ryegrass Pastures

The analysis of variance calculated with the arc $\sin\sqrt{\text{percent}}$ transformed data presented in Table 17 is shown in Appendix 8[3/]. All four main treatments showed significance at the 1 percent level, except kind of livestock, which was significant at 5 percent.

Methods were found to be significantly different ($LSD_{0.01}$ = 2.9 degrees). The dry-weight-rank method showed the lowest mean, hand separation and constituent differential showed the highest, and the mean obtained by applying the weight-estimate was intermediate

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3/ It should be clearly understood that the interpretation of the analysis of variance are based on the arc $\sin\sqrt{\text{percentage}}$ transformation in the ryegrass pastures, therefore, the LSD values calculated in each case are not percentages, but degrees.

Table 17. Ryegrass percentages[1/] as obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

Kind of Livestock	Sampling Period	Replicates (Grazing Intensity)								Total	Mean
		I (Low)				II (High)					
		RM_1	WE_0	HS	CD	RM_1	WE_0	HS	CD		
Sheep	1	55.5	84.5	79.0	79.0	61.0	84.5	89.5	89.5	622.5	77.8
	2	66.5	73.5	70.0	70.0	64.0	71.5	68.5	68.5	552.5	69.1
	3	56.5	67.5	62.5	65.0	68.0	76.5	68.5	68.5	533.0	66.6
	4	59.0	59.5	36.5	36.0	62.5	69.5	65.5	65.5	454.0	56.7
	5	45.0	49.5	62.0	62.0	61.5	60.5	61.0	61.0	462.5	57.8
	6	46.0	19.5	36.5	38.0	51.5	51.5	68.0	69.0	380.0	47.5
	7	37.5	29.0	39.5	39.0	35.5	41.5	51.0	51.5	324.5	40.6
	8	33.0	27.5	54.5	55.0	26.5	14.5	26.5	26.5	264.0	33.0
Cattle	1	60.5	80.5	82.0	82.0	60.0	89.0	87.5	87.5	629.0	78.6
	2	60.0	76.0	56.0	56.0	69.0	76.0	80.0	80.0	553.0	69.1
	3	61.5	63.0	49.5	50.0	64.5	66.5	69.5	70.0	494.5	61.8
	4	58.5	54.0	53.0	54.5	52.5	54.5	58.5	58.5	444.0	61.3
	5	38.5	38.5	52.0	52.0	45.0	51.5	50.5	49.5	377.5	47.2
	6	43.0	36.0	35.0	35.0	49.0	44.0	60.0	58.5	360.5	45.1
	7	32.5	29.0	19.5	19.0	28.0	40.5	35.5	36.0	240.0	30.0
	8	41.0	36.0	42.0	42.0	20.0	16.0	51.5	51.5	300.0	37.5
	Mean	49.6	51.5	51.8	52.8	51.2	56.7	62.0	62.0		

1/ Rounded off to the nearest 0.5 percent.

(Table 18). These results indicate that the dry-weight-rank method clearly underestimated the ryegrass percentage. No definite statement can be made about the weight-estimate as it is in an intermediate position. It may belong to the same group as the dry-weight-rank method or the same group as hand separation and the constituent differential methods; it may even be in a group by itself (Li, 1964). Only further experimental evidence will clarify the situation. The constituent differential proved to be an accurate method, as it gave results similar to those obtained by hand separation (Figure 15).

Sampling periods were shown to be significantly different ($LSD_{0.01}$ = 5.7 degrees). There was a clear decreasing trend in ryegrass as the season progressed, due largely to unfavorable climatic conditions which permitted the establishment of some annual grasses (Figure 16).

Although the difference in ryegrass percentage brought about by the kind of livestock was not important throughout the growing season, a significant difference at the 5 percent level was determined ($LSD_{0.05}$ = 1.5 degrees), indicating that cattle seemed to graze ryegrass a little heavier, on the average, than sheep (Figure 17). Bedell (1966) arrived at a similar conclusion working in the same pastures using esophageal fistula technique to determine dietary preferences.

Grazing intensities were found to be significantly different

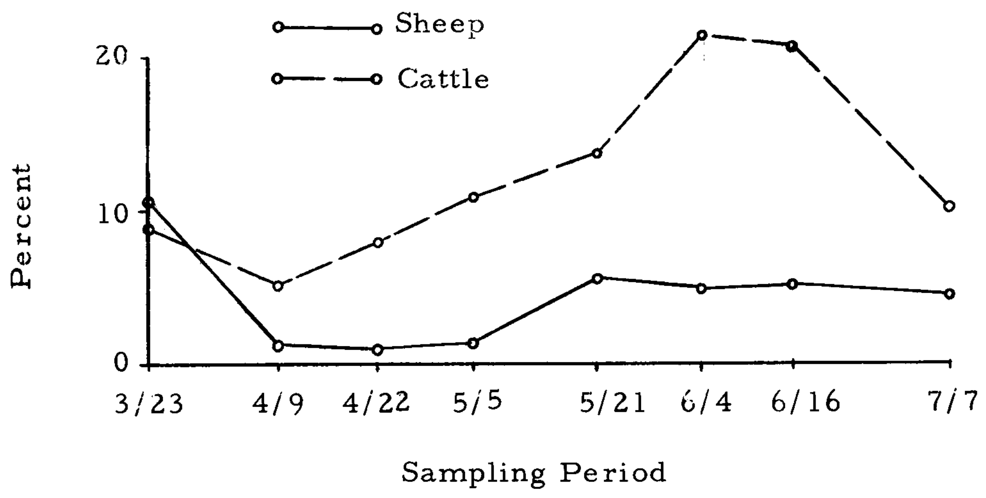

Figure 14. Mean other species percentage in the fescue pastures as influenced by sheep and cattle grazing.

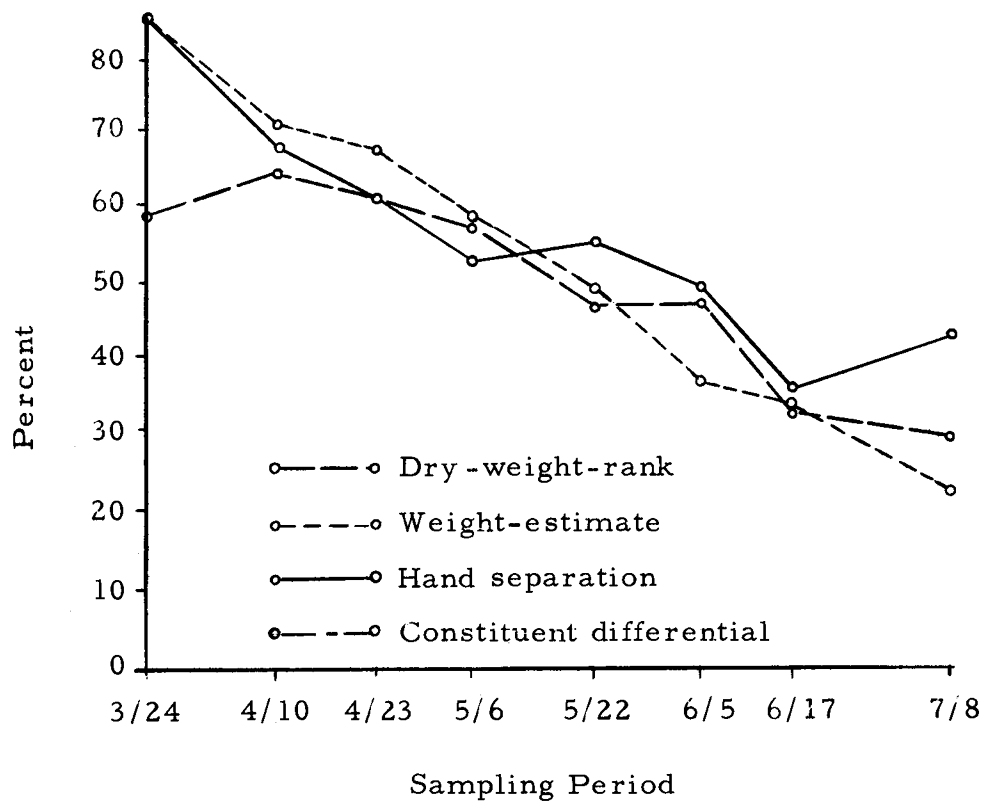

Figure 15. Mean ryegrass percentages obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods. These last two methods are shown in the same line in this figure, as their values were very close together.

