Modelling Phosphorous digestion, retention & excretion in pigs

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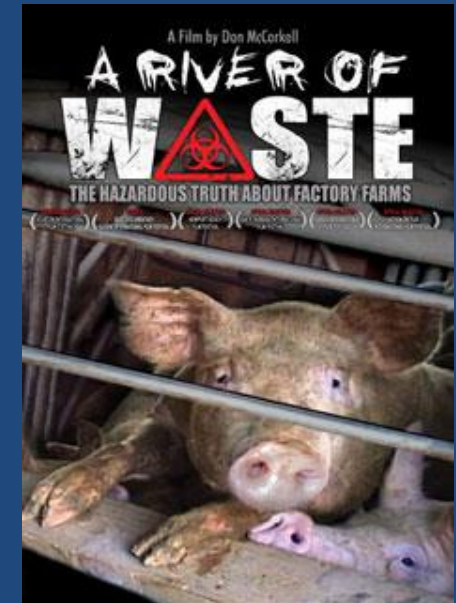Newcastle University, England

Why are we interested in Phosphorous?

Supplementation of inorganic P is:
(1)**Expensive**
(2)Non-renewable resource

Environmental degradation: **Eutrophication**

Environmental degradation causes **bad publicity**

Do we need another P model?

- **Currently there are (at least) three very good P digestion models in the literature**

- **Their limitations are:**

  1. **P intake is an input**

  2. **They do not account for pig genotype (and hence maximum retention)**

  3. **There is no link between P retention and retention of other body components**

  4. **The predictions do not distinguish between the different forms of P excreted**

The necessary steps to predict P excretion

1. Describe feed composition in necessary and consistent terms

2. Describe the animal in sufficient terms to estimate (maximum) rates of P deposition (Requirements)

3. Develop a P digestion module

4. Predict the different forms of P excreted

Description of feed composition

- **Total P (g/kg)**
  - total phytate P (oP)
  - total non- phytate P (NPP) (g/kg)
- **Total Calcium (Ca) (g/kg)**
- **Total phytase content (FTU)**
  - Amount of plant phytase – e.g. wheat
  - Amount and origin of exogenous phytase added- e.g. *E. coli* or *A. niger*
  - Extent of inactivation of feed phytases

