Nomenclature and definitions in grazing studies

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Introduction

At a recent symposium of the British Grassland Society (1975) it was accepted that an attempt should be made to produce an agreed list of definitions of terms used to describe the biological processes in grazing systems. The proposals which follow are made after an appraisal of previous publications on the subject in the UK and elsewhere, particularly the lists of definitions given by Spedding (1971) and the Society for Range Management (1974), and after detailed discussions with many colleagues actively engaged in grazing research. Some of the terms used have direct parallels in quantitative ecology (Milner and Hughes, 1968), but it usually seemed sensible to retain the agricultural equivalent because of established usage and because the framework within which the terms are used is so different. Terminology is considered here primarily in the context of temperate grassland and dwarf shrub communities in Europe, though the concepts should be of general application.

The concepts behind the choice of terms, and the reasons for proposing particular definitions, are explained briefly. Terms in general use have been adopted where possible, though in some cases minor changes in accepted definitions have been suggested in the interests of clarity. A problem common to many other fields of technology is the pressure to find single words or short phrases to describe relatively complex processes or concepts; this can create difficulties and in some cases relatively cumbersome but explicit phrases have been preferred to shorter but rather vague alternatives.

Terms are considered under five main headings: the sward; the grazing process; the balance between the grazing animal and the grazed sward; animal production from grazing systems; and grazing management. Terms for which definitions are suggested are given in bold type and these terms are collected together in a glossary at the end.

The sward

The words sward, pasture and herbage are variously used, singly or in combination, to describe either the above-ground parts only or the above- and below-ground parts of populations of plants. All three terms are well entrenched in common usage, but could usefully be distinguished by adopting the following definitions:

Sward The above- and below-ground parts of a population of herbaceous plants, characterized by a relatively short habit of growth and relatively continuous ground cover.

Sward canopy The above-ground parts of a sward as defined above. This term carries with it connotations of the distribution and arrangement of the constituent plant parts, to distinguish it from:

Herbage The above-ground parts of a population of herbaceous plants, viewed as an accumulation of plant material with characteristics of mass and nutritive value, but no connotations of organization or structure.

Pasture An area of sward, usually bounded by a fence, considered as a functional unit for grazing.

The terms sward, sward canopy and pasture all carry implications of a living, responsive
organism, but the term herbage would not normally do so. A discussion of the terminology relating to canopy structure will follow in a later paper by H. Thomas.

The instantaneous measure of the total weight of herbage per unit area of ground, preferably measured to ground level, is best termed the herbage mass. Herbage accumulation (strictly, net accumulation) is the change in herbage mass between successive instantaneous measurements, summed over time where appropriate. It is the difference between the rate of growth of new plant material and the rate of loss due to senescence and decomposition, and to removal by non-agricultural consumers. Herbage growth is defined as the development and increase in size and weight of new leaf and stem tissue. The term herbage accumulation states exactly what is being measured, and is preferred to the commonly used herbage production, which is best reserved for use as a general descriptive term, analogous to animal production. The definition of herbage accumulation does not necessarily involve any assumptions about harvesting. Herbage yield is therefore not an acceptable alternative either, and is better avoided altogether. Rather, the mass of herbage per unit area removed by grazing animals at a single grazing or series of grazings is termed herbage consumed, and that removed by mechanical means herbage harvested.

All of the above terms may refer to the herbage in total or to some component of it. The reference base, preferably ground level, should always be specified.

The grazing process

Defoliation is defined as the process of the complete or partial removal of the above-ground parts of plants, living or dead, by grazing animals or cutting machines. Grazing is the defoliation by animals of rooted plants in the field. It usually applies to the defoliation of the above-ground parts of plants in the ground layer of vegetation, to distinguish it from browsing on shrubs and trees. This is not a clear-cut distinction, however, since the term grazing would normally be applied to the defoliation of dwarf shrubs on the one hand and of tall-growing gramineous species on the other. From the point of view of the animal, the grazing process involves searching for, prehending and ingesting plant material.

When used in a general sense, the term grazing may also carry implications of the associated effects of treading and the deposition of dung and urine. However, in a specific sense it refers only to the defoliation process.

