# EPDs and RISK

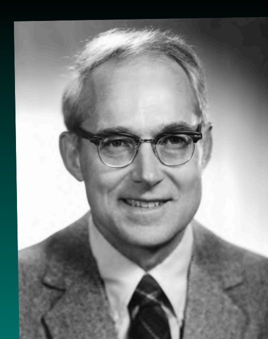
6-16-2016 DVV

## EPDs and RISK

Old?

Growing older?

6-16-2016 DVV



EPDs and RISK

6-16-2016 DVV

EPDs and RISK
What is accuracy?
Do we need accuracy?

6-16-2016 DVV

TOPICS
Emphasis on accuracy (a limited survey)
History
Accuracy
Reliability
BIF-Accuracy
Future Progeny Accuracy
Standard Error of Prediction
Confidence Ranges
The Gambler

TOPICS (cont'd)
Standard Error of Prediction
Difference between pair of EBV
Covariance between a pair of EBV
One table for all traits?
G-BLUP
Bayes-Gibb's sampling chains
EBV; EPD = EBV/2 ******
Good luck!

A SURVEY

| Bull | EBV | Accuracy |
|---|---|---|
| X | +10.0 | 0.60 |
| Y | +10.0 | 0.90 |

Choose: X or Y ?

| Bull | EBV | Accuracy |
|---|---|---|
| X | +10.0 | 0.60 |
| XX | + 4.0 | 0.90 |

Choose: X or XX ?

| Bull | EBV | Accuracy [REL] |
|---|---|---|
| X | +10.0 | 0.36 |
| XX | + 4.0 | 0.81 |

Choose: X or XX ?

| Bull | EBV | Accuracy [BIF] |
|---|---|---|
| X | +10.0 | 0.20 |
| XX | + 4.0 | 0.56 |

Choose: X or XX ?

| Bull | EBV | Accuracy [PROG] |
|---|---|---|
| X | +10.0 | 0.30 |
| XX | + 4.0 | 0.45 |

Choose: X or XX ?

HISTORY

Traditionally: *Accuracy = Correlation*

Correlation(EPD, true PD) [0 <-> 1]

Correlation(EBV, true BV) [0 <-> 1]

*Squared-Accuracy* is fraction of genetic variance accounted for by EBV [0 <-> 1]

A CONFLICT?

EPD = EBV/2 has dollar value.

High accuracy is reassuring.

Too much emphasis on accuracy?

Not directly associated with $$$

How to de-emphasize accuracy?

The *Dairy* attempt

The *Beef* attempt

RELIABILITY

The *DAIRY* attempt (successful?)

Predicted Transmitting Ability

PTA = EPD = EBV/2

*Reliability = Squared-Accuracy*

Fraction of genetic variance accounted for by EBV

Limits are 0.0 <-> 1.0

Paul VanRaden ~ 1989

| Accuracy | Reliability |
| --- | --- |
| 0.20 | 0.04 |
| 0.30 | 0.09 |
| 0.40 | 0.16 |
| 0.50 | 0.25 |
| 0.60 | 0.36 |
| 0.70 | 0.49 |
| 0.80 | 0.64 |
| 0.90 | 0.81 |
| 0.99 | 0.98 |

**BIF-ACCURACY**

The *BEEF* attempt (successful, confusing?)

BIF-Accuracy

Birthed near a tornado in Atlanta in 1984!

Uses squared-accuracy

Tracks Standard Error of Prediction (SEP)

SEP = SQRT[Variance of Prediction Error]

Need Variance(breeding values) = Vg

Richard Willham ~ 1984

**Prediction Error, PE**

PE = (EBV – True BV)

Variance of PE = Var[EBV – True BV]

Var(PE) = (1 – squared-accuracy) x Var(BV)

= (1 – acc$^2$)Vg

***Standard Error of Prediction***

SEP = SQRT[Var(PE)] = SQRT[(1 – acc$^2$)Vg]

**BIF-Accuracy**

*BIF-Accuracy = 1 – SQRT[(1 – acc$^2$)]*

SQRT[(1 – acc$^2$)] is standardized SEP

SEP = SQRT[(1 – acc$^2$)Vg]

As acc$^2$ increases towards ONE,

SEP decreases towards ZERO

As SEP decreases towards ZERO,

BIF-accuracy goes to ONE

Limits are 0 <-> 1.0

| Accuracy | Reliability | BIF-Accuracy |
| --- | --- | --- |
| 0.20 | 0.04 | 0.02 |
| 0.30 | 0.09 | 0.05 |
| 0.40 | 0.16 | 0.08 |
| 0.50 | 0.25 | 0.13 |
| 0.60 | 0.36 | 0.20 |
| 0.70 | 0.49 | 0.28 |
| 0.80 | 0.64 | 0.40 |
| 0.90 | 0.81 | 0.56 |
| 0.99 | 0.98 | 0.86 |

