

Models in Broiler Nutrition: a Quest for Optima

martin.zuidhof@ualberta.ca

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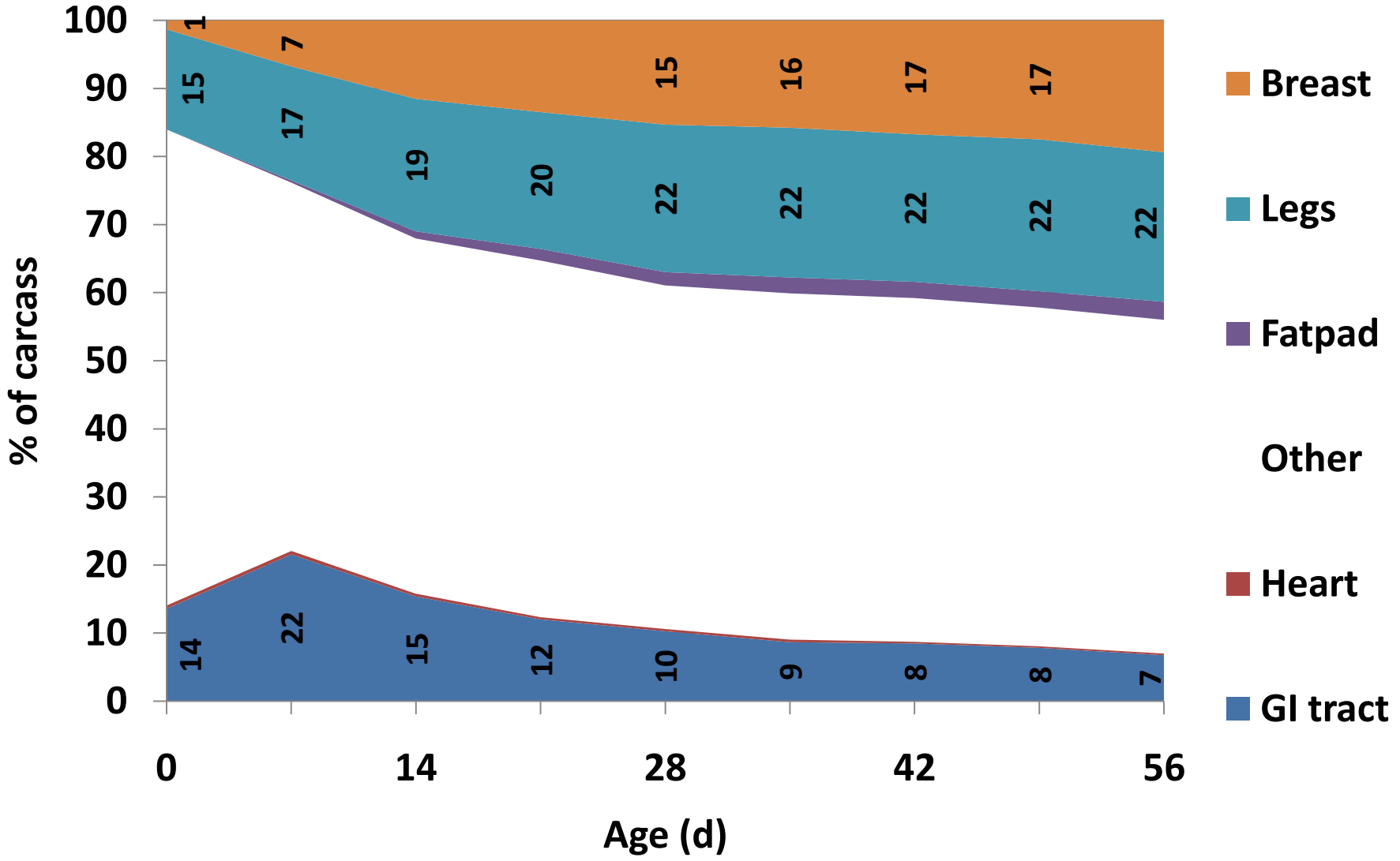


Background

- Many variables in broiler production are nonlinear
  - BW vs. Age
  - Allometric growth (composition of gain)
  - Carcass composition (maintenance costs)



Change in Composition



Males



Objective

- To develop robust nonlinear prediction equations to describe growth and development in response to
  - nutrient intake
    - 'Prestarter' nutrition
    - Dietary ME
    - Dietary balanced protein
  - Genotype
    - sex



Experimental Design

- 2 x 2 x 3 x 5 factorial arrangement of treatments
- 2 sexes
- 2 prestarter nutrient densities (0 to 11 d)
  - Recommendation† for maximized growth rate and feed efficiency
  - Recommendation† for reduced feed cost

†Cobb Broiler Nutrition Supplement, 2004, Cobb-Vantress, Inc., Siloam Springs, AR, 72761



Experimental Design

- 3 ME levels (11 to 56 d)
  - 94% — E94
  - 97% — E97
  - 100% of recommendation† — E100
- 5 Dietary Balanced Protein (DBP) levels
  - 85% — P85
  - 92.5% — P92.5
  - 100% — P100
  - 107.5% — P107.5
  - 115% of recommendation† — P115

†Recommendation for maximized growth rate and feed efficiency
Cobb Broiler Nutrition Supplement, 2004, Cobb-Vantress, Inc., Siloam Springs, AR, 72761



Approach

- Strain: Cobb x Avian 48
- Individual weekly BW data on 1,200 broilers
- Serial dissection of 2,224 broilers
  - 8 birds per sex x PS interaction at 11 d
  - 2 birds per treatment at 3 and 4 wk of age
  - 4 birds per treatment semi-weekly from 4.5 to 8 wk of age



Variables Measured

- BW
- Feed intake
- Processing – weights of
  - Eviscerated carcass (feet, head and neck removed)
  - Breast (P. major + P. minor)
  - Abdominal fatpad (including fat on gizzard)
  - Legs (drum + thigh)
  - Wings



