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Relationships between live weight, body condition, dimensional and ultrasound scanning measurements and carcass attributes in adult Angora goats

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ABSTRACT

Real-time ultrasound scanning is an accurate non-invasive technique used to improve quality in sheep, cattle and pig meat production but has been overlooked in meat production from heavy goat carcasses. The aims of this study were to: determine subjective and objective carcass attributes of 6 year old Angora castrate goats prior to and following slaughter; and determine the relationships between carcass attributes, bodyweight, body condition score (BCS), body dimension measurements and ultrasound measurements using multiple regression modelling. Key attributes were: on-farm bodyweight (range 35–77 kg), BCS (1, very thin to 4.3, fat), dimensional frame measures (wither height, heart girth, anterior-posterior circumference, body volume (circumference × girth)), carcass weight (range 11.6–33.2 kg), GR tissue depth of carcasses (1–27 mm) and the ultrasound measurements of eye muscle depth (EMD, 17–35 mm) and subcutaneous fat depth (SFD, 1–6 mm). Goats from three genetic backgrounds were grazed on pasture together for 6 years. In the three months preceding slaughter the goats grew from an average live weight of 50.7 kg gaining live weight at an average of 117 g/d to reach an average live weight of 62 kg. There were moderate correlations between all measurements. BCS accounted for 55.1% of the variance in carcass weight, 51.3% of the variance in EMD, (3.2% more than did GR tissue depth) and 59.9% of the variance in SFD. Live weight accounted for 83.8% of the variance in carcass weight. The best prediction equation for carcass weight included terms for live weight, SFD, EMD and sire, accounting for 91.5% of variance. Body dimensional measurements were not as useful as BCS in predicting carcass weight, with the best, body volume, accounting for 5% less of the variance than live weight. The best prediction for the EMD included terms for BCS and carcass weight, accounting for 61% of variance. GR tissue depth was primarily associated with SFD, and in combination with carcass weight and BCS explained 71.9% of the variance. In relation to predicting carcass traits, girth accounted for more of the variance in EMD, SFD and GR tissue depth than wither height or body circumference. If breeders aim to alter the EMD and SFD of Angora goats then ultrasound scanning provided better estimates compared with relying on live weight with or without body condition scoring. Both EMD and SFD were also in the best model for predicting carcass weight. BCS was a useful on-farm measurement for estimating carcass attributes but girth was not as useful as body volume in explaining the variance in live weight.

1. Introduction

Meat production is an important component of the financial returns from fibre and wool producing systems of animal production. In Australian wool producing enterprises, sales of surplus young and aged sheep for meat contribute 25–40% of total income with a similar proportion of total income arising from meat sales in mohair enterprises in Australia (McGregor, 2010a). The Australian mohair industry imported South African and Texan Angora goat strains in the early 1990s. While the production and quality of mohair from the new genetics has been investigated, there is scant information regarding the production and quality of carcasses when these Angora goats are sold as adults.

The evaluation of carcass attributes is an important component of sheep improvement programs. In centralized breeding schemes in Australia, where real-time ultrasound scanning has been used on-farm to measure eye muscle depth (EMD) and subcutaneous fat depth (SFD) in meat sheep (Hopkins et al., 2007; LambPlan, 2015), improvements have been obtained in growth, carcass weight and a

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significant medium-term return on investment has been obtained (Holst, 1999). While a centralized breeding scheme for goats has been available in Australia for some years (KidPlan, 2015) few breeders have availed themselves of the service. Real-time ultrasound scanning offers a fast, accurate and safe method of quality control in meat production (Silva and Cadavez, 2012; Scholtz et al., 2015) but its use as an in vivo pre-slaughter technique to improve goat meat quality has been overlooked in recent reviews (Goetsch et al., 2011; Kannan et al., 2014; Scholtz et al., 2015) and what little information that is available is focused on kid carcasses (Monau et al., 2013).

EMD and SFD are measurements of interest in meat production as they form both the muscles and fat covering along the back of animals which provide the high value meat cuts from sheep and cattle carcasses such as: loin and chump chops, racks, saddle, fillet, porterhouse, sirloin, Scotch and T-bone steaks. There has been little measurement and selection within goat breeds for increased eye muscle area and SFD. The lack of application of the measurement of EMD and SFD are probably the result of goat carcasses being traditionally sold with little or no differentiation between cuts, mainly as slices off the fresh carcass, as whole carcasses, or in western export countries in cubed or six-way cut boxed meat (MLA, 2013) and perhaps the lack of evidence regarding the relevance of the measurements in goats.

The relevance and specific transfer of research findings with sheep to goat carcasses needs to be cautioned by the knowledge that fat distribution within goats differs significantly to that of sheep and so the growth and development of goats cannot be directly equated with that of sheep (Lapido, 1973; Fehr, 1981; Goetsch et al., 2011) and goats have been subject to far less genetic selection for carcass traits than have sheep. From about 20 kg live weight, internal and subcutaneous fat deposits in Angora goats increase at a proportionally greater rate than the empty body, leading to proportionally increased carcass fatness and carcass weight as body weight increases (McGregor, 1992a, 2011) but the changes in other carcass attributes are poorly documented.

