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ORIGINAL ARTICLE

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Vicia sativa as a grazed forage for lactating ewes in a temperate grassland production system

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Abstract
Here, we present research to overcome a current limitation of temperate grassland systems to provide home-grown, early season protein for lactating ewes—a period of high protein demand in these systems. Traditionally used as a forage crop, there is renewed interest in common vetch (*Vicia sativa*) due to its ability to grow during low temperatures over-winter compared to other legumes. We hypothesised that vetch would support the sustainable development of lamb production by reducing reliance on purchased protein typically used in grass-only systems. A grazing study determined the performance of early lactation ewes and their twin lambs grazing either an Italian ryegrass (IRG) sward or a vetch/IRG (V/IRG) mix over a six-week period. The experiment comprised replicate plots of two treatments, with 8 ewes, each rearing twin lambs, grazing each plot. Plots were divided into sub-plots using electric fencing and rotationally grazed. Findings showed i) ewes selectively grazed vetch as evidenced by a drop in vetch percentage by, on average, 10% units between the start and end of grazing; ii) vetch re-grew when rotationally grazed with a 21– 28-d rest period, with vetch percentage of the sward increasing 10% units; and iii) grazing lactating ewes on V/IRG improved combined ewe and lamb weights by five weeks post-lambing but longer term effects were limited by vetch availability. Furthermore, there was a tendency for lamb live-weight gains to be higher for lambs whose dams grazed on vetch/IRG compared to IRG swards (573 versus 563 g ewe^{-1} d^{-1}, respectively, $p = 0.056$). As the need for alternatives to imported protein feed increases, this research demonstrates how vegetative common vetch, as part of a mixed sward, has the potential to provide a home-produced winter-grown protein feed in temperate grasslands.

KEYWORDS
common vetch, grazing, high protein forages, ovine, ruminant, sustainable intensification

1 | INTRODUCTION

Livestock production systems provide one third of the protein consumed by humans, and demand for animal products is rising globally due to increased meat consumption per capita and population growth (Vranken et al., 2014). Approximately 86% of global livestock feed intake consists of feed materials that are non-edible for humans (Mottet et al., 2017), thus producing protein for human consumption without necessarily competing for feed resources. However, globally in livestock systems, there is an over-reliance on soya, an imported protein feed which is in direct opposition to sustainability and environmental protection. For ease of management, temperate farming systems have tended to focus on grass-only monocultures supported with concentrate feedstuffs and artificial N fertiliser to maintain economically viable ryegrass yields. As such, sheep farmers often rely on purchasing protein feed to deliver essential nutrients to livestock including during winter to early spring to meet the nutritional requirements of lactating ewes for milk production. Insufficient nutrition is detrimental for animal health, welfare and productivity. Inadequate feeding during embryonic, foetal and early postnatal growth can harm the near-term and future performance of adult animals (Bell & Greenwood, 2016). In sheep farming, post-lambing, the growth of the lamb is highly dependent on the mother's milk for a period of six weeks. The ewe can compensate for the increased demand for milk production to an extent, but a certain amount of body fat also needs to be mobilised, especially in twin and triplet-suckling ewes. Lactation can result in a 70% increase in demand for energy for a ewe suckling twins (Castro et al., 2012). Meeting this seasonal nutritional gap is possible with supplemental feeding but makes these systems highly vulnerable to changes in global market prices and supply chains (Galko & Jayet, 2011).

To improve food security, there is an urgent need to build a global food system that is impervious to market shocks. This was exemplified most recently by the impact of the COVID-19 pandemic which resulted in a rise of 43% in soya bean prices compared to the same period one year prior to the pandemic (Maluleke, 2020), due to delayed harvests and heightened global demand from increasing livestock production in Asia. For example, whilst China is one of the top ten producers of soya, it is the largest consumer, responsible for 60% of global imports (FAOSTAT, 2021). Whilst oilseed production has increased in some temperate regions, there is now increasing demand for this resource for biofuel, risking its viability as an animal feed (Gradziuk et al., 2021). In Europe, 70% of protein feed supplements are imported from outside the region (Reckling et al., 2016) and the area under harvest of leguminous crops has declined from over 50k ha in 1961 to under 30k ha in 2018 (FAOSTAT, 2020). However, increasing focus on the biodiversity and sustainability of farming ecosystems (Hart et al., 2016; Hughes et al., 2008; Verwimp et al., 2018) and increasing consumer demands for improved food quality have awakened new opportunities for more sustainable and economically viable grassland-based systems for ruminant livestock production (Reckling et al., 2016). It is increasingly recognised that mixed grassland systems are key providers of essential ecosystem services worldwide: linking human well-being to farmed animal systems for their role as provisioning (food, drinking water), regulating (climate, disease), cultural (recreation, aesthetics) and supporting (soil formation, biodiversity) services (Bengtsson et al., 2019).

FIGURE 1 Common Vetch (*Vicia sativa*) as a grazing forage for ewes in early lactation

Common vetch (*Vicia sativa*) (Figure 1) is a globally economically important forage and green mature crop (Mikic et al., 2009) and a rich source of protein, fatty acids and minerals (Akpinar & Akpinar, 2001; Mao et al., 2015; Renna et al., 2014) for livestock (Kaya et al., 2013) and humans (Akpinar & Akpinar, 2001; Francis et al., 2000). As we adapt to climate change, there is renewed interest in the value of common vetch as a forage crop for marginal land, as a drought and cold-tolerant leguminous crop, with research highlighting its potential to protect soil by providing cover in Australia (Ghahramani et al., 2020), as part of a cropping system on the Loess Plateau of China (Wang et al., 2020) and as a means to increase agricultural diversity in Southern Tibet (Brown et al., 2019).