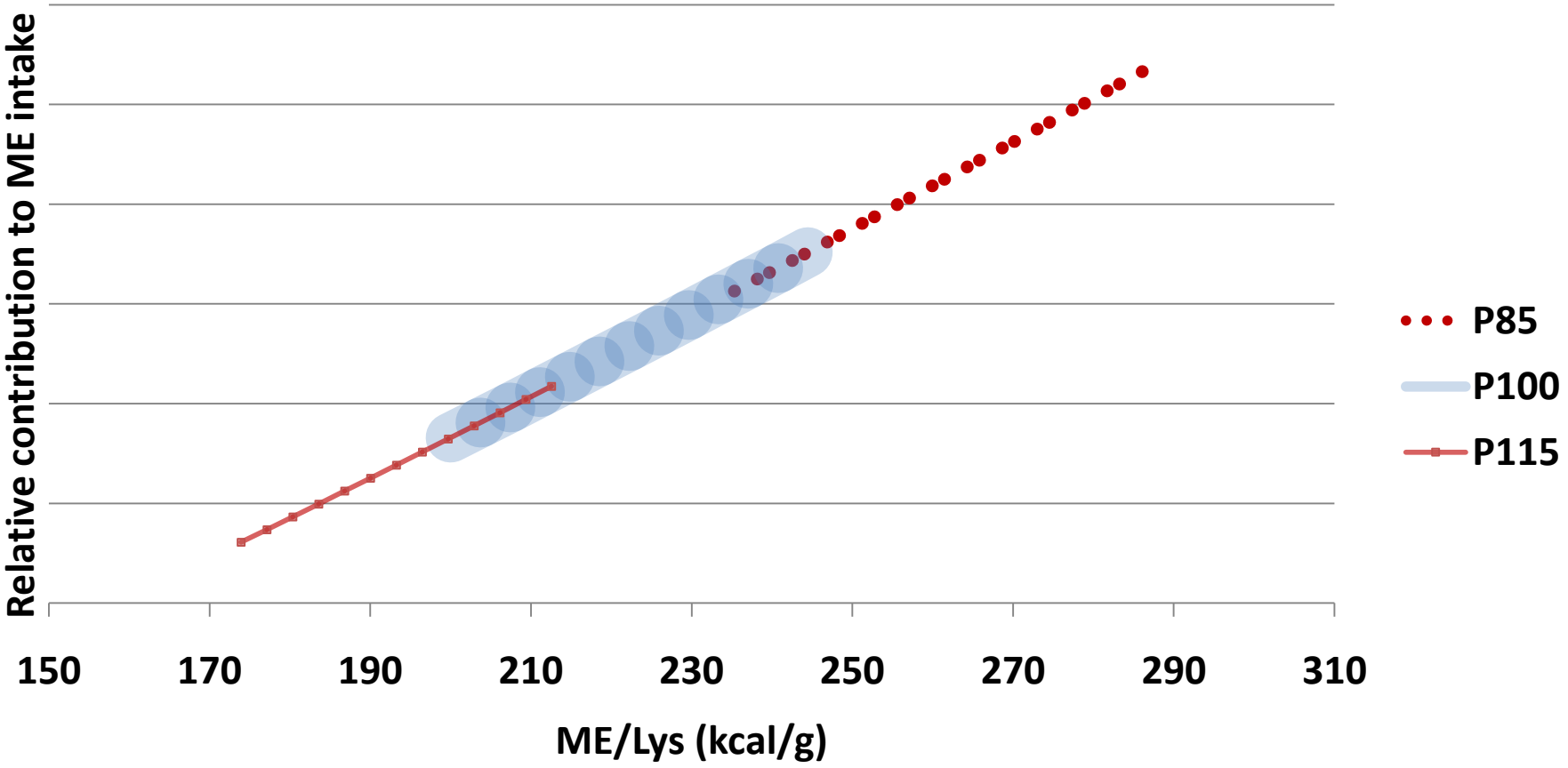
Nonlinear models

- Feed intake
- BW
- Yield

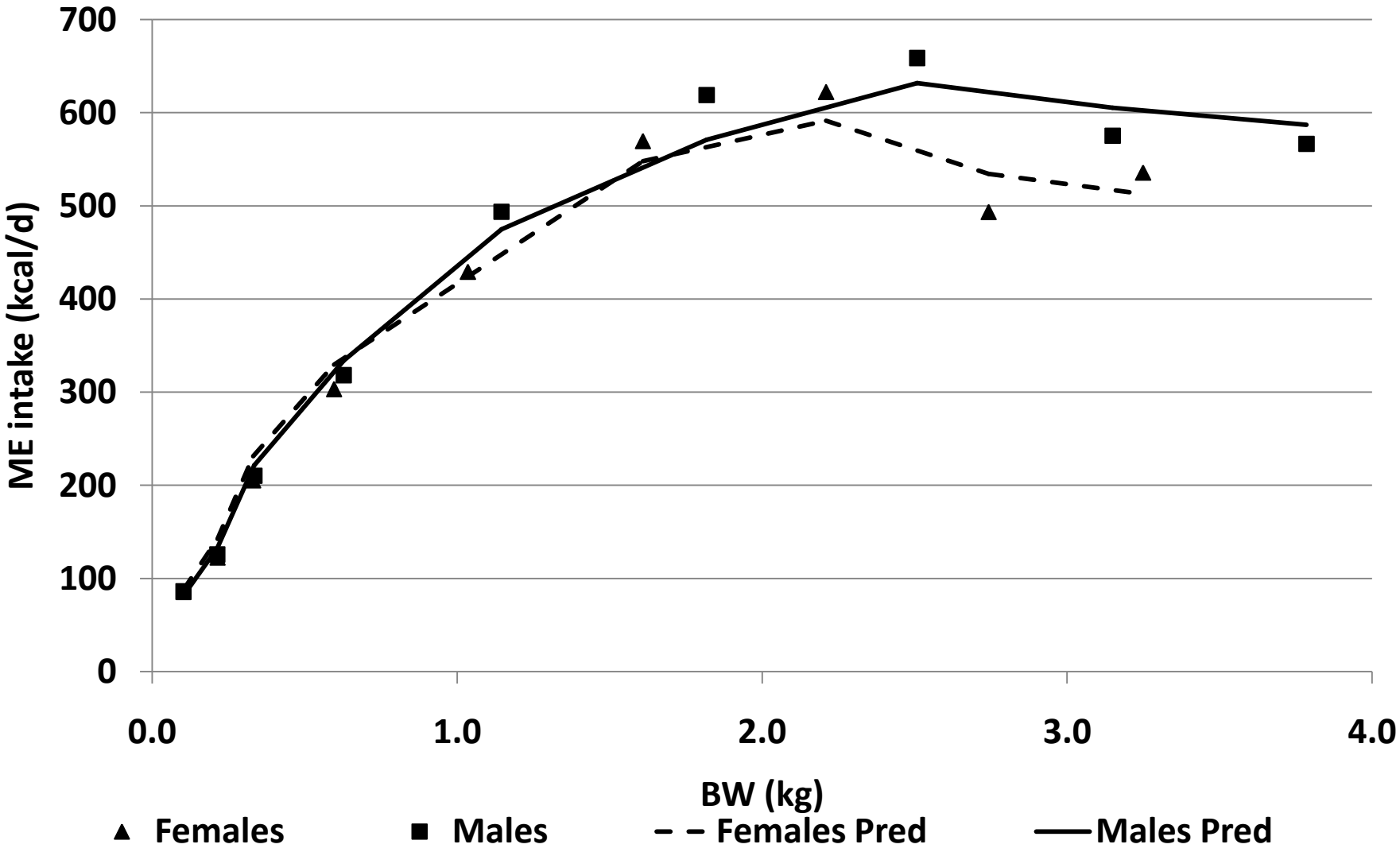
Feed Intake Model

$$ME\ intake = f(BW, ME, Lys, ADG, Sex)$$

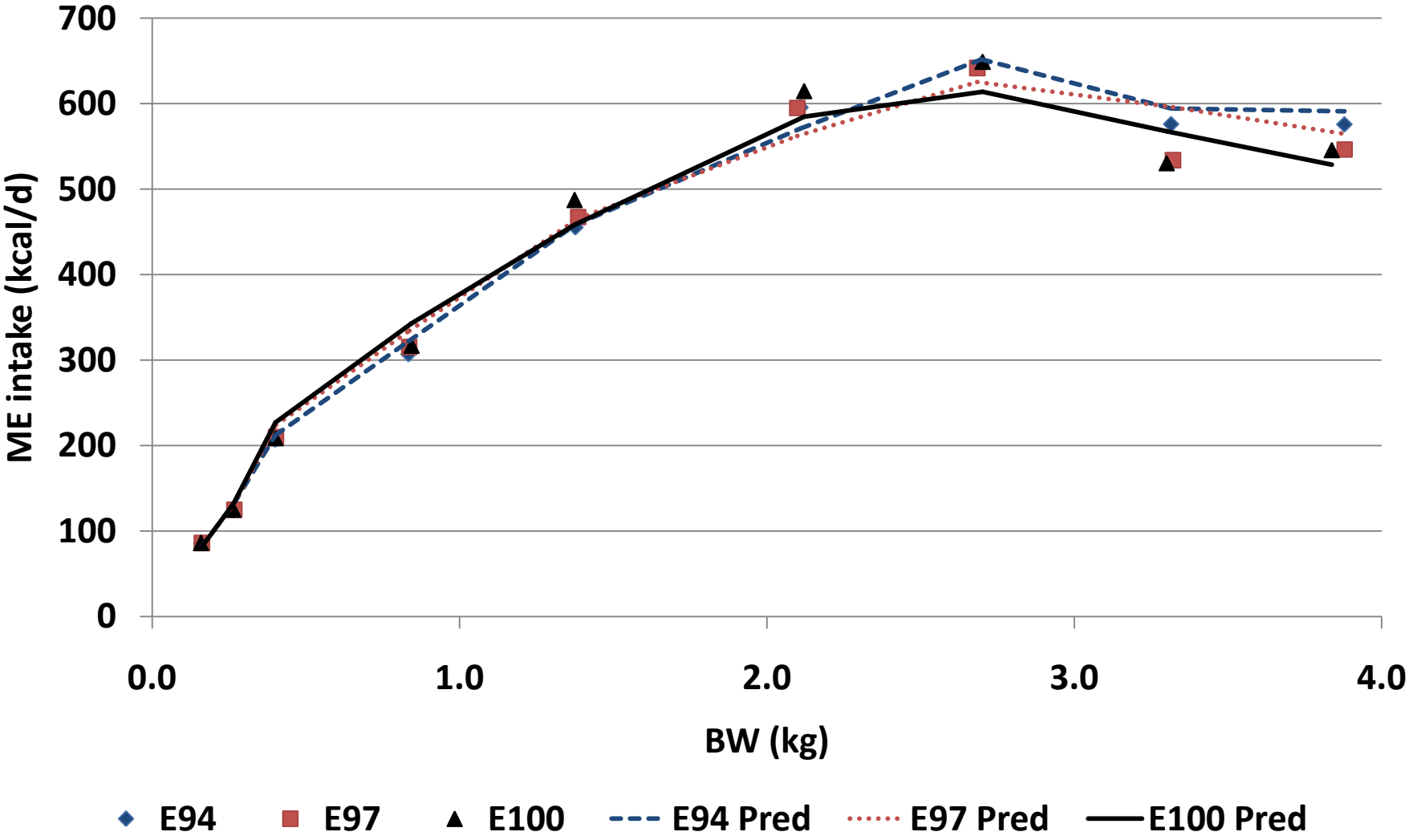
$$ME\ intake = 0.14BW^{0.456}(ME/Lys)^{1.227}(1-0.013 \times Sex) + 0.67ADG^{1.44}(1-0.17 \times Sex)$$



Feed Intake – Sex Effect



Feed Intake – ME Effect

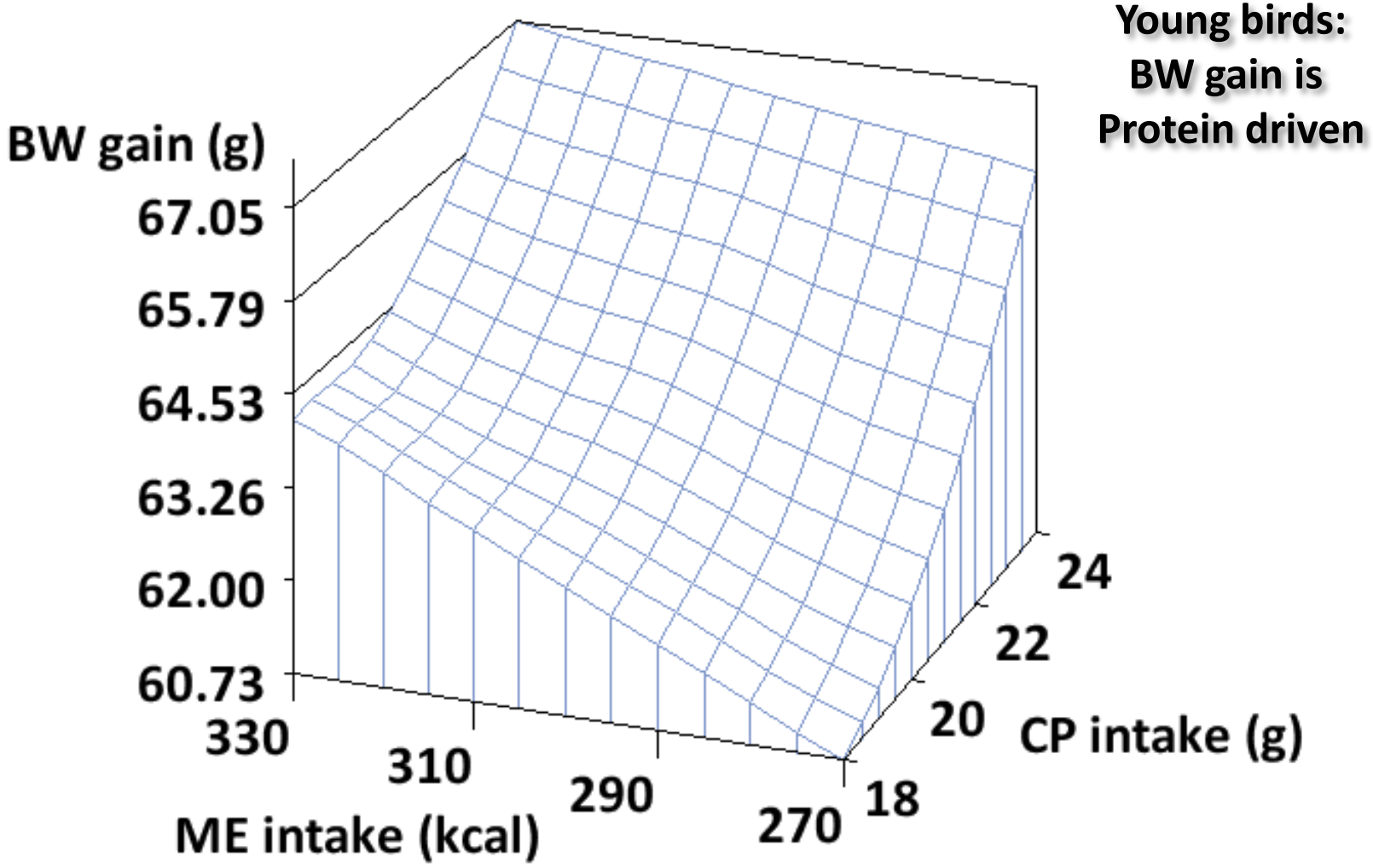




How Does Nutrient Intake Affect BW Gain?

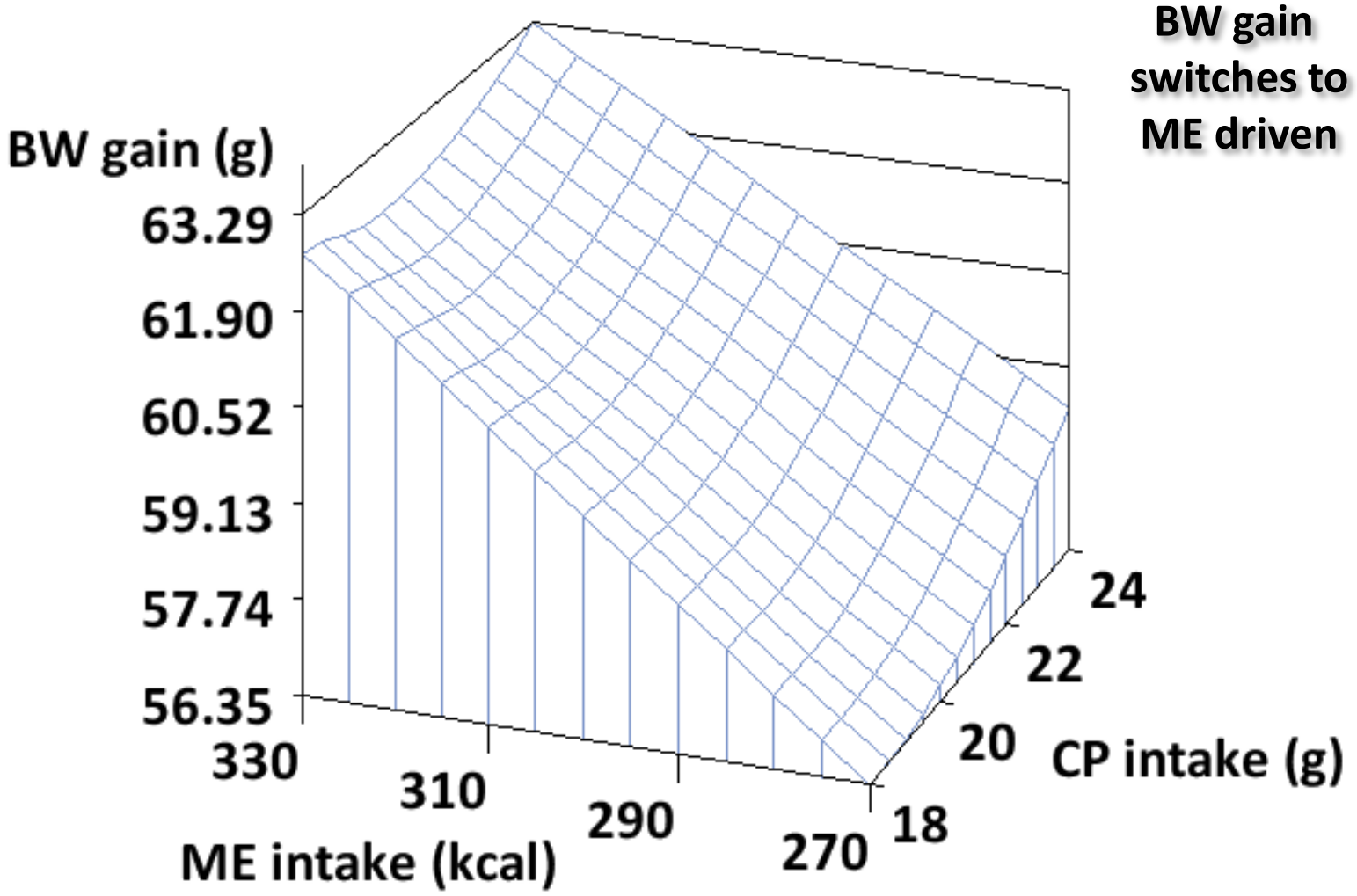
$$BW = f(ME, Lys, CP, age)$$

Diet Composition Effect on BW Gain (per 100 g of feed; 21 d)