***Future Progeny Accuracy***

Progeny w/records >> Bull EPD = EBV/2

EPD is expected transmission to future progeny

Accuracy for any new progeny is one-half accuracy of EPD or EBV of the sire*

Progeny accuracy can never exceed 0.50 unless records of self, dam, etc.

| Accuracy | Reliability | BIF Acc | Prog Acc |
|---|---|---|---|
| 0.30 | 0.09 | 0.05 | 0.15 |
| 0.40 | 0.16 | 0.08 | 0.20 |
| 0.50 | 0.25 | 0.13 | 0.25 |
| 0.60 | 0.36 | 0.20 | 0.30 |
| 0.70 | 0.49 | 0.28 | 0.35 |
| 0.80 | 0.64 | 0.40 | 0.40 |
| 0.90 | 0.81 | 0.56 | 0.45 |
| 0.99 | 0.98 | 0.86 | 0.50 |

**Summary so far**

**Four Measures of Accuracy**

| Bull | EBV | $Acc^{1}$ | $Acc^{R}$ | $Acc^{B}$ | $Acc^{P}$ |
|---|---|---|---|---|---|
| X | +10.0 | 0.60 | 0.36 | 0.20 | 0.30 |
| XX | + 4.0 | 0.90 | 0.81 | 0.56 | 0.45 |

Choose: X or XX ?

EPD = EBV/2 has $$$ value.

What is $$$ value of RISK (accuracy)?

Need quantitative measure of RISK

**Names for Quantitative Measures of Risk**

- Margin of Error
- Possible Change
- Confidence Range
- Standard Deviation
- Standard Error of Prediction

In units of measurement (e.g., lb)

Accuracies are unit-less (zero to one)

**Usual Quantitative Measure of Risk**

*Standard Error of Prediction**

Possible (Probable) Change

Confidence Range

Uses traditional accuracy (squared)

Uses genetic standard deviation, SQRT[Vg]

Confidence Range assumes 'normality', the bell-shaped curve

**Review Standard Error of Prediction**

PE = (EBV – True BV)

Variance of PE = Var[EBV – True BV]

Var(PE) = (1 – squared-accuracy) x Var(BV)

= (1 – $acc^2$)Vg($lb^2$)

*Standard Error of Prediction*

SEP = SQRT[Var(PE)]

= SQRT[(1 – $acc^2$)Vg](lb)

As $acc^2$ increases, SEP decreases towards ZERO, dependent on SQRT[(1 – $acc^2$)]

| Accuracy | Reliability | BIF Acc | SEP(lb) |
|---|---|---|---|
| 0.30 | 0.09 | 0.05 | 22.8 |
| 0.40 | 0.16 | 0.08 | 21.0 |
| 0.50 | 0.25 | 0.13 | 18.8 |
| 0.60 | 0.36 | 0.20 | 16.0 |
| 0.70 | 0.49 | 0.28 | 12.8 |
| 0.80 | 0.64 | 0.40 | 9.0 |
| 0.90 | 0.81 | 0.56 | 4.8 |
| 1.00 | 1.00 | 1.00 | 0.0 |

| Accuracy | Reliability | BIF Acc | SEP(lb) | p |
|---|---|---|---|---|
| 0.30 | 0.09 | 0.05 | 22.8 | 1.5 |
| 0.40 | 0.16 | 0.08 | 21.0 | 2.9 |
| 0.50 | 0.25 | 0.13 | 18.8 | 5.0 |
| 0.60 | 0.36 | 0.20 | 16.0 | 8.4 |
| 0.70 | 0.49 | 0.28 | 12.8 | 14.4 |
| 0.80 | 0.64 | 0.40 | 9.0 | 26.7 |
| 0.90 | 0.81 | 0.56 | 4.8 | 64.0 |
| 1.00 | 1.00 | 1.00 | 0.0 | ++++ |

**CONFIDENCE RANGES**

SEP = SQRT[Var(PE)] = SQRT[(1 – $acc^2$)Vg]

Is a standard measure of risk

*68% Confidence Range* to include true BV

From [EBV – (1)SEP] to [EBV + (1)SEP]

Chance BV *greater than* [EBV+(1)SEP],16%

Chance BV *less than* [EBV – (1)SEP] is 16%

Chance BV> EBV = 50%

Chance BV < EBV = 50%

*95% Confidence Range* to include true BV

From [EBV – (2)SEP] to [EBV + (2)SEP]

Chance BV >>> [EBV + (2)SEP] is 2.5%

Chance true BV <<< [EBV – (2)SEP] is 2.5%

Range not limited to (1) or (2) SEP

*50% Confidence Range:*

SEP x (0.7) gives about 25%,25%,25%,25%

Equal chance of going up or going down!

