Genetics: Breeds, Selection, and Crossbreeding

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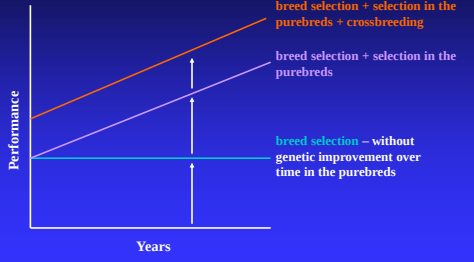
Effective Utilization of Genetics in the U.S. Sheep Industry



Breeds – the raw material for genetic improvement

Over 60 Breeds - Large Variation

Breed Diversity

- It is important to preserve all our present breeds
- Minor or rare breeds are potential reservoirs for genes that may be important in the future.
- However, only a small number of breeds will be commercially important at any one time.
- Producers wishing to benefit the most from current commercial markets need to use breeds that best meet the criteria of those markets.

U.S. Purebred Sheep Registrations, average of 1965 and 1966

Rank	Breed	No. of registrations	% of total registrations
1	Suffolk	32,314	27.9
2	Hampshire	26,168	22.6
3	Corriedale	12,448	10.7
4	Southdown	8,986	7.7
5	Columbia	6,502	5.6
6	Shropshire	6,352	5.5
7	Dorset	6,070	5.2
8	Rambouillet	5,742	4.9
9	Cheviot	3,274	2.8
10	Montadale	2,718	2.3
Top 10 breeds		110,574	95.3
All breeds		116,011	100.0

U.S. Purebred Sheep Registrations, average of 2014 and 2015

Rank	Breed	No. of registrations	% of total registrations	% change from 1965/66
1	Hampshire	8,238	12.2	-69
2	Katahdin	8,037	11.9	NA
3	Dorper	7,858	11.6	NA
4	Suffolk	6,751	10.0	-79
5	Dorset	5,733	8.5	-6
6	Southdown	5,125	7.6	-43
7	Shropshire	2,258	3.3	-64
8	Rambouillet	2,039	3.0	-64
9	Shetland	2,026	3.0	NA
10	Polypay	1,389	2.0	NA
	Top 10 breeds	49,451	73.2	-55.3
	All breeds	67,596	100.0	-41.7

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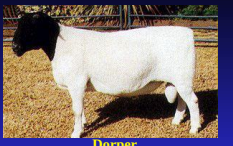
Recently - More Popular Breeds

Katahdin



Dorper

Shetland

Polypay

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U.S. Hampshires: 1960 - 1915

1st Place Pen of Ram Lambs, Chicago International, 1960, University of Wisconsin

The popularity of a breed changes over time – and individuals within a breed also change over time due to selection.

2015 model

Selection – determining which animals will be parents

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Selection for Conformation is Effective – In Changing Conformation

U.S. Southdowns – Then and Now

However, conformation is not highly correlated with performance for most production traits.

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Production Traits

Traits that result in improved lamb, wool, and/or milk production

Litter size, lamb survival, milk production, weaning weight, postweaning gain, loin eye area, fat thickness, fleece weight, disease resistance, etc.

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Production Traits

Steps in selection of replacements for production traits

1. Initial selection on performance records or estimates of genetic value – without looking at the animals. Select 10 – 15% more animals than needed.
2. Visual appraisal of only the animals selected on the basis of records. Cull the poorest 10 – 15% on visual appraisal.

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Selection of Replacement Ewe Lambs

Minimum record-keeping requirements:

1. Individual identification of ewes and lambs
2. Record birth date, lamb ID, dam ID, and sex of each lamb
3. Record number of lambs born and raised by each ewe and birth-rearing type of each lamb
4. Weigh lambs at weaning and record date of weaning

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Adjust Litter Size for Age of Ewe

Age of Ewe Multiplicative Adjustment Factors for Litter Size	
Age, yr.	Adjustment
1	1.48
2	1.17
3	1.05
4	1.01
5 - 6	1.00
7	1.02
8	1.05
9+	1.13

Adjust litter size for age of the ewe.

Select replacement ewe lambs from dams with high average adjusted litter size.

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Adjust Lamb Weaning Weight for Age at Weaning, Age of Dam, Sex of Lamb, and Type of Birth-Rearing of Lamb.

Multiplicative Adjustments for Lamb Weaning Weight		
Item	Class	Adj. Factor
Age of dam, yr.	1	1.14
	2	1.08
	3 - 6	1.00
	7+	1.05
Sex of lamb	Ram	.91
	Wether	.97
	Ewe	1.00
Type of birth-rearing of lamb	Single - Single	1.00
	Single - Twin	1.17
	Twin - Single	1.11
	Twin - Twin	1.21
	Triplet+ - Single	1.19
	Triplet+ - Twin	1.29
	Triplet+ - Triplet+	1.36

Select replacement ewe lambs with highest adjusted weights.

