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Investigating the role of stocking rate and prolificacy potential on profitability of grass based sheep production systems

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ABSTRACT

The objective of this study was to simulate and compare the profitability of a grass based sheep production system under three stocking rates and two prolificacy rates. Analysis was conducted using the Teagasc Lamb Production Model (TLPM), a stochastic budgetary simulation model of a sheep farm. Experimental data from the Teagasc Athenry Research Demonstration Flock was used to parameterise the model at three stocking rates (10, 12 and 14 ewes/ha) and two prolificacy potentials (1.5 and 1.8 lambs weaned per ewe joined to the ram). The TLPM assessed the performance of the key factors affecting profitability and was also used to evaluate the spread in profitability associated with some stochastic variables included in the analysis. The number of lambs weaned per hectare increased with stocking rate and prolificacy potential from 16 lambs/ha to 27 lambs/ha resulting in carcass weight produced per hectare ranging from 272 kg/ha to 474 kg/ha. Increasing stocking rates resulted in lower individual lamb performance from grass and milk, thereby increasing the proportion of lambs which required concentrate for finishing, which resulted in higher input costs on a per animal basis. As the number of lambs weaned per hectare increased, net profit increased from €361/ha to €802/ha. Across all stocking rates, increasing weaning rate from 1.5 to 1.8 lambs weaned per ewe joined increased net profit, on average, by €336/ha. Increasing stocking rate, at 1.5 lambs weaned per ewe joined, increased net profit on average by €15/ha while increasing stocking rate, at 1.8 lambs weaned per ewe joined increased net profit on average by €87/ha. Risk analysis showed that across all stocking rates the high prolificacy scenarios achieved greater profits across the variation in input variables. Results from this study indicate that lambs weaned per hectare linked with grass growth and utilisations are the key drivers of profitability on Irish grass based sheep production systems.

1. Introduction

Stocking rate and ewe prolificacy have been described as key drivers of flock productivity and output across both Irish and international sheep systems (Keady and Hanrahan, 2006; Ho et al., 2014), and therefore are key determinants of farm profitability in grass based sheep production systems. Prolificacy, although not as pertinent in beef or dairy systems, has been shown to be of paramount importance in the profitability potential of sheep flocks, with higher numbers of lambs weaned per hectare resulting in higher profit margins (Teagasc, 2016a). Stocking rate has long been described as a key factor in the productivity and profitability of pasture based dairy farms (Macdonald et al., 2008; Mccarthy et al., 2011). Previous studies have shown that increased stocking rate increases total pasture production, quality and utilisation, as well as, increasing output per unit area across beef, sheep and dairy enterprises, however, individual animal performance generally reduces (Conway, 1963; Drennan, 1971; Mccarthy et al., 2011). Current national figures for Irish sheep flocks show that the average lowland stocking rate and prolificacy potentials are 7.4 ewes/ha and 1.3 lambs weaned per ewe joined to the ram, respectively (Teagasc, 2016b). In comparison to international estimates for the UK (18.3 lambs weaned per hectare) and New Zealand (12.7 lambs weaned per hectare) (Connolly, 1999), Ireland's average number of lambs weaned per hectare (9.6) remains low, indicating that there is potential scope for improvements in this key performance indicator. Previous studies have assessed the effect of stocking rate and ewe prolificacy on ewe and lamb performance, lamb output (Earle et al., 2016) and on total flock performance (Earle et al., 2017) in grass based sheep production systems, but the economic performance of such systems have not been quantified to date.

The objective of this paper therefore was to assess the profitability of Irish grass based sheep production across three stocking rates and

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two prolificacy potentials using experimental data as outlined by (Earle et al., 2016, 2017). Risk analysis was also conducted to assess the profitability of alternating stocking rate and prolificacy potential by varying levels of key input parameters.