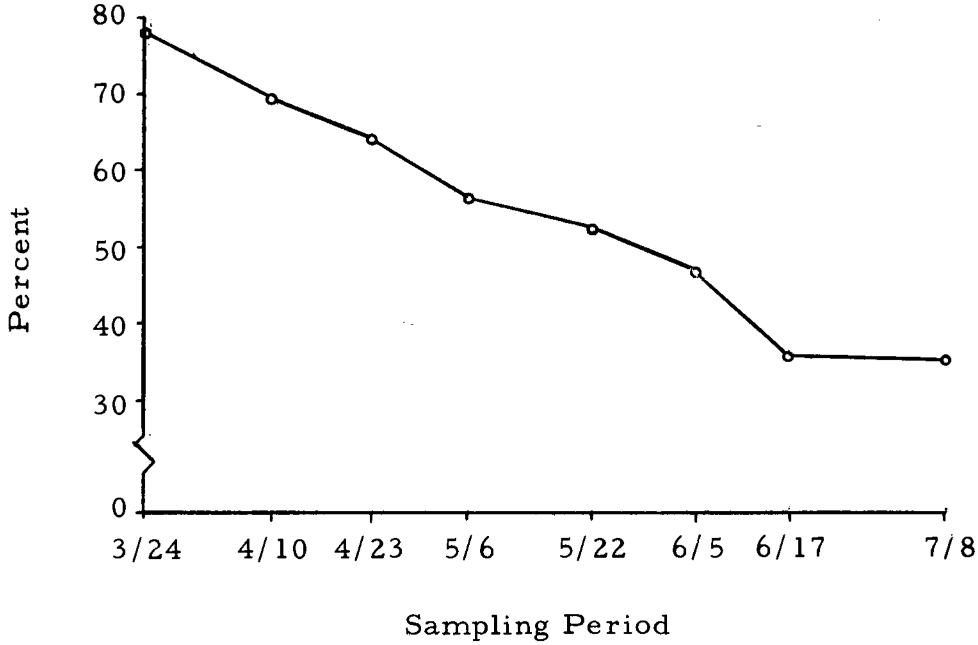

Figure 16. Mean seasonal trend of ryegrass percentages.

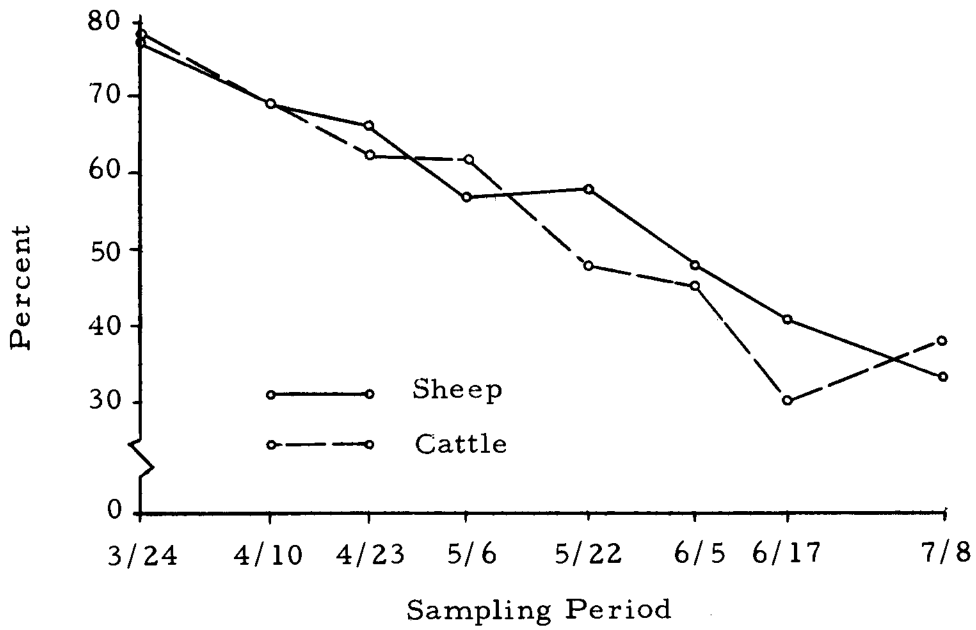

Figure 17. Mean ryegrass percentages when grazed by sheep and cattle.

Table 18. Mean ryegrass percentage as obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

	Methods			
	RM_1	WE_0	HS	CD
	50.4	54.1	56.8	57.4

($LSD_{0.01}$ = 2.0 degrees). The mean seasonal data presented in Figure 18 show a tendency to increase the ryegrass percentage at high grazing intensity. This effect might be explained on the basis of a poorer, competitive ability of annual species in heavily stocked pastures, as they were being grazed constantly and had little chance to recover. In the lightly stocked ryegrass pastures, livestock had a better opportunity to select ryegrass, which as Bedell (1966) pointed out was preferred over the rest of the mixture components, and as a consequence, a high percentage of the annual grasses matured which resulted in a consistently lower ryegrass percentage.

Significant interactions were detected for: method x sampling period (0.01), methods x grazing intensity (0.05), sampling period x kind of livestock (0.05), and sampling period x grazing intensity (0.01).

In the method x sampling period interaction presented in Figure 15, the $LSD_{0.01}$ was 8.1 degrees, indicating that the

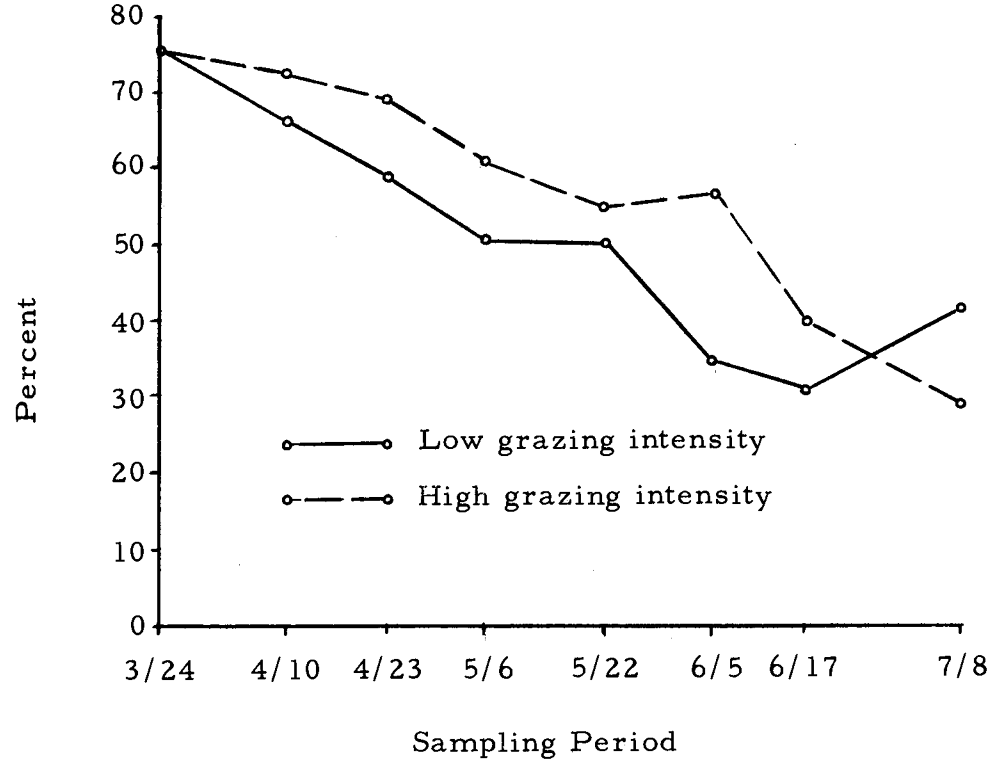

Figure 18. Mean ryegrass percentages obtained when light and heavy grazing is applied.

