Scotland's Rural College

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Published in:
Small Ruminant Research

DOI:
10.1016/j.smallrumres.2016.03.018

First published: 01/01/2016

Document Version
Peer reviewed version

Accepted Manuscript

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PII: S0921-4488(16)30067-0
DOI: http://dx.doi.org/doi:10.1016/j.smallrumres.2016.03.018
Reference: RUMIN 5183

To appear in: *Small Ruminant Research*

Received date: 4-12-2015
Revised date: 8-2-2016
Accepted date: 17-3-2016

Please cite this article as: MORGAN-DAVIES, Claire, MORGAN-DAVIES, Justin, BEATON, Iain, Jenna, KYLE, WATERHOUSE, Tony, McCRACKEN, Davy, Restocking extensive mountain areas with young ewes *minus* does origin matter?.Small Ruminant Research http://dx.doi.org/10.1016/j.smallrumres.2016.03.018

Restocking extensive mountain areas with young ewes – does origin matter?

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Abstract

Recent renewed drives to maintain farming activities on extensive areas have been encouraged at the EU level, which previously had witnessed a phenomenon of partial abandonment and reduction in flock sizes. Successful restocking with naïve animals from outwith the farm is a challenge, as these animals are not familiar with the landscape and may lack the social interactions and 'hefting' qualities their homebred counterparts develop. This paper presents results from an experiment where young ewes from different origins (homebred and bought-in) were reintroduced onto a mountain range grazing area. Focal animals of both types were monitored using GPS tracking collars over a one year period whilst performance was recorded for the whole flock over a two year period, to gauge whether or not their origin had an influence on ranging behaviour and performance. Although initially the bought-in animals developed their own home range and interacted little with the main flock, after one summer grazing period they appeared to learn from and socially interact with their homebred counterparts, developing a knowledge of the grazing landscape. Despite initial weight change differences, later performance results of the animals were not affected by their origin. Provided that animals are encouraged and given opportunity to socially interact with the main homebred flock, this study indicates that it is feasible to restock extensive farms with animals from different origins.

Keywords: mountain, sheep, GPS, ranging

1. Introduction

European mountain areas have witnessed a phenomenon of agricultural abandonment in the last decade (Bernués et al., 2011; Chatellier and Delattre, 2005; MacDonald et al., 2000; Morgan-Davies et al., 2012). This phenomenon can be explained by several varied reasons; the impact of European agricultural policies (Morgan-Davies et al., 2012; Royal Society of Edinburgh, 2008; SAC Rural Policy Centre, 2008); the impact of disease outbreaks such as the Foot & Mouth disease outbreak in the UK in 2001 (Thompson et al., 2002) but also by social elements linked to the changing expectations from livestock farming lifestyle (Madelrieux and Dedieu, 2008). This period of decline of agricultural activity in the mountain areas has however recently been followed by a relative increase in prices for agricultural products, in particular sheep, leading to a renewed interest into this sector (SAC Rural Policy Centre, 2011). This is most likely due to an increase in lamb prices, better rate exchanges between the Sterling and the Euro, and a tightening of supplies (Quality Meat Scotland, 2013). The latest European agricultural policy, with its proposal of recoupling some support with production in geographically challenged areas is also anticipated to encourage farmers in mountain areas to maintain or increase their level of young animals for replacement (Matthews et al., 2013; Scottish Government, 2015). As a result, in areas where mountain grazing had been underused and where flock sizes had declined dramatically, there is now a drive for reintroducing animals and to increase flock sizes.

Sheep bred in a particular environment are thought to have a unique knowledge of their grazing areas and adhere to a “home range” (Hunter, 1964). This term describes an area of land that the grazing sheep are familiar with. This ‘familiarity’ allows for efficient use of forage and water resources (Provenza and Balph, 1987). In the UK, the process of establishing a home range in mountain sheep is often referred to as “hefting” (Defra, 2008), which is defined as the instinctive nature of extensively managed breeds such as the Scottish Blackface to remain and graze in a relatively small local area (the heft) and to pass on this knowledge of local area to offspring.

Conversely, bought-in animals, unaware of local conditions, may have difficulty in locating areas of good grazing and establishing such home range. This may lead to risks of malnutrition or extreme ranging (Provenza, 1995; Warren and Mysterud, 1993). As such, the performance of homebred sheep has long been considered superior to that of bought-in sheep. Knowledge of the pasture is thought to be passed from ewe to lamb (Defra, 2008; Hunter and Milner, 1963; Lawrence, 1990), so that she shapes food and habitat selection of her offspring and increases their likelihood of survival (Provenza, 1995). In addition, Blakesley and McGrew (1984), as well as Nelson and Mech (1991) found lower rates of predation associated with this familiarity of the land.

Whilst there are considerable drawbacks into introducing naïve animals into an extensive environment, buying-in breeding stock remains one of the most viable options to increase flock size rapidly. Where and how these newly introduced animals will choose to stay and forage is therefore important to determine. A number of studies (Dumont and Petit, 1998; Edwards et al., 1996; Hewitson et al., 2004) have shown the ability of sheep to use spatial memory to enhance their foraging behaviour and determine feeding-sites selection. This becomes essential when resources are sparse with no visual cue available, such as on extensive mountain ground (Dumont and Petit, 1998). Sheep are also extremely social animals and their social behaviour will dictate how they spread across pasture when foraging (Dumont and Boissy, 2000; Sibbald et al., 2005). In some circumstances, social bonds can be as important as food preference in determining diet selection in lambs (Scott et al., 1995). A lack of social interaction between newly introduced animals and existing animals may disrupt the ranging and grazing behaviour of the whole flock.

