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REVIEW ARTICLE

Triplet lambs and their dams – a review of current knowledge and management systems

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ABSTRACT
Triplet-bearing ewes and their lambs have the potential to improve flock productivity however, the lack of robust information on optimal nutrition and management is limiting their performance. In comparison to twins, the triplet lamb is; lighter, more metabolically challenged, has lower body temperature, and receives less colostrum and milk which combined results in lower survival rates and weaning weights. While scientifically based management guidelines are available for singletons and twins, guidelines are generally lacking for triplets. Although there is some knowledge on the impacts of nutrition, further studies are required to examine the impacts of varying feeding regimens in pregnancy and lactation, across the body condition range. Characterising the impacts of shelter and other paddock factors, stocking rate, mob size and human intervention would also be of benefit. Future studies must be large enough to allow for evaluation of lamb survival and litter birth weight variation.

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Introduction

An increase in the relative value of sheep meat in comparison to wool has resulted in many sheep production systems including those in Australia and New Zealand obtaining an increased proportion of their income from the sale of animals for meat compared to wool (Young et al. 2016; B + LNZ 2018a). Within a sheep production system, increasing the total weight of lamb available for sale per ewe depends on both the number of lambs weaned within a given production cycle and the weight of those lambs. Higher lambing percentages are associated with greater efficiency in terms of kg of meat produced per kg of feed consumed or per ewe live weight (Mishra et al. 2007; Earle et al. 2017), and greater income (Morel and Kenyon 2006). These factors have resulted in an increase in lambing percentages over the last 25 years in countries like New Zealand and Australia (MacKay et al. 2012; B + LNZ 2018a; ABARES 2018). Most sheep producers in both countries have focused on increasing lambing percentages through better ewe nutrition and genetic selection as fertility and fecundity are heritable traits (Safari, Atkins, Fogarty

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et al. 2005, Safari, Fogarty, Gilmour 2005). In Australia there has also been significant displacement of Merino ewes with more fecund Maternal ewe types, which are focused on prime lamb production. However, increased fecundity is associated with an increase in the proportion of triplet-born lambs (Amer et al. 1999). Triplets have reduced survival rates and lower weaning weights compared to their singleton and twin-born counterparts (see later sections). This is limiting the potential performance of the triplet-bearing ewe.

High lamb mortality may be considered by consumers and society in general, as both an animal welfare and ethical issue (Mellor and Stafford 2004; Ferguson et al. 2014; Dwyer et al. 2016). This can influence purchasing decisions. Elliot et al. (2011) reported that Australian farmers were concerned with lamb mortality rates and were worried about consumer perceptions. However, they themselves did not perceive lamb mortality as an animal welfare issue. Farmers believed that they could increase their flock productivity by improving lamb survival and were willing to investigate potential options to do so. In support of this, New Zealand farmers also reported concern about public perception of more fecund animals (Small et al. 2005) and rated twin/triplet management and improved lamb growth and survival as important areas in need of research (Greer et al. 2015).

The following review focuses on current knowledge of triplet dam and lamb performance with a focus on pastoral based conditions, management options to improve performance and identifies areas where there is insufficient knowledge that may benefit from further investigation.

Comparison of the triplet and its dam with singletons and twins

The triplet foetus

Triplet foetuses are smaller than their twin and singleton counterparts from at least mid-pregnancy (Rattray et al. 1974; Kenyon et al. 2007). A meta-analysis undertaken by Gootwine (2013) indicated that being a triplet was a significant impairment to foetal growth. Triplet foetuses have smaller crown rump lengths and body mass indexes than both singletons and twins (Gootwine 2013). Further they have smaller and more varied foetal and organ weights, within litters, compared to twins (McDonald et al. 1981; Kenyon et al. 2007; Gootwine 2013). Triplet gravid uterine weight, is greater in late pregnancy than in singleton and twin pregnancies (Grazul-Bilska et al. 2006), although, there are fewer generally larger and heavier placentomes and cotyledons per foetus (Grazul-Bilska et al. 2006; Kenyon et al. 2007). The larger size is likely in an attempt to compensate for less placentomes and cotyledons. At term, the gravid mass of singleton, twin and triplet pregnancies have been reported to be in the range of 9–11, 14–19 and 20 - 22 kg respectively (Rattray et al. 1974; Kenyon et al. 2007; Blair et al. 2011). The gestation length of triplet-bearing ewes are shorter, but generally only by a few days, than both singletons and twins (Glimp 1971, Gootwine and Rozov 2006, Dwyer and Morgan 2006).

Dwyer et al. (2005) indicated that triplet lambs suffer a degree of placental insufficiency, compared to lesser pregnancy ranks, as placenta and cotyledon weight and number increased with twinning, but not thereafter. In support of this, Rurak and Bessette (2013) and Kenyon et al. (2007) reported that increasing foetal number was associated with lower placental oxygen and foetal glucose but higher lactate concentrations in late gestation. Placental insufficiency can negatively impact lamb survival (Mellor and Stafford 2004).

Physiological parameters

In newborn lambs, the concentrations of glucose, fructose, insulin, protein, triiodothyronine (T3) and thyroxine (T4) have been reported to decrease with increasing litter size, being lower in triplets compared to singletons and twins in most studies (Barlow et al. 1987; Kenyon et al. 2005; Kerslake et al. 2009, 2010a, 2010b; Chniter et al. 2013). The effects on T3 and T4 concentrations have been reported to be most evident in the smallest lamb within the triplet litter (Stafford et al. 2007; Kerslake et al. 2010d). Further in most studies, immunoglobulin and/or immunoglobulin G (IgG) concentrations have also been reported to be lower in triplets than in singletons and twins (Halliday 1974; Logan and Irwin 1977; Gilbert et al. 1998; Kerslake et al. 2009, 2010b; Kenyon et al. 2010a), with effects sometimes being breed specific (Halliday 1968). Stafford et al. (2007) and Kerslake et al. (2010d) reported greater lactate concentration in triplets. Combined these results, in addition to the previously outlined foetal studies, indicate that triplets are more likely to be metabolically compromised at birth, than their singleton and twin counterparts, through sub-optimal in-utero nutrition, supporting the notion of placental insufficiency. This is primarily driven by the inability of the triplet-bearing ewe to proportionally meet the additional needs of triplets (see later sections), compared to singletons and twins. This results in a number of downstream consequences which are outlined in the following sections.

Birth weight

As part of this review, a meta-analysis was undertaken to quantify the impact of being born a triplet on lamb birth weight. Studies were compiled using a systematic search within three databases (WOK, SCOPUS, PubMed) for studies published before 18 January 2018. The search key included the keywords 'sheep', 'triplets', 'survival' and its variants. The final dataset consisted of 52 studies (and 55 experiments) from which 119 birth weight comparisons were extracted. To quantify the proportion difference of triplet birthweight in relation to singleton and twin birth weight, the effect size Hedge's g (Hedges 1981) was used as the effect size metric of this study. The negative values of Hedge's g obtained in the present study indicate the difference in birth weight of triplets relative to singletons or twin, in terms of standard deviations, with a correction for small sample sizes.

Meta-analysis and meta-regression were conducted using the metafor package (v.1.9-4) in R (R Core Team, 2018). Birth weight comparisons arising from the same study (e.g. studies reporting birth weights for the three litter types) was statistically controlled for using the methods reported by Gleser and Olkin (2009). Traditional random-effects meta-analysis was used to estimate the overall difference in birth weight between triplets relative to singletons and twins across all studies and to determine the amount of variation (i.e. heterogeneity) in the data. In this intercept-only model, experiment non-independence was controlled for by including experiment identity as a random effect in the model. Heterogeneity was estimated by an extended version of the I2 index proposed by Higgins and Thompson (2002) and Nakagawa and Santos 2012 (cf. Cheung 2014). Moreover, the meta-regression model was constructed as a mixed model that incorporated experiment identity as a random effect, the fixed class effect of treatment type (i.e. no treatment, negative treatment, positive treatment) and litter type comparison (whether triplets birthweight was compared to singletons and twins). This last predictor was coded as a binary variable (1 for singletons and −1 for twins), with a standard deviation of one. Its regression coefficient (β) can, therefore, be interpreted as the amount of change in the estimated effect for treatment type when triplets were compared to singletons (β × 1) or twins (β × −1).

The meta-analysis results indicate that triplets were one standard deviation lighter ($P < 0.05$) than both singletons and twins combined across all studies (Overall effect = −0.99, 95% CI = [−1.13, −0.87], Figure 1), although there was a significant amount of variation in the data (I2total = 96%). When the comparison was made against singletons and twins individually, triplets were 1.3 and 0.7 standard deviations lighter, respectively. Another approach to compare birth weights across birth rank is via mean birth weights. However, this can be disported by the fact breeds vary considerably in birth weight. Therefore a proportional approach may be more informative. Hinch et al. (1985a), across three flocks, using a proportional approach, showed that birth weights of twins and triplets were between 0.75–0.87 and 0.58–0.72% respectively of their singleton counterparts. Table 1 extends this approach to 61 studies across a range of environments and breeds. The results found support for the findings of Hinch et al. (1985a), with triplets being a mean of 66 and 81% of the birth weights on singletons and twins respectively.

Newborn rectal temperature and heat production

Within the first few hours after birth, triplet-born lambs have lower rectal temperatures than both singleton and twin lambs (Barlow et al. 1987; Dwyer and Morgan 2006; Kerslake et al. 2010c; Chniter et al. 2013). Further, Kerslake et al. (2010c) reported that rectal temperature was lowest in the lightest lamb within a set. Lower rectal temperature in lambs is associated with lower survival (Barlow et al. 1987; Brien et al. 2010; Hegarty et al. 2017). Martin et al. (2013) reported that lamb survival was positively related to maximal heat production on a per kg basis in twins and triplets. Further, lamb glucose, T3, T4, GGT (Gamma-glutamyl transferase) concentrations are positively related to maximal heat production (Kerslake et al. 2010a).

Triplet lambs have lower total base and maximal heat production than twins but, not on a weight basis (Kerslake et al. 2009, 2010b, 2010d; Kenyon et al. 2010b). This indicates that on a per kg basis triplets are not compromised, but as they are lighter at birth their total thermo-regulatory capability is. Therefore as birth weight increases in triplets, so does total maximal heat production (Kerslake et al. 2009). In support of this, Kerslake et al. (2010d) reported that within a triplet set, while the heaviest lamb produced the greatest total maximal heat production there was no difference within the set on a per kg basis. These results, combined with the fact the triplet lambs have lighter birth weights and smaller body mass to surface area ratios, explain why triplet lambs are so susceptible to losses due to exposure (see later section).

