TECHNICAL NOTE TN755 / November 2021

Using Estimated Breeding Values (EBVs) in Sheep

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Summary

- **Estimated Breeding Values (EBVs) estimate the genetic potential of an animal for particular traits.**
- **Genetic evaluation separates the influence of genetics from environmental factors (for example rearing type or feeding level) to facilitate fair comparison of animals based on their genetic merit within and across flocks.**
- **Selection using EBVs will lead to faster rates of genetic gain and flock improvement than selection based on eye or raw data, for example weights or lambs born.**
- **EBVs are now available not only for production focused traits such as lamb growth rate, prolificacy and carcass traits but also those that impact cost of production and losses such as mature ewe size, longevity, lamb survival, lambing ease and worm resistance.**
- **Index scores incorporate EBVs important to the specific breeding objective to provide an overall score of genetic merit. Index scores are a useful tool to rank animals and assist selection.**
- **Breed benchmarks are published each year allowing an animal to be ranked within the breed for each EBV and by Index.**
- **Assuming rams are structurally sound and healthy. Appropriate selection should focus on a selection of specific EBV traits important to the flock breeding objectives, whilst using Index scores as a tool for comparison and balance.**

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Why use EBVs?

It is essential that we select the rams, and ewes, with the best genetic potential for profit driving traits to breed from to continually improve flock productivity and profitability. However, this is not easily done as an animal's phenotype (visual, performance) is influenced both by its genes and the environment in which it is reared.

Selecting a tup by eye may lead to unsatisfactory offspring performance as a larger well fed, single born older ram would draw the eye but in fact a twin born ram from another sale pen may well possess superior growth potential. Also, consider all the traits such as daughter prolificacy, maternal ability or true muscularity that cannot be measured by eye or size.

The only influence a ram has on its offspring's performance is through its genes. A maternal ram purchased in 2021 could easily have daughters lambing down in the flock in 2030. Each years' tup selection has a major impact on future flock performance. Estimated Breeding Values (EBVs) offer a tool to help us select on genetic merit, independent of environment.

What are EBVs?

Breeders who sell stock with EBVs have carried out performance recording of their flock. This is based on recording of parentage, identification of the individual (EID) and recording traits of interest. All flocks record weight traits as a minimum. This data is sent for genetic evaluation to produce EBVs.

Genetic evaluation uses BLUP statistical analysis (Best Linear Unbiased Prediction) which takes into account the animal's performance data and that of its offspring and relatives. This is adjusted for known environmental factors – birth/rearing type, dam age, season, management groups – and genetic factors to generate estimates of genetic merit for each trait called Estimated Breeding Values (EBVs).

Genetics are well shared within most breeds in the UK meaning that through genetic linkage the genetic evaluation can adjust individual performance to allow fair comparison between flocks and different systems. This means that animals from one flock can be fairly compared to animals from another even if the other flock feeds more.

EBVs are breed specific under current analysis, therefore EBVs are not comparable across different breeds. However, initial across breed analysis is in development, for instance terminal sire genetics are compared across breeds in the RamCompare project.

EBVs are a tool to aid selection and should not take away from the importance of selecting tups that are healthy and structurally sound with correct feet, teeth and testes and of desired visual/breed type for your end market.

Standard EBV traits

Standard performance recording by stud breeders of lambs born and lamb weights at 8 weeks and ~17-21 weeks (scan weight) with ultrasound scanning generates the core EBVs below:

EBV	Indicator of:
Eight-week weight (kg)	Growth rate to 8 weeks of age
Scan weight (kg)	Growth rate to finishing
Muscle depth (mm)	Loin muscularity
Fat depth (mm)	Potential to produce lean/fat carcases
Maternal ability (kg)	Ewe milking ability
Litter size (lambs)	Ewe prolificacy

The EBVs and Indexes in this note refer to those published by the UKs genetic evaluation company Signet Breeding Services. For more information and to search for stock and recorded breeders visit the website at **www.signetdata.com**.

EBVs published in other countries genetic evaluations and by independent breeding companies will vary, however, the principals and traits recorded are largely similar.

Growth and carcass traits

Growth

Faster growing lambs mean more profit from heavier sale weights, reduced cost of production – feed, proportion finished off grass, vet and med and labour – from reduced days to slaughter and potentially better timing of sale realising higher prices per kg.

