Phenotypic factors associated with lamb live weight and carcass composition measurements in an Irish multi-breed sheep population[1]

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ABSTRACT: Understanding the phenotypic factors that affect lamb live weight and carcass composition is imperative to generating accurate genetic evaluations and further enables implementation of functional management strategies. This study investigated phenotypic factors affecting live weight across the growing season and traits associated with carcass composition in lambs from a multibreed sheep population. Four live weight traits and two carcass composition traits were considered for analysis namely; birth, preweaning, weaning, and postweaning weight, and ultrasound muscle depth and fat depth. A total of 427,927 records from 159,492 lambs collected from 775 flocks between the years 2016 and 2019, inclusive were available from the Irish national sheep database. Factors associated with live weight and carcass composition were determined using linear mixed models. The heaviest birth, preweaning, and weaning weights were associated with single born lambs ($P < 0.001$), however by postweaning, there was no difference observed in the weights of single and twin born lambs ($P > 0.01$). Breed class affected lamb live weight and carcass composition with terminal lambs weighing heaviest and having greater muscle depth than all other breed classes investigated ($P < 0.001$). Lambs born to first parity dams were consistently lighter, regardless of time of weighing ($P < 0.001$), while dams lambing for the first time as ewe lambs produced lighter lambs than those lambing for the first time as hoggets ($P < 0.001$). Greater heterosis coefficients (i.e., >90% and ≤100%) resulted in heavier lambs at weaning compared with lambs with lower levels of heterosis coefficients ($P < 0.001$). A heterosis coefficient class <10% resulted in lambs with greater muscle depth while recombination loss of <10% increased ultrasound fat depth ($P < 0.001$). Results from this study highlight the impact of multiple animal level factors on lamb live weight and carcass composition which will enable more accurate bio-economic models and genetic evaluations going forward.

Key words: carcass composition, live weight, phenotypic factors, sheep

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INTRODUCTION

As we strive for more efficient ruminant production systems, an important emphasis has been placed on identifying key performance indicators and meeting production targets on farms. This conveys the importance of monitoring animal performance and enables farmers to benchmark themselves vs. the most efficient producers, both economically and sustainably (Byrne et al., 2010; Brown et al., 2015).

In the majority of sheep production systems, lamb sales are the primary output (Bohan et al., 2018). Therefore, achieving optimum lamb growth rates and carcass composition are fundamental to the profitability of a sheep farm. Inferior growth rates mean an increased number of days to slaughter, higher maintenance energy costs, and a reduction in production efficiency (Gascoigne and Lovatt, 2015); which results in a missed opportunity to sell lambs when demand is strong and market prices are at their highest. This coupled with the identification of live-weight, including live-weight gain, and carcass output as key performance indicators on sheep farms underlines the importance of achieving optimum lamb growth throughout the production season.

Although a plethora of previous studies have examined the effects of non-genetic (David et al., 2011; McHugh et al., 2017) and genetic factors (Safari et al., 2005; Fitzmaurice et al., 2020) on lamb live weight, less information is available on factors affecting potential carcass composition. For the most part, this is due to the inherent difficulty in assessing carcass composition on farms where lambs are selected as sires and dams of the next generation. Carcass composition is often assessed using correlated traits, for example, ultrasound muscle and fat measurements, in order for animals to be ranked within the national genetic evaluations on their carcass merit (Puntila et al., 2002). Identifying the impact of phenotypic factors associated with these correlated traits is therefore crucial to allow for appropriate adjustments within national genetic evaluation models. Therefore, the objectives of this study were: 1) to investigate phenotypic factors affecting live weight pre-, post-, and at the point of weaning, 2) to examine ultrasound muscle and fat depth measurements postweaning in a multibreed sheep population. Results from this study provide a better understanding of the phenotypic factors associated with lamb live weight and potential carcass composition within the Irish sheep population.

MATERIALS AND METHODS

Phenotypic Data Collection

A total of 427,927 live weight records from 159,492 lambs collected from 775 flocks between the years 2016 and 2019 inclusive, were extracted from the Irish national database hosted by Sheep Ireland (http://www.sheep.ie). Lamb live weight was recorded at four time points in a lamb's lifetime: birth, preweaning, weaning, and postweaning by Irish producers using weigh-scales. Lambs with a recorded weight at birth between 2 and 9 kg were retained and lamb birth weight was rounded to the nearest half kilogram. Preweaning weight was defined in the present study as the live weight taken between 20 and 65 d of age; only records of lambs weighing between 12 and 32 kg were retained. Weaning weight was defined as the live weight taken between 66 and 120 d of age; only records of lambs weighing between 20 and 50 kg were retained. Postweaning weight was defined as a lamb between 121 and 180 d of age and weighing between 25 and 65 kg. Ultrasound muscle and fat depth were also measured with postweaning weight. Only ultrasound muscle depths between 20 and 35 mm and fat depths between 1 and 15 mm were retained.