Survival

Lamb mortality to weaning under both pastoral and indoor conditions can range from as low as five percent to well over 30%, with higher loss rates associated with greater litter

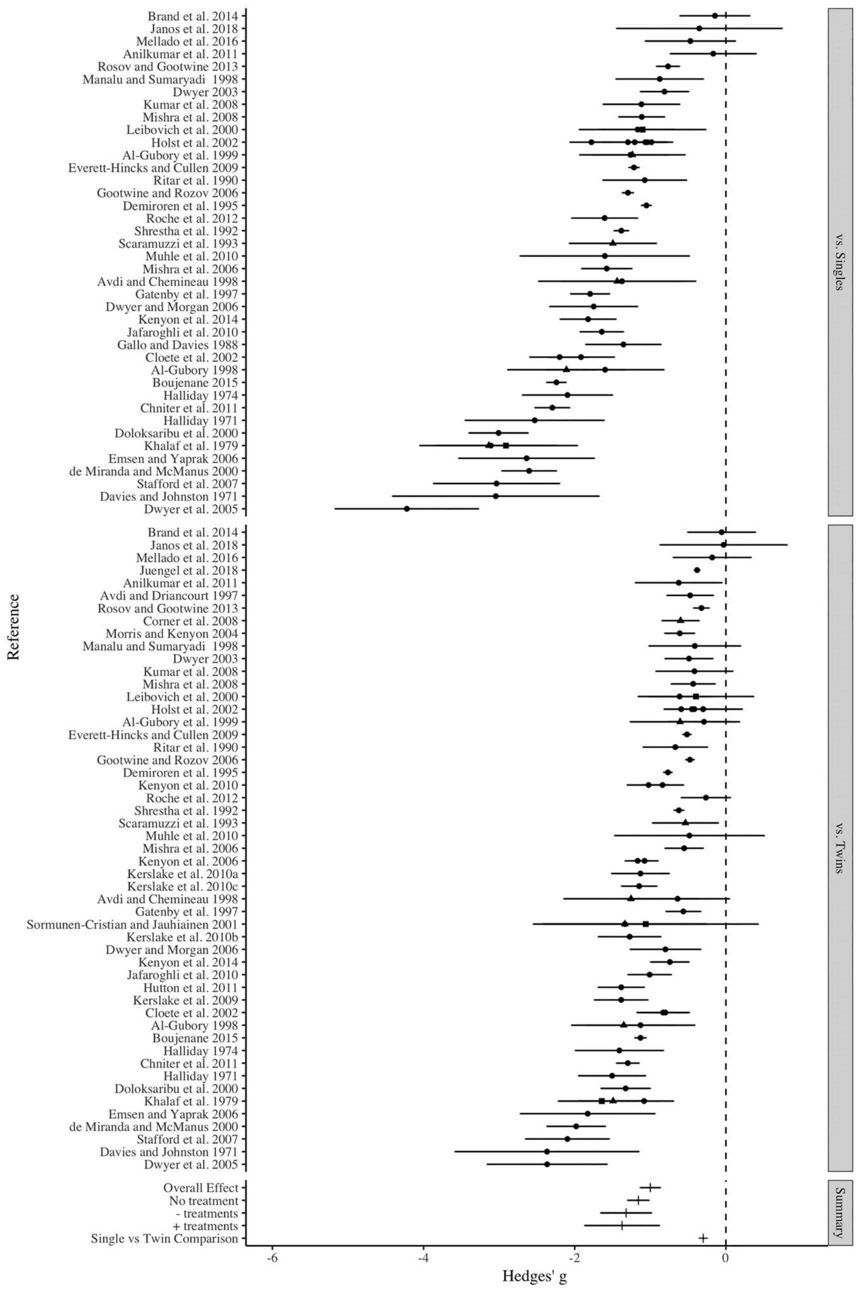

Figure 1. Meta-analysis (Overall Effect) and meta-regression coefficients of lamb birth weight across studies. Individual study means and SE (black dots and bold horizontal lines) represent the difference in lamb birthweight between singletons vs. triplets and twins vs. triplets. Overall random-effects meta-analysis and meta-regression coefficients (mean, ± 95 CI) for studies comparing lamb birth weights in studies without any treatments (No treatment) applied, those that imposed a treatment designed to either increase (+ treatments) and decrease (− treatments) lamb birth weight. The difference in magnitude between studies comparing singletons or twins vs. triplets (Single vs. Twin Comparison).

Table 1. The weight of triplet lambs within a given study as the proportion of its singleton and twin counterparts (note the analysis includes 61 individual studies, but some studies has more than one comparison group).

	Triplet birthweight as a proportion	
Reference	Singletons	Twin
Al-Gubory 1998	0.65	0.80
Al-Gubory 1998	0.66	0.77
Al-Gubory et al. 1999	0.64	0.89
Al-Gubory et al. 1999	0.60	0.76
Anilkumar et al. 2011	0.63	0.86
Avdi and Chemineau 1998	0.81	0.90
Avdi and Chemineau 1998	0.71	0.79
Avdi and Driancourt 1997		0.90
Boujenane 2012	0.72	0.85
Brand et al. 2014	0.71	0.84
Chniter et al. 2011	0.72	0.86
Cloete et al. 2002	0.65	0.80
Cloete et al. 2002	0.67	0.82
Cloete et al. 1993	0.66	0.83
Corner et al. 2008		0.84
Davies et al. 1971	0.66	0.77
de Miranda and McManus 2000	0.41	0.52
Demiroren et al. 1995	0.71	0.84
Doloksaribu et al. 2000	0.53	0.70
Dwyer 2003	0.76	0.84
Dwyer 2003	0.59	0.78
Dwyer 2003	0.65	0.83
Dwyer and Morgan 2006	0.66	0.84
Dwyer et al. 2005	0.61	0.74
Emsen and Yaprak 2006	0.51	0.67
Everett-Hincks and Cullen 2009	0.62	0.80
Gallo and Davies 1988	0.81	
Gatenby et al. 1997	0.66	0.85
George 1976	0.68	0.82
George 1976	0.60	0.74
Gootwine and Rozov 2006	0.68	0.83
Gootwine et al. 1995	0.61	0.75
Hadjipieris and Holmes 1966	0.67	0.96
Hadjipieris and Holmes 1966		0.91
Halliday 1971	0.67	0.79
Halliday 1974	0.63	0.76
Hinch et al. 1983	0.59	0.81
Hinch et al. 1983	0.60	0.76
Holst et al. 2002	0.67	0.85
Holst et al. 2002	0.69	0.86
Holst et al. 2002	0.66	0.81
Holst et al. 2002	0.63	0.77
Holst et al. 2002	0.71	0.85
Holst et al. 2002	0.71	0.85
Hutton et al. 2011		0.78
Jafaroghli et al. 2010	0.67	0.80
Janos et al. 2018	0.73	0.95
Juengel et al. 2018		0.84
Kenyon et al. 2014	0.74	0.82
Kenyon et al. 2010a		0.85
Kenyon et al. 2010b		0.82
Kenyon et al. 2006		0.84
Kenyon et al. 2006		0.83
Kerslake et al. 2010a		0.80
Kerslake et al. 2010b		0.81
Kerslake et al. 2010c		0.82

(*Continued*)

Table 1. Continued.

Reference	Triplet birthweight as a proportion	
	Singletons	Twin
Kerslake et al. 2009		0.79
Khalaf et al. 1979	0.54	0.72
Khalaf et al. 1979	0.60	0.80
Khalaf et al. 1979	0.69	0.79
Kumar et al. 2008	0.70	0.86
Knight et al. 1985	0.64	0.79
Knight et al. 1985	0.68	0.87
Knight et al. 1985	0.70	0.82
Knight et al. 1985	0.72	0.89
Leibovich et al. 2000	0.58	0.76
Leibovich et al. 2000	0.78	0.93
Manalu and Sumaryadi 1998	0.74	0.88
Mellado et al. 2016	0.56	0.66
Mishra et al. 2006	0.68	0.85
Mishra et al. 2008	0.71	0.85
Morris and Kenyon 2004		0.80
Muhle et al. 2010	0.56	0.78
Ritar et al. 1990	0.77	0.87
Roche et al. 2012	0.74	0.91
Rosov and Gootwine, 2013	0.67	0.82
Ruttle 1971	0.68	0.77
Scales et al. 1986	0.63	0.80
Scaramuzzi et al. 1993	0.71	0.89
Shelton et al. 1991	0.57	0.68
Shrestha et al. 1992	0.71	0.85
Sormunen-Cristian and Jauhiainen 2001		0.73
Sormunen-Cristian and Jauhiainen 2001		0.75
Sormunen-Cristian and Jauhiainen 2001		0.74
Stafford et al. 2007	0.59	0.67
Mean	0.66	0.81
Minimum	0.41	0.52
Maximum	0.94	0.96

sizes (Mellor and Stafford 2004; Hinch and Brien 2014). Lamb survival rates to weaning across 29 studies clearly indicate triplet lambs (mean value across studies 67.5%) have lower survival than their singleton (89.5%) and twin (85.5%) counterparts (Table 2). Most lambs die within three days of birth but, triplets can have higher loss rates past this period (Kleeman et al. 1993; Hinch and Brien 2014; Holmøy et al. 2014, 2017; Holmøy and Waage 2015; Refshauge et al. 2016), presumably driven by a mismatch in milk supply and demand (see later section). Ferreira et al. (2015) reported that when artificially reared, after one day of age, triplet survival did not differ from singletons and twins. This further supports the idea that a mismatch between milk supply and demand plays a significant role in triplet lamb deaths after one day of age.

It is well established across all birth ranks that lamb mortality is highest at the birth weight extremes, resulting in a U-shaped relationship (Hight and Jury 1970; Fogarty et al. 1992; Holst et al. 2002; Geenty et al. 2014). In a study examining a large data set, Everett-Hincks and Dodds (2008) reported that the lighter the birth weight of a triplet lamb, compared to the mean of the population, the lower its survival, with the lowest survival occurring in those 2 kg lighter than the mean. The data also suggested that at heavier birthweights lamb survival could be reduced, although the results of Juengel et al. (2018) indicate that only a small proportion of triplets would be classed as relatively 'heavy'.