dry-weight-rank method in this kind of pasture, gave statistically different ryegrass percentages in the first and eighth sampling periods, and the weight-estimate in the eighth only. The rest of the sampling periods did not show significant differences. These results, again, stress the need of a conscientious training in estimating dry matter ranks and species weight.

The method x grazing intensity interaction had a $LSD_{0.05}$ of 3.1 degrees. The mean ryegrass percentages presented in Table 19 show that at a high grazing intensity the dry-weight-rank method and

Table 19. Mean ryegrass percentages obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods, at low and high grazing intensities.

Grazing Intensity	Methods			
	RM_1	WE_0	HS	CD
Low	49.6	51.5	51.8	52.1
High	51.2	56.7	62.0	62.0

the weight estimate do not give the same ryegrass percentages as those obtained by hand separation and the constituent differential methods. At low grazing intensity, no differences were detected.

The sampling period x kind of livestock interaction showed an $LSD_{0.05}$ of 4.3 degrees, and the data are presented in Figure 17. These results indicate that, on the average, cattle grazed the ryegrass component of the mixture more heavily than sheep, especially at the fifth and seventh sampling periods. Obviously, this fact accounted for the significant differences of sheep and cattle in their influence on ryegrass percentages.

For the sampling period x grazing intensity interaction an $LSD_{0.01}$ of 5.7 degrees was determined. These data are presented in Figure 18, where it can be observed that the major difference occurs at the sixth sampling period, at which time, as explained previously, competition between annual grasses and ryegrass was taking place. Also, at the eighth sampling period differences were observed. Because of the different dry matter content of the species (Table 20), the livestock were selecting annual grasses when grazing at a low intensity and ryegrass at a high intensity.

Table 20. Dry matter percent of ryegrass and other annual species in early July.

Grazing Intensity	Species	
	Ryegrass	Other Species
Low	64.4	58.7
High	77.4	80.7

The subclover percentages in the ryegrass pastures were relatively constant throughout the season, especially the sheep grazed sections. As shown in Table 21, the percentages ranged from 0 to 4.4. This last figure actually may be smaller, because in the sixth sampling period, the constituent differential method was not very accurately compared with hand separation since the dry matter content of ryegrass and other species was practically the same. This fact affected subclover determinations because it was calculated by difference. In the cattle grazed pastures, the subclover percentages were higher, particularly during mid-season,

Table 21. Subclover percentages[1/] in the ryegrass pastures obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

Kind of Livestock	Sampling Period	Replicates (Grazing Intensity)								Total	Mean
		I (Low)				II (High)					
		RM_1	WE_0	HS	CD	RM_1	WE_0	HS	CD		
	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	2.5	4.5	2.0	2.0	0.0	1.0	0.5	0.5	13.0	1.6
	3	2.0	3.0	2.0	2.0	1.0	2.0	2.0	2.0	16.0	2.0
Sheep	4	1.5	2.5	1.0	1.0	0.0	1.5	0.5	0.0	8.0	1.0
	5	7.5	7.0	2.0	1.0	0.0	2.5	0.0	0.0	20.0	2.5
	6	0.5	5.5	1.0	22.0	0.0	0.5	3.0	3.0	35.5	4.4
	7	3.0	3.0	0.5	1.0	0.0	0.5	0.0	0.0	8.0	1.0
	8	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
	1	2.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	5.0	0.6
	2	2.5	4.5	0.5	0.5	5.0	3.5	0.0	0.0	16.5	2.1
	3	3.0	5.0	9.5	9.5	4.0	4.0	3.5	3.5	42.0	5.2
Cattle	4	7.0	14.0	4.5	3.0	3.5	8.0	5.0	5.0	50.0	6.2
	5	14.5	23.5	6.5	6.5	7.5	10.0	5.0	5.5	79.0	9.9
	6	4.5	12.0	6.0	6.0	5.0	11.0	3.5	4.0	52.0	6.5
	7	0.0	5.5	1.5	1.5	1.5	2.5	1.0	0.5	13.8	1.7
	8	0.0	0.5	0.0	0.0	0.5	1.5	0.0	0.0	2.5	0.3
	Mean	3.1	5.7	2.3	3.5	1.9	3.0	1.5	1.5		

1/ Rounded off to the nearest 0.5 percent.

where it reached a peak of 9.9 percent (Figure 19), indicating that cattle were not grazing clover to a great extent. It is apparent that the lightly grazed pastures had a slightly higher subclover percentage and also that the weight-estimate method tends to overestimate these percentages.

The percentages of other species, whose analysis of variance is presented in Appendix 9, are shown in Table 22. The conclusions of this analysis of variance are similar to those obtained for the ryegrass component, so a discussion of these results will not add anything that has not already been examined. Even the mean squares values are quite similar. Nevertheless, two differences can be observed: there were no significant differences detected for variation due to kind of livestock (Figure 20), or for the kind of livestock x sampling period interaction.

Methods were shown to be significantly different, and as in ryegrass, there was also a significant variation due to the grazing intensity x methods interaction. In connection with this, apparently the weight-estimate method underestimated the other species percentage when used in lightly grazed pastures, and overestimated it in the heavily grazed ones. The dry-weight-rank method, on the other hand, always overestimated the percentage of other species.

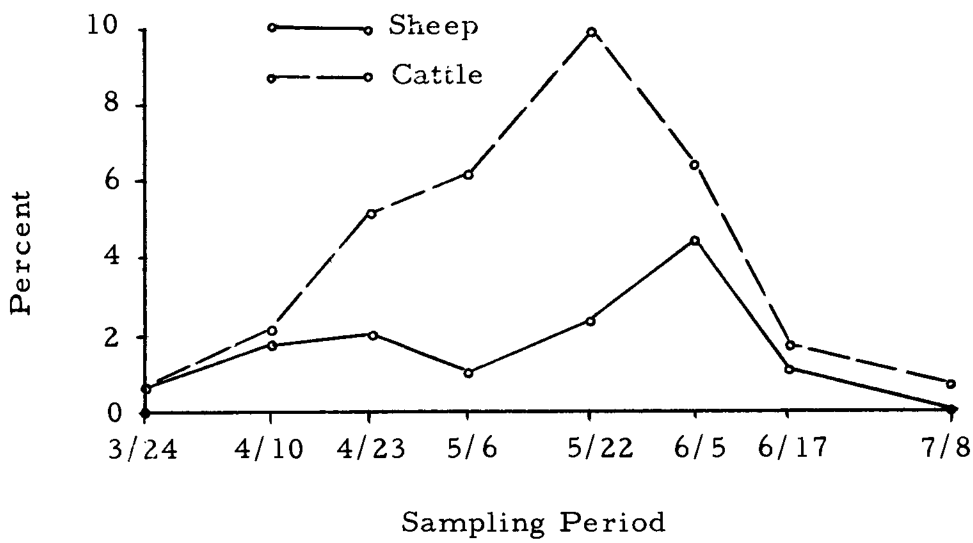

Figure 19. Mean subclover percentages in the ryegrass pastures determined for cattle and sheep grazing.

