Genetic analysis of uniformity of egg shell color in purebred and crossbred laying hens

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ISA
A Hendrix Genetics Company

Acknowledgement

www.isapoultry.com

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Introduction

- Uniformity of eggs is important for retailers and consumers
  - Uniform egg weight/size
  - Uniform eggshell color: either brown or white

Introduction

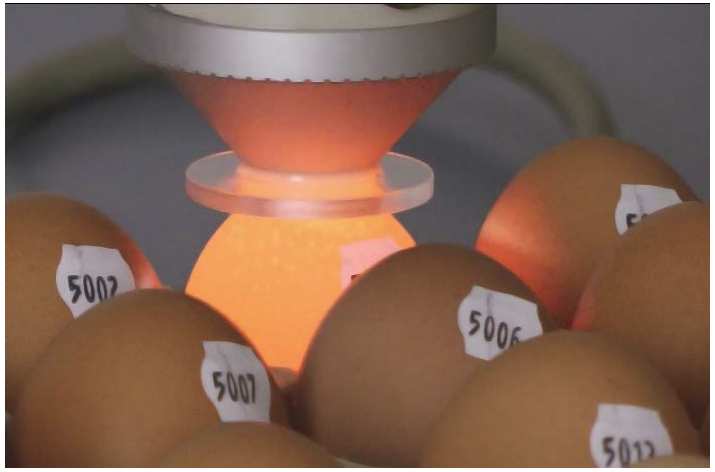
- Selection to improve uniformity?
  - Requires genetic variation
- Existence of genetic variance in residual variance
  - Hill and Mulder (2010)
  - Wolc et al. (2012) showed for egg weight
- Existence of genetic variance in residual variance of eggshell color is unknown
  - Unknown genetic correlation purebred and crossbred laying hens ($r_{pc,m}$ and $r_{pc,v}$)

Objective

- To estimate genetic variance in residual variance of eggshell color for purebred and crossbred laying hens

- To estimate the genetic correlations between eggshell color and its residual variance in purebred and crossbred laying hens

Data: trait measurement



- Egg color: - L^* (lightness: 0 black; 1000 white)
  - a^* (red-green scale: <0 red; >0 green)
  - b^* (blue-yellow scale: <0 blue; >0 yellow)
- Egg shell color index: $L^* - a^* - b^*$

Data used in analysis

- Editing
  - Crossbred data (cage housed)
    - ≥ 40 egg records per sire
  - Purebred (individually housed)
    - ≥ 40 daughters per sire
    - ≥ 5 records per hen for estimation of permanent environmental effects
- After editing
  - Purebred hens: 167,651 eggs
  - Crossbred hens: 85,454 eggs

Estimation of genetic variance within purebred or crossbred hens

- Double hierarchical generalized linear model (Rönnegård et al., 2010; Felleki et al., 2012)

$$\begin{bmatrix} \mathbf{y} \\ \mathbf{y_v} \end{bmatrix} = \begin{bmatrix} \mathbf{X} & \mathbf{0} \\ \mathbf{0} & \mathbf{X_v} \end{bmatrix} \begin{bmatrix} \mathbf{b} \\ \mathbf{b_v} \end{bmatrix} + \begin{bmatrix} \mathbf{Z} & \mathbf{0} \\ \mathbf{0} & \mathbf{Z_v} \end{bmatrix} \begin{bmatrix} \mathbf{s} \\ \mathbf{s_v} \end{bmatrix} + \begin{bmatrix} \mathbf{W} & \mathbf{0} \\ \mathbf{0} & \mathbf{W_v} \end{bmatrix} \begin{bmatrix} \mathbf{n} \\ \mathbf{n_v} \end{bmatrix} + \begin{bmatrix} \mathbf{e} \\ \mathbf{e_v} \end{bmatrix}$$

- Fixed effects
  - purebred: date, hatching-date
  - crossbred: date, line, laying house-row-level
- Random effects
  - Purebred: sire + permanent environmental effect
  - Crossbred: sire + cage effect

Estimation of genetic correlations between purebred and crossbred performance

$$\mathbf{G} = \begin{bmatrix} \sigma^2_{a_{m,p}} & cov_{a_{m,p},a_{m,c}} & cov_{a_{m,p},a_{v,p}} & cov_{a_{m,p},a_{v,c}} \\ & \sigma^2_{a_{m,c}} & cov_{a_{m,c},a_{v,p}} & cov_{a_{m,c},a_{v,c}} \\ & & \sigma^2_{a_{v,p}} & cov_{a_{v,p},a_{v,c}} \\ & & & \sigma^2_{a_{v,c}} \end{bmatrix}$$