Data Edits

Records were discarded if flock of birth or dam parity were unknown; dam parity was subsequently categorized as 1, 2, 3, 4, 5, 6, or ≥ 7. Age of the dam at first lambing was categorized as lambing either: 1) between 8 and 18 mo of age (hereafter these animals will be referred to as ewe lambs) or 2) between ≥18 and 28 mo of age (hereafter these animals will be referred to as hoggets). Birth type was defined as the recorded number of lambs born (alive or dead) per lambing event; only birth types between one (singles) and four (quadruplets) were retained for analysis. Rearing type per lamb was defined as the number of lambs reared in the litter (including the lamb itself); only rearing types between one and three were retained. Lambs recorded as artificially reared were not considered for further analysis. For each trait investigated, the breed compositions of each lamb and dam were calculated. The five major performance recording breeds in Ireland (Belclare, Charollais, Suffolk, Texel, and Vendeen) were the most widely represented within each dataset. Lambs were also subsequently grouped into five broad breed classifications based on their dominant breed composition: terminal, dual purpose, hill, maternal, and other breed class as defined by Bohan et al. (2017). Heterosis and recombination loss coefficients were calculated for each lamb and dam as $1-\sum_{i=1}^{n}\text{sire}_i\cdot\text{dam}_i$ and $1-\sum_{i=1}^{n}\frac{\text{sire}_i^2+\text{dam}_i^2}{2}$, respectively, where sire_i and dam_i are the proportion of breed i in the sire and dam, respectively. Heteroris and recombination loss coefficients were subsequently grouped into distinct classes (Van der Werf and De Boer, 1989). For ewe and lamb heterosis, three distinct classes were formed: <10%, 10–90%, and 91–100%. For recombination loss, two classes were formed: <10% and 10–50%.

Each lamb was allocated to a contemporary group of flock-date of weighing for each live weight trait (i.e., birth, preweaning, weaning, and post-weaning) investigated. For the carcass composition traits, contemporary group were based on flock-date of measurement. Across all traits, only contemporary groups with at least five records were retained for analyses. Following all edits, 56,472 birth, 53,290 preweaning, 59,187 weaning, and 36,573 postweaning live weight records, and 10,815 carcass composition records remained (Table 1).

Statistical Analyses

Factors associated with lamb live weight and carcass composition traits were estimated separately using linear mixed models in PROC HPMIXED (SAS Inst. Inc., Cary, NC); dam and contemporary of flock-date of weighing were included in all models as random effects. Potential fixed effects considered in the models included: birth and rearing type (single, twin, triplet, or quadruplet); sex of the lamb (male or female); lamb breed proportions of Belclare, Charollais, Suffolk, Texel, and Vendeen breeds; parity of dam (1, 2, 3, 4, 5, 6, and ≥7); age at first lambing of dam (8 and 18 mo of age or ≥18 and 28 mo of age); and both the heterosis (<10%, ≥10% and ≤90%, >90% and ≤100%) and recombination loss (<10%, ≥10% and <50%) coefficients of the lamb and dam. In a subsequent analysis, breed proportion fixed classes were replaced by lamb breed classification (terminal, dual purpose, hill, maternal, or other). In all analysis, the age of the lamb on the day of weighing at preweaning, weaning, and postweaning was also included as a covariate when the dependent variable was preweaning, weaning, and postweaning live weight, respectively. For all dependent variables and all analysis, a multiple regression model was also built up using stepwise forward–backward regression, including interactions of biological interest; the significance threshold for entry and exit of variables into/from the model was set at 1%.

RESULTS

The proportion of lambs born as single, twins, triplets, and quadruplets was 23%, 60%, 15%, and 2%, respectively; the corresponding proportion of lambs reared as singles, twins, or triplets was 27%, 66%, and 7%, respectively. The sex ratio of the lambs with live weight data was 49.8% female and 50.2% male. On average, 92% of the live weight data originated from purebred flocks and 8% originated from commercial flocks. Across all data Texel (25%), Charollais (13%), and Suffolk (11%) represented the main breed composition of the lambs.