Warren and Mysterud (1993) monitored the location of newly introduced animals using radio transmitters. However, such devices often present considerable error (Bevan and Hibbins, 2008), which may reduce reliability. More recently, Global Positioning System (GPS) technology has been used to monitor the ranging and locational behaviour of livestock (Asher et al., 2014; Bevan and Hibbins, 2008; Falzon et al., 2013; Taylor et al., 2011; Trotter et al., 2010). GPS tracking collars can be fitted around the neck of most livestock, and can be programmed to record up to 6 location points per minute, with a positional accuracy of approximately 5 metres (Blue Sky Telemetry, 2008). Bevan and Hibbins (2008) successfully utilised GPS technology to determine movements, and consequentially the grazing behaviour of cattle. Likewise, Umstätter et al. (2008) used similar sensors to study sheep grazing behaviour in mountain areas in Scotland. Grazing behaviour obtained from GPS tracking collars can also be used to identify diet selection and diet quality (Umstätter et al., 2009), both of which are major determinants of animal performance. Although the study of a whole flock dynamic would required each and every animal to be fitted with a GPS collar, Trotter et al. (2010) suggested that 'mob monitoring' (or tracking flock movement) may only require a small number of collars fitted on strategic animals. Likewise, Taylor et al. (2011) argued that 'focal' animals (GPS collared) are not behaviourally independent from the rest of the group, and consequently small numbers of GPS collars can still provide a sufficient means to observe animal behaviour and environment utilisation.

This paper addresses the issues of restocking an extensive mountain area with young animals. It presents results from an experiment conducted on a mountain research farm in Scotland, where young ewes from different origins (homebred and bought-in) were reintroduced on a mountain range grazing area. Focal animals were monitored using GPS collars over a one year period. Regular weighing and performance was recorded for the whole flock over a two year period, to gauge whether or not their origin had an influence on ranging behaviour and performance, and thus ascertain the potential challenges of restocking a mountain farm with young replacement animals.

2. Materials and methods

2.1. Location/Farm environment:

The research was carried out at a mountain research farm, situated in the North West of Scotland (SRUC's Hill and Mountain Research Centre, Kirkton and Auchtertyre farms). The farm has an area of 2,200 hectares and has the capacity to carry up to 2000 ewes. It is composed of two sub-units – Unit A (Auchtertyre), which carries at present 380 ewes managed extensively, and Unit B (Kirkton), which carries 900 ewes. The Unit A flock was reduced in 2008 following a health issue which resulted in 800 ewes being cleared from its mountain pasture. One hundred and fifty ewes remained and since 2009, the flock has been slowly built up with homebred replacement young ewes. In 2012, Unit A carried 380 ewes. The restocking study was carried out on Unit A mountain pasture (Figure 1), which rises to over 1,000 metres above sea level and is predominantly made up of unimproved grassland or rough grazing (1320 ha). The rest is a combination of woodland (298 ha), species rich grassland (212 ha), wetland (219 ha) and bracken patches (30 ha).

Both Units A and B are exposed to the typical oceanic climate of western Scotland. Summers are generally cool and moist, while winters are commonly wet and windy. This typically wet weather is evident by the average annual rainfall measured between 1991 and 2010 of 2,528mm (Holland, 2014).

2.2. Animals:

The restocking project began in 2012, when young ewes were brought into an existing ewe flock of 380 sheep.

A total of 230 animals from four different origins were introduced, to compare different strategies involved in restocking extensive mountain areas:

1) 110 young ewes came from the existing in-situ ewe flock grazing Unit A extensively (Homebred extensive: HB-Ex)
2) 40 young ewes came from an adjacent ewe flock grazing a better quality mountain pasture ground (Unit B) and managed semi-extensively (Homebred semi-extensive: HB-SE)
3) 56 young ewes were purchased from two semi-extensive farms (Bought-in semi-extensive: BI-SE)
4) 24 young ewes were purchased from an extensive farm (Bought-in extensive: BI-Ex)

These varied origins allow for the restocking comparison between homebred or bought-in animals, and from extensive or semi-extensive managed flocks. The difference between extensive and semi-extensive flocks was mainly due to pasture and soil quality, as well as altitude. All animals were of the Scottish Blackface breed.

2.2.1. Management:

The bought-in animals were purchased and brought to Unit A in October 2012. Homebred and bought-in animals were then sent to their winter grazing locations (wintering off farm) at three different farms (Inverness; Buckie; Torbex), as is customary with extensive farms, and in line with the practical management of the flocks at the Research Centre. The division of the animals between the winter grazing farms was as follows: Inverness: 24 BI-Ex, 30 BI-SE; Buckie: 110 HB-Ex, 26 BI-SE; Torbex: 40 HB-SE.

Animals were brought back from winter grazing and were released onto Unit A mountain pasture in April 2013. Apart from four weeks spent on the lower fields in November 2013, the animals stayed on the mountain pasture until February 2014, when they were ultrasound scanned to detect pregnancy and foetal number for each animal.

After scanning, the animals were put onto different grazing areas according to their pregnancy status, as was the rest of Unit A flock, until lambing time in April-May 2014. The twin-bearing animals were kept on the lower part of Unit A mountain pasture, whilst the single bearing and barren animals were sent back to grazing on Unit A mountain pasture grounds. After lambing, the animals were gathered in June 2014 for marking and weighing their born lambs, in July 2014 for shearing, in August 2014 at weaning and in October 2014, prior to mating. Animals grazed on Unit A mountain pasture for the whole of that period.

2.2.2. Measurements

All animals were individually identified using electronic identification (EID) tags, and weighed using an electronic weigh crate fitted with an EID reader (a Prattley system for automatic weighing and autodrafting in combination with a Tru-Test® XR3000 weigh head).

2.2.2.1. Liveweight change:

Liveweight changes (in %) were calculated over eight time-periods (from October 2012 until October 2014, when the animals were weighed one last time for the purpose of this comparison before the subsequent mating).

The periods were defined as follows:

1. October 2012-April 2013 (wintering off-farm)
2. April 2013 – June 2013 (1^{st} spring grazing)

3. July 2013 – September 2013 (1st summer grazing)
4. October 2013 – November 2013 (1st autumn grazing)
5. November 2013-February 2014 (early pregnancy)
6. February 2014-June 2014: 2nd spring grazing and lambing
7. June 2014-August 2014: 2nd summer grazing
8. August 2014 – October 2014: 2nd autumn grazing

Correction factor:

One of the off-wintering farms (Inverness) was substandard in the quality of grazing, compared to the two other locations. To avoid subsequent bias in the liveweight change analysis, a correction factor has been applied to the weight of the animals off-wintered on that farm, to obtain a post-wintering corrected weight that was no longer biased. The correction factor was calculated as the difference between in weight gain between the substandard (Inverness) and standard (Buckie) off-wintering farms and was added to the recorded weight (in April 2013) of young ewes coming back from the Inverness farm. The corrected April 2013 weights have been used thereafter in subsequent calculations for these particular sub-groups (all of BI-Ex and 30 of the 56 BI-SE).

