Evaluating Cumulative Cow Productivity

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Background

Ideal cow (Hohenboken, 1988)

- Conceives at first opportunity – weans an older, heavier calf every year
- Easy-care – problem free, no special treatment or handling
- Extended productive life – flexibility in culling/replacement decisions
  - market high-value bred cows? cow beef?

Progress towards herd of ideal cows should

- Increase number of calves weaned – higher conception, calving, weaning rates
- Increase weight of calves weaned – older calves, more calves from mature dams
- Reduce replacement rate & heifer development costs
  - Or increase mature bred cows for sale
- Reduce treatment costs & handling problems

Selection for ideal cow

- Little progress by culling problem cows
- Genetic evaluations needed to select sires whose daughters come closest to ideal

Background

Stayability

- Stayability to age 6 was first attempt to evaluate sires in NCE
  - Indirectly addresses some characteristics of ideal cow. If cows are culled for reproductive failure and other problems, probability of siring daughters who remain in production at 6 and older may reflect probability that daughters will be fertile and problem-free.

Stayability improved – whole-herd reporting

- Refined definitions and earlier evaluations enabled by annual cow production records
  - calf, reason for no calf, or reason for disposal
  - 5 calves by age 6 (Red Angus, Gelbvieh)
  - Stayability to younger ages (Bringham et al., 2007) – earlier evaluations before daughters have opportunity for age 6 observation, combined in aggregate stayability to 6
  - Random regression (Jamrozik et al., 2014, Speidel et al., 2016, 2017)
    - Include observations from multiple ages to predict regression coefficients for curve describing stayability
    - EPD for stayability to a specific age projected from age x regression coefficients

Background

- Cow fertility and productivity in NCE
  - Days to calving (Johnston et al., 1996)
    - Days between turning bulls out and calving, value for non-calvers is maximum observed + penalty
  - Length of productive life (Coffey et al., 2007; Bringham, 2012)
  - Calves born or weaned by a specific age (MacNeil & Vukasinovic, 2011; Moore et al., 2017)
  - Interval between first and second calf (Coffey et al., 2007; Moore et al., 2017)
  - Except for days to calving, most traits proposed or used in NCE use one observation per cow
- Can useful EPD be obtained from random regression techniques applied to annual cow records?
  - What is the impact of different culling and reporting strategies?

Data

Cumulative production traits

- Counts
  - Number of pregnancies – may not be explicitly reported
  - Number of calves born
  - Number of calves weaned
- Continuous measures
  - Days nursing – sum of calves' weaning ages
    - Annual record equivalent to negative days-to-calving, except that zero for non-calvers implies a penalty of minimum weaning age
  - Weight weaned – sum of calves' actual weaning weights
    - Not adjusted for calf age – favor cows weaning older, heavier calves
    - May be adjusted for calf sex (# steer calves - # heifer calves)

Data

- USMARC Germplasm Evaluation Project (GPE)
  - Historic - 37 sire breeds evaluated in 8 cycles with 6-10 breeds, including Hereford and Angus, in each cycle
  - Current – continuous evaluation of 18 breeds with national cattle evaluations
  - Heifers exposed in same mating group considered to have same opportunity for lifetime production
    - Bred AI followed by natural service or natural service only depending on phase in cycles
    - ~25% AI calves in current GPE
  - Cows generally kept for 6-7 matings with minimal culling
    - Extreme problems
    - Open twice or open following two consecutive breeding seasons
      - Spring & Fall calving – open females moved to next season

Data

- Pedigree
  - 115,119 individuals (through Fall 2017)
    - Ancestors of AI sires sampled in GPE (supplied by breed associations)
    - Recorded pedigree of females transferred to GPE from other populations
- Breeding, calving, weaning records
  - 13,715 GPE-born females exposed to calve first as 2-year-old
    - 73,242 exposures & pregnancy tests (5.3/female)
      - Accumulated 0/1 pregnancy test results following each breeding season
    - 70,149 potential calvings & weaned calves (5.1/female)
      - Calving and weaning unknown for pregnant culls
      - Sum of number of calves born (weaned) for each calf born (weaned) at each age
        - Included twins (not fostered by another cow)
      - Added calf age (weight) to cumulative days nursing (weight weaned) for each calf weaned
      - Failure recorded
        - Cumulative record at an age = record at previous age if no calf born (weaned)

