

# Omega-3 and Sex Ratio of Lambs

**Dr Edward Clayton**

NSW Department of Primary Industries  
Wagga Wagga Agricultural Institute

Dr John Wilkins, Mr Richard Meyer - NSW DPI  
Ms Catherine Gulliver, Dr Michael Friend,  
Dr Bindi King, Dr Susan Robertson - CSU



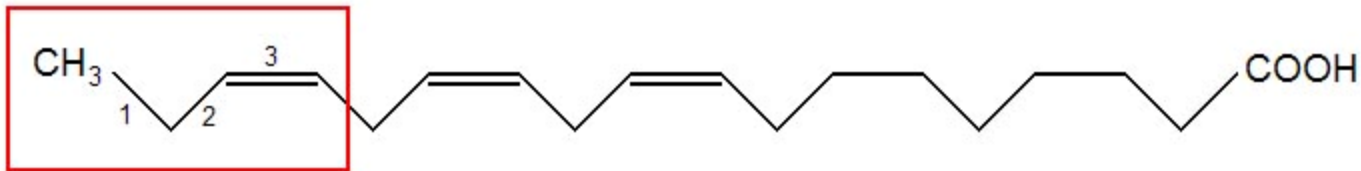
Department of  
Primary Industries



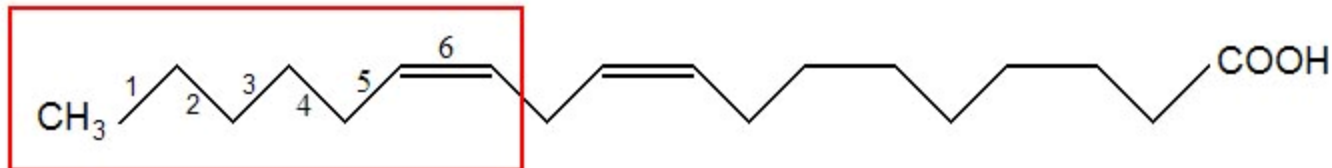
# Omega-3 and Omega-6 Fatty Acids

- Fish oil - rich source of omega-3
- Health benefits in humans
  - cardiovascular disease (Simopoulos, 1999)
  - inflammatory diseases (Horrobin, 1999)
  - mental health disorders (Clayton et al., 2007)
- Health benefits in animals?