Comparison of Fescue and Ryegrass Pastures

There were remarkable differences among the methods in the way they determined botanical composition when compared in relation to the fescue and ryegrass pastures. According to the analyses of variance presented in Appendices 7 and 8, all four methods were very accurate in determining botanical composition in the fescue pastures, as no significant variations were detected due to method, or to any of the interactions in which methods were involved. In the ryegrass pastures, however, the methods were significantly different, as well as the method x sampling period and grazing intensity x methods interactions. Obviously, the inherent characteristics of these pastures are important. Fescue has a growth habit which

Table 22. Percentages[1/] of other species in the ryegrass pastures obtained by dry-weight-rank, weight-estimate, hand separation and the constituent differential methods.

Kind of Live-stock	Sam-pling Period	Replicates (Grazing Intensity)								Total	Mean
		I (Low)				II (High)					
		RM_1	WE_0	HS	CD	RM_1	WE_0	HS	CD		
	1	44.5	15.5	21.0	21.0	39.0	15.5	10.5	10.5	177.5	22.2
	2	31.0	22.0	28.0	28.0	36.0	27.5	31.0	31.0	234.5	29.3
	3	41.5	29.5	35.5	33.0	31.0	21.5	29.5	29.5	251.0	31.4
Sheep	4	39.5	38.0	62.5	63.0	37.5	29.0	34.0	34.5	338.0	42.2
	5	47.5	43.5	36.0	37.0	38.5	37.0	39.0	39.0	317.5	39.7
	6	53.5	75.0	62.5	40.0	48.5	48.0	29.0	28.0	384.5	48.1
	7	59.5	68.0	60.0	60.0	64.5	58.0	49.0	48.5	467.5	58.4
	8	67.0	72.0	45.5	45.0	73.5	85.5	73.5	73.5	535.5	66.9
	1	37.5	19.5	18.0	18.0	37.0	11.0	12.5	12.5	166.0	20.7
	2	37.5	19.5	43.5	43.5	26.0	20.5	20.0	20.0	230.5	28.8
	3	35.5	32.0	41.0	40.5	31.5	29.5	27.0	26.5	263.5	32.9
Cattle	4	34.5	32.0	42.5	42.5	44.0	37.5	36.5	36.5	306.0	38.2
	5	47.0	38.0	41.5	41.5	40.5	38.5	44.5	45.0	336.5	42.1
	6	52.5	52.0	59.0	59.0	60.0	45.0	36.5	37.5	401.5	50.2
	7	67.5	65.5	79.0	79.5	70.5	57.0	63.5	63.5	546.0	68.2
	8	59.0	63.5	58.0	58.0	79.5	82.5	48.5	48.5	497.5	62.2
	Mean	47.2	42.8	45.8	44.3	47.3	40.2	36.5	36.5		

1/ Rounded off to the nearest 0.5 percent.

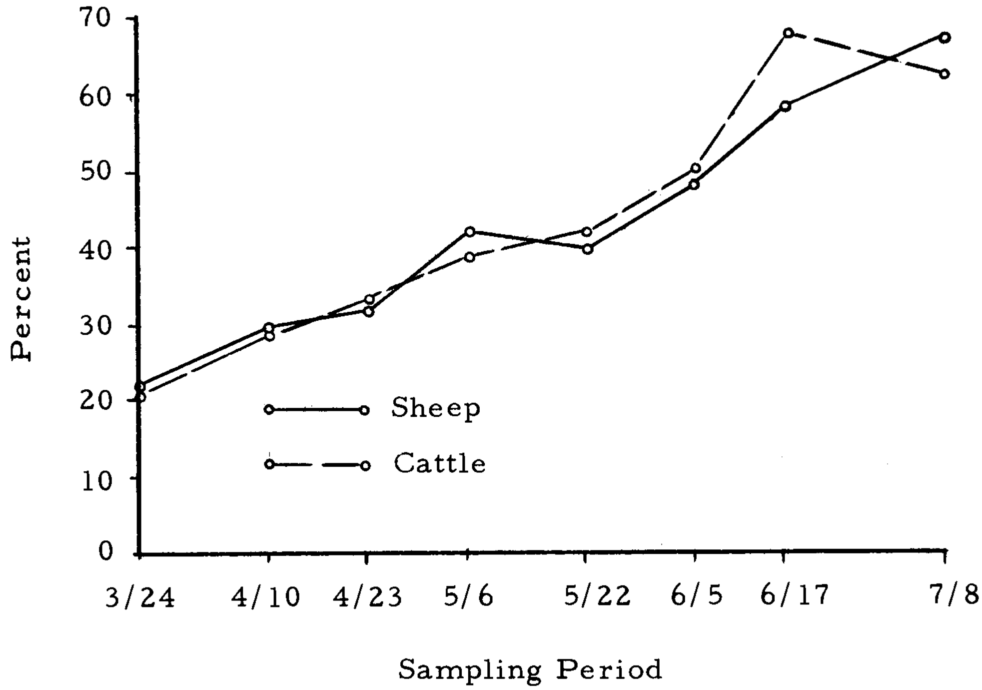

Figure 20. Mean percentages for other species determined in the sheep and cattle grazed pastures.

facilitates production and dry-weight-rank estimations, whereas in ryegrass at some stages of development it is very difficult to estimate production or dry weight ranks, depending on its associated species. Precision of the estimates could be increased if ryegrass were easily recognized.

Sampling period affected both kinds of pastures in a similar way until early June, as there was intense competition with annual grasses, the major component of the other species group. In early July, fescue percentage had increased while ryegrass percentage had continued to decrease, because ryegrass was more adversely affected by competition from annuals.

Grazing intensity affected ryegrass percentages, as it was found that at higher grazing intensities the ryegrass percentage increased. No effect was observed in the fescue pastures.

Kind of livestock affected both fescue and ryegrass percentages. It was determined that sheep grazing promoted stands with higher fescue and ryegrass percentages.

Subclover reacted similarly in both pastures, but was generally more abundant in the ryegrass pastures. Methods, on the average, did not seem to give strikingly different results. Subclover followed a similar trend in both pastures; those units grazed by sheep always showed a lower percentage, and it was not affected by grazing intensity.

The other species component had an opposite response to that showed by the main species, since they were increasing as the main species were decreasing. In fescue pastures, the percentage of other species was lower than in the ryegrass pastures.

Methods Evaluation on Selected Areas

Mean percentages based on 20 observations of each species as determined with each of the methods are presented in Figure 21. These data are from locations higher in subclover percentage because of more favorable moisture conditions.

