IDENTIFICATION OF THE UNIT IN EXPERIMENTS ON SUPPLEMENTARY FEEDING OF BEEF CATTLE GRAZING NATIVE PASTURE.

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SUMMARY

Published results of similar grazing experiments reveal inconsistencies about whether the animal or paddock variation is the appropriate estimate of experimental error. To look at the problem of identifying the experimental unit (EU) in supplementary feeding trials, we present results from the analysis of 24 experiments with growing beef cattle grazing native pasture and covering a range of environmental and management conditions in Queensland.

Our investigation showed that in many cases the individual animal could be regarded as the EU and animal variation gave a good estimate of random error; but this could not be recommended universally. The difficulties of obtaining uniform replicates resulted in significant interactions in experiments from one site and demonstrated that paddock replication was essential in all experiments.

INTRODUCTION

In the five distinct types of grazing experiment in Table 1, the nature of the treatments dictates whether the experimental animals may graze together as one herd, or need to be grouped in separate treatment paddocks. The correct identification of the experimental unit (EU) is the first step in any design. Text book definitions aimed at covering experimental design in any field are "the unit of material to which one application of a treatment is applied" (Steel and Torrie 1960), and "the unit corresponds to the smallest division of the experimental material such that any two units may receive different treatments in the experiment" (Cox 1958). With respect to grazing experiments these definitions are incomplete - it remains to define "material".

TABLE 1 The different types of grazing experiment with beef cattle

Type of experiment		Nature of the treatments	Experimental material
1. Pasture comparison		Pasture types	Pasture+animals
2. Stock management	(i)	Stocking rates	Pasture+animals
	(ii)	Management strategies such as set-stocked vs rotational grazing	
3. Supplementary feeding		Energy and/or protein and/or mineral supplements vs unsupplemented	Animals (paddock fed)
4. Veterinary procedure	(i)	Dipping	Animals
	(ii)	Drenching	
	(iii)	Mineral therapy vs untreated, in each case	
5. Breed comparison		Breed types	Animals

Beattie and Alexander (1973) give unequivocal advice to experimenters in the choice of unit for a number of types of grazing experiment with beef cattle. In general, their EU is the paddock for the first two types of experiment in Table 1, but when the animal "carries" its treatment with it, the EU is the

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animal. Supplementary feeding experiments are a special case of the animal as the EU since for practical reasons the supplement is paddock fed; our study is restricted to this third type. Animals may also be grouped for veterinary comparisons where treated and untreated animal groups have to be isolated to avoid contamination. With breed comparisons the animals may graze together as one herd. Whenever animals are grouped the paddocks need to be replicated or paddock differences would be completely confounded with treatment effects.

Defining the individual animal to be the EU determines that animal variance is the experimental error. The paddock replication x treatment interaction would be used to test the effect of treatments only if replicates are taken to be a random effect (Henderson 1959) i.e. the replicate sets of paddocks are sited at randomly (or objectively) selected sites in the region so as to broaden the applicability of results. We examine whether within paddock variation is an appropriate estimate of animal variance and whether it can be used to test the effect of treatments. This approach has attracted two major criticisms in the past (i) the within paddock variation may seriously underestimate or overestimate animal variance because of group feeding or competition effects, respectively and (ii) that the experimental error should contain both pasture and animal variation. As Morley and Spedding (1968) note the problem merits investigation.

MATERIALS and METHODS

Weexaminedthe analysis of variance results from 24 supplementary feeding experiments, which were carried out between 1968 and 1979 by QDPI officers at two sites at "Swan's Lagoon" near Ayr, and at one site at "Brian Pastures" near Gayndah. All experiments involved growing beef cattle grazing native pasture (NP) of mainly speargrass (Heteropogon contortus). The range in experimental and management conditions is summarised in Table 2.

TABLE 2 Experimental and management conditions

Variable	Range
Animal age	Weaners, yearlings, 2 year olds
Stocking rate (animals/ha)	0.37 - 2.1
Breed	Brahman X, Sahiwal X, Shorthorn, Hereford
Sex	Steers, mixed, heifers
Time of supplementation	Start : December - July
	Finish: September - November (Spring)
Length of feeding period (days)	84-357 (mean 191)
Length of post-feeding period (days)	82-281 (mean 174)
Location of animals in post-feeding period	Common grazing: 10 experiments
	Treatment paddocks: 14 experiments

All experiments were stocked at a heavier rate than the district average for animals of the same age grazing native pasture - the rates varied from 25% higher to four times the average for the region. During the feeding period the growth rate of the unsupplemented NP groups varied from -234 to 332 g/h/d.

The experimental supplement treatments were mainly based on molasses and/or urea, with particular treatments comparing either mineral additives or level of feeding; in two experiments urea/molasses were compared with a standing legume supplement fed in sub-paddocks. An unsupplemented NP treatment was included in all experiments. All urea/molasses based supplements were paddock fed either by a drum-licker or block. A common feature of the design of all 24 experiments was the use of paddock replication (2, 3 or 4 replicates) in a randomized block layout, with the replicate sets of paddocks being set up at one experimental site; this minimal replication at the same site provides a check on the presence of replication by treatment interaction. Individual animals were allocated to paddocks by stratified randomization based on initial liveweight; a different draft of animals was used in each experiment.

