Whither animal nutrition science?

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Research on how to feed pigs

Some notable advances in animal nutrition

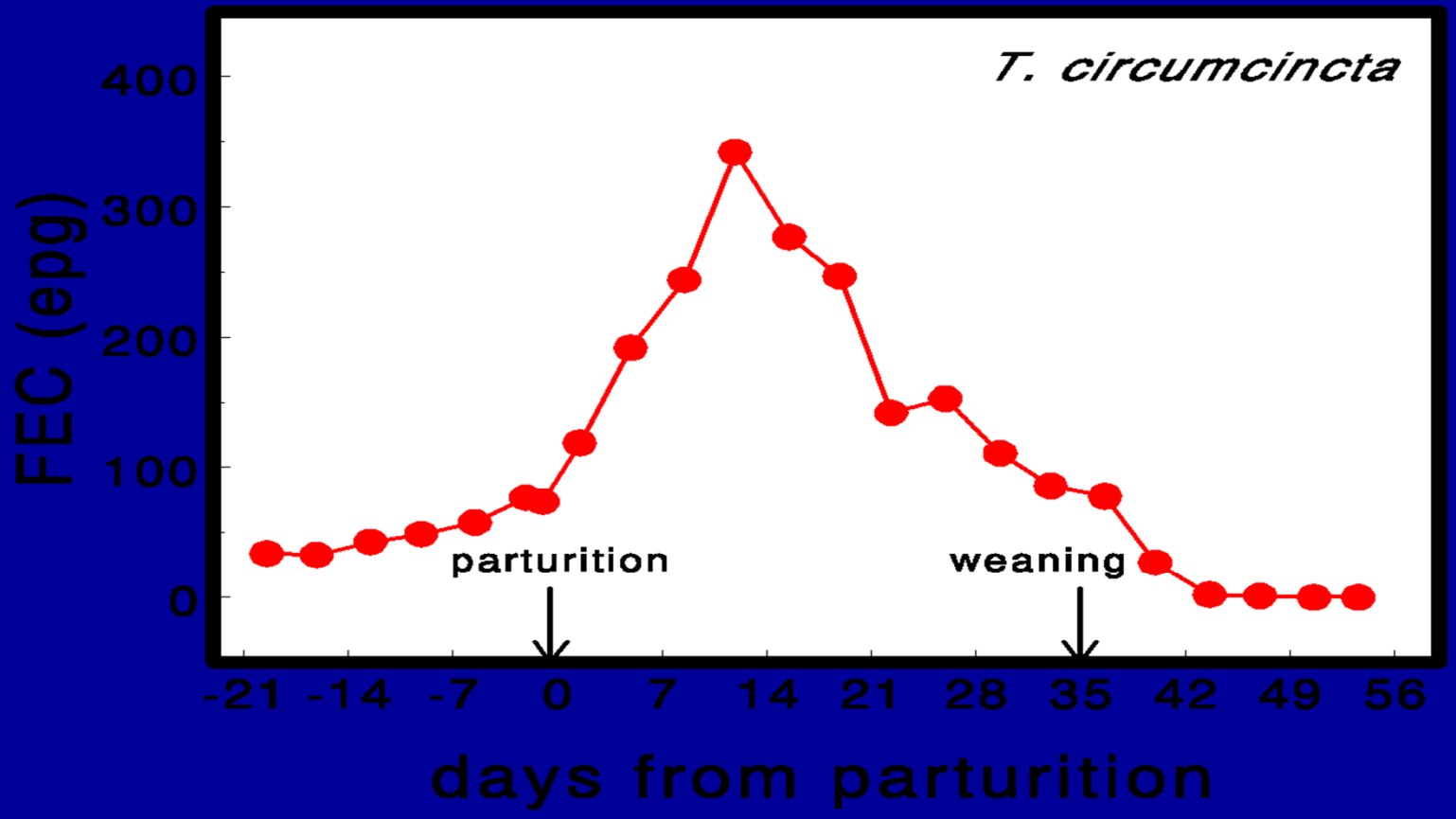
- **1920/30s Discovery of vitamins and essential micronutrients**
- ***1930s Shift towards the use of oilseeds to replace animal products as proteins sources***
- **1940s Development of alternative sources for animal diets (Phosphorous shortages)**
- ***1950s Introduction of nutritional standards***
- **1970s Introduction of mathematical models in animal nutrition**

An opportune paradigm shift

- Increased interest in functional end points other than performance (i.e. health and well being)
- Focus on alternatives to pharmaceutical to control disease.
- Advances in molecular tools to support nutritional research (-omics)
- Concerns over use of protein resources in livestock Systems (Food Security)

A scientific challenge

- **Most mammals suffer from a relaxation of immunity around parturition**



Houdijk et al.

A scientific challenge

- Most mammals suffer from a relaxation of immunity around parturition

- The phenomenon plays a major role in the epidemiology of many infections
  - the mother acts as the source of infection

- Its extent seems to vary greatly both between and within species, but also between individuals

Hypotheses to account for the phenomenon

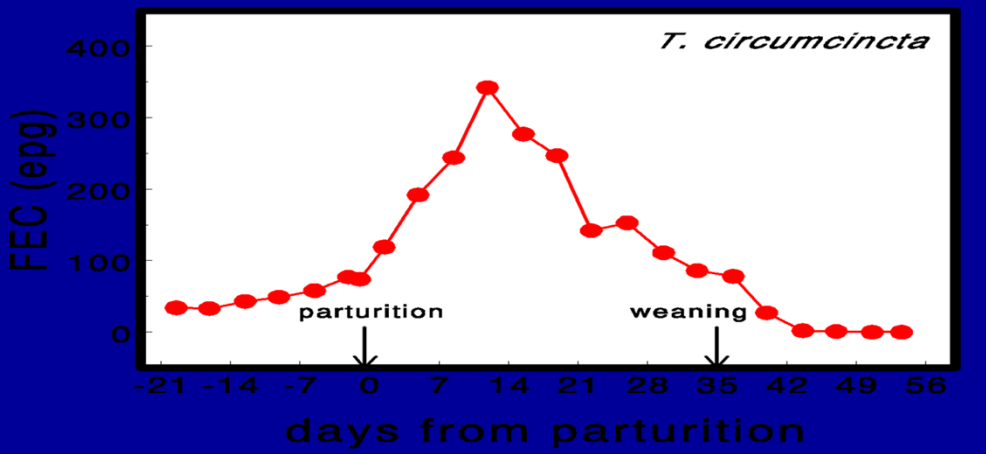
- Most mammals suffer from a relaxation of immunity around parturition
- **Several theories have been suggested to account for it:**

Hypotheses to account for the phenomenon

- Most mammals suffer from a relaxation of immunity around parturition
- Several theories have been suggested to account for it:
  - Association with hormonal changes, especially a rise in prolactin
  - Stress associated with parturition
  - Carry-over of the foetal tolerance during pregnancy
  - Diversion of antibodies to colostrum
  - Seasonal association

Two simple questions

- Is it possible that the relaxation of immunity during reproduction has a nutritional basis?