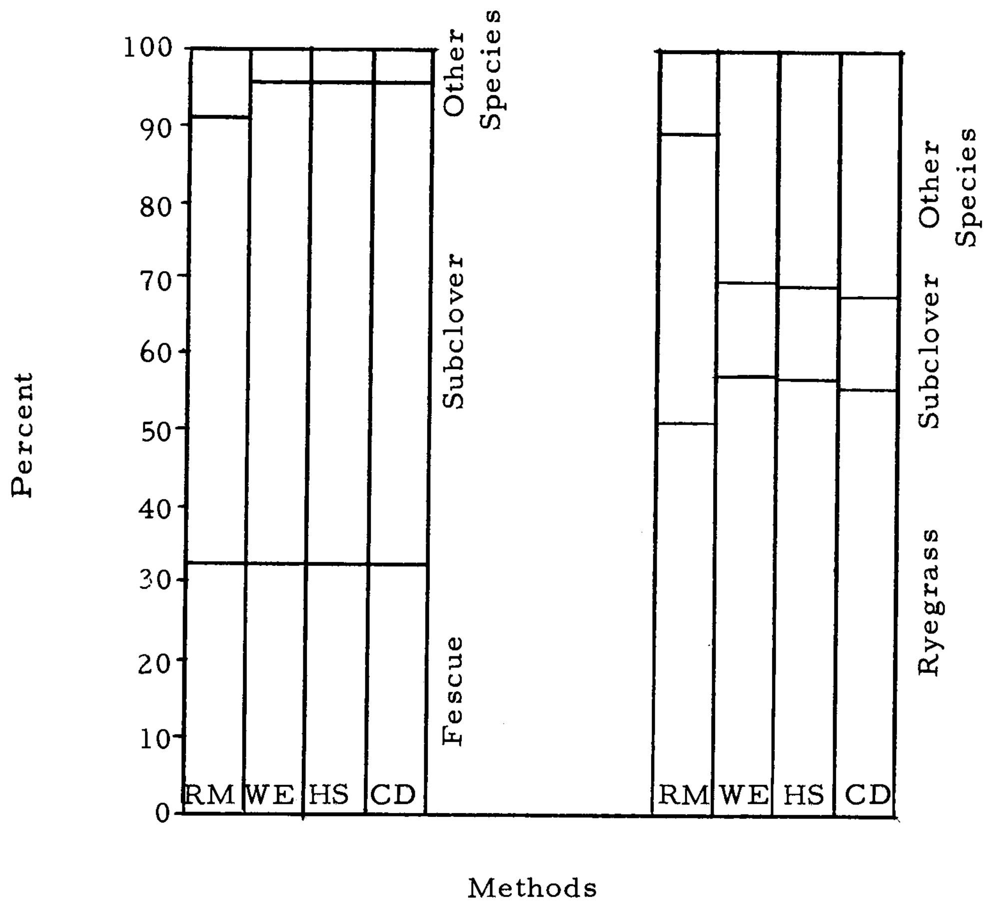

Figure 21. Mean botanical composition of selected areas, outside the experimental pastures, obtained by dry-weight-rank, weight-estimate, hand separation, and the constituent differential methods.

Fescue Pastures

In these pastures, with high clover percentages, the weight-estimate, hand separation, and constituent differential methods, gave exactly the same results for all species. The dry-weight-rank method gave the same fescue percentages, underestimated in 5 percent the subclover, and consequently, overestimated the other species by the same percentage. The evaluation of these methods under a more representative mixture proved that the use of any of these methods is acceptable; its selection will depend only on the efficiency of each method and personnel availability.

Ryegrass Pastures

Again, it was found that it is more difficult to estimate weight or dry-weight ranks in these mixed kind of pastures. The subclover did interfere with the estimates of the dry-weight ranks, as this method greatly overestimated it and underestimated both ryegrass and other species. The other three methods gave very similar percentages for all three species.

RESEARCH RECOMMENDATIONS

According to the results of this study, the constituent differential method of determining botanical composition on pastures was found to be the most promising one; therefore, more attention should be directed toward it. Hand separation can be replaced advantageously by determining the dry matter percentages of the forage mixture and its components.

With the constituent differential method, however, it is difficult to get a representative sample of the mixture. In connection with this problem, it would be advisable to develop a study involving the following factors:

I. Sampling procedure

   A. Plot method (would allow production determination)

      1. Plot size

      2. Number of plots to clip

      3. Influence of moisture loss during sampling and how to minimize it

   B. Plotless method

      1. Number of clipped handfuls

      2. Influence of moisture loss during sampling

II. Dry matter determination

   A. Use of different temperatures or other procedures

1. 105°C

2. 80°C

B. Use of a given drying period

C. Drying to a constant weight

III. Range in the difference of dry matter percent of species in which the method gives reliable results.

IV. Alternatives when range of the difference of dry matter percent is not large enough

A. Interpolate between two alternate sampling periods

B. Determine another constituent

1. Ash

2. Protein

3. Calcium

V. Different kinds of vegetation.

The weight-estimate, the oldest one tried in this study, has been extensively compared with other methods; therefore, some comparisons among different ways of applying this method would be of interest.

The dry-weight-rank method, which has developed only recently, needs more testing in different kinds of vegetation, and at different composition percentages, as it is apparent that in each case a new set of multipliers should be calculated.

SUMMARY

There is an obvious need for a quick and precise method for determining botanical composition, especially when this kind of information complements other essential studies. An evaluation of four methods to determine botanical composition on pastures of tall fescue (*Festuca arundinacea* Schreb.) and perennial ryegrass (*Lolium perenne* L.) pastures was undertaken on the Adair land of the Oregon Agricultural Experiment Station in 1965.

The study area is located in the foothills of the Coast Range near Corvallis, where both fescue and ryegrass pastures were grazed by sheep and cattle at two grazing intensities.

The objectives were two-fold: (1) Compare four different methods to determine botanical composition. These methods were: dry-weight-rank, weight-estimate, hand separation, and the constituent differential; and (2) Compare the seasonal botanical composition of the fescue and ryegrass pastures grazed by sheep and cattle at two different intensities.

Botanical composition was determined at biweekly intervals between March 23 and July 8. The methods were used simultaneously on 2.4-square-foot plots, taking 50 observations with the dry-weight-rank method, 25 with the weight-estimate, and 5 plots were clipped to hand separate and apply the constituent differential method in each

of the pasture units studied.

For the dry-weight-rank method, new sets of multipliers had to be calculated, because those given by Mannetje and Haydock (1963) were underestimating the major component of the mixture. In both pastures, three different groupings of the data were used in determining the multipliers for the rank method:

1. All available data obtained from one pasture through the growing season were used as one set to calculate the multipliers (RM_1).

2. All the available data obtained from each of the four fescue and ryegrass pastures (heavily grazed and lightly grazed sheep pastures, and heavily and lightly grazed cattle pastures) were used to calculate the multipliers (RM_4).

3. All available data collected in each of the eight sampling periods were used separately to calculate the multipliers (RM_8).

The same groupings were adopted for testing the weight-estimate method in order to correct the estimates using a regression equation for each species, plus the use of estimates without any correction.

The results from these groupings of data, within each of the two methods, were tested by analysis of variance. The analyses showed that the best way to group these data was the RM_1 and WE_4 in the fescue pastures, and RM_1 and WE_8 in the ryegrass. These groupings showed the smallest experimental errors.

An analysis of variance was run with data obtained by the four methods for fescue and ryegrass. In the fescue pastures, it was found that the use of any of these methods would be equally effective in determing botanical composition; there was a change in species percentage as the season progressed; sheep preferred the annual grasses and subclover, whereas cattle preferred the fescue; and grazing intensity did not affect the botanical composition. Some interactions were also detected such as sampling period x kind of livestock, sampling period x grazing intensity and grazing intensity x kind of livestock.

In the ryegrass pastures, results from the various methods were found to be different, especially the dry-weight-rank method which generally underestimated the ryegrass percentages. Botanical composition also changed because of the annual species competition as the season progressed. Cattle seemed to graze ryegrass heavier than sheep, and heavier stocking rates, on the average, tended to produce a higher ryegrass percentage. Some interactions were also detected such as method x sampling period, method x grazing intensity, sampling period x kind of livestock, and sampling period x grazing intensity.