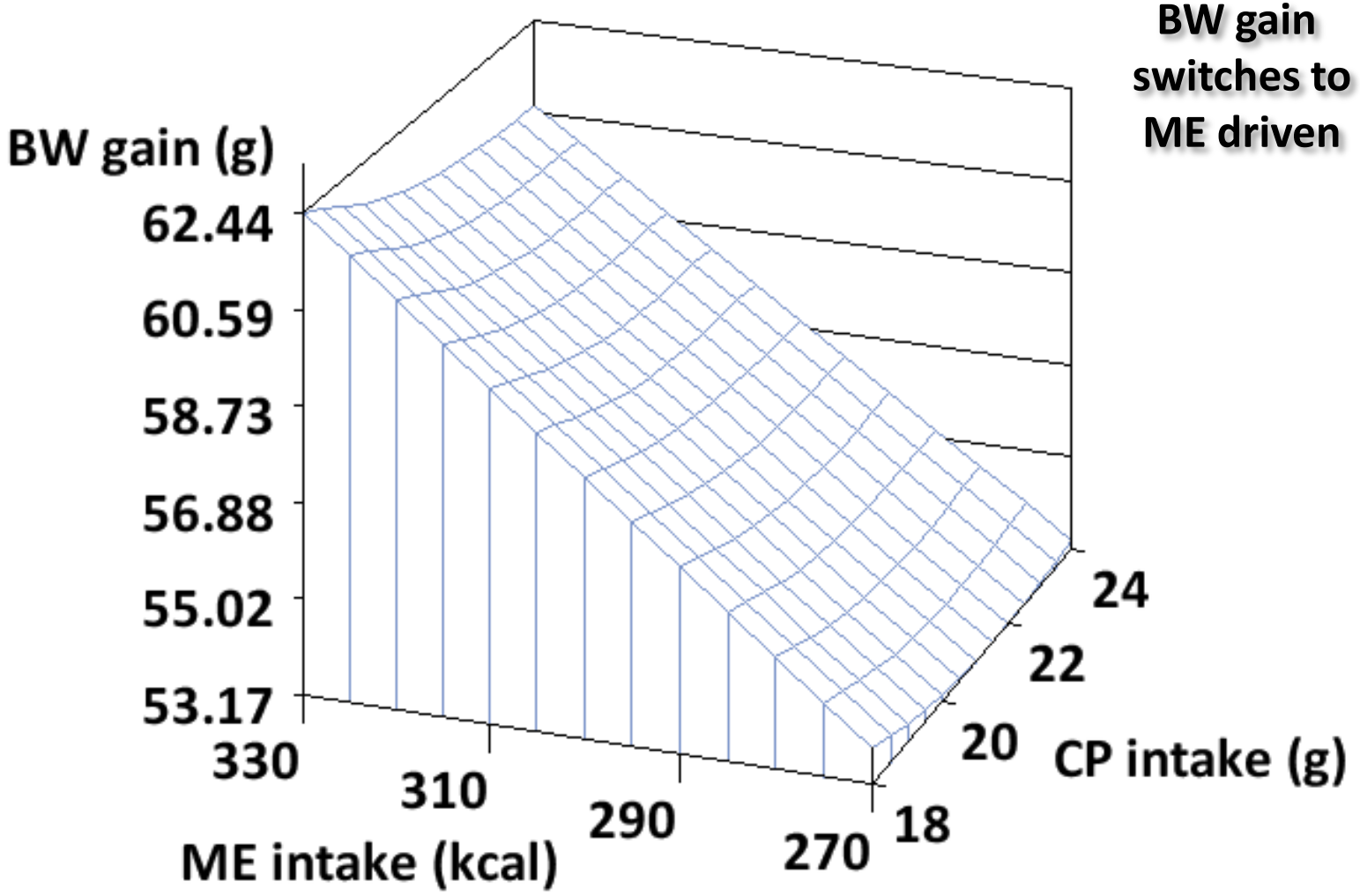


Young birds: BW gain is Protein driven

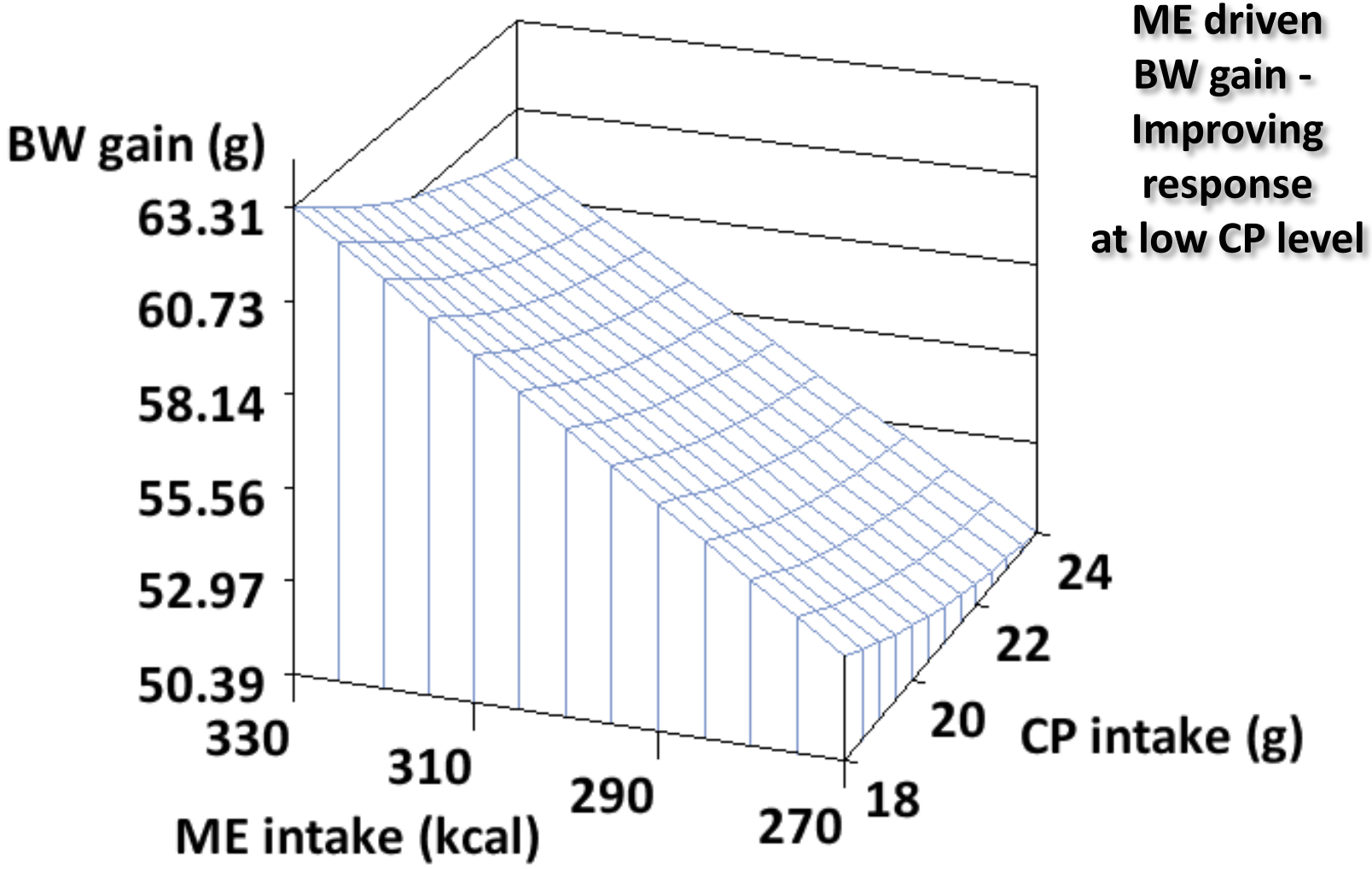
Diet Composition Effect on BW Gain (per 100 g of feed; 28 d)



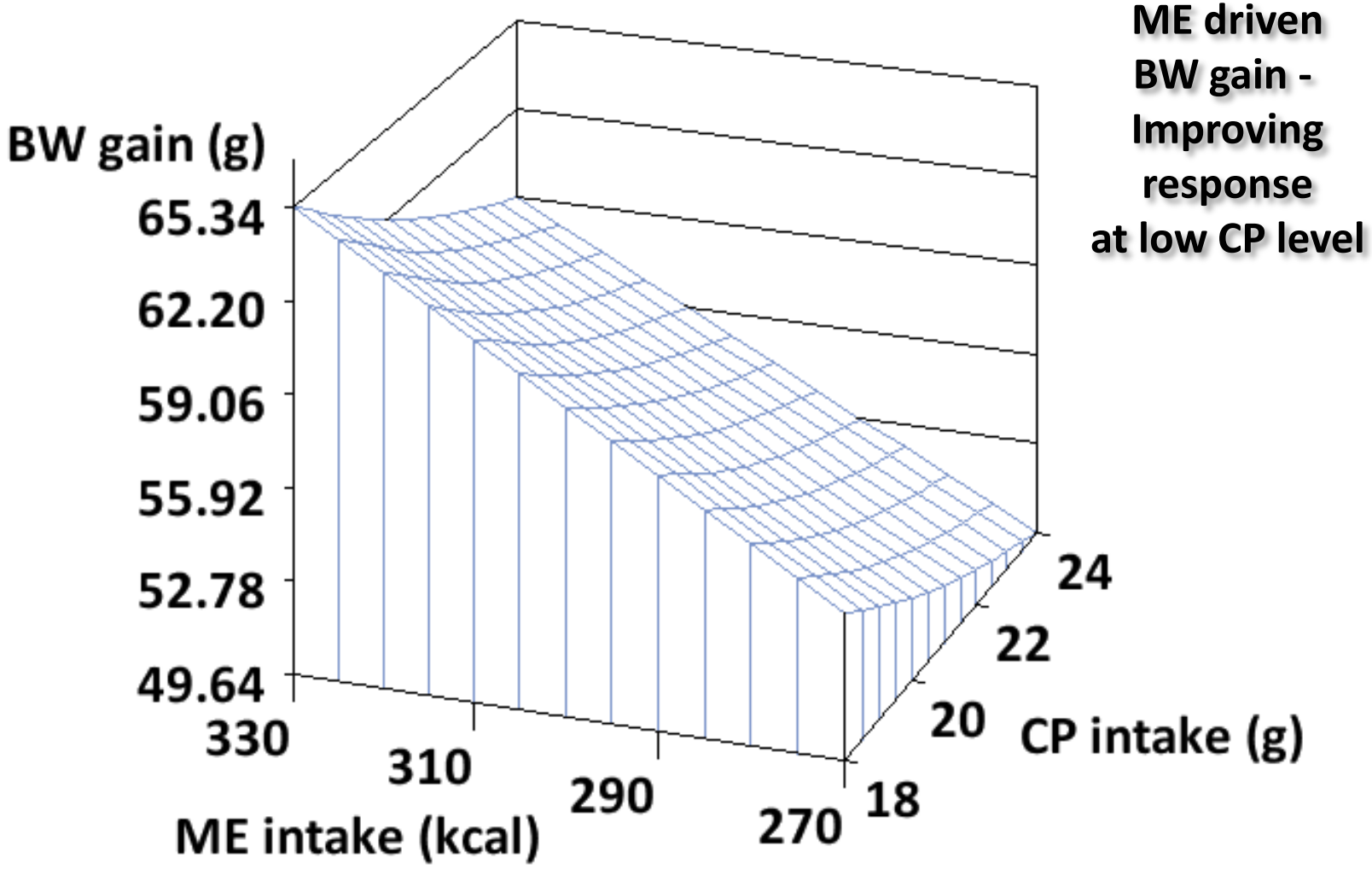
Diet Composition Effect on BW Gain (per 100 g of feed; 35 d)



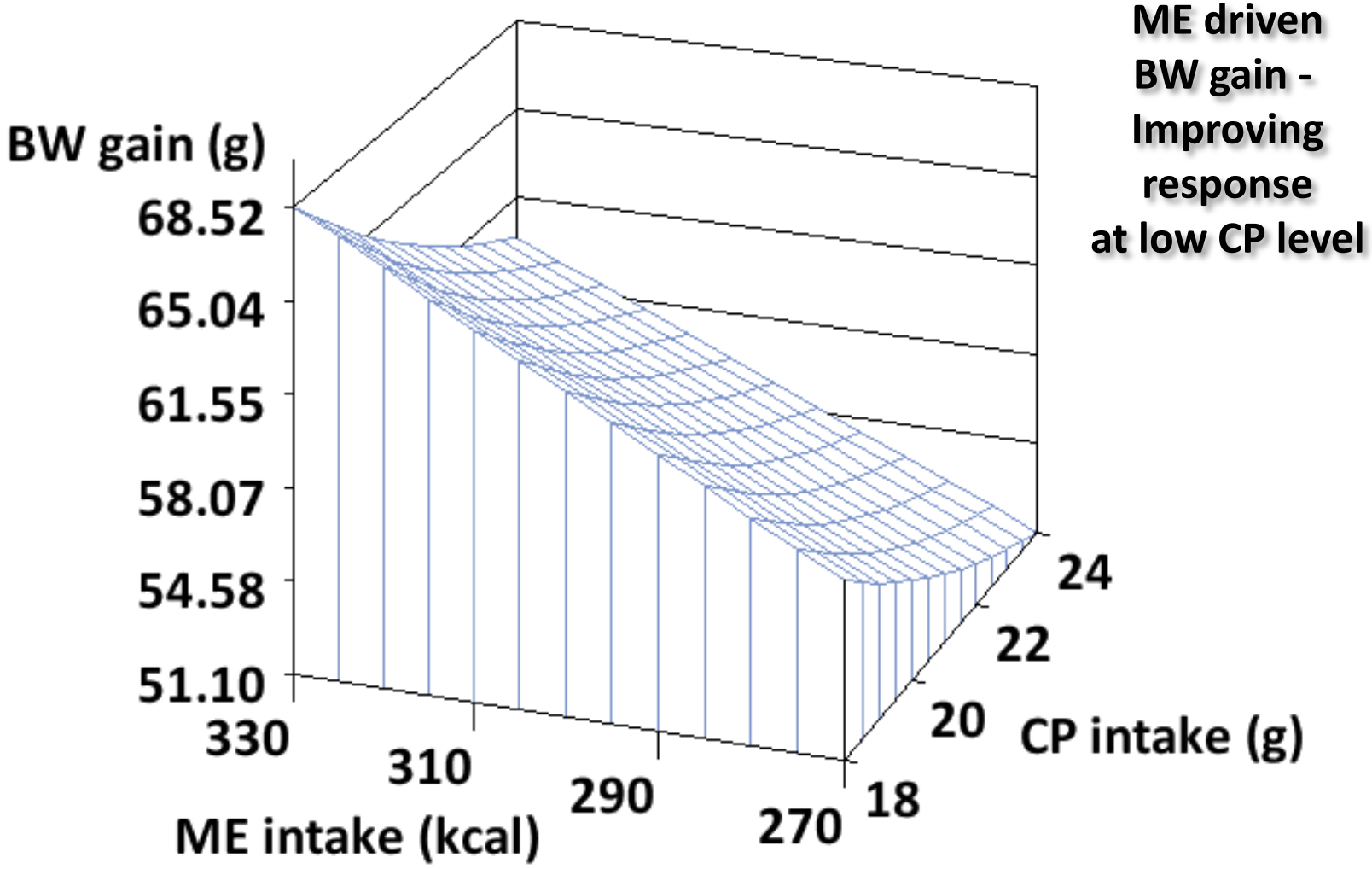
Diet Composition Effect on BW Gain (per 100 g of feed; 42 d)