Estimation of P Requirements

1. **Estimate Ph Requirements for maintenance (P_{maint})**

$$P_{maint} = p \cdot Pr \cdot Pr_m^{-0.27}$$

2. **Estimate the net efficiency of P use for growth**

   **Current estimates range from 0.7- 0.97**

3. **Estimate the maximum capacity for P deposition (PR_{max})**

   P retention was made an isometric function of protein retention

The necessary steps to predict P excretion

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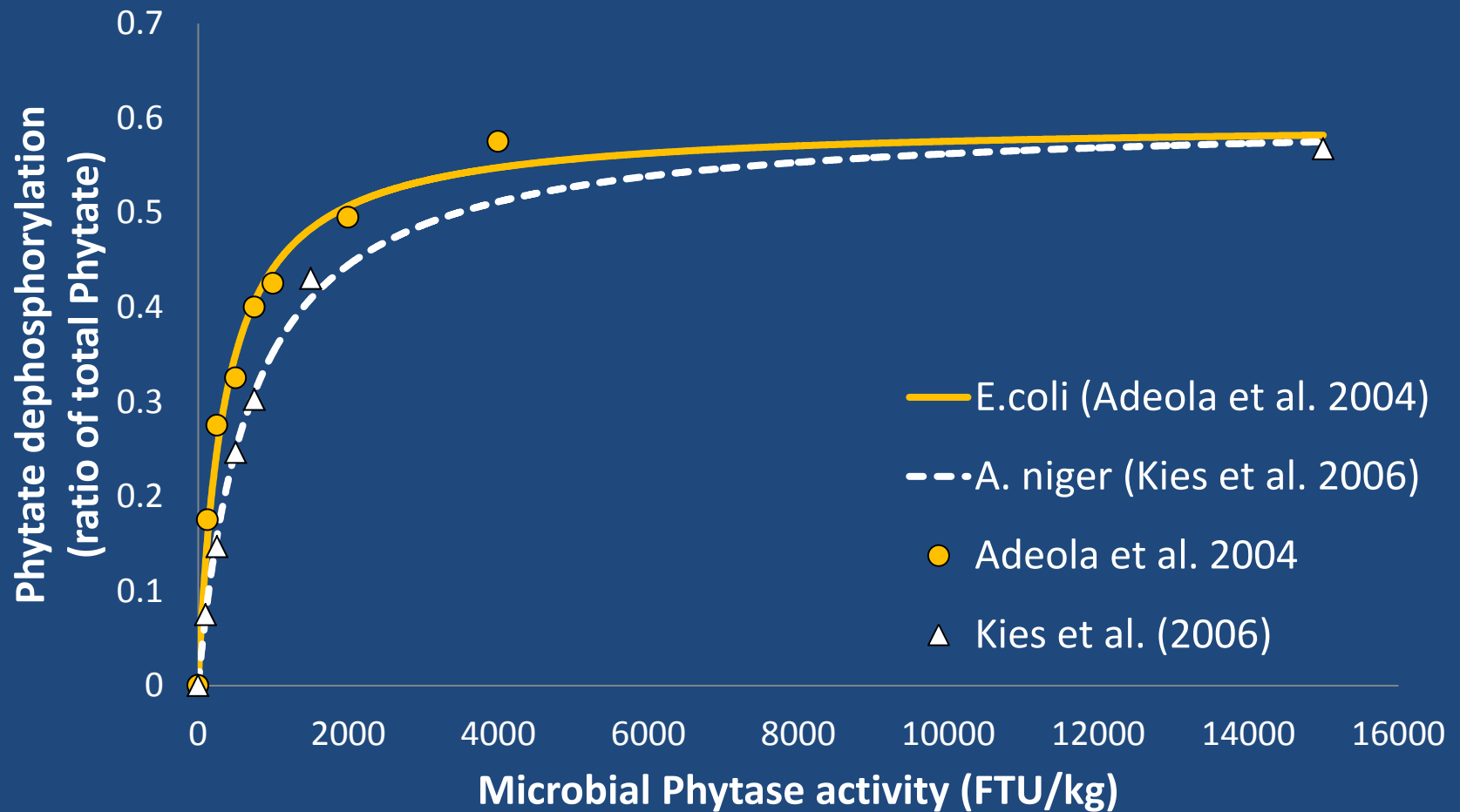4. Predict the different forms of P excreted