It is apparent from this study that the constituent differential method is a promising one. More attention should, therefore, be given to future development of the constituent differential method. A study was proposed to explore some of the factors influencing the use of the constituent differential method for determining production and botanical composition on mixed grass-legume pastures.

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APPENDICES

Appendix 1. Sets of multipliers obtained for fescue and ryegrass mixtures using different ways of calculating them.

Ways of Grouping	Mixture						Used on Sampling Periods	Calculations Based on Pastures	Grazing Intensity
	Fescue			Ryegrass					
	k_1	k_2	k_3	k_1	k_2	k_3			
RM_1	101.7	-4.7	3.0	79.0	23.0	-2.0	1 - 8	all	low and high
RM_4	106.9	-9.0	2.1				1 - 8	fescue - sheep	low
RM_4	109.2	-12.5	3.3				1 - 8	fescue - sheep	high
RM_4	103.5	-2.4	-1.1				1 - 8	fescue - cattle	low
RM_4	98.8	-0.1	1.3				1 - 8	fescue - cattle	high
RM_4				67.8	36.7	-4.5	1 - 8	ryegrass - sheep	low
RM_4				83.7	16.6	-0.3	1 - 8	ryegrass - sheep	high
RM_4				82.4	18.4	-0.8	1 - 8	ryegrass - cattle	low
RM_4				71.0	44.7	-15.7	1 - 8	ryegrass - cattle	high
RM_8	120.5	-27.9	7.4	95.4	1.0	3.6	1	all	low and high
RM_8	122.5	-48.6	26.2	86.3	15.1	-1.4	2	all	low and high
RM_8	97.3	-9.9	12.6	79.9	19.3	0.8	3	all	low and high
RM_8	83.6	6.2	10.2	61.1	43.4	-4.5	4	all	low and high
RM_8	79.2	-11.8	32.6	89.7	11.1	-0.8	5	all	low and high
RM_8	98.1	0.3	1.6	98.2	0.3	1.5	6	all	low and high
RM_8	105.5	-6.6	1.3	79.1	22.7	-1.9	7	all	low and high
RM_8	104.1	-4.5	0.5	59.5	42.4	-1.9	8	all	low and high

Appendix 2. Fescue, subclover and other species percentages as determined by the dry-weight-rank method, using one (RM_1), four (RM_4), and eight (RM_8) sets of multipliers.

Kind of Live-stock	Sam-pling Period	Light Grazing Intensity								
		Fescue			Subclover			Other		
		RM_1	RM_4	RM_8	RM_1	RM_4	RM_8	RM_1	RM_4	RM_8
Sheep	1	87.5	91.5	100.0	3.5	2.0	0.0	9.0	6.5	0.0
	2	93.5	98.5	100.0	1.0	0.0	0.0	5.5	1.5	0.0
	3	95.5	100.0	92.0	2.0	0.0	1.0	2.5	0.0	7.0
	4	97.5	100.0	81.0	2.5	0.0	10.5	0.0	0.0	8.5
	5	83.5	87.5	66.5	1.0	0.0	18.5	15.5	12.5	15.0
	6	83.5	87.5	80.5	2.0	0.5	1.5	14.5	12.0	18.0
	7	81.0	85.0	84.0	2.5	1.5	1.0	16.5	13.5	15.0
	8	93.0	98.0	95.5	2.0	1.5	2.5	5.0	1.5	2.0
Cattle	1	83.5	84.5	97.5	4.0	1.0	2.5	12.5	14.5	0.0
	2	91.5	93.5	100.0	5.5	3.0	0.0	3.0	3.5	0.0
	3	93.5	95.0	89.5	6.5	5.0	10.0	0.0	0.0	0.5
	4	91.5	93.0	76.0	5.0	2.5	12.0	3.5	4.5	12.0
	5	81.5	82.5	67.5	0.5	0.0	16.5	18.0	17.5	16.0
	6	83.0	84.5	80.5	2.0	0.0	1.0	15.0	15.5	18.5
	7	81.0	82.5	83.5	2.0	0.0	0.5	17.0	17.5	16.0
	8	85.0	86.5	87.0	1.5	0.0	0.5	13.5	13.5	12.5

Appendix 2. Continued.

Kind of Livestock	Sampling Period	Heavy Grazing Intensity								
		Fescue			Subclover			Other		
		RM_1	RM_4	RM_8	RM_1	RM_4	RM_8	RM_1	RM_4	RM_8
	1	73.5	78.0	85.5	1.0	0.0	0.0	25.0	22.0	14.5
	2	85.5	91.0	100.0	3.0	1.5	0.0	11.5	7.5	0.0
	3	97.5	100.0	94.0	2.0	0.0	1.0	0.5	0.0	5.0
Sheep	4	95.5	100.0	79.0	2.5	0.0	10.0	2.0	0.0	11.0
	5	89.5	95.5	70.5	1.5	0.5	21.0	9.0	4.0	8.5
	6	95.5	100.0	92.0	1.0	0.0	1.0	4.5	0.0	7.0
	7	91.5	98.5	95.0	2.0	1.5	0.5	6.5	0.0	2.0
	8	93.5	100.0	95.5	2.0	0.0	0.5	4.5	0.0	4.0
	1	75.0	73.5	87.0	1.0	1.0	0.0	24.0	25.5	13.0
	2	89.0	87.0	100.0	5.0	5.0	0.0	6.0	8.0	0.0
	3	83.0	81.0	79.5	3.0	3.0	9.0	14.0	16.0	11.5
Cattle	4	91.5	89.0	76.0	2.0	2.5	10.0	6.5	8.5	14.0
	5	91.5	79.0	72.0	2.5	1.0	17.0	6.0	20.0	11.0
	6	83.0	81.0	80.5	1.0	1.0	1.0	16.0	18.0	18.5
	7	79.0	77.0	81.5	1.0	1.0	0.0	20.0	22.0	18.5
	8	91.0	89.0	93.5	1.0	0.5	0.0	8.0	10.5	6.5

Appendix 3. Sets of equations (values of y') obtained for each of the components in the fescue pastures using three different ways of grouping the data

Ways of Grouping	Calculations based on pastures	SPECIES Fescue	Subclover	Other	Annuals	Perennials	Grazing intensity
WE_1	all	46.13+0.81x	-0.04+1.24x	0.84+0.73x	-0.17+1.33x	1.28+0.61x	low and high
WE_4	fescue-sheep	45.08+0.83x	0.00+1.20x	0.77+0.14x	0.75+0.26x	0.22+0.10x	high
WE_4	fescue-sheep	67.50+0.70x	0.24+0.39x	0.41+0.49x	3.06+0.62x	1.37+0.08x	low
WE_4	fescue-cattle	29.60+0.86x	-0.10+1.30x	4.65+0.69x	0.54+1.31x	1.22+1.29x	high
WE_4	fescue-cattle	69.50+0.94x	0.03+1.33x	1.83+1.13x	-3.48+1.87x	2.21+0.32x	low
WE_8	all	- 6.20+1.33x	0.00+1.00x	0.27+0.78x			low and high
WE_8	all	00.35+1.07x	0.00+1.00x	1.55+0.31x			low and high
WE_8	all	12.08+1.13x	0.53+1.12x	2.28+1.33x			low and high
WE_8	all	49.16+0.72x	0.82+0.50x	2.41+0.63x			low and high
WE_8	all	76.95+0.75x	-1.78+1.39x		-1.02+1.47x	0.09+4.86x	low and high
WE_8	all	52.09+0.97x	2.29+0.36x		-5.42+2.40x	1.16+0.42x	low and high
WE_8	all	70.94+0.78x	0.74+0.92x		-1.81+1.18x	1.17+1.16x	low and high
WE_8	all	66.61+1.01x	0.12+0.01x		0.47+0.98x	1.89+0.53x	low and high

Appendix 4. Fescue, subclover and other species percentages as determined by the weight-estimate method, using none, one, four, and eight sets of equations per species.