We considered three major experimental periods: supplement feeding, post-feeding and total. Individual animal growth rates in the three periods were estimated by average daily gain calculated from full liveweights. For each experiment and period animal variances within treatments groups were tested for homogeneity using Bartlett's test, and paddock variance was compared with animal variance (by F-test).

RESULTS AND DISCUSSION

TABLE 3 Experimental error mean squares for average daily gain (g/h/d)

		Animals				Paddocks $			
Period:		Feeding	Post-feeding	Total	DF	Feeding	Post-feeding	Total	DF
Site	Experiment								
1	1	2990	4120	2210	132	13500 *	23900 *	11400 *	5
1	2	3220	9030 @	3490	132	31300 *	4450	11900 *	5
1	3	5850	5970	2670	132	39300 *	7970	11300 *	5
1	4	4130	10700	2500	132	10800 *	36500 *	3890	5
2	5	7180 @	7550	4100	67	15800	1850	2830	3
2	6	2650	12600	2210	63	9720 *	10300	3700	3
2	7	3480	7750	1650	63	9710 *	14200	1010	3
2	8	4250	5500	2790	73	31500 *	3180	9130 *	3
2	9	5690	4170	2350	74	3030	1720	730	3
1	10	1940	9750	2320	112	21600 *	5150	6250 *	4
1	11	3770 @	3540	1990	106	2010	10400 *	4830 *	5
1	12	1740	4670	1510	106	42500 *	17000 *	6440 *	5
1	13	1980	5700	1550	105	7570 *	5860	3400	5
1a	14	3180	7770	2940	32	1580	12100	3010	4
1a	15	2540	9940	2540	40	19900 *	9290	10900 *	5
1a	16	1820	8970	1610	40	5540 *	8100	1780	5
2	17	3840	7000	3130	76	11300 *	3930	6820	3
2	18	3640	12800	3820	76	3770	2810	3850	3
2	19	1800	13000	2000	76	5720 *	18300	5490 *	3
2	20	3590	16000 @	3370	77	25300 *	21200	7980	3
3	21	3130	8330	2420	36	494	5220	2080	1
3	22	2070	6980	2110	28	63	9750	1780	1
3	23	2750	3430	1300	23	1710	7020	3020	3
3	24	4250	7400	3160	11	8250	9110	4060	6
Mean ++		3500	7940	2500	76	15000	11200	5840	4
Median		3200	7650	2390		9720	8610	3980	-
Range :	min	1740	3430	1300	11	63	1720	730	1
	max	7180	16000	4100	132	42500	36500	11900	6

$ Paddocks error mean squares expressed on a per animal basis.
@ Indicates significant differences (P<0.05) by Bartlett's test of homogeneity of within paddocks treatment variances.
* Indicates significant differences (P<0.05) by F-test of paddock mean squares versus animal mean squares.
++ Mean squares weighted by degrees of freedom.

In general, when the variances between animals within treatments were tested for homongeniety, they were not significantly different ($P>0.05$). In particular, there was no indication that unsupplemented animals were more or less variable than supplemented animals. Consider the arguments about group effects influencing the between animals estimate of error. There could be a social affect of animals grazing together which tends to make measurements of animals within a paddock correlated, and so within paddock variation would underestimate true animal variance. On the other hand, animals grazing native pasture at the high stocking rates used in the 24 experiments, could be stressed with perhaps the lighter animals faring better than the heavier animals; this negative correlation would tend to increase animal variation. With supplemented animals, some animals could consume more supplement than others and this could result in larger animal variation in the supplemented groups. We concluded from the homogeneity tests that there are no appreciable group effects on the between animals estimate of error.

Estimates of animal variance are reasonably consistent across experiments. For the feeding, post-feeding and total periods, the paddock variation was significantly greater than the animal variation in 15,4 and 9 experiments respectively. A problem in interpretation arises when paddock replication X treatment interaction is significant since one must be more careful in interpreting the main effect obtained for treatments. These interactions occurred most frequently in the analyses of two series of experiments (1...4,10...13); both at the same site. Analysis of two years data of a uniformity trial on this site revealed that there were consistent paddock differences and that paddocks were not uniform within a replicate. By using information on paddock differences as a covariate in the analyses of the experiments on that site, the interaction was explained in about half the analyses.

Since some interaction effects remain unexplained for site one, our conclusions from this investigation are not clear-cut. In most cases, one can expect the animal variation to be a good estimate of random error. The unexplained replicate X treatment interactions remain a problem; further work is planned to find a suitable measure to explain paddock variation. In addition to uniformity trials, pattern analysis on soil and moisture measurements could help in selecting uniform paddocks for a replicate. The alternative is to increase paddock numbers and estimate error from paddock variation; but there is a difficulty in obtaining uniform paddocks and maintaining sufficient animals in a paddock to simulate a commercial herd. Depending on the number of treatments, a minimum of 20 paddocks are usually necessary to reliably determine experimental error.

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