Schematic description of the model of phosphorus intake, retention and excretion
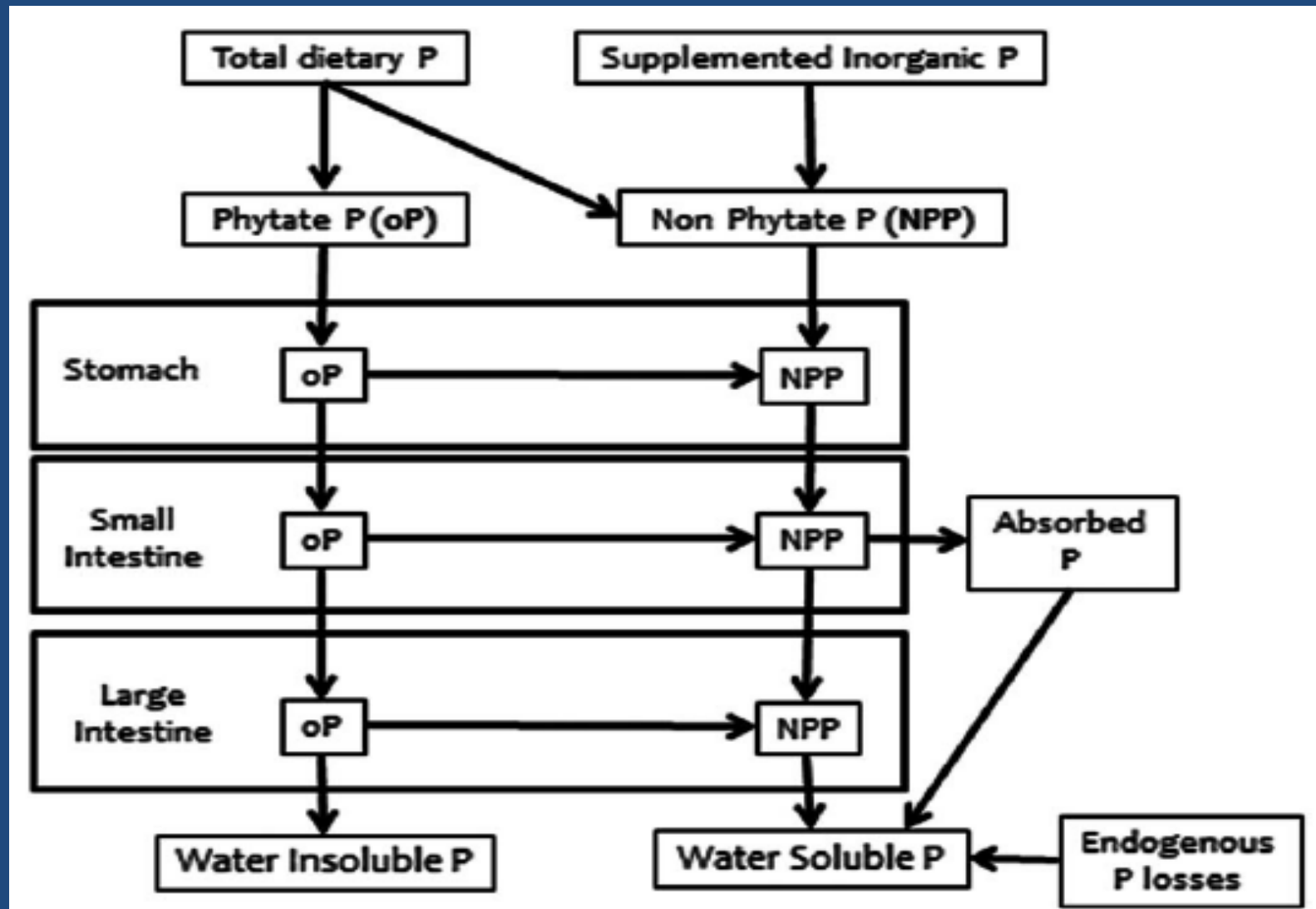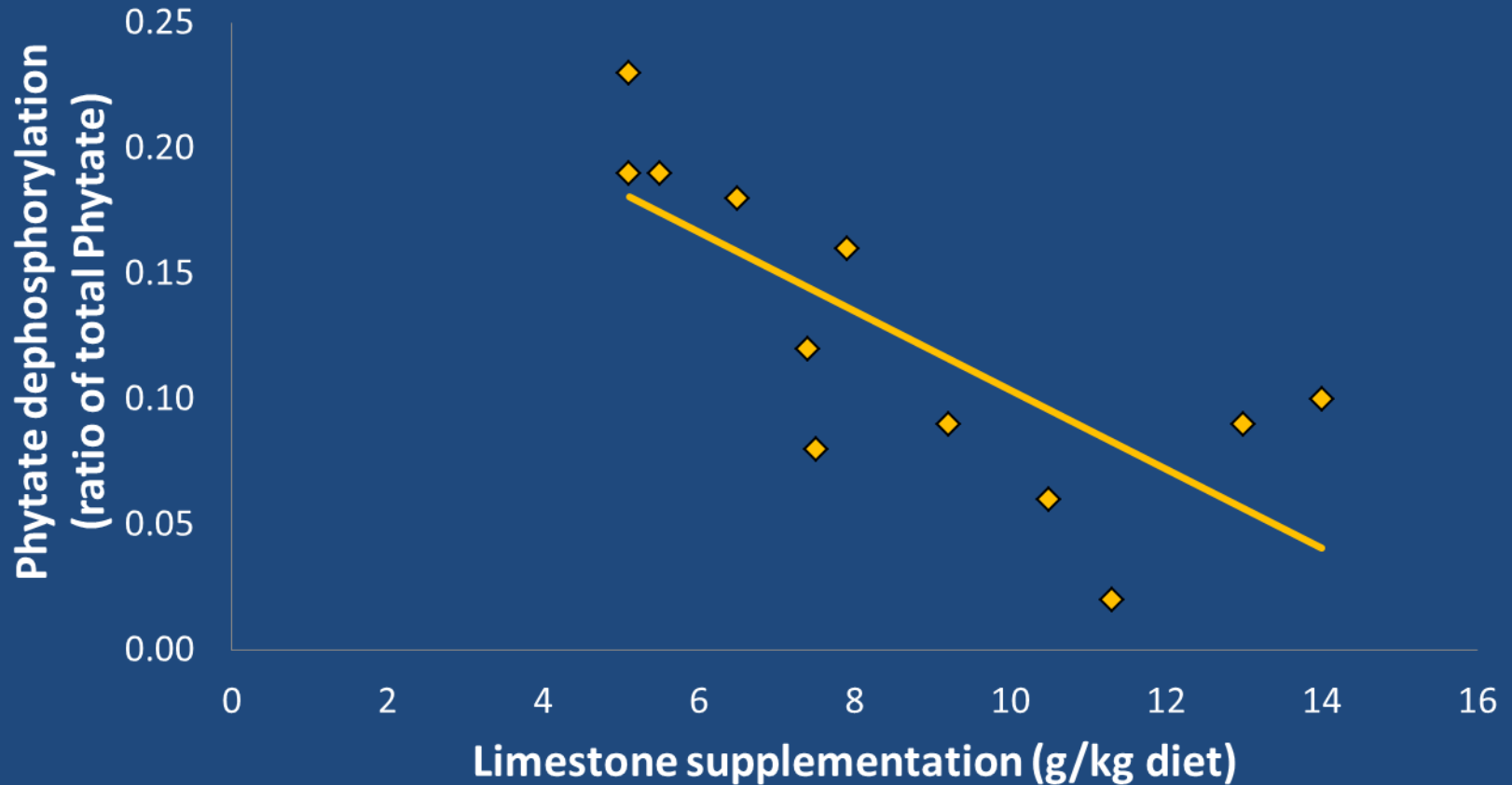
Three central relationships to solve