Birth Weight

The average birth weight was 4.32 ± 1.36 kg. Factors associated with lamb birth weight included: birth type, the interaction between birth type and sex, dam parity and age at first lambing, and the lamb breed proportion of the Belclare, Charollais, Suffolk, Texel and Vendeen breeds; lamb birth weight did not differ by the heterosis or recombination loss class of either the lamb or dam. The random effects of contemporary group (flock-date of weighing) and dam included in the model explained 58% and 14% of the variation in lamb birth weight, respectively.

The heaviest birth weight was associated with singleton born lambs (5.05 kg); the lightest birth weight was associated with quadruplet born lambs (3.51 kg; Table 2). Across all birth types, male lambs were heavier at birth than females and ranged from +0.19 kg for singletons to +0.23 kg for quadruplet male lambs ($P < 0.001$). Lighter birth weights

Table 1. Number of lambs (n), trait mean (μ; standard deviation [SD] in parenthesis), mean lamb age, and number of contemporary groups (CGs), sires, and dams for each live weight, growth, and carcass composition trait

Trait group	Trait	n	μ (SD)	Age	No. CGs	No. flocks	No. sires	No. dams
Live weight	Birth weight, kg	56,472	4.32 (1.36)	0	4,778	423	2,323	24,468
	Preweaning weight, kg	53,290	19.90 (4.38)	47	1,949	476	2,581	24,113
	Weaning weight, kg	59,187	33.88 (7.44)	98	1,928	477	2,672	27,093
	Postweaning weight, kg	36,573	44.01 (9.17)	147	1,479	419	2,284	19,499
Carcass composition	Muscle depth, mm	10,815	29.50 (3.26)	150	513	230	1,019	6,756
	Fat depth, mm	10,815	6.02 (1.75)	150	513	230	1,019	6,756

Table 2. Number of lambs (N), least square means, and standard error (SE) for each birth type for birth, preweaning, weaning, and postweaning weight (kg)

	Birth weight		Preweaning weight		Weaning weight		Postweaning weight	
Birth type	N		N		N		N	
Single	11,861	5.24 (0.02)[a]	11,722	21.45 (0.09)[a]	13,767	36.42 (0.33)[a]	8,419	46.68 (0.49)[a]
Twin	34,043	4.62 (0.02)[b]	32,112	19.98 (0.08)[b]	35,652	35.37 (0.27)[b]	21,803	45.77 (0.36)[a]
Triplet	9,578	3.99 (0.02)[c]	8,609	19.00 (0.08)[c]	8,856	33.82 (0.17)[c]	5,749	44.60 (0.21)[b]
Quadruplet	990	3.50 (0.03)[d]	847	18.27 (0.13)[d]	912	32.98 (0.27)[d]	602	43.49 (0.37)[c]

[a–d]Within columns, least square means with different superscripts differ ($P < 0.05$) from each other.

were associated with lambs born to first (4.00 kg), second (4.30 kg), and third parity (4.40 kg) dams ($P < 0.001$); lamb birth weight did not differ in ewes of parity four onwards ($P > 0.01$; Figure 1). Dams that lambed for the first time as ewe lambs produced lambs that were 0.19 ± 0.03 kg lighter compared with dams that lambed for the first time as hoggets ($P < 0.001$).

Each 1% increase in the lamb breed proportion of the Suffolk, Texel, Charollais, Vendeen, and Belclare breeds increased lamb birth weight by 0.086 (±0.003), 0.062 (±0.003), 0.051 (±0.003), 0.035 (±0.006), and 0.029 (±0.003) kg, respectively ($P < 0.001$). When lambs were grouped into five broad classifications based on the dominant breed composition (i.e., terminal, dual purpose, hill, maternal, and "other"), the heaviest weights were observed in the terminal breed lambs (4.53 kg; Table 3), with the lightest birth weights recorded for hill-bred lambs (3.95 kg; $P < 0.001$).