On-farm assessments can involve body weight and body dimension measurements, subjective body condition scoring (BCS) and indirect objective measurements using ultrasound scanning. In the abattoir, direct measurements of carcass weight and tissue depth measurements can be made. In meat production, real-time ultrasound scanning (ultrasonography) is an accurate non-invasive indirect in vivo measurement technique used to measure the EMD (*M. longissimus thoracis et lumborum*), measured at the USFat C site, 45 mm from the midline (at the 12/13th rib) and subcutaneous back fat depth using the same techniques that are used with sheep and pigs (Wood and Fisher, 1990; Stanford et al., 1995; Amin et al., 2000; Hopkins et al., 2007; Teixeira et al., 2008; Monau et al., 2013). This technique provides a visual cross-section image of carcass tissues and enables the direct measurement of tissue depths. BCS was first explained by McClymont and Lambourne (1958) and Jefferies (1961) for use in sheep, and has been applied with goats since at least 1982 (McGregor, 1983, 2010b). BCS in goats has been shown to be related to the commercially important parameters of goat live weight, milk production, carcass production, carcass fatness, reproductive performance and mortality (McGregor, 1990, 1992a; McGregor and Butler, 2008).

The practical question is therefore to what extent does ultrasound measurement provide better estimates of carcass yield, carcass composition and EMD of goats than the easily applied techniques of on-farm bodyweight measurements, dimensional frame measures, and BCS? However, the costs of both equipment and hire of consultants to conduct ultrasound scanning are likely to result in this technique being applicable only in larger commercial breeding flocks, during genetic selection programs for carcass attributes and where carcass attributes are important in the classification of carcasses at meat works. Thus in developing economies and in remote regions where ultrasound scanning cannot be accessed, low cost subjective evaluation methods such as subjective BCS are the only alternative. Furthermore, previous studies using ultrasound scanning of goat carcasses are limited to young goats with no data on heavy goats. Therefore the aims of this study were to: determine subjective and objective carcass attributes of adult Angora goats prior to and following slaughter; and determine the relationships between carcass attributes, bodyweight, BCS, body dimension measurements and ultrasound measurements.

2. Materials and methods

2.1. Management

Management details for the Angora goats have been provided in earlier reports (McGregor et al., 2012, 2013). In brief, Angora goats born in September 2002 in a progeny testing evaluation at Horsham, Victoria, (36°42′50″S, 142°18′30″E, altitude 180 m) with pedigree breeding records from known sires, were grazed on pasture from birth until 6 years of age. The goats were progeny of various genetic sources including sires of 100% South African origin ($n = 2$), 100% Texan origin ($n = 4$), and other interbred admixtures that included sires of South African, Texan and Australian origin ($n = 4$). These sires were representative of the genotypes available in Australia (Ferguson and McGregor, 2005). Records of dam, birth weight and birth parity were taken for castrated males (wethers). One month after shearing in February 2004 the goats were transported to Attwood, Victoria (37°40′S, 144°53′E, altitude 135 m) and grazed as one flock until November 2008 at near the recommended stocking rate on improved annual temperate pasture (McGregor, 2010b). Goats were moved between paddocks to match feed requirements. Shelter was available in the form of covered and enclosed building that was always accessible and could accommodate all goats. Fresh rainwater was provided in all paddocks.

During most years in autumn and winter, pastoral conditions were affected by drought and supplementary feeding was undertaken following Australian practice (McGregor, 2005) from mid May to early September to maintain live weight. A mineralised stock block was always available (Ridley AgriProducts Pty. Ltd., Melbourne) with the following content: minimum content Ca 4.9%; P 1%; S 2%; Cu 600 mg/kg; Co 60 mg/kg; I 60 mg/kg; Zn 1000 mg/kg; Fe^{2+} 1100 mg/kg; Se 5 mg/kg; based on NaCl 75–85%. Goats were vaccinated against 5 in 1 *Clostridia* spp. and "drenched" with an effective anthelmintic to control gastro-intestinal parasites no more frequently than once per year.

In the six months prior to slaughter, supplementary drought feeding was supplied at a rate of 250–310 g/goat/d depending on pastoral conditions between late March and mid-August 2008. Prior to slaughter goats were shorn in September 2008.

2.2. Animal and carcass measurements

In most months during the study all goats were weighed to the nearest 0.2 kg. At each weighing BCS was recorded by an experienced operator by palpating the short ribs and assigning a score as follows: 1 (very lean, sharp prominent backbone and spinal processes, little flesh coverage); 2 (lean); 3 (medium, slight rounding of flesh over spine); 4 (fat); 5 (very fat, cannot detect any backbone or spinal processes) with two intermediate scores assigned between each of these main categories i.e. 2.3, 2.7, 3.0, 3.3 (McGregor, 1983, 1992a, 2005).

Prior to slaughter in November, the goats were weighed, BCS and the EMD (mm) and SFD (mm) of the goats were determined by a very experienced ultrasonic scanning technician (Advanced Live-