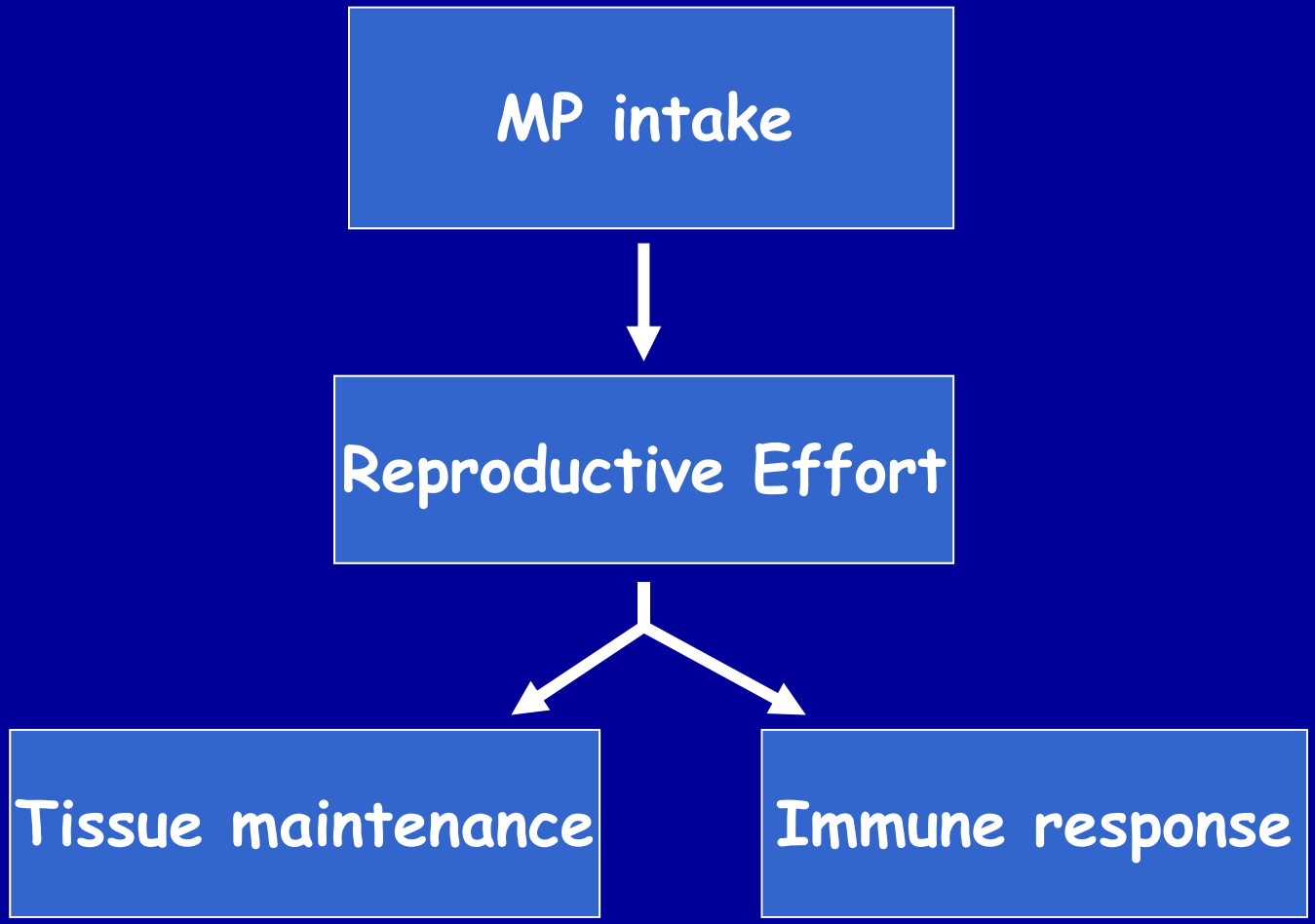
Houdijk et al.

- Can all previous theories to account for its occurrence be encompassed by this single suggestion?

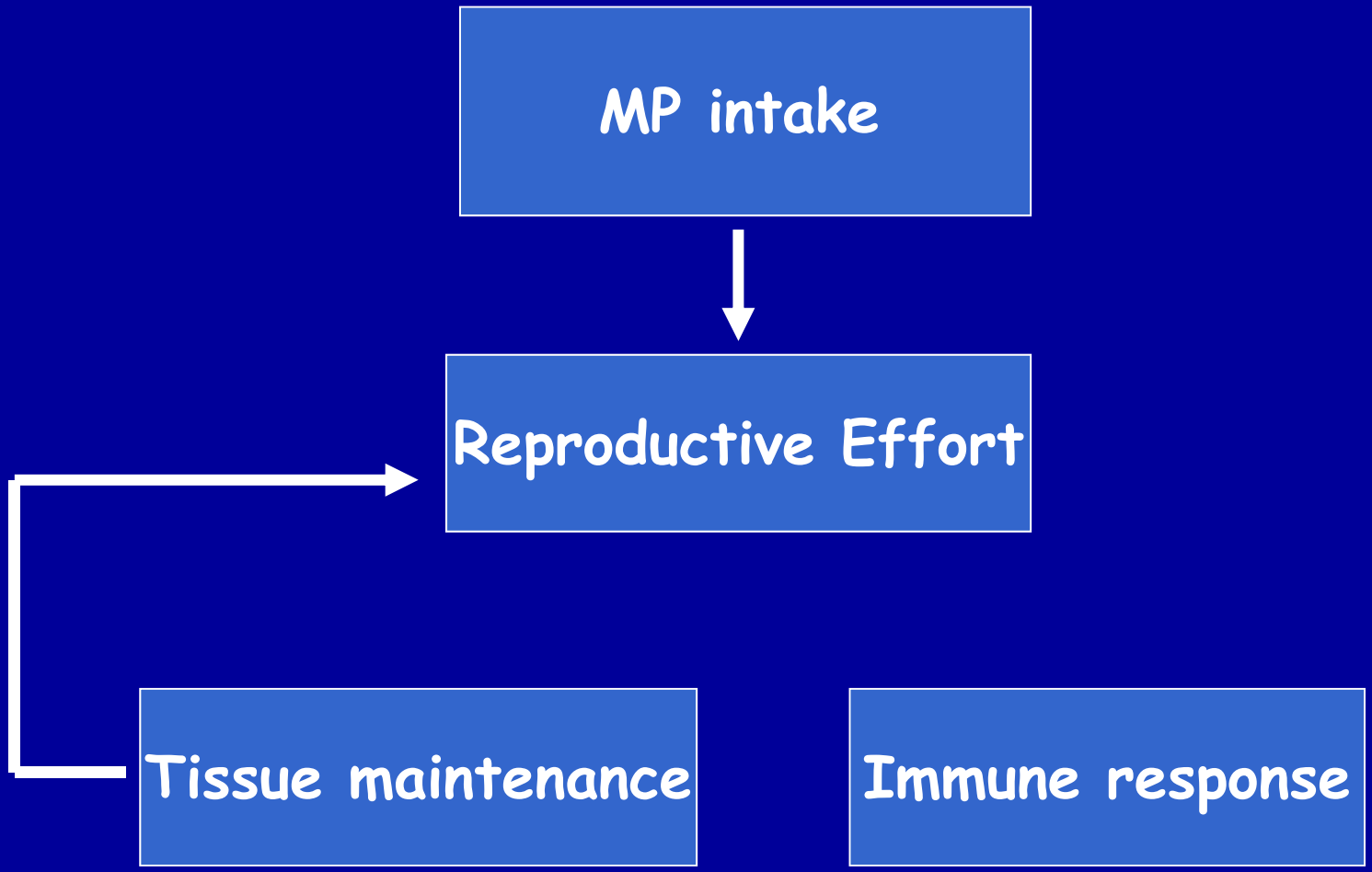
An evolutionary hypothesis

- In mammals, reproductive functions (growth of foetus and milk production) are prioritised over all other maternal functions when nutrient resources are scarce
- This implies that functions such as maintenance of body reserves and immune responses (or even integrity of damaged tissues) may be penalised
- This may have long term effects
- Periparturient relaxation of immunity can be seen as a nutrient partitioning problem

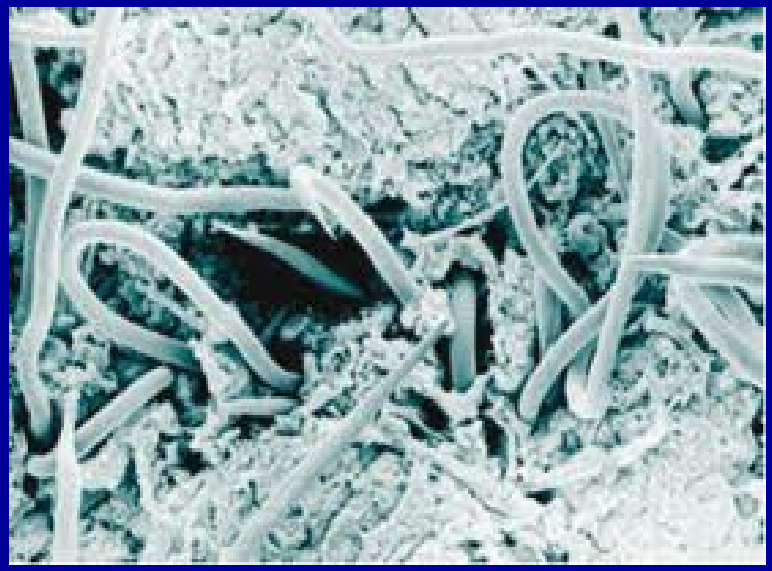
A partitioning framework during reproduction



A partitioning framework during reproduction



The experimental system used



Pathogen: Nematode worms

Ruminant model: Twin bearing ewes

Evidence 1 in support of the hypothesis

- The relaxation of immunity depends on the intensity of the reproductive effort (e.g. single vs. twin rearing) .