Table 2. The effect of birth rank on lamb survival to weaning. Note the table consists of data from 29 studies, but some studies had more than one comparison.

		Percentage (%) of surviving lambs		
Study Author	Year	Singletons	Twins	Triplets
Anilkumar et al.	2011	92.7	85.9	67.7
Bichard and Cooper	1966	87.9	85	66
Boujenane	2012	99	94	88
Chniter et al.	2011	96.1	90.1	84.8
Cloete et al.	1993	92.5	92	72.2
Cloete et al.	1993	87.5	89.7	63
Corner et al.	2008		84.7	70.4
Demiroren et al.	1995	80	80	73
Doloksaribu et al.	2000		81.4	45.3
Gatenby et al.	1997	94.5	90.2	72.2
Gootwine et al.	1995	93	90	77
Hanford et al.	2006	90.1	94.8	88.8
Hinch et al.	1983	88.5	75.6	50.3
Hinch et al.	1983	92.9	82.4	65.1
Hinch et al.	1996	85.4	78.5	55.8
Hutton et al.	2011		90	69
Jafaroghli et al.	2010	89	89.8	83.67
Juengel et al.	2018		84.9	74.1
Kenyon et al.	2006		80.4	60.3
Kenyon et al.	2006		80.7	53.9
Kenyon et al.	2010a		90.1	78.4
Kenyon et al.	2010a		84	65
Kenyon et al.	2011			69.5
Kenyon et al.	2011			56
Kenyon et al.	2011			61.7
Kenyon et al.	2011			64.5
Kenyon et al.	2011			60.3
Kenyon et al.	2011			56.7
Kenyon et al.	2011			62.7
Kenyon et al.	2011			57.7
Kenyon et al.	2012			66.8
Kenyon et al.	2012			72.9
Kenyon et al.	2012			71.1
Kenyon et al.	2012			75.1
Kenyon et al.	2012			65.1
Kenyon et al.	2013			67.45
Kenyon et al.	2013			61.9
Kenyon et al.	2013			76.1
Kenyon et al.	2013			72
Kenyon et al.	2013			65.4
Kenyon et al.	2014	94.6	83.7	76.2
Kerslake et al.	2009		94	73
Kerslake et al.	2010a		85.2	62
Khalaf et al.	1979	100	82	58.4
Khalaf et al.	1979	92.9	86.2	73
Khalaf et al.	1979	100	100	78.8
Knight et al.	1985	84	78	63
Knight et al.	1985	88	87	67
Knight et al.	1985	81	77	59
Knight et al.	1985	88	83	56
Mellado et al.	2016	71	74	64.7
Morris and Kenyon	2004		86	68
Scales et al.	1986	85.9	85.3	67
Shrestha et al.	1992	84	84	72
Mean		89.5	85.5	67.5
Lower quartile		85.9	81.8	61.9
Upper quartile		93.0	90.0	73.0

Juengel et al. (2018) found that triplet survival only marginally increased when birth weight was above 3.0 kg. However, as approximately 25% of triplets were born below this weight, and over 40% of lambs lighter than 3.0 kg died, they suggested increasing birthweight has the potential to have a significant impact on flock survival. Combined the data suggest that within the triplet lamb population there is likely to be an optimal birth weight range. Hinch et al. (1985b) proposed that the optimum birth weight for survival was similar between birth ranks but the issue for triplet lambs is that many fail to get near such an optimum. However, somewhat in conflict with this notion, Paganoni et al. (2014) reported that across sire and ewe genotype combinations, the survival of a 4 kg lamb was 85%, 79% and 66% for singleton, twin and triplet lambs respectively, indicating birth rank itself can affect survival independent of birth weight.

The study of Welsh et al. (2006) suggested that examining both individual birth weight and within litter birth weight variation would be a worthwhile approach to improve understanding. Since then a number of studies have examined the impact of these traits on triplet survival. Mathias-Davis et al. (2010) reported that the heavier the average litter weight the greater the survival. However, examining just the mean rather than examining variations within the set may not tell the whole story. Morel et al. (2008) found that the mortality rate for the 'light', 'medium' and 'heavy' lamb within a triplet set was 56%, 40% and 28%, respectively, and consequently mortality rate was 3.2 times higher in the lightest compared to the heaviest lamb within the set. In support of this Mathias-Davis et al. (2010) and Juengel et al. (2018) both reported that the smallest lamb within the triplet set was at greatest risk of death. Interestingly, Morel et al. (2008) found that within the 'light' lamb group, as birth weight increased mortality decreased, although no such relationship was found for the 'medium' lamb group. Conversely, in the 'heavy' lamb group, there was a trend of increased birth weight being associated with increased mortality.

There is greater variation in birth weights across litters in triplets than in twins (Juengel et al. 2018). Mathias-Davis et al. (2010) reported the greater the variation in litter weight within a triplet set the lower the overall litter survival. Morel et al. (2008) also reported that across the three lamb size groups within triplet litters, there was a negative relationship between lamb mortality and the percentage of total litter weight, suggesting that the optimum would be for all lambs within the set to have the same birth weight. In support of this, Juengel et al. (2018) found that triplet lamb survival was lowest when the birth weight difference between the heaviest and lightest lambs >1.3 kg, and that this suppression of survival was strongest in the lightest lamb but still occurred at a birth weight difference of 0.75 kg. However, for the medium sized lamb within a triplet set, birth weight difference did not affect survival (Juengel et al. 2018). Combined these studies also suggest interventions that can reduce the variation in birth weight within a litter set should have positive effects on litter survival (Morel et al. 2008; Mathias-Davis et al. 2010), although the challenge is to develop such interventions. To date most studies examining the impacts of various interventions on birth weight have presented just mean litter weight (see later sections), therefore the ability of interventions to reduce litter weight variation is unknown.

Cause of death

There are established lamb autopsy procedures (Hinch et al. 1986; Holst et al. 2002; Everett-Hincks and Dodds 2008; Refshauge et al. 2016; Holmøy et al. 2017). The majority of lamb autopsy studies to date have focused on the cause of death of singleton and twin lambs, as these have traditionally made up the bulk of all lambs born. Thus the data on causes of triplet lamb deaths is sparse in comparison. Dystocia (or damage due to a difficult birth process) has traditionally been thought of as a birth weight/size and pelvic opening mismatch issue. Dystocia is infact a multi-factorial problem, influenced by factors including, but not limited to, foetal pelvic disproportion, disturbance during lambing, foetal entanglement, mis-presentation, ewe weakness and a prolonged birthing process, ewe nutrition and sire selection. Therefore dystocia is not specific to just large singleton lambs (Table 3). While dystocia predominately causes lambs to be born dead though through brain and/or liver damage, oedema or hypoxia (McCutcheon et al. 1981; Mellor and Stafford 2004; Hinch and Brien 2014), it can also cause injuries to the central nervous system resulting in the lamb failing to suck and having depressed viability and heat production.

Dystocia, birth trauma, presentation difficulties and still birth can be major causes of death in triplets (Table 3). Further, Everett-Hincks and Dodds (2008) reported that lamb viability at birth was lower in triplets compared to singles and twins. Horton et al. (2017) reported low birthweight dystocia increased with litter size, with 40% of dystocias found in ewes at least four years of age, giving birth to triplets. Everett-Hincks and Dodds (2008) reported that triplets were of a greater risk of dystocia than twins, especially in lambs 2 kg lighter than the mean. Further, Mathias-Davis et al. (2010) reported that the lightest lamb within a triplet set was more likely at risk of death by dystocia, than its littermates. In support of this, Refshauge et al. (2016) found that lighter twins and triplet lambs were more likely to get dystocia than lighter singletons and that lighter triplets were more likely to be born stillborn than lighter twins. The traditional relationship of dystocia rates being higher in heavier lambs at birth has also has been reported in triplets (George 1976). Supporting these contradicting results, Brown et al. (2014) and Horton et al. (2017) found increased rates of dystocia at the birth weight extremes, especially in triplets.

Collectively these studies indicate that death in triplets due to dystocia can be an issue for both light and heavy lambs, indicating birth weight itself, is likely not the only factor contributing to these deaths. Hinch et al. (1986) stated that prolonged birth hypoxia associated death seemed to be closely linked to litter size and is likely a major contributor to the litter size effects on mortality, independent of birth weight. In support of this, Speijers et al. (2010) found that oversized triplets were not a driver of dystocia but instead malpresentation was, supporting Hinch et al. (1986) who also found that malpresentation was a potential issue in large litters. Further, Cloete et al. (1993) reporting that prolonged births were most common in triplet-bearing ewes compared to both singletons and twins. Everett-Hincks et al. (2007) subsequently reported that first-born triplet lambs which did not survive took at least twice as long to be born, than those that did. Further, they found that those that died and presented with moderate to severe oedema, took three times longer to be born than those who died but had no- to minor-signs of oedema.

Lamb death due to either starvation and/or exposure are generally interrelated and are often considered together, as one can compound the effects of the other (McCutcheon et al. 1981). Broadly starvation is when a lamb fails to suckle enough milk to survive, while exposure occurs when the lamb is subjected to conditions where it cannot produce sufficient body heat to survive regardless of milk intake (Mellor and Stafford

Table 3. Comparison[a] of causes of death (%) of newborn lambs as identified by autopsy.

	Pre-natal death				Dystocia[b]		Starvation exposure			Dystocia/starvation exposure			Other[f]		
	S[c]	Tw[d]	Tpl[e]	S	Tw	Tpl	S	Tw	Tpl	S	Tw	Tpl	S	Tw	Tpl
Cloete et al. 1993				25	25	30	50	19	30		13		25	43	40
Cloete et al. 1993				100	27	50		22	22		6	8		45	20
Hinch et al. 1986	17	10	31	33	40	38	0	10	13	17	17	14	33	23	9
Hinch et al. 1986	17	21	28	57	36	36	3	11	11	13	7	8	10	26	15
Hinch et al. 1986	0	3	0	68	36	33	13	12	17	7	30	33	13	18	17
Holmøy et al. 2017				48	30	29	5	5	7				48	65	64
Holst et al. 2002				33	14	24	10	23	22	49	49	44	8	14	10
Kerslake et al. 2005				61	49	50	20	29	27	7	9	9	11	13	14
Scales et al. 1986	3	12	7	75	39	7	13	33	50	1	3	29	6	13	7
Range	0–17	3–21	0–31	25–100	14–49	7–50	0–50	5–33	7–50	1–49	3–49	8–44	6–48	13–65	7–64

[a]As identified by autopsy.
[b]Dystocia includes prolonged birth, rupture and central nervous system damage.
[c]S – Single.
[d]Tw - Twin.
[e]Tpl – Triplet.
[f]Other – either another cause of death or unknown.
Note: Individual % values have been rounded to the nearest whole number.