To date, there have been no specific common vetch varieties bred for commercial use in pasture-based ruminant systems. Research investigating the integration into low-input farming systems of common vetch cultivars bred under high-input conditions has showed considerable potential (Vlachostergios et al., 2011) and indicated that common vetch can also be an economically viable alternative to alfalfa when presented as a hay-based protein substitute to ewes (Greveniotis et al., 2019). Typically, grass-based swards require the regular application of N-based fertilisers or manure to provide key soil nutrients to meet demands essential for viable forage and, thus, ruminant production. As a legume, common vetch has the ability to fix nitrogen if either its seeds are inoculated with a suitable rhizobium strain, or it has been previously sown in the same field (Sattell et al., 1998), thereby potentially reducing reliance on external inorganic N sources. Despite this, although, common vetch is a plant with a historical association in the UK landscape (Campbell, 1988), it is not in widespread use as a livestock fodder here or in other temperate grasslands. Anecdotally, this is potentially due to some reports of a risk of gorging, colic and other stomach disorders or bloat, as seen with other legumes if ruminants are grazed on swards with a high legume content after a period of feed withdrawal (Colvin & Backus, 1988). Common vetch has been implicated in numerous cases of poisoning in humans and animals, particularly monogastrics (Tate et al., 1999). This is due to presence of γ-glutamyl-β-cyano-alanine (GBCA) toxin in the seed pods which has hindered common vetch's use in agriculture (Ressler et al., 1997), although this may be avoided by maintaining vetch in a vegetative state through regular grazing or conservation of the forage prior to seed setting. Recent research on the development of a zero-toxin vetch variety may further propelled the value of this often overlooked grain legume as a home-grown source of protein for both human and animal food (Nguyen et al., 2020), which could then also be managed to self-regenerate.

There are a range of diverse home-grown protein forages available for use within multi-species grassland systems, including red clover (*Trifolium pratense*), white clover (*Trifolium repens*) and chicory (*Cichorium intybus*). These forages provide a real opportunity as alternative, traceable and low-cost sources of high-quality nutrients for ruminant livestock, with the feeding these forages to ruminants proven to improve feed intake, improving feed conversion efficiency and increasing productivity in sheep when compared with feeding equivalent ryegrass forage only (Scales et al., 1994; Marley et al., 2007). Yet, the winter period in temperate climates is the most difficult time to produce a home-grown forage protein source, as most of these high protein forage crops require a rest period due to winter dormancy so as not to affect growth in the subsequent season (Lockhart et al., 1969). Therefore, in colder months, farmers rely heavily on purchased high protein animal feeds (Cherney et al., 2020; Johnston, 2020) for pregnant ewes.

With the increasing socio-political drive towards more sustainable farming systems, the time is right to re-assess alternative crops with the potential to meet localised farming demands. Common vetch is a plant with a long history in agroecosystems and one that may be suitable to meet the new regulatory, environmental and economic pressures facing livestock farmers. This study investigates a potential role for common vetch as a primary pasture legume for use in temperate, forage-based sheep farming systems. The specific objective was to investigate the effects of common vetch, grown over the winter period, on the performance of grazing ewes and their twin lambs in early lactation. We hypothesised that providing common vetch as a forage protein to grazing ewes post-lambing would improve livestock productivity compared to grass-only swards.

2 | MATERIALS AND METHODS

2.1 | Experimental site and design

The experiment was conducted at the Institute of Biological, Environmental and Rural Sciences (IBERS), Aberystwyth University, Wales, UK (Grid reference: 52.421443, −4.057058). Soil temperatures are typical of a temperate European climate in this area of the UK with the 50 year average ranging from 3.8º C in winter to 16.8º C in summer. The experimental design comprised two forage treatments: a common vetch (*V. sativa*) / Italian ryegrass (*Lolium multiflorum*) mix compared to an Italian ryegrass only (control) treatment. Triplicate experimental plots (approx. 0.8 ha each) were sown of each treatment in a completely randomised layout. However, only two replicate plots of each treatment were used for the experiment as flooding in a third replicate plot of vetch early in the season restricted growth prior to the start of the grazing. One IRG plot, selected at random, was also removed to rebalance the experimental design.

2.2 | Forages

Experimental plots (approx. 0.8 ha each) were sown on 19 September 2014. The vetch/ (cv. Slovena) / Italian ryegrass (cv. Dorike) mix (Vetch/IRG) was sown at a rate of 24.7 and 24.7 kg ha^{-1} respectively (i.e. a 50:50 mix by weight). The control Italian ryegrass (cv. Dorike) (IRG) was sown at a rate of 34.6 kg ha^{-1}. Prior to sowing, ground limestone was applied at 2.5 t ha^{-1} to achieve an optimal soil pH of 6.5 and compound fertiliser was applied as P_2O_5 and K_2O, both at a rate of 90 kg ha^{-1}, to maintain soil phosphate and potash indices of 2+ (DEFRA, 2007).

All seed was sown using a Duncan seed drill (Duncan Ag, Timaru, NZ), cross-drilled to avoid competition between the two forage species. Ryegrass seed was sown on all plots at 24.7kg ha^{-1} in one direction, with the remaining 9.9 kg ha^{-1} on the IRG plots sown at right angles to the first sowing line. On the Vetch/IRG plots, vetch seed was sown at 24.7 kg ha^{-1} at right angles to the first sowing of ryegrass. Vetch seed was direct drilled to a maximum depth of 20 - 30mm, and bird scarers deployed to reduce bird damage.