# Omega-3 and Omega-6 in Plants

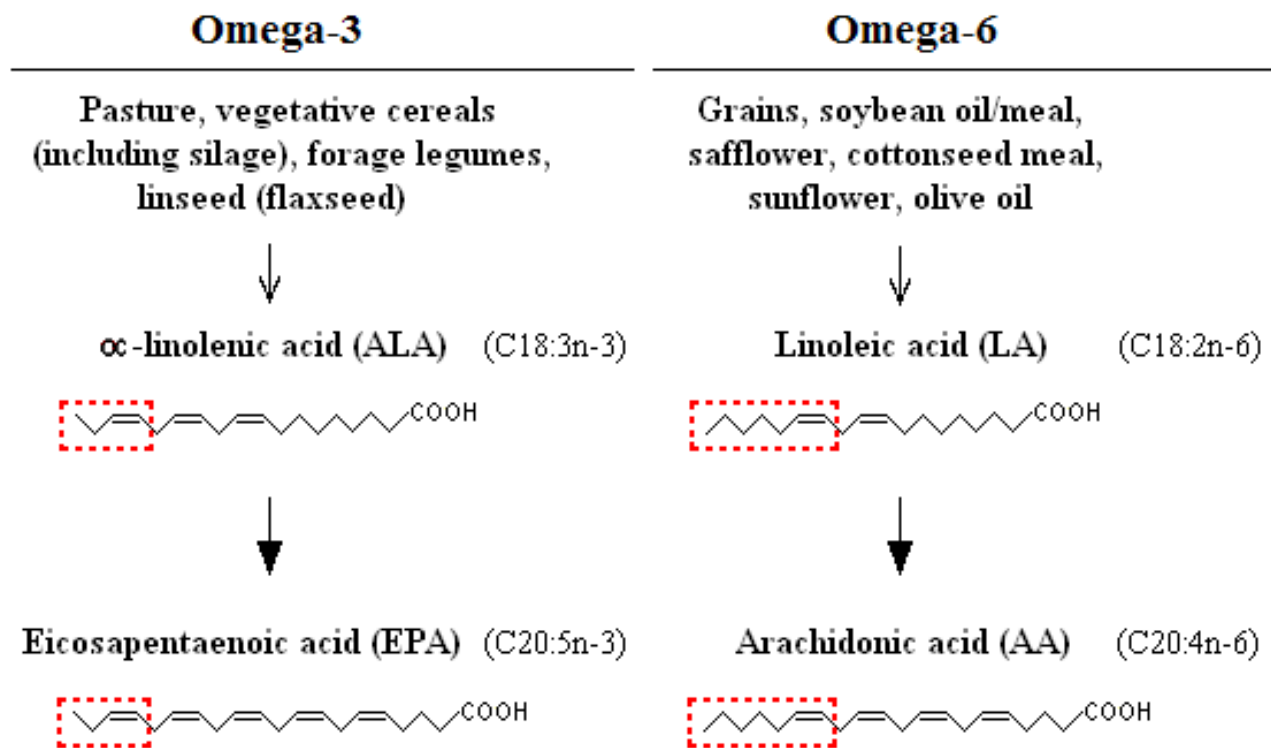


***α*-linolenic acid (ALA) - C18:3n-3 - Omega-3**



**Linoleic acid (LA) - C18:2n-6 - Omega-6**

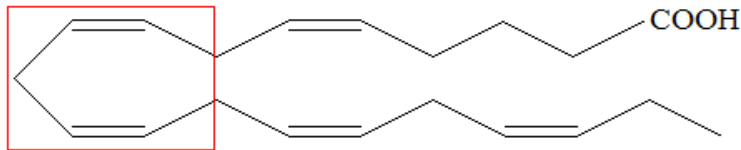
# Sources of Omega-3 and Omega-6



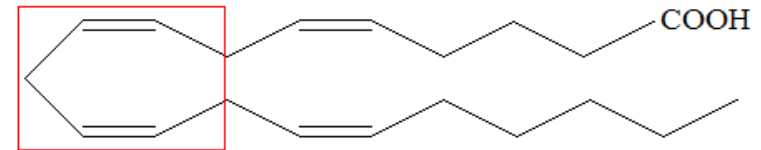
# Omega-3 in Animal Feed

Forage	Type	Omega-3 (%)	Omega-6 (%)	n-6:n-3 Ratio
Pasture	Improved	47.9	10.0	0.21
Pasture	Lucerne	46.6	14.7	0.32
Cereal	Oat/Pea	44.9	14.8	0.33
Pasture	Native/Improved	28.8	18.0	0.62
Silage	Ryegrass	49.1	3.59	0.31
Silage	Oats	37.1	13.3	0.36
Silage	Barley	31.4	12.8	0.41
Grain	Oats	1.1	33.7	31.5
Grain	Barley	4.3	47.6	11.0
Grain	Maize	11.0	52.5	4.8
Cottonseed	CSM	0.3	42.7	164.3