2004). The starvation exposure complex has traditionally been associated with small/light weight lambs as these lambs have less body reserves (predominately brown fat), have a greater surface area to body mass ratio and therefore lose body heat more readily to the environment (Hinch and Brien 2014). However, for all lambs, regardless of birth size, starvation exposure can occur as a result of dystocia (causing central nervous system damage of the lamb or ewe), poor mothering ability, lack of milk, cut teats, separation of lamb and ewe and extreme cold conditions (McCutcheon et al. 1981; Mellor and Stafford 2004). Hinch et al. (1986) reported that starvation exposure rates increased as litter size increased. In support of this, Everett-Hincks and Dodds (2008) reported that triplet lambs had a greater risk of starvation exposure than both singletons and twins and that losses due to starvation exposure were positively associated with predicated heat loss, based on their weather data. While, Scales et al. (1986) reported the biggest killer of triplet-born lambs were exposure, starvation and a combination of exposure, starvation and dystocia. Mathias-Davis et al. (2010) reported that the lightest lamb within a triplet set was more likely at risk of death due to starvation exposure. Holmøy et al. (2017) and Holland et al. (2018) also reported that the proportion of lambs dying from infections was higher in triplets and twins than in singletons. Triplet lambs were significantly more affected by entropion than singletons or twins (Claine et al. 2013). Combined the pre-mentioned studies indicate that both dystocia and starvation exposure can be significant contributors to triplet lamb deaths. Therefore management strategies to prevent these occurring and interventions to reduce their impacts during and after post the birthing process would be of benefit.

Ewe-lamb bonding and lamb behaviour soon after birth

The behaviour of the lamb soon after birth is critical for determining survival. Lambs progress through a series of behavioural events including standing, udder seeking and sucking, which are all influenced by their dams behaviour (Dwyer et al. 2016). Behaviours such as grooming, suckling and bleating are important in the first few hours for successful establishment of the ewe-lamb bond (Dwyer et al. 2005; Dwyer and Lawrence 2005). Lambs that are slow to stand or whose mothers spend less time grooming them, are more likely to be mis-mothered and less likely to survive (Owens et al. 1985; Dwyer et al. 2005; Dwyer and Lawrence 2005).

Triplet lambs display poorer lamb behaviour traits (i.e. time to stand, attempt to suckle, suckle, play and bleat) than both singletons and twins (Cloete et al. 2002; Dwyer 2003; Dwyer et al. 2005; Dwyer and Morgan 2006) but not in all studies (Corner et al. 2010). Owens et al. (1985) reported that the first-born lamb within the triplet set was slower to stand, find the udder and attempt to suckle than singletons and first-born twins. Further, the second born within the set was also slower to suck than its twin counterpart, although this is not always the case (Lockwood et al. 2019b). They also noted that as time increased from birth to attempting to stand, standing and seeking the udder the chance of survival decreased. These poorer behavioural traits probably contribute to the lower survival rates in triplets.

The behaviour of the ewe is influenced by the number of lambs she has given birth too and may contribute to the lower survival rates of triplet lambs. Owens et al. (1985) reported that triplet-bearing ewes displayed a longer period of restlessness prior to lambing than both singleton and twin-bearing ewes. Everett-Hincks et al. (2007) reported that while total birth time was longer in triplets, the time from the presence of the first feet to the birth of the second lamb, did not differ between twin- and triplet-bearing ewes. Pollard (1992) observed that compared with ewes rearing a singleton, triplet-rearing ewes bleated more when their litters were intact, but less when one of their lambs was removed. When separated by 10 m, only 70% of triplet sets compared with 91% and 100% of twins and singletons respectively, were reunited within 5 min of separation. They also found that post-separation, triplet lambs were more likely to be left to approach the ewe, rather than the ewe approach them. The triplet ewe also bleated less in the absence of a lamb compared to smaller litter sizes and when a triplet lamb failed to reunite with the rest of its litter the bleating response of their dams attenuated rapidly. This suggests that a triplet-bearing ewe is poorer at communicating when separated from some of its lambs and/or is less able to determine if all of their lambs are present compared to a twin rearing ewe.

Maternal behaviour score (MBS) is a subjective measure of the ewes behaviour while her lambs are being handled and has been suggested to be related to lamb survival (O'Connor et al. 1985; Everett-Hincks et al. 2005). Given that many breeders handle lambs soon after birth, for identification purposes, it has been put forward as a tool for identifying ewes who have greater ability to successfully rear their triplet sets. However, Dwyer et al. (2016) stated that maternal attachment scores and maternal behaviour have a negligible correlation with lamb survival. This is supported by Gronqvist (2015) who reported no influence of triplet ewe MBS on lamb survival in triplet sets. However, Everett-Hincks and Dodds (2008) reported that poorer MBS in triplet-bearing ewes was associated with lower lamb survival rates to three days of age. Interestingly, Everett-Hincks and Dodds (2008) in their study reported that triplet ewes displaying poorer MBS were associated with an increased risk of both dystocia and starvation exposure, but whether these were associations or cause and effect relationships was not be possible to determine. Further studies are required to verify this result. There are also breed differences in maternal care, with those breeds less selected for human intervention at lambing displaying higher levels of maternal care than those who have been more intensively selected and reared (Brien et al. 2014). This suggests the use of MBS as a tool for improving triplet lamb survival is likely dependent on breed and the heritability of MBS as a trait (see later section).

Ewe milk production and lamb intake

Hall et al. (1990) found that triplet-bearing ewes produced less milk in the first 24 h post-partum than those with twins. Both peak and total milk yield of triplet-rearing ewes has either been reported not to differ (Peart and Donaldson 1972, Manalu and Sumaryadi 1988, Alexandre et al. 2001; Pollott and Gootwine 2004) or to be greater, but not proportionally (Peart et al. 1975; Gallo and Davies 1988, 1991; Kaabi et al. 2002; Hutton et al. 2011) than twin rearing ewes. The data of Hinch (1989) suggests that by week three, milk production of triplet-rearing ewes is less than the theoretical demand of their lambs. Interestingly, Loerch et al. (1985) observed that triplet-rearing ewes produced 21% more milk per unit of metabolic body weight and were 10% more efficient in the conversion of feed to milk than twin rearing ewes.

Shubber et al. (1979) reported that there was no difference in twin- and triplet colostrum production although, Dwyer and Morgan (2006) reported that triplet-rearing ewes produced colostrum with decreased protein and Vitamin E content but greater fat percentage than twin rearing ewes. Concentrations of IgG and GGT are measures of colostrum uptake (Tessman et al. 1997; Maden et al. 2003) and glucose concentrations are indicative of the newborn lamb's nutritional state. Kenyon et al. (2005) reported greater glucose concentrations in twins than triplets. GGT and IgG concentrations of twin- and triplet-born lambs have been reported not to differ in Finnish (Halliday 1968), Finnish cross Dorset (Halliday 1971) and Romney lambs (Kenyon et al. 2005) although, differences have been reported in Scottish blackface lambs (Halliday 1968).

Hess et al. (1974) found that triplet lambs sucked less frequently and in shorter bouts than either singleton or twins. While Hinch (1989) observed that increasing litter size resulted in increased frequency of suckling but this was associated with a decline in the duration of suckling itself. Further, Graves et al. (1977) reported that time spent suckling per day was similar for singles and twins but lower for triplet lambs. Hinch (1989) reported that there was significant variation in the number of suckling bouts within a triplet set, with the worst lamb achieving 37% fewer bouts than the next poorest, resulting in a 24% difference in apparent milk intake between the best and worst suckling lamb. In an undisturbed suckling session, Van Welie et al. (2016) observed that the 'heavy' lamb within a set of triplets sucked less often and for less time overall but still gained similar live weight to their 'lighter' littermates, suggesting they were more efficient at extracting milk. While in a competitive suckling session, the 'lightest' lamb tended to gain less live weight and competed with the 'middle' lamb for the teat not preferred by their heavier counterpart. They suggested that these observations indicate that the heavy lamb within a set of triplets is an efficient feeder, while the middle lamb needs to work harder to achieve the same milk intake, and that the lightest lamb cannot compete and obtains a lower milk intake, contributing to their lower weight. These results clearly indicate on a per lamb basis, triplets receive less milk which explains some of the difference observed in both lamb survival and growth between birth ranks. Overall these studies also provide evidence to support the notion that the lightest lamb within a triplet set is the one that would benefit the most from additional support.

Lamb growth

Due to triplet lambs receiving proportionally less milk than their singleton and twin counterparts they display slower growth to weaning and lighter weaning weights (Peart and Donaldson 1972; Fahmy 1989; Gallo and Davies 1991; Emsen and Yaprak 2006; Corner et al. 2008; Boujenane 2012; Paganoni et al. 2014; Behrendt et al. 2019). In addition, the number of lambs weaned within a triplet set can negatively affect individual lamb weaning weights (Table 4), although total weaning weight of a litter is highest when all three lambs are weaned. There is greater variation in litter weaning weight in triplets than twins (Roy et al. 1999). Further, Kenyon and Blair (2014) and Gholizadeh and Ghafouri-Kesbi (2015) reported that triplets can be lighter than singletons and twins to at least one year of age.

The ewe

A ewe's pregnancy is generally divided into three periods, which are often referred to as the three 'trimesters' of pregnancy. During the first 50 days of pregnancy the energy requirements for the developing embryo and conceptus are relatively small, with nutritional

Table 4. The effect of birth rank and rearing rank on lamb weight (kg) at weaning.