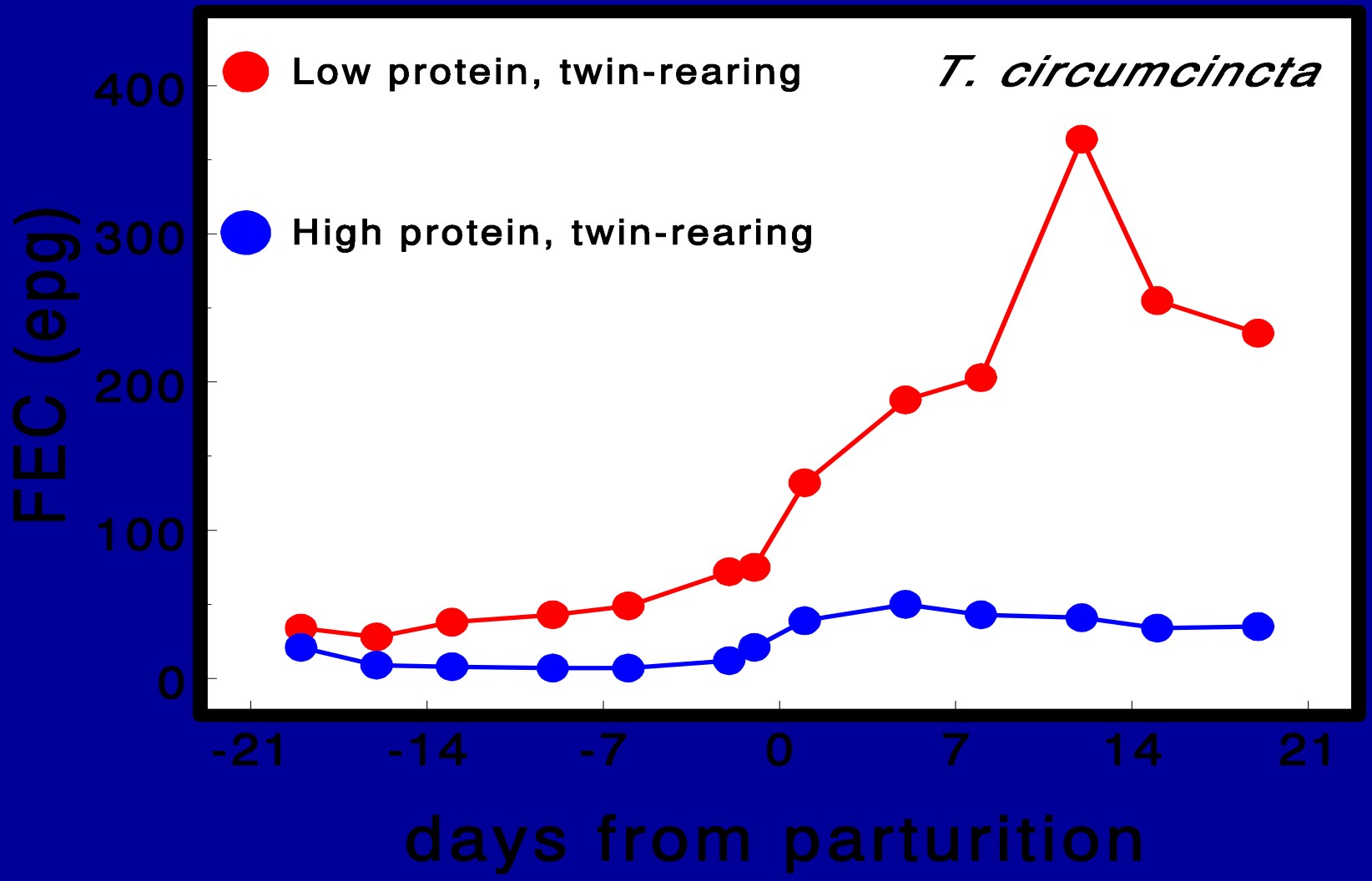
- Reductions in nutrient demand reduce the degree of relaxation of immunity

Reproductive Effort

=

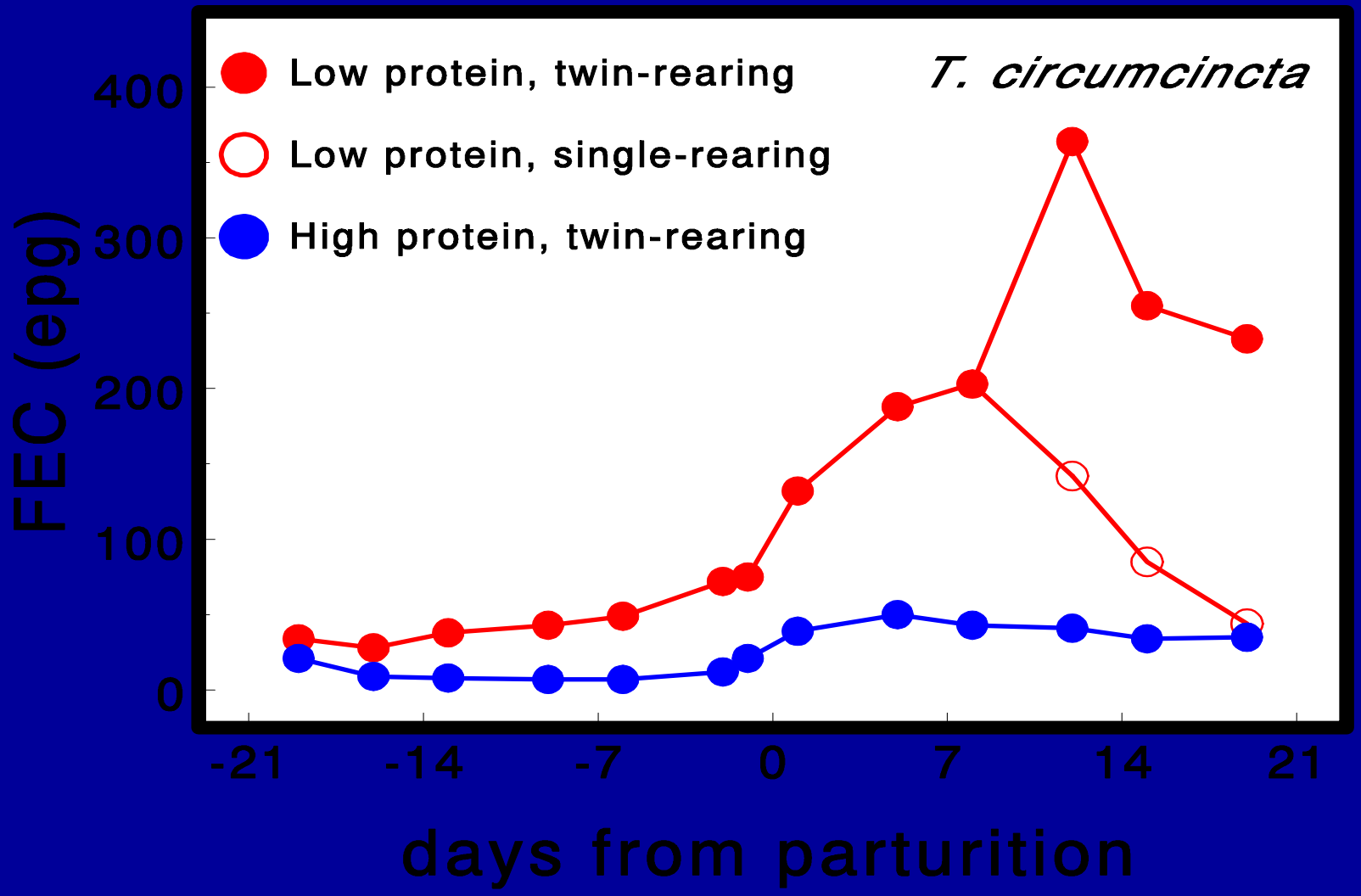
Breakdown of Immunity

Effect of nutrient supply on immunity to parasites in twin-rearing ewes



Houdijk et al. (2006)

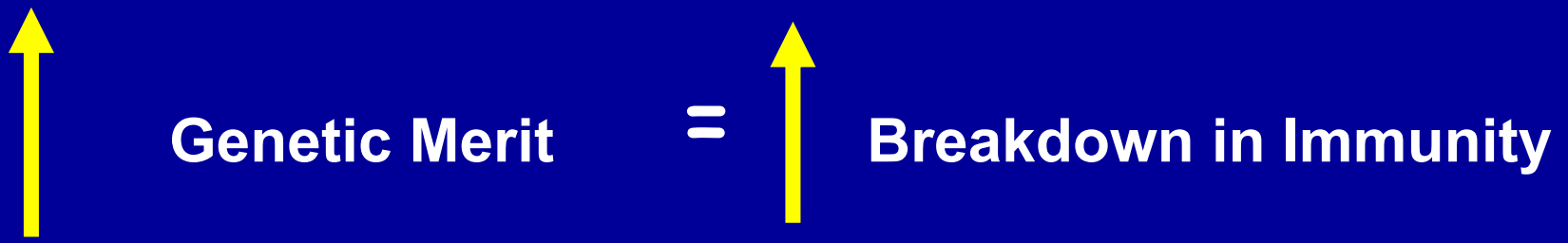
Rapid improvement of immunity following a reduction in nutrient demand



