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A transformation of the Domin scale

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Abstract

Some of the problems associated with the use of both percentage cover and cover-abundance scales for describing vegetation are discussed. A transformation, referred to as 'Domin 2.6', is outlined for use with the Domin scale. This transformation allows more accurate estimates of means of Domin scores to be obtained, than are produced by direct averaging of the Domin scores themselves. The transformation is a close approximation to the relationship between percentage cover and the Domin scale and permits rapid transformation of one to the other.

'Domin 2.6' is tested on both simulated and field data. The results show that 'Domin 2.6' corrects for the underestimation of means, calculated by the direct averaging of Domin scores. This is particularly noticeable when widely differing Domin scores are involved. A number of possible uses for this transformation are introduced and discussed.

Introduction

Vegetation scientists, interested in the cover and/or abundance of plant species, have a number of important decisions to make before they can start to collect data. One of these concerns the accuracy of measurement. A high accuracy measure of percentage cover using point quadrats, is very time consuming to collect. As Goodall (1970) points out, if the vegetation under consideration has a high sampling variance, as is common in ecological studies, then the replication required will make such methods impracticable. On the other hand, the use of rather more subjective cover-abundance scales such as those of Domin or Braun-Blanquet (Mueller-Dombois & Ellenberg 1974), which may produce a saving of up to 80% in the time taken for data collection (Bannister 1966), introduce data handling and interpretation problems which form the subject of this paper.

One of the advantages of cover-abundance scales is that, in most cases, they are non-linear. They attach more importance to differences in species representation at the lower end of the scale than at the upper end. It is probable that this is how many observers perceive vegetation, in that they are more interested in differences in representation of locally rare species than of locally common ones. For example a difference in species representation from 1% in one quadrat to 11% in another, is likely to be of greater ecological importance than a difference between 71% and 81%, although on a linear scale they are equivalent. Cover-abundance scales lie somewhere between presence-absence records and a fully quantitative measure such as percentage cover. They are in fact non-linear transformations of cover,

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which decrease the emphasis on dominance, which is a feature of cover data. A transformation with these properties has for some time been regarded as desirable in both ordination and classification (Austin & Greig-Smith 1968, Smartt *et al.* 1974, 1976, Jensén 1978, Van der Maarel 1979).

The use of these scales is however not without its problems. Problems in the use of the Braun-Blanquet scales have been addressed by Dagnélie (1960) and Van der Maarel (1979) and this paper will examine the problems associated with the use of the Domin scale. The latter has been much used in Britain and to varying extents in other countries, and was discussed by Bannister (1966).

Problems with the use of the Domin scale

A significant problem with non-linear scales, such as the Domin scale, is that simple mathematical operations, such as taking the means of several scores, is not straight forward. If the two Domin scores 4 and 8 are averaged then the result will be 6. If however we take the mean cover values implied by these scores namely 7% and 62% (Table 1), the mean value is 34.5%. A Domin score of 6, however implies a mean cover value of 28.5%. Since a non-linear relationship exists between cover and Domin score, direct averaging tends to under-estimate the true value of cover. This effect is more marked, the greater the spread of the Domin scores to be averaged.

Table 1. The relationship between the Domin scale, percentage cover and the calculated parameters 'Domin 2.6' and its inverse.

Domin score	% Cover range	Mean of % cover range	'Domin 2.6'	Conversion
10	95 – 100	97.5	99.5	9.9
9	75 – 94	84.5	75.7	9.4
8	50 – 74	62.0	55.7	8.3
7	33 – 49	41.0	39.4	7.1
6	25 – 32	28.5	26.4	6.2
5	10 – 24	17.0	16.4	5.1
4	5 – 9	7.0	9.2	3.6
3	1 – 4	2.5	4.3	2.4
2	<1	0.5	1.5	1.3
1	<1		0.3	
+	<1		–	

Bannister's approach

Bannister (1966) partially overcame this problem by considering the Domin scale to be a combination of two elements. The first is percentage cover in the quadrat, which is of relatively little importance at the lower end of the scale. The second is frequency in 100 subdivisions of the quadrat. The latter is of greater importance at the lower end and separates quadrats on differences in the number and distribution of individuals, rather than their contribution to cover. The Domin score can then be approached by:

$$\text{Domin score} = 1.88 + 0.0428\,(\text{cover }\% + \text{Frequency }\%) \quad (1)$$

This conversion shows an approximately linear relationship with the Domin scale. If Domin scores of 4 and 8 are converted in this way before calculating the mean, then a value equivalent to Domin rating 6.5 results. This implies a cover value of 32.5% which is close to the true value of 34.5%.