2.2.2.2. Reproductive performance and mortality

Reproductive performance, measured as the number of lamb/animal scanned and the number of barren animals, was calculated using the recorded pregnancy result for each animal determined in February 2014 at mid-pregnancy scanning. The mortality rate (% dead animals) was calculated over the whole study period (October 2012 – October 2014). Additionally, any animal missing over more than two consecutive periods was presumed dead.

2.3. Locational study

2.3.1. GPS collars:

Five location tracking GPS collars (Blue Sky Telemetry Inc., Edinburgh, Scotland) were used to obtain sets of movement data from young ewes across 3 time periods during the 2013 grazing periods; April – June (Period A), July – September (Period B) and October – November (Period C). Available battery life of the collars prohibited extended use beyond a 3 month (70 day) maximum period. In April 2013 a total of five randomly selected young 'focal' ewes (2 homebred and 3 bought-in) were fitted with GPS tracking collars (Taylor et al., 2011) and released onto Unit A mountain pasture with the rest of the flock. The selected young ewes were in good condition, with an average weight of 44.2 Kg (range from 42.8 kg to 45.8 kg). The GPS units attempted to obtain location fixes every 10 minutes to maximise battery life (Asher et al., 2014) until the collars were retrieved on 12th June 2013. The recorded GPS fix data was then downloaded and entered into Microsoft Excel (Microsoft Corporation, 2006) for analysis and manipulation before it could be imported into ARCGIS version 10 (ESRI, 2012) for spatial mapping tasks. The subsequent two periods of GPS tracking followed the same procedure with five young ewes (this time, in rotation, 3 homebred and 2 bought-in) being fitted for period B and five young ewes in period C (3 homebred and 2 bought-in). Different randomly selected young ewes were collared each time. Batteries were replaced after each period.

The spatial locations of the young ewes were used in conjunction with analysis functions within ARCGIS to estimate the home range ('heft') extent of each animal (an area polygon bounded by the limit of GPS fixes recorded), the habitat preference used (analysed by comparison to a vegetation classified map layer) and a density measure for each sheep (showing the 'hotspot' spatial clustering of GPS fixes and hence the core areas used by each collared animal). Calculation of the foraging distance for each animal in each time period was carried out using the Geospatial Modeling Environment version 0.7.2.0 - a set of plugin tools useable with ARCGIS (Beyer, 2012).

2.3.2 Stragglers:

The term 'straggler' was used to define animals that had wandered across the Unit A boundary onto neighbouring farms. As is the case with many of Scotland's extensive mountain farms, the boundary of Unit A is not fully fenced. It therefore relies on the concept of 'hefting' to manage the movement of sheep, and to thereby restrict animals from wandering across the boundary into neighbouring farms. A record of the number of these stragglers brought back to Unit A throughout the study was maintained, in order to measure the number of stragglers observed within each group of young ewes. There were 4 main dates when animals were returned (two within period B; two within period C). No stragglers were brought back during period A. Therefore, to allow further locational comparison during the three time-periods, the number of animals missing during period A was used instead as a proxy.

2.4. Statistics

All statistical analyses (including descriptive statistics) were carried out using the statistical package Genstat (16th Edition, VSN International, 2013). Analysis of variance (one way ANOVA) was used for parametric data (liveweight changes). Datasets expressed as character frequency (mortality rate, scanning rate, straggler counts, GPS fixes, home range and habitat data) were tested for differences using chi-squared (X^2) and F- tests.

3. Results

3.1. Animal performance

3.1.1. Effect of origin on liveweight changes

The mean liveweights of the animals were similar at the beginning of the study (Table 1). The mean liveweight percentage changes across the eight periods for the four groups of animals are shown in Table 1.

<*Table 1*>

Although there was a difference between the animals during the off-wintering period (October 2012 – April 2013), with the Bought-in Extensive animals only gaining 0.4 % (± 1.9) of their liveweight, and the Homebred Extensive animals displaying the highest liveweight gain (37.7% (± 1.2)), they were not statistically applicable, due to the correction factor applied to this period.

1st spring, summer and autumn grazing (Periods A, B and C): during the first grazing period (Period A), the Bought-in Extensive group performed the best, gaining 12.3% (± 1.3) liveweight, whilst the Homebred Extensive performed worst, losing 4.6% (±0.5) liveweight ($P<0.001$). Although the summer grazing period (Period B) showed higher and more homogeneous liveweight changes amongst the four groups of animals (ranging from 20.8% to 25.2%), the differences were significant ($P=0.007$). The first autumn grazing period (Period C) showed a reduction in liveweight gain for the four groups of animals, with the Bought-in Semi-Extensive having the lowest ($P=0.009$) gain (1.5 %) and the Homebred Extensive having the highest gain (7.8%).

The early pregnancy period also showed significant (P<0.001) differences between the four groups of young ewes. Whilst all animals lost weight during this period, the Homebred Extensive group lost the most (19.2% of their weight). The animals from the three other groups lost less (Table 1 and Figure 2).

<Figure 2>

After the early pregnancy period (from February 2014 till October 2014), the origin of the animals did not show any significant effect on their liveweight percentage change (Table 1). The origins of the animals however, had a significant (P<0.001) effect on the overall (October 2012-October 2014) liveweight percentage change, with the Bought-in Semi-Extensive animals performing worst with an overall percentage change of +62.2% (± 3.3).