Performance recorded flocks weigh lambs at eight weeks of age to produce the Eight-week Weight EBV and again at 17-21 weeks, when the lambs are ultrasound scanned for loin muscle and fat depth, to produce the Scan Weight EBV.

EBV	Indicator of:	Example
Eight-week Weight (kg)	Early growth potential to 8 weeks of age.	Ram with an EBV of +3kg is estimated to produce lambs which are 1.5kg* heavier at eight weeks than a ram with an EBV of 0.
Scan Weight (kg)	Growth rate potential to scanning (~17-21 weeks of age).	Ram with an EBV of +4kg is estimated to produce lambs which are 1kg* heavier than a ram with an EBV of 2.

*A tup is only ½ the genetics of his offspring so halve the EBV difference between two sires.
EBVs are stated against a baseline year with the average for each trait in the baseline year being 0.

Within the Suffolk breed there is over 4.6kg difference in Scan Weight EBV between a breed average ram in 2021 and one that is in the top 5%. As such buying a ram in the top 5% could produce lambs over 2.3kg, or more, heavier at 20 weeks of age than the offspring of an average ram selected by eye.

Carcase quality

Profits from finished lambs can be furthered through genetics for improved carcase weight (Kill Out – KO%) and carcase quality – superior conformation, muscularity and optimal fat covering. Ultrasound scanning and computed tomography (CT) are valuable tools to aid selection.

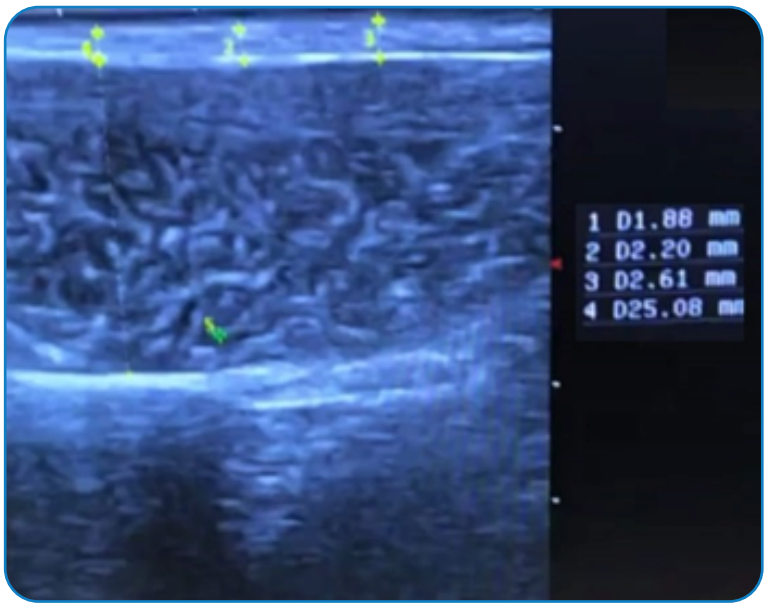
The commercial progeny test RamCompare found top performing rams, within the high genetic merit recorded terminal sires used, to produce offspring worth £4-6 more in carcass value (weight, specification) compared to flock averages across the 7 farms in the project.

Therefore, selecting the right ram can enhance profitability by over £1,200-1,500 per sire. Top sires were also found to reduce days to slaughter by 4-29 days depending on farm and rams used.

Ultrasound scanning

Carcase sale value can be improved with genetics for superior conformation and optimal fat with flock returns increased with the proportion of in-spec carcases.

Lambs are ultrasound scanned at 17-21 weeks of age at over 35kg. The scan is taken at the 3rd lumbar vertebra along the loin muscle with eye muscle and fat depths measured. Typical range for fat depth is 0.5-8mm and 20-36mm for muscle depth but up to 40mm.



Ultrasound scan of a 47kg maternal breed ram lamb (Source: Daniel Stout)

Scan data is adjusted to a fixed liveweight to facilitate selection of individuals that will produce progeny with improved loin muscling and optimal fat at typical finishing weights.

Prior to 2019, ultrasound measurement were age adjusted. This was less commercially relevant as heavier well fed animals tend to have greater muscle depth and were rewarded as such. It should, however, be noted that under the previous analysis fat and muscle depth were positively correlated. Now being weight adjusted they are negatively correlated with an increase in lean muscle associated with reduced fat.