Preweaning Weight

Preweaning weight was recorded at an average age of 47 d, with an average live weight of 19.90 ± 4.38 kg. The average daily gain recorded between birth and preweaning was 330 ± 83 g/d. Preweaning weight differed by: age at weighing, birth and rearing type, dam parity and age at first lambing, and the lamb breed proportions of the Belclare, Charollais, Suffolk, Texel, and Vendeen breeds ($P < 0.01$). The proportion of variation in preweaning weight explained by the contemporary group and dam effect was 44% and 14%, respectively. The heaviest weight at preweaning was recorded in single born lambs and the lightest in quadruplets (Table 2; $P < 0.001$). Lambs reared as singles were on average 1.45 ± 0.05 kg and 1.80 ± 0.08 kg heavier at preweaning then lambs reared as twins and triplets, respectively ($P < 0.001$). A significant interaction between sex and rearing type was recorded; male lambs reared as singles, twins, and triplets were 1.33, 1.05, and 1.11 kg heavier at preweaning, respectively than female lambs ($P < 0.001$). Lambs born to third and fourth parity dams, which did not differ from each other, were heaviest at preweaning; the lightest lambs at preweaning were born to first parity dams (Figure 1; $P < 0.001$). The preweaning weight recorded in lambs born to ewes that lambed for the first time as ewe lambs or hoggets was 19.33 ± 0.13 kg and 19.92 ± 0.08 kg, respectively ($P < 0.001$). Each 1 d increase in lamb age increased preweaning weight by 276 ± 2.10 g ($P < 0.001$). With the exception of the terminal bred lambs (19.96 ± 0.08 kg), the live weight at preweaning did not differ between the hill (18.92 ± 0.28 kg), dual-purpose (19.10 ± 0.18 kg) or maternal (19.17 ± 0.10 kg) breeds ($P > 0.01$; Table 3).

Weaning Weight

The average weight recorded at weaning was 33.88 ± 7.44 kg, recorded at an average age of 98 d of age. The average daily gain recorded between preweaning and weaning was 290 ± 95 g/d. Weaning weight differed by: age at weaning, birth and rearing type, sex, dam parity and age at first lambing, lamb and dam heterosis class and the lamb breed proportion of Belclare, Charollais, Suffolk, Texel, and Vendeen ($P < 0.01$). The proportion of variation explained by the random effects of dam and contemporary group was 9% and 57%, respectively. A difference of 3.44 kg at weaning weight was observed in lambs that were born as singles compared with lambs that were born as quadruplets ($P < 0.001$; Table 1). Lambs reared as singles were 2.18 ± 0.16 kg and 2.28 ± 0.32 kg heavier compared with twins and triplets, respectively ($P < 0.001$), which did not differ from each other ($P > 0.01$). A significant interaction between birth and rearing type was also observed in weaning weight, irrespective of birth type lambs that were reared as singles reached heavier weights at weaning compared with lambs reared as twins or triplets ($P < 0.001$). In addition, lambs born and reared as singles were heavier than all other lambs at weaning, including