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Selection of Replacement Rams

Most commercial flocks purchase their rams

Since fewer rams are selected than ewes, rams should have higher genetic values than ewes

Most of the genetic improvement in flocks is the result of ram selection rather than ewe selection

Select rams from flocks that are serious about genetic improvement for production traits

The most accurate estimate of genetic merit is the Estimated Breeding Value (EBV) or Expected Progeny Difference (EPD)

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EBV and EPD

Estimated Breeding Value (EBV) = An estimate of the sum of the individual effects of all genes possessed by an animal that affect a particular trait.

Expected Progeny Difference (EPD) = The expected performance of a group of progeny from a sire or dam when the other parent is of average genetic merit.

Since a parent passes a sample half of its genes to its progeny, EPD = ½ EBV.

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EBVs

60-day weaning wt, lb.	120-day postweaning wt., lb.	Maternal milk, lb.	Milk + Growth, lb.	Number born, no. lambs / 100 ewes
+ 3.0	+ 8.2	+ 0.2	+ 1.8	+ 2.2
Average for active adult rams:				
+ 0.0	+ 0.2	- 0.2	- 0.2	- 4.8

ISU 7104 is expected to have genes that result in him having a 120 day weight that is 8.0 lb. greater than an average NSIP Hampshire ram, and his lambs are expected to weigh 4.0 lb. more at 120 days of age than lambs from an average NSIP Hampshire ram.

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How much is a superior EBV/EPD worth?

50 commercial white-faced ewes mated to a Hampshire ram

Lambs sold at 180 days of age as market lambs

Average NSIP Hampshire ram:
50 ewes x 1.60 lambs/ewe x 122 lb. x $1.50/lb. = $14,640

ISU7104:
50 ewes x 1.60 lambs/ewe x 128 lb. x $1.50/lb. = $15,360

ISU7104 expected advantage = $720/year, $1,440 in 2 years, and $2,160 in 3 years

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Where Do I Get EBVs?

EBVs are obtained through the National Sheep Improvement Program (NSIP, www.nsip.org).

EBVs available for several reproductive, growth, carcass, and wool traits.

Several indexes are available that combine several traits.

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Top NSIP Polypay Active Rams for U.S. Maternal Index