1. The amount of oP dephosphorylated by *plant* phytase activity

2. The amount of oP dephosphorylated by *microbial* phytase activity

   – *It was assumed that the effects of plant and microbial phytases are additive*

3. The amount of oP bound by Ca in the small and large intestine

   – *It was assumed that NPP has a lower affinity than oP to Ca*

# The effect of exogenous phytase on oP dephosphorylation

Chart axes:
- Y-axis: Phytate dephosphorylation (ratio of total Phytate), values 0 to 0.7
- X-axis: Microbial Phytase activity (FTU/kg), values 0 to 16000

Legend:
- E.coli (Adeola et al. 2004)
- A. niger (Kies et al. 2006)
- Adeola et al. 2004
- Kies et al. (2006)

The effect of dietary Ca on small intestine oP deposphorylation
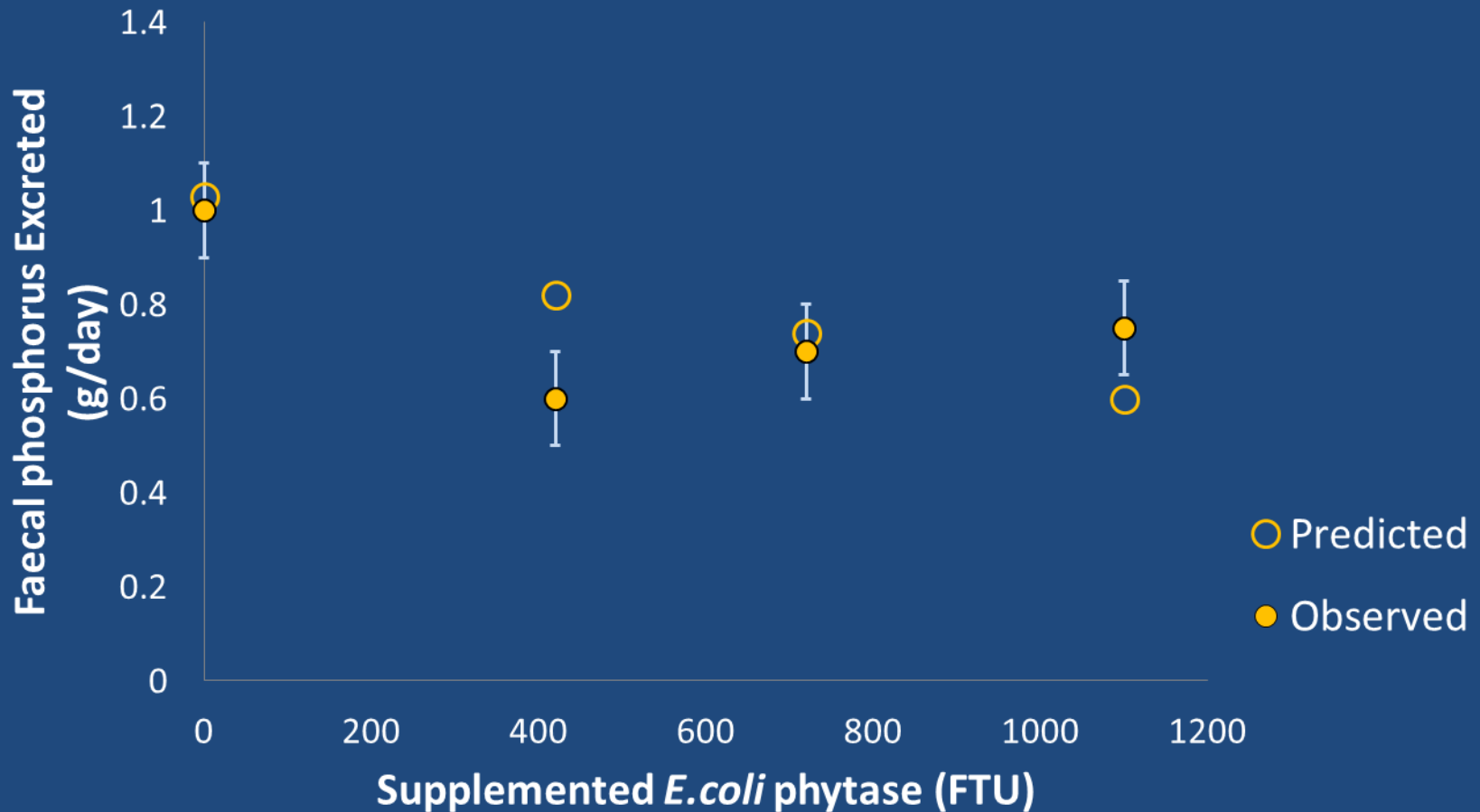

Plumstead et al. (2008)