Diet Composition Effect on BW Gain (per 100 g of feed; 49 d)



Diet Composition Effect on BW Gain (per 100 g of feed; 56 d)

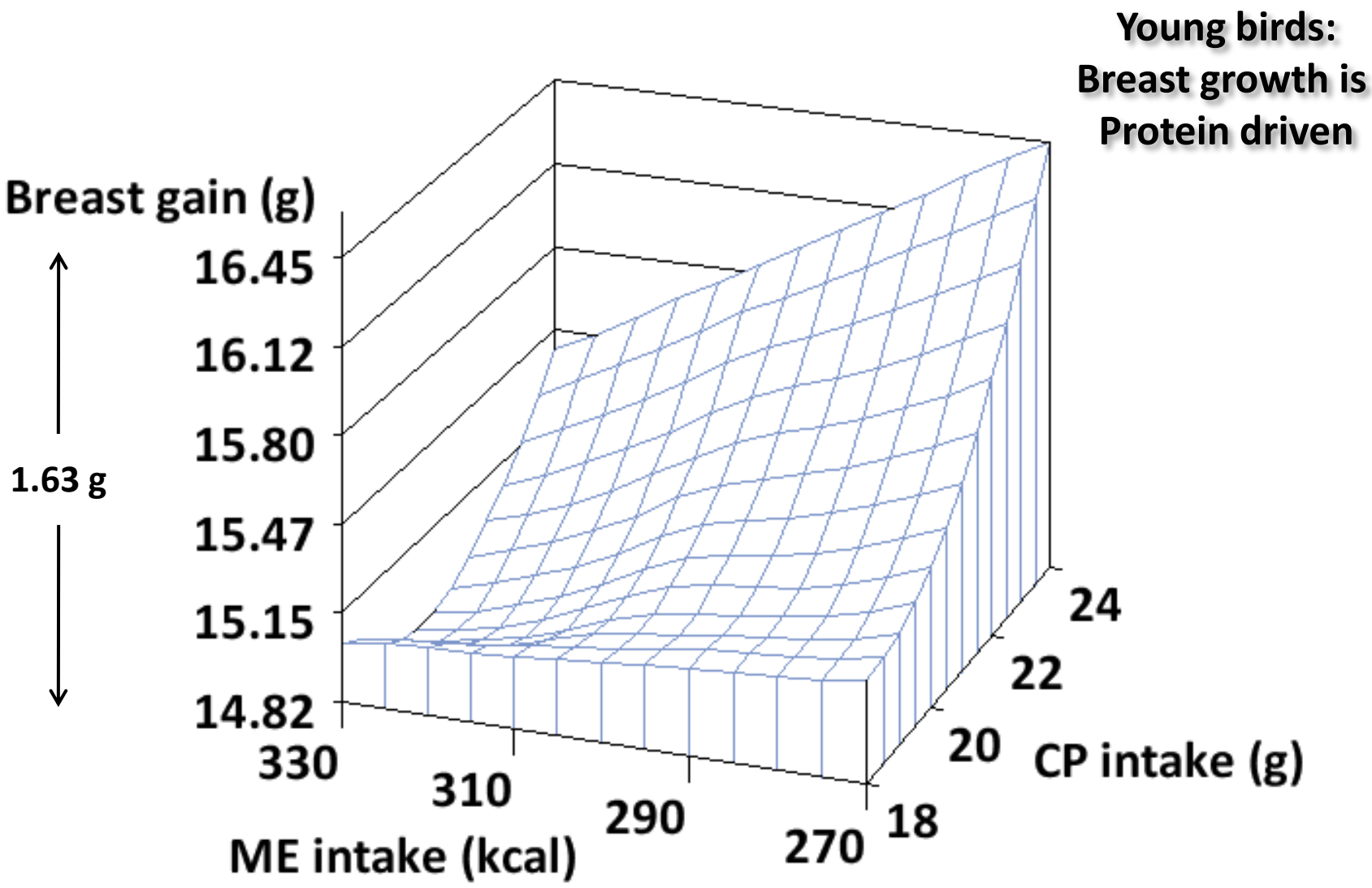




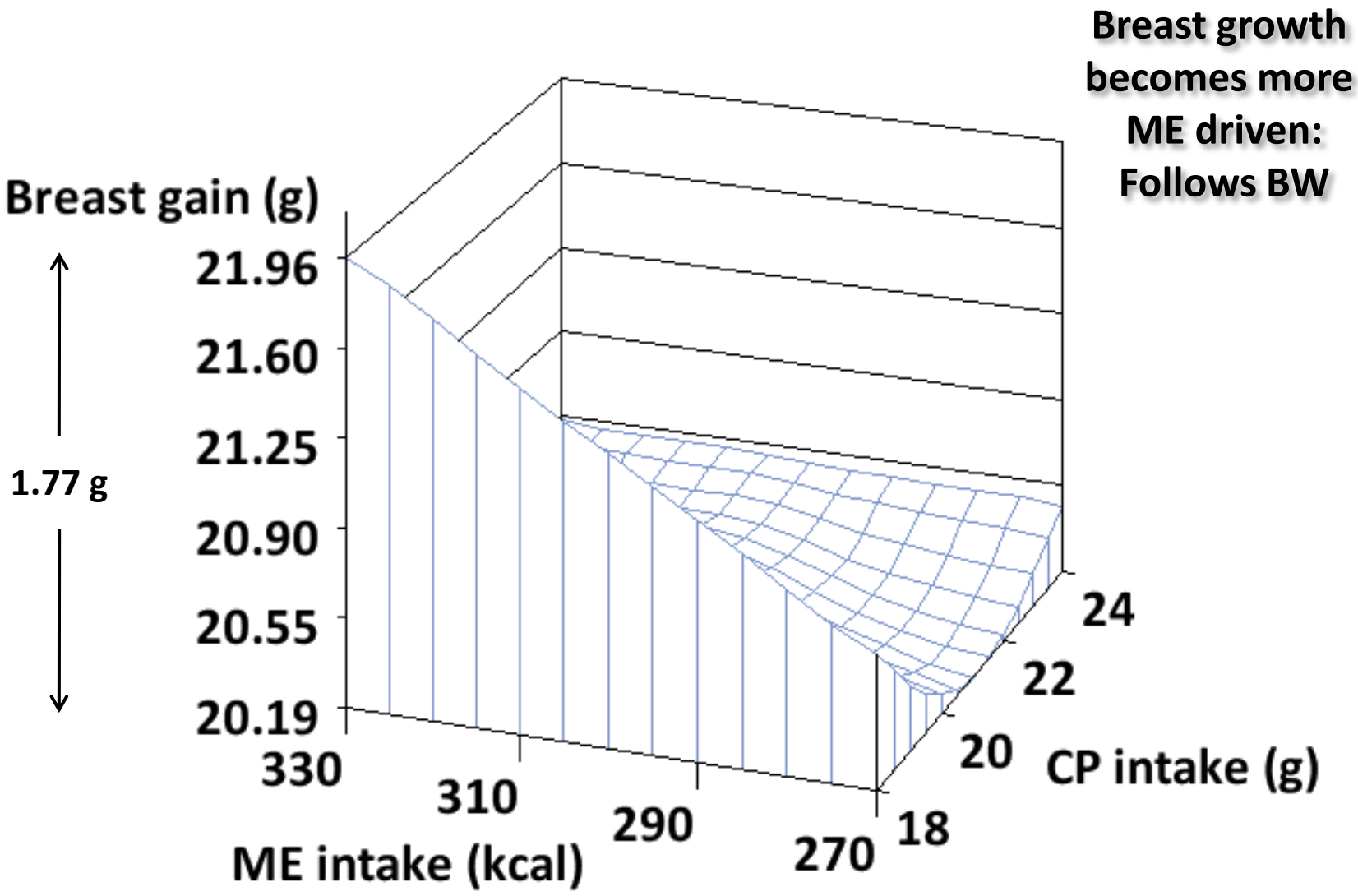
How Does Nutrient Intake Affect Breast Muscle Growth?

$$ADG_{Breast} = f(ME, Lys, CP, age)$$

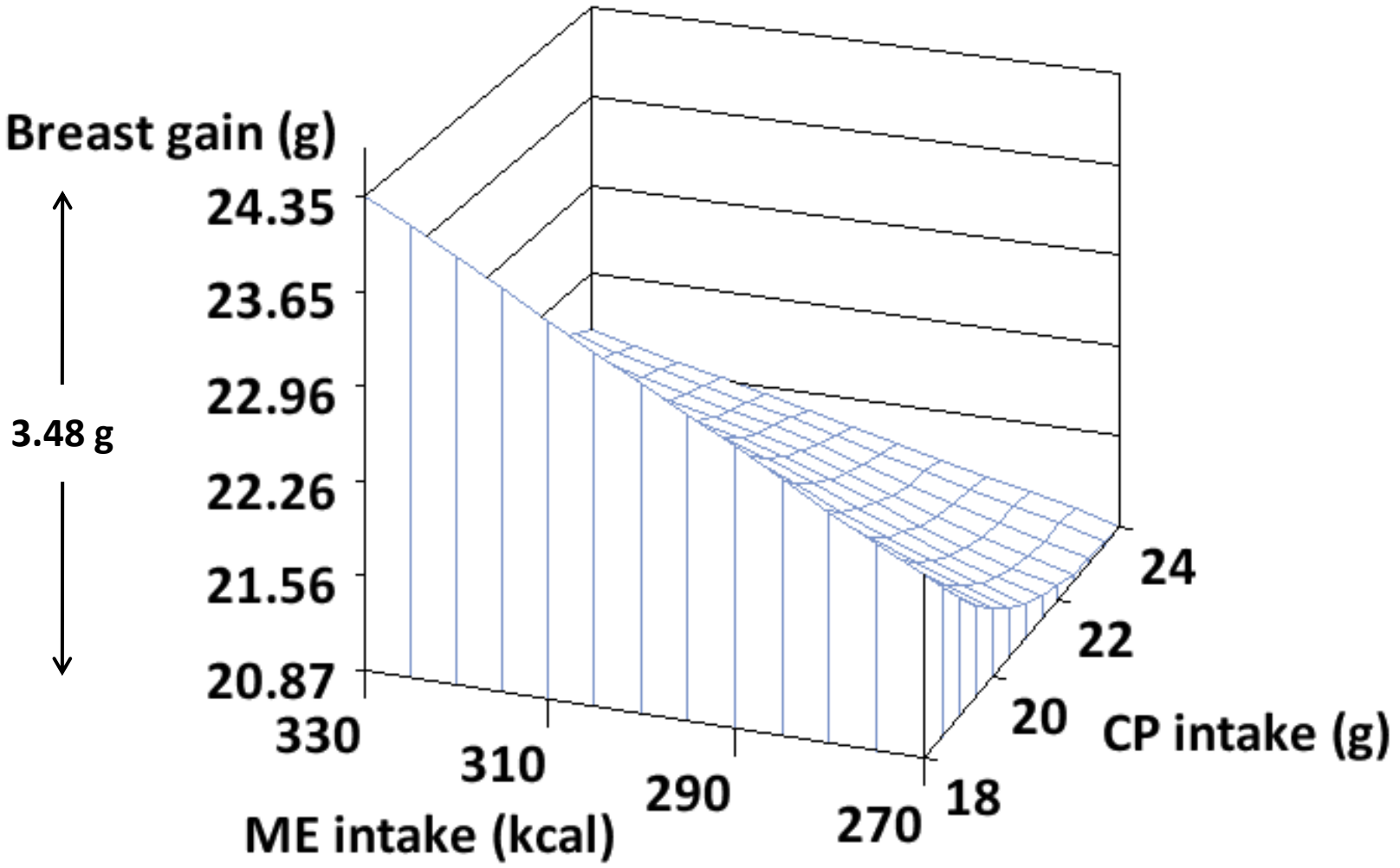
Diet Composition Effect on Breast Gain (per 100 g of feed; 28 d)