3.1.2. Effect of origins on reproductive performance and mortality:

Although the scanning rate was slightly higher for the Homebred animals (both Extensive and Semi-Extensive), the differences were not statistically significant (Table 1). Likewise, the origin of the animals did not have a significant effect on their mortality rate (Table 1). However, when only considering the two homebred groups, the Semi-Extensive animals had a significantly (P<0.001) lower mortality rate (3.2% vs. 19.6%) than their Extensive counterparts.

3.2. Locations

Out of 15 potential sets of data over the 3 periods, a total of 12 were recorded (3 failed to record any data). The number of GPS data recording days in the first period (Period A) of the study (n = 5 collar datasets) averaged 38 days with a standard deviation of ±18 (range from 20 to 56); period B (n=4 collar datasets; 2 BI and 2 HB) averaged 48 days with standard deviation of ±21 days (range from 27 to 69); and period C (n=3 collar datasets; 1 BI and 2 HB) averaged

29 days with a standard deviation of ±21 days (range from 8 to 50). All collars were tested to receive GPS fixes prior to deployment in each period. Locational accuracy for all collars used was measured before application at a maximum of ±5 m. Variation in total recording days was caused by GPS or collar failures, (e.g. battery failure or due to environmental factors such as physical knocks and humidity entering the GPS housing).

The 12 GPS datasets collected yielded 61,117 GPS fixes (average of 5,093 per sheep). Figure 3 presents this data in the form of density 'heat' maps for focal young ewes indicative of their group over periods A, B and C. The density (colour) gradations shown used natural breaks in the GPS data classified into five grades (from lowest density to highest density) within ARCGIS. The hotspot areas indicate dense clusters of GPS fixes suggesting a zone where the animals spent much of their time. The disparity of distribution in GPS fixes for one of the homebred animals compared to one of the bought in animals during period A is presented in Figure 1. Habitat designations for the study area in this figure clearly show the area and vegetation types favoured for foraging by these ewes.

3.2.1 Home Ranges

The bought-in young ewes clearly remained mostly separate for the April to June period (A) from the homebred animals, foraging across the east facing slope of Unit A while the homebred ewes spent the majority of time on the eastern slope of the mountain dividing Unit A from Unit B (shown in Figure 1). The only crossover locations were the lower elevation grassland bounding the southern woodland strip and the wetland surrounding the stream through the western valley of Unit A. The home ranges (areas roamed) of both groups were not significantly different (Table 2) in extent (mean of ~185 ha for HB; mean of ~193 ha for BI) indicating that neither group were restricted in their roaming in any way. The bought-in animals however clearly roamed a far greater distance, (mean of ~168 km) than the homebred (mean of ~75 km) over the same time period.

During period B (Figure 3b) the homebred ewes crossed over to a similar foraging area used by the bought-in animals during period A. Much of their time in this period was spent on the lower ground around the stream and wetlands and on the east facing slope of Unit A. The bought-in animals by contrast swapped over to the mountain between the two valleys and remained somewhat separated from the main homebred flock. Roaming measurements (Table 2) indicated that again the bought-in ewes had a larger home range although the distance travelled during this period (mean of ~113 km) was less than the homebred animals (mean of ~162 km). Density maps for this period indicate the bought-in ewes had two main foraging areas on the mountain s slopes either side of the stream running through unit A.

Although the Autumn (period C) dataset was limited to one animal from the BI group and two from the HB group, both groups of animals showed similar home range extents and distances travelled (Figure 3c); when compared to the previous time periods. The ewes with collars showed a choice of foraging location on the sheltered western slope of Unit A with only one homebred animal spending limited time over the ridge into Unit B. Overall, there was no significant differences found in both home range extent and foraging distance between the two groups across the complete GPS recording period (Table 2). Differences between groups within each time period were also not significant.

<Table 2> <Figure 1>

3.2.2. Habitat preferences

The two groups of young ewes showed significant differences during period A in their choice of foraging habitat (Table 3). The homebred group foraged more often among bracken (*Pteridium* *aquilinum*) patches and the wetlands around the stream in Unit A whilst the bought-in animals almost always avoided the patches. The HB group also spent more time in the scattered woodland fringe than the bought-in animals that remained almost exclusively on the open unimproved grassland. During period B the foraging habits became more similar although the bought-in ewes spent between 7% and 10% of their time in the species rich grassland of Unit B and the homebred group spent approximately 20% of their time in the woodland fringe. Overall for this period, habitat choice was not significant. Period C also showed no significant differences between the young ewes groups as their home ranges now overlapped. Almost all time (> 75%) was spent by both groups in the unimproved grassland or species rich patches within the grassland areas. The woodland areas and bracken (mature seasons growth) were avoided by both groups.

<*Figure 3*>

3.2.4. Stragglers

Figure 4 displays the effect of origin on the proportion of stragglers observed, over the 3 time periods (A, B, C) when the animals were fitted with the GPS collars. After an initial increase between period A and period B, the percentage of stragglers decreases between period B and period C. There were significant differences ($P<0.005$) found between the origins during period B, with the quantity of stragglers observed in the Bought-in group being significantly higher. However, over period C, this difference is no longer significant and the numbers of straying animals from both groups decrease.

4. Discussion

The results of the present study suggest that bought-in young ewes are initially likely to have differing foraging behaviour from homebred animals. This effect, however, appears to diminish over time as the two groups become more integrated. In agreement with the theory of Provenza (1995) that naïve animals in an unfamiliar environment walk greater distances than homebred animals - the bought-in young ewes roamed double the distance of the homebred animals during period A (although their home ranges more or less equated). Most likely, this exploration of the landscape by the naïve animals was a search for suitable grazing areas. The concept of spatial memory may have also contributed. Several studies (Dumont and Petit, 1998; Edwards et al., 1996) have demonstrated the ability of sheep to use spatial memory during foraging, allowing the animals to remember, re-locate and thus exploit preferred food patches in an environment of mixed forage quality (Hewitson et al., 2004). However, in some cases spatial memory may actually inhibit foraging ability. For example, it is often the case on mountain farms that young sheep adopt the grazing area of their dams (Lawrence, 1990) storing the location of such patches within their spatial memory. Therefore, it can be assumed that homebred sheep are likely to adopt a home range that is based around the grazing area of their dam rather than the availability of the most suitable forage, that might change location year to year. In contrast, bought-in animals do not have this memory for the new environment they find themselves in. They are therefore more likely to develop a short-term spatial memory (post initial exploration period) to locate areas of preferred food patches and to adopt a home range that is based largely on the quality and quantity of surrounding forage and not on the preferred foraging locations of the rest of the flock (Scott et al., 1995); for example, the relative avoidance of bracken, wetland and woodland zones in Period A. The results of this study appear to indicate a conscious decision to avoid non grassland areas and also suggest that the BI-Ex group may have been able to effectively locate areas of improved grazing, as demonstrated by the substantial summer weight gain, that were not necessarily conterminous with the foraging knowledge of the main flock.