Bulls: X and Y

SEP = SQRT[(1 – $acc^2$) x Vg]

Vg = 625$(lb)^2$ SQRT[Vg] = 25(lb)

Bull X, accuracy = 0.60

SEP(X) = SQRT[ (1 – 0.36) x 625 ] = 20.0(lb)

Bull Y, accuracy = 0.90

SEP(Y) = SQRT[ (1 – 0.81) x 625 ] = 10.9(lb)

| Bull | EBV | Accuracy | SEP |
|---|---|---|---|
| X | +10.0 | 0.60 | 20.0 |
| Y | +10.0 | 0.90 | 10.9 |

68% Confidence Ranges:

Bull X: 10.0 – (1)(20.0) to 10.0 + (1)(20.0)

[ -10.0 to +30.0 ]

Bull Y: 10.0 – (1)(10.9) to 10.0 + (1)(10.9)

[ -0.9 to +20.9 ]

Choose: X or Y ?

| Bull | EBV | Accuracy | SEP |
|---|---|---|---|
| X | +10.0 | 0.60 | 20.0 |
| Y | +10.0 | 0.90 | 10.9 |

95% Confidence Ranges:

Bull X: 10.0 – (2)(20.0) to 10.0 + (2)(20.0)

[ -30.0 to +50.0 ]

Bull Y: 10.0 – (2)(10.9) to 10.0 + (2)(10.9)

[ -11.8 to +31.8 ]

Choose: X or Y ?

The Gambler:

Bull X (accuracy = 0.60),

16% > 30.0

2.5% > 50.0

Bull Y (accuracy = 0.90),

16% > 20.9

2.5% > 31.8

But, as many down, as up!

| Bull | EBV | Accuracy | SEP |
|---|---|---|---|
| X | +10.0 | 0.60 | 20.0 |
| XX | + 4.0 | 0.90 | 10.9 |

68% Confidence Ranges:

Bull X: [10.0 – (1)(20.0)] to[10.0+(1)(20.0)]

[ -10.0 to +30.0 ]

Bull XX: [ 4.0 – (1)(10.9)] to [4.0 +(1)(10.9)]

[ -6.9 to +14.9 ]

Choose: X or XX ?

| Bull | EBV | Accuracy | SEP |
|---|---|---|---|
| X | +10.0 | 0.60 | 20.0 |
| XX | +4.0 | 0.90 | 10.9 |

95% Confidence Ranges:

Bull X: [10.0 – (2)(20.0)] to [10.0+(2)(20.0)]

[ -30.0 to +50.0 ]

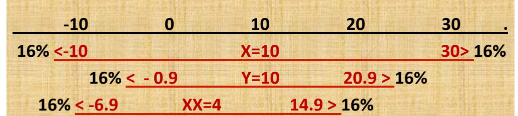
Bull XX: [ 4.0 – (2)(10.9)] to [ 4.0+(2)(10.9)]

[ -17.8 to +25.8 ]

Choose: X or XX ?

EBVx = 10 EBVy = 10 EBVxx = 4

SEPx = 20 SEPy = 10.9 SEPxx = 10.9




Can extend to comparison of two animals:

Prediction of Difference: EBV(X) – EBV(Y)

Accuracy of difference between X and Y?

Now SE of Prediction of Difference (SEPD) rather than SEP

Is not SE of an EPD!

$SEP(EPD_X) = SEP(EPD_X - \text{Constant})$

Now confidence ranges are centered on difference: EBV(X) – EBV(Y)

***Prediction Error for Difference*** **(PED):**

$PED(X\text{-}Y) = [(EBV_X - BV_X) - [(EBV_Y - BV_Y)]$

$PED = PE_X - PE_Y$

$\text{Variance}(PED) = \text{Variance}(PE_X - PE_Y)$

[review: $(A - B)^2 = A^2 + B^2 - 2(AB)$]

$\text{Variance}(PED) = V(PE_X) + V(PE_Y) - (2)\text{Covariance}(PE_X, PE_Y)$

$V(PED) = [(1 - accx^2)Vg + (1 - accy^2)Vg] - (2)\text{Covariance}(PE_X, PE_Y)$

**Prediction Error for Difference in EBV:**

V(PED) = $[(1 - accx^2) + (1 - accy^2)]Vg$

$-$ (2)Covariance($PE_X$,$PE_Y$)