EBV	Indicator of:	Example
Muscle Depth (mm)	Depth of muscle across the loin.	A ram with an EBVs of +2mm is estimated to produce lambs with 1mm greater loin muscle depth than a ram with an EBV of 0.
Fat Depth (mm)	Fat cover across the loin.	A ram with an EBV of -0.5mm is estimated to produce lambs with 0.25mm less fat across the loin than a ram with an EBV of 0.

How should I select on fat?

How to select on Fat Depth EBV is flock specific. Use grading sheets and finishing weights to influence which way to select and look up current sire EBVs. If getting too many over fat lambs then select more negative sires, if on a grass-based system and wanting to finish lambs sooner select more positive scores.

Negative fat depth allows:

- **Reduced carcass fatness at a given weight.**
- **Increased slaughter weight at a given fatness.**

Positive fat depth allows:

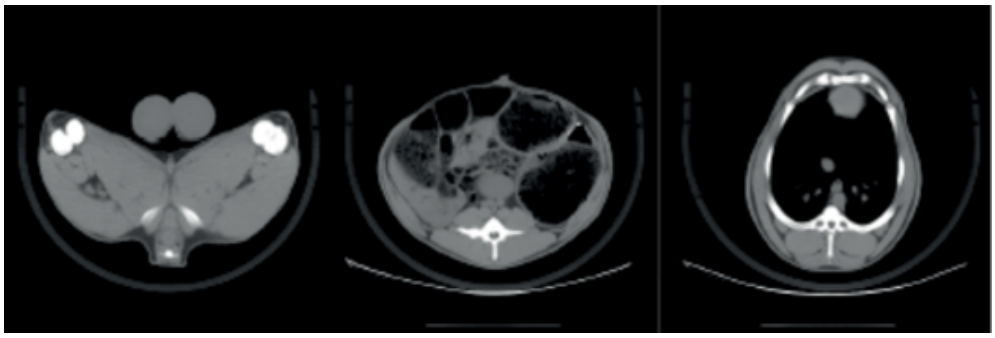
- **Earlier finishing lambs with reduced days to slaughter but at potentially lower carcass weight.**

Computed tomography (CT)

Some breeders will make the investment to scan a small selection of their best lambs, generally ram lambs based off ultrasound results, using Computed tomography (CT) to gain an even greater understanding of carcase composition and value.

CT measures carcase composition – weight of lean muscle, fat, bone – to very high accuracy in the live animal.

The accuracy is superior to that of ultrasound scanning, therefore it can facilitate faster rates of genetic gain. It also allows dimensional measurements of muscles and spine to be carried out to identify animals with superior carcase characteristics such as gigot muscularity, eye muscle area and carcass length.



The 3 cross sectional images analysed through CT (Source: SRUC)

CT traits are weight adjusted to identify rams whose progeny will have superior carcase attributes at typical slaughter weights. Therefore, the CT Lean Weight EBV facilitates selection of rams that will produce offspring with better carcase weight (KO%).

EBV	Indicator of:	Example
CT Lean Weight (kg)	Weight of lean muscle in the carcase.	A ram with an EBV of +0.5 is estimated to produce lambs with 0.25kg more muscle in the carcase than a ram with an EBV of 0.
CT Fat Weight (kg)	Weight of fat in the carcase.	A ram with an EBV of -0.4kg is estimated to produce lambs with 0.2kg less fat in the carcase than a ram with an EBV of 0.
CT Gigot Muscularity (mm)	Width of gigot – muscularity.	A ram with an EBV of +2mm is estimated to produce lambs with 1mm wider gigots than a ram with an EBV of 0.
CT Muscle Area (m^2)	Loin muscle area.	A ram with an EBV of +3mm^2 is estimated to produce lambs with 1.5mm^2 larger loin area than a ram with an EBV of 0.
CT Intramuscular Fat (%)	Meat eating quality.	A ram with an EBV of +0.10 is estimated to produce lambs that have 5% more intramuscular fat (marbling) than a ram with an EBV of 0.
Spine traits	Carcase length and number of vertebrae (chops).	Various traits.

Maternal traits

Attentive milky ewes, which rear heavy lambs to weaning, with strong fertility and optimal prolificacy are at the core of profitable sheep systems. These are traits which cannot be identified visually.

Maternal ability

Lamb eight-week weight data is analysed to separate out the maternal influence, of its mothers' milking ability (Maternal Ability EBV), from genetics for growth rate potential (Eight-week Weight EBV) and environmental factors.