Houdijk et al. (2006)

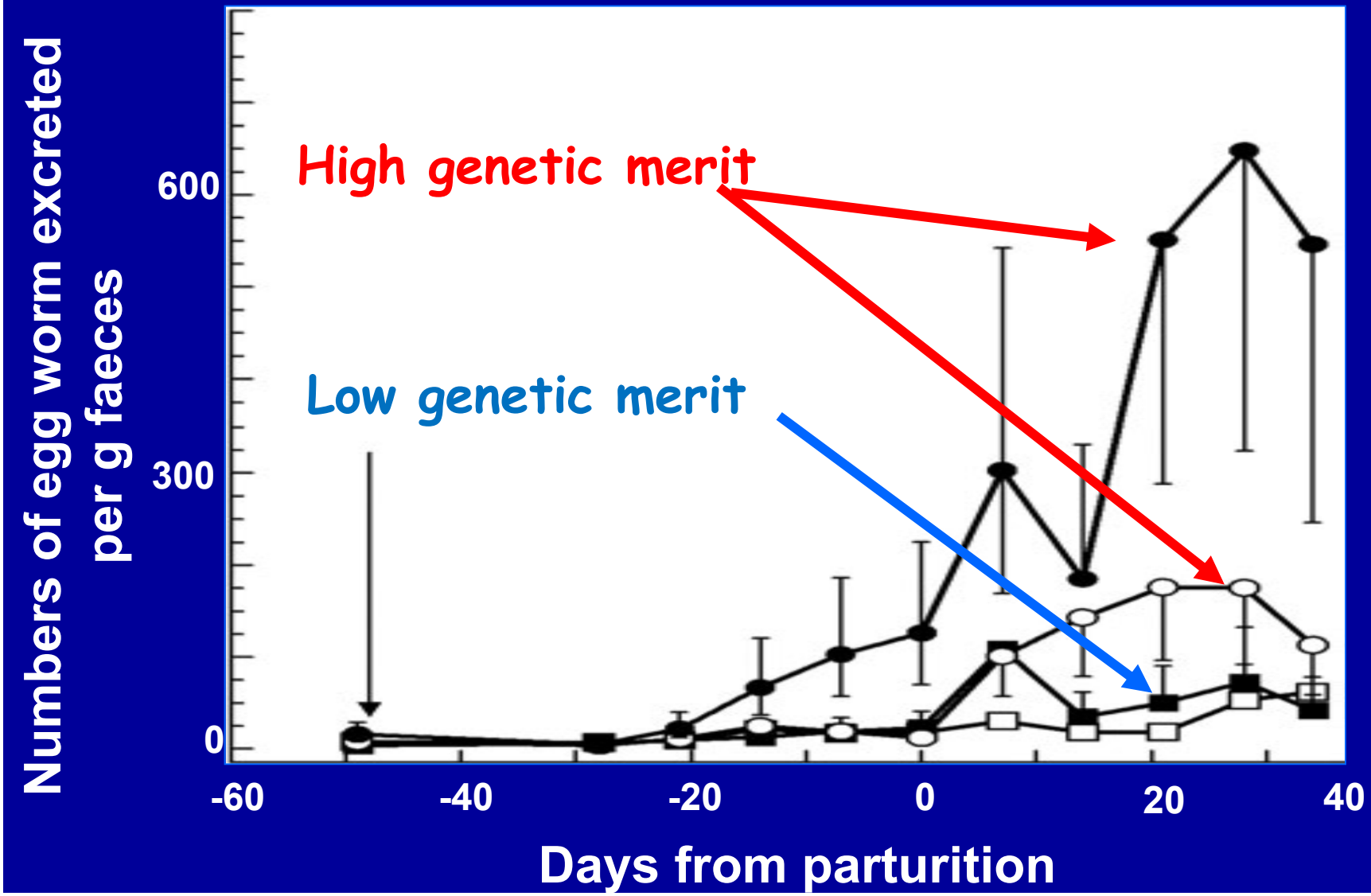
Evidence 2 in support of the hypothesis

- **Genetic merit** (e.g. high milk yield) influences the degree of relaxation of immunity



- This is analogous to the effect of nutrient demand on the degree of relaxation of immunity

The periparturient relaxation of immunity in ewes of two breeds



Questions of interest that arise from the scientific framework

1. What nutrient resources are involved in the breakdown of immunity?
2. Is there an involvement of body reserves?
3. What protein resources are effective in reversing the breakdown of immunity?
4. Are there interactions between nutrients and gene expression at the site of infection?

What nutrient resources are involved in the relaxation of immunity?

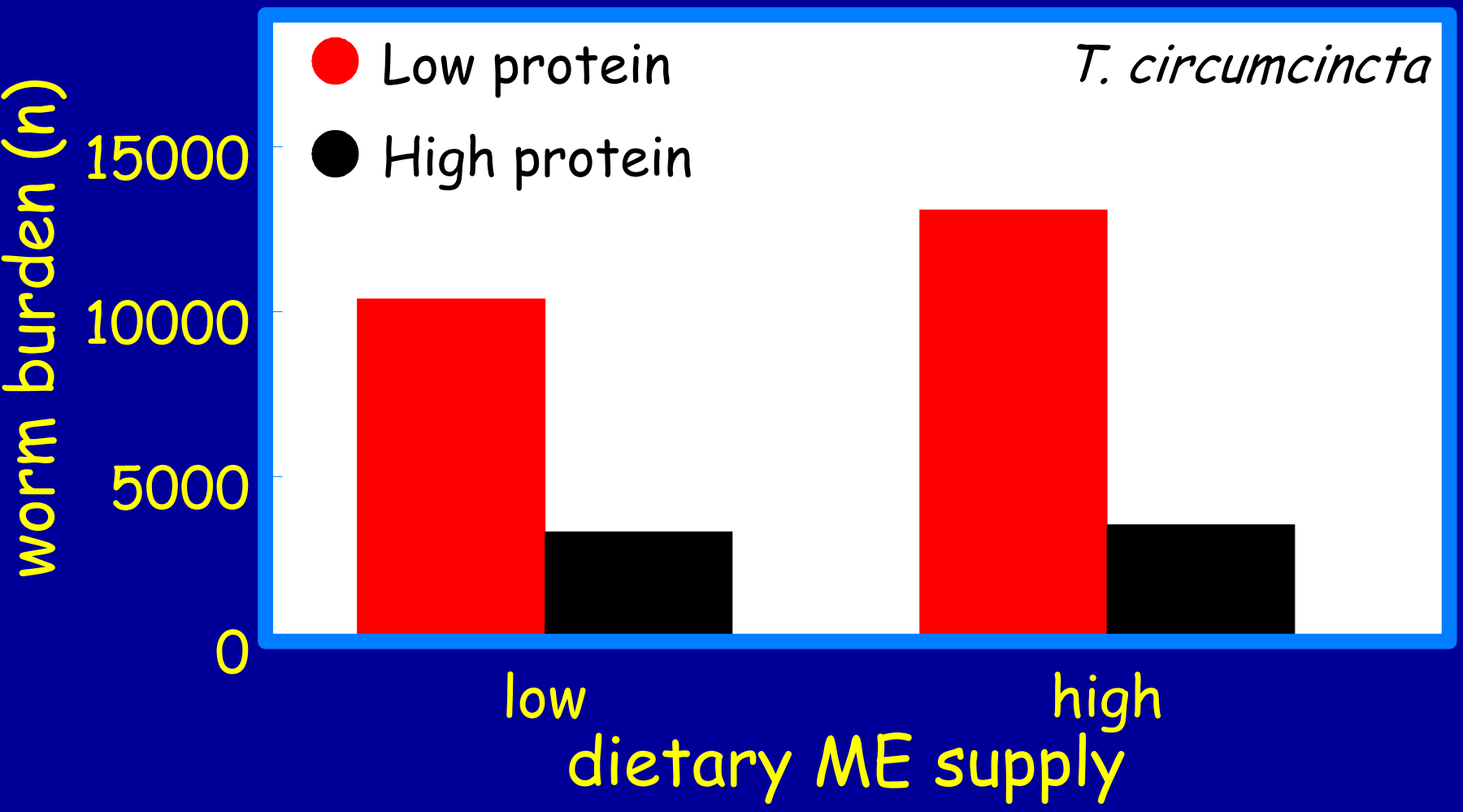
- On the basis of previous information and the composition of effector molecules and cells metabolisable protein (MP) is the most likely candidate

What nutrient resources are involved in the relaxation of immunity?