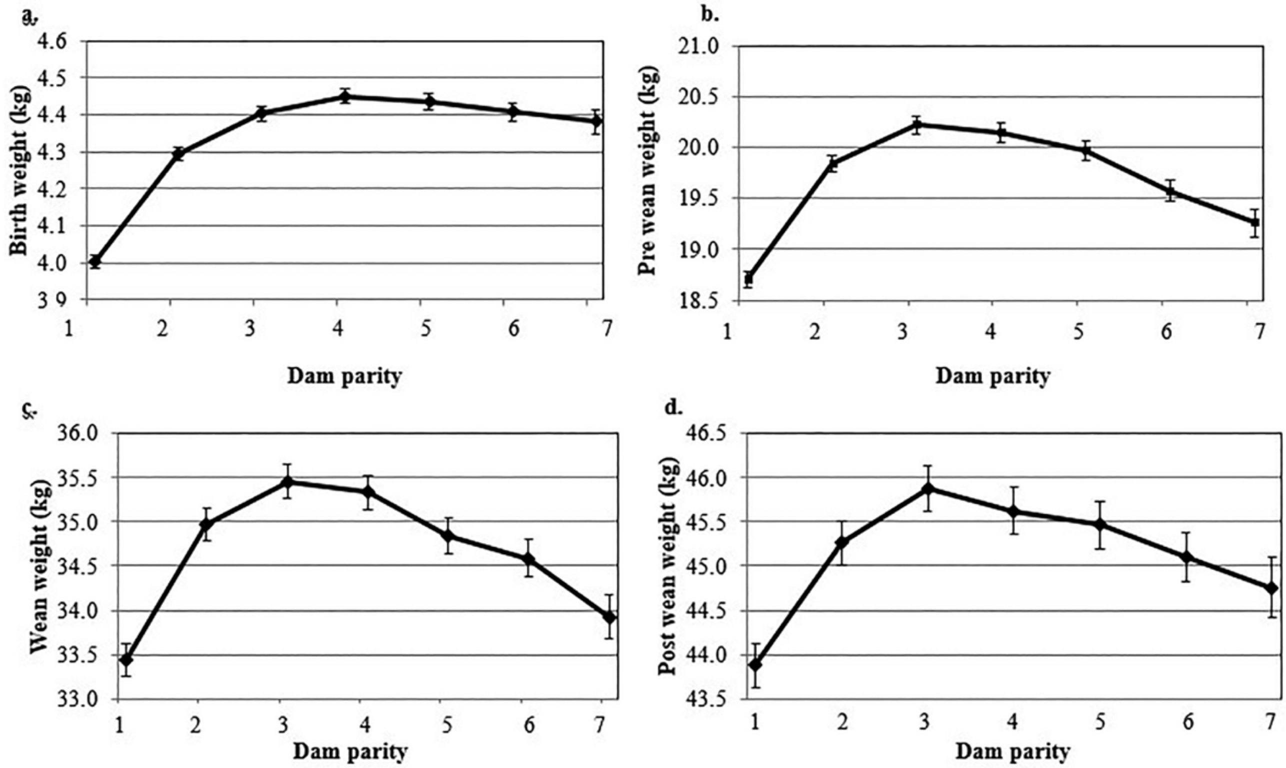

Figure 1. Least square means (standard errors included in error bars) for dam parity for birth (a), preweaning (b), weaning (c), and postweaning (d) weight (kg).

Table 3. Least square means and standard error (SE) for each breed class for birth, preweaning, weaning, and postweaning weight (kg)

	Birth weight	Preweaning weight	Weaning weight	Postweaning weight
Breed class				
Dual	3.95 (0.03)[a]	19.10 (0.18)[a]	33.90 (0.27)[a]	43.67 (0.34)[a]
Hill	4.10 (0.04)[b]	18.92 (0.28)[a]	33.62 (0.42)[a]	43.28 (0.48)[a]
Maternal	4.27 (0.02)[c]	19.17 (0.20)[a]	34.23 (0.22)[a]	44.43 (0.29)[b]
Terminal	4.53 (0.01)[d]	20.00 (0.08)[b]	35.60 (0.19)[b]	46.10 (0.48)[c]

[a–d]Within columns, least square means with different superscripts differ ($P < 0.05$) from each other.

those born as twins but reared as singles ($P < 0.001$). Female lambs were 2.57 ± 0.05 kg lighter at weaning compared with male lambs ($P < 0.001$). Greatest weaning weights were recorded in lambs born to third or fourth parity dams which did not differ from each other (Figure 1). The weaning weight of lambs born to dams that lambed for the first time was ewe lambs or hoggets was 34.22 ± 0.23 kg and 35.00 ± 0.19 kg, respectively ($P < 0.001$). Lambs with greater heterosis coefficients (i.e., >90% and ≤100%) were heavier at weaning (34.94 ± 0.20 kg) compared with lambs with lower levels of heterosis coefficients ($P < 0.001$). However for dam heterosis coefficient the opposite trend was observed whereby ewes with heterosis coefficients of <10% produced heavier lambs at weaning (34.92 ± 0.18 kg) compared with ewes with greater classes of heterosis ($P < 0.001$). Each 1% increase in the lamb breed proportion of the Suffolk, Charollais, Texel, Vendeen, and Belclare breeds increased lamb weaning weight by 0.049 (±0.002), 0.036 (±0.002), 0.035 (±0.002), 0.024 (±0.004), and 0.022 (±0.002) kg, respectively ($P < 0.001$).

Postweaning Weight

Average postweaning weight recorded at 147 d of age was 44.01 ± 9.17 kg. The average daily gain recorded between weaning and postweaning weight was 229 ± 88 g/d. Postweaning weight differed by: age at weighing, birth and rearing type, lamb sex, dam lactation number and age at first lambing, the lamb breed proportion of Belclare, Charollais, Suffolk, Texel, and Vendeen ($P < 0.01$). The proportion of variation explained by the random effects of dam and contemporary group was 7% and 62%, respectively. Postweaning weight increased by 192 ± 3.46 g/d ($P < 0.001$). Male lambs were 4.37 ± 0.12 kg heavier at postweaning compared with female lambs ($P < 0.001$). The greatest live weight postweaning was recorded in single and twin born lambs (Table 1).