The Maternal Ability EBV identifies rams whose daughters produce heavier lambs at eight weeks of age through superior milking ability and maternal care. The trait is adjusted for number of lambs reared and is expressed independent of prolificacy.

Litter Size

Flock prolificacy can be improved faster and more reliably by using Litter Size EBVs than it can by selecting those born as twins or triplets.

Whilst twinning rate increases with flock prolificacy/scanning percentages, once at ~170% scanning the increase in twinning rate generally ceases and is replaced with triplet lambs. As such, farm resources - grass, feed and labour – and current lamb mortality must be factored in to identify optimal flock prolificacy to influence selection for prolificacy.

Mature size

Selection for increased lamb growth rates – Eight Week Weight and Scan Weight EBVs – within the breeding flock will result in increased ewe weights because lamb growth and ewe mature size are positively correlated.

Whilst heavier lambs and higher ewe cull value are beneficial, the impact of ewe weight on individual ewe feed requirements, stocking rate (driver of output and profitability), ewe efficiency and suitability for the environment (hill systems) must be considered.

The weight adjusted Muscle Depth EBV means that selection can now be made for improved muscularity in maternal breeding programmes without inadvertently selecting for increased ewe weights. The correlation between mature weight and early lamb weights is less strong than with scan weight. As such maternal breeders should consider putting more focus on Eight-week Weight EBVs, and Maternal Ability EBV, than Scan Weight EBV to improve lamb growth rates whilst limiting increases in mature ewe weight.

EBV	Indicator of:	Example
Maternal Ability (kg)	Ewe milkiness and care, ability to wean heavy lambs.	A ram with an EBV of +2kg is estimated to produce daughters who through superior milking ability will rear lambs that are 1kg heavier at eight weeks than a ram with an EBV of 0.
Litter Size Born (lambs)	Ewe prolificacy.	A ram with an EBV of +0.20 is estimated to have daughters which produce 10% more lambs than a ram with an EBV of 0.
Litter Size Reared (lambs)	Breeding potential for lambs successfully reared.	A ram with an EBV of +0.10 is estimated to produce daughters that will rear 5% more lambs than a ram with an EBV of 0.
Mature Size/ Weight (kg)	Mature ewe weight.	A ram with an EBV of +6kg is estimated to produce daughters that are 3kg heavier as ewes than a ram with an EBV of 0.
Longevity (years)*	Ewe productive lifespan.	A ram with an EBV of +0.02 is estimated to produce daughter that will have longer productive lives in the flock than a ram with an EBV of 0.
Age at First Lambing (years)*	Fertility – genetics capable of lambing at an earlier age.	A ram with an EBV of -0.02 is estimated to produce daughters that can reproduce at an earlier age than a ram with an EBV of 0.10
Lambing interval (days)*	Fertility – shorter interval between 1st and 2nd lambing events.	A ram with an EBV of -4 is estimated to produce daughters that will get back into lamb quicker for their 2nd mating than a ram with an EBV of 0.

*New traits only available in select maternal breeds.

Lambing traits

Birth weight

The optimal lamb birth weight is not linear, high birth weight increases the risk of lambing issues and associated mortality risk, whilst low birth weights can lead to reduced lamb survival through increased susceptibility to hypothermia and weak lambs that fail to suckle.

How to select on Birth Weight EBV is flock specific. Consider current birth weights and lambing issues and also the EBVs of current sires. Selection of low birth weight rams can reduce lambing difficulty (dystocia). Avoid extremely high birth weight rams but also low birth weight sires if small lambs are an issue.

Lambing ease

Lambing difficulty increases the risk of lamb and ewe mortality through trauma and subsequent weak lambs whilst also having a major impact on labour requirements at lambing and suitability for outdoor lambing.

The Lambing Ease EBV is only available in certain breeds and not all breeders record it (5 point score of assistance level) so pay close attention to accuracy values and speak to breeders.

The EBV is a direct trait of the ease of which a ram's offspring will be born. It is not a reflection of how easily daughters will give birth themselves.

Lamb survival

The new Lamb Survival EBV available in certain breeds is derived from whether lambs weighed at birth (alive or dead) are then alive later in life based on whether eight-week weight and scan weights are submitted. This provides the opportunity to identify genetics with improved lamb resilience and survival.