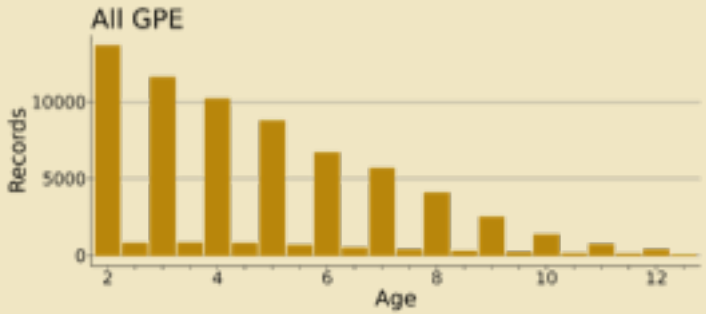
Data

- Culling and reporting policies
  - All GPE records
  - Imposed first-open culling
    - Discarded records from matings after a female was open once, including records from daughters born after she was open once
    - 12,994 females
      - 59,990 exposures (4.6/female)
      - 57,592 potential calvings (4.5/female)
  - AI-sired calves (mimic incomplete reporting)
    - Only accumulated records from AI-sired calves
      - Failure not recorded – record unknown if female was open, did not calve or had a calf sired by natural service
    - 6,078 females
      - 10,907 exposures, calving, weaning records (1.8/female)

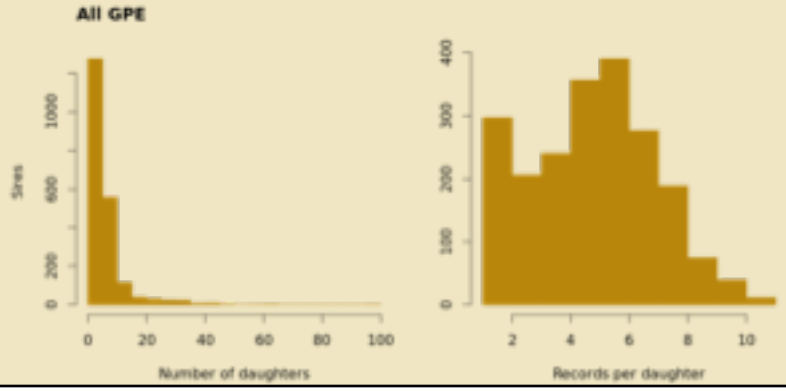
Exploratory analyses

- Random regression with quadratic B-spline function (3-term polynomial)
  - Model included
    - opportunity group (birth year, season, mating group)
    - cow age (0.5 year increments)
    - animal
    - permanent environment
  - WOMBAT (Meyer, 2007) to estimate variance components and predict EBV
  - EBV projected to ages 2, 3, 5, 6 & 8
    - Correlations among EBV
    - Sire EBV and daughters' mean stayability to age 6
  - Accuracy of calves weaned and days nursing EBV
    - Need 3x3 prediction error covariances from inverse coefficient matrix