Reference[1]	Twin /Twin	Triplet/Triplet	Triplet/Twin	Triplet/Singleton
Morris and Kenyon 2004	27.4 ± 0.4^{c}	22.7 ± 0.5^{a}	25.3 ± 0.5^{b}	
Kenyon et al. 2010a	23.1 ± 0.5	22.5 ± 0.6	23.7 ± 0.8	
Kenyon et al. 2010b	24.4 ± 0.5^{b}	22.2 ± 0.7^{a}	22.6 ± 0.7^{a}	
Kerslake et al. 2010a	16.0 ± 0.3^{b}	14.5 ± 0.7^{a}	15.1 ± 0.6^{ab}	
Hutton et al. 2011	20.8 ± 0.4^{b}	17.6 ± 0.5^{a}	17.9 ± 0.7^{a}	15.3 ± 1.3^{a}
Kenyon et al. 2011a		18.8 ± 0.3^{a}	19.6 ± 0.3^{a}	22.0 ± 0.6^{b}
Kenyon et al. 2011b		24.2 ± 0.7^{a}	26.1 ± 0.6^{ab}	28.0 ± 1.0^{b}
Kenyon et al. 2012		25.5 ± 0.6^{a}	27.2 ± 0.7^{b}	28.7 ± 1.1^{ab}
Kenyon et al. 2013		21.0 ± 0.6^{a}	23.8 ± 0.6^{b}	26.8 ± 1.0^{c}

[1]Data adapted from the various studies.

demand not differing across pregnancy ranks (Nicol and Brookes 2007). Nutritional levels in the second 50-day period affects placental growth with placental weight peaking between days 90–100. Interestingly there is a general lack of data on the effect of mid-pregnancy nutrition on foetal and placental development in triplets, although data exists for singletons and twins (see review Kenyon and Blair 2014). The nutritional demand between pregnancy ranks is considered not to differ in this period. The last 50 days of pregnancy is the period of rapid foetal growth with approximately two-thirds occurring in this period (Rattray et al. 1974) and therefore is the period of greatest nutritional demand, with clear differences in feed demand between pregnancy ranks (Nicol and Brookes 2007). Nicol and Brookes (2007) calculated that in the last six weeks of gestation to meet the pregnancy requirements only, a twin-bearing ewe giving birth to two, four kg lambs would need to consume 400 MJ ME, while a triplet-bearing ewe destined to give birth to three, four kg lambs would need to consume 600 MJ ME, above their maintenance requirements.

Morris and Kenyon (2004) reported that intakes of triplet-bearing ewes did not differ from twins, under both restricted (approximately 800 kg DM/ha, 2 cm sward height) and unrestricted ryegrass based feeding conditions (a minimum of 1200 kg DM/ha, or 4 cm). Similarly, Petit (1997) reported that intakes did not differ in twin and triplet-bearing ewes offered supplementation plus silage in late pregnancy. Morris and Kenyon (2004) suggested that in late pregnancy triplet-bearing ewes can fail to consume their theoretical requirements, even under unrestricted pasture conditions, due to ruminal space restriction. In support of this, Everts (1990a) reported that ewe intake in the last weeks of pregnancy actually decreased and that this was related to litter size. They suggested that this reduction in intake with larger litter sizes was potentially explained by; reduce abdomen space due to rapid uterine expansion, greater heat stress from more lambs in the uterus especially in ewes with an intact fleece, higher levels of oestrogen which has been shown to reduce intake, and a ewe in an energy deficit state is driven to energy mobilisation resulting in increased levels of free fatty acids which could result in reduced intake.

Everts (1990b) and Fogarty et al. (1992) reported that glucose levels were negatively affected by litter size after mid-pregnancy. In addition, triplet-bearing ewes in late pregnancy display higher ketone, Beta-hydroxybutyrate (BHB) and non-esterified fatty acid (NEFA) concentrations than twin-bearing ewes (Barlow et al. 1987; Morris and Kenyon 2004; Corner et al. 2008; Kenyon et al. 2010a, 2010b). Within some studies, these impacts on ewe metabolites in late pregnancy did not occur at all-time points (Morris and Kenyon 2004; Corner et al. 2008; Kenyon et al. 2010a). Barry and Manley (1985) reported that in late pregnancy triplet-bearing ewes were in negative energy balance and that amino acid requirements were likely to exceed substantially net absorption from the digestion of fresh forage diets fed *ad libitium*. They reported that this caused maternal tissues to go into negative N balance to ensure adequate foetal growth. Combined the results across studies indicate that triplet-bearing ewes are under great nutritional stress in late pregnancy. This contributes to their greater death rates (Kleeman et al. 1993, up to 9% greater than singletons and twin lambing ewes), and cull rates (Abdelqader et al. 2012, 1.7–2.0 times more likely than singleton lambing ewes), and effects foetal development.

In lactation, Sormunen-Cristian and Jauhiainen (2001) reported food intakes did not differ between twin and triplet-rearing ewes on either a fescue/timothy grass silage, hay or combination of both. Further, with unrestricted ryegrass based conditions (Morris and Kenyon 2004) and with supplementation in addition to silage (Petit 1997) no difference in intake was observed. Gallo and Davies (1991) reported that in the first month of lactation intakes of triplet-bearing ewes rearing either two or three lambs did not differ. Combined these results indicate that a triplet-rearing ewe is more likely to be under nutritional stress in lactation than twin rearing ewes and therefore it is not surprising that triplet-rearing ewes lose more body condition (Gallo and Davies 1988; Roy et al. 1999; Alexandre et al. 2001; Kenyon et al. 2010a; Hutton et al. 2011). Further, Kenyon et al. (2013) noted that triplet dams rearing a full set of triplets had lower body condition and live weight at weaning than a ewe rearing only one or two of their triplet lambs.

Summary of intervention studies

Birth weight

Triplets are lighter at birth than twins or singletons and this has negative consequences for their survival. Therefore increasing birth weight should be advantageous and increase their survival. However, due to the limited number of studies in the literature, it was not possible to detect, via meta-analysis, the impact of management manipulations (e.g. nutrition, ewe body condition) on triplet lamb birthweight. However, the meta-regression showed that studies with no manipulations (i.e. studies comparing just the birth weights of singletons, twins and triplets) resulted in triplets that were 1.5 and 0.9 standard deviations lighter ($P < 0.05$) than singletons and twins, respectively (No treatment in Figure 1). Studies with treatments designed to increased birthweight (+ treatments in Figure 1) resulted in triplets being 1.7 and 1.1 standard deviations lighter than singleton and twins respectively. These greater differences, in comparison to studies with no treatments, suggests triplet birth weight was increased by a lesser extent then their singleton and twin counterparts. Further studies with treatments designed to reduced birth weight (- treatments in Figure 1) resulted in triplets being 1.6 and 1.0 standard deviations lighter than singleton and twins, respectively, suggesting a bigger reduction in birth weight for triplets that in their singleton or twin counterparts. These results are unsurprising given the physical, physiological and nutritional stress triplet-rearing ewes experience in late pregnancy, compared to those carrying fewer lambs.

A number of studies have examined the impact of ewe nutrition in pregnancy on foetal growth and lamb birthweight (see review Kenyon and Blair 2014) but few have examined impacts in triplets. Kenyon et al. (2011b) reported that early pregnancy nutrition had no impact on triplet birth weight. While Fogarty et al. (1992) reported minimal to no impacts of mid-pregnancy nutrition. However, it is important to acknowledge that in both studies ewes were provided adequate levels of nutrition in later stages of pregnancy. Khalaf et al. (1979) found that restricting triplet ewe nutrition to 483 MJ, which is below nutritional requirements, compared to 974 MJ in the last eight weeks of pregnancy reduced lamb birth weight. Under ryegrass based sward conditions Morris and Kenyon (2004) found that offering a minimum grazing height of 2 cm (approximately 800 kg DM/ha) from mid-pregnancy until birth, resulted in reduced lamb birth weight compared to greater sward heights (4, 6 or 8 cm). Lamb birth weight under 4, 6 and 8 cm sward heights did not differ. Based on this study, further studies were undertaken to determine the optimal feeding regimen in mid- to late pregnancy to minimise ewe-feeding requirements without negatively affecting lamb birth weight. Combined these studies suggested that under ryegrass based sward conditions ewes could be offered a minimum of 2 cm grazing sward heights until approximately two weeks prior to the start of lambing as long as ewe intake was unrestricted (minimum 4 cm) in the last two weeks of pregnancy (Corner et al. 2008; Kenyon et al. 2011a, 2012, 2013).

Hutton et al. (2011) and Kenyon et al. (2010a) both reported that offering *ad libitium* herb-clover (chicory, plantain, red- and white-clove) mixes did not increase lamb birth weight, compared to an unrestricted ryegrass based pasture. However, in both of these studies ewes were only offered these swards from very late in pregnancy. Sormunen-Cristian and Jauhiainen (2001) reported lamb birth weights did not differ between ewes fed either a fescue/timothy grass silage or hay or combination of both, in last weeks of gestation. Similarly, Barry and Manley (1985) found no effect of offering *ad libitium* either kale, perennial ryegrass or a perennial ryegrass and barley mix in late pregnancy. Combined these few studies suggest herbage type may have no impact when ewe intake is unrestricted although, to date only a limited number of alternative herbages have been studied with triplets.

To address the inability of the triplet-bearing ewe to meet her additional nutritional needs in pregnancy, a number of studies have examined the impacts of supplementary nutrition. Under restricted ryegrass based sward conditions, supplementation of triplet-bearing ewes with a grain-based concentrate has increased lamb birth weight (Kenyon et al. 2005). However, under unrestricted ryegrass based conditions the results have been inconsistent with supplementation either having no effect (Kleeman et al. 1993; Kerslake et al. 2009; Kenyon et al. 2010b) or only a small positive effect (Kerslake et al. 2010b). While, Petit (1997) reported no effect on lamb weight from offering late pregnant ewes either a commercial concentrate or a beet/soybean pulp meal, in addition to unrestricted grass-based silage. In contrast, Hinch et al. (1996) reported that supplementation of ewes with cottonseed meal, under 'abundant' pasture conditions in mid- to late-pregnancy increased lamb birth weight slightly. Supplementation with either fat or vitamin E (Capper et al. 2006), Sodium Monessen (Austin and Wilde 1985) or iodine (Kerslake et al. 2010a) have been found to have no impact on birth weight. Combined these studies suggest that any positive effect of supplementation depends on the type of supplement used and the level of herbage otherwise offered. There appears to be a lack of evaluation as to the economic impact of supplementation.

