VARIATION IN BEEF CATTLE LIVEWEIGHTS

L. E. WOODS* and G. W. M. KIRBY*

Summary

Standard deviations for beef cattle liveweights and liveweight gains have been collected from a number of large scale grazing experiments under tropical monsoon conditions in the Northern Territory. The information is summarized so that it may be used in the design of experiments.

I. INTRODUCTION

Large scale experiments with beef cattle were made under tropical monsoon conditions in the Northern Territory of Australia, and variation in the measured liveweights was examined. Information on such variation is scanty but is useful in planning further experiments because the degree of replication necessary for a specified precision can be calculated.

II. STATISTICAL METHODS

(a) Expected variances

Expected variances in animal husbandry experiments are discussed by Henderson (1959) and his notation will be followed in this paper.

Suppose p groups of q cattle are weighed at r successive intervals. The liveweight of the k^{th} animal in group j at time i may be represented by X_{ijk}, and the gain or loss in liveweight of the k^{th} animal in group j during the time interval i to (ii-l) is represented by Y_{ijk}. It will be assumed that the model is:

$$X_{ijk} = \mu + a_{jk} + t_i + g_j + (tg)_{ij} + e_{ijk}$$

where μ is a common mean; a_{jk} is the difference between the average weight of the jk^{th} animal and the mean of group j; t_i is the average change in liveweight with time at time i; g_j is the average effect on liveweight of the treatment applied to group j plus any initial group deviation; $(tg)_{ij}$ is the effect, at time i, of the j^{th} treatment; and e_{ijk} is the error attached to the observation. Each term, except μ, has an associated variance component; for example, $\sigma^2_{a:gt}$ is associated with a_{jk} and represents variation between animals within groups and times.

The analysis of such a set of data presents a number, of problems. The standard analysis of variance requires that the effects listed in the above model be additive. In animal data this is usually so only on a logarithmic scale. The e_{ijk} need to be independent, normally distributed, and to have a common variance (Cochran 1947). These conditions would be reasonably satisfied by e_{jk} at a particular time i, or by $e_{.jk}$, but in practice, e_{ijk}, t_i and $(tg)_{ij}$ at time (i+1) may not be independent of the corresponding effects at time i. Among other things, the time intervals should be of equal length, and the groups of equal size, for the e_{ijk} to have a common variance. Similar conditions should be satisfied by the components of Y_{ijk}.

*Northern Territory Administration, Darwin, N.T.

are inflated by the component $\sigma^2_{a:g}$ which lowers the precision of the experiment. $\sigma^2_{a.g}$ can be reduced by grouping the animals according to initial weight, age, sex, breed or history in addition to the treatment groups. It can also be reduced by using a covariate such as initial weight, or by selecting uniform animals from a much larger herd (Henderson 1959; Cochran and Cox 1957).

A mixed model is appropriate in the above case, as the treatments applied cannot be regarded as a random selection from some population of treatments. Times, with regard to environmental effects, and animals may both be regarded as random selections, and conclusions from the experiment may be extended to the population of times or animals. However in some cases, times or animals may not be random selections from larger populations, and conclusions are restricted to the times or animals used in the experiment.

(c) Biological implications

The liveweight gain, Y_{jk}, for a particular period may be biased through differences in gut-fill, handling, time of day in relation to drinking, and body water content at the two weighings. These differences would also contribute to σ^2_2.

The possibility of reducing the variation between animals component, $\sigma^2_{a:g}$, of σ^2_1 depends on the aim of the experiment. For example, in an experiment to assess the direct effect of a mineral deficiency on growth, uniform groups of animals