EBV	Indicator of:	Example
Birth Weight (kg)	Lamb birth weight.	A ram with an EBV of -0.5kg would be expected to produce lambs that are 0.25kg lighter at birth than a ram with an EBV of 0.
Lambing Ease (%)	Direct lambing ease – potential of a lamb to be born without assistance.	A ram with an EBV of +6 would be expected to produce 3% more unassisted lambing events than a ram with an EBV of 0.
Lamb Survival	Direct postnatal lamb survival.	A ram with an EBV of 0.1 would be expected to produced lambs with superior survival rates than a ram with an EBV of 0.

Worm resistance

Widespread anthelmintic resistance is a threat to the sustainability of sheep systems. Reducing anthelmintic use is a key strategy to help slow the rate of resistance development.

Faecal Egg Count (FEC) EBVs facilitate identification of animals that have greater resistance to gut worms. Animals with superior resistance are found to shed less worm eggs. Negative EBV scores are desirable.

The new Saliva IgA EBV provides an alternative indicator of worm resistance based on immune response through the IgA antibody. Positive scores are desirable denoting superior antibody response. The Saliva IgA EBV should ideally be used alongside FEC EBVs to aid selection because it is new and often has low accuracy,

The greatest benefit of worm resistance selection using EBVs is in breeding replacement stock as superior acquired resistance only kicks in around 4-5 months of age.

EBV	Indicator of:	Example
FEC- • Strongyles (S) • Nematodirus (N) • Combined	Worm resistance based on worm eggs shed. Less eggs indicates superior resistance.	A ram with an EBV of -1 will produce progeny that shed less worm eggs on pasture than a ram with an EBV of 0.
Saliva IgA	Worm resistance (*T.circumcincta)* based on IgA antibody response. More indicates superior resistance.	A ram with an EBV of +0.05 will produce progeny that produce more saliva IgA than a ram with an EBV of 0.

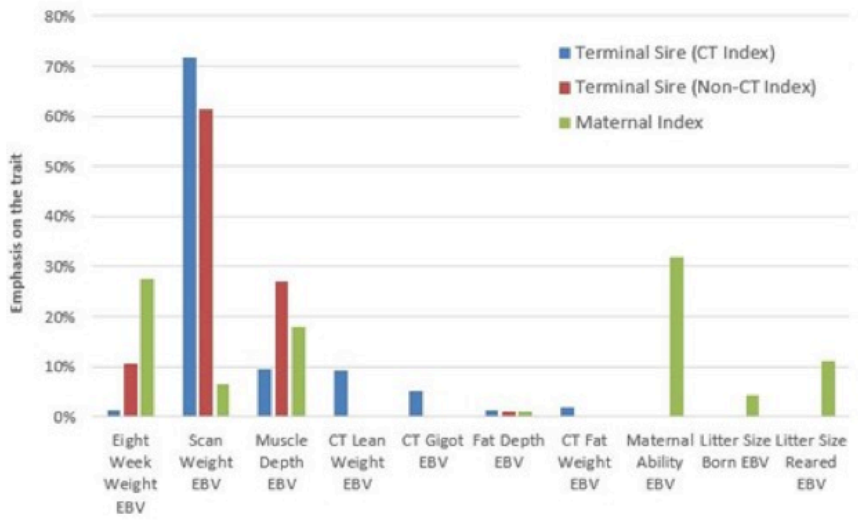
Indexes

EBVs predict an animal's genetic merit for a particular traits, however, within any sheep system there are a multitude of different traits that influence profitability. To aid selection EBVs are combined into Indexes which are weighted according to the importance of each traits to the specific breeding objective. This provides an overall score of merit from a set of balanced traits.

Terminal Index

Designed to select for profitable slaughter lambs with improved growth rates, muscling and lean meat yield in the carcase. Where CT data is available then the analysis is run with a reduced weighting on Muscle Depth in favour of CT Lean Weight and including Gigot muscularity.

Historically a negative weighting was placed on fat. This has changed recently to a small positive weighting to avoid selection of excessively lean genetics when selection for muscling and lean weight is high.



Weighting of traits within the Terminal Sire index and also the Maternal Index of the Suffolk and Dorset breeds (Source: Signet)

Maternal Indexes

Selecting rams for breeding replacement females is complex with many traits influencing profitability and several of these unfavourably correlated, such as growth rate and mature size. There are several different maternal breeding indexes which are adapted to suit each breeds objectives.