The impact of ewe live weight on lamb birth weight has been examined in three modelling based studies. Paganoni et al. (2014) using singleton, twin and triplet data reported that an extra 10 kg of ewe live weight at breeding was associated with an extra 0.32 kg of lamb birth weight, while a 10 kg increase in early pregnancy was associated with an increase of 0.21 kg in birth weight, irrespective of birth rank. In late pregnancy an increase of 10 kg in ewe live weight was associated with an extra 0.34 kg. Behrendt et al. (2019) have recently found similar coefficients for Maternal composite ewes; a 10 kg increase in live weight at breeding, during early/mid or late pregnancy increased birth weights by 0.25, 0.33 and 0.43 kg respectively, regardless of birth type. While these are positive impacts, they did require relatively large increases in ewe live weight for quite small changes in birth weight. Interestingly, Schreurs et al. (2012), using data from a range of studies, reported that while heavier ewe weights at breeding and in the various stages of pregnancy had a positive relationship with singleton lamb birth weight it had a negative relationship with twins and triplets. It is difficult to explain the contrasting results but the analysis utilised data from different breeds and managed under different environmental and nutritional conditions.

In sheep, body condition score is measured of the range of 1–5 with 1 reflecting an emaciated animal (see review Kenyon et al. 2014). In general low ewe body condition scores are associated with reduced lamb birth weight and this effect is more likely to occur due to poor nutrition (Kenyon et al. 2014). Therefore given the greater pregnancy requirements of triplet-bearing ewes, it might be expected that low body condition would negatively influence lamb birthweight. However, Kenyon et al. (2011a, 2012, 2013) reported no effects of mid- to late-pregnancy ewe body condition score on birth weight over 2.0–3.5 body condition range. It is important to note that in these studies, ewe herbage intake was not restricted in late pregnancy. In the work reported by Behrendt et al. (2019) where differences in condition score were maintained through until the end of lambing, low body condition score had a significant negative influence on the birth weights of triplet lambs at one research site and on the birth weight of multiples (twins and triples combined) at other sites. It could be hypothesised that under poor nutritional conditions, the impact of ewe body condition would be significant, and warrants investigation.

Shearing single and twin-bearing ewes in mid-pregnancy (days 50–110 of gestation) has been shown to consistently increase lamb birth weight (see review Kenyon et al. 2003). In triplets under both indoor (Maund 1980) and outdoor pastoral conditions (Kenyon et al. 2006) mid-pregnancy shearing has also increased birth weight. However, to achieve a birth weight response it has been hypothesised ewes need to be in adequate body condition and well fed (Kenyon et al. 2003), a combination not always present with triplets.

Ewe breed can affect triplet lamb birth weight (Demiroren et al. 1995), suggesting that some breeds may be more suitable than others for giving birth to triplet lambs of more appropriate weights. Birth weight is also a heritable trait (Safari, Atkins, Fogarty et al. 2005, Safari, Fogarty, Gilmour 2005) and selection could potentially be utilised to increase birth weight. However, this could have negative impacts on those ewes in the flock that give birth to singletons and therefore may be an unlikely approach for farmers. There appears to be a lack of work exploring the effects of genotype by nutritional management of the ewe on triplet lamb birthweight, and it maybe that there are breeds or genotypes within breed, which produce triplet lambs of more similar birth weights regardless of nutritional conditions during pregnancy.

There is significant variation in birth weight within a triplet litter and it's the smallest lamb that is most likely to die (see earlier section). Therefore reducing variation in litter weight should improve overall lamb survival. However, to date there has been a general lack of studies specifically undertaken to reduce this variation. Generally, studies present the mean birth weight data only. In future, it would be advantageous if authors were to present the mean birth weight of the smallest, middle and largest lamb within a triplet litter, or the live weight difference between the smallest and largest lamb. Juengel et al. (2018) is one of the few studies to look at the mechanism to reduce variation in litter weight. They found that birth weight difference within litter was not heritable nor repeatable, indicating there is little opportunity to use genetic selection to reduce variation in birth weight within litter.

Colostrum and milk production and intake

In both singleton and twin lambs, poor ewe nutrition in pregnancy can result in decreased colostrum production and intake (Mellor and Murray 1985a, 1985b, 1986). Therefore similar results might be expected in triplet-born lambs, although few studies have specifically examined this, with most focusing on the impact of ewe feeding levels above pregnancy requirements. Kenyon et al. (2005) found that lambs born to ewes offered a 2 cm ryegrass based sward from mid-pregnancy until birth tended to have lower GGT and glucose concentrations at 24–36 h of age than those offered greater sward heights, but no benefits were observed above 4 cm. In support of this latter finding, also under ryegrass based conditions no impacts of pregnancy nutrition on lamb glucose, GGT and IgG have been observed (Kenyon et al. 2012, 2013) when unrestricted conditions were provided in very late pregnancy. Moreover, Kenyon et al. (2010a) reported no difference in IgG concentrations in lambs born to ewes offered unrestricted intakes on either a Herb clover mix or a ryegrass based sward in very late pregnancy. Further, with unrestricted ryegrass based sward conditions, grain-based concentrate supplementation of ewes has had no impact on lamb glucose, IgG (Kerslake et al. 2009, 2010b; Kenyon et al. 2010b) and a tendency to increase GGT concentrations (Kerslake et al. 2009, 2010b). Ewe body condition score range of 2.0–3.0, had no impact on lamb glucose and GGT concentrations (Kenyon et al. 2012, 2013) when late pregnancy ewe nutrition was unrestricted. Combined these studies suggest that when triplet-bearing ewes are offered unrestricted feeding conditions in late pregnancy there may be little impact of earlier nutritional conditions. However, if intakes are restricted in late pregnancy negative impacts can potentially occur. Further research is required before firm conclusions can be drawn.

In triplets, birthweight has a positive impact on GGT and glucose levels at 24–36 h of age (Kenyon et al. 2005). This suggests that any manipulation that increases birth weight should have positive effects on colostrum uptake. Kerslake et al. (2010a) reported that ewe iodine supplementation increased lamb IgG concentrations and tended to increase glucose concentrations, but not GGT concentrations under unrestricted herbage conditions, when ewes were not iodine deficient. Combined these two studies offer a potential means to increase colostrum uptake but further studies are required to verify and quantify this.

Few studies have measured the impacts of various management interventions on milk production in ewes rearing triplets. Petit (1997) reported that offering triplet-bearing ewes either a grain-based concentrate supplement or a beet pulp and soy-bean meal mix supplement, in addition to silage in late pregnancy and in early lactation, had no effect on milk production or composition. This was likely not surprising given the lack of difference in crude protein and total dry matter intake of the supplements. While Roy et al. (1999) reported that offering a higher crude protein supplement (21% vs. 15%) in both late pregnancy and lactation to ewes with unrestricted access to two types of brome grass silage, had no effect on milk production. However, the silage type with the higher metabolisable energy and crude protein and lower fibre concentration, resulted in greater ewe intakes and milk production. Hutton et al. (2011) reported that a herb clover mix, containing chicory, plantain and red- and white-clover, increased ewe milk production in comparison to a ryegrass based sward, both under unrestricted herbage conditions. This result was likely driven by the greater herbage quality (Kemp et al. 2010) of the herb clover mix. In dairy cattle, it has been reported that as the proportion of chicory and white clover in the diet increased, milk production also increased (Waghorn and Clark 2004; Chapman et al. 2008). Combined, these results indicate that the management of triplet-bearing ewes should ensure they are provided with a high-quality diet to maximise milk production.

Lamb body heat production

Any increase in the capacity of triplet lambs to produce body heat should have positive effects on their survival. Martin et al. (2013) in their meta-analysis found that neither ewe live weight nor body condition score (range 1.5–4.0) in late pregnancy or changes in these parameters (range −0.5–1.5) had any effect on triplet lamb maximal heat production. Kerslake et al. (2010b) reported that ewe iodine supplementation had no effect on lamb rectal temperature or maximal heat production, although in that study there was no suggestion that untreated ewes were iodine deficient. Kenyon et al. (2010b) reported no effect of ewe grain based concentrate supplementation on lamb heat production while Kerslake et al. (2009) reported a positive effect. In both studies, ryegrass-based pasture was not restricted. The reason for these contrasting results is unknown. However, combined these results suggest it could be possible to increase heat production through supplementation and this warrants further investigation, as do other potential mechanism to increase heat production.

Lamb survival

Mechanisms to increase triplet lamb survival would improve flock productivity, to varying degrees, depending on the proportion of triplet-bearing ewes in the whole flock. Elliot et al. (2011) stated that while Australian farmers generally had a positive attitude towards improving lamb survival, they did have an underlying feeling that a level of mortality was inevitable. However, the farmers did believe that they could increase productivity by improving survival and were willing to investigate potential solutions. Broad approaches suggested included genetics, control of predators, feed and nutrition and flock management. New Zealand farmers suggested more research was required in the area of lamb survival (Greer et al. 2015). A single solution to improve lamb survival that's fits all farm systems is unlikely (Dwyer et al. 2016), and identifying the best practices to implement needs to be considered on a case by case basis.

It is generally accepted that both breed and genotype affect lamb survival (Fogarty et al. 1992; Paganoni et al. 2014; Ferreira et al. 2015). However, triplet focused research has been inconsistent (Gootwine et al. 2008; Wolfova et al. 2011). Interestingly, Refshauge et al. (2016) reported that triplets born to terminal sire types had a lower probability of dying from starvation-mismothering than triplets born to Merino and maternal breed sires. This suggests an interaction between sire type and the risk of starvation exposure although, not all potential sire by dam breed combinations were evaluated and further studies are warranted to confirm this result. However the data does suggest there is potential for farmers to use breed or genotype selection as a means of improving triplet lamb survival but, further research focused on triplets is required to verify that.

A large number of factors contribute to lamb survival and therefore unsurprisingly heritability and repeatability estimates for lamb and litter survival are low (Everett-Hincks et al. 2005; Safari, Atkins, Fogarty et al. 2005, Safari, Fogarty, Gilmour 2005; Brien et al. 2010; Hinch and Brien 2014, Everett-Hincks and Cullen 2009, Ferreira et al. 2015; Hebart and Brien 2018) indicating slow genetic progress only. Welsh et al. (2006) suggested that even slow genetic progress is worth targeting as a long-term solution. Hebart and Brien (2018) indicated that considering lamb survival separately for each birth rank would be more effective than treating it as a single trait across rank. Therefore, a farmer could focus selection on triplet litter survival within that subset of ewes. However, in practise on-farm, especially under extensive outdoor conditions, this may be difficult to implement and individual farms would need a large number of triplets litter sets to make progress.