TABLE 2

Observed variability in N.T. Administration breeding experiments

Breed*	Mean Age (months, m; or years, y)	Number of cattle in group	Average Weight† (kg)	Standard Deviation of an Individual Weight (σ_1)	Coefficient of Variation (%)
S	8 m	50	112	33.4	30.0
S	19 m	35	183	29.9	16.4
S and SGxS	Birth	75	25	3.1	12.1
S and SGxS	9 m	51	104	34.5	33.1
S and SGxS	16 m	37	195	42.5	21.8
S and SGxS	Birth	68	26	6.1	23.0
S and SGxS	8 m	51	121	36.8	30.5
S and SGxS	17 m	46	198	64.1	32.3
BxS and SGxS	Birth	82	30	8.7	29.2
BxS and SGxS	6 m	75	121	36.7	30.4
BxS and SGxS	18 m	75	218	51.4	23.5
BxS and SGxS	Birth	126	30	7.4	24.7
BxS and SGxS	6 m	118	104	26.0	24.9
BxS	1¼ y	24	158	42.4	26.9
BxS	2 y	16	217	29.5	13.6
S	2½ y	49	290	38.5	13.2
S	2-4 y	35	196	41.3	21.0
SGxS	2-4 y	35	280	55.7	19.9
S	3-4 y	30	297	39.8	13.4
BxS	2-6 y	61	329	58.4	17.7
SGxS	5-9 y	17	458	60.0	13.1
S	5-10 y	138	346	47.0	13.6

*S=Shorthorn; SG=Santa Gertrudis;
B=Brahmam
†Weights are unadjusted for known variables

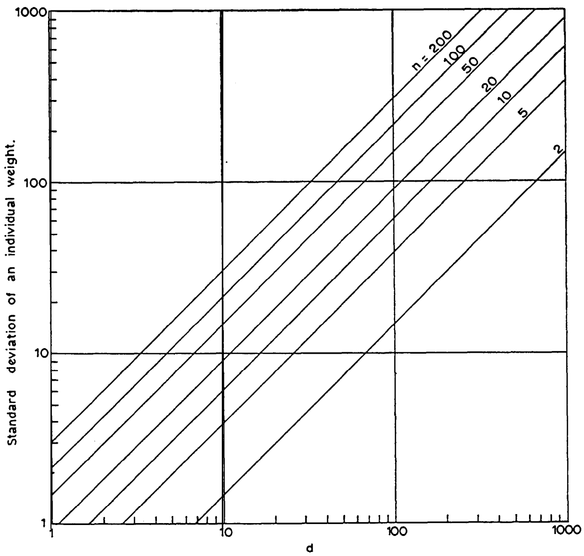

Fig. 2.—The number of individuals (n) per treatment group needed to detect a treatment difference of d or greater. (This is based on Tukey's (1953) method, with 30 degrees of freedom for the standard deviation, and 4 treatments in a completely randomised design. The probability of Type I or II errors is 0.05.)

IV. DISCUSSION

The values in Tables 1 and 2 may be used as a guide to the magnitude of standard deviations to be expected in future experiments in the N.T. Figures 1 or 2 may then be entered with the standard deviation and the size of the treatment effect that it is desired to detect, and the necessary group size read off. Suppose four treatments are being compared, and it is desired to detect a difference of 45 kg in liveweight. If σ_1 is estimated to be 40 kg, then groups of 20 cattle will be needed for each treatment.

A Type I error is the error of deciding that a treatment effect exists when actually it does not; and a Type II error is the error of deciding that no treatment effect exists when there is a real effect present.

Figures 1 and 2 apply to a restricted range of experiments and powers of tests. The treatment group size should be calculated according to Tang (1938), for other experiments or powers of tests.

V. REFERENCES

COCHRAN, W. G. (1947). ***Biometrics* 3: 22.**

COCHRAN, W. G., and COX, G. M. (1957). "Experimental Designs". (Wiley: New York).

FEDERER, W. T. (1955). "Experimental Design". (MacMillan: New York).

HENDERSON, C. R. (1959). In "Techniques and Procedures in Animal Production Research". ***Monogr. Am. Soc. Anim. Prod.***

TANG, P. C. (1938). ***Statist. Res. Mem. Univ.*** *Coll.Lond.* ***2:*** 126.

TUKEY, J. W. (1953). "The Problem of Multiple Comparisons". Mimeographed publication, Princeton University.