2. Materials and methods

2.1. Bio-economic model

The Teagasc Lamb Production Model (TLPM) is a bio-economic computer simulation model that simulates a sheep production system using specific inputs to derive physical and financial outputs (Bohan et al., 2016). The model can be used to assess the effects of institutional, technical or environmental changes on the systems physical and financial outputs. The model integrates animal inventory and valuation, lamb drafting, feed requirements, land and labour utilisation and economic analysis. The TLPM simulates a 12 month cycle of a farm with the production year beginning at mating and is driven by the net energy requirement of the flock for maintenance, growth, body condition change, pregnancy and lactation (O'Mara, 1996). To meet the net energy requirement of the flock the TLPM calculates the flock energy requirement and creates a feed budget of grass, grass silage and concentrate depending on time of year and stage of production. Key model outputs include: farm cash flow, profit and loss and balance sheet, feed supply and demand, livestock trading schedule and physical ratios. The stochastic nature of the TLPM allows risk analysis to be conducted on varying modelled scenarios.

2.2. Stocking rate and prolificacy potential scenarios

Six stocking rate and prolificacy potential scenarios were investigated in the current study (Table 1) using data obtained from the Sheep Research Demonstration Flock, Teagasc, Animal and Grassland Research Centre, Mellows Campus, Athenry, Co Galway, Ireland (54° 80'; N; 7°25' W), from the production years 2013–2015, inclusive (Earle et al., 2016, 2017). The experimental design and flock management are described in detail elsewhere (Earle et al., 2017), but in summary the study was a 2 × 3 factorial design, consisting of two differing ewe prolificacy potentials (medium prolificacy − 1.5 lambs weaned per ewe joined and high prolificacy − 1.8 lambs weaned per ewe joined), which were assigned to one of three stocking rates 10, 12 or 14 ewes/ha. Detailed information on key performance indicators such as mortality, lamb growth rates and grass utilisation were available on each of the six scenarios investigated (Table 2; Earle et al., 2016, Earle et al., 2017). All scenarios were simulated on a 20 ha farm and the key input variables for each scenario are outlined below and are summarised in Table 1. Grass growth and utilisation was increased in line with flock energy requirements when stocking rate and ewe prolificacy increased, as outlined below and in Table 2.

Table 1
Model input assumptions for each scenario included in the Teagasc Lamb Production Model (TLPM).

Scenario[a]	1	2	3	4	5	6
Farm size (ha)	20	20	20	20	20	20
Ewes joined to the ram	213	256	294	215	259	299
Stocking rate (ewes/ha)	10	12	14	10	12	14
Scanning rate (lambs/ewe)	1.70	1.72	1.80	2.16	2.09	2.11
Weaning rate (lambs/ewe)	1.50	1.50	1.50	1.80	1.80	1.80
Nitrogen use (kg/ha)	113	145	181	113	145	181

[a] Scenario 1 = 10 ewes/ha, weaning 1.5 lambs per ewe joined, scenario 2 = 12 ewes/ha, weaning 1.5 lambs per ewe joined, scenario 3 = 14 ewes/ha, weaning 1.5 lambs per ewe joined, scenario 4 = 10 ewes/ha, weaning 1.8 lambs per ewe joined, scenario 5 = 12 ewes/ha, weaning 1.8 lambs per ewe joined, scenario 6 = 14 ewes/ha, weaning 1.8 lambs per ewe joined.

Table 2
Comparison of physical details for each scenario including animal numbers, animal performance, feed and labour requirements.