Covariance($PE_X$,$PE_Y$):

Likely small vs. V($PE_X$) and V($PE_Y$)

except close relatives (sire-son, PHS)

Difficult to obtain with many animals

V($PE_X$) and V($PE_Y$) usually approximated

from approximated $accx^2$ and $accy^2$

Not easy to approximate Cov($PE_X$,$PE_Y$)

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V(PED) = $[(1 - accx^2) + (1 - accy^2)]Vg$

$-$ (2)Covariance($PE_X$,$PE_Y$)

If ignore Cov($PE_X$,$PE_Y$), say it is ZERO, then

V(PED) = $[2 - accx^2 - accy^2]Vg$ and

standard error of EBVx – EBVy is (SEPDx-y)

SEPD* = SQRT$[(2 - accx^2 - accy^2)Vg]$

SEPD* somewhat greater than SEPD

Works for any trait, need only its Vg

Makes easy to apply?

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V(PED) = $[(1 - accx^2) + (1 - accy^2)]Vg$

$-$ (2)Covariance($PE_X$,$PE_Y$)

| V($PE_X$) | V($PE_Y$) | r | C($PE_X$,$PE_Y$) | SEPD |
|---|---|---|---|---|
| 100 | 100 | 0.00 | 0 | 14.14 |
| 100 | 100 | 0.05 | 5 | 13.78 |
| 100 | 100 | 0.10 | 10 | 13.42 |
| 400 | 100 | 0.00 | 0 | 22.37 |
| 400 | 100 | 0.05 | 10 | 21.97 |
| 400 | 100 | 0.10 | 20 | 21.25 |

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**Prediction error for difference in EBV:**

SEPD = SQRT$[(2 - accx^2 - accy^2)Vg]$

Works for ANY TRAIT or INDEX, need

only the Vg for the trait or INDEX

Many possible pairs of EBV:

most not of interest

1) For specific pair, 'hand' calculator

2) Use a table for pairs of accuracy,

then one multiplication

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**Prediction error for difference in EBV:**

SEPD = SQRT$[(2 - accx^2 - accy^2)Vg]$

Table for pairs of acc: accx and accy

| | 0.05 | 0.15 | 0.25 | 0.35 | 0.45 | 0.55 | 0.65 | 0.75 | 0.85 | 0.95 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | | | | | | | | | | |
| 0.15 | | | | | | | | | | |
| 0.25 | | 1.41 | | 1.41 | | 1.38 | | 1.30 | | 1.09 |
| 0.35 | | | | | SQRT$[2.0 - accx^2 - accy^2]$ | | | | | |
| 0.45 | | 1.40 | | 1.39 | | 1.37 | | 1.28 | | 1.07 |
| 0.55 | | | | | | | | | | |
| 0.65 | | | | | | | | | | |

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**Prediction error for difference in EBV:**

SEPD = SQRT$[(2 - acc1^2 - acc2^2)Vg]$

A table for pairs of acc: acc1 and acc2

For our example bulls

| .acc1/acc2 | 0.30 | 0.60 | 0.90 . |
|---|---|---|---|
| 0.30 | 1.35 | 1.25 | 1.05 |
| 0.60 | 1.25 | 1.13 | 0.91 |
| 0.90 | 1.05 | 0.91 | 0.62 |

A table for pairs of acc: accx and accy

| . | 0.30 | 0.60 | 0.90 |
|---|---|---|---|
| 0.30 | 1.35 | 1.25 | 1.05 |
| 0.60 | 1.25 | 1.13 | 0.91 |
| 0.90 | 1.05 | 0.91 | 0.62 |

For Bull X (acc = 0.60)
For Bull Y (or XX) (acc = 0.90)
Table value for (X,Y) = 0.91;
With Vg = 625 and SQRT(625) = 25
SEPD(X - Y ) = 0.91 x 25 = 22.75

A table for pairs of acc: accxx and accy

| . | 0.30 | 0.60 | 0.90 | . |
|---|---|---|---|---|
| 0.30 | 1.35 | 1.25 | 1.05 | |
| | 0.60 | 1.25 | 1.13 | 0.91 |
| 0.90 | 1.05 | 0.91 | 0.62 | |

For bull Y (acc = 0.90)
For bull XX (acc = 0.90)
Table value (Y,XX) = 0.62
With Vg = 625 and SQRT(625) = 25
SEPD(Y - XX) = 0.62 x 25 = 15.50

