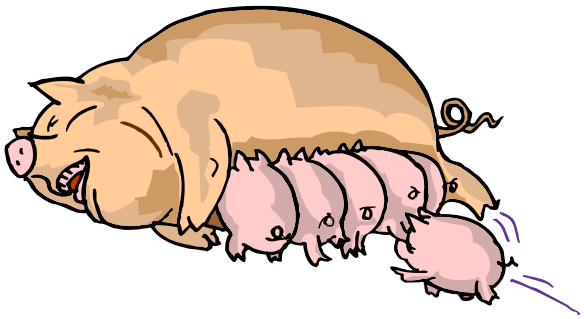
Lecture 13

Permanent Environmental Effects: Non-Inherited

Impacts on Between and Within Family Selection

Permanent Environmental Effects

- Non inherited Maternal effects
  - Mastitis
  - Other maternal infection
  - Maternal Injuries (Damaged teats)
  - Intra Uterine Effects



Impact

- If Ignored
  - Reduces Response to Selection
- Solution
  - Within Family Selection
    - If maternal effects
    - How to weight the between vs within family information
  - BLUP
    - Estimate the effect and remove the effect

Permanent Environmental Effects

$$y_{ijkmn} = (HY)_i + S_j + D_k + P_n + e_{ijkmn}$$

Herd Year

Sex

Direct Genetic

Permanent Environment

Random error

Fixed Effects

Random Effects

Permanent Environmental Effects

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z}_1\mathbf{d} + \mathbf{Z}_2\mathbf{p} + \mathbf{e}$$

Direct effect

Maternal Non-genetic

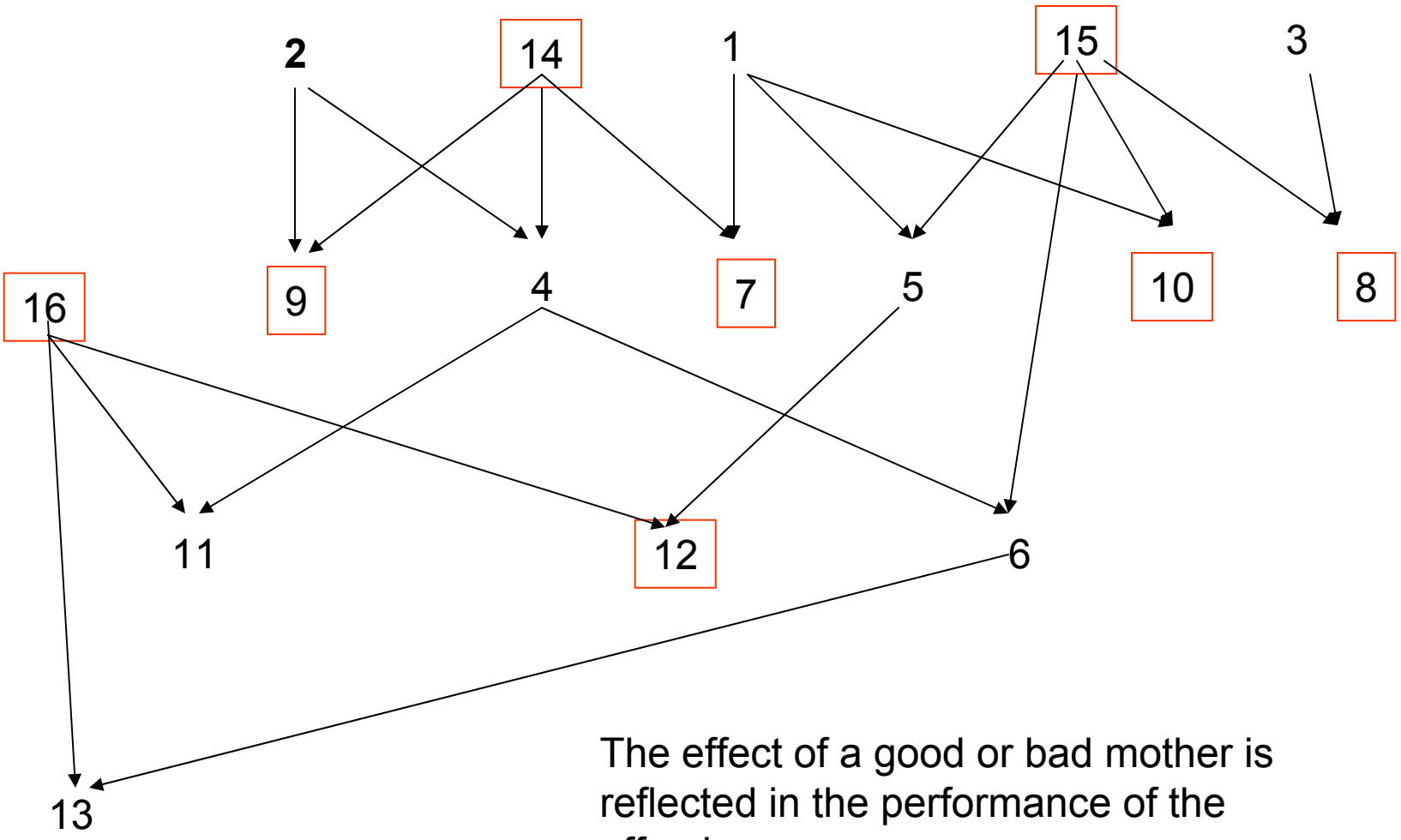
$$V\begin{bmatrix}\mathbf{d}\\ \mathbf{p}\\ \mathbf{e}\end{bmatrix} = \begin{bmatrix}\mathbf{A}\sigma_d^2 & 0 & 0\\ 0 & \mathbf{I}\sigma_p^2 & 0\\ 0 & 0 & \mathbf{I}\sigma_e^2\end{bmatrix}$$