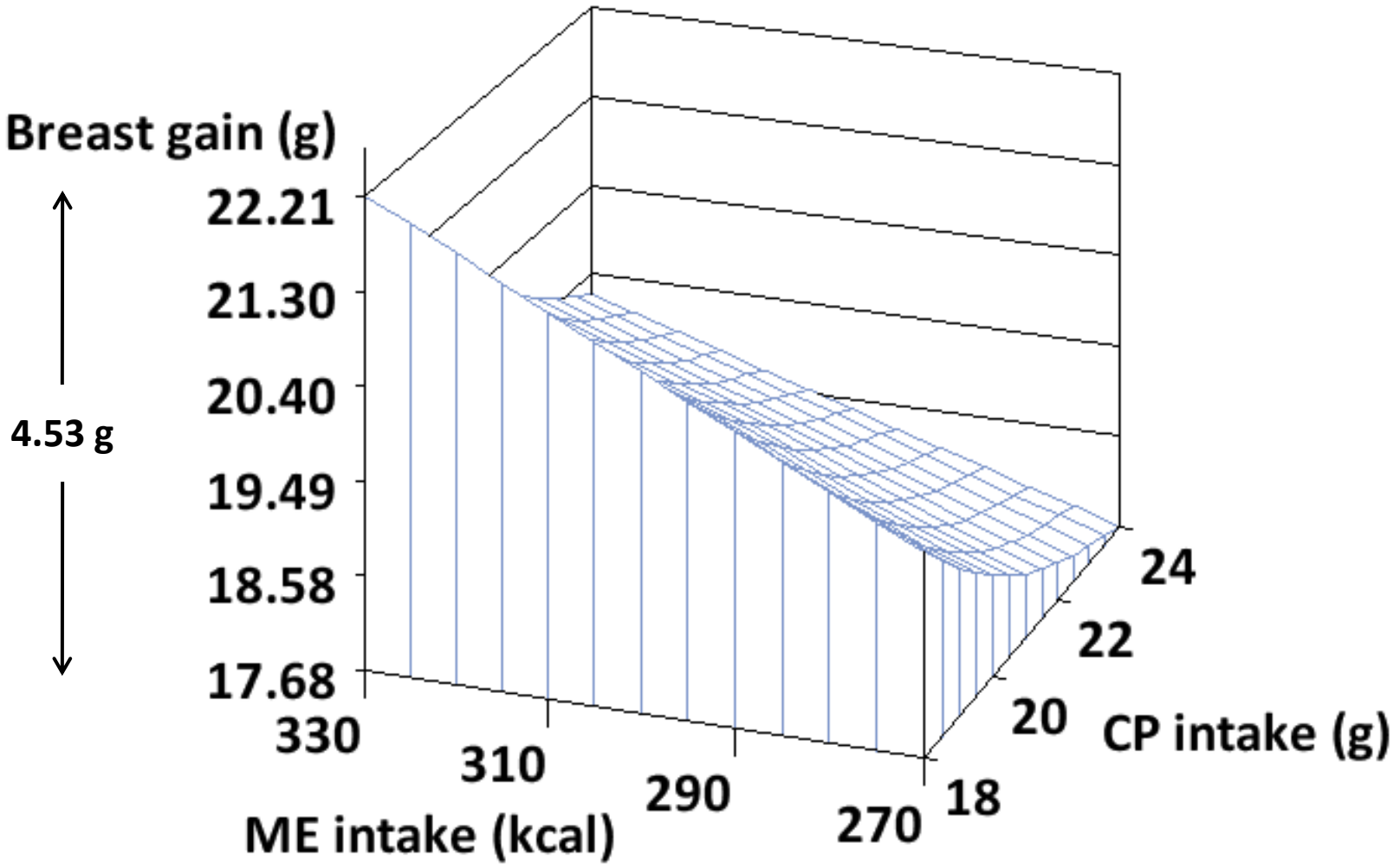
Diet Composition Effect on Breast Gain (per 100 g of feed; 35 d)



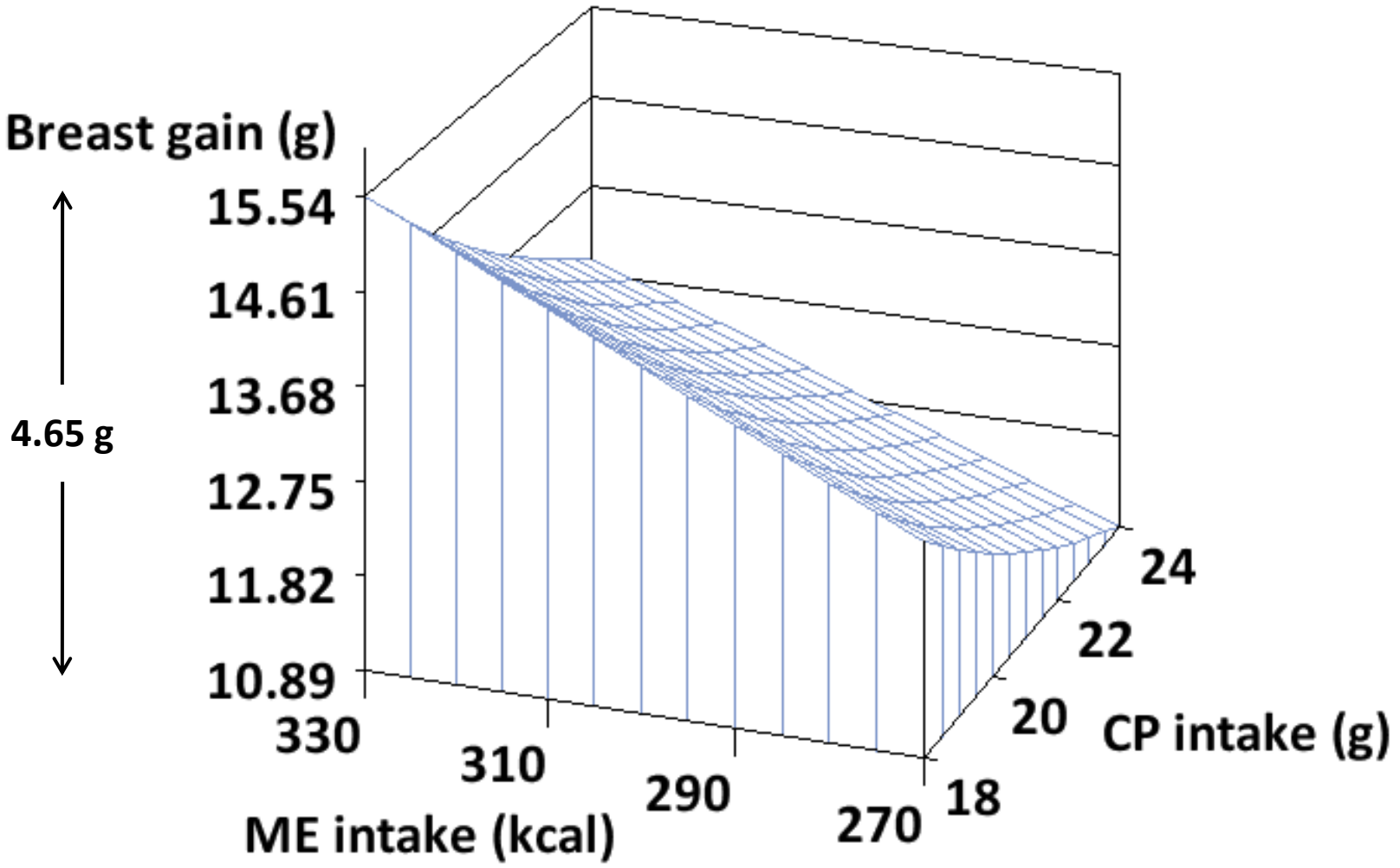
Diet Composition Effect on Breast Gain (per 100 g of feed; 42 d)



Diet Composition Effect on Breast Gain (per 100 g of feed; 49 d)

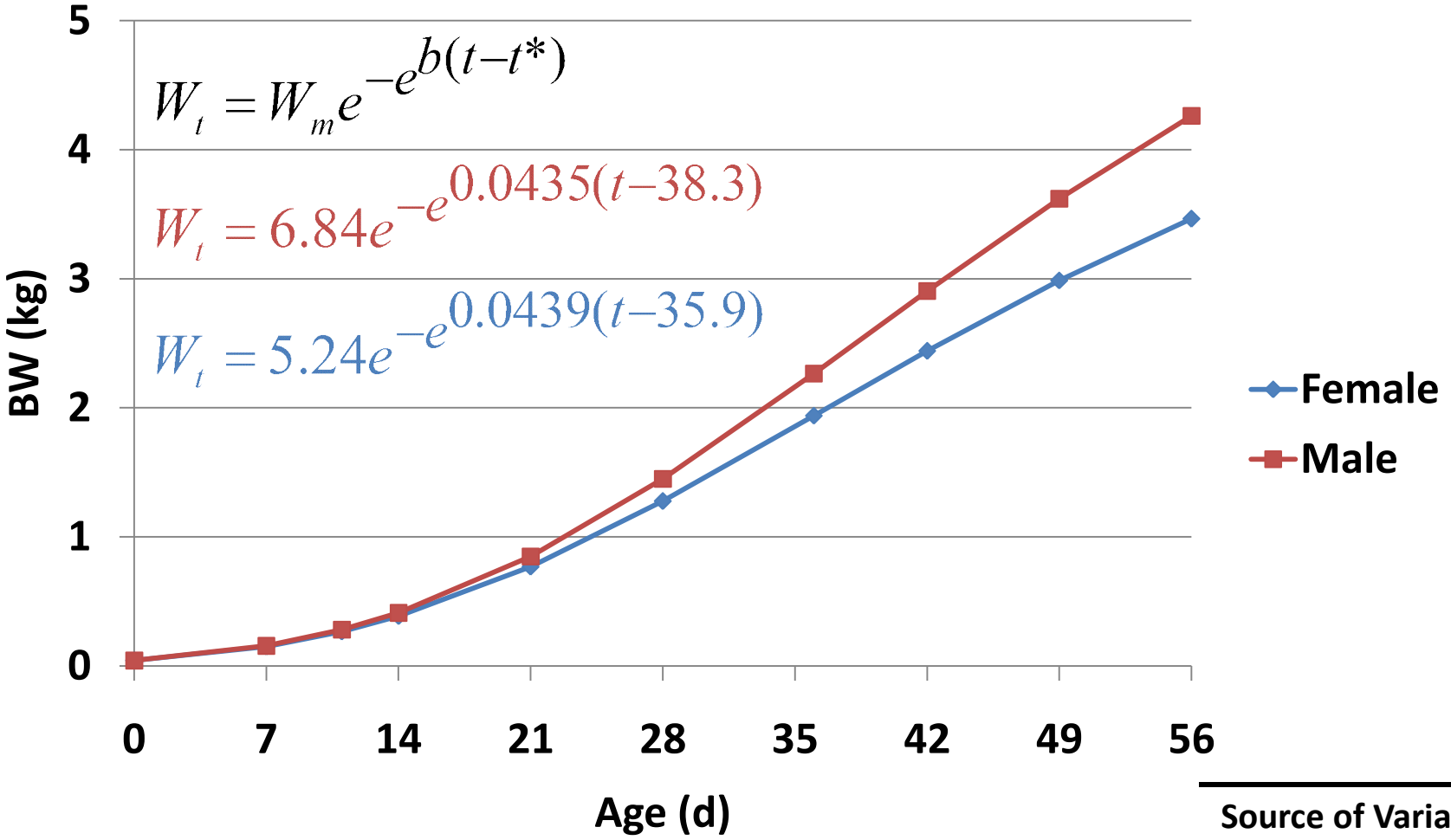


Diet Composition Effect on Breast Gain (per 100 g of feed; 56 d)