The existence of a difference between the composition of the diet and that of the sward as a whole is not necessarily evidence of discriminatory grazing activity. It could equally be the consequence of random grazing activity superimposed upon the non-random distribution of plant components within the sward canopy. Any terms implying discrimination by the animal should therefore be used with great care. In this context the term palatable and its derivatives have been much abused. The dictionary definition of palatable is ‘pleasant to the taste’ (Chambers 20th Century Dictionary, 1972), and in this sense describes an inherent characteristic of the plant. This definition of the term is recommended and it would be advisable to retain it for the rare situations where it can be strictly applied.

Until we are in a better position to assess the relative importance of the various factors involved, more general use should be made of the term preference for the discrimination exerted by animals between swards or sward components, in the field or in feeding trials. This term describes an animal response, but involves no assumptions about the mechanisms determining the response. Used in this way, preference is a relative term and has little relevance in any absolute sense. The preference ranking is the ranking of a series of plant species, varieties or morphological units, or of plots subjected to different experimental treatments, in terms of the preferences exhibited for them. If possible the ranking should be based on measurements of relative herbage intakes in free-choice trials. Complete freedom of choice is seldom possible, particularly under grazing conditions where the structure of the sward may restrict access to some components and where the relative proportions of the different components start to change as soon as grazing is imposed. Diet selection by the grazing animal is the removal of some sward component(s)—plants or plant parts—rather than others. It is a function of preference as defined above, modified by the opportunity for selection, which is determined by the relative proportions of the preferred components in the sward, and their distribution within the canopy. The selection ratio, defined as the proportion of a component in the diet divided by the proportion
in the sward, describes the degree of selection exerted for or against a particular component. The proportions of the component in the diet and the sward canopy should be stated whenever a selection ratio is quoted.

Terms like herbage available and availability should be avoided. In current usage they may mean simply the herbage mass as defined above, with some arbitrary reference base, in which case the terms are unnecessary and confusing. Alternatively they may involve unwarrantable assumptions about the accessibility of herbage to grazing animals. In the latter sense an alternative term is preferred: ease of prehension is defined as the ease with which sward components can be approached and grasped in the mouth during grazing. Thus it is primarily a function of the size of the component in question, and its position and alignment within the sward canopy, and is analogous to intrinsic availability as defined by Alden and Whittaker (1970). The term is qualitative, and is therefore used in a relative sense; it can only be quantified in terms of its effect upon the rate of herbage consumption.

It will be more useful to consider the terminology relating to the mechanics of the grazing process when current thinking on the subject has stabilized.

A description of harvesting procedures should include information on the degree and rate of defoliation, its frequency and (where possible) its uniformity. The quantity of herbage removed at a single defoliation has been defined already as the herbage consumed (or harvested). The ratio of the amount removed to the original amount is the degree of defoliation. Both definitions are important in many circumstances, as is a knowledge of the residual herbage—the amount remaining after defoliation. The original herbage mass, the herbage consumed and the amount of residual herbage should all be specified. All may be expressed in terms of the total herbage or some component of it. The rate of defoliation is the herbage consumed per unit of time (mass per unit area per unit time) during a period of defoliation.

Defoliation may also be described in terms of (a) the frequency of defoliation of areas of sward or individual plant units (number of defoliations per unit time), or its reciprocal, the defoliation interval (time interval between defoliations) and (b) the uniformity of defoliation, essentially a term describing the distribution of the residual herbage within a defined area, with gradation from aggregated (= patchy) to dispersed (= random in relation to the confines of a grazed area, though not to individual plant units).

The efficiency of grazing (or of harvesting in the case of cutting management) has been defined in two ways: (a) the herbage consumed at each defoliation expressed as a proportion of the herbage mass originally present, or preferably (b) the herbage consumed expressed as a proportion of herbage accumulation over the same time interval, whether for a single defoliation or a series of defoliations up to and including the grazing season as a whole. For a single defoliation, definition (a) is synonymous with degree of defoliation and is better described as such. Definition (b) is preferred because it avoids the difficulty of counting herbage residues more than once (Leaver, 1976) and is more useful in describing the dynamics of herbage accumulation and consumption. It would be preferable to make this definition in terms of the growth of new herbage, rather than net accumulation, but the former measurement is seldom attempted.

The gross efficiency of conversion (of ingested herbage into animal product) is the ratio of animal product to herbage consumed. Then the efficiency of utilization (of herbage for animal production) is defined as the ratio of animal product to herbage accumulated, and is the product of efficiency of grazing and gross efficiency of conversion as defined above. All of these efficiencies may be described in terms of the ratios of the fresh or dry weights of herbage and animal product, or (more usually) of some constituent (e.g., energy, nitrogen).