A rotational cutting plan was implemented to prepare the plots ahead of the grazing experiment. Four weeks prior to the start of grazing (16 March 2015), each plot was divided into four sub-plots (A-D) using electric sheep fencing and a rotation grazing system set up by cutting one sub-plot within plot on a weekly basis. Throughout the experiment, forages were maintained in a vegetative state by grazing rotationally across each plot using electric fencing and back-fenced weekly to allow regrowth. The grazing experimental period lasted 42 days (23 April to 4 June 2015) during which the post-lambing performance of the ewes was monitored. Each of the four sub-plots was grazed twice during the 42-d grazing period, whereby between Days 0 and 28, sub-plots A-D were sequentially grazed for 7 days and then between Days 29 and 35, sub-plots A and B were combined and grazed for 7 days and between Days 36 and 42, sub-plots C and D were combined and grazed for the final 7 days of the experiment.

2.3 | Animals and management

Mule ewes (n = 114) (Blue-faced Leicester x Welsh Mountain) from the same flock were placed with Texel rams (17 November 2014) in 3 groups (38 ewes $group^{-1}$), with ewes balanced according to age. All ewes were housed three weeks prior to lambing (23 March 2015) and fed according to scanning results. Lambing commenced 12 April 2015. All twin-rearing ewes were moved outdoors 24 h post-lambing and grazed as one group on a standard grass pasture, and all offered purchased ewe concentrate (18% crude protein and containing soyabean meal, rapeseed meal and palm kernel as the protein source) at 400 g $head^{-1}$ d^{-1}. From this cohort, ewes (n = 32) and their twin lambs were allocated to their respective treatment within 72h on the basis of lambing date, ram group at mating and lamb birth weight and gender respectively. Further consideration was given to ewe live weight, ewe condition score and ewe age. Any ewes rearing fostered lambs were not used in the experiment. On Day 0, eight ewes, each rearing twin lambs, were placed on each replicate experimental plot. During the grazing experiment, ewes did not receive concentrates, in accordance with standard farm practice where sward height is above 4 cm and had free access to a magnesium lick (Mag Rich Rockies Ltd., Winsford, UK).

Ewes were vaccinated against clostridia and pasteurellosis (Heptavac P Plus, MSD Animal Health UK Ltd, Milton Keynes, UK) on 12 March 2015. All ewes received anthelmintics prior to turn out post-lambing (Cydectin, Zoetis, Tadworth, UK). All lambs were treated with a coccidiostat (Vecoxan, Elanco, Basingstoke, UK) and anthelmintics at 5 weeks of age. An anthelmintic drench was given on a regular basis to all lambs according to standard farm practice.

2.4 | Forage measurements

Forage biomass was determined from four 0.5 x 1 m quadrats, cut to ground level using a hedge trimmer, within each sub-plot at the start and end of grazing each week. The fresh weight of each sample was determined, and a sub-sample taken to determine dry matter (DM) content. A second sub-sample was taken and bulked on a sub-plot basis. This material was thoroughly mixed and then sub-sampled for botanical separations. The forage was separated into sown ryegrass, common vetch, weed grasses and broadleaf weeds. The separated material was dried, and the composition of the sward expressed on a DM basis. A second sub-sample of the bulked material from each sub-plot was freeze-dried and milled through a 1-mm screen prior to chemical analysis.

The DM content of the forage was determined by drying to constant weight at 80 ºC in a forced-draught oven for 18 h. Ash was measured by igniting samples in a muffle furnace at 550°C for 16 h. Concentrations of WSC were determined spectrophotometrically using anthrone in sulphuric acid on a Technicon Autoanalyser (Thomas, 1977). Total nitrogen (TN) concentrations were determined using a Leco FP 428 nitrogen analyser (Leco Corporation, St. Joseph, MI, US) and expressed as crude protein (CP; TN × 6.25). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) analyses were carried out according to the method of (Van Soest et al. 1991). *In vitro* Digestible Organic Matter in the total Dry matter (DOMD) was predicted by the pepsin cellulase method (Jones & Hayward, 1975).

2.5 | Animal performance

Ewes were weighed, and body condition scored at housing and again at lambing and ewe litter size were also recorded. All ewe and lamb weights were recorded weekly as ewes were moved to new grazing sub-plots. Ewe BCS was monitored for management considerations only (data not shown). Allowing for a 14-d adaptation period to changes in management and diet (Cowan et al., 1980), as ewes transitioned from housing at lambing to pasture post-lambing, the experimental measurement period ran between Day 14 and Day 49 post-lambing.

2.6 | Data processing and analysis

Forage data were analysed by repeated measures ANOVA using GenStat® (Release 19; Baird et al., 2017). Although there were no differences in live weight between the two groups on allocation or at the end of the first week, live-weight changes in the first week on the trial plots were not included since any treatment effects could be confounded by changes in diet and associated changes in gut fill and nutrient balance during the onset of lactation. Ewe and lamb live-weight changes were compared between sward types by one-way ANOVA and were therefore calculated as the difference between live weights measured 14 and 49 days post-lambing, defined as the experimental measurement period. Combined ewe and lamb live-weight data were also compared between swards by repeated measures ANOVA. In all cases, plots were treated as the experimental units.