Predicted BW Curves: Sex

- Males were heavier than females

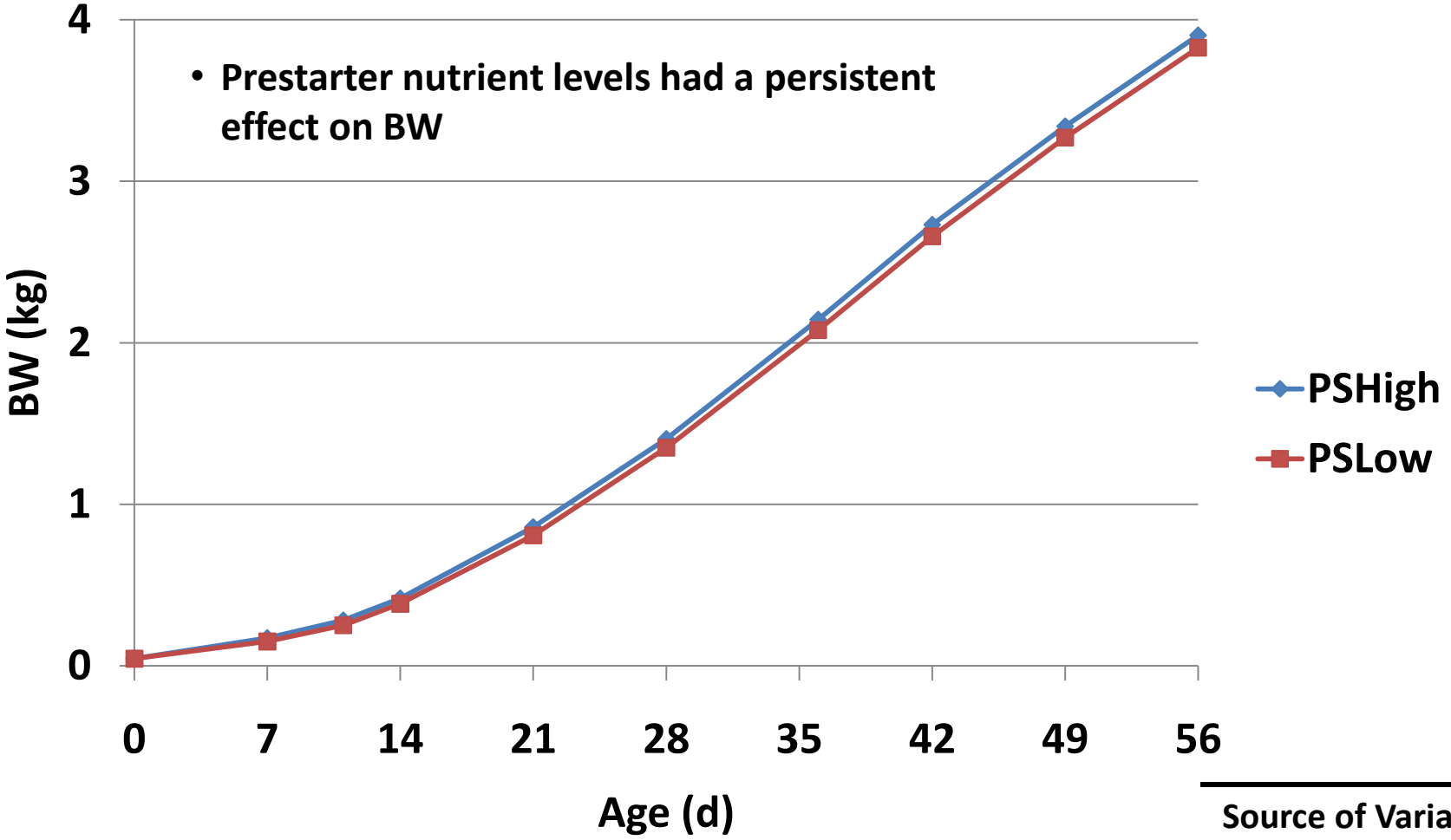


*Mixed Gompertz model

Source of Variation	
Sex	P<0.0001



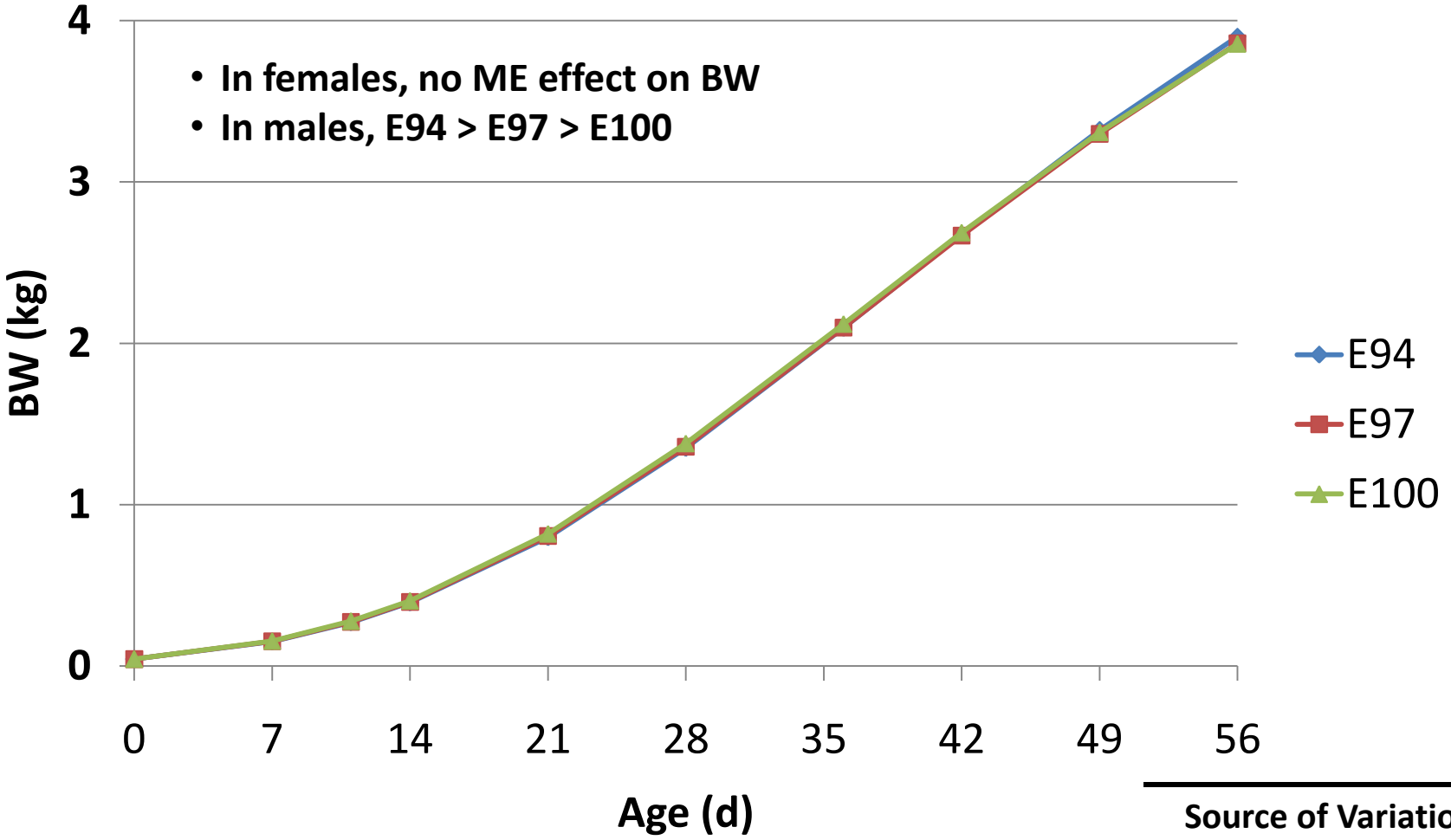
BW Curves: Prestarter



Source of Variation	
PS	P=0.0002

*Mixed Gompertz model

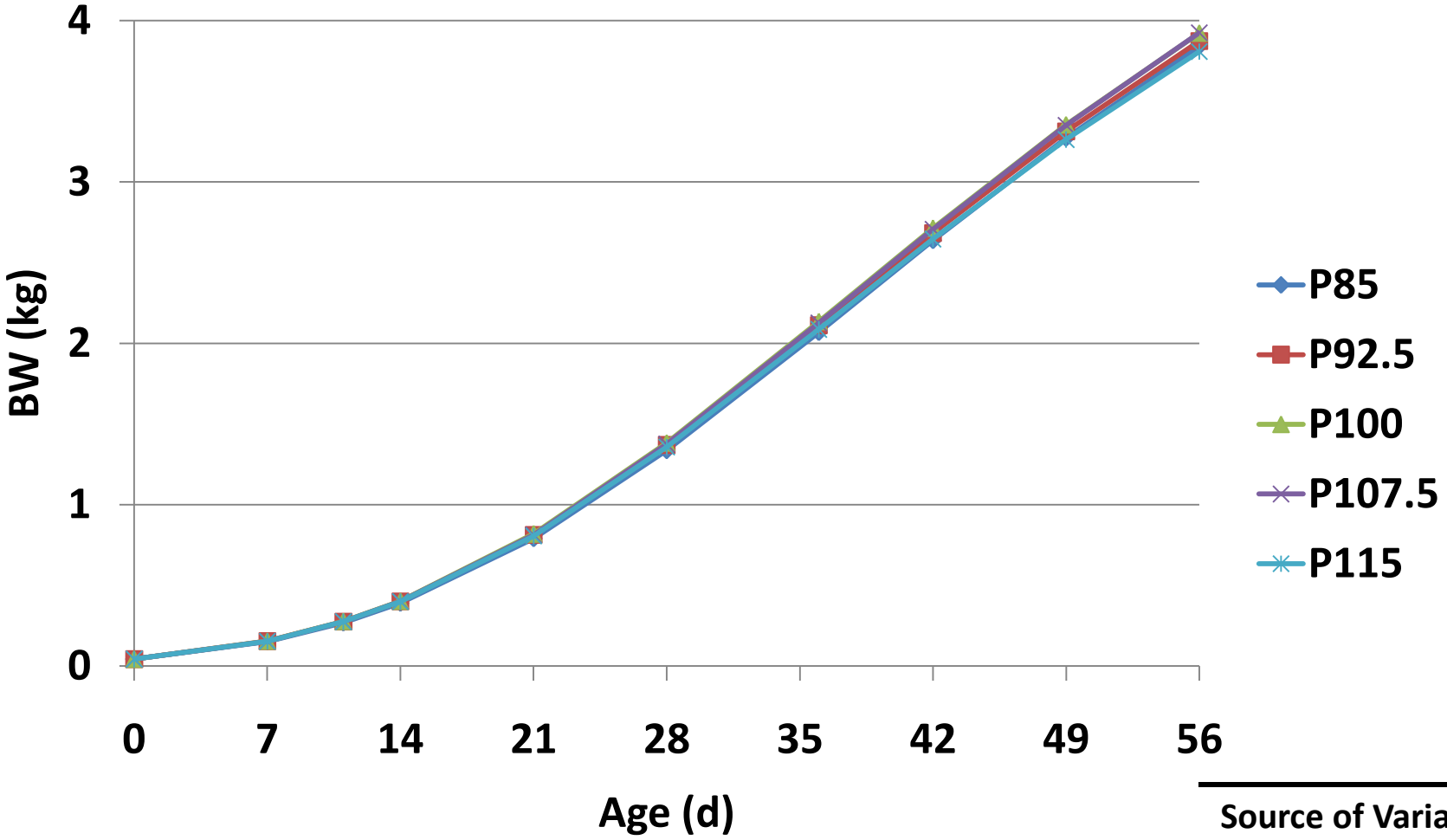
Predicted BW Curves: Energy



Source of Variation	
ME x sex	P<0.05

*Mixed Gompertz model

Predicted BW Curves: Protein



*Mixed Gompertz model

Source of Variation	
DBP	ns



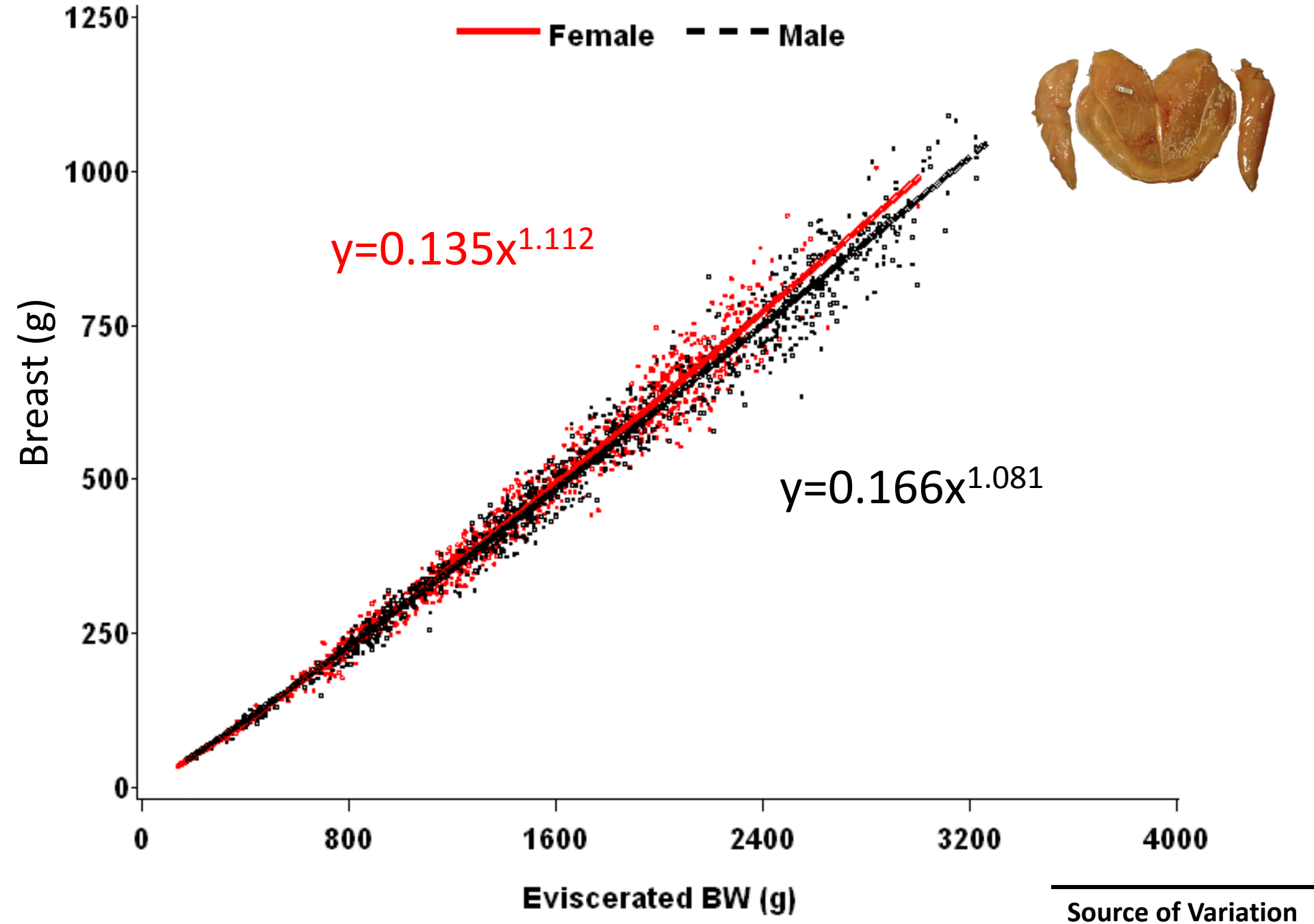
Yield Analysis (nonlinear)