Kind of Live-stock	Sam-pling Period	Light Grazing Intensity											
		Fescue				Subclover				Other			
		WE_0	WE_1	WE_4	WE_8	WE_0	WE_1	WE_4	WE_8	WE_0	WE_1	WE_4	WE_8
	1	84.5	91.0	94.5	88.0	1.0	0.0	0.0	1.0	14.5	9.0	5.5	11.0
	2	99.5	99.0	99.5	99.5	0.5	0.0	0.0	0.5	0.0	1.0	0.5	0.0
	3	99.0	98.5	99.0	96.5	0.5	0.0	0.5	0.5	0.5	1.5	0.5	3.0
Sheep	4	95.0	95.5	97.5	95.0	0.5	1.0	0.5	1.0	4.5	3.5	2.0	4.0
	5	92.0	90.5	94.0	90.0	2.0	2.0	1.0	1.5	6.0	7.5	5.0	8.5
	6	93.0	91.0	94.5	89.0	1.0	1.0	0.5	1.0	6.0	8.0	5.0	10.0
	7	92.5	90.5	94.0	92.0	0.5	0.5	0.5	0.5	7.0	9.0	5.5	7.5
	8	81.5	82.5	90.5	89.0	0.0	0.0	0.0	0.0	18.5	17.5	9.5	11.0
	1	95.0	98.0	97.0	96.0	2.5	0.0	0.0	0.0	2.5	2.0	3.0	2.0
	2	95.0	97.0	96.5	95.0	1.0	0.5	0.5	1.0	4.0	2.5	3.0	4.0
	3	94.0	95.5	95.5	90.5	2.0	1.5	1.0	2.5	4.0	3.0	3.5	7.5
Cattle	4	81.0	88.0	88.5	89.5	5.5	4.5	3.0	2.5	13.5	7.5	8.5	8.0
	5	78.5	77.5	78.5	78.5	7.5	7.5	6.0	6.0	14.0	15.0	15.5	15.5
	6	74.5	74.5	75.5	70.0	3.0	3.0	2.5	2.0	22.5	22.5	22.0	28.0
	7	80.0	77.0	77.0	83.5	2.0	2.0	1.5	1.5	18.0	21.0	21.5	15.0
	8	87.5	87.5	88.0	91.5	0.0	0.0	0.0	0.0	12.5	12.5	12.0	8.5

Appendix 4. Continued.

Kind of Livestock	Sampling Period	Heavy Grazing Intensity											
		Fescue				Subclover				Other			
		WE_0	WE_1	WE_4	WE_8	WE_0	WE_1	WE_4	WE_8	WE_0	WE_1	WE_4	WE_8
	1	89.0	98.0	99.0	97.0	1.0	0.0	0.0	1.0	10.0	2.0	1.0	2.0
	2	99.0	99.0	99.0	99.0	0.5	0.0	0.0	0.5	0.5	1.0	1.0	0.5
	3	99.5	98.5	99.0	95.5	0.5	0.0	0.0	1.0	0.0	1.5	1.0	3.5
Sheep	4	96.5	97.0	98.5	95.0	0.5	0.5	0.0	1.0	3.0	2.5	1.5	4.0
	5	97.0	97.0	98.0	97.5	0.5	0.5	0.5	0.0	2.5	2.5	1.5	2.5
	6	92.5	94.5	97.5	94.0	0.5	0.5	0.5	0.5	7.0	5.0	2.5	3.5
	7	96.0	96.5	98.0	97.5	0.5	0.0	0.0	0.5	3.5	3.5	2.0	2.0
	8	96.5	98.5	98.0	96.5	0.0	0.0	0.0	0.0	3.5	1.5	2.0	3.5
	1	89.5	95.0	89.0	92.0	2.5	1.0	1.5	2.0	8.0	4.0	9.5	6.0
	2	97.5	97.5	94.5	97.5	0.5	0.5	0.5	0.5	2.0	2.0	5.0	2.0
	3	89.0	94.0	89.0	87.0	1.5	1.0	1.0	2.0	9.5	5.0	10.0	11.0
Cattle	4	89.0	92.0	89.0	92.0	2.0	2.0	2.0	1.5	9.0	6.0	9.0	6.5
	5	84.5	87.5	84.5	91.5	6.0	5.0	5.0	2.5	9.5	7.5	9.5	6.0
	6	76.0	84.5	80.0	83.5	3.5	2.0	2.5	3.0	20.5	13.5	17.5	13.5
	7	71.0	82.5	76.5	87.5	2.0	1.5	1.5	1.5	27.0	16.0	22.0	11.0
	8	95.0	96.5	93.5	96.5	0.5	0.5	0.5	0.0	4.5	3.0	6.0	3.5

Appendix 5. Botanical composition of the ryegrass pastures determined by the dry-weight-rank method, using one, four, and eight sets of multipliers.

Kind of Live-stock	Sam-pling Period	Light Grazing Intensity								
		Ryegrass			Subclover			Other		
		RM_1	RM_4	RM_8	RM_1	RM_4	RM_8	RM_1	RM_4	RM_8
		Percent								
	1	55.5	54.5	55.5	0.0	0.0	3.5	44.5	46.5	41.0
	2	66.5	61.0	70.5	2.5	3.0	1.5	31.0	36.0	28.0
	3	56.5	54.5	56.0	2.0	2.0	4.0	41.5	43.5	40.0
Sheep	4	59.0	54.5	51.5	1.5	1.5	0.5	39.5	45.0	48.0
	5	45.0	45.5	51.0	7.5	3.0	1.0	47.5	51.5	48.0
	6	46.0	45.5	47.0	0.5	0.0	0.5	53.5	54.5	52.5
	7	37.5	38.5	37.5	3.0	4.0	3.0	59.5	57.5	59.5
	8	33.0	38.5	40.5	0.0	0.0	0.0	67.0	61.5	59.5
	1	60.5	62.0	67.0	2.0	2.5	3.0	37.5	35.5	30.0
	2	60.0	62.0	63.5	2.5	2.5	1.5	37.5	35.5	35.0
	3	61.5	63.0	61.5	3.0	3.0	4.5	35.5	34.0	34.0
Cattle	4	58.5	59.5	53.0	7.0	7.0	9.5	34.5	33.5	37.5
	5	38.5	38.0	38.0	14.5	14.0	12.5	47.0	48.0	49.5
	6	43.0	43.0	45.5	4.5	4.5	1.0	52.5	52.5	53.5
	7	33.5	31.5	33.5	0.0	0.5	0.0	66.5	68.0	66.5
	8	41.0	39.5	46.5	0.0	0.0	0.0	59.0	60.5	53.5

Appendix 5. Continued.