Although the number of GPS collars used was relatively small and only a few animals were collared in each sub-group, results obtained can nonetheless give a robust indication of how the rest of the flock behaves providing that enough GPS points over a suitable time period are gained. A recent study by Taylor et al. (2011) used 10 collars on 5 'focal' ewes from two different groups to inform on their shelter-seeking behaviour while Williams et al. (2009; 2010) also reported using only a few collared ewes (4 per observation period) as 'core' animals to inform on the hill grazing behaviour of the whole group. These authors also encountered similar issues relating to battery operation and communication loss between transmitter and receiver. The collars in this study had been used in previous experiments and thus had already been subject to extended periods of wear and tear. Rapid recent developments in GPS sensor technology are however driving marked improvements in both spatial and temporal data recording and accuracy (Dodge et al., 2016; Kays et al., 2015). The increased availability of civilian Global Navigation Satellite Systems (GNSS) offer significant increases in the amount of highly accurate movement data for detailed studies of animal behaviour (de Weerd et al., 2015). New sensors such as accelerometers and bio 'data loggers' are now offering scientists unparalleled levels of behavioural and physiological ancillary data (Dodge et al., 2016; Umstätter et al., 2015). The application of such sensors to this type of study could provide valuable insights into the flock integration process for new animals and offer fine scale data on the rate at which bought-in ewes adapt to a new environment.

A number of other factors also influence choice of grazing areas for sheep including topography, weather, forage quality and quantity, and social interactions (Bailey and Provenza, 2008; Sibbald et al., 2008). The GPS data obtained from the initial period of tracking (April to June) suggest that little to no social interaction occurred between the bought-in and homebred ewes. Although all the young ewes fitted with GPS collars attended the same winter grazing location, contact between these homebred and bought-in animals during the five months of off-wintering appeared to be insufficient to allow social integration to take place. Over time however, the bought-in animals were found to roam less (on average) than the homebred group although their overall home range was still larger. This therefore suggests that a level of interaction between the bought-in group and the homebred group occurred during the second period and that the bought-in animals were possibly dividing their foraging time between the grazing locations they knew and the locations the other sheep were using. Sheep with familiar companions seemingly graze their preferred sites for longer (Boissy and Dumont, 2002).

The shearing of the ewes took place prior to this second recording period, and may offer some explanation for the presumed increase in social integration. Sense of smell plays a significant role in the identification of individuals in sheep (Kendrick, 2008), and thus it is possible that the change in smell caused by shearing encouraged the young bought-in ewes to associate with, follow (or be more accepted by) the main homebred flock. This integration phenomenon was further observed in period C. Density maps (Figure 3c) clearly indicate that both groups of animals limit their home range for the period to the eastern slope of Unit A and spend nearly a fifth of their time on the species rich grassland (15.6% for HB, 19.1% for BI). These observations appear to indicate increased social integration and a better understanding of preferable forage locations (the eastern slope has the better quality grassland this time of year). Boissy and Dumont (2002) similarly noted how the strength of social bond can influence sheep foraging on patchy grasslands.

Social integration of homebred and bought-in animals is thought to influence the level of extensive ranging and overall performance achieved by bought-in animals. Scott et al. (1995, 1996) stated that in sheep, the social interactions within groups help the animals to adopt a wider range of foods, while Bailey et al. (2000) suggested that experienced homebred animals are capable of transferring knowledge of their environment to help naïve/bought-in animals 'learn the landscape'. The successive reduction in home range and forage location choice of the bought-in ewes to overlap with the homebred animals suggests that this learning process occurred also in this study, and offers evidence of likely performance of bought-in extensive ewes in general.

The 2 years performance results of this study suggest that the origin of young Scottish Blackface ewes had a significant effect on their early performance in extensive environments. This concurs with earlier research into the effect of nutrition in early life on the subsequent lifetime performance of sheep (Gunn et al., 1995). Specifically, the homebred young ewes initially outperformed the bought-in animals in terms of liveweight gain (%) and survival rate (%). However, once the bought-in animals seemed to integrate with the flock, their performance improved to almost equal that of the homebred animals. This appears to contradict the view of Provenza and Balph (1990) who stated that naïve or bought-in animals are inefficient foragers when introduced to areas that are unfamiliar. However, the study's results indicate that bought-in ewes with higher mean liveweights may not be able to maintain this weight advantage even with better nutritional forage. The BI-SE group underperformed compared to all other groups and seemed the most prone to negative change throughout the periods measured. Nonetheless, the relatively rapid gain in liveweight of BI-Ex ewes during period A differed markedly to the reduction in liveweight observed in both the BI-SE and HB-Ex groups during the same period. This may be somewhat explained by the phenomenon of compensatory growth, whereby an accelerated period of growth occurs following a period in which growth is impaired due to nutrient restriction, as shown by Kamalzadeh et al. (1997) in lambs.

The present study found there to be no significant difference in pregnancy scanning results observed between the homebred and bought-in young ewes. Likewise, there was a noticeable but non significant difference between the mortality rate of homebred and bought-in young ewes. The results are somewhat skewed by the high and low mortality rates respectively found in the HB-Ex and HB-SE groups. Comparing the mortality rate of only the HB-SE group with the bought-in animals shows a clear similarity with the results of previous studies such as Warren and Mysterud (1993). So, although there were initial weight change differences, later performance results did not appear to be affected by the origin of the animals.