Maternal Effects Example

Schaeffer Table 8.7

Animal	Sire	Dam	Year	Sex	Wean Wt
7	14	1	86	M	400
4	14	2	86	F	380
8	15	3	86	M	410
5	15	1	87	F	350
9	14	2	87	M	420
6	15	4	87	F	360
10	15	1	88	M	390
11	16	4	88	F	390
12	16	5	88	M	430
13	16	6	88	F	370

Pedigree



The effect of a good or bad mother is reflected in the performance of the offspring

Year sex
86 87 88 m

$$\mathbf{X} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix}$$

Herd
Year

Sex

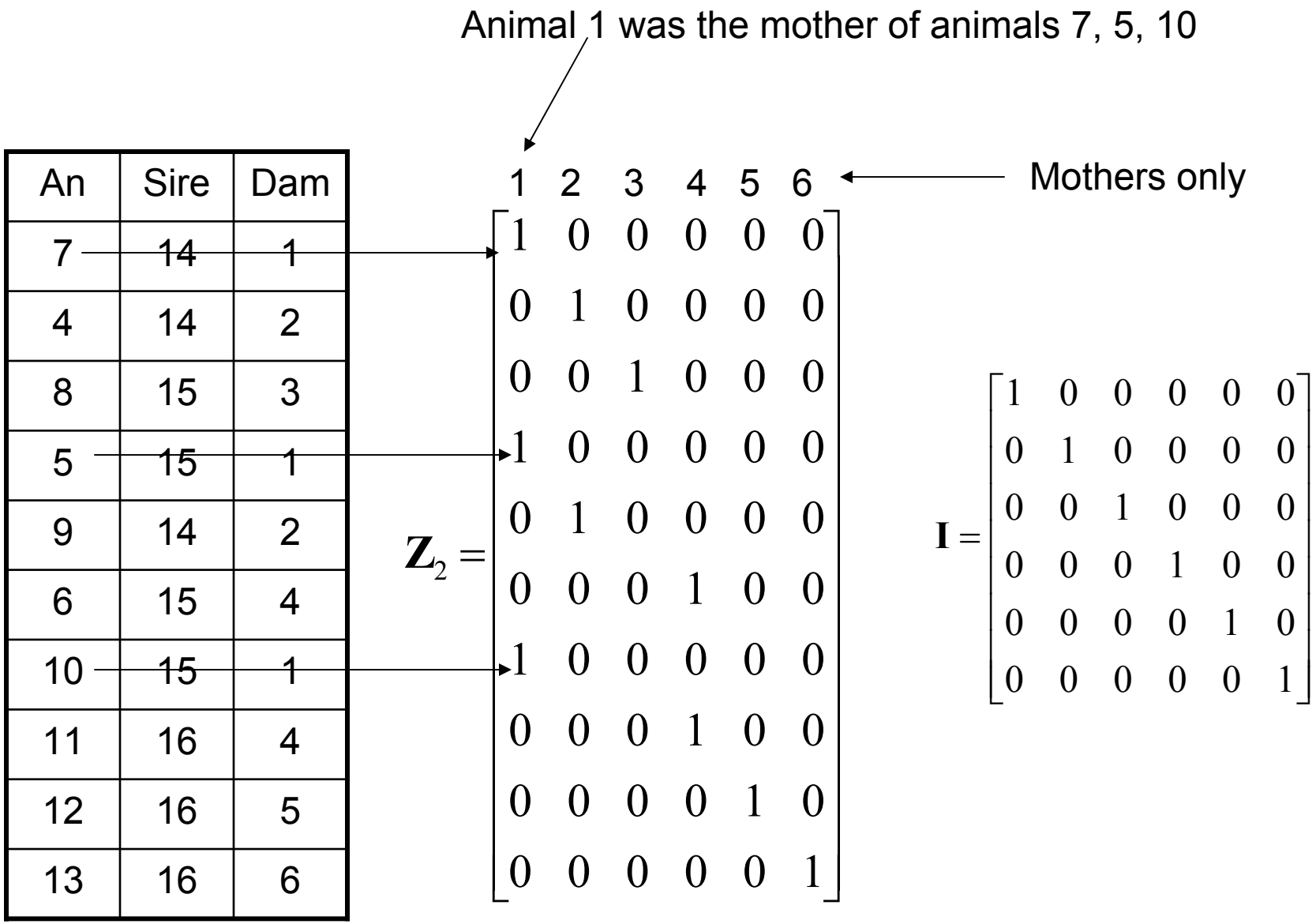
$$\mathbf{Y} = \begin{bmatrix} 400 \\ 380 \\ 410 \\ 350 \\ 420 \\ 360 \\ 390 \\ 390 \\ 430 \\ 370 \end{bmatrix}$$