Kind of Livestock	Sampling Period	Heavy Grazing Intensity								
		Ryegrass			Subclover			Other		
		RM_1	RM_4	RM_8	RM_1	RM_4	RM_8	RM_1	RM_4	RM_8
		Percent								
	1	61.0	63.0	67.0	0.0	1.0	3.5	39.0	36.0	29.5
	2	64.0	66.0	67.5	0.0	0.5	0.0	36.0	35.5	32.5
	3	68.0	70.0	68.0	1.0	1.5	3.0	31.0	28.5	29.5
Sheep	4	62.5	64.0	54.0	0.0	1.0	0.0	37.5	35.0	46.0
	5	61.5	63.0	65.5	0.0	0.0	0.0	38.5	37.0	34.5
	6	51.5	51.0	51.5	0.0	0.0	1.0	48.5	49.0	47.5
	7	35.5	33.0	35.5	0.0	1.0	0.5	64.5	66.0	64.0
	8	27.0	22.5	41.5	0.0	0.0	0.0	73.0	77.5	58.5
	1	60.0	60.0	65.5	3.0	0.0	3.0	37.0	40.0	31.5
	2	69.0	62.5	75.0	5.0	0.0	4.0	26.0	37.5	21.0
	3	64.5	64.0	64.0	4.0	0.0	5.0	31.5	36.0	31.0
Cattle	4	52.5	54.5	49.5	3.5	0.0	4.5	44.0	45.5	46.0
	5	45.0	46.0	46.5	7.5	5.5	5.0	47.5	48.5	48.5
	6	49.0	51.0	51.5	5.0	0.0	3.0	46.0	49.5	45.5
	7	28.0	35.0	27.5	1.5	0.0	1.5	70.5	65.0	71.0
	8	20.0	33.5	33.5	0.5	0.0	2.0	79.5	66.5	64.5

Appendix 6. Sets of equations (values of y') obtained for each of the components in the ryegrass pastures using three different ways of grouping the data

Ways of grouping	Calculations based on pastures	SPECIES					Grazing intensity
		Ryegrass	Subclover	Other	Annuals	Perennials	
WE_1	all	- 2.77+2.27x	-0.07+1.46x	1.25+1.68x	18.07+1.27x	0.23+1.47x	low and high
WE_4	ryegrass-sheep	1.62+1.88x	0.13+0.38x	-2.89+1.93x	2.52+1.76x	0.16+0.53x	high
WE_4	ryegrass-sheep	0.91+2.30x	0.11+0.74x	1.30+1.48x	- 5.85+2.94x	0.10+1.66x	low
WE_4	ryegrass-cattle	- 1.50+2.08x	0.44+1.24x	0.00+1.74x	0.55+2.22x	0.27+1.16x	high
WE_4	ryegrass-cattle	9.88+1.45x	-0.19+1.60x	3.55+1.52x	24.21+1.45x	0.53+1.65x	low
WE_8	all	2.36+0.88x	0.00+1.00x	0.63+0.79x			low and high
WE_8	all	1.64+1.01x	0.13+0.19x	5.10+0.33x			low and high
WE_8	all	7.40+1.49x	0.12+2.43x	11.79+0.76x			low and high
WE_8	all	12.19+0.98x	0.34+1.03x	2.85+1.57x			low and high
WE_8	all	15.70+1.87x	-2.96+2.07x		- 3.55+2.84x	0.91+0.83	low and high
WE_8	all	1.18+2.48x	-1.29+1.98x		-11.96+3.35x	-1.06+2.68x	low and high
WE_8	all	11.61+1.42x	0.11+0.82x		11.46+1.50x	0.88+1.14x	low and high
WE_8	all	7.53+2.95x	0.00+0.01x		1.71+2.26x	0.40+0.83x	low and high

Appendix 7. Analysis of variance of data collected in fescue pastures by four methods of determining botanical composition.

Source of Variation	d. f.	Sum of Squares	Mean Square
Grazing intensity	1	4. 50	4. 50
(Treatments)	(63)	(6412. 53)	(101. 79**)
Kind of livestock	1	2993. 13	2993. 13**
Sampling period	7	1530. 00	219. 57**
Methods	3	53. 42	17. 81
Kind of livestock x sampling period	7	1064. 18	152. 02**
Kind of livestock x methods	3	42. 29	14. 10
Sampling period x methods	21	446. 88	21. 28
Kind of livestock x sampling period x methods	21	282. 63	13. 46
Grazing intensity x kind of livestock	1	358. 82	358. 82**
Grazing intensity x methods	3	86. 55	28. 85
Grazing intensity x sampling period	7	382. 62	54. 66*
Error	52	1070. 54	20. 59
Total	127	8315. 56	

* Significant at the 5% level.
** Significant at the 1% level.

Appendix 8. Analysis of variance of data collected in ryegrass pastures by four methods of determining botanical composition.

Source of Variation	d. f.	Sum of Squares	Mean Square
Grazing intensity	1	530. 56	530. 56**
(Treatments)	(63)	(12320. 21)	(195. 56**)
Kind of livestock	1	104. 40	104. 40*
Sampling period	7	10026. 26	1432. 32**
Methods	3	369. 80	123. 27**
Kind of livestock x sampling period	7	283. 27	40. 47*
Kind of livestock x methods	3	8. 83	2. 94
Sampling period x . methods	21	1331. 41	63. 40**
Kind of livestock x sampling period x methods	21	196. 19	9. 34
Grazing intensity x kind of livestock	1	0. 91	0. 91
Grazing intensity x methods	3	168. 02	56. 01*
Grazing intensity x sampling period	7	824. 37	117. 77**
Error	52	971. 84	18. 30
Total	127	14814. 09	

* Significant at the 5% level.
** Significant at the 1% level.

Appendix 9. Analysis of variance of the other species percentage in the ryegrass pastures, determined by four methods of determining botanical composition.

Source of Variation	d. f.	Sum of Squares	Mean Square
Grazing intensity	1	259.35	259.35**
(Treatments)	(63)	(12397.27	(196.78**)
Kind of livestock	1	8.82	8.82
Sampling period	7	10194.53	1456.36**
Method	3	362.96	120.99**
Kind of livestock x sampling period	7	226.81	32.40
Kind of livestock x method	3	36.26	12.09
Sampling period x method	21	1361.96	64.85
Kind of livestock x sampling period x method	21	205.93	9.81
Grazing intensity x methods	3	204.92	68.31*
Grazing intensity x kind of livestock	1	0.34	0.34
Grazing intensity x sampling period	7	608.64	86.95**
Error	52	1025.01	19.71
Total	127	14495.53	

* Significant at the 5% level.
** Significant at the 1% level.

Appendix 10. Analysis of variance of the functional factorial calculated from data collected in the fescue pastures by three methods of determining botanical composition.

Source of Variation	d. f.	Sum of Squares	Mean Squares
Sampling period	7	1050. 12	150. 02**
Grazing intensity	1	6. 25	6. 25
Kind of livestock	1	2405. 00	2405. 00**
Methods	2	86. 76	43. 38
Sampling period x grazing intensity	7	305. 60	43. 65
Sampling period x kind of livestock	7	565. 19	80. 74**
Sampling period x methods	14	470. 19	33. 58*
Grazing intensity x kind of livestock	1	229. 71	229. 71**
Grazing intensity x methods	2	47. 98	23. 99
Kind of livestock x methods	2	4. 48	2. 24
Error	51	801. 82	15. 72
Total	95	5973. 10	

* Significant at the 5% level.
** Significant at the 1% level.

Appendix 11. Analysis of variance of the functional factorial calculated from data collected in the ryegrass pastures by three methods of determining botanical composition.

Source of Variation	d. f.	Sum of Squares	Mean Square
Sampling period	7	8139.72	1162.82**
Grazing intensity	1	341.26	341.26**
Kind of livestock	1	134.43	134.43**
Methods	2	241.88	120.94**
Sampling period x grazing intensity	7	417.16	59.59**
Sampling period x kind of livestock	7	151.87	21.70
Sampling period x methods	14	1452.45	103.75**
Grazing intensity x kind of livestock	1	5.41	5.41
Grazing intensity x methods	2	87.46	43.73
Kind of livestock x methods	2	50.05	25.02
Error	51	800.94	15.71
Total	95	11922.63	

* Significant at the 5% level.
** Significant at the 1% level.