The postweaning weight recorded in lambs reared as singles, twins, and triplets was 46.41 ± 0.28, 44.73 ± 0.21, and 44.26 ± 0.46 kg, respectively ($P < 0.001$). An interaction between birth and rearing type was observed in postweaning weight; with the exception of quadruplet born lambs reared as singles, lambs born or reared as a single were heavier postweaning compared with all other birth or rearing types ($P < 0.001$). Lambs born to first and seventh parity dams had lighter postweaning weights compared with all other parities, which did not differ from each other (Figure 1). Lambs born to ewes that lambed for the first time as ewe lambs were 0.89 ± 0.20 kg lighter at postweaning compared with lambs born to dams that lambed for the first time as hoggets ($P < 0.001$). As shown in Table 3, the heaviest weight at postweaning was reported in terminal breeds (46.11 ± 0.26 kg), intermediate in maternal breeds (44.43 ± 0.29 kg), and lightest for dual purpose (43.67 ± 0.35 kg) and hill (43.28 ± 0.48 kg) breeds, which did not differ from each other.

Carcass Composition Traits

The average muscle and fat depth recorded using ultrasound was 29.50 ± 3.26 and 6.02 ± 1.75 mm, respectively. The factors associated with ultrasound muscle included: age at scanning, the interaction between birth and rearing type, sex, dam parity and the lamb breed proportion of Belclare, Charollais, and Texel ($P < 0.01$). The proportion of variation explained by the random effects of dam and contemporary group was 6% and 45%, respectively. Ultrasound muscle depth increased by 0.04 ± 0.002 mm/d ($P < 0.001$). An interaction between birth and rearing type was observed in ultrasound muscle depth with greatest muscle depths recorded in lambs that were reared as singles irrespective of birth type ($P < 0.001$). An interaction between rearing type and sex of the lamb was also observed with greater muscle depths recorded for male lambs across all rearing types but the magnitude of the difference between males and females was greater in lambs reared as singles (+0.88 mm) and triplets (+0.93 mm) compared with twins (+0.65 mm; $P < 0.001$). Muscle depth differed by parity of the dam, with lower muscle depths reported in lambs reared by first parity dams (28.9 ± 0.26 mm) compared with second (29.3 ± 0.26 mm) and third (29.3 ± 0.26 mm) parity dams ($P < 0.001$); all other dam parities did not differ from each other ($P > 0.01$). Greater ultrasound muscle depth was recorded in lambs with a heterosis coefficient class of <10% (30.33 ± 0.16 mm) compared with lambs with a heterosis coefficient class of ≥10% and ≤90% (29.1 ± 0.24 mm) or >90% and ≤100% (29.17 ± 0.23 mm; $P < 0.001$). Terminal lambs had greater muscle depth than maternal lambs ($P < 0.001$; Figure 2). Each 1% increase in the lambs breed proportion of Belclare, Charollais, and Texel increased muscle depth by 0.006 (±0.001), 0.010 (±0.001), and 0.014 (±0.001) mm, respectively ($P < 0.001$; Figure 3). The percentage increase in the breed proportion of Suffolk and Vendeen breeds had no effect on muscle depth ($P > 0.01$).

Factors associated with fat depth included: age at ultrasound scanning, the interaction between birth type and sex, dam parity, lamb recombination class and the lamb breed proportions for the Suffolk and Vendeen breed. The proportion of variation explained by the random effects of dam and contemporary group was 5% and 57%, respectively. Ultrasound fat depth increased by 0.002 (±0.001 mm)/d ($P < 0.001$). Ram lambs born as twins had greater ultrasound fat depths at postweaning (0.61 ± 0.01 mm) compared to female lambs (0.62 ± 0.01 mm; $P < 0.001$), however fat depths did not differ by sex for any of the other birth types ($P > 0.01$). Lower ultrasound fat depths were associated between lambs born to first parity dams (0.61 ± 0.01 mm) compared with lambs born to dam parities of 2 or greater, which did not differ from each other. Ultrasound fat depth differed by the recombination loss class of the lamb with greater fat depths associated with lambs with a recombination loss class of <10% (0.63 ± 0.01 mm) compared with lambs with a recombination loss class of ≥10% and <50% (0.61 ± 0.01 mm; $P < 0.001$). For each 1% increase in the breed proportion of the Suffolk and Vendeen breeds, ultrasound fat depth increased by 0.03 (± 0.01 mm) and 0.13 (± 0.02 mm), respectively ($P < 0.001$; Figure 3). There was no effect on fat depth when the percentage of Belclare, Charollais, and Texel was investigated ($P > 0.01$).