- On the basis of previous information and the composition of effector molecules and cells protein (MP) is the most likely candidate
- **However, in ruminants experimental responses to MP and ME may be confounded**
- **As a result there is some confusion on whether energy supplementation affects or not the relaxation in immunity**

Worm burden

housed ewes



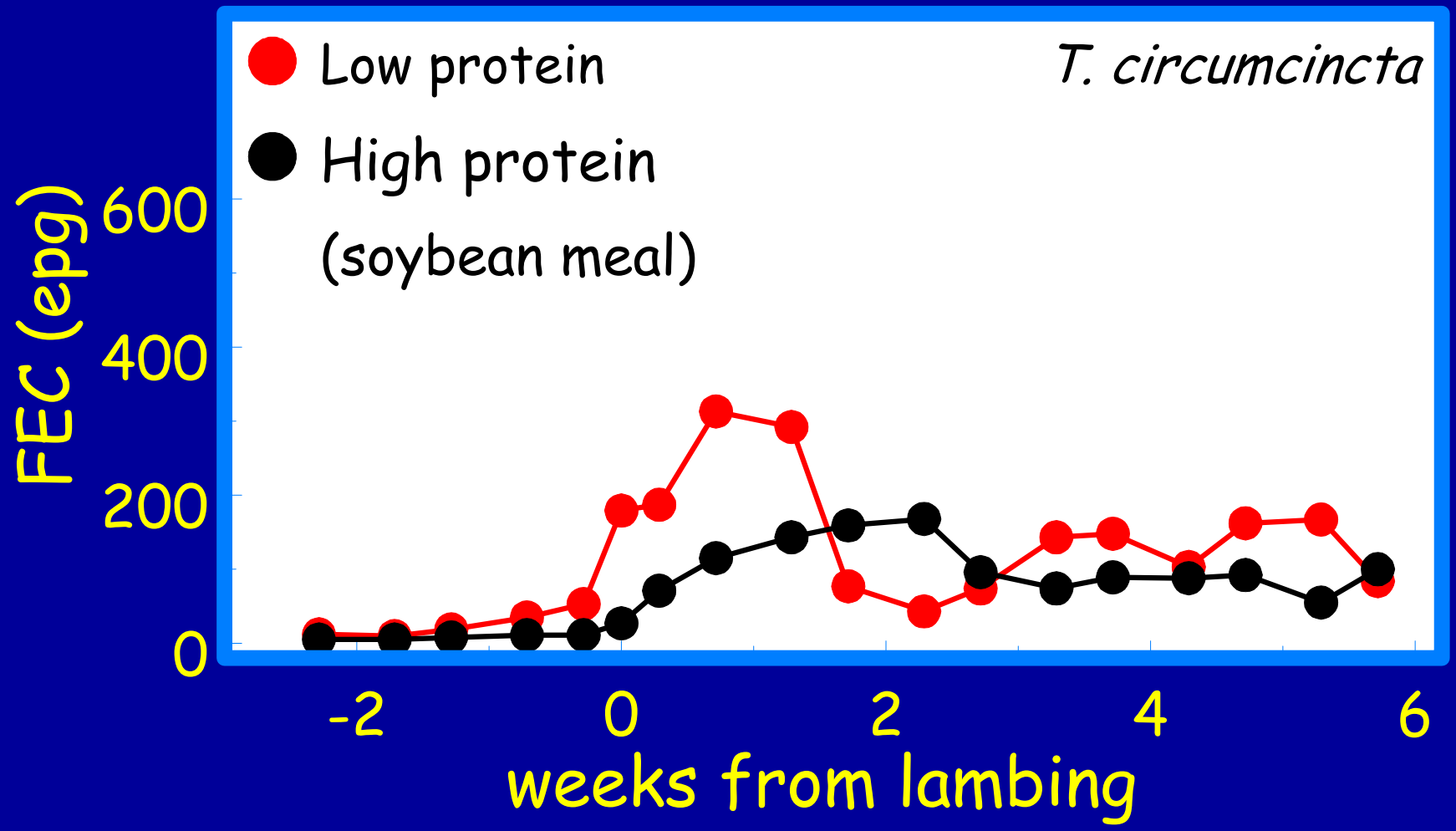
Donaldson et al. (1998)

Body protein reserves

- Body protein can be mobilized at times of dietary nutrient scarcity
- Interactions between body protein reserves and nutrient scarcity may be expected
- **Proposition:** nutrient scarcity has larger penalty on immunity in animals with reduced body reserves

Faecal egg counts

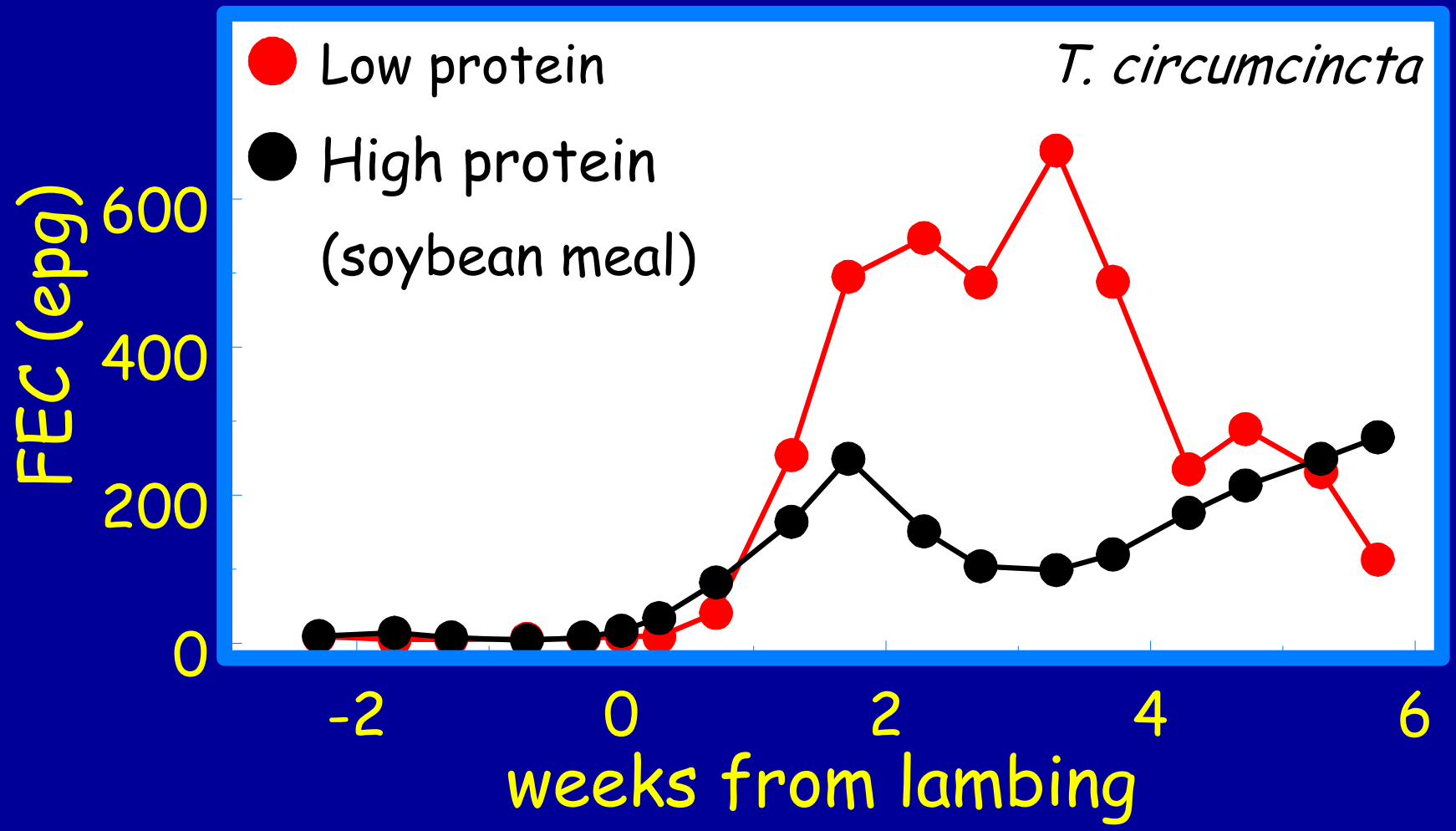
body protein reserves maintained



Houdijk et al. (2001)