Animal

An	Sire	Dam
7	14	1
4	14	2
8	15	3
5	15	1
9	14	2
6	15	4
10	15	1
11	16	4
12	16	5
13	16	6

$$\mathbf{Z}_1 =$$

14	1	2	15	3	16	7	4	8	5	9	6	10	11	12	13
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1


Animal 1 was the mother of animals 7, 5, 10
Mothers only
An Sire Dam
7 14 1
4 14 2
8 15 3
5 15 1
9 14 2
6 15 4
10 15 1
11 16 4
12 16 5
13 16 6
1 2 3 4 5 6
$\mathbf{Z}_2 =$
$\mathbf{I} =$

MME

$$\begin{bmatrix} \mathbf{X'X} & \mathbf{X'Z_1} & \mathbf{X'Z_2} \\ \mathbf{Z_1'X} & \mathbf{Z_1'Z_1} + \mathbf{A}^{-1}k_{11} & \mathbf{Z_1'Z_2} \\ \mathbf{Z_2'X} & \mathbf{Z_2'Z_1} & \mathbf{Z_2'Z_2} + \mathbf{I}k_{22} \end{bmatrix} \begin{bmatrix} \hat{\mathbf{b}} \\ \hat{\mathbf{a}} \\ \hat{\mathbf{p}} \end{bmatrix} = \begin{bmatrix} \mathbf{X'y} \\ \mathbf{Z_1'y} \\ \mathbf{Z_2'y} \end{bmatrix}$$

$$\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} = \begin{bmatrix} \sigma_d^2 & 0 \\ 0 & \sigma_p^2 \end{bmatrix}^{-1} \sigma_e^2$$