Bannister's approach is not accurate, however. It performs very poorly when Domin scores of 2 or less are included in calculations. Because the transformation is a combination of two components which have differing relative importance in different parts of the scale, results are difficult to relate to the field situation. Specifically a graph of % cover + % frequency is difficult to interpret since the relative importance of the two components is not known.

Other approaches

If the Domin scale is recognised as a non-linear function of cover only, it must be transformed to a linear one to calculate simple statistics, such as means. There are a number of possible approaches to this problem.

1. Transform each Domin score to the mean percentage cover implied by that value. Calculations could then be performed and the result trans-

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formed back to the corresponding Domin score, if required. This procedure would require constant reference to a conversion table which would be tedious when performed manually and clumsy when used as part of a computer program. In addition it can only give integer equivalents for Domin scores unless linear interpolation is used.

2. Generate a high order polynomial function which is constrained to pass through all the points on a graph of Domin score against percentage cover. This would enable conversion in either direction and could also generate non-integer intermediate values on conversion back to the Domin scale. Statistics could be calculated whilst the figures were in the percentage cover form and the results could be expressed either in that form or by back transformation to continuous values on the Domin scale. A major disadvantage of such an approach is that conversion would be extremely time consuming to carry out manually since a polynomial of at least order five would be required.
3. A more practical solution would be to determine a simple function which approximates to the relationship between the Domin scale and percentage cover. This function could again be used for conversion in either direction between Domin score and percentage cover. Statistics would be calculated whilst values were in the percentage cover form. This approach has the advantage of simplicity of operation whilst at the same time being relatively accurate, so long as a function which fits the relationship between Domin score and percentage cover can be found.

'Domin 2.6' – a simple function

The cover element of the Domin scale in the range 4–10 approximates to the square root of cover but this function does not adequately describe the lower parts of the Domin scale. A much closer approximation to the functional relationship between Domin scores and percentage cover over the whole Domin range is:

$$\text{Percentage cover} = (\text{Domin score})^{2.6}/4 \qquad (2)$$

and conversely:

$$\text{Domin score} = (4 \times \text{Percentage cover})^{1/2.6} \qquad (3)$$

Table 1 shows both of these parameters in relation to actual Domin scores and percentage cover values. This function is plotted in Fig. 1 and is the dashed-line labelled 'Domin 2.6'. Figure 1 also shows as a solid line the relationship between Domin score and the percentage cover value implied by that score from Table 1. The function, which will henceforward be termed 'Domin 2.6', is a very good fit to the relationship between percentage cover and Domin score ($R^2 = 0.9891$). It may readily be calculated using a pocket calculator and is very easy to build into computer programs. It is however further simplified if mean Domin scores are required, since both the division by 4 and subsequent multiplication by 4 may both be omitted. The example used earlier will illustrate this procedure.

Taking Domin scores of 4 and 8:

$$\text{Mean Domin Score} = \left\{ \frac{4^{2.6} + 8^{2.6}}{2} \right\}^{1/2.6} = 6.50 \qquad (4)$$

The percentage cover implied by this Domin score is:

$$\text{Percentage cover} = \frac{6.50^{2.6}}{4} = 32.47\% \qquad (5)$$

This figure is similar to that obtained via the Bannister transform which itself was close to the theoretical value of 34.5%.