The balance between the grazing animal and the grazed sward

Several terms are available to describe the balance between the demand for and supply of herbage in grazing systems. Grazing pressure is defined as the number of animals of a specified class per unit weight of herbage. It is well established in general usage, but for use in grazing studies the term herbage allowance, defined as the weight of herbage per unit of animal live weight, is preferred because it gives a better impression of the balance between demand and supply. Ultimately this balance would be best expressed as the ratio of herbage mass (or herbage growth per unit area of land) to potential herbage intake per unit area (as
determined by the number of animals, and animal and sward characteristics). Attempts to scale appetite on the basis of live weight alone are likely to be of limited precision, and the use of this expression must await more accurate prediction of potential herbage intake.

The terms grazing pressure and herbage allowance are inversely related. The latter is normally used in the context of a predetermined allowance of herbage, whereas the former may often describe the results of a change in the balance between herbage growth and consumption. Both terms provide an instantaneous assessment of the balance between animal numbers, or weight, and weight of herbage in systems of continuous stocking (see below), where sward canopy changes are relatively slow. The concept of herbage allowance is also appropriate to rotational grazing systems where individual plots are grazed down rapidly over finite intervals of time and the contribution from concurrent growth can be ignored. In this case herbage allowance in effect describes a ration of herbage and it is appropriate to use it in relation to a unit of time, e.g. daily herbage allowance. This use is acceptable for systems where plots are grazed for 1–2 days, but is not really suitable where longer periods of grazing are involved, unless the contribution of concurrent growth to the total herbage supply can be taken into account. The F/D Ratio, defined by Hart (1972) as herbage accumulation (kg ha⁻¹) divided by animal numbers (animal d ha⁻¹) goes some way to meet this difficulty and, if the denominator included animal weight instead of numbers, would effectively average herbage allowance over time.

Animal production from grazing systems

Stocking rate has been defined either as the number of animals of a specified class per unit area of land, or its reciprocal, area per animal, over a period of time. The former definition is most useful when considering production from a grazing system, the latter when considering the supply of herbage per animal. The use of the alternative definitions has been discussed in detail by Shaw (1970). It would be helpful to concentrate on one definition as far as possible, and the former is probably the better suited to temperate grasslands where the number of cattle or sheep per ha is usually greater than unity.

As in the case of grazing pressure and herbage allowance, there would be advantages in the use of an expression which provided a better indication of the potential herbage intake of the animals concerned. However, with the exception of expressions of total animal mass per unit area, such a refinement is seldom attempted. Animal Production (P) per unit area is then simply:

\[ P = \text{stocking rate} \times \text{production per animal}. \] (1)

Where fluctuations in stock numbers or land area occur throughout the year, it is usually advisable to break down the total period into sub-periods of relative stability. It is difficult to be categorical about an acceptable minimum time period, but the duration of a given stocking rate should always be stated. Grazing systems of differing complexity can be compared in terms of Animal Days (AD) per unit area:

\[ \text{AD per unit area} = \Sigma (\text{stocking rate} \times \text{days}) \] (2)

or Animal Production (P) per unit area:

\[ \text{P per unit area} = \text{AD per unit area} \times \text{Production per animal per day}. \] (3)

It should be noted, however, that any given value of AD or P per unit area can be arrived at by a number of different combinations of the component variables, and care is required in interpreting any results so obtained.

Baker et al. (1964) described the recording of grassland output in terms of Utilized Starch Equivalent from the recorded information on the number of animal grazing days, the live weight of the animals concerned and their production as milk or weight gain. The same basic information should now be used to calculate the Total Metabolizable Energy (ME) Consumed per unit area of land, using ME standards (MAFF 1975). The ME provided from any other feeds should be deducted. If an allowance is included for the energy cost of grazing its magnitude should be clearly stated. The calculations may be made for individual animals or for groups of animals provided that they are homogeneous. This method provides a useful basis for comparison, so long as its limitations are recognized (Cray, 1963; Foot, 1963). In order to keep terminology in line with other recommendations (p. 13), the appropriate term to use is Total ME Consumed, rather than Utilized ME.