Maternal Index

Designed to enhance pre-weaning growth rates and number of lambs reared by improving maternal ability and prolificacy. Indexes vary between breeds, but most have a high weighting on Litter Size, Eight-week Weight and Maternal Ability EBVs. Whilst also putting a positive selection on carcass traits and in most cases a negative weighting on the Mature Size EBV to limit increases in ewe weight which could negatively impact efficiency.

Scottish Hill Index

Designed to enhance the overall productivity of the hill ewe. Aimed at increasing lamb growth rates, maternal ability, lambs reared and carcase weight and conformation. This complex index uses most of the EBVs available.

Welsh Hill Index

Designed to enhance maternal ability, lamb growth rate and carcase quality whilst optimising lambs reared and avoiding increased mature size to maintain appropriate ewes for the hill environment.

The newly (2020) revised Hill Index puts positive weighting on Eight-week Weight, Scan Weight and Maternal Ability EBVs with high positive weightings on Muscle Depth and Lamb Survival EBVs. Unlike the previous Index it now includes a positive but low weighting on Litter Size EBV to improve rearing rates.

Accuracy

Accuracy values indicate how much information is available to calculate an EBV. Values increase as an animal has more recorded progeny on the ground. The higher the value (%) the more confidence in the EBV and the lower likelihood that it will change over time.

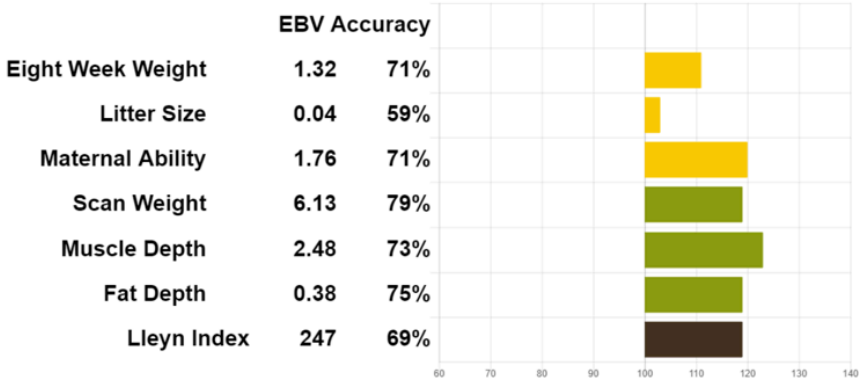
Accuracy values for each trait are presented next to each EBV score as shown in the EBV card below. Traits with low heritability (greater influence of environment) such as maternal traits will tend to have lower accuracy than high heritability traits, such as weight, as more data is required to make them accurate and robust.

EBV card

EBVs are presented, as shown for the ram below, to aid in selection. The centre line indicates the current average for the breed. Bars to the right indicate above average for the breed, whilst bars to the left indicate below average EBV scores. As such it is generally beneficial to be on the right hand side, but there are a couple to note:

- **Right hand, above average, for Birth Weight EBV is for lighter at birth.**
- **Right hand, above average, for Mature Size/weight EBV is heavier.**
- **Right hand, above average, for Fat Depth EBV and CT Fat Weight EBV are fatter.**

Sale card of a Lleyn ram showing a selection of the core EBVs (Source: Sean Cursiter)



Benchmark

Breed benchmarks are published each year. These show the range in values within the breed for each trait and allow animals to be ranked within the breed for individual EBVs and index by % bands for that particular year.

Taking the Lleyn ram above as an example, referencing the rams EBVs shown in the sale card against the Lleyn breed benchmark below, we can see that the ram has a breed Index score of 247 putting it in the top 10% (above 236) of the breed in 2021.

The ram has an above average Litter Size EBV and is within the top 25% for Eight-week Weight EBV. With a Scan Weight EBV of 6.13kg it is within the top 10% (above 5.65kg) of the breed and is also top 10% (fatter) for Fat Depth EBV. A Maternal Ability EBV of 1.76kg puts it in the top 5% of the breed for daughter milking ability and a Muscle Depth EBV of 2.48mm puts its well within the top 5% for loin muscularity.