3 | RESULTS AND DISCUSSION

3.1 | Forage biomass and quality

The mean forage, vetch and IRG biomass and mean chemical composition are shown in Table 1. The biomass data confirmed that forage biomass availability did not differ significantly between treatments throughout the experiment. Mean herbage availability (kg DM ha^{-1}) of the vetch/IRG forage treatment as determined pre- and post-grazing each week is shown in Figure 2 and showed that the vetch availability declined during grazing. Common vetch is reported to have a CP concentration of 22% at flowering, which declines with maturity (Alzueta et al., 2001), as found in other legumes. However, despite the mean CP and NDF concentrations of the vetch/IRG treatment prior to grazing in the current experiment being numerically 12% units higher and 23% units lower than the

TABLE 1 Mean forage, vetch and IRG biomass (kg DM ha^{-1}) and chemical composition of the vetch/Italian ryegrass (Vetch/IRG) mixed sward or the Italian ryegrass (IRG) only sward over the experimental period

		Vetch/IRG	IRG	s.e.d.	Prob
Pre-grazing					
Biomass Availability (kg DM ha^{-1})	Vetch	235	-	-	-
	IRG	1241	1453	51.4	0.054
	Total	1913	1917	37.0	0.914
Forage composition (g kg^{-1} DM)	Dry Matter (g kg^{-1})	211	217	7.9	0.567
	Crude Protein	107	95	4.7	0.131
	WSC	277	271	25.1	0.838
	NDF	438	461	17.2	0.315
	ADF	240	246	8.1	0.502
	Ash	68	70	1.7	0.483
	DOMD	670	660	23.1	0.702
Post-grazing					
Biomass Availability (kg DM ha^{-1})	Vetch	31	-	-	-
	IRG	885	1011	141.2	0.466
	Total	1201	1390	154.8	0.346
Forage composition (g kg^{-1} DM)	Dry Matter (g kg^{-1})	229	239	15.5	0.608
	Crude Protein	87	80	4.4	0.220
	WSC	269	270	16.3	0.939
	NDF	479	503	22.3	0.391
	ADF	260	267	12.4	0.647
	Ash	66	67	1.9	0.714
	DOMD	655	641	12.5	0.384

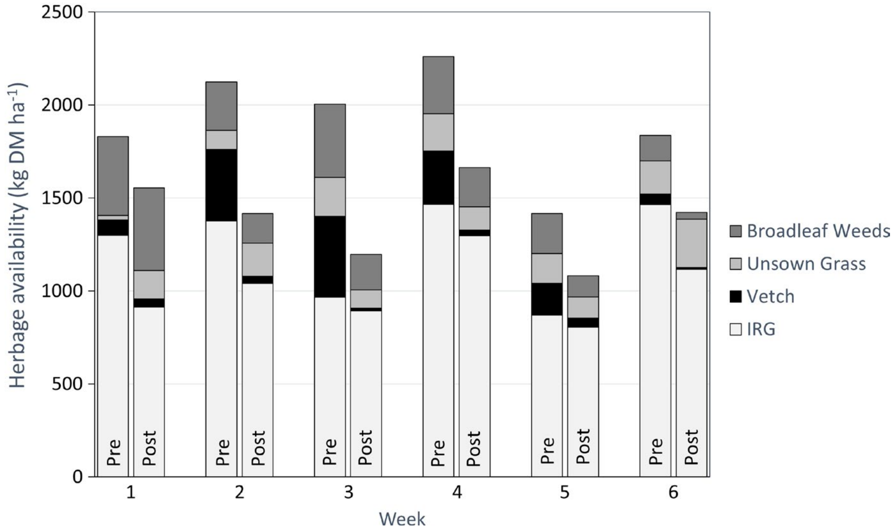

FIGURE 2 Mean herbage availability (kg DM ha^{-1}) of vetch/IRG forage treatment as determined pre- and post-grazing each week throughout the experimental period

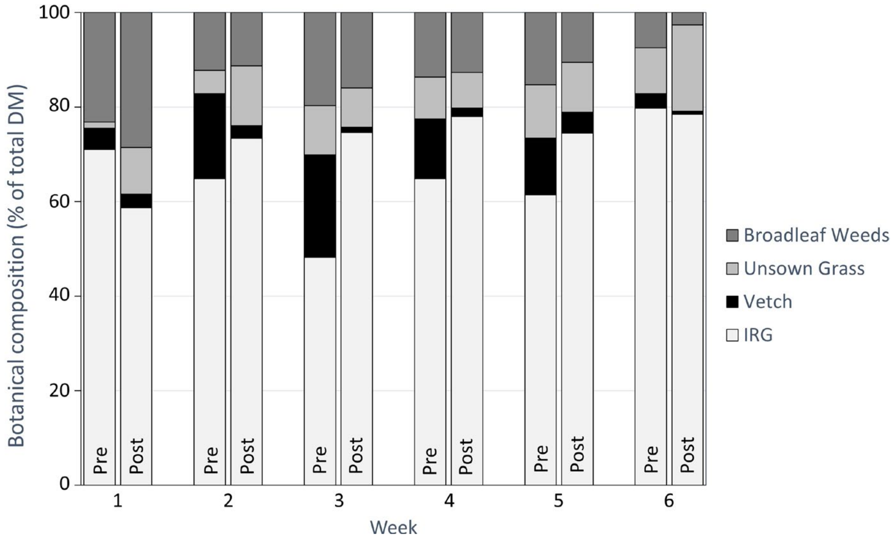

FIGURE 3 Mean botanical composition (as % of total DM) of vetch/IRG forage treatment as determined pre- and post-grazing each week throughout the experimental period

ryegrass control, respectively, there were no statistically significant differences in chemical composition between the forage treatments.