The nature of the relationship between stocking rate and animal performance (Jones and Sand-
land, 1974) means that terms like optimum stocking rate or carrying capacity are not likely to be helpful and may be misleading, since both involve assumptions about acceptable levels of animal performance and/or sward management which may or may not be stated. There seems no alternative here to a description of the management procedures and target levels of animal production or herbage accumulation specified, together with the maximum stocking rates at which these can be sustained.

Calculations of stocking rate should be based on the total grazing area used to support a given number of animals over the stated period of time. Stocking density, on the other hand, is the number of animals per unit area on land actually being used for grazing at a point in time. Thus, whereas under continuous stocking management (see below) stocking rate and stocking density are identical, under rotational grazing managements stocking density will always be higher than stocking rate. It should be noted that neither of these expressions involves any assumptions about whether or not the animals actually make use of the whole of the area to which they have access.

Grazing management

The choice of terms to describe particular methods of grazing management has always created difficulties, and will continue to do so as long as we continue to try to coin single words or short phrases to describe specific, often complex routines. The difficulty can only be overcome by ensuring that for any particular system, full details of management of animals and pasture are given under four major heads:

(a) The extent to which grazing and cutting for conservation on the same area of land are integrated, if at all. Thus a farm may be entirely devoted to grazing, or areas for grazing and cutting may be separate (e.g. Hood, 1974). The relative proportions of the areas grazed and cut may change with seasonal changes in the rate of herbage growth (e.g. Baker et al., 1971) or cutting and grazing may alternate in some formalized or haphazard manner (e.g. Bailie, 1976).

The term forage feeding is preferred for the practice of cutting herbage from a sward (and leaf and stem material from forage crops) for feeding fresh to animals, rather than the conventional zero grazing.

(b) The duration of the period of use of an area of land for cutting or grazing, and information on the time scale of any alternation between cutting and grazing. The term grazing season, used to describe the main period of use of pastures, may be misleading because many pastures are grazed throughout the year, and in some cases there may be more than one season of use in the year.

(c) Description of the management of animals on the grazing area.

(i) Animals may have unrestricted access to the whole area earmarked for grazing at a particular time, or they may be excluded from sections of the grazing area (not necessarily in a regular manner) for periods of time to allow herbage to accumulate. Continuous stocking (not continuous grazing) is preferred as a description where animals are kept on an area continuously and set stocking where the number of animals is constant for the whole or a major part of a grazing season. Rotational grazing is a regular sequence of grazing and rest for particular areas of sward, with either fixed divisions (paddock grazing; Baker et al., 1971) or movable divisions (strip or fold grazing; Holmes, et al., 1950). In this case the number of subdivisions used should be stated. Any less formalized procedure requires detailed description.

(ii) Different classes of stock may be physically separated to a greater or lesser degree. Lambs and calves may be allowed to graze areas which their dams cannot reach (creep grazing) under either continuous stocking or rotational grazing, and different groups of animals may be restricted to separate subdivisions within the same rotational sequence (e.g. leader and follower systems; Leaver, 1976). In these cases it is important to distinguish between the rotation of groups of animals and the rotation of periods of use and rest of particular areas; the two may be very different. At present, the use of cattle and sheep in a common grazing system is described as mixed grazing, irrespective of the system of management employed and the degree of separation of the two species.
(d) Information on the time scale of any alternate use and resting of grazing areas within a rotational system. Enough information is required to allow definition of the length of each period of use (grazing period) and of rest from grazing (rest period) of a pasture: in a routine system of rotation the sum of the two is the duration of the grazing cycle.

Conclusions

No attempt has been made to present an exhaustive list of terms and definitions relating to grazing studies and grazing managements. Rather, it seemed more sensible to highlight some of the major sources of confusion in current terminology and suggest how these might be overcome, and to indicate how developments in our understanding of grazing ecology may create the need for new terms. However, it is clear that progress in this subject, as in any other, is likely to be inhibited unless rationalization of the existing terminology can be agreed and adopted on as wide a basis as possible.

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Glossary (Refer to text for details)

The sward

1 Sward a population of herbaceous plants, characterized by a relatively short habit of growth and relatively continuous ground cover, including both above- and below-ground parts.

2 Sward canopy the above-ground parts of a population of herbaceous plants, including connotations of the distribution and arrangement of the constituent plants and their parts.