# Metabolism to Prostaglandin



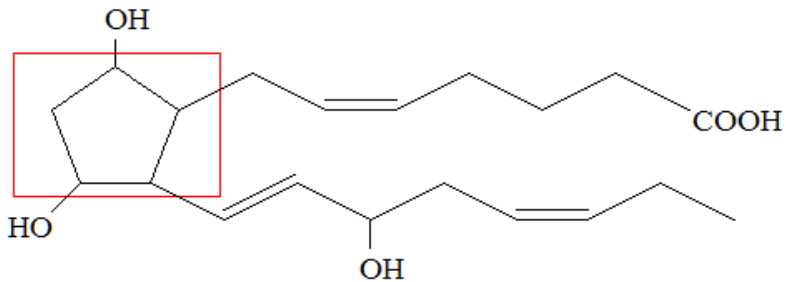
**EPA - Omega-3**



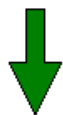
**AA - Omega-6**



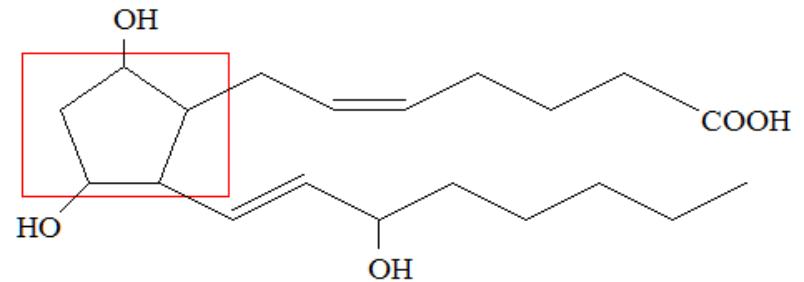
Removal of 2 double bonds



**PGF<sub>3α</sub>**



**Inflammation**



**PGF<sub>2α</sub>**



**Inflammation**

# Experimental Work

- Series of studies examining omega-3 and omega-6 fatty acids in sheep
  - Potential inflammation - prostaglandin
  - Sex ratio of lambs

# Treatment Diets

## Omega-3

**90% Silage - 10% Molasses**



**Omega-6 : Omega-3**

**0.93 : 1**

## Omega-6

**70% Oats - 8% CSM**



**Omega-6 : Omega-3**

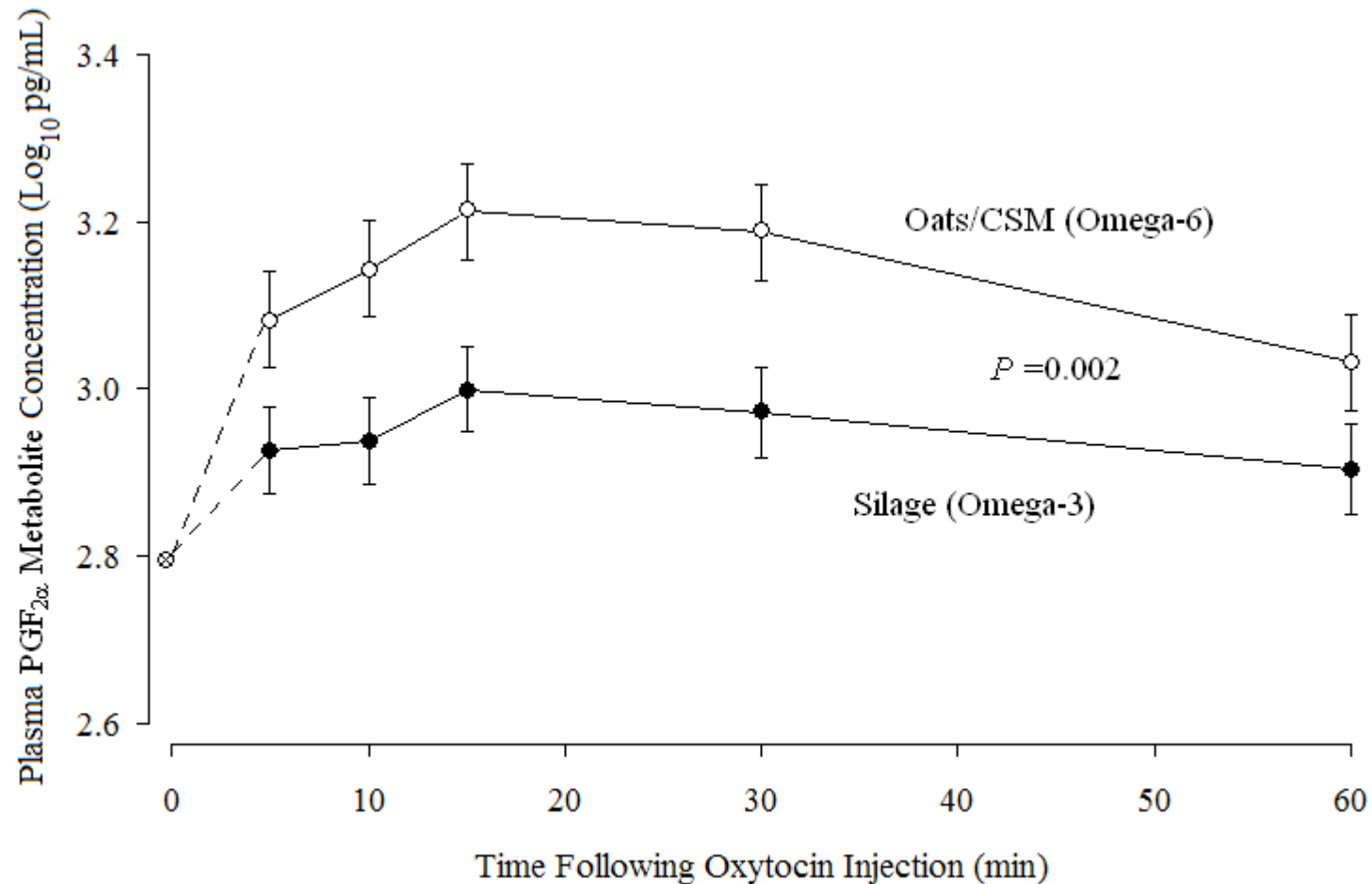
**13.0 : 1**



# Study 1 - Prostaglandin Response

- Border Leicester x Merino ewes
  - Silage (n = 15)
  - Oats/CSM (n = 15)
- Oxytocin (10 IU) used to stimulate PG
- Plasma PG metabolite measured prior to oxytocin and for 60 min following oxytocin

# Prostaglandin Response



# Why Change the Sex Ratio of Lambs?

- Terminal sire enterprises prefer males;
  - faster growth rate
  - increased muscle accumulation
- Self-replacing enterprises and stud breeders prefer females

# Omega-3 and Sex Ratio

- Increased proportion of males;
  - North American possum - fish (Austad, 1986)
  - Mice - fat supplement (Fountain et al., 2008)
  - Sheep polyunsaturated fats?? (Green et al., 2008)



Sources:

[www.poctos.com/live/opossum-american-virginia](http://www.poctos.com/live/opossum-american-virginia)

[www.picturesforcoloring.com/mouse](http://www.picturesforcoloring.com/mouse)

Omega-3 and sex ratio of lambs - Dr Edward Clayton (Livestock Research Officer - Ruminant Nutrition)



Department of  
Primary Industries

# Studies 2 to 6 - Sex Ratio

- 5 studies conducted between 2010 and 2012

## **X-Breds**

- 2010 - n = 148 per diet
- 2011 - n = 152 per diet
- 2012 - n = 152 (diet crossover)

## **Merinos**

- 2011 - n = 160 per diet
- 2012 - n = 160 (diet crossover)

- Diets fed for 6 weeks pre and 17 days post-joining or 6 weeks pre-joining only

# Pen Design - 2010

BLOCK/REP 1		BLOCK/REP 2		BLOCK/REP 3		N ↑
<b>Pen 1</b>	<b>Pen 2</b>	<b>Pen 3</b>	<b>Pen 4</b>	<b>Pen 5</b>	<b>Pen 6</b>	
<b>Silage</b> (Omega-3)	<b>Oats/CSM</b> (Omega-6)	<b>Silage</b> (Omega-3)	<b>Oats/CSM</b> (Omega-6)	<b>Oats/CSM</b> (Omega-6)	<b>Silage</b> (Omega-3)	
Pre + Post- conception	Pre + Post- conception	Pre + Post- conception	Pre + Post- conception	Pre + Post- conception	Pre + Post- conception	

**Silage** (Omega-3) - n = 148

**Oats/CSM** (Omega-6) - n = 148

# Pen Design – 2011-12

BLOCK/REP 1				BLOCK/REP 2				N ↑
<b>Pen 1</b>	<b>Pen 2</b>	<b>Pen 3</b>	<b>Pen 4</b>	<b>Pen 5</b>	<b>Pen 6</b>	<b>Pen 7</b>	<b>Pen 8</b>	
<b>Oats/CSM</b> (Omega-6)	<b>Silage</b> (Omega-3)	<b>Silage</b> (Omega-3)	<b>Oats/CSM</b> (Omega-6)	<b>Oats/CSM</b> (Omega-6)	<b>Silage</b> (Omega-3)	<b>Oats/CSM</b> (Omega-6)	<b>Silage</b> (Omega-3)	
Pre-conception	Pre + Post-conception	Pre-conception	Pre + Post-conception	Pre + Post-conception	Pre-conception	Pre-conception	Pre + Post-conception	

**Silage - Pre + Post-conception (Omega-3) - n = 76**  
**Oats/CSM - Pre + Post-conception (Omega-6) - n = 76**

} Cross-over design in year 2



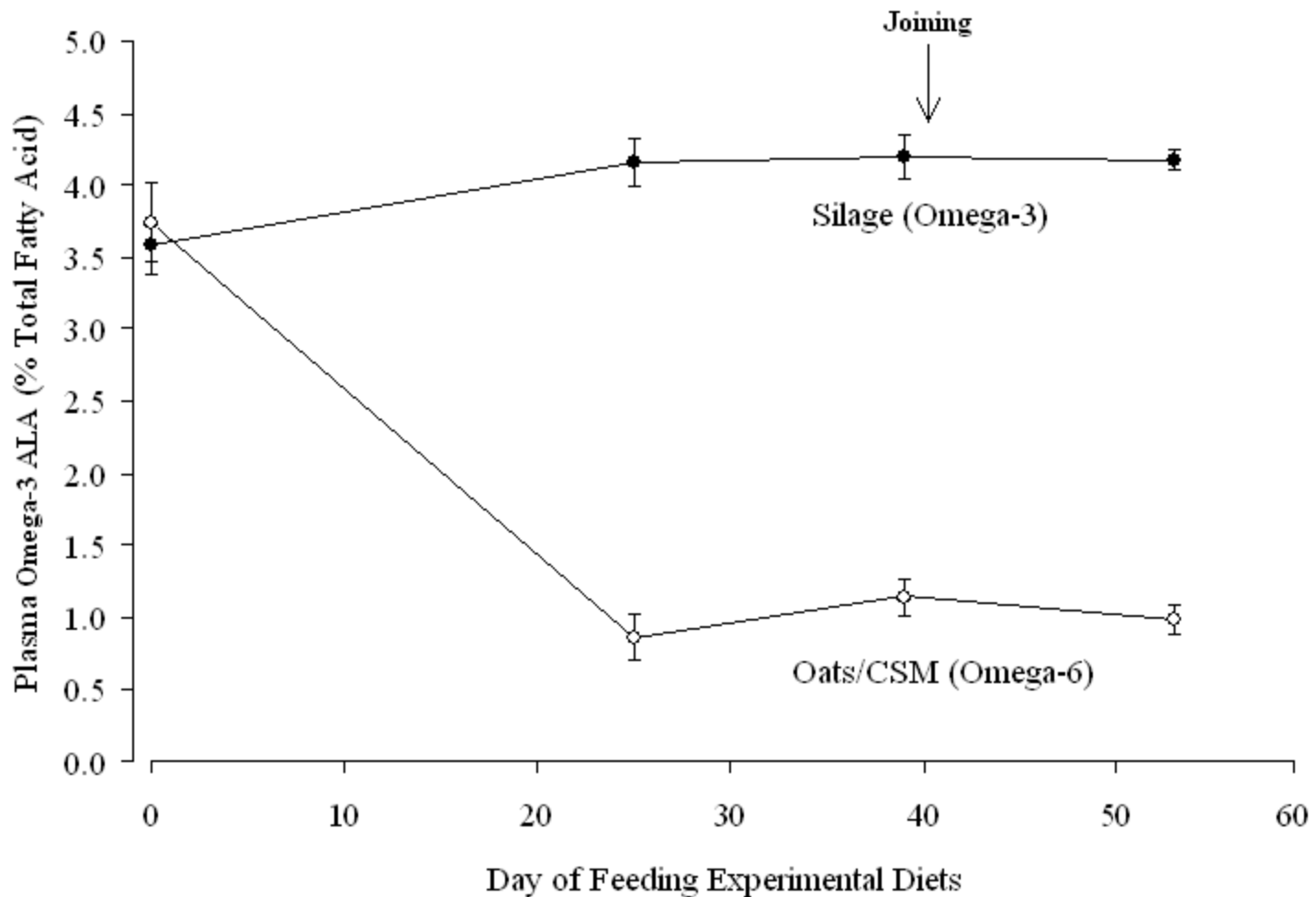


# Mating and Oestrus Detection

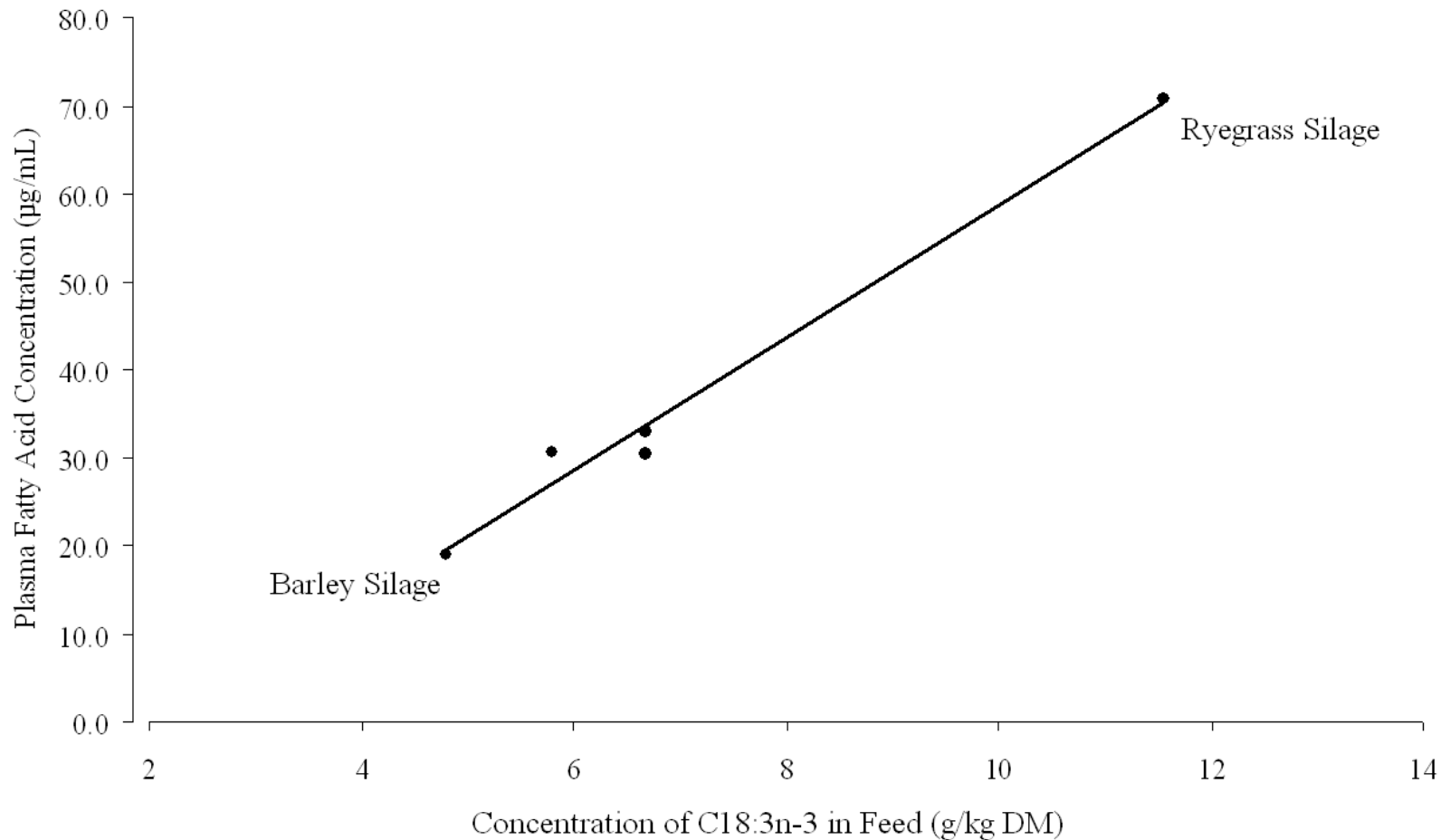
- Natural mating - 2 rams per pen



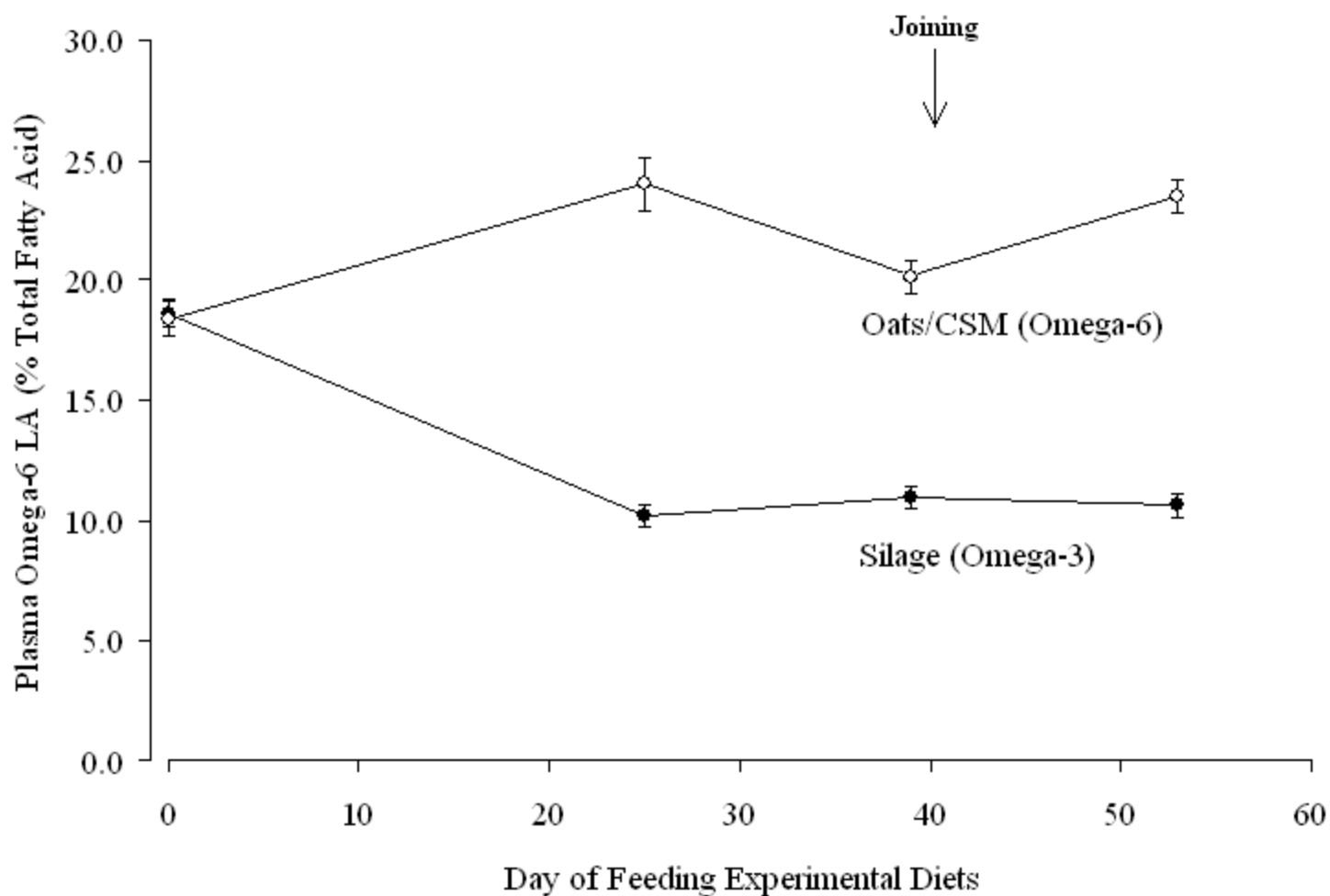
# Blood Omega-3



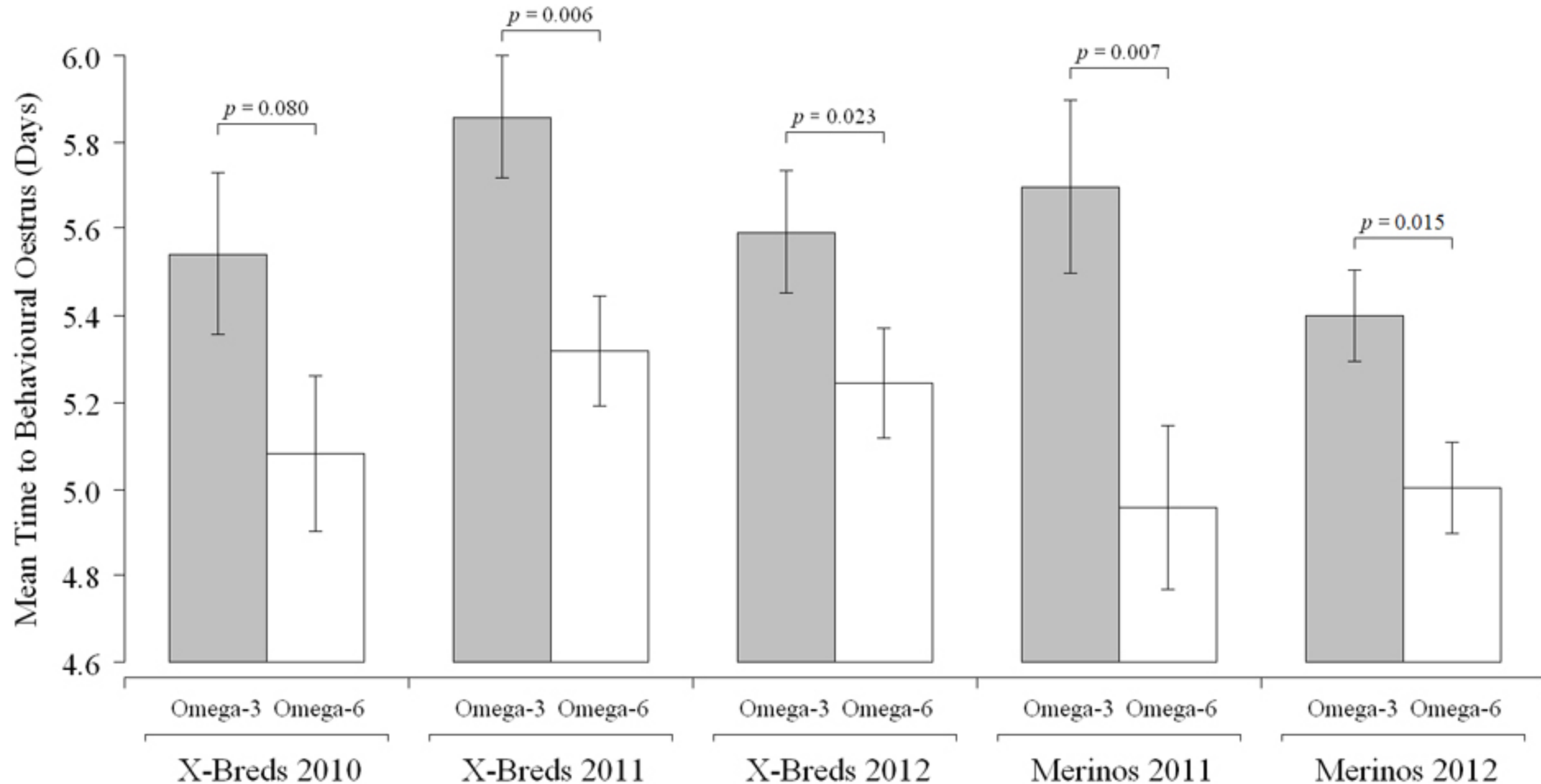
# Omega-3 in Feed and Blood