Finally, although the bought-in animals initially tended to stray (or straggle) more than their homebred counterparts, as also observed by Warren and Mysterud (1993) in Norway, this phenomenon decreased over time (Figure 4). Extensive ranging or wandering of sheep off the farm can be a major concern for sheep farmers in mountain un-fenced areas since substantial financial costs are associated with the excess labour time required in dealing with the stray animals that have to be brought back by neighbouring farmers. The presence of stragglers may also raise health and welfare concerns, as the absent animals may suffer from external and internal parasites due to lack of anthelmintic doses and can potentially transfer such pests to other flocks and pastures (Morgan-Davies et al., 2006). However, this study highlights the potential for reducing issues of stragglers over time when young ewes of different origins can be integrated into the overall flock – which in turn may be achieved through close contact at wintering.

5. Conclusions:

In conclusion, this study indicates that restocking extensive farms with bought-in young ewes of different origins is feasible, provided that they are encouraged to socially integrate as soon as possible with the main flock of homebred animals that ‘know’ the area and preferred grazing locations. Although the bought-in young ewes initially appear to choose their own home range and roam further – leading to the possibility of straggling and loss, they still 'learn the landscape' from a combination of individual roaming and social interaction with the main flock. After only one summer grazing period, the animals of different origins, that have had no prior experience of the landscape, appear to have developed a valuable knowledge of the area.

This study shows that in the longer term, there is no impact of the origin of the young ewes on their later performance. The early observed differences in performance rate (especially in liveweight gain) appear to have been due to the quality of nutrition over the winter period; also, the division of the flock during off-wintering most likely affected integration of the new animals. However, this study shows that if off-wintering is used, the initial summer period grazing does not appear to have an impact on later life performance; possibly thanks to an effect of compensatory growth.

These results also reinforce, in agreement with previous work, the fact that the Scottish Blackface are able to make use of poorer quality forage - even to recover performance after a period of weight loss. Scottish Blackface born in a semi-extensive (upland) environment still successfully improve performance even when placed on extensive grassland during their main growing period.

These results are likely to resonate with many areas across Europe, where livestock are grazed extensively with no constraining boundaries features. The findings therefore have the potential to inform the restocking of extensive areas. This is of particular relevance now when agricultural policies in Europe are encouraging new entrants and renewed farming activities on extensive farms, which may have been previously semi-abandoned or had neglected extensive pastures.

Acknowledgements

SRUC receives financial support from the Scottish Government's Rural and Environment Science and Analytical Services Division (RESAS), as part of the 2011-2016 Strategic Research Programme 1: Environment. Dr Christina Umstätter is also gratefully acknowledged for her help in setting up the initial experiment. The authors would like to thank the two anonymous referees for their very helpful comments on the manuscript.

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Figure 1. *GPS location points for all collared homebred (HB – left map) and bought-in (BI – right map) animals combined during Period A of the study (April – June 2013), and location of Unit A and Unit B.*

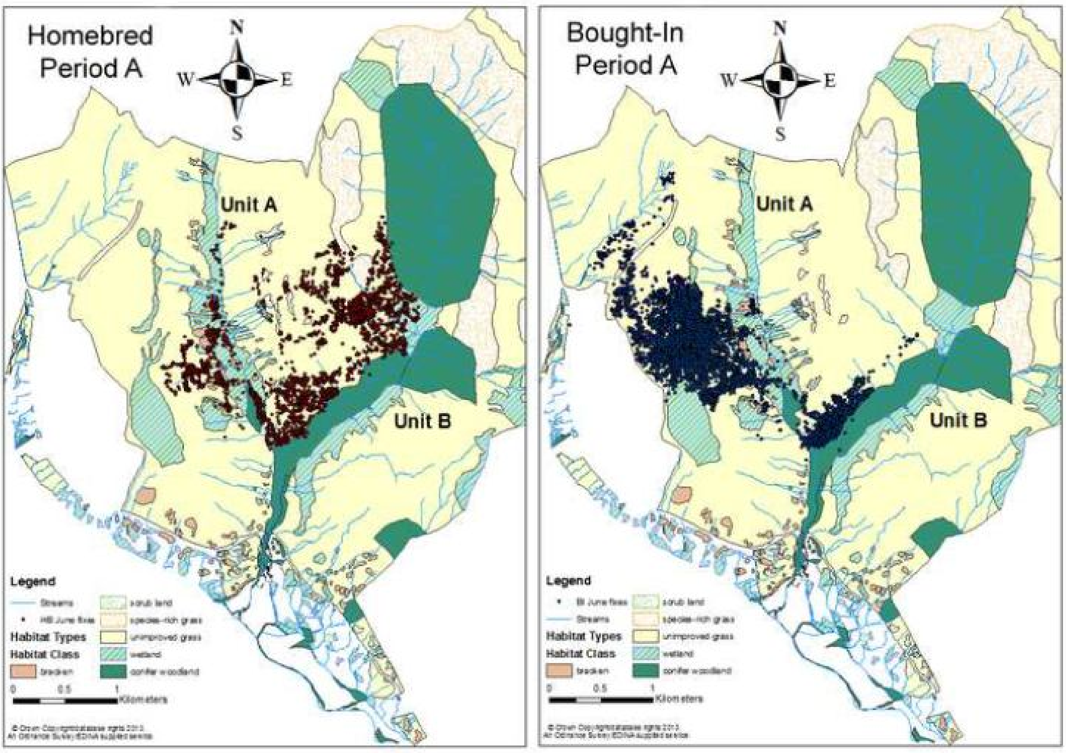

Figure 2. *Weights (in kg) of young ewes (by origin, BI-Ex=Bought-in Extensive; BI-SE=Bought-in Semi-Extensive; HB-Ex=Homebred Extensive; HB-SE=Homebred Semi-Extensive) during the experiment. NB: for all BI-Ex and 30 out of 56 BE-SE, the April 2013 weights are the corrected weights.*