3.2 | Forage biomass and composition

The mean ±sem botanical composition in the IRG (control) sward was 73 ± 1.81% IRG, 14.6 ± 0.56% weed grasses, 12.5 ± 0.53% broadleaf weeds (BLW) and 0.04 ± 0.01% clover. This distribution of species was as expected for an experimental sward with only one grass species sown and confirmed that the control sward was representative of the treatment to be tested. The mean botanical composition of the vetch/IRG treatment pre- and post-grazing is shown in Figure 3. The botanical composition data taken post-grazing confirmed visual observations from the experiment that the sheep preferentially grazed the vetch compared to the ryegrass in this treatment. Data on the percentage of vetch in the sward at the start and end of grazing each week (Table 1) showed that the vetch composition in the sward dropped by, on average, 10% units from an average of 12.2% of the total sward at the start of grazing down to 2.2% at the end of grazing. In other studies, conducted where sheep grazed pure swards of vetch in Armidale, Australia, high stocking rates meant that the recovery of the vetch post-grazing was slow (Spurway et al., 1974). In this current study, at the start of grazing in week 5, sub-plot A and B were combined and had a mean vetch percentage of 12.7%, a 10% unit increase from an average 2.75% vetch found at the end of grazing on Day 7 and Day 14, indicating that the vetch re-grew when rotationally grazed with a rest period of between 21 and 28 days. Furthermore, data from the start of grazing in week 6, where sub-plot C and D were combined, indicated that a period of 7 – 14 days was not sufficient for vetch regrowth when rotationally grazed, reducing the proportion of vetch in the sward and available to the ewes in the final week of grazing. Given the known effects of defoliation on the ability of legumes to fix nitrogen (Butler, 1987) and the use of slurry fertiliser to increase DM yields of frequently harvested legumes (Crotty et al., 2018), further studies are needed to determine the benefits of additional fertiliser to improve vetch recovery and to reduce the time interval required in a rotational grazing system.

3.3 | Animal performance

Lambs gained weight (average 284 g head^{-1} d^{-1}) throughout the experiment on both forage treatments (Figure 4). There was no significant effect of forage treatment on lamb live weight or live-weight gain (573 versus 563 g ewe^{-1} d^{-1}; s.e.d. 8.6) on vetch/IRG or IRG treatments respectively), but there was a tendency for lamb live-weight gains to be higher for lambs whose dams grazed on vetch/IRG compared to IRG swards during the measurement period ($p = 0.056$). Ewe live weight declined post-lambing (by 74 and 98 g ewe^{-1} d^{-1} on the vetch/IRG and IRG treatment respectively), which was within the expected range typically reported for ewes in the first few weeks post-lambing (Cowan et al., 1980) when offered intermediate planes of nutrition in lactation (Corner-Thomas et al., 2015), but there was no significant difference in ewe live weight between forage treatments ($p > 0.05$).

There was no significant difference in the overall mean combined ewe and lamb weight gain between forages (499 v 439 g ewe plus two lambs d^{-1} on vetch/IRG or IRG treatments respectively) ($p = 0.161$). By experimental Day 35, the combined live weight of ewes and their lambs on the Vetch/IRG treatment was higher than that of those

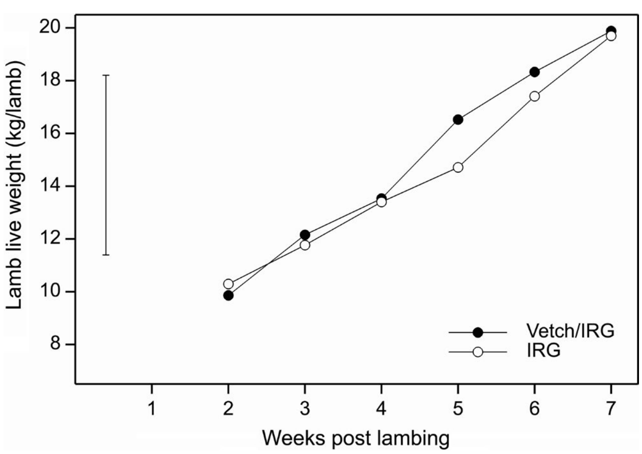

FIGURE 4 Mean live weight of lambs when their dams grazed on either vetch/IRG swards or Italian ryegrass swards for up to 7 weeks post-lambing. Vertical bars represent LSD for comparison between treatments within a time point ($p < 0.05$) and Bonferroni adjustment for multiple comparisons

on the IRG only sward but the effects were not sustained. This was likely due to the key finding that the vetch was selectively grazed and availability was limited due to inadequate recovery when plots with shorter term rotation in the latter stages of the study (Figure 5). This finding suggests that offering common vetch, as part of a mixed sward, has the potential to improve the performance of lactating ewes at grazing but that these benefits required time to become apparent.

Is common vetch a suitable protein forage for use within temperate grassland-based sheep production systems? The design and execution of field-scale livestock experiments presents many challenges, and, in particular, it is noted that the loss of a third experimental replicate in this study due to temporary flooding during sward establishment in this study limited the statistical power given the variances associated with field research. Despite this caveat, this is the first replicated field experiment to study the potential for common vetch to be used as a grazed forage for ewes and their lambs during early lactation and it provides some useful findings of value to industry, to future research on this currently under-valued legume and to the develop of more sustainable ruminant livestock systems. In particular, this study confirmed that there were no deleterious effects of ewes grazing common vetch maintained in a vegetative state, that vetch is preferentially grazed by sheep when offered a choice between this forage and ryegrass and that the vetch re-grew when the grazing interval was between 21 – 28 days under rotational grazing management, all key messages for end-users of this research. Guidance to farmers on vetch use should highlight the need to maintain this forage in a vegetative stage of growth to optimise forage protein concentrations (Alzueta et al., 2001), thereby reducing reliance on imported N fertiliser and feed, and to avoid the risks of anti-nutritional factors which may be present during seed-heading (Ressler et al., 1997).