Faecal egg counts

body protein reserves reduced



Houdijk et al. (2001)

AA composition of microbial and milk protein (g/kg protein)

	Microbial Protein	Milk Protein
Histidine	5	3
Isoleucine	8	8
Leucine	10	14
Lysine	17	11
Methionine	3	3
Phenylalanine	5	7
Threonine	8	8
Valine	9	8

AA composition of immunoglobulins (g/kg protein)

	Microbial Protein	Milk Protein	IgA	IgE
Histidine	5	3	11	18
Isoleucine	8	8	13	39
Leucine	10	14	120	87
Lysine	17	11	39	57
Methionine	3	3	6	7
Phenylalanine	5	7	26	30
Threonine	8	8	75	103
Valine	9	8	96	80

AA composition of immune response proteins (g/kg protein)

	Microbial Protein	Milk Protein	Acute phase proteins	Mast cell proteases	Mucin
Histidine	5	3	28	29	nd
Isoleucine	8	8	43	69	15
Leucine	10	14	65	90	31
Lysine	17	11	73	53	18
Methionine	3	3	21	33	nd
Phenylalanine	5	7	72	29	15
Threonine	8	8	57	45	224
Valine	9	8	55	73	222

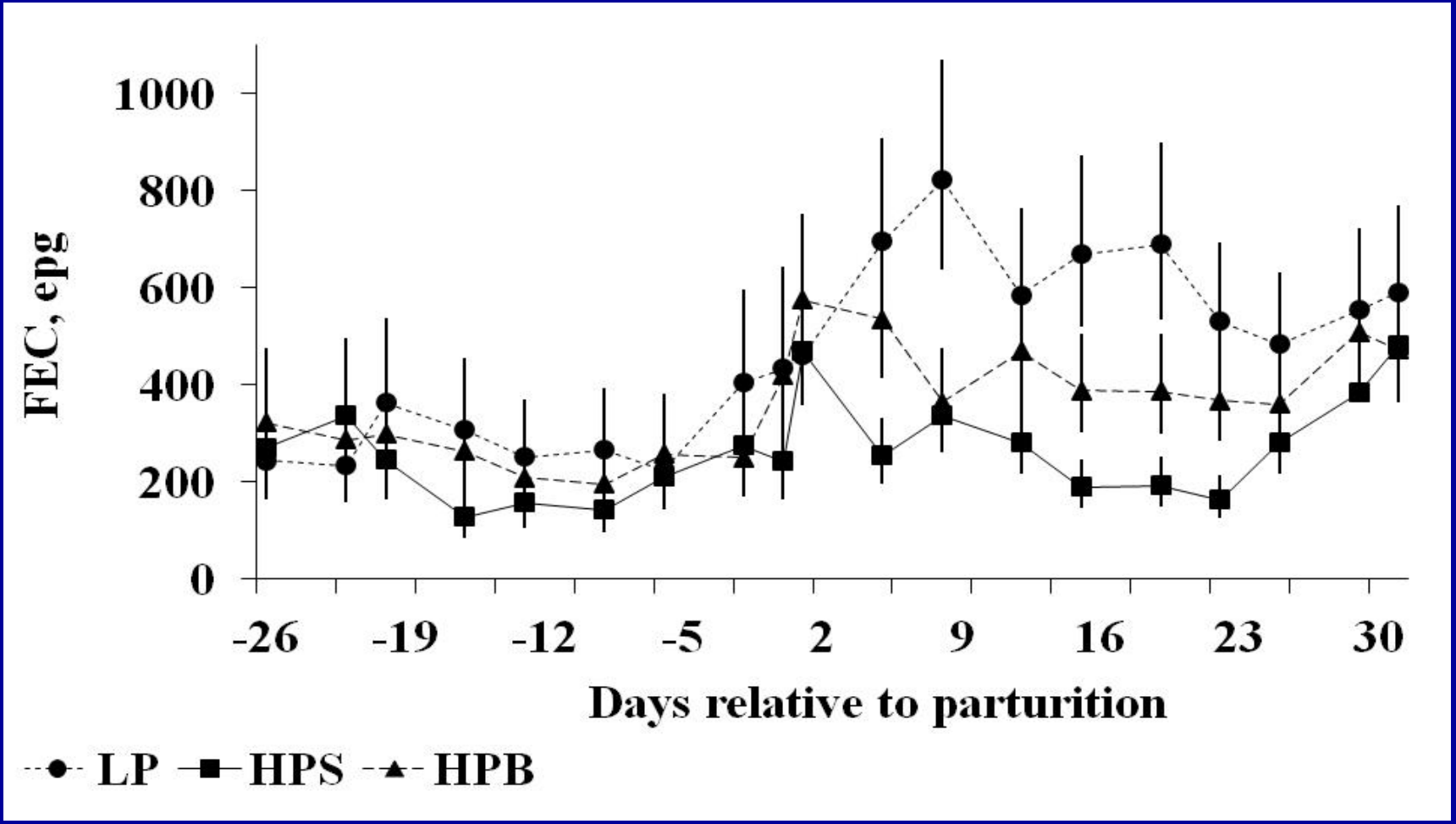
What protein resources are effective in enhancing immunity?

1. Rumen degradable protein sources appear to be **less effective** in reducing the periparturient relaxation of immunity

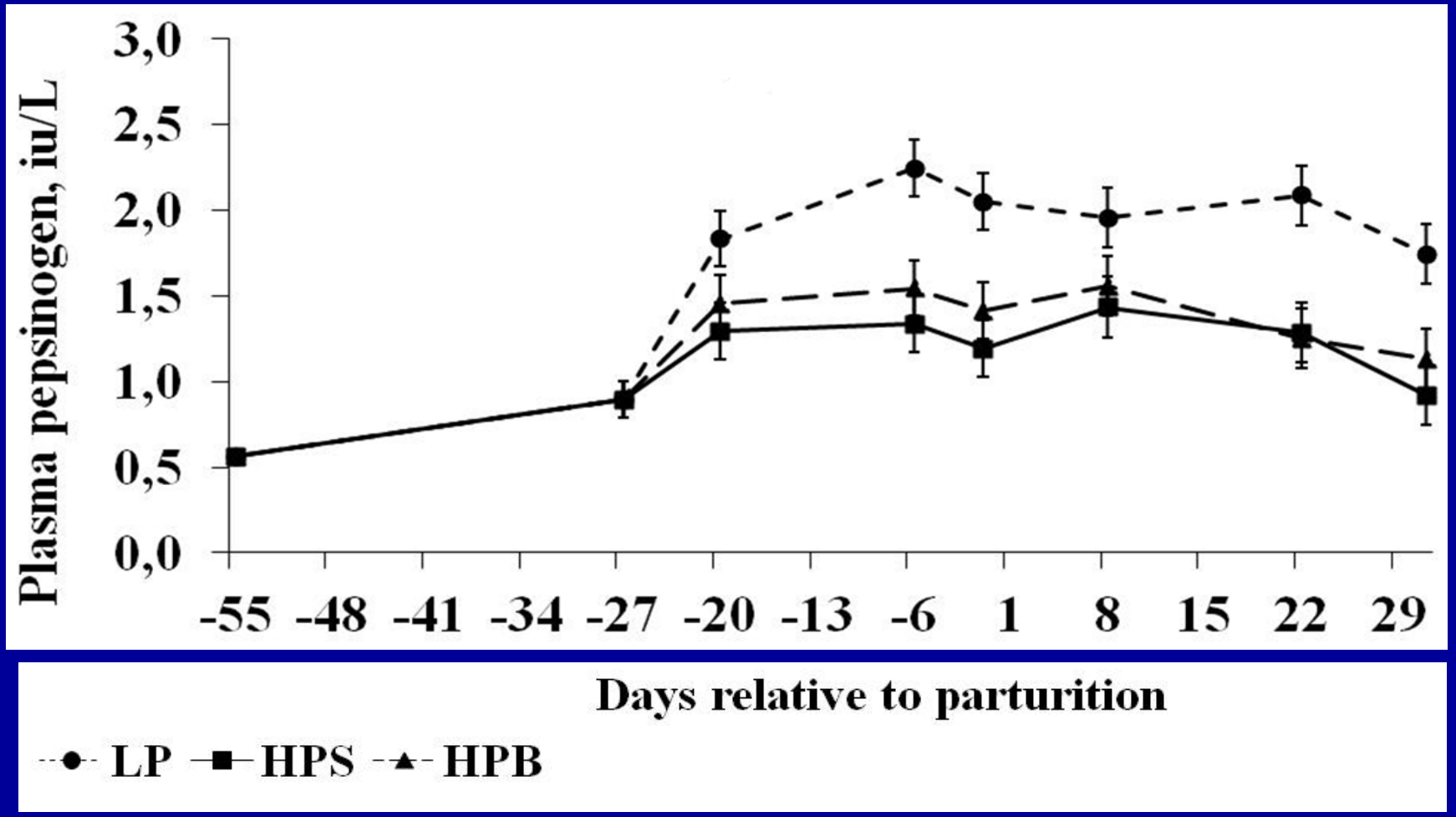
2. Much higher levels of MP from such sources are required to achieve same effect as MP from undegradable protein sources

