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Review

A review of cashmere nutrition experiments with suggestions for improving their design and conduct

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ABSTRACT

The scientific literature contains divergent views about the effects of nutrition on cashmere. The consequences of ignoring nutrition will be an increase in the number of goats suffering lower production, increased welfare risks and premature mortality. This review evaluated published reports to identify current knowledge and best practice in regard to the design and management of cashmere nutrition experiments. The ability of experiments to distinguish between treatments was evaluated based on their statistical evidence. Many experiments had serious deficiencies in their design, conduct and reporting. Six of 16 papers did not provide statistical information that would enable a reader to verify differences between treatments. For most experiments to detect nutrition affects at $P < 0.05$, they required a difference between treatments of 0.2–0.8 μm in cashmere mean fibre diameter and 15–42 g in clean cashmere production. Government Research Institutes research was characterised by more experienced authors conducting longer ($P < 0.05$) and larger ($P < 0.05$) experiments than those conducted by Universities. Much of the "debate" regarding the affects of nutrition on cashmere production arises from the misinterpretation of both experiments that did not detect statistically significant effects and of experiments that did detect statistically significant effects. Based on a comparison between experiments reporting responses to nutrition with those reporting no response, 13 design and management features were identified that are related to the ability of experiments to detect significant treatment affects. Methods must be adopted to reduce the variance in cashmere production within treatments, by using sufficient animals per treatment, and having replication to provide sufficient degrees of freedom to reduce error terms in analysis. The power of experimental designs should be evaluated before experiments commence. Cashmere production records from a previous full production year could be used as co-variants during statistical analyses but this requires that potential experimental goats are managed in one flock, without variations resulting from different grazing, reproduction or other management for a year prior to an experiment. It is preferable to use more productive and older goats, and goats that are used to handling, and to the conditions and feed to be used. Allocation of animals to treatments must take into account live weight. Nutrition treatments need to be sufficiently different to produce different growth curves. An appropriate control is needed such as live weight maintenance. Evidence of both nutrition intake and growth curves must be published with cashmere production data so the claims made can be verified by the actual responses. As cashmere production is an order of magnitude less than fibre production of Merino sheep or Angora goats and is more difficult to measure, the requirements for measurement, sampling and testing cashmere fleeces are summarised. The use of mid side cashmere patches

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to determine cashmere growth and quality is seriously biased and must be avoided, preferably by shearing goats prior to and at the end of experiments. In order to obtain higher fleece growth responses and improve the ability of experiments to detect treatment effects it is preferable to start cashmere growth experiments by midsummer and conduct experiments for at least 4 months. These requirements make it difficult for many university students to plan, undertake and complete long-term cashmere nutrition experiments without considerable management support. It is not possible for experiments to disprove the Null hypothesis regarding the effects of nutrition on cashmere production as they can only report a failure to detect treatment effects. Researchers and journals need to be more rigorous in providing statistical information including: degrees of freedom for error terms, treatment variances, standard error of differences or similar to enable readers to compare treatment effects. Publications that do not provide sufficient statistical information should be disregarded from future discussions. Claims that an experiment shows no responses to nutrition should be subject to rigorous examination using the issues identified in this review.

1. Introduction

Cashmere fibre production is affected by genetic and environmental influences. Variations in animal nutrition are generally the most important environmental influence on animal fibre production mediated via rate of stocking, seasonal droughts, cold stress, supplementary feeding of energy and protein, live weight change, changes in body energy reserves and impacts of parturition and lactation (Black and Reis, 1979; Morley, 1981). Within the scientific literature divergent views exist about the effects of nutrition on cashmere growth. Given that nutrition management has major affects on sheep, cattle and goat growth, wool and mohair production, reproduction, and the ability of goats to survive adverse weather events, it is unusual that many authors have concluded that nutrition is not important for cashmere production. The consequences of ignoring nutritional management of cashmere goats will be an increase in the number of goats suffering poor nutrition, with lower production, reduced reproduction, increased welfare risks and premature mortality as a consequence of overstocking, loss of body energy reserves during adverse seasons, increased disease risk and greater susceptibility to hypothermia (McGregor and Butler, 2008a).

Some of the critical issues (design, conduct, and interpretation of experiments) contributing to this paradox regarding the importance of nutrition for cashmere growth were first discussed at an international conference in China and subsequently published (McGregor, 1996a, 1998). Since 1995, when that review was written, further scientific reports on the nutrition of cashmere goats have been published or come to light. However, the number of published experiments that reported no effect of nutrition on cashmere growth and quality attributes are still leading some scientists to conclude that nutrition is not important (Wang et al., 1996; Ivey et al., 2000; Rafat and Shodja, 2004) and such views may be misguiding development efforts aimed at improving cashmere production and the economic well-being of pastoralists.

This review aims to evaluate published reports to identify current knowledge and best practice in regard to the design and management of cashmere nutrition experiments. The review evaluates the ability of experiments to distinguish between nutrition treatments and discusses findings of experiments that detected affects of nutrition on cashmere production. The implications of concluding that nutrition is not important for cashmere production are also briefly summarised. It is also necessary to briefly review aspects of cashmere fleece testing and to explain the background to developments in Australia, where many of the earliest cashmere nutrition experiments were conducted.

2. Materials and methods

Published papers in animal science journals, proceedings of scientific societies and internet science journals were located. It is likely that some non-English language reports were not identified. A total of 16 papers were located that made conclusions regarding the impact of nutrition on cashmere growth and fibre diameter. The statistical data from each paper were tabulated and the smallest effect detectable for each experiment was calculated for cashmere mean fibre diameter and cashmere production as: standard error of difference (s.e.d.) × t_{df}. Where a standard error of mean (s.e.m.) was provided s.e.d. was determined as: $\sqrt{2}$ × s.e.m. Where no treatment effect was detected the smallest effect detectable has been tabulated as: > (the difference between the largest and the smallest value provided in tables of treatment effects). For experiments where the smallest effect detectable could not be determined the 95% confidence limits were estimated as: ±1.96 × s.e. The design features and results were summarised for each experiment and comparisons made between those detecting affects of nutrition with those that were not able to detect differences. The size and duration of experiments published from Universities were compared with those originating from other institutions by the use of two-sided *t*-tests.

3. Features of published cashmere nutrition experiments

3.1. Statistical data for experiments

Table 1 summarises statistical data for published experiments. Six of the published papers (37%) do not provide statistical information that would enable a reader to verify differences between treatments or to calculate the smallest detectable effect (Table 1) although for two of these papers a confidence interval could be estimated. Only two of the papers clearly reported the number of degrees of freedom for the error term used in the analysis of variance calculations to determine treatment effects. Surprisingly, two experiments had zero degrees of freedom for the error term and so should not have been published in any circumstance.

For most experiments to detect nutrition affects at $P < 0.05$, they required a difference between treatments of 0.2–0.8 μm in cashmere mean fibre diameter and 15–42 g in clean cashmere production (Table 1). As many inves-