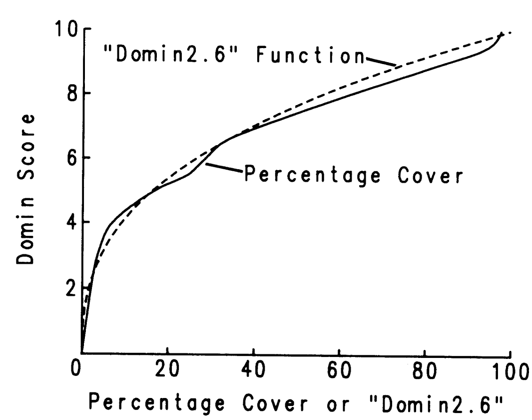

Fig. 1. The relationship between the Domin scale and percentage cover with 'Domin 2.6' for comparison.

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Testing the function
The 'Domin 2.6' function was tested on two data sets to examine its performance on both simulated and field data.

The simulated data consist of all combinations of four Domin scores and their corresponding percentage cover values. The field data were taken from a transect of 64 $1/4 \times 1/4$ m quadrats across a hummock-hollow complex, in an area of wet heath vegetation in N. E. Iceland. The hummocks were covered by a mixture of bryophytes and dwarf shrubs and the hollows contained a number of *Carex* species. The periodicity of this transect was about 8 quadrats. For each quadrat both a visual estimate of percentage cover and Domin scores were available for each of 41 species present in the transect.

The following four parameters were calculated: 1. Arithmetic means of the Domin scores; 2. Means of the Domin scores calculated by the method outlined in Bannister (1966); 3. Means of the Domin scores transformed to 'Domin 2.6' and the answers transformed back to Domin values; 4. Mean percentage cover values.

The above four parameters were used to analyse: a) Each combination of four values in the simulated data set; (b – g) Each species in 2, 4, 8, 16, 32 and 64 contiguous quadrats respectively, in the field data set.

Results

The simulated data set

Figure 2 summarises the performance of the methods of averaging Domin scores. The mean percentage cover against Domin score is shown as a solid line (c.f. Figure 1). The values from which this line is derived are shown in Table 1. In each case, the mean percentage cover (parameter 4) of the original data, is plotted against the mean Domin score. The simple arithmetic mean of the four Domin scores is clearly unsatisfactory as a summary statistic (2a). There is considerable scatter, which is most marked when Domin scores at opposite ends of the scale are averaged. Over most of the range the mean Domin score is lower than the mean percentage cover value

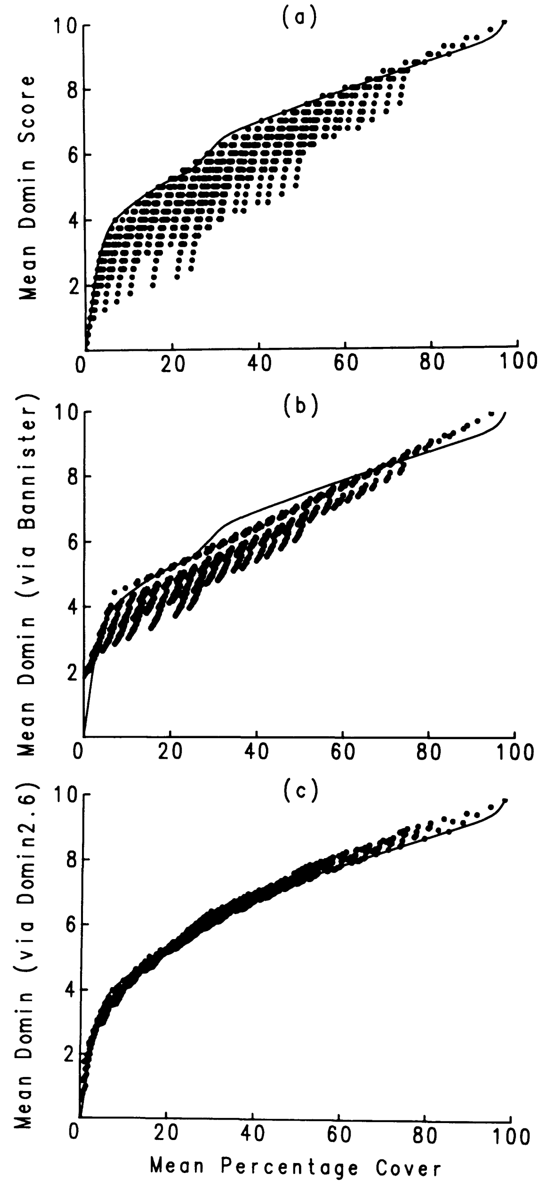

Fig. 2. The simulated data set – the result of calculating means of all combinations of four Domin scores and their corresponding percentage cover values: a) by direct averaging, b) via Bannister's transformation, c) via the 'Domin 2.6' transformation.

would suggest. In other words taking a simple arithmetic mean of Domin scores will underestimate the contribution of the species concerned.