With Vg = 625 and SQRT(625) = 25
SEPD(X - Y) = 0.91 x 25 = 22.75
Sepd(X - XX) = 0.91 x 25 = 22.75
SEPD(Y - XX) = 0.62 x 25 = 15.50
"t-value's"
EBV(X) – EBV(Y): [10 – 10]/22.75 = 0.00
EBV(X) – EBV(XX): [10 – 4]/22.75 = 0.26
EBV(Y) – EBV(XX): [10 – 4]/15.50 = 0.39

SEPD(X-Y), SEPD(X-XX) = 0.91 x 25 = 22.75
SEPD(Y-XX) = 0.62 x 25 = 15.50
68% Confidence Ranges
EBV(X) – EBV(Y): [0 – 22.75] to [0 + 22.75]
[10 – 10]: [-22.75 to +22.75]
EBV(X) – EBV(XX):[6 – 22.75] to [6 + 22.75]
[10 – 4]: [-16.75 to +28.75]
EBV(Y) – EBV(XX):[6 – 15.50] to [6 + 15.50]
[10 – 4]: [ -9.50 to +21.50]

SEPD(X-Y) & SEPD(X-XX)=0.91 x 25= 22.75
SEPD(Y-XX) = 0.62 x 25 = 15.50
68% Confidence Ranges
EBV(X) – EBV(Y): [0 – 22.75] to [0 + 22.75]
Chance BV(X) > BV(Y) by 22.75 is 16%
EBV(X) – EBV(XX):[6 – 22.75] to [6 + 22.75]
Chance BV(X) > BV(XX) by 28.75 is 16%
EBV(Y) – EBV(XX):[6 – 15.50] to [6 + 15.50]
Chance BV(Y) > BV(XX) by 21.50 is 16%
*But, what could go up, could also go down!*

## G-BLUP and Risk

Genotyped sires will have 'similar'
accuracy, SEP, SEPD ?
unless many phenotyped progeny
Top 214, most reliability of 72-76%
with no progeny
One with 3800 daughters, REL = 99%

| Accuracy | Reliability | BIF Accuracy | |
|---|---|---|---|
| 0.30 | 0.09 | 0.05 | |
| 0.40 | 0.16 | 0.08 | |
| 0.50 | 0.25 | 0.13 | |
| 0.60 | 0.36 | 0.20 | |
| 0.70 | 0.49 | 0.28 | |
| 0.80 | 0.64 | 0.40 | G alone, |
| 0.90 | 0.81 | 0.56 | p ~ 50 |
| 0.99 | 0.98 | 0.86 | |

## G-BLUP and Risk

Genotyped sires will have 'similar' accuracy, SEP, SEPD ?

But not same confidence ranges

CR will be centered on EBV

Accuracy may depend on 'chip'

Will covariance($PE_X$,$PE_Y$) ~ 0.00 ?

## Bayesian *'Solutions'*

Accuracy and SEP cannot be obtained directly for current EBV solutions because coefficient matrix is too large to invert.

Accuracy must be approximated and from approximated accuracy, approximate SEP. Instead use Bayes-Gibb's MCMC chains?

## Bayesian *'Solutions'*

Gibb's MCMC chains provide empirical measures of prediction error variances

Empirical PEV can be used to calculate approximate accuracies?

Odds ratios?

What about Covariance($PE_X$,$PE_Y$) ?

From all pairs of chains ? [too many ?]

1,000,000 chains, ~ 1,000,000,000,000/2 pairs

## SUMMARY

After 30 years, do we need to go beyond accuracy, reliability or BIF accuracy?

Standard error of prediction uses accuracy and is on scale of units of measurement.

Confidence ranges based on standard errors of prediction are quantitative measures of risk.

## SUMMARY

Standard error of prediction of difference between pairs of EBV uses accuracy of both EBV and is on scale of unit of measurement.

Confidence range based on standard error of prediction of difference between EBV is measure of risk between two animals.

***But, is difficult to explain and interpret!!***

**SUMMARY**

**Genomic BLUP may lead to accuracy being similar for many genotyped animals. Confidence ranges would differ only by EBV.**

**Bayesian analyses provide 'confidence ranges' directly without approximations and can be used to approximate accuracies.**

**THANK YOU**

**and**

**GOOD LUCK**

**Selection in simplest form is comparison of two animals: predict difference with measure of risk. The general "t-test"**

$$\frac{[X_1 - X_2]}{SQRT[V(X_1) + V(X_2) - 2COV(X_1,X_2)]}$$

**Similar for difference between two EBV**

**EBV(X) – EBV(Y)**

**Now prediction error for the difference is:**

**PED = [(EBV$_X$ – true BV$_X$) – [(EBV$_Y$ – true BV$_Y$)]**