$$\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} = \begin{bmatrix} 2000 & 0 \\ 0 & 500 \end{bmatrix}^{-1} 6500 = \begin{bmatrix} 3.25 & 0 \\ 0 & 13 \end{bmatrix}$$

```
proc iml;
start main;

y={400,
   380,
   410,
   350,
   420,
   360,
   390,
   390,
   430,
   370};

 X={1 0 0 1,
    1 0 0 0,
    1 0 0 1,
    0 1 0 0,
    0 1 0 1,
    0 1 0 0,
    0 0 1 1,
    0 0 1 0,
    0 0 1 1,
    0 0 1 0};
```

```
Z1={0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0,
    0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0,
    0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0,
    0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0,
    0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0,
    0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0,
    0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0,
    0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0,
    0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0,
    0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1};
```

```
Z2={ 1  0  0  0  0  0,
     0  1  0  0  0  0,
     0  0  1  0  0  0,
     1  0  0  0  0  0,
     0  1  0  0  0  0,
     0  0  0  1  0  0,
     1  0  0  0  0  0,
     0  0  0  1  0  0,
     0  0  0  0  1  0,
     0  0  0  0  0  1};
```

```
Ainv={2.5  .5  1  0   0   0  -1  -1  0  0  -1  0  0  0  0  0,
       .5 2.5  0  1   0   0  -1   0  0 -1   0  0 -1  0  0  0,
       1   0  2  0   0   0   0  -1  0  0  -1  0  0  0  0  0,
       0   1  0  3  .5   0   0  .5 -1 -1   0 -1 -1  0  0  0,
       0   0  0 .5 1.5   0   0   0 -1  0   0  0  0  0  0  0,
       0   0  0  0   0 2.5   0 .5  0 .5   0 .5  0 -1 -1 -1,
      -1  -1  0  0   0   0   2  0  0  0   0  0  0  0  0  0,
      -1   0 -1 .5   0 .5   0  3  0  0   0 -1  0 -1  0  0,
       0   0  0 -1  -1   0   0  0  2  0   0  0  0  0  0  0,
       0  -1  0 -1   0 .5   0  0  0 2.5  0  0  0  0 -1  0,
      -1   0 -1  0   0  0   0  0  0  0   2  0  0  0  0  0,
       0   0  0 -1   0 .5   0 -1  0  0   0 2.5 0  0  0 -1,
       0  -1  0 -1   0  0   0  0  0  0   0  0  2  0  0  0,
       0   0  0  0   0 -1   0 -1  0  0   0  0  0  2  0  0,
       0   0  0  0   0 -1   0  0  0 -1   0  0  0  0  2  0,
       0   0  0  0   0 -1   0  0  0  0   0 -1  0  0  0  2};

K11=3.25;K12=0;K21=0;K22=13;
LHS=((X`*X)||(X`*Z1)||(X`*Z2))
      //((Z1`*X)||(Z1`*Z1+AINV#K11)||(Z1`*Z2))
      //((Z2`*X)||(Z2`*Z1)||(Z2`*Z2+I#K22));
RHS=(X`*Y)//(Z1`*Y)//(Z2`*Y);
C=INV(LHS);
BU=C*RHS;
print BU ;
finish main;run;quit;
```

B

369.87
363.57
375.03 } Year
40.76 ← Sex

â

Animal

1.81	14
-3.80	1
2.783	2
-3.56	15
0.13	3
2.63	16
-1.96	7
3.46	4
-1.57	8
-3.88	5
3.91	9
-0.90	6
-6.31	10
4.56	11
1.22	12
0.12	13