Lleyn breed benchmark for 2021

Trait	Bottom 10%	Bottom 25%	Breed average	Top 25%	Top 10%	Top 5%
Eight-week Wt. (kg)	-0.06	0.35	0.80	1.25	1.66	1.9
Litter Size (lambs)	-0.09	-0.03	0.03	0.09	0.15	0.18
Maternal Ability (kg)	-0.09	0.28	0.70	1.12	1.49	1.72
Scan Weight (kg)	0.01	1.35	2.83	4.32	5.65	6.45
Muscle Depth (mm)	0.06	0.54	1.07	1.60	2.08	2.37
Fat Depth (mm)	-0.51	-0.32	-0.11	0.10	0.29	0.4
Lleyn Index	103	134	169	204	236	255

*Simplified benchmarks. Breed benchmarks show all traits and go to top and bottom 1% bandings.

Comparing different rams

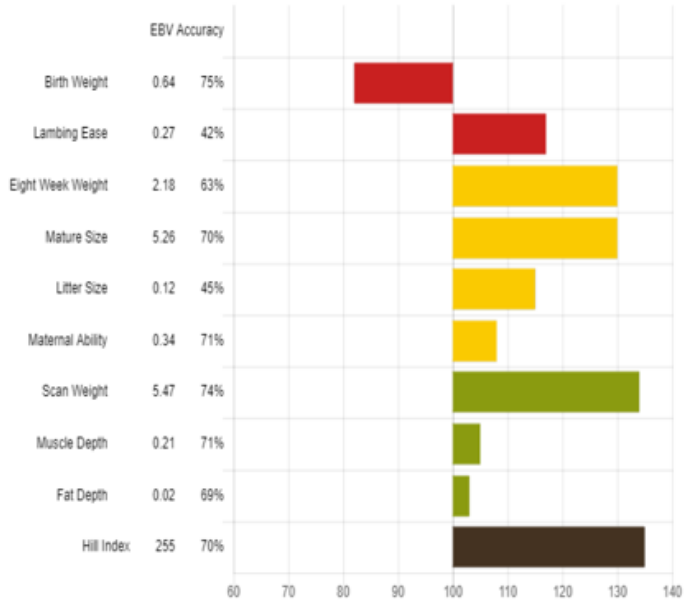
Whilst indexes are a valuable selection tool in providing an estimate of overall merit, if a ram excels in one or two particular traits it can become high index despite failings in another area which could be one your flock's priority traits. As such it essential to focus on EBVs specific to your breeding objectives as priority whilst using Indexes to simplify and balance selection.

Shown below are two high index Scottish Blackface rams but high index for very different reasons. Ram A has top 1% growth trait EBVs, top 10% Litter Size and good Maternal Ability but is average for carcass traits and is high for Mature Size with an EBV of +5.26kg.

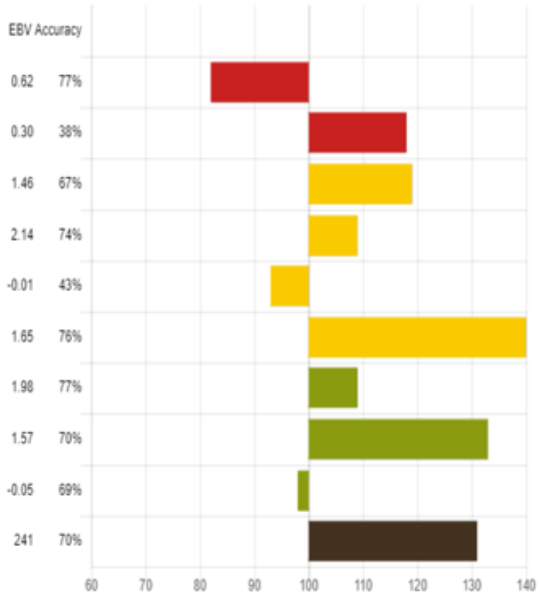
Ram B is slightly lower index and lower for Eight Week and Scan Weight (still top 10% and top 25%). However, if improving Maternal Ability (Top 1%) and carcass conformation (Top 1% Muscle Depth) whilst avoiding heavier ewes (Mature Size EBV +2.14kg) or increased scanning percentages are breeding priorities then Ram B is more appropriate than ram A.

The aim is to balance overall index, individual EBVs of importance and off course visual assessment. One means to do this is to pick a threshold say only rams in top 20% Index for the breed or only those above a certain EBV figure then select through the resulting smaller group of rams based on all three factors.

Ram A



Ram B



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