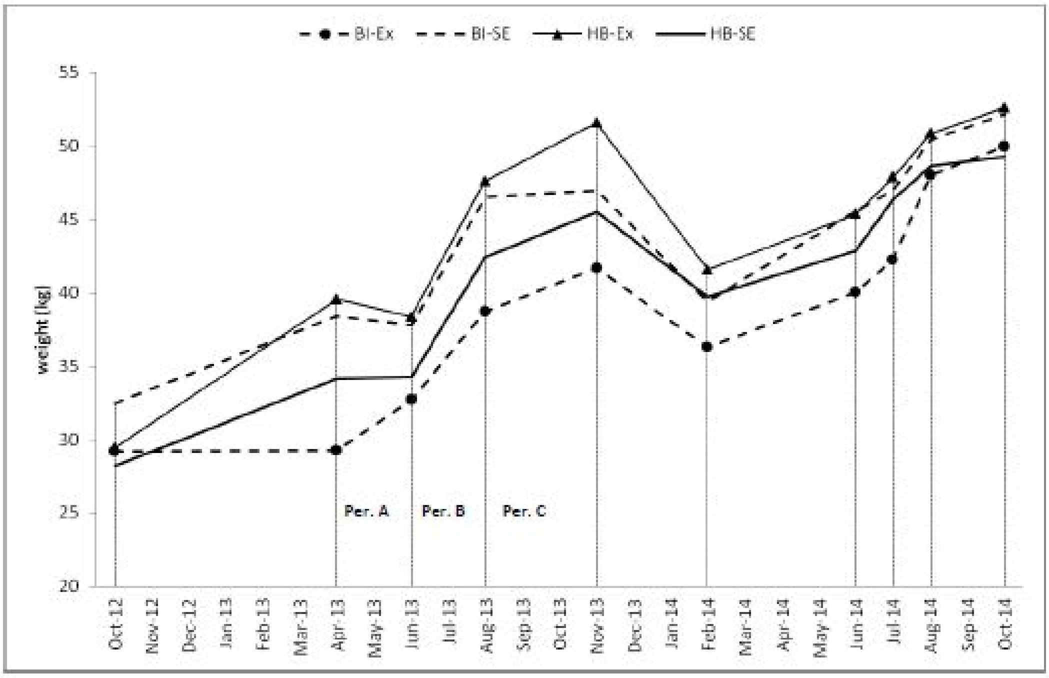

Figure 3 (a, b, c). *Density maps of focal young ewes (BI - Bought-in – left; HB – Homebred – right) recorded during (a) Period A (April to June), (b) Period B (July to September)and (c) Period C (October to November).*

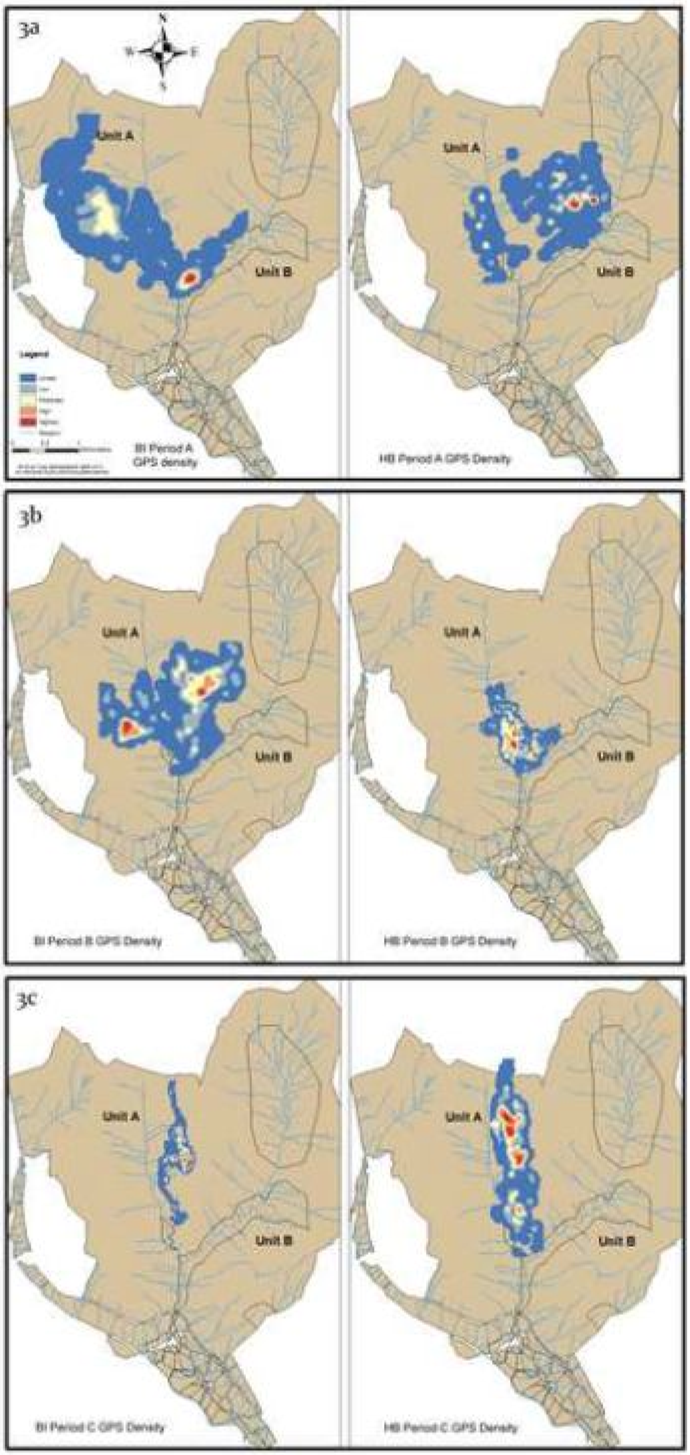

Figure 4. *Percentage (%) of stragglers observed within both group of origin (Bought-in and Homebred), per time period.*