Some ‘potentially sustainable’ EU-grown protein sources

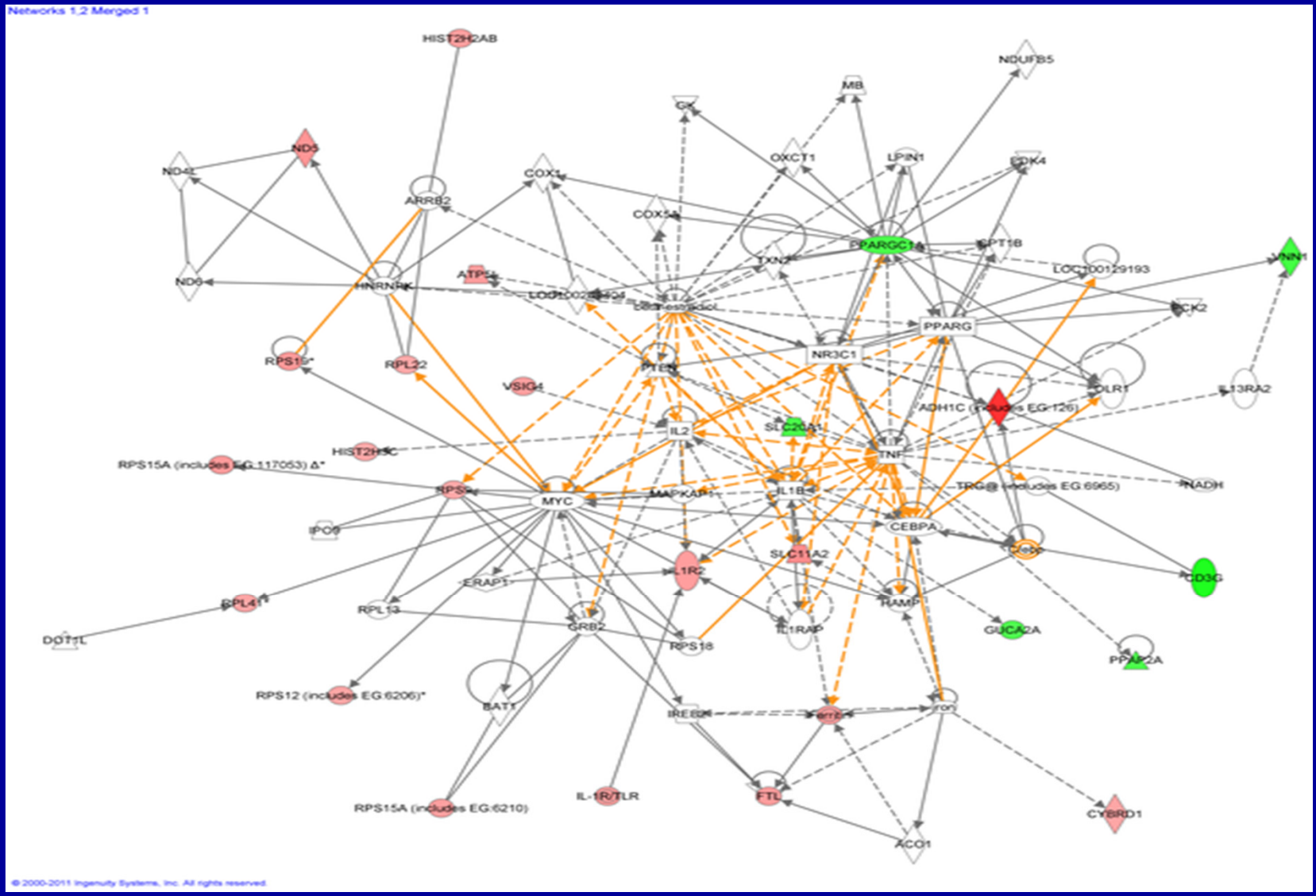
The effect of protein source on the relaxation of immunity



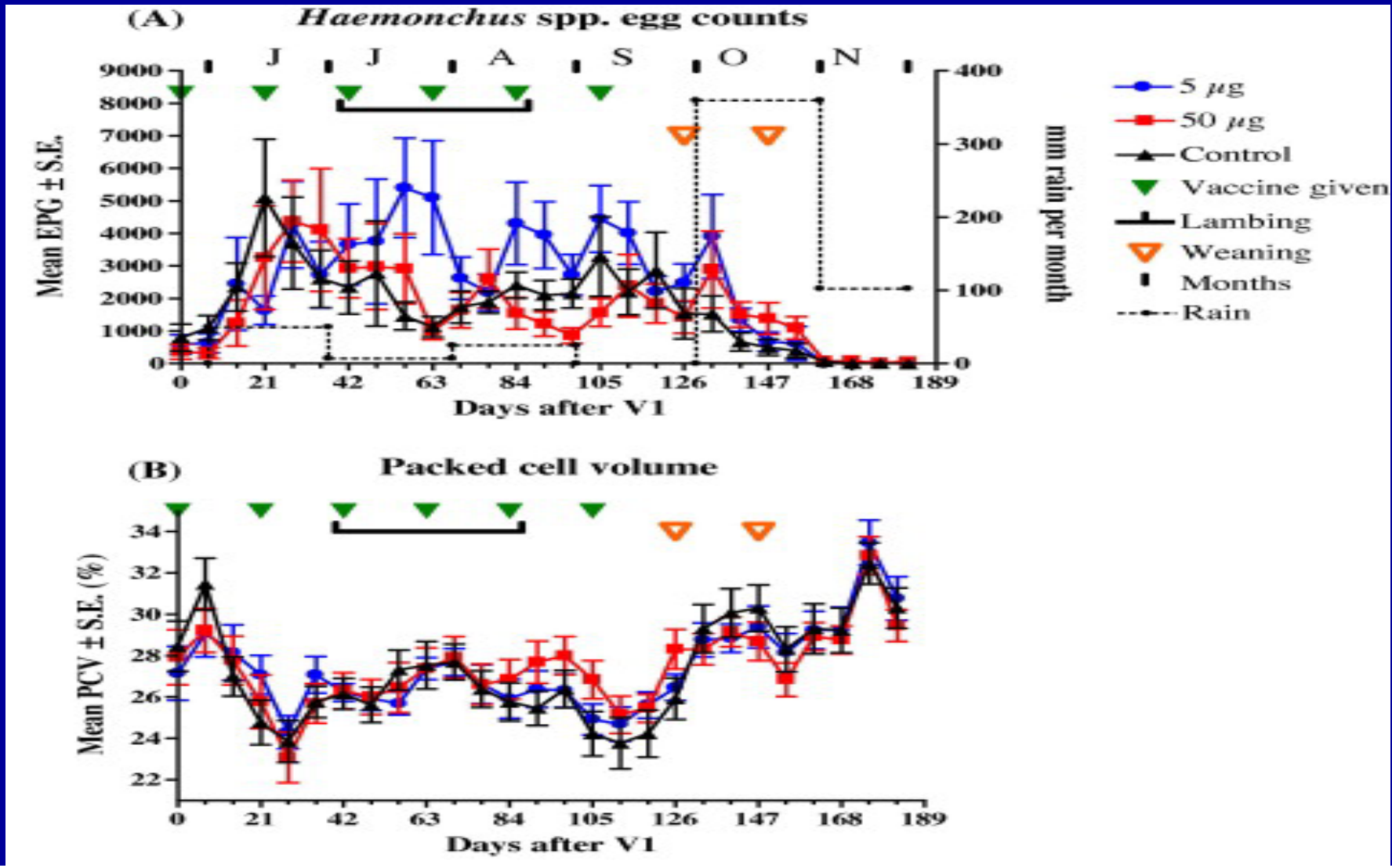
The effect of protein source on mucosal integrity



Representation of merged networks as affected by protein supplementation and infection