- Allometric analysis was conducted using Huxley's equation

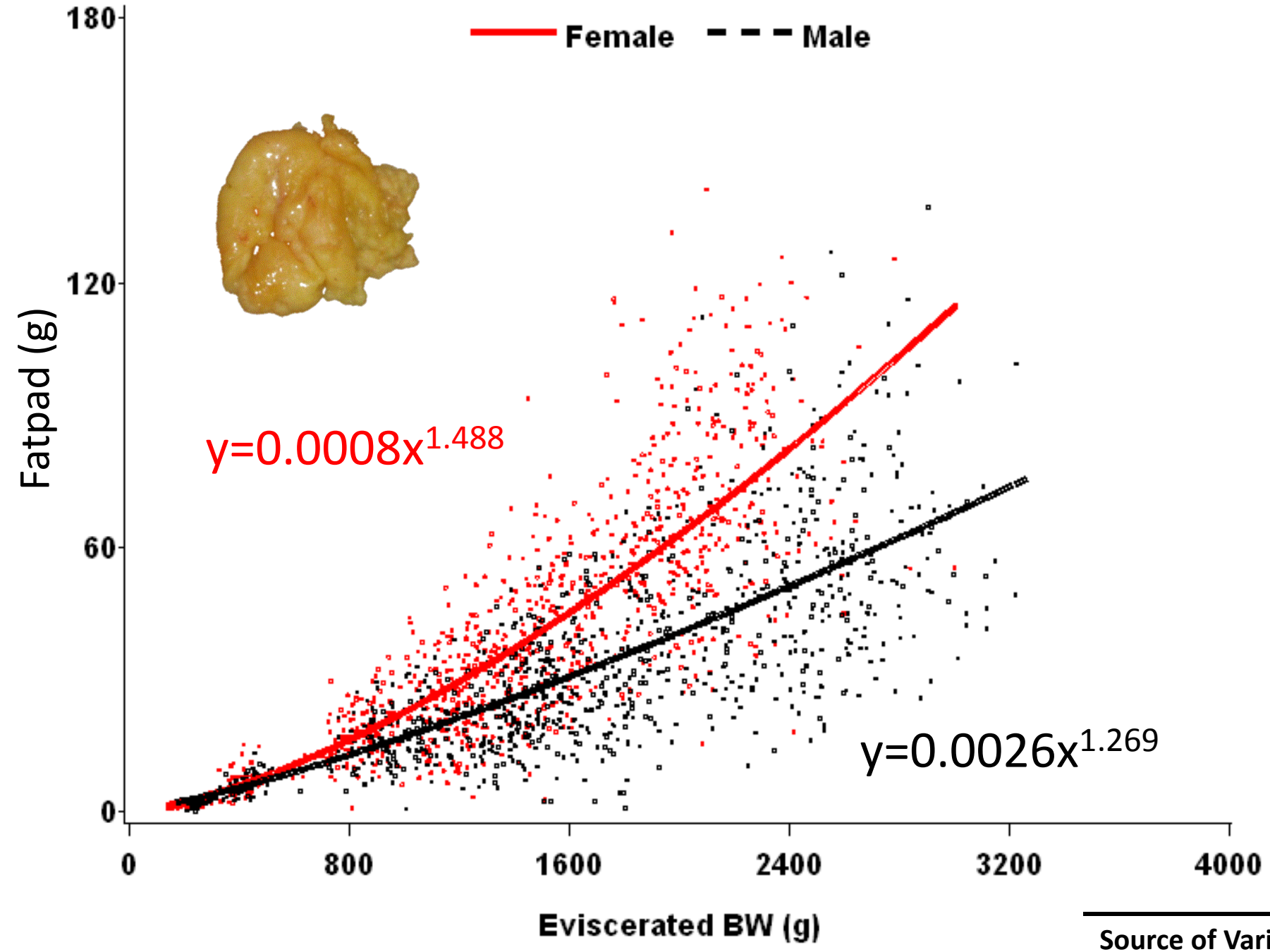
$$y = ax^b$$

  - y was the weight of the carcass part (g)
  - x was the weight of the eviscerated carcass (g)
  - a and b were coefficients, estimated using the NLIN procedure of SAS

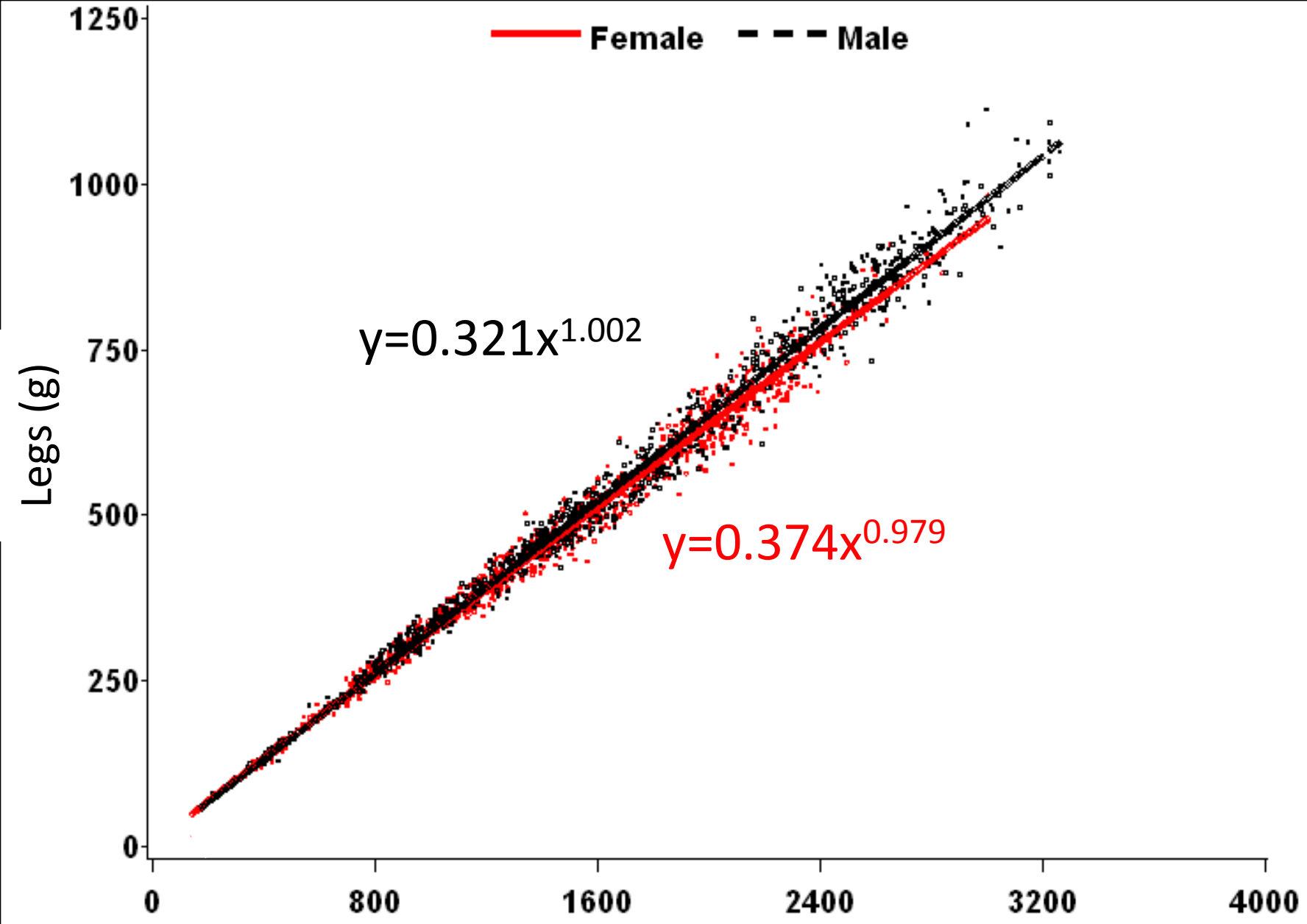
Huxley, Julian S. 1932. Problems of Relative Growth. 36 Essex Street W. C., London: Methuen & Co. Ltd.



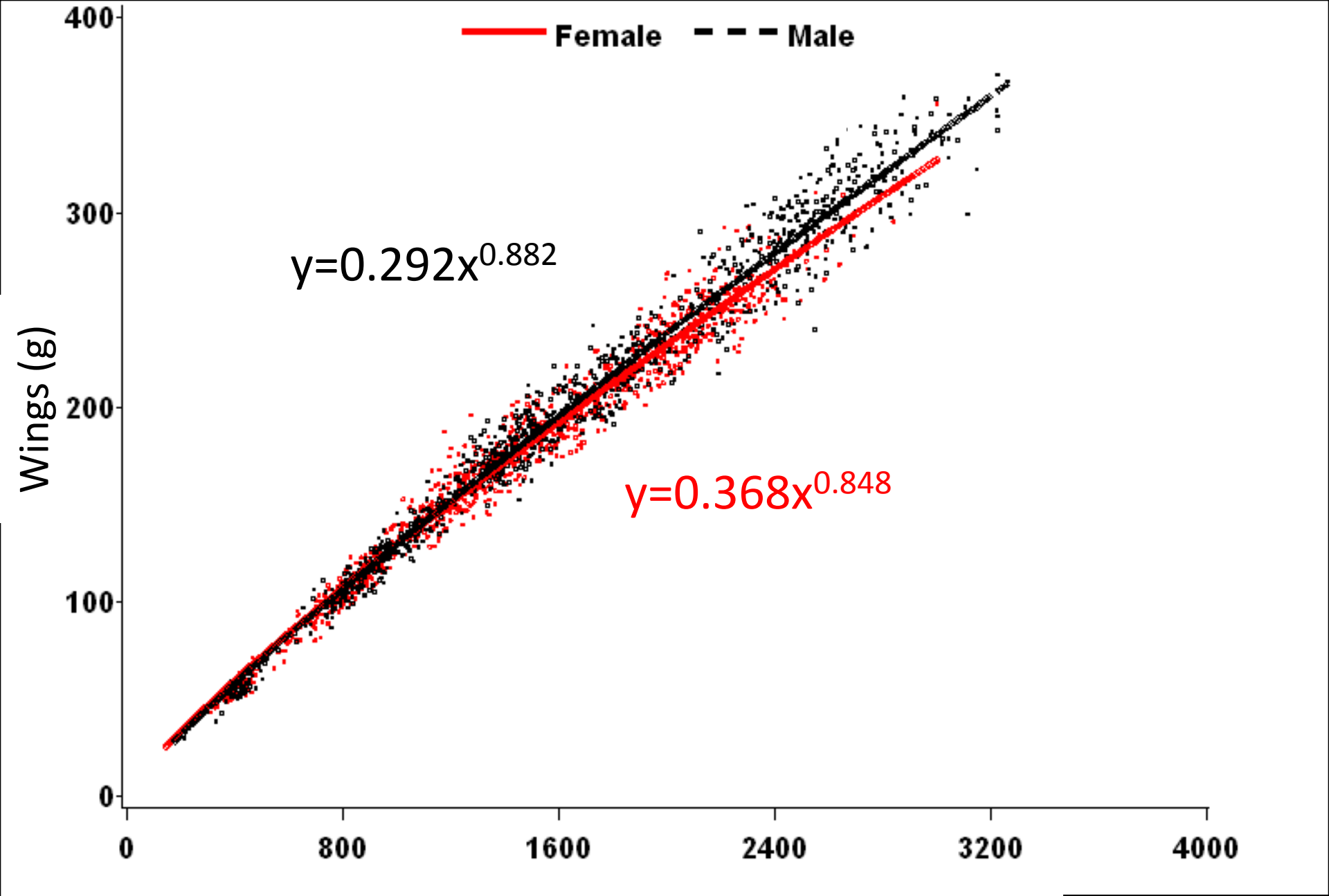
Source of Variation	
Sex	P<0.0001



Source of Variation	
Sex	P<0.0001



Source of Variation	
Sex	P<0.0001



Source of Variation	
Sex	P<0.0001



LowPS

HighPS

$y=0.155x^{1.092}$

$y=0.176x^{1.075}$

Breast (g)

1250

1000

750

500

250

0

0

800

1600

2400

3200

4000

Eviscerated BW (g)

Source of Variation	
PS	P=0.0378

P85 P92.5 P100 P107.5 P115



P115 $y=0.171x^{1.081}$ a

P107.5 $y=0.163x^{1.087}$ ab

P100 $y=0.171x^{1.080}$ b

P92.5 $y=0.180x^{1.070}$ c

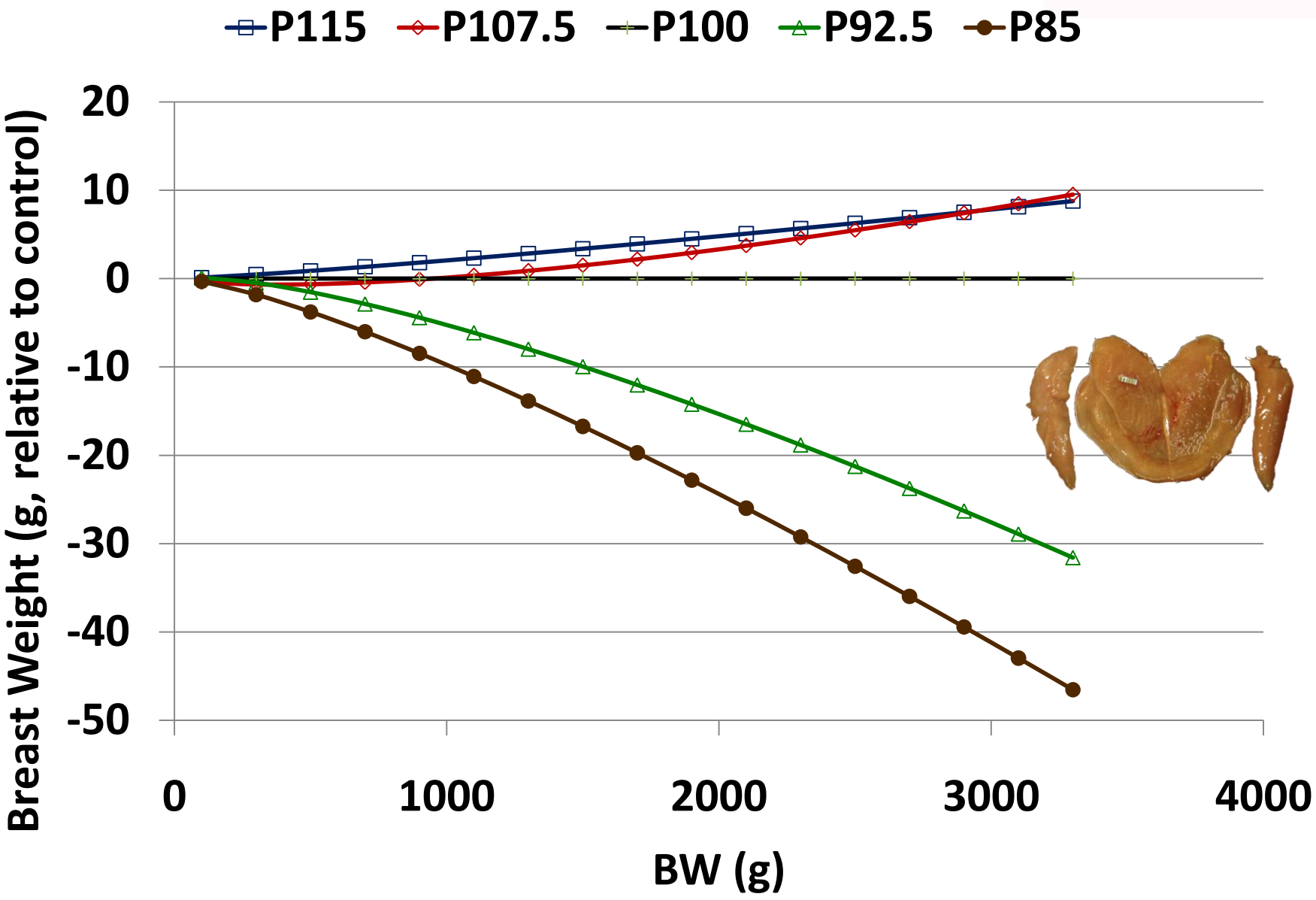
P85 $y=0.176x^{1.071}$ d

breast (g)