The response to di-Calcium phosphate supplementation
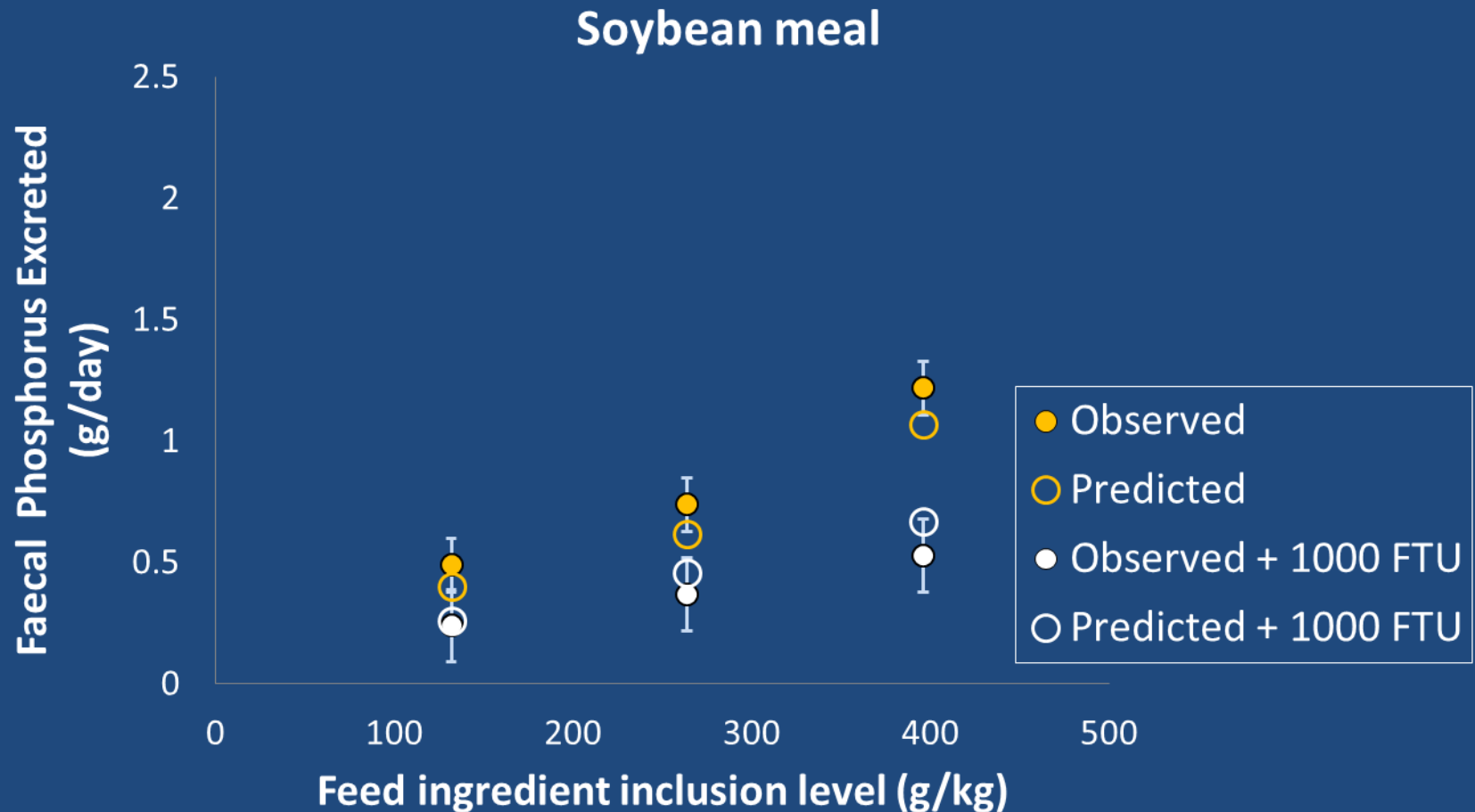