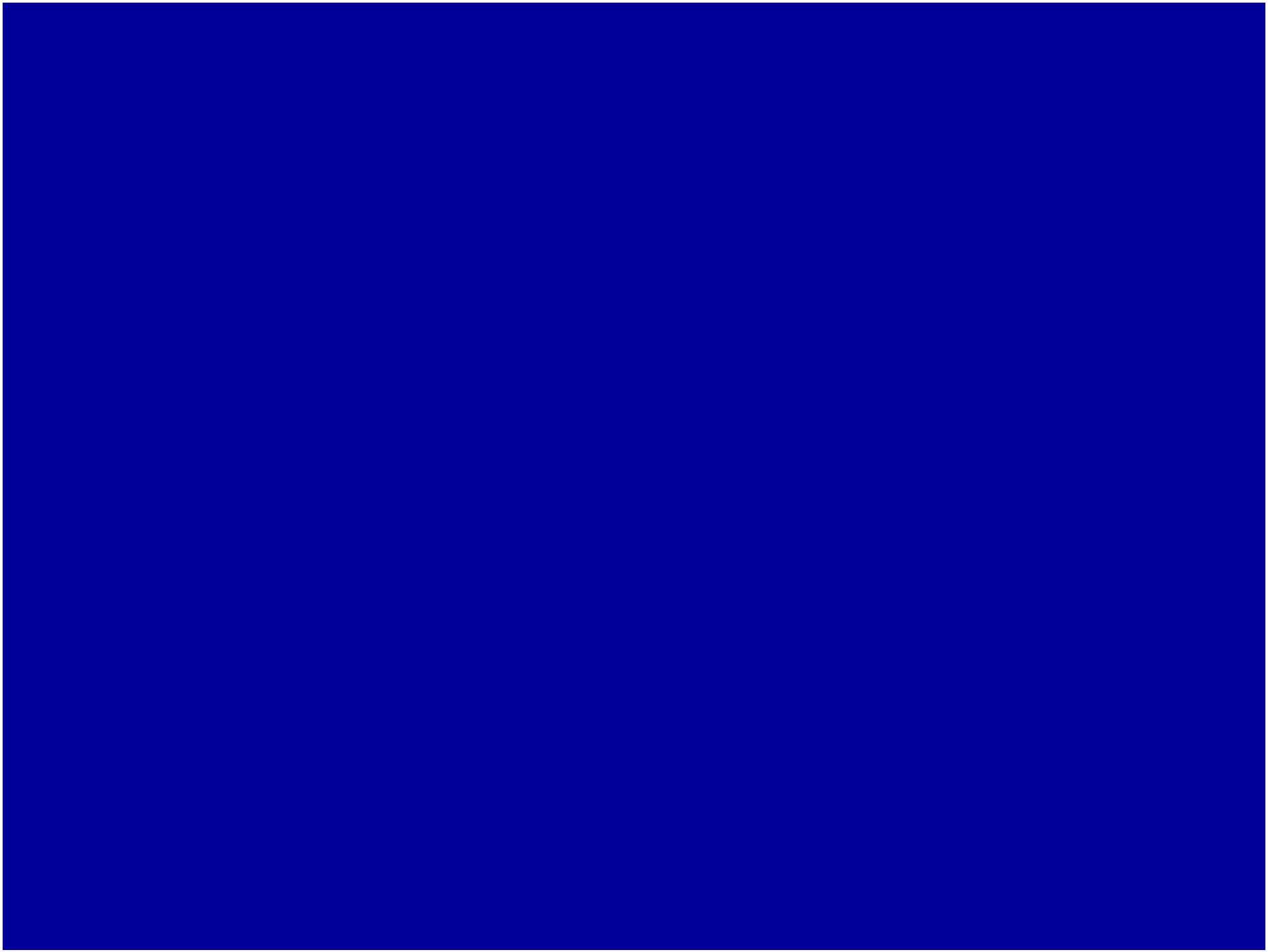
The application of a novel vaccine to prevent breakdown of immunity in ewes



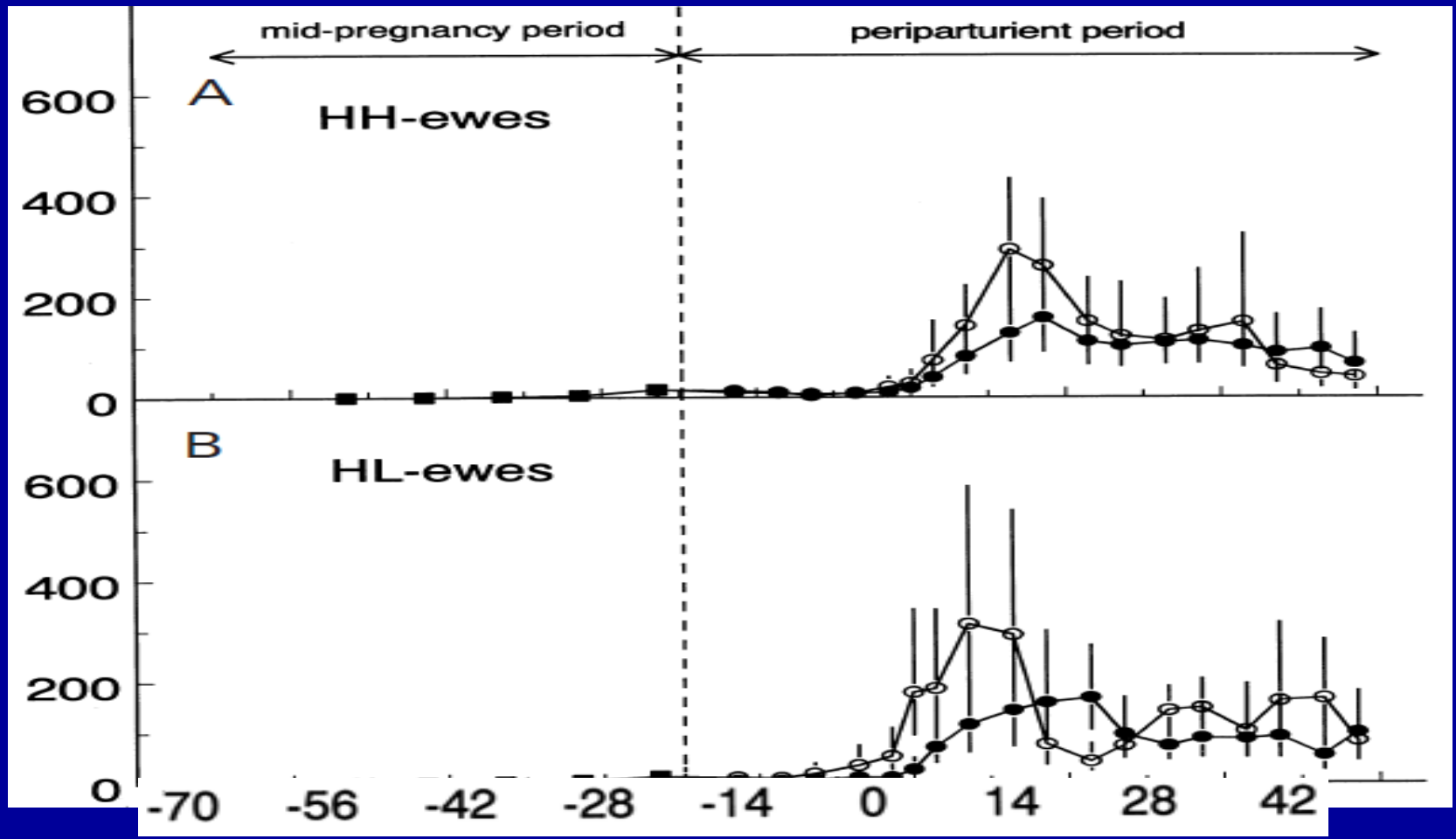
The way forward

- Animal nutrition science has an important contribution to make and be an attractive career path
- In order to do so it needs to explore both cutting edge technologies and the interface with other disciplines
- The Leroy Award for a 25 year career in a ‘mature science’ discipline provides support to my proposition

Thanks for your attention!



What about body lipid reserves effects?



Nutritional recommendations (1)

1. Target high yielding animals
2. Target animals with low body condition score
3. Consider the increased requirements for MP in more infectious environments
4. Provide undegradable protein sources as opposed to degradable ones

Nutritional recommendations (2)

- Our current estimates of the costs associated with the immune response and tissue repair in sheep are:

  >3 g MP per kg $BW^{0.75}$

- Additional MP will increase resilience, but also will decrease the spread of pathogens in the environment and will have epidemiological consequences
- Cost-benefit analysis of MP supply for parasite control should include both these improvements