$r_{pc,m}$ = genetic correlation between eggshell color in purebred and crossbred hens

$r_{pc,v}$ = genetic correlation between residual variance of eggshell color in purebred and crossbred hens

Genetic variance in mean eggshell color

	Purebred	Crossbred
Genetic variance	2212 (221)	2419 (160)
Permanent environmental /cage variance	2870 (36)	391 (17)
Residual variance	3552 (13)	5418 (27)
Heritability	0.32 (0.03)	0.38 (0.02)

Heritabilities for mean eggshell color are similar in purebred and crossbred laying hens

Genetic variance in residual variance of eggshell color

	Purebred	Crossbred
Genetic variance	0.08 (0.01)	0.06 (0.01)
Permanent environmental /cage variance	0.33 (0.01)	0.11 (0.01)
Heritability (Mulder et al., 2007)	0.009	0.009
GCV (Mulder et al., 2007)	0.28	0.24

Substantial genetic variation in uniformity:
1 genetic SD → 24-28% change in residual variance

Genetic correlations between purebred and crossbred performance

- Mean performance: $A_{m,p}$ and $A_{m,c}$
- Residual variance: $A_{v,p}$ and $A_{v,c}$

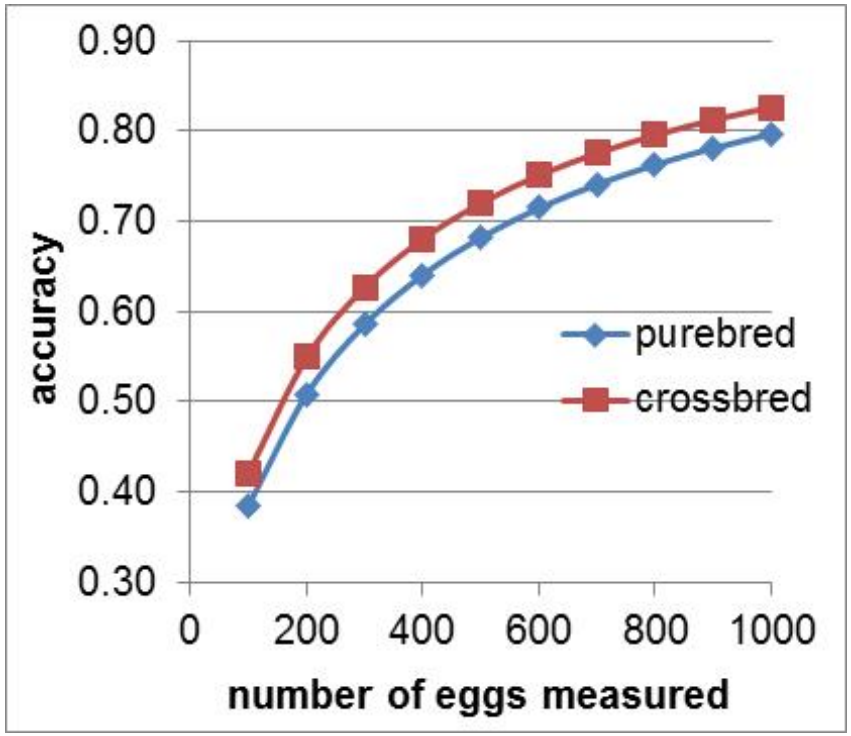
	$A_{m,c}$	$A_{v,p}$	$A_{v,c}$
$A_{m,p}$	0.87(0.05)	-0.06(0.08)	0.22(0.13)
$A_{m,c}$		-0.01(0.11)	0.45(0.08)
$A_{v,p}$			0.71(0.15)

Purebred and crossbred residual variance of eggshell color seem to be different traits

Accuracy of selection (selection index)

- Purebred hen: 10 own observations: accuracy = 0.26
- Rooster: - purebred daughters each with 10 observations
  - eggs from crossbreds in cages

High accuracies feasible in roosters



Conclusion

- Substantial heritable variation in residual variance of eggshell color in purebred and crossbred laying hens
  - Large selection responses possible
  - Accuracy of selection can be reasonably high for roosters
- Genetic correlation purebred-crossbred residual variance is 0.71
  - Combined Crossbred Purebred Selection advised to increase uniformity

Thank you for your attention!