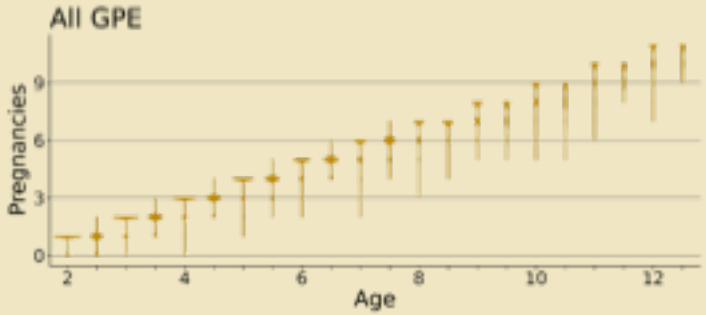
Number of records by age



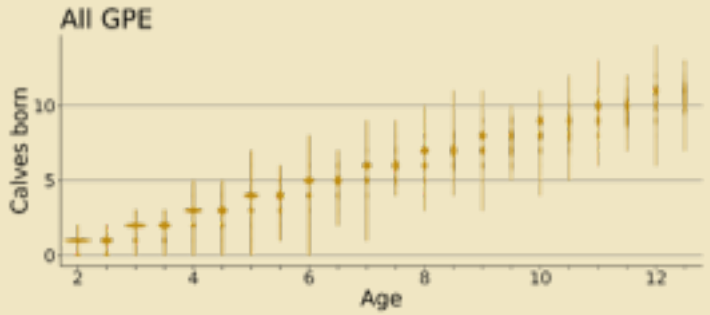
Daughters per sire



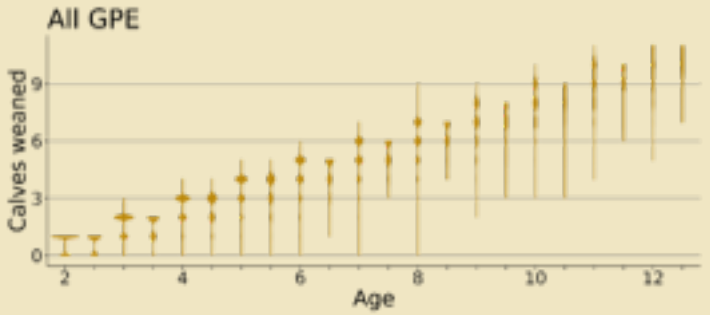
Pregnancies



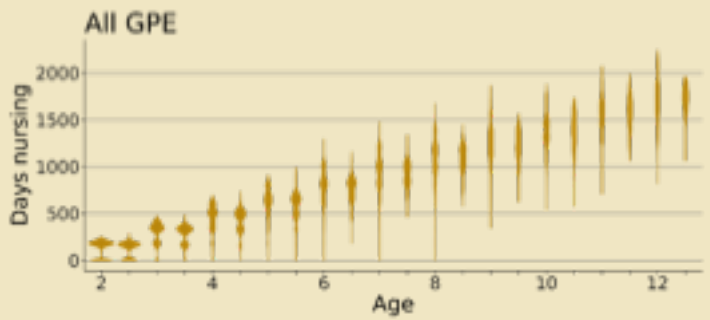
Calves born



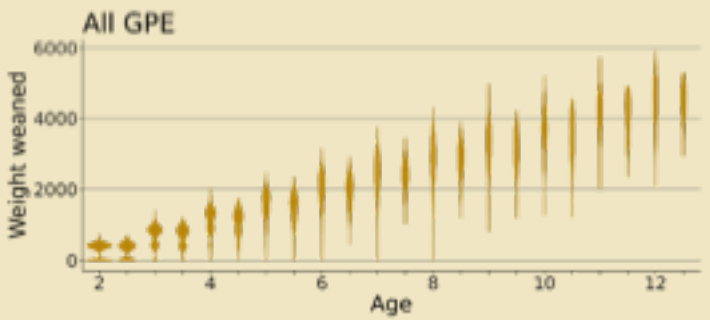
Calves weaned



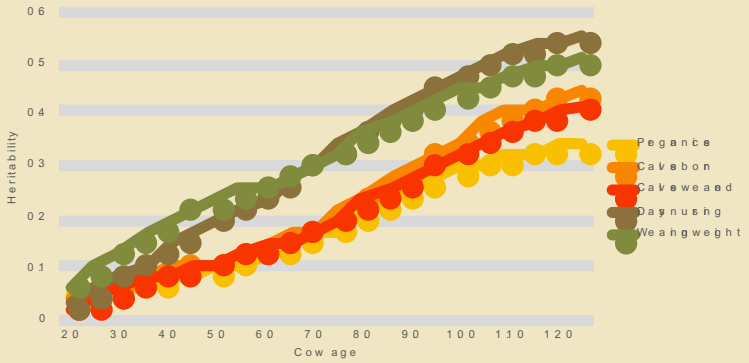
Days nursing



Weight weaned



Age-specific heritability estimates (All GPE)



Correlations among ages - pregnancies

Age	2	3	5	6	8
2		0.849	0.620	0.584	0.542
3	0.866		0.914	0.857	0.721
5	0.715	0.947		0.986	0.889
6	0.714	0.918	0.992		0.952
8	0.724	0.852	0.941	0.975	

Random regression genetic correlations above diagonal
Correlations among sire EBV below diagonal

Correlations among ages – calves born

Age	2	3	5	6	8
2		0.807	0.615	0.555	0.416
3	0.829		0.911	0.810	0.532
5	0.709	0.906		0.973	0.793
6	0.656	0.806	0.978		0.911
8	0.546	0.598	0.866	0.951	

Random regression genetic correlations above diagonal
Correlations among sire EBV below diagonal

Correlations among ages – calves weaned

Age	2	3	5	6	8
2		0.736	0.698	0.727	0.726
3	0.813		0.964	0.905	0.688
5	0.885	0.981		0.981	0.829
6	0.935	0.937	0.987		0.922
8	0.964	0.798	0.896	0.957	

Random regression genetic correlations above diagonal
Correlations among sire EBV below diagonal

Correlations among ages – days nursing

Age	2	3	5	6	8
2		0.701	0.556	0.549	0.534
3	0.798		0.951	0.904	0.760
5	0.796	0.984		0.988	0.896
6	0.817	0.962	0.994		0.954
8	0.841	0.895	0.953	0.980	

Random regression genetic correlations above diagonal
Correlations among sire EBV below diagonal