p̂

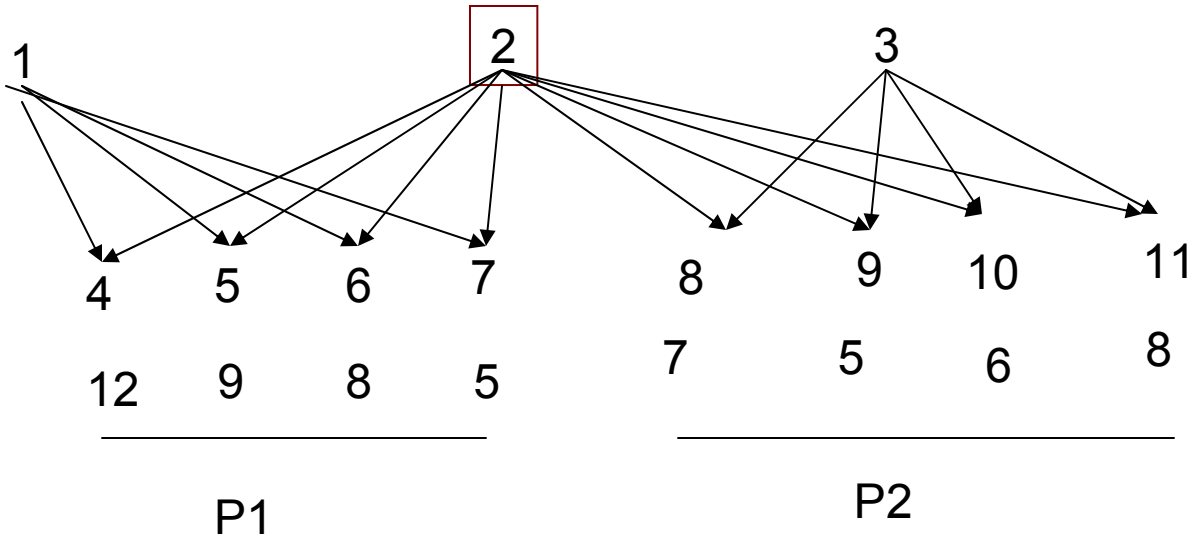
Animal

-2.365897	1
1.226796	2
0.0671247	3
0.5146638	4
0.9262775	5
-0.368965	6

What to do with the estimates in a breeding program

- Just use estimate of breeding value, permanent environment effect is example of random block factor

Example
Impact of PE effects on Breeding program



```
proc iml;
start main;

y={12,
   9,
   8,
   5,
   7,
   5,
   6,
   8};

 X={1,
    1,
    1,
    1,
    1,
    1,
    1,
    1};
```

```
Z1={0 0 0 1 0 0 0 0 0 0 0,
    0 0 0 0 1 0 0 0 0 0 0,
    0 0 0 0 0 1 0 0 0 0 0,
    0 0 0 0 0 0 1 0 0 0 0,
    0 0 0 0 0 0 0 1 0 0 0,
    0 0 0 0 0 0 0 0 1 0 0,
    0 0 0 0 0 0 0 0 0 1 0,
    0 0 0 0 0 0 0 0 0 0 1};

Z2={1  0,
    1  0,
     1  0,
     1  0,
     0  1,
     0  1,
     0  1,
     0  1};

I={1  0,
   0  1};
```

```
A={1  0   0  .5 .5  .5 .5   0   0   0   0,
     0  1   0  .5 .5  .5 .5  .5  .5   .5  .5,
     0  0   1   0  0   0  0  .5  .5   .5  .5,
    .5 .5   0   1 .5  .5 .5  .25 .25  .25 .25,
    .5 .5   0  .5  1  .5 .5  .25 .25  .25 .25,
    .5 .5   0  .5 .5   1 .5  .25 .25  .25 .25,
    .5 .5   0  .5  .5  .5 1  .25 .25  .25 .25,
     0 .5  .5  .25 .25 .25 .25 1  .5   .5  .5,
     0 .5  .5  .25 .25 .25 .25 .5  1   .5  .5,
     0 .5  .5  .25 .25 .25 .25 .5 .5    1  .5,
     0 .5  .5  .25 .25 .25 .25 .5 .5   .5   1};
```

```
AINV=INV(A);
```

Impact of Relative Magnitude of

$$\frac{\sigma_e^2}{\sigma_p^2}$$

As ratio gets smaller, permanent environmental effects are more important

```
K11=1;K12=0;K21=0;K22=.1;
LHS=((X`*X)||(X`*Z1)||(X`*Z2))
//((Z1`*X)||(Z1`*Z1+AINV#K11)||(Z1`*Z2))
//((Z2`*X)||(Z2`*Z1)||(Z2`*Z2+I#K22));
RHS=(X`*Y)//(Z1`*Y)//(Z2`*Y);
C=INV(LHS);
BU=C*RHS;
RMSE=(Y`*Y-BU`*RHS)#(1/6);
print BU ;
finish main;
run;
quit;
```

Impact on Choice of Animals for Breeding

Dam		$\frac{\sigma_e^2}{\sigma_p^2} = 13$		$\frac{\sigma_e^2}{\sigma_p^2} = 1$		$\frac{\sigma_e^2}{\sigma_p^2} = .1$	
1	4	1.700	x	1.397	x	1.201	x
	5	0.700	x	0.397	x	0.201	x
	6	0.367	x	0.064		-0.131	
	7	-0.632		-0.935		-1.131	
3	8	-0.367		-0.064		0.131	x
	9	-1.0342		-0.730		-0.535	
	10	-0.700		-0.397		-0.201	
	11	-0.034		0.269	x	0.464	x
	p1	0.109		0.615		0.941	
	p2	-0.109		-0.615		-0.941	