Eviscerated BW (g)

Source of Variation	
DBP	P<0.0001




P115
P107.5
P100
P92.5
P85
Breast Weight (g, relative to control)
20
10
0
-10
-20
-30
-40
-50
0
1000
2000
3000
4000
BW (g)

Females P85 P92.5 P100 P107.5 P115

Males P85 P92.5 P100 P107.5 P115

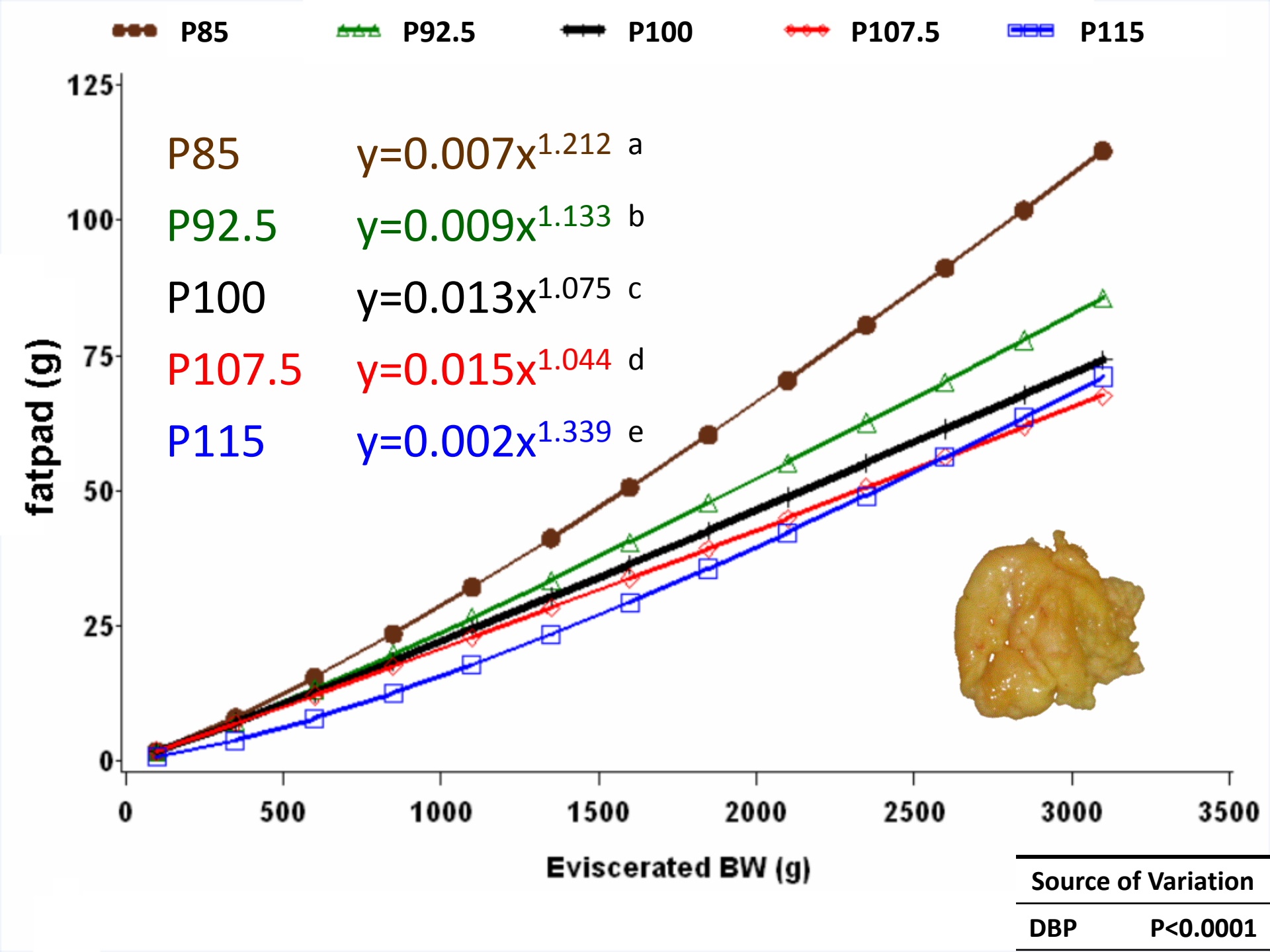


Breast (g, relative to P100 males)

50
40
30
20
10
0
-10
-20
-30
-40

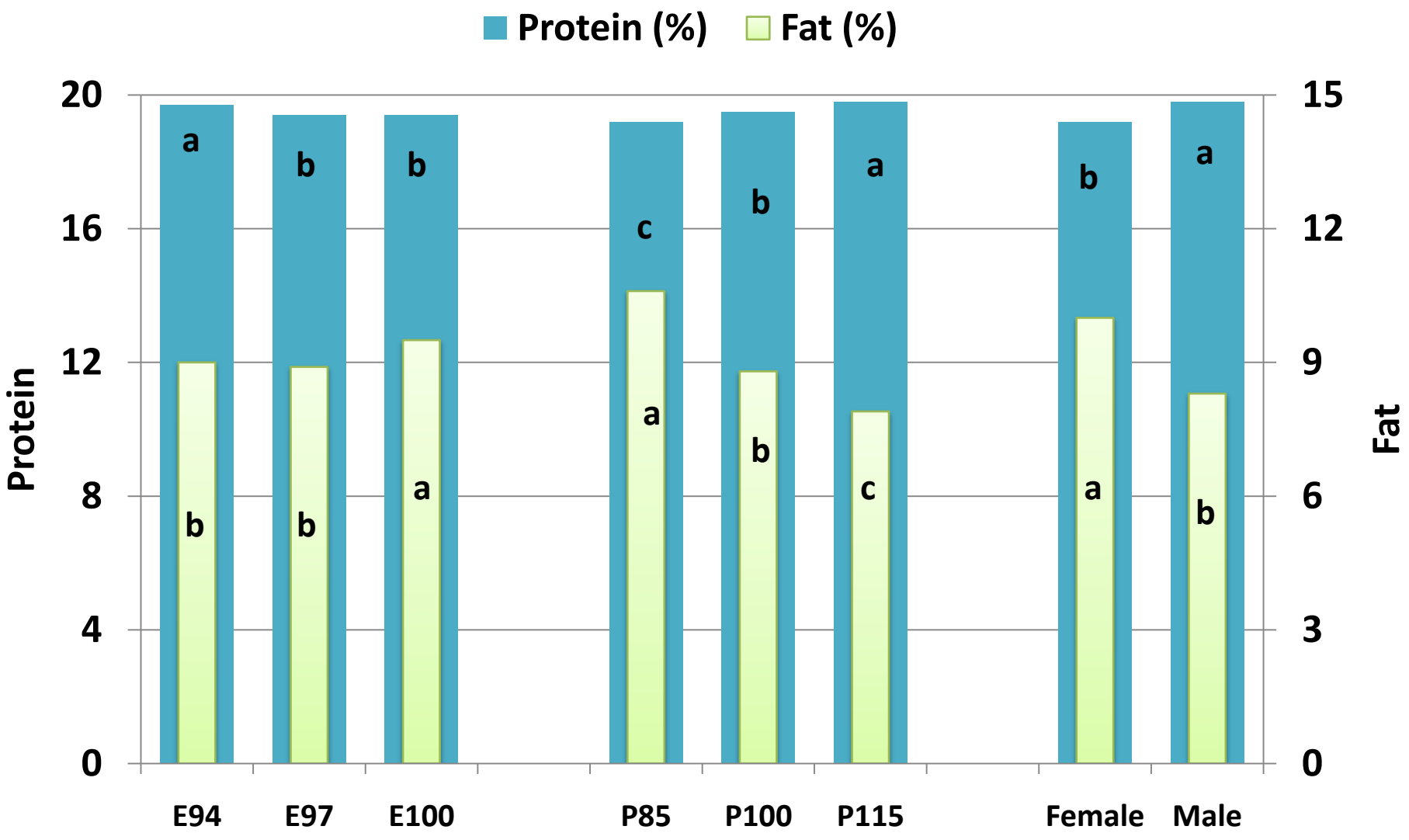
0 500 1000 1500 2000 2500 3000

BW (g)



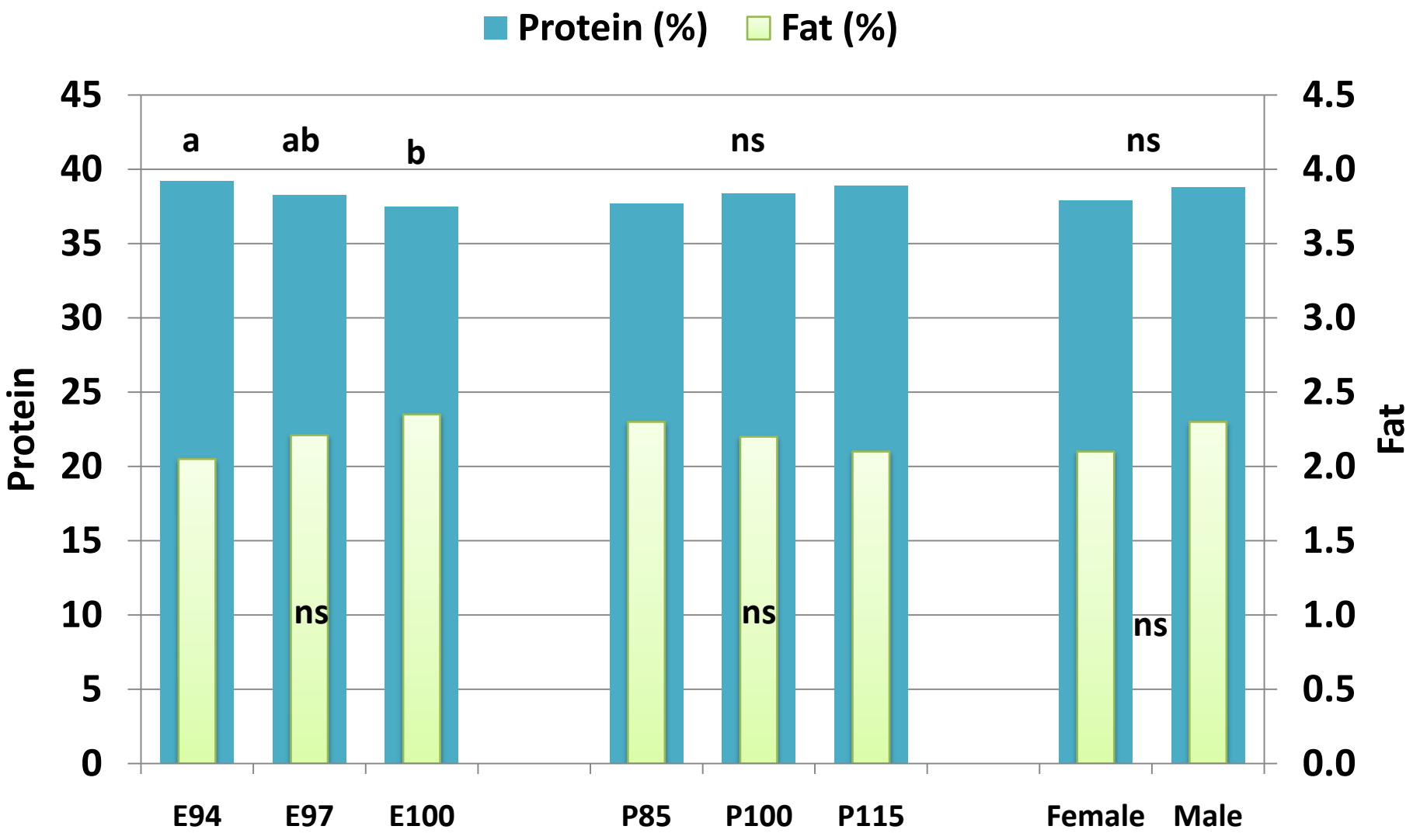
Source of Variation	
DBP	P<0.0001

Carcass Composition (52 d)



Source: B. L. Schneider, MSc thesis

P. Major Composition (52 d)



Source: B. L. Schneider, MSc thesis



Conclusions

- Sex, prestarter nutrition, and subsequent dietary ME and DBP levels had significant nonlinear effects on
  - Feed intake
  - BW
  - Yield dynamics
- Practical nonlinear models were robust enough to identify similar trends as ANOVA
- Strain-, environment-, and management-specific data will improve the prediction value of the model in commercial applications

Questions

Now go solve your nutritional puzzles!

Who knows what doors predictive modeling will open for you?

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