Further studies are needed to determine the optimal sowing rates and inclusion rate of vetch in a sward to optimise livestock performance, including a range of treatments with replicated treatments of vetch present at different percentages to build on the findings presented here. A higher ratio of vetch to ryegrass may be achieved through differing sowing rates or via different grazing intervals and vetch management before grazing animals are introduced which may again, further reduce reliance on the amount of inorganic N and provide further improvements in animal performance, provided these changes do not result in vetch being present to livestock at the seed pod stage.

Replacing protein in an animal's diet is only half the story: a high protein feed does not reduce the need for high energy supplements. As sustainable farming systems are

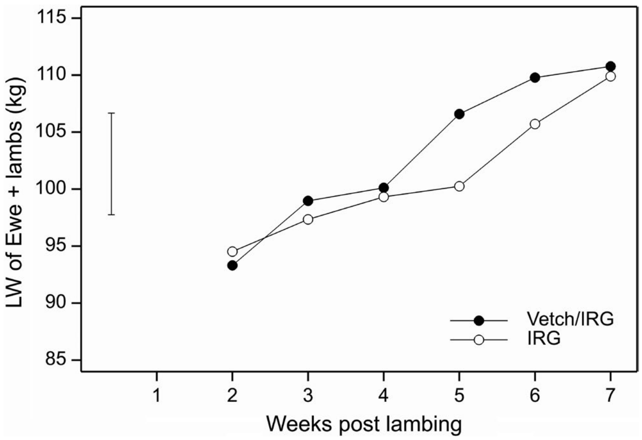

FIGURE 5 Mean combined ewe and lamb live weights when ewes grazed on either vetch/IRG swards or Italian ryegrass swards for up to 7 weeks post-lambing. Vertical bars represent LSD for comparison between treatments within a time point ($p < 0.05$) and Bonferroni adjustment for multiple comparisons

important for the future survival of the farming industry and farmers are facing pressure to diversify, then home-grown protein may prove to be a critical component of any long-term strategy. The economics of the use of vetch as a leguminous forage crop as part of a farming system may be debated (and will continue to be so for years to come), but of the available forage crops, common vetch appears to deserve consideration for wider adoption. It is a native, hardy and tolerant Western European plant and has generally favourable nutritive characteristics and a wide variety of uses. There are still limitations due to gaps in our knowledge that may yet be needed to further overcome any resistance to its use. Finally, it is not insignificant that common vetch can be beautiful. If the rural landscape is more than just a surface for farming but a canvas on which the picturesque (and economically important for tourism) countryside is displayed, then vetch can clearly play its aesthetic part as well as offering value in supporting pollinators and other biodiversity as part of the role of grasslands in providing ecosystem services (Mallinger et al., 2019).

4 | CONCLUSIONS

The study described here demonstrated that common vetch did not have any deleterious effects on grazing sheep; but neither did it consistently confirm the experimental hypothesis that a vetch/IRG mix would improve the performance of ewes and their offspring compared to an IRG only diet. There was only a tendency ($p = 0.056$) for lamb live-weight gains to be higher for lambs whose dams grazed on vetch/IRG compared to IRG swards, and the higher combined ewe and lamb weights on the vetch/IRG treatment was only on Day 35 of the grazing experiment, with no effects of treatment on combined ewe and lamb live-weight gains overall.

Vetch presents a novel solution to help farmers to provide a home-grown, early season protein source forage for lactating ewes, a critical period for protein demand in temperate grassland systems. Findings showed that common vetch was preferentially grazed by ewes but was able to persist when managed using a 21-day rotational grazing system that allowed the vetch to re-grow following grazing. It is important to highlight the vetch was maintained and grazed in a vegetative state, thus mitigating any potential risks from anti-nutritional factors, which may be present during seed-heading. Overall, this research provides new insights into how common vetch has the potential to provide a home-grown winter protein feed for the sustainable development of ovine production systems in temperate regions.

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CONFLICTS OF INTEREST

There are no conflicts of interest to be declared by the authors of this publication.

REFERENCES

Akpinar, N., Ali Akpinar, M., & Türkoğlu, Ş. (2001). Total lipid content and fatty acid composition of the seeds of some *Vicia* L. species. *Food Chemistry*, *74*(4), 449–453. https://doi.org/10.1016/S0308-8146(01)00162-5

Alzueta, C., Caballero, R., Rebole, A., Trevino, J., & Gil, A. (2001). Crude protein fractions in common vetch (*Vicia sativa* L.) fresh forage during pod filling. *Journal of Animal Science*, *79*(9), 2449–2455. https://doi.org/10.2527/2001.7992449x

Baird, D., Murray, D., Payne, R., & Soutar, D. (2017). *Introduction to Genstat® for Windows*™, 19th ed. VSN International.

Bell, A. W., & Greenwood, P. L. (2016). Prenatal origins of postnatal variation in growth, development and productivity of ruminants. *Animal Production Science*, *56*(8), 1217–1232. https://doi.org/10.1071/AN15408

Bengtsson, J., Bullock, J. M., Egoh, B., Everson, C., Everson, T., O'Connor, T., O'Farrell, P. J., Smith, H. G., & Lindborg, R. (2019). Grasslands-more important for ecosystem services than you might think. *Ecosphere*, *10*(2), e02582. https://doi.org/10.1002/ecs2.2582

Brown, C., Yadav, L. P., Zhang, J., & Zhouma, D. (2019). Sustainability of agricultural diversity in the farm households of southern Tibet. *Sustainability*, *11*(20), 5756. https://doi.org/10.3390/su11205756

Butler, J. H. A. (1987). The effect of defoliation on growth and N-2 fixation by *Medicago* sp. grown alone or with ryegrass. *Soil Biology and Biochemistry*, *19*, 273–279. https://doi.org/10.1016/0038-0717(87)90009-5

Campbell, B. (1988). The diffusion of vetches in medieval England. *The Economic History Review*, *41*, 193–208.