Ekpe et al. (2002)
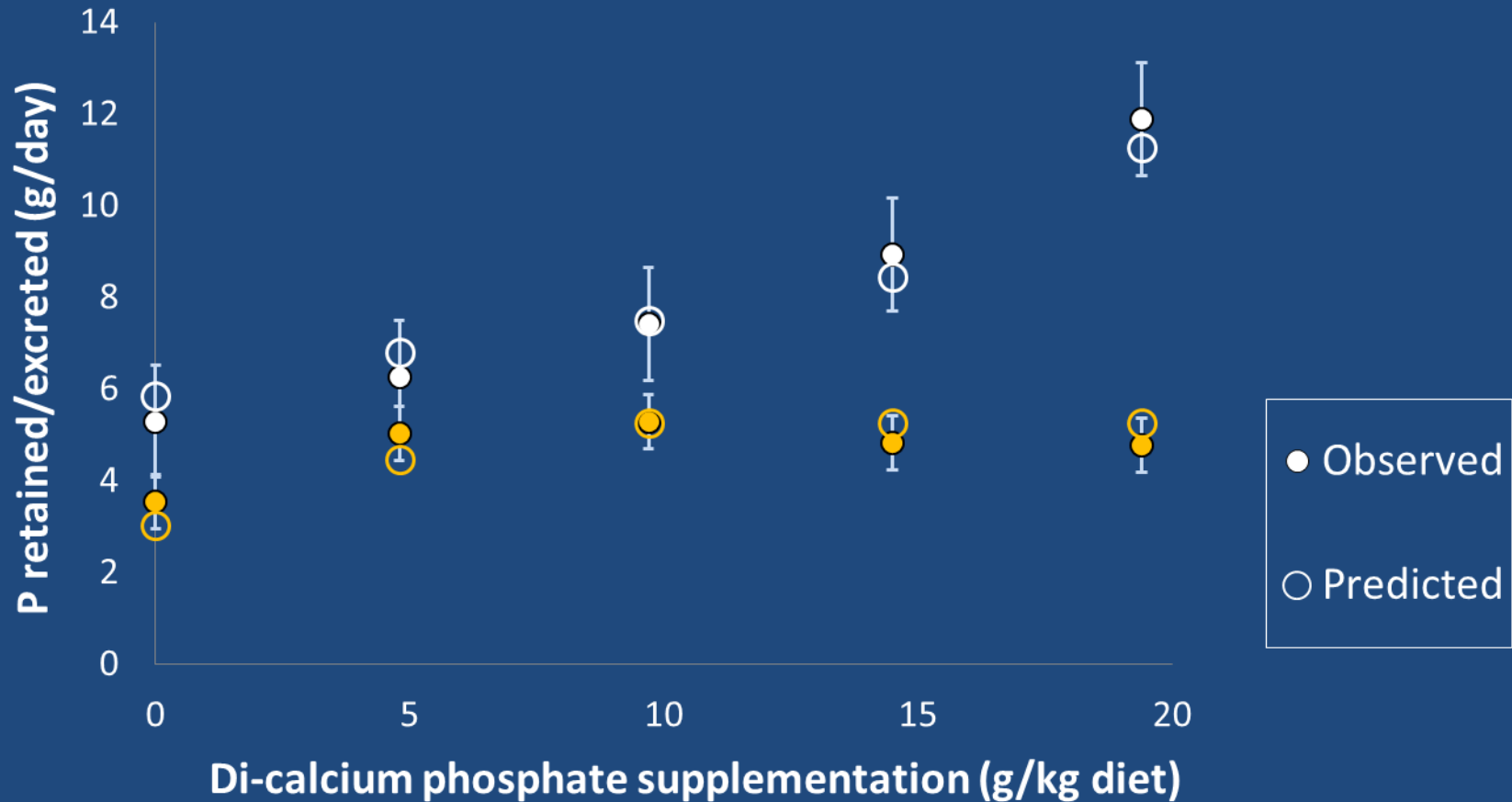
The relationship between exogenous phytase and faecal P excreted

Almeida & Stein (2012)

Feacal P excreted by soyabean based diets supplemented with phytase

Soybean meal

Akinmusire & Adeola (2009)

Feacal P excreted by canola based diets supplemented with phytase

Canola meal

Faecal Phosphorus Excreted (g/day) vs Feed ingredient inclusion level (g/kg)

Legend:
- ● Observed
- ○ Predicted (orange outline)
- ● Observed + 1000 FTU (white)
- ○ Predicted + 1000 FTU (white outline)