Elite Report - Polypay - Rams with 2015 - 2016 Offspring

Maternal — **August 2016**

ID / Flock	Prg.Flks / Inbrd.Coef	BWt kg	MWWt kg	WWt kg	PWWt kg	YWt kg	NLW %	NLB %	PFEC %	YGFW %	YFD mc	PSC cm	PFAT mm	PEMD mm	USMAT	Sire / Dam
620061201515519	23 : 1	0.27	3.10	1.69	3.54	1.79	24.9	13.5	0.0	-0.8	0.0	1.4	0.00	0.00	118.8	620981201413009
Uncompahgre Polypay Farm	0.00	76	43	77	79	65	35	39	0	53	0	48	0	0		620981201213085
620007201440437	21 : 1	0.40	2.15	2.02	4.73	4.20	30.5	31.8	0.0	0.0	0.0	0.0	0.00	0.00	118.1	620007201313043
JCC Polypay	0.19	78	50	78	78	65	40	46	0	0	0	0	0	0		620007201313018
620096201SH15028	9 : 1	0.62	1.64	3.16	6.92	5.43	29.8	23.8	0.0	8.9	0.0	0.0	0.00	0.00	117.4	620095201 3K3047A
Hausser Polypays	0.03	69	45	68	69	58	39	43	0	52	0	0	0	0		620096201 2H12034
620078201501 5301	48 : 1	0.76	1.14	2.23	3.38	3.39	33.8	17.6	0.0	0.0	0.0	0.0	0.00	0.00	117.4	620078201 0P10190
UW-Madison Polypay Sheep Unit	0.12	82	57	83	85	72	50	54	0	0	0	0	0	0		620078201 3P12349
620074201 0PA0210	214 : 3	0.43	3.19	2.26	4.49	2.86	20.9	32.7	0.0	0.0	0.0	0.0	0.00	0.00	117.1	620074200 7PA7146
	0.10	92	74	91	92	79	60	65	0	0	0	0	0	0		620074200 8PT820
620078201501 5319	3 : 1	0.57	0.71	2.15	3.65	3.21	36.7	28.2	0.0	0.0	0.0	0.0	0.00	0.00	117.0	620078201 0P10190
UW-Madison Polypay Sheep Unit	0.15	88	57	88	89	80	52	55	0	0	0	0	0	0		620078201 0P10416
620076201 3E3082T	89 : 3	0.53	2.31	2.00	3.86	3.04	25.8	26.1	22.3	0.0	0.0	0.0	0.00	0.00	116.8	620074201 1WA1041
Elm Creek Polypay	0.09	86	65	82	79	64	59	64	53	0	0	0	0	0		620075201 0E8963V
620098201 9H5103B	25 : 1	0.19	1.89	2.20	6.42	5.83	28.0	27.6	0.0	0.0	0.0	0.0	0.00	0.00	116.7	620007201313043
Henke Family Polypay	0.03	76	47	75	77	64	39	42	0	0	0	0	0	0		620082201 2HP0281
620078201 0P10190	261 : 4	0.70	0.98	1.97	2.51	2.48	32.3	14.1	0.0	2.4	0.0	0.0	0.00	0.00	116.4	620007200 9020909
UW-Madison Polypay Sheep Unit	0.00	87	63	92	91	85	77	61	0	72	0	0	0	0		620078200 5P05026
620078201501 5398	40 : 1	0.72	0.80	2.17	3.22	2.15	32.8	26.4	0.0	0.0	0.0	0.0	0.00	0.00	115.8	620078201 0P10190
UW-Madison Polypay Sheep Unit	0.05	91	53	77	75	63	47	51	0	0	0	0	0	0		620078201 3P13357
620007201515 0508	31 : 1	0.67	2.00	2.89	5.45	3.67	24.0	27.5	0.0	0.0	0.0	0.0	0.00	0.00	115.8	620074201 0PA0210
JCC Polypay	0.01	79	50	78	78	65	40	44	0	0	0	0	0	0		620007201 2130243
620078201 4P14305	36 : 1	0.42	2.10	0.76	0.59	0.62	25.9	23.0	0.0	0.0	0.0	0.0	0.00	0.00	115.7	620075201 2E2050B
UW-Madison Polypay Sheep Unit	0.01	79	49	77	79	66	45	46	0	0	0	0	0	0		620078201 2P12429
620098201 9H5027T	31 : 1	0.42	2.67	1.73	3.37	2.39	20.8	25.8	0.0	0.0	0.0	0.0	0.00	0.00	115.6	620098201 4H14022
Henke Family Polypay	0.03	73	43	70	68	54	36	40	0	0	0	0	0	0		620082201 1HP0217

USA Maternal Index = (0.265 x WWT EBV) + (1.200 x MWWT EBV) + (0.406 x NLW EBV) – (0.035 x NLB EBV).

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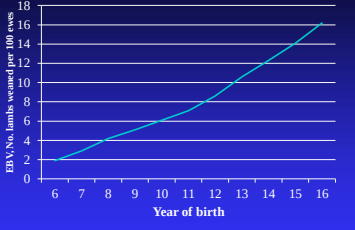
Polypay Genetic Trend for Number of Lambs Weaned (NSIP, 2006-2016)



Polypay sheep born in 2016 had an average NLW EBV of +16.2 lambs/100 ewes.
Polypay sheep born in 2006 had an average NLW EBV of +1.9 lambs/100 ewes.

An average genetic change of +1.4 lambs weaned per 100 ewes lambing/year.

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Performance of Crossbred Lambs Sired by NSIP and Non-NSIP Suffolk Rams

- **245 Suffolk x dairy lambs born at University of Wisconsin in 1999 and 2000**
- **7 NSIP Suffolk sires (average 120-day wt. EPD = + 2.6 lb.) and 4 non-NSIP Suffolk rams**
- **Lambs raised in confinement on high-energy diets**

Body weights (lb.) of lambs sired by NSIP and non-NSIP Suffolk rams in 1999 and 2000

Sire source	Number	Birth	60 d	120 d
NSIP	130	12.7	55.8	103.4
Non-NSIP	115	12.7	54.0	99.6

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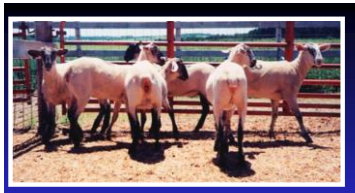

NSIP-sired Lambs, 2000

Non-NSIP-sired Lambs, 2000

The Basics of Making Progress from Selection is Simple!!

Collect performance information on individual sheep

Calculate estimates of genetic value – EBV

Select individuals for parents that have superior EBVs and physical soundness

The details (e.g. individual identification, maintaining pedigree records, recording performance, selecting on EBVs rather than on visual or phenotypic traits) may be less easy.