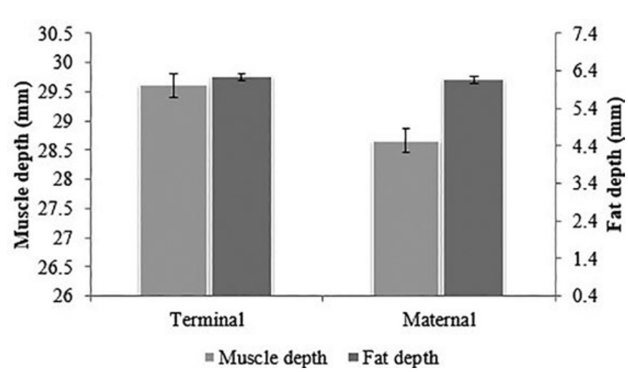

Figure 2. Least square means (SE included in error bars) for breed class for muscle depth and fat depth (mm).

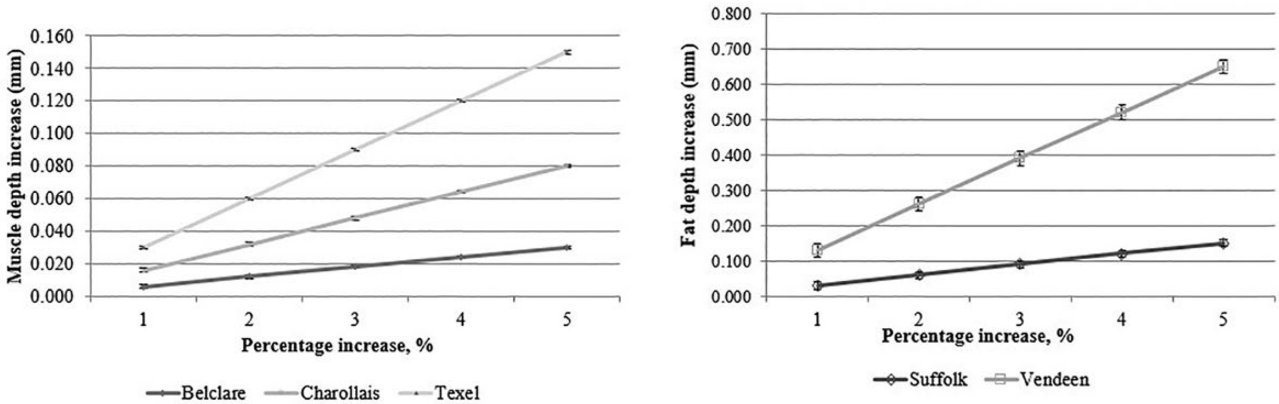

Figure 3. The regression coefficient (SE included in error bars) for muscle and fat depth (mm) for each percentage increase in the breed proportion of each breed.

DISCUSSION

Live weight is one of the primary key performance indicators with which farmers can assess their flock productivity and benchmark their animal performance throughout the production season. The main objectives of this article were to determine the phenotypic factors affecting both live weight and carcass composition in lambs from a multibreed sheep population. In agreement with previous literature, our results indicate that there are a plethora of factors affecting both live weight and carcass composition with birth type, age and parity of the dam contributing to the main differences in lamb live weight recorded across flocks (Greenwood et al., 2000; Morgan et al., 2007; McHugh et al., 2017).

Results obtained for live weight recorded at birth and preweaning in the present study align with values reported by McHugh et al. (2017); however the mean live weights recorded at preweaning, weaning, and postweaning are lower than those shown by Fitzmaurice et al. (2020). This reduction in live weight may be attributed to the use of only terminal, purebred lambs in the aforementioned study while maternal, dual purpose and hill bred lambs were also considered for analysis in the present study. In accordance with on farm data collection for the generation of national genetic evaluations in Ireland postweaning weight, muscle depth and fat depth are recorded simultaneously on lambs. Previous authors have reported greater muscle and fat depths of 33.28 and 8.05 mm, respectively (O'Brien et al., 2017; Fitzmaurice et al., 2020), than those stated in the present study. The difference observed is likely due to the incorporation of data collected from various breed classes in the current study.

The national sheep genetic evaluations are based upon contemporary comparisons which account for the variation in environmental effects and on farm management practices. Contemporary group was defined in the current study as flock-date of weighing/measurement and not expectantly accounted for the largest proportion of variation in all traits examined. Earle et al. (2017) demonstrated the effect of ewe stocking rate at pasture on lamb live weight with lambs reared by ewes stocked at 14 ewes/ Ha lighter than those reared by ewes stocked at 10 or 12 ewes/Ha. Diet type has also been shown to influence both live weight and carcass composition with pasture fed lambs having lighter live weights and leaner carcasses at slaughter (Santos-Silva et al., 2002). Therefore, ensuring germplasm is represented across contemporary groups is crucial as environmental and management effects can greatly affect phenotypic characteristics in growing lambs.