Bannister's (1966) transformation reduces the scatter of the points (2b), but still underestimates the true mean value of percentage cover. It should how-

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ever be borne in mind that percentage cover plus percentage frequency, is the basis of Bannister's method and not cover alone.

The 'Domin 2.6' transformation further reduces scatter (2c) while at the same time confining the underestimation to a small portion of the scale at around a Domin score of 4. It is at this point in the scale where the emphasis shifts from frequency (< 4) to cover (> 4). A slight overestimation of cover occurs at the upper end of the scale in the range Domin 8 – 10.

Hummock-hollow field data

The basis of the tests using these data is that if the

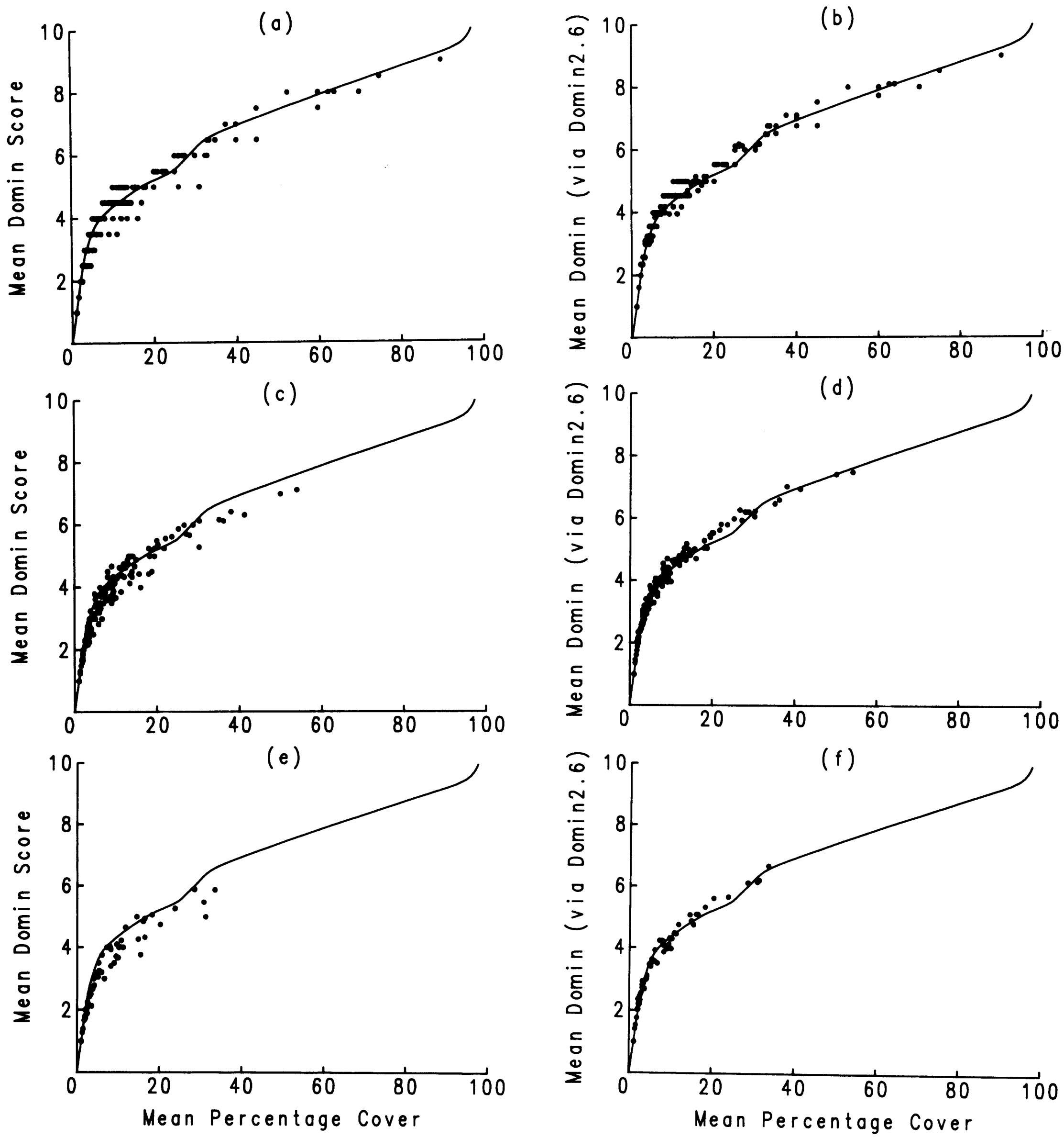

Fig. 3. The hummock-hollow data set – the result of calculating means of Domin scores and the corresponding percentage cover values for: a and b – 2 values, c and d – 8 values, e and f – 32 values; calculated by: a, c and e – direct averaging, b, d and f – transformation to 'Domin 2.6'.

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Domin scores for small numbers of adjacent quadrats are averaged, then the average will be very similar to the constituent scores, as the adjacent quadrats will have a similar floristic composition. As the number of contiguous quadrats averaged is increased, the variance will also increase. This will lead to averaging over a larger portion of the Domin scale, which is likely to cause more serious problems of underestimation of mean values. Fig. 3 shows the results for the means of 2 contiguous quadrats (3a and 3b), 8 contiguous quadrats (3c and 3d) and 32 contiguous quadrats (3e and 3f). In each of these cases there are two graphs, illustrating the results of direct averaging of the Domin scores (3a, 3c and 3e) and averaging via 'Domin 2.6' (3b, 3d and 3f). In all figures it can be seen that direct averaging produces more scatter than averaging via 'Domin 2.6'. Problems of underestimation become more acute as the number of values averaged, and thus the variance of the data increase. The means of 32 quadrats (3e and 3f) illustrate the very much better performance of 'Domin 2.6' than direct averaging, under these circumstances. The field data demonstrate the potential that this transformation has in improving the accuracy of estimates of simple statistics when using Domin scores, drawn from a heterogeneous environment.