Incorporation of more than one Source of Maternal Effects :e.g. Maternal Genetic and Permanent Environmental

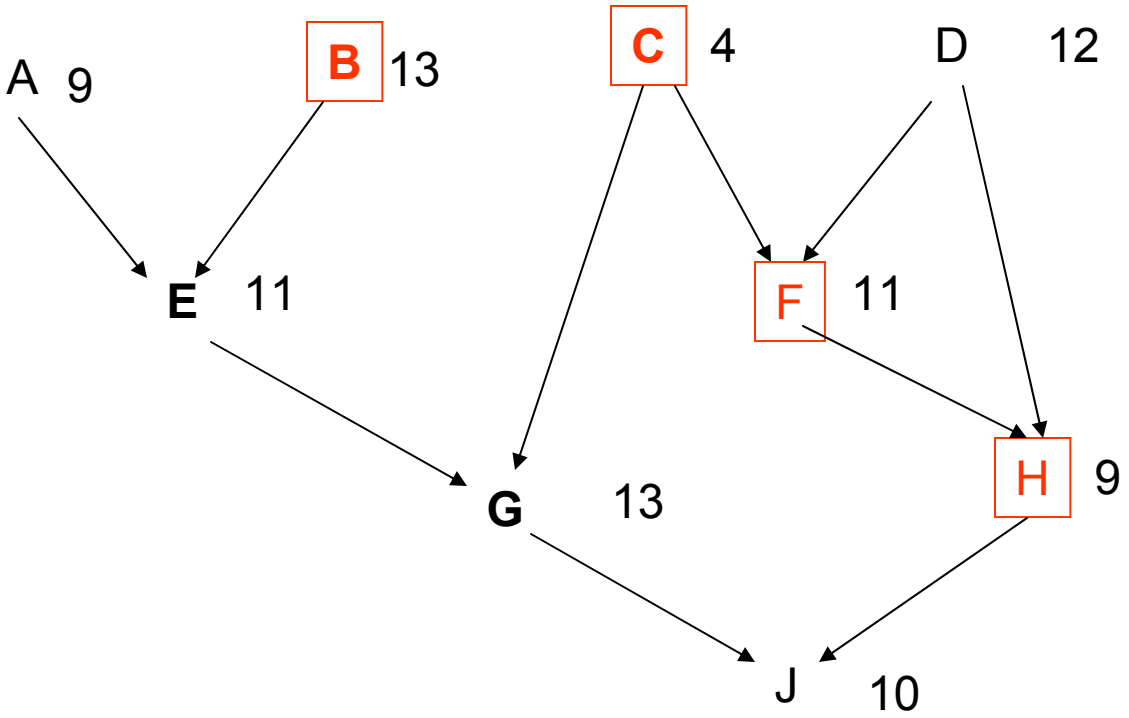
$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z}_1\mathbf{d} + \mathbf{Z}_2\mathbf{m} + \mathbf{Z}_3\mathbf{p} + \mathbf{e}$$

$$V\begin{bmatrix}\mathbf{d}\\ \mathbf{m}\\ \mathbf{p}\\ \mathbf{e}\end{bmatrix} = \begin{bmatrix}\mathbf{A}\sigma_d^2 & \mathbf{A}\sigma_{d,m} & 0 & 0\\ \mathbf{A}\sigma_{d,b} & \mathbf{A}\sigma_m^2 & 0 & 0\\ 0 & 0 & \mathbf{I}\sigma_p^2 & 0\\ 0 & 0 & 0 & \mathbf{I}\sigma_e^2\end{bmatrix}$$

Conclusions

- Permanent Environmental Effects
  - Important where maternal effects are large
    - Swine
    - Beef Cattle
    - Sheep
    - Not
      - Chickens
      - Dairy cattle
      - Fish
  - If not incorporated when needed can greatly impair breeding program

Lab Problem 8.1 PE



Fit an animal model with permanent environmental effects, assume error variance as previously estimated and

$$\frac{\sigma_e^2}{\sigma_a^2} = 1 \qquad \frac{\sigma_e^2}{\sigma_p^2} = .1 \qquad \text{or} \qquad \frac{\sigma_e^2}{\sigma_p^2} = 15$$

What impact does it have on ranking of animals for breeding