Female replacement animals can either give birth for the first time as maiden ewe lambs (~1 yr old) or as hoggets (~2 yr old) depending on numerous factors including her own live weight gain as a lamb and ultimately individual farmer preference (McHugh et al., 2020). While it is a constant debate amongst farmers, results from this study indicate that animals lambing for the first time as maiden ewe lambs produce lighter lambs than those lambing as hoggets. This reduced live weight in lambs born to maiden ewe lambs has previously been associated with the partitioning of nutrients between both the dam and her progeny whereby continued growth of the dam is favored (Wallace, 2000). Despite lower live weights, lambing maiden ewe lambs has many advantages including increased farm profitability through increased lamb sales, greater total live weight production per ewe throughout her productive life and elevated rates of genetic gain (Kenyon et al., 2004; Gootwine et al., 2007). Furthermore, previous analysis carried out by McHugh et al. (2016) verifies that maiden ewe lambs do not require additional management at lambing once dam breed and litter size are taken into account.

One of the main factors affecting both live weight and carcass composition traits was dam parity. First parity dams had lighter lambs at each of the time-points investigated, with lower muscle and fat depths. Similarly to the effects of age of first lambing, this is in agreement with studies in both cattle (Stadnik et al., 2008) and sheep (Loureiro et al., 2012) whereby primiparous dams produce lighter progeny due to the competition in the partitioning of nutrients between the dam, to maintain her continued growth and to produce milk for the growing offspring. However, while the impact of lighter live weights in lambs due to age at fist lambing is associated with the first lamb crop only, the effect of parity was also associated with older parity dams (i.e., parity >4) who also produced lighter lambs (Annett et al., 2011). Interestingly, while there was poorer productive performance of progeny from older parity dams, lamb live weight remained greater than that of first parity dams. Therefore, blanket dam culling decisions based on age would not be recommended and should be based on individual progeny performance.

Terminal sire breeds, namely Charollais, Suffolk, Texel, and Vendeen in this case, are known to produce heavier lambs with greater muscle and fat depth (Kremer et al., 2004; Fitzmaurice et al., 2020). Maternal breeds (e.g., Belclare) are associated with greater numbers of lambs born, mothering ability and milk production (Byrne et al., 2010). In agreement live weights in the current study were heavier among terminal based breeds and lightest for both hill and dual purpose breeds. In Ireland, hill sheep are bred for hardiness, survivability and mothering ability, characteristics similar to the maternal based breeds rather than the terminal based breeds.

Unsurprisingly male lambs were heavier than female lambs, irrespective of rearing type, at all time-points investigated. Regardless of castration, male animals have been shown to achieve higher growth rates and reach greater live weights when compared to females (Fogarty et al., 2005; Stadnik et al., 2008). Coinciding with increased live weights observed in male born lambs, muscle depths were also greater amongst male lambs (Silva et al., 2006). Interestingly in growing lambs, postweaning, there is no difference in fat depth between males and females which corroborates with the findings of Romdhani and Djemali (2006) who stated that under 180 d of age fat depth is the same in both male and female lambs however once lambs reach 200 d of age male lambs have higher fat depths.

The results of the present study are in agreement with previous work stating that lambs born and reared as singles are consistently heavier at birth, preweaning, and weaning when compared with those born or reared in multiple litters (2+ lambs per litter; Thomson et al., 2004; McGovern et al., 2015; McHugh et al., 2017). The greater live weight observed amongst single born and reared lambs, even when compared with all those reared as singles, indicates that in-utero muscle fiber development is greatest in single fetuses thus enhancing postnatal live weight gain over and above lambs born into multiple litters (Greenwood et al., 2006). However, the lack of difference in live weight between twin and single born lambs postweaning demonstrates the ability of the lamb to undergo compensatory growth once an adequate supply of quality feed is available (Hatcher et al., 2008).

CONCLUSIONS

A large number of phenotypic factors were associated with both lamb live weight and ultrasound scan measurements. Regardless of diet type and farm management factors, lambs are predisposed to higher live weight gains and greater muscle development due to birth type, sex, and dam parity. Management decisions such as deciding whether to breed maiden ewe lambs further influence progeny live weight from birth to postweaning. The impact of these decisions must however be evaluated against the additional profit received due to increased lifetime production.

Conflict of interest statement. None declared.

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