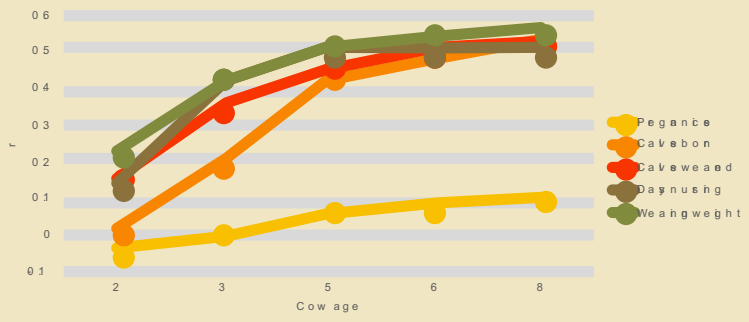
Correlations among ages – weight weaned

Age	2	3	5	6	8
2		0.817	0.712	0.694	0.638
3	0.901		0.959	0.913	0.761
5	0.883	0.981		0.988	0.891
6	0.882	0.954	0.993		0.950
8	0.856	0.870	0.943	0.975	

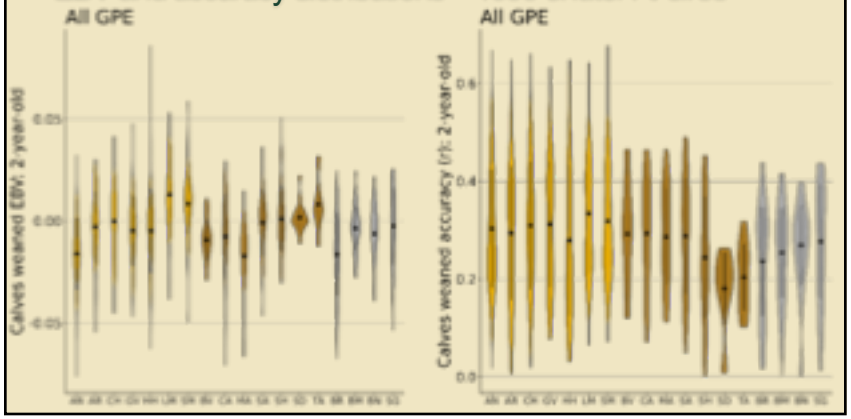
Random regression genetic correlations above diagonal
Correlations among sire EBV below diagonal

Correlations - sire EBV with daughters' stayability

269 sires with ≥ 10 daughters with opportunity to stay to age 6



EBV and accuracy distributions – 1999 & later AI sires



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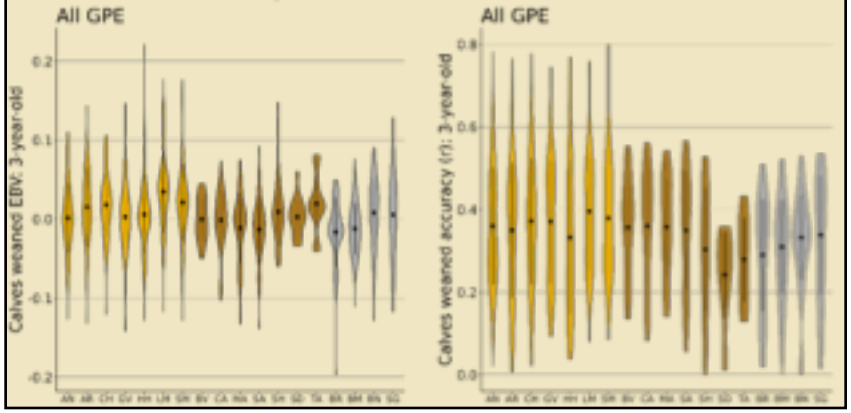

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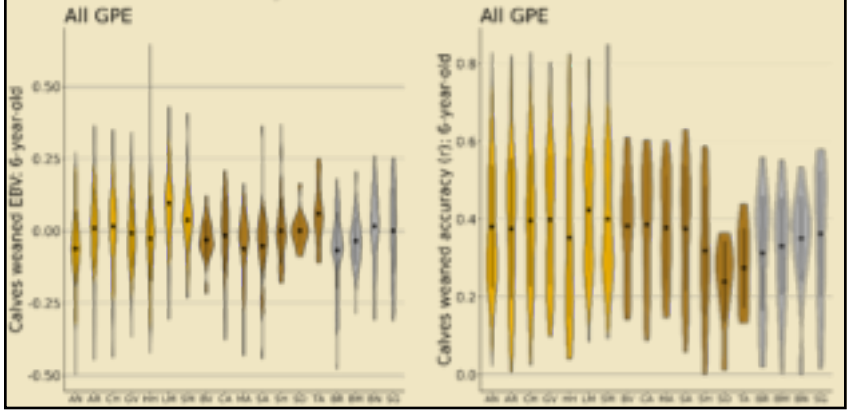