Scenario[a]	1	2	3	4	5	6
Ewes joined to the ram[b]	213	256	294	215	259	299
Lamb mortality (%)[b]	12.64	13.38	17.82	17.67	14.56	15.67
Weaning weight[b]	31.53	32.56	31.34	31.58	28.73	30.47
Lambs weaned	320	385	440	387	468	538
Lambs weaned/ha	16	19	22	19	23	27
Lambs sold/ha	14	17	20	17	20	24
Total carcass sold (kg/ha)	272	327	393	341	403	474
Drafted by October 1st (%)	75	55	47	63	68	50
Total concentrates/ha	456	613	813	552	664	888
Grass Grown (t DM/ha)[b]	10.07	11.61	12.79	11.56	13.01	14.37
Grass utilised (t DM/ha)[b]	8.06	9.87	11.51	9.25	11.07	12.94
Total labour requirement (h)	1201	1442	1681	1201	1442	1683
Total Hired labour (h)	11	74	135	12	74	136

[a] Scenario 1 = 10 ewes/ha, weaning 1.5 lambs per ewe joined, scenario 2 = 12 ewes/ha, weaning 1.5 lambs per ewe joined, scenario 3 = 14 ewes/ha, weaning 1.5 lambs per ewe joined, scenario 4 = 10 ewes/ha, weaning 1.8 lambs per ewe joined, scenario 5 = 12 ewes/ha, weaning 1.8 lambs per ewe joined, scenario 6 = 14 ewes/ha, weaning 1.8 lambs per ewe joined (Earle et al., 2016, 2017).

[b] Modelled assumptions based on data provided from Earle et al., (2016, 2017).

2.2.1. Scenario 1: low stocking rate - low prolificacy

The first scenario (scenario 1) had an average stocking rate of 10 ewes/ha across the year, which required 213 ewes to be joined to the ram at mating. The low prolificacy potential ewes (1.5 lambs weaned per ewe joined) were dictated by sire breed and were Suffolk crossbred ewes and had average live weight of 80.8 kg at mating. The pregnancy scan rate achieved in this scenario was 1.7 lambs per ewe joined to the ram, which after accounting for lamb mortality equated to 1.5 lambs weaned per ewe joined. Total lamb mortality (pregnancy scanning to sale) was 12.6%. The average lamb birth weight was 5.2 kg; average lamb weaning weight for the scenario was 31.5 kg. Lamb drafting commenced in June and ceased in January, with 75% of the lambs slaughtered by October 1st off a grass only diet. Ewe replacement rate was 18.2%, which consisted of 6.4% mortality and 11.8% culling; this resulted in the retention of 38 ewe lambs for replacement. The average annual grass growth was 10,071 kg dry matter (DM)/ha and 8063 kg DM/ha (80%) was utilised.

2.2.2. Scenario 2: medium stocking rate - low prolificacy

The stocking rate in scenario 2 was on average 12 ewes/ha across the production year, which equated to the mating of 256 ewes. The low prolificacy potential (1.5 lambs weaned per ewe joined to the ram) was represented by Suffolk crossbred ewes, with an average live weight of 77.9 kg at mating. The pregnancy scan rate achieved in scenario 2 was 1.7 lambs per ewe joined to the ram, which after lamb mortality equated to 1.5 lambs weaned per ewe joined. Total lamb mortality (pregnancy scanning to sale) was 13.4%. The average lamb birth weight was 5.1 kg; average lamb weaning weight for scenario 2 was 32.6 kg. Lamb drafting commenced in June and ended in January, with 55% of the lambs slaughtered by October 1st off a grass only diet. Ewe replacement rate was 19.3% which resulted in the retention of 49 ewe lambs for replacement purposes. The 19.3% replacement rate consisted of 5.9% mortality and 13.4% culling. Grass growth for scenario 2 was 11,606 kg DM/ha and grass utilisation was 9872 kg DM/ha (85%).

2.2.3. Scenario 3: high stocking rate - low prolificacy

Scenario 3 had an average stocking rate across the production year of 14 ewes/ha which resulted in the mating of 294 ewes. The low prolificacy potential (1.5 lambs weaned per ewe joined to the ram) Suffolk crossbred ewes had an average live weight of 79.7 kg at mating. The pregnancy scan rate for scenario 3 was 1.8 lambs per ewe joined to the ram, which after accounting for lamb mortality equated to 1.5 lambs weaned per ewe joined. Total lamb mortality (pregnancy