Akinmusire & Adeola (2009)
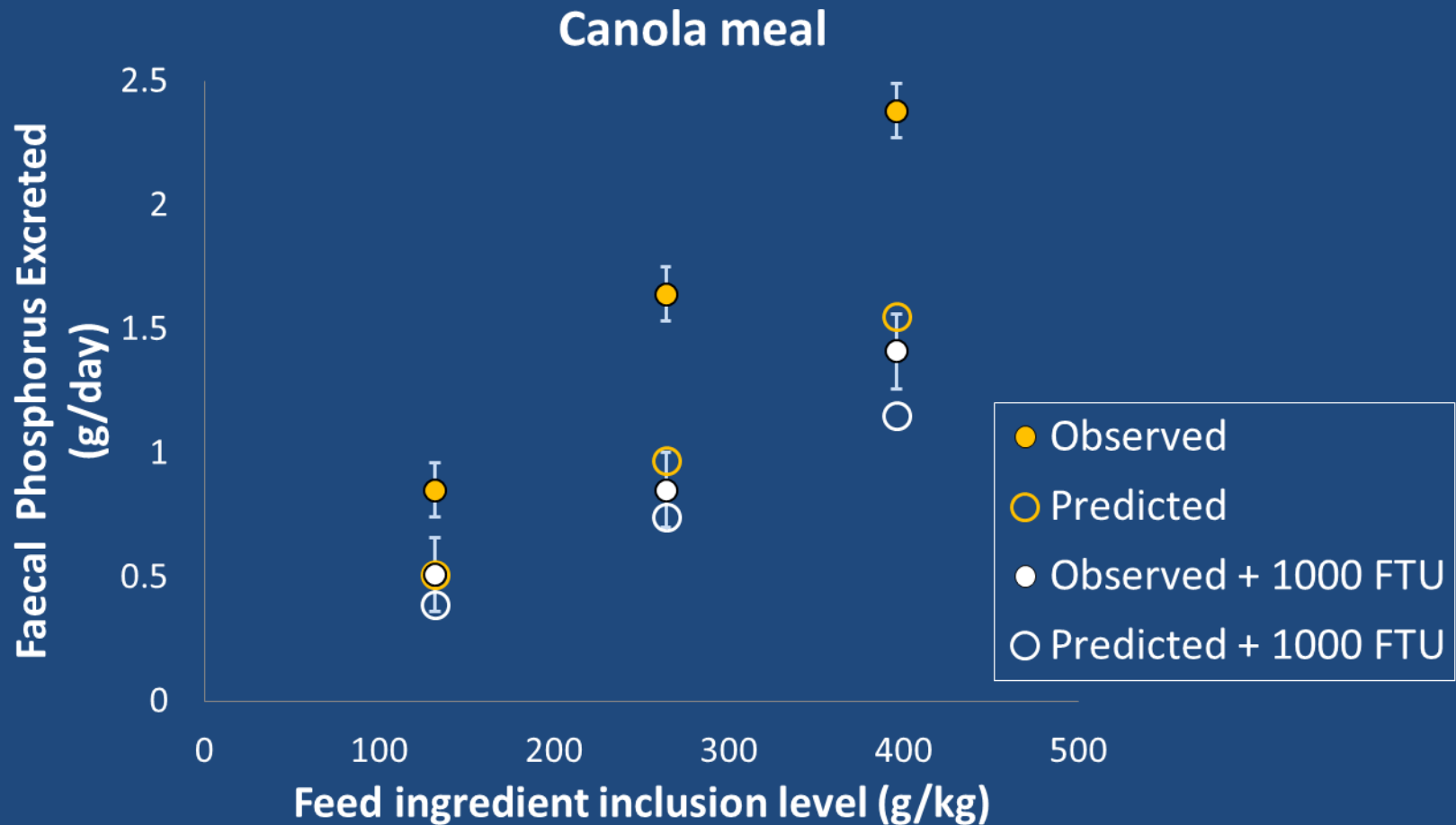
Interim Conclusions

- **A deterministic, dynamic model that predicts P intake, digestion, retention and excretion has been developed**

- **The model is applicable to pigs of different genotypes given access to diets of very different compositions**

- **The model does not make accurate predictions for pigs offered access to rapeseed-based diets**
  - **Is the description of the feed adequate?**