Castro, F. A. B. D., Ribeiro, E. L. D. A., Mizubuti, I. Y., Silva, L. D. D. F. D., Barbosa, M. A. A. D. F., Sousa, C. L. D., Paiva, F. H. P. D., & Koritiaki, N. A. (2012). Influence of pre and postnatal energy restriction on the productive performance of ewes and lambs. *Revista Brasileira De Zootecnia*, *41*(4), 951–958. https://doi.org/10.1590/S1516-35982012000400017

Cherney, J. H., Kallenbach, R. L., & Picasso Risso, V. D. (2020). Systems for temperate humid areas. In K.J. Moore, M. Collins, C.J. Nelson & D.D. Redfearn (Eds.), *Forages* (pp. 369–386). Wiley. https://doi.org/10.1002/9781119436669.ch20

Colvin, H. W., & Backus, R. C. (1988). Bloat in sheep (Ovis aries). In *Comparative biochemistry and physiology -- part a: Physiology* (Vol. 91, Issue 4, pp. 635–644). Pergamon. https://doi.org/10.1016/0300-9629(88)90941-3

Corner-Thomas, R. A., Hickson, R. E., Morris, S. T., Back, P. J., Ridler, A. L., Stafford, K. J., & Kenyon, P. R. (2015). Effects of body condition score and nutrition in lactation on twin-bearing ewe and lamb performance to weaning. *New Zealand Journal of Agricultural Research*, *58*(2), 156–169. https://doi.org/10.1080/00288233.2014.987401

Cowan, R. T., Robinson, J. J., McDonald, I., & Smart, R. (1980). Effects of body fatness at lambing and diet in lactation on body tissue loss, feed intake and milk yield of ewes in early lactation. *The Journal of Agricultural Science*, *95*(3), 497–514. https://doi.org/10.1017/S002185960008789X

Crotty, F. V., Fychan, R., Sanderson, R., & Marley, C. L. (2018). Increasing legume forage productivity through slurry application–A way to intensify sustainable agriculture? *Food and Energy Security*, *7*(4), e00144. https://doi.org/10.1002/fes3.144

FAOSTAT (2020). *Food and Agriculture Organization of the United Nation*. Retrieved from: http://www.fao.org/faostat/en/#compare. Accessed August 12, 2020

FAOSTATS (2021). *Food and Agriculture Organization of the United Nation*. Retrieved from: http://www.fao.org/faostat/en/#search/soybeans. Accessed November 12, 2021

Francis, C. M., Enneking, D., & Abd El Moneim, A. M. (2000). *When and where will vetches have an impact as grain legumes?* (pp. 375–384). Springer. https://doi.org/10.1007/978-94-011-4385-1_34

Galko, E., & Jayet, P.-A. (2011). Economic and environmental effects of decoupled agricultural support in the EU. *Agricultural Economics*, *42*(5), 605–618. https://doi.org/10.1111/j.1574-0862.2011.00538.x

Ghahramani, A., Kingwell, R. S., & Maraseni, T. N. (2020). Land use change in Australian mixed crop-livestock systems as a transformative climate change adaptation. *Agricultural Systems*, *180*, 102791. https://doi.org/10.1016/j.agsy.2020.102791

Gradziuk, P., Jończyk, K., Gradziuk, B., Wojciechowska, A., Trocewicz, A., & Wysokiński, M. (2021). An economic assessment of the impact on agriculture of the proposed changes in EU biofuel policy mechanisms. *Energies*, *14*(21), 6982. https://doi.org/10.3390/en14216982

Greveniotis, V., Kantas, D., Deligiannis, C., Gemtos, T., Mavromatis, A., & Sioki, E. (2019). Substituion of soybean meal with local produced legume forages in ewes rations. *AGROFOR International Journal*, *4*(2), 120–126.

Hart, S. P., Schreiber, S. J., & Levine, J. M. (2016). How variation between individuals affects species coexistence. *Ecology Letters*, *19*(8), 825–838. https://doi.org/10.1111/ele.12618

Hughes, A. R., Inouye, B. D., Johnson, M. T. J., Underwood, N., & Vellend, M. (2008). Ecological consequences of genetic diversity. In *Ecology letters* (Vol. *11*, Issue 6, pp. 609–623). John Wiley & Sons, Ltd. https://doi.org/10.1111/j.1461-0248.2008.01179.x

Johnston, D. (2020). *The Role of Higher Protein Forages and Home Grown Protein Sources Within Northern Ireland Dairy Production Systems (Doctoral dissertation, Queen's University Belfast).*

Jones, D. I. H., & Hayward, M. V. (1975). The effect of pepsin pretreatment of forage on the prediction of dry matter digestibility from solubility in fungal cellulase solution. *Journal of Science Food & Agricultural*, *26*, 711–718.

Kaya, A., Yörük, M. A., Esenbuga, N., Temelli, A., & Ekinci, Ö. (2013). Retraction: the effect of raw and processed common vetch seed (*Vicia sativa*) added to diets of laying hens on performance, egg quality, blood parameters and liver histopathology. *The Journal of Poultry Science*, *50*(3), 228–236.