Dwyer et al. (2016) hypothesised that there might be scope to look at component traits of lamb survival, for example, improved suckling behaviour. However, the extra work to assess single traits is likely to be prohibitive on farm and most studies examining single traits have found that only moderate progress at best, can be made. Cause of lamb death traits, as identified by autopsy, and lambing ease have low heritability (Everett-Hincks et al. 2005; Brown et al. 2014; Horton et al. 2017; Juengel et al. 2018) while birth weight, lamb vigour, sucking ability of lambs and MBS have moderate heritability (Matheson et al. 2012; Brown et al. 2014; Turner et al. 2016). Given the difficulty in measuring many of these traits, which would require 24 h monitoring, the use of many of these on-farm, especially under extensive outdoor conditions, is likely to be limited. However, if simpler scoring systems could be developed for triplets, especially for extensive conditions (Brien et al. 2010), uptake could be greater.

Brown et al. (2014) stated that lambing ease, a trait based on the amount of assistance given during parturition, had the highest genetic correlation with the various lamb autopsy traits and that this implied that lambs experiencing difficulty during parturition were more likely to die or contribute to poor survival rates in future generations. They suggested that this reinforces the use of an 'easy-care lambing system' such as used in New Zealand, where ewes who fail to rear a lamb successfully for any reason are culled. There are a number of ewe temperament tests prior to lambing that has been evaluated as a means of improving lamb survival, these include; the arena test, flight time test and the Isolation Box test (Brien et al. 2014). The expression of temperament in an animal is its behavioural reactivity or emotivity (Brien et al. 2014). Although it has been suggested by some the use of a temperament test has the potential to increase lamb survival (Horton et al. 2009; Hocking-Edwards et al. 2011; Plush et al. 2011; Hinch and Brien 2014) large scale studies in triplets have not been undertaken. However, the results of Brown et al. (2016) suggested that selection based on either flight time test or the Isolation Box test would have little impact on lamb survival, although that was not directly measured. Brien et al. (2014) suggested that more practical and cheaper to measure indicators of temperament may prove more effective in the future as a means of improving lamb survival.

Lamb survival is a binomial trait i.e. lambs either survive or they do not. Therefore, to detect a difference in lamb survival by as little as 5% requires up to 150 lambs within each treatment groups. Many studies which have examined the impact of given management intervention on triplet lamb survival have had lamb numbers well below this, and therefore their data needs to be interpreted with caution. Kleeman et al. (1993) reported pastoral feeding conditions during mid-pregnancy had no effect on triplet lamb survival. In addition, the results from a series of studies under ryegrass based feeding conditions in early-, mid– and/or late-pregnancy suggest that ewes can be offered a minimum of 2 cm (approximately 800 kg DM/ha), until approximately two weeks pre-lambing,, without negatively affecting lamb survival (Morris and Kenyon 2004; Corner et al. 2008; Kenyon et al. 2011a, 2011b, 2012, 2013), as long as intake is not restricted post this point. Interestingly in one of their studies, unrestricted feeding in late pregnancy actually negatively affected triplet survival (Kenyon et al. 2012). The reasons for this result are unknown.

Kleeman et al. (1993) reported that under pasture grazing conditions a protein supplementation in late-pregnancy did not influence triplet lamb survival. Similarly, grain-based concentrate supplementation of pregnant ewes under unrestricted feeding ryegrass based feeding conditions has had no effect on triplet lamb survival (Kerslake et al. 2009, 2010b; Kenyon et al. 2010b). Although, Hinch et al. (1996) reported that supplementation with cottonseed meal under 'abundant' pasture conditions in mid- and late-pregnancy had a consistent positive effect across birth ranks on survival. While, giving poor vigour triplet lambs dextrose post birth, with the aim of improving lamb glucose concentration, did not improve lamb vigour and survival (Hegarty et al. 2017) indicating such intensive intervention is likely unwarranted. Only the studies of Kenyon et al. (2012 and 2013) had more than 150 lambs born within their treatment groups tested and therefore, caution is required when interpreting the data of the other studies examining triplet lamb survival.

Combined the results of these nutritional based studies discussed in this section on lamb survival suggest triplet lamb survival may be difficult to manipulate via ewe pregnancy nutrition alone. It is however critically important to note that in none of these pre-mention studies were ewes subjected to levels of nutrition well below their theoretical demand which can occur in parts of Australia, especially when lambing in autumn and early winter. Therefore it is likely that the length of nutritional restriction and ewe body condition influences the probability of ewe nutrition in pregnancy affecting lamb survival. Khalaf et al. (1979) reported that feeding ewes below their nutritional demand during the last eight weeks of pregnancy and in early lactation reduced lamb survival. Similarly, Behrendt et al. (2019) reported data from three replicated experiments involving 374–544 multiple bearing maternal ewes which were differentially fed following pregnancy scanning to reach target condition scores at lambing of 2.4, 2.8, 3.2 or 3.6. They found that survival of multiple born lambs increased from 78% to 89% across this range in condition scores, when the nutritional stress was imposed until the end of lambing. At the one site where triplets were treated separately in the analysis, it appeared that the effects of ewe condition on lamb survival were more dramatic below maintenance conditions although the difference was not statistically significant. Higher triplet ewe body condition either had no effect or a positive effect on triplet lamb survival (Kenyon et al. 2011a, 2012, 2013) supporting the inconsistency reported in the body condition review of Kenyon et al. (2014). This inconsistency is likely influenced by ewe nutrition and likely requires further investigation.

Kenyon et al. (2010a) reported that lamb survival was increased by offering a herb clover mix compared to a ryegrass based sward at unrestricted levels, in very late pregnancy and in lactation, in one of two breeds. However, in a follow-up study, the herb clover mix only tended to increase lamb survival (Hutton et al. 2011). Before clear conclusions on the impact of pregnancy nutrition can be made, large-scale studies under a range of ewe nutritional conditions, with ewes of varying body conditions are required to quantify both their individual affects and potential interactions between pregnancy and lactational nutrition.

Shearing single and twin-bearing ewes in mid-pregnancy (days 50–110 of gestation) is an accepted means of increasing their lamb's survival (Kenyon et al. 2003; De Barbieri et al. 2018) and is also effective in triplets (Maund 1980; Kenyon et al. 2006). It has been suggested that for mid-pregnancy shearing to have a positive affect on lamb survival, through an increase in birthweight, birthweights must have otherwise been destined to be below optimal and any increase in birth weight must be large enough to move a significant proportion of otherwise lightweight lambs into the optimal range (Kenyon et al. 2002). Other potential mechanisms to improve lamb survival, independent of birthweight changes from mid-pregnancy shearing, include: (i) increased depth of the wet lamb fleece, (ii) a change in dam behaviour (i.e. the seeking of shelter), (iii) easier lambing, (iv) increased ease for lamb finding the teat, (v) increased dam awareness of the lamb, (vi) fewer ewes failing to stand after lambing with consequent loss of their lambs, (v) few ewe castings, (vi) increase ewe milk production, (vii) improved lamb vigour and thermoregulation (Kenyon et al. 2003, 2006; Cam and Kuran 2004; Banchero et al. 2010; Sphor et al. 2011). These mechanisms have not been examined in triplets. Using shearing to encourage ewes to seek shelter at lambing, requires shearing to occur within the last few weeks of pregnancy and is therefore not generally a practise adopted by farmers (Hinch and Brien 2014). It is unlikely to be utilised in triplets given the metabolic risk from having ewes off feed, to empty out, prior to shearing in very late in pregnancy.

A limited number of small scale studies have suggested that higher mob sizes or stocking rates during lambing increases the risk of mis-mothering, ewe-lamb separations and hence lamb mortality (Winfield 1970; Cloete 1992; Robertson et al. 2012). However few studies have specifically examined the impact of mob size or stocking rate of ewes at lambing on lamb survival (Hinch and Brien 2014). Lambing density is expected to have a greater effect on the survival of multiple born lambs because more lambs are born per day which presents a greater risk of mis-mothering. In support of this, survey data collected from commercial sheep producers in south-east Victoria found that the survival of single and twin-born lambs increased by 1.4% and 3.5% from decreasing mob size by 100 ewes, regardless of breed (Lockwood et al 2019c). Experimental data subsequently collected by Lockwood et al (2019b) in southern Australia confirmed that survival increased by 1.9–2.5% from reducing mob size by 100 twin-bearing ewes regardless of ewe breed. In this experiment stocking rate of ewes was not found to influence lamb survival and the relationship between mob size and lamb survival was not influenced by characteristics of the lambing paddock or the amount of herbage available. However, variation in the effect of mob size on lamb survival was observed in intensive experimental work conducted in two contrasting seasons. The survival of twin lambs decreased by 4% per additional 100 ewes in the mob when herbage mass was below 390 kg DM/ha and ewes were trail fed supplements during lambing (Lockwood et al 2019a), whereas the survival of single- and twin-born lambs was not observed to differ between mob sizes of 50 and 130 ewes when herbage mass at lambing exceeded 2400 kg DM/ha (Lockwood et al 2019d). This suggests that the effect of mob size on lamb survival could be influenced by herbage mass and supplementary feeding. It is possible that under poor pasture feeding conditions, trail feeding increases the risk of separation of the ewe from her lamb(s). It would be of interested to determine if the same effect would be observed with lick feeders. Hinch and Brien (2014) stated that the limited data available suggests maximum flock sizes of 100–250 and 200–500 for twin and singleton-bearing ewes respectively, however, the optimal mob sizes are likely to be significantly smaller than this based on the recent work by Lockwood et al. (2019a, 2019b, 2019c, 2019d) and no such recommendations are available for triplets. Given the potential for many triplet lambs to be born in a short space of time, at a preferred lambing site, the impact of stocking rate and especially mob size on triplet survival requires investigation.

Knight (1983) reported that on steep paddocks, with slopes between 32–44 degrees, 34 and 52% of singletons and twins lambs respectively died, due to slippage resulting in separation from their dams. They recommended that steep-sloped paddocks should be avoided for twins. However, given that they also found death rates 4 and 12% in singletons and twins respectively on paddocks with slopes of 24–31 degrees, their data suggest milder slopes impact twin lamb survival. The impacts of slope on triplet lamb survival have not been examined. Given the poor ability of the triplet ewe to communicate and reunite with its missing lambs (see earlier section), it might be expected that increased slope will have an even greater negative impact on survival.