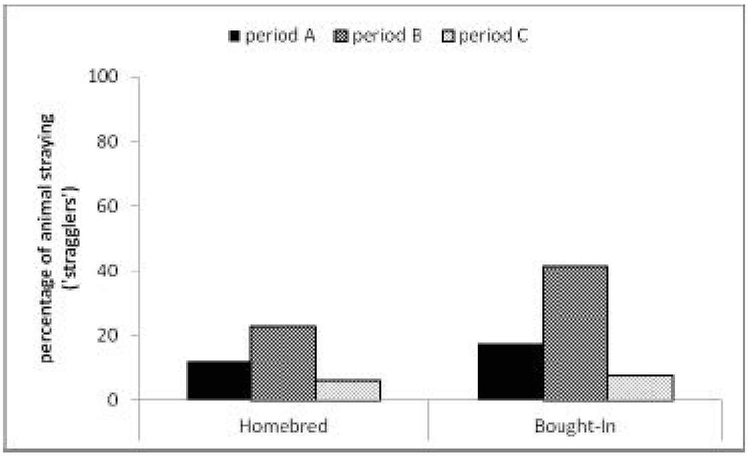

Table 1. *Measurements of animal numbers by group used in the study, mean liveweights (LW) (in kg) and liveweight changes (in %) by period, mortality and pregnancy scanning percentages with significance values (between groups) for each measurement. NB – measurements 1 and 2 used the April 2013 corrected liveweights for all the bought-in extensive and 30 out of 56 bought-in semi-extensive animals.*

	Homebred		**Bought-in**		**P sig**
	Semi-extensive	**Extensive**	**Semi-extensive**	**Extensive**	
Number of animals (Oct 2012)	40	110	56	24	
Mean liveweight (LW) in kg (±SD) (Oct 2012)	28.2 ± 2.7	29.5 ± 4.1	32.6 ± 3.0	29.2 ± 1.9	NS
1. Oct 2012 – April 2013: LW change in % (± SE) (corrected for wintering farm)	21.5 ± 1.4	37.7 ± 1.2	17.4 ± 2.5	0.4 ± 1.9	N/A[1]
2. Period A (April 2013 to June 2013): LW change in % (± SE) (with April 2013 corrected weights)	1.4 ± 1.3	(-)4.6 ± 0.5	0.3 ± 1.5	12.3 ± 1.3	<0.001
3. Period B (June 2013 to Sept 2013): LW change in % (± SE)	25.2 ± 1.3	24.6 ± 0.7	20.8 ± 1.0	21.5 ± 1.5	0.007
4. Period C (Sept 2013 to Nov 2013): LW change in % (± SE)	4.0 ± 2.5	7.8 ± 0.9	1.5 ± 1.1	6.3 ± 2.8	0.009
5. Nov 2013 – Feb 2014 (early pregnancy): LW change in % (± SE)	(-) 12.1 ± 2.4	(-) 19.2 ± 0.7	(-) 16.1 ± 1.7	(-) 13.7 ± 3.1	P<0.001
6. Feb 2014 – June 2014 (2nd spring): LW change in % (± SE)	7.9 ± 2.2	10.6 ± 1.3	14.2 ± 1.8	12.1 ± 3.6	NS
7. June 2014-Aug 2014 (2nd summer): LW change in % (± SE)	12.8 ± 1.3	11.6 ± 1.0	12.2 ± 1.6	18.0 ± 2.4	NS (0.08)
8. Aug 2014- Oct 2014 (2nd autumn): LW change in % (± SE)	6.3 ± 0.6	5.7 ± 0.5	3.8 ± 1.0	5.4 ± 0.6	NS
Overall mean LW change (Oct 2012-Oct 2014) in % (± SE)	84.5 ± 3.8	85.4 ± 2.7	62.2 ± 3.3	73.4 ± 4.9	<0.001
Mortality rate (Oct 2012 – October 2014)	3.2%	19.6%	14.6%	13.0%	NS
Scanning % (no. lamb/ewe scanned)	1.04	1.05	0.90	0.82	NS
Barren rate % (no. ewes scanned empty)	0.07	0.11	0.23	0.27	NS

[1]non applicable due to correction factor applied

Table 2. *Derived location data for the 12 young ewes by period (Period A = April to June, B = July to September, C = October to November) with significance (F test) between groups (HB = homebred and BI = bought-in).*

		HOME RANGE	**ROAM**
Period	**Type**	**Area (ha)**	**Distance (km)**
A	HB	174	73
A	HB	196	77
MEAN		**185**	**75**
A	BI	241	95
A	BI	191	209
A	BI	146	201
MEAN		**193**	**168**
B	HB	136	125
B	HB	86	199
MEAN		**111**	**162**
B	BI	144	58
B	BI	243	167
MEAN		**194**	**113**
C	HB	46	12
C	HB	135	124
MEAN		**90**	**68**
C	BI	51	51
Significance		NS	NS

Table 3. *Habitat preferences for the 12 young ewes across the 3 periods with significance (F test) between groups (HB = homebred and BI = bought-in) across all habitat types.*

Period	**Type**	**Habitat GPS fixes (% proportion of habitats used)**				
		Bracken	**Species Rich**	**Unimproved**	**Wetland**	**Woods**
A	HB	74 (3)	0 (0)	2077(83)	224 (9)	128 (5)
A	HB	173 (7)	63 (2)	2012 (77)	360 (14)	12 (0)
A	BI	27 (1)	0 (0)	2561 (92)	165 (6)	27 (1)
A	BI	94 (1)	3 (0)	7080 (90)	652 (8)	9 (0)
A	BI	107 (1)	7 (0)	7027 (91)	550 (7)	30 (0)
Sig.	**< 0.01**					
B	HB	114 (2)	0 (0)	3665 (63)	931 (16)	1107 (19)
B	HB	198 (2)	0 (0)	5150 (57)	2064 (23)	1639 (18)
B	BI	35 (2)	221 (11)	1660 (79)	183 (9)	1 (0)
B	BI	200 (2)	632 (7)	7579 (86)	432 (5)	5 (0)
Sig.	**NS**					
C	HB	30 (0)	649 (9)	6419 (86)	358 (5)	9 (0)
C	HB	0 (0)	153 (22)	522 (77)	7 (1)	0 (0)
C	BI	1 (0)	698 (19)	2939 (80)	16 (0)	0 (0)
Sig.	**NS**					