Lockhart, D. A. S., Herriott, J. B. D., Cunningham, J. M. M., & Heddle, R. G. (1969). The effects of winter grazing on subsequent production from pasture. *Grass and Forage Science*, *24*(2), 146–150. https://doi.org/10.1111/j.1365-2494.1969.tb01060.x

Mallinger, R. E., Franco, J. G., Prischmann-Voldseth, D. A., & Prasifka, J. R. (2019). Annual cover crops for managed and wild bees: Optimal plant mixtures depend on pollinator enhancement goals. *Agriculture, Ecosystems & Environment*, *273*, 107–116. https://doi.org/10.1016/j.agee.2018.12.006

Maluleke, I. (2020). The impact of COVID-19 on soya bean markets: markets. *Oilseeds Focus*, *6*(2), 28–29.

Mao, Z., Fu, H., Nan, Z., & Wan, C. (2015). Fatty acid, amino acid, and mineral composition of four common vetch seeds on Qinghai-Tibetan plateau. *Food Chemistry*, *171*, 13–18. https://doi.org/10.1016/j.foodchem.2014.08.090

Marley, C. L., Fraser, M. D., Fisher, W. J., Forbes, A. B., Jones, R., Moorby, J. M., MacRae, J. C., & Theodorou, M. K. (2007). Effects of continuous or rotational grazing of two perennial ryegrass varieties on the chemical composition of the forage and the performance of finishing lambs. *Grass and Forage Science*, *62*(3), 255–264.

Mikic, A., Mihailovic, V., Hauptvogel, P., Cupina, B., Petrovic, M., Krstic, D., Jovicic, D., Milosevic, B., & Hauptvogel, R. (2009). Wild populations of vetches (Vicia) as forage and green manure crops for temperate regions. *Irish Journal of Agricultural and Food Research*, *48*(265).

Mottet, A., de Haan, C., Falcucci, A., Tempio, G., Opio, C., & Gerber, P. (2017). Livestock: On our plates or eating at our table? A new analysis of the feed/food debate. In *Global food security* (Vol. 14, pp. 1–8). Elsevier B.V. https://doi.org/10.1016/j.gfs.2017.01.001

Nguyen, V., Riley, S., Nagel, S., Fisk, I., & Searle, I. R. (2020). Common Vetch: a drought tolerant, high protein neglected leguminous crop with potential as a sustainable food source. *Frontiers in Plant Science*, *11*, 818. https://doi.org/10.3389/fpls.2020.00818

Reckling, M., Bergkvist, G., Watson, C. A., Stoddard, F. L., Zander, P. M., Walker, R. L., Pristeri, A., Toncea, I., & Bachinger, J. (2016). Trade-offs between economic and environmental impacts of introducing legumes into cropping systems. *Frontiers in Plant Science*, *7*, 669. https://doi.org/10.3389/fpls.2016.00669

Renna, M., Gasmi-Boubaker, A., Lussiana, C., Battaglini, L. M., Belfayez, K., & Fortina, R. (2014). Fatty Acid Composition of the Seed Oils of Selected *Vicia* L. Taxa from Tunisia. *Italian*

Journal of Animal Science, *13*(2), 3193. https://doi.org/10.4081/ijas.2014.3193

Ressler, C., Tatake, J. G., Kaizer, E., & Putnam, D. H. (1997). Neurotoxins in a vetch food: Stability to cooking and removal of γ-glutamyl-β-cyanoalanine and β-cyanoalanine and acute toxicity from common vetch (*Vicia sativa* L.) legumes. *Journal of Agricultural and Food Chemistry*, *45*(1), 189–194.

Sattell, R., Dick, R., Luna, J., McGrath, D. M., & Peachey, R. E. (1998). *Common vetch (Vicia sativa L.)*.

Spurway, R. A., Wheeler, J. L., & Hedges, D. A. (1974). Forage and sheep production from oats, rape and vetch sown in autumn with or without nitrogen fertilizer. *Australian Journal of Experimental Agriculture*, *14*(70), 619–628. https://doi.org/10.1071/EA9740619

Tate, M. E., Rathjen, J., Delaere, I., & Enneking, D. (1999). Covert trade in toxic vetch continues. *Nature*, *400*, 207. https://doi.org/10.1038/22198

Thomas, T. A. (1977). An automated procedure for the determination of soluble carbohydrates in forage. *Journal of Science Food & Agricultural*, *28*, 639–642.

Van Soest, P.J., Robertson, J.B., & Lewis, B.A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74*, 3583–3597.

Verwimp, C., Ruttink, T., Muylle, H., Van Glabeke, S., Cnops, G., Quataert, P., Honnay, O., & Roldán-Ruiz, I. (2018). Temporal changes in genetic diversity and forage yield of perennial ryegrass in monoculture and in combination with red clover in swards. *PLoS One*, *13*(11), e0206571. https://doi.org/10.1371/journal.pone.0206571

Vlachostergios, D., Lithourgidis, A., Korkovelos, A., Baxevanos, D., Lazaridou, T., Khah, A., & Mavromatis, A. (2011). Mixing ability of conventionally bred common vetch (*Vicia sativa* L.) cultivars for grain yield under low-input cultivation. *Australian Journal of Crop Science*, *5*, 1588–1594. https://www.researchgate.net/publication/234055581

Vranken, L., Avermaete, T., Petalios, D., & Mathijs, E. (2014). Curbing global meat consumption: Emerging evidence of a second nutrition transition. *Environmental Science and Policy*, *39*, 1–12. https://doi.org/10.1016/j.envsci.2014.02.009

Wang, Z., Jiang, H., & Shen, Y. (2020). Forage production and soil water balance in oat and common vetch sole crops and intercrops cultivated in the summer-autumn fallow season on the Chinese Loess Plateau. *European Journal of Agronomy*, *115*, 126042. https://doi.org/10.1016/j.eja.2020.126042

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