The review of Fisher and Mellor (2002) concluded that overall there was no evidence to indicate shepherding ensures either easier births or integrity of the ewe-lamb contact; equally they found no clear support for shepherding being harmful. Although this review was undertaken when the proportion of triplets in flocks in New Zealand were low. There appear to be no studies directly examining the impact of shepherding, or the intensity of shepherding, on triplet ewe and lamb survival. However, given the economic and societal impacts of lamb survival, there is likely the justification for the development of intensive outdoor lambing systems to ensure appropriate survival rates of triplets. The development of such systems under outdoor conditions would likely require greater infrastructure and labour inputs, and therefore costs. It is possible that societal demands may require these changes irrespective of costs. Fisher and Mellor (2002) made the following observations, firstly, human presence can inhibit or delay parturition, secondly, extended parturition can increase the risk of, or is associated with dystocia, and thirdly, disturbance at birth can compromise ewe-lamb bonding and consequently lamb survival. They suggested in extensive flocks, where sheep have been selected for easy-care lambing it may be detrimental to intervene via shepherding; if shepherding is to be utilised, ewes should be well accustomed to the presence of the shepherd. Hinch and Brien (2014) stated that while it is likely farmers will continue to intervene with difficult births, under extensive farming conditions, farmer preference is likely to be for the minimal use of mothering-up, fostering and artificial rearing. This suggests that other management interventions to improve lamb survival are likely to be utilised by industry before more intensive management under extensive grazing conditions.

Wind and rain cause chilling of lambs and has a greater impact on small lambs, especially when milk intake is less than optimal. Therefore it could be argued that triplet lambs would benefit the most from the shelter. Effective shelter will protect lambs from wind, rain, radiative and conductive heat loss, as well as allowing lambs exposure to the sun and can be in both natural and artificial forms (Pollard 2006). Shelter should be well dispersed to encourage ewes to isolate at lambing (Pollard 2006). Several reviews have concluded shelter can improve lamb survival although the size of any positive effects varies and this variation is likely somewhat explained by environmental conditions (Bird et al. 1984; Pollard 2006; Baker et al. 2018). Many authors have suggested that the benefits and management of effective shelter require further research, as little research has been undertaken for many years (Pollard 2006; Hinch and Brien 2014; Baker et al. 2018). There appears to be a lack of studies directly examining the use of shelter to increase triplet lamb survival.

Given the low survival rates of triplet lambs, especially the smallest with the set, and the failure of the triplet-bearing ewe to produce proportionally more milk, there may be some merit in removing one lamb to be either mothered-on to another ewe, or to be artificially reared. While Hinch and Brien (2014) suggested that under extensive conditions farmers may not utilise such intensive activity, if prices for lambs are high intensive practises may become more common. Protocols for successfully mothering-on and artificially rearing lambs exist (Alexander et al. 1987; Eales et al. 2004,) and are being used by industry (B+LNZ 2018b; Dalton 2018; NZAgbiz 2018). However, there is an apparent lack of robust economic analysis which is needed.

Holmøy et al. (2014) reported that loss rates of triplets were dependent on the age of the ewe; for example for ewes giving birth to triplet lambs, the odds of losing at least one lamb were 2.7 times greater in 1-year-old ewes than in 3-year-old ewes. Mothering experience may play an important role in triplet lamb survival. Farmers could use this knowledge to place greater emphasis on monitoring and supporting of younger ewes during the lambing period or they could manipulate the age structure of their flock, to ensure a greater proportion of older ewes.

Lamb weaning weight

Few studies appear to have examined the impact of ewe nutrition in pregnancy on triplet lamb weaning weight. Those which have used unrestricted herbage conditions in lactation, likely impacting on the result observed from pregnancy nutrition. These studies have either reported no effect (Morris and Kenyon 2004; Kenyon et al. 2011b, 2013) or only a minor effect (Corner et al. 2008; Kenyon et al. 2012). Similarly, offering a grain-based concentrate supplement in late pregnancy, had either no (Kenyon et al. 2010b; Kerslake et al. 2010b) or a minor positive effect (Kerslake et al. 2009) on weaning weight. In these studies, herbage intake was not restricted. Combined these studies suggest that if a ewe can be offered unrestricted grazing conditions in lactation there are likely minimal impacts on the weight of their lamb at weaning, regardless of the feeding conditions the ewe experienced in pregnancy. However, the impacts of pregnancy nutrition when ewe intake in lactation is restricted appears to not have been investigated and should be.

Roy et al. (1999) reported that offering a higher crude protein supplement in both late pregnancy and in lactation to ewes offered unrestricted brome grass silage increased lamb live weight in mid-to late-lactation. While Davies and Gallo (1988) found that offering higher levels of protein in a complete diet, under unrestricted feeding conditions in lactation, increased lamb growth to weaning. Combined these studies suggest there may be an opportunity to utilise supplementation in lactation to increase triplet lamb weaning weight, although the economics of such practices need to be examined and the nutritional levels required to get an effect characterised.

It appears few studies have examined the potential of alternative herbages to increase weaning weight. A herb clover mix in comparison to a ryegrass based sward has been shown to increase weaning weights although the results have been inconsistent (Kenyon et al. 2010a, Hutton et al. 2011) making clear conclusions difficult. In the review of Kenyon et al. (2014) ewe body condition score was found to have either a positive influence or no effect on lamb weaning weight, with the likelihood of an effect likely being influenced by ewe nutrition and the body condition score. In the few studies that have examined the effect of ewe body condition score (range 2.0–3.5) in triplets, inconsistent effects have been observed (Kenyon et al. 2011a, 2012, 2013), but again in these studies herbage intake was not restricted in very late pregnancy and lactation. Further studies are required over a greater range of body condition scores and which includes restricted herbage in late pregnancy and/or lactation before clear conclusions can be drawn. There would also be benefits from examining the impacts of a greater range of alternative herbages in lactation.

Orr et al. (1979) reported that triplet birthweight was positively related to weaning weight and growth within a set. Further, they suggested that milk intake within a set is driven by birth weight. Therefore interventions that positively affect either birth weight or ewe milk production, or both (as discussed earlier), should have a positive impact on the weight of triplet lambs at weaning and would be of interest to farmers.

Milk production of triplet-rearing ewes can limit triplet lamb weaning weight. A potential approach to alleviate this constraint is creep feeding. Creep feeding allows lambs access to either a grain-based supplement or a high-quality herbage (also terms creep grazing), in addition to the herbage they are grazing with their dams but prevents their dam's access to it. Lambs start nibbling and consuming solid feed from as early as a week of age (Janssens and Ternouth 1987; Danso et al. 2014) and therefore creep feeding can begin relatively early in the lactation period. A number of studies have shown that creep feeding with either a high-quality herbage or a grain-based supplement can increase lamb growth to weaning (De Villiers et al. 2002; Moss et al. 2009; Terblanche et al. 2012; Brand and Brundyn 2015). The economics of this approach and the development of management practices to make this feasible with triplets under extensive grazing conditions warrants further investigation. Further advantages of creep feeding include the advancement of rumen development in the lamb (Ward 2008) and the potential to increase ewe live weight at weaning through reduced lactational demand (De Villiers et al. 2002; Terblanche et al. 2012).

Early weaning of lambs onto a high-quality herbage is another potential means to alleviate the constraint of proportionally less milk being produced by the triplet-bearing ewe and removing grazing competition between the lamb and its dam. Recently it has been shown that twin lambs weaned at a minimum of 16 kg, at approximately eight weeks of age, onto a herb clover mix can grow at the same rate or faster than those left on their dams on a ryegrass based sward to a conventional weaning age, of approximately 100 days (Ekanayake et al. 2017, 2019; Corner-Thomas et al. 2019). Early weaning also allows more time for the ewe to gain live weight and condition before rebreeding, which can be an issue for triplet ewes.

Ewe live weight and body condition

The impacts of nutrition during pregnancy and lactation on ewe live weight and body condition have been well characterised for both singleton and twin-bearing/rearing ewes. However, relatively few studies have examined the impacts of nutrition on triplet ewe bearing/rearing ewes. A series of studies using ryegrass-based pastures have shown that offering minimum pasture sward heights of 2 cm at different stages in pregnancy reduces ewe live weight, body condition score and back fat depth in comparison to minimum sward heights of 4 cm (Morris and Kenyon 2004; Corner et al. 2008; Kenyon et al. 2011a, 2011b, 2012, 2013). Morris and Kenyon (2004) reported no further improvement of ewe performance above a 4 cm sward height. It was also observed across these studies that if sward heights were a minimum of 4 cm in very late pregnancy and/or in lactation any negative impacts on ewe live weight or body condition from poorer feeding conditions earlier in pregnancy were no longer present at weaning. Based on the studies it is recommended for both the benefit of the ewe and her lambs that triplet-bearing ewes are offered a minimum of 4 cm sward heights on a ryegrass based sward in the last two weeks of pregnancy and in lactation, with heights not being lower than 2 cm earlier in pregnancy. There appears to be a lack of studies examining the impact on ewe live weight and body condition from offering restricted feeding levels in lactation.

Due to the potential for rumen restriction limiting intake in late pregnancy, a number of studies have examined the potential use of grain-based supplements in addition to herbage grazed in late pregnancy. Offering supplementation either under unrestricted ryegrass based feeding conditions or when fed silage, has been found to increase ewe live weight (Kerslake et al. 2009, 2010b) although not in all studies (Petit 1997; Roy et al. 1999; Kenyon et al. 2010b). Even in those studies where supplementation had a positive impact on ewe live weight in late pregnancy, any effect was not apparent at weaning, under unrestricted feeding conditions in lactation. However, again there appears to be a lack of information on the effect on ewe live weight and body condition of offering supplements to ewes under restricted feeding conditions in either pregnancy or lactation. It would be expected that such practise could have positive effects and warrant investigation.

Herb clover mixes have greater herbage quality than a ryegrass-based sward (Cranston et al. 2015) and therefore it is not surprising that offering these in very late pregnancy and during lactation can increase ewe live weight and body condition score at weaning (Kenyon et al. 2010; Hutton et al. 2011). There appears to be a lack of information on the effect of other alternative herbages in either pregnancy or lactation on the performance of triplet-bearing ewes. These warrant investigation.

Conclusion

In comparison to its twin counterpart the triplet lamb is more challenged at birth, or soon after, resulting in lower survival rates and weaning weights. Before clear guidelines can be developed for the management of triplets bearing/rearing ewes and their lambs additional research is required. Future studies need to examine the impacts on both the ewe and her lambs of varying feeding regimens in both pregnancy and lactation, across the body condition score range. In addition, knowledge of the impacts of shelter and other paddock factors, stocking rate, mob size, and human intervention is required. Future studies must be large enough in size to allow for the evaluation of lamb survival and should present the impacts of the various interventions on litter birth weight variation.

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