3 Herbage the above-ground parts of a population of herbaceous plants, viewed as an accumulation of plant material with characteristics of mass and nutritive value, but no connotations of organization or structure.

4 Pasture a population of herbaceous plants, usually bounded by a fence, considered as a functional unit for grazing.

5 Herbage mass the total mass of herbage per unit area of ground, usually above ground level but otherwise above a definite reference level which must be stated.

6 Herbage growth the development and increase in size and weight of new leaf and stem tissue.

7 Herbage accumulation the change in herbage mass between successive instantaneous measurements, summed over time as appropriate.

8 Herbage consumed the mass of herbage removed per unit area by animals at a single grazing or series of grazings.

9 Herbage harvested the mass of herbage removed per unit area by mechanical means at a single harvest or series of harvests.

The grazing process

10 Defoliation the complete or partial removal of the above-ground plant parts, living or dead, by grazing animals or cutting machines.

11 Grazing the defoliation by animals of the above-ground parts of rooted plants in the ground layer of vegetation.

12 Browsing the defoliation by animals of the above-ground parts of shrubs and trees.

13 Palatable pleasant to the taste.

14 Preference a general term describing the discrimination exerted by animals between areas of sward or the components of a sward canopy, and between or within samples of cut herbage.

15 Preference ranking the ranking of a series of swards, herbage samples or morphological units, based if possible on the relative intakes determined in free-choice trials.

16 Selection the removal of some components of a sward or a sample of herbage rather than others, a function of preference modified by the opportunity for selection.

17 Selection ration the proportion of a component in the diet divided by the proportion of the same component in the sward canopy.
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18 Ease of Prehension a qualitative term describing the ease with which a particular component within the sward canopy can be approached and grasped in the mouth during grazing.

19 Degree of defoliation the ratio of the amount of herbage consumed to the original herbage mass.

20 Residual herbage the herbage remaining after defoliation.

21 Rate of defoliation herbage consumed (see 8) per unit of time during a period of defoliation.

22 Frequency of defoliation the number of defoliations per unit time of an area of sward or of individual plant units.

23 Defoliation interval the time interval between successive defoliations of an area of sward or of individual plant units.

24 Uniformity of defoliation a qualitative term describing the distribution of the mass of residual herbage between adjacent areas of sward or individual plant units.

25 Efficiency of grazing herbage consumed (see 8), expressed as a proportion of the herbage accumulated (see 7) since the previous defoliation, summed if necessary over a series of defoliations.

26 Gross efficiency of conversion (of ingested herbage to animal product) the ratio of animal product to herbage consumed.

27 Efficiency of utilization (of herbage for animal production) the ratio of animal product to herbage accumulated per unit area of land (= efficiency of grazing \times efficiency of conversion).

The balance between animal and sward

28 Grazing pressure the number of animals of a specified class per unit weight of herbage (dry or ash-free) at a point in time.

29 Herbage allowance the weight of herbage (dry or ash-free) per unit of animal live weight at a point in time.

30 Daily herbage allowance the weight of herbage allocated per unit of animal live weight per day in a rotational grazing system involving individual grazing periods (see 39) of only one or two days.

Animal production from grazing systems

31 Stocking rate the number of grazing animals of a specified class per unit of land used to support them over a specified period of time.

32 Stocking density the number of animals of a specified class per unit area of land actually being grazed at a point in time.

Grazing management

33 Forage feeding the practice of cutting herbage from a sward (or foliage from other forage crops) for feeding fresh to animals.

34 Continuous stocking the practice of allowing animals unrestricted access to an area of land for the whole or a substantial part of a grazing season.

35 Set stocking the practice of allowing a fixed number of animals unrestricted access to a fixed area of land for a substantial part of a grazing season.

36 Rotational grazing the practice of imposing a regular sequence of grazing and rest from grazing upon a series of grazing areas.

37 Creep grazing the practice of allowing young animals (lambs or calves) to graze an area which their dams cannot reach.

38 Mixed grazing the use of cattle and sheep in a common grazing system, whether or not the two species graze the same area of land at the same time.

39 Grazing period the length of time for which a particular area of land is grazed.

40 Rest period the length of time between the end of one grazing and the start of the next on a particular area.

41 Grazing cycle the length of time between the beginning of one grazing and the beginning of the next (= grazing period + rest period).

References


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