Correlations between same-age sire EBV

Pregnancies	2	1.000	0.744	0.365	0.581	0.493
	3	1.000	0.653	0.399	0.487	0.479
	5	1.000	0.583	0.439	0.528	0.503
	6	1.000	0.534	0.423	0.534	0.493
	8	1.000	0.466	0.403	0.536	0.470
Calves born	2	0.744	1.000	0.624	0.638	0.650
	3	0.653	1.000	0.744	0.549	0.668
	5	0.583	1.000	0.837	0.641	0.738
	6	0.534	1.000	0.862	0.683	0.757
	8	0.466	1.000	0.889	0.741	0.779
Calves weaned	2	0.365	0.624	1.000	0.813	0.799
	3	0.399	0.744	1.000	0.725	0.823
	5	0.439	0.837	1.000	0.740	0.847
	6	0.423	0.862	1.000	0.764	0.858
	8	0.403	0.889	1.000	0.813	0.875
Days nursing	2	0.581	0.638	0.813	1.000	0.813
	3	0.487	0.549	0.725	1.000	0.790
	5	0.528	0.641	0.740	1.000	0.813
	6	0.534	0.683	0.764	1.000	0.829
	8	0.536	0.741	0.813	1.000	0.861
Weight weaned	2	0.493	0.650	0.799	0.813	1.000
	3	0.479	0.668	0.823	0.790	1.000
	5	0.503	0.738	0.847	0.813	1.000
	6	0.493	0.757	0.858	0.829	1.000
	8	0.470	0.779	0.875	0.861	1.000

Culling and reporting policies

Correlations between sire EBV for same age and trait using all GPE records and imposed first-open culling

Age	Pregnancies	Calves born	Calves weaned	Days nursing	Weight weaned
2	0.593	0.799	0.810	0.875	0.931
3	0.517	0.747	0.867	0.912	0.929
5	0.585	0.867	0.916	0.926	0.936
6	0.394	0.900	0.929	0.931	0.940
8	0.253	0.916	0.933	0.935	0.943

Culling and reporting policies

Correlations between sire EBV for same age and trait using all GPE records and accumulated AI calf records

Age	Pregnancies	Calves born	Calves weaned	Days nursing	Weight weaned
2	0.457	0.198	0.274	0.188	0.346
3	0.228	0.077	0.206	0.130	0.267
5	0.187	0.111	0.225	0.118	0.269
6	0.135	0.132	0.246	0.099	0.277
8	-0.254	0.009	0.273	0.052	0.284

Observations, Questions, Concerns

- Cumulative cow productivity to mature and older ages appears to be at least moderately heritable
  - Number of pregnancies less heritable than other traits
  - h^2 low in heifers and increases with age – similar pattern observed in other data
    - Artifact of data structure – few sires have aged daughters?
- Moderate to strong genetic correlations among all ages
  - Usually high correlations between sire EBV projected to different ages
    - Value of aged cow records – truncate at 8, 9, 10?
  - EBV rank for age 3 similar to 5, 6 & 8
    - Rescaled – larger differences at later ages
- Sire evaluations similar using all records or first-open culling, but little agreement between all records and cumulative AI calf records
  - Annual success or failure needed for meaningful evaluations?

Observations, Questions, Concerns

- Weaning age?
  - Differences between cows that wean calves is not affected by average weaning age
  - Weaning age will affect differences in days nursing and weight weaned between cows that do or do not wean a calf
    - Bias in multi-herd evaluation favoring sires of herds that wean early
- Continuous traits mask reproductive success/failure?
  - Observations for cows with a late/light calf every year can be similar to same-age cows who weaned early/heavy calves but missed a calf
- Economic values?
  - Economically relevant traits related to cumulative cow productivity depend on production system and marketing

Observations, Questions, Concerns

- Further analyses
  - Indicator traits observed on young cattle (prior to first breeding)
    - Reproductive tract score
    - Antral follicle count
  - Genomics
    - GGP-F250 functional SNP genotypes
      - Evaluate genomic predictions in GPE and other populations genotyped with F250
    - Relevance of ungenotyped historic GPE to current genotyped GPE?

Conclusions

- Annual records from whole-herd reporting enable genetic evaluations of cow productivity traits
  - Records of success and failure needed
  - Random regression can use all records to predict productivity at any age
  - Further investigation
    - Adequate records
    - Trait definitions for multiple-herd evaluations
    - Trait values
    - Reliable indicators