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Quote from Dan Morrical, Sheep Extension Specialist, Iowa State University:

"There's been a switch in selection method," said Morrical. "Buyers used to look at phenotype, then see if the numbers backed up what they were seeing. Now it's the other way around. They select for numbers, then see if they look right."

From: Genetic Data Pays Off At Sale Barn. September 2016. Sheep Industry News, ASI. 20(9):10-11.

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Crossbreeding – mating rams and ewes of different breeds

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Crossbreeding – Why?

1. Breed complementarity – Utilize the strong points of two or more breeds in a crossbreeding system to maximize performance.


X

2. Hybrid vigor or heterosis – increased performance of crossbreds compared to the purebreds that make up the cross.

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Hybrid Vigor Example – 60-day Weaning Weight

Hampshire x Hampshire lambs = 60 lb.

Hampshire x Dorset and Dorset x Hampshire lambs = 58 lb.

Average of purebred Hampshire and Dorset lambs = (60 + 50) / 2 = 55 lb.

Hybrid vigor = 58 – 55 = 3 lb.

% HV = ((crossbred – purebred) / purebred) x 100
= ((58 – 55) / 55) x 100 = (3 / 55) x 100
= .05 x 100 = 5 %

Dorset x Dorset lambs = 50 lb.

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Estimates of Hybrid Vigor

Trait	Ind., %	Mat., %	Pat., %
Conception rate	2.6	8.7	1.0 (30.0 if fall mating)
Litter size	2.8	3.2	-1.0
Lamb survival	9.8	2.7	2.0
Lamb weaning wt.	5.0	6.3	3.0
Lamb wt. wn./ewe mated	17.8	18.0	3.0
Post-weaning wt.	6.6	5.0	0.0
Carcass traits	0.0	0.0	0.0

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Trait	% Ind. HV	% Mat. HV	% Pat. HV
Lb. lamb weaned / ewe mated	18 %	18 %	3 %

+ 43 %
93 lb. — Cross rams x Cross ewes = 4-breed cross lambs

Paternal HV = 3%

+ 39 %
90 lb. — Pure rams x Cross ewes = 3-breed cross lambs

Maternal HV = 18%

+ 18 %
77 lb. — Pure rams x Pure ewes = 2-breed cross lambs

Individual HV = 18%

65 lb. — Pure rams x Pure ewes = Pure lambs

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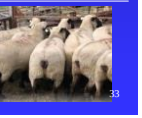
Crossbreeding Systems

Performance of three breeds of sheep

Breed	Fertility, %	Prolificacy, no.	Lamb survival, %	Lamb wean. wt., lb.	Wt. wean. per ewe, lb.
Finnsheep	90	2.30	90	40	74
Dorset	90	1.60	85	48	59
Hampshire	90	1.45	80	55	57
Average	90	1.78	85	48	63





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3-Breed Roto-Terminal Crossbreeding System

Rotation (25-35 ewes)	Terminal (65-75 ewes)	Market Lambs
F rams x D ewes		All Hamp-sired lambs, all F- and D-sired male lambs, some F- and D-sired cull ewe lambs
D rams x FD ewes	FD ewes x Hamp rams	
F rams x DF ewes	DF ewes x Hamp rams	
D rams x FD ewes	FD ewes x Hamp rams	95 lb. lamb weaned per ewe exposed
(system continues)		

Advantages:

1) All ewes (after start) and all lambs are crossbred – good use of individual and maternal hybrid vigor (67% of Mat HV, 67% & 100% Ind HV)
2) Good breed complementarity

Disadvantage: ?

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Crossbreeding Summary Comments

1. Good crossbreds result from good purebreds.
2. Don't expect hybrid vigor to compensate for poor or inappropriate genetics.
3. Limit the number of breeds to those that have high levels of performance.
4. Hybrid vigor is maximized when no breeds are in common in the sire and dam.
5. More hybrid vigor is obtained when less related breeds are crossed.
6. An organized crossbreeding system is needed to take best advantage of hybrid vigor and breed complementarity.

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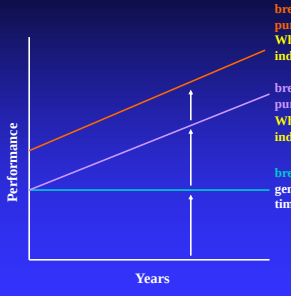

breed selection + selection in the purebreds + crossbreeding
Where the commercial sheep industry should be!!

breed selection + selection in the purebreds
Where the purebred sheep industry should be!!

breed selection – without genetic improvement over time in the purebreds

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