Discussion

The simple functional relationship between percentage cover and Domin score may have a number of possible uses.

1. It enables simple statistics to be calculated from Domin values with greater accuracy than is afforded by direct averaging of the Domin values themselves. The results of such calculations are then transformed back to Domin values for presentation as a summary of the original data. This is especially useful for retrospective study of data such as are contained in McVean & Ratcliffe (1962).
2. It allows the Domin scale to be used for large numbers of vegetation samples when the primary interest is in the actual percentage cover of species, because Domin scores can be assigned relatively quickly in numerous replicates covering the range of variation under consideration. These data can then be transformed to percentage cover at a later stage rather than spending much time in the field collecting the more accurate percentage cover data.
3. Percentage cover data may be reduced to a non-linear form for use in ordination or classification. This has the effect of reducing the emphasis on dominance and increasing that on presence and absence.

The transformation proposed is one of a class of transformations of a general form:

$$y = ax^w \tag{6}$$

as described by Van der Maarel (1979), in which we can vary the contribution that dominance makes to an assessment of floristic similarity. It enables the large amount of data already collected using the Domin scale to be compared with values using other scales (e.g. Braun-Blanquet via transformations given in Van der Maarel (1979)). A further benefit is that simple statistics may be used with Domin data without the attendant biases introduced by its non-linearity. In common with Van der Maarel's (1979) ordinal scale, which is an extension of the Braun-Blanquet scale, this paper does not propose a new scale but seeks to capitalise on the advantages of an already established methodology. Entirely new scales such as the decimal scale of Londo (1979) may have advantages in some respects, but values are not readily interchangeable with established and well used scales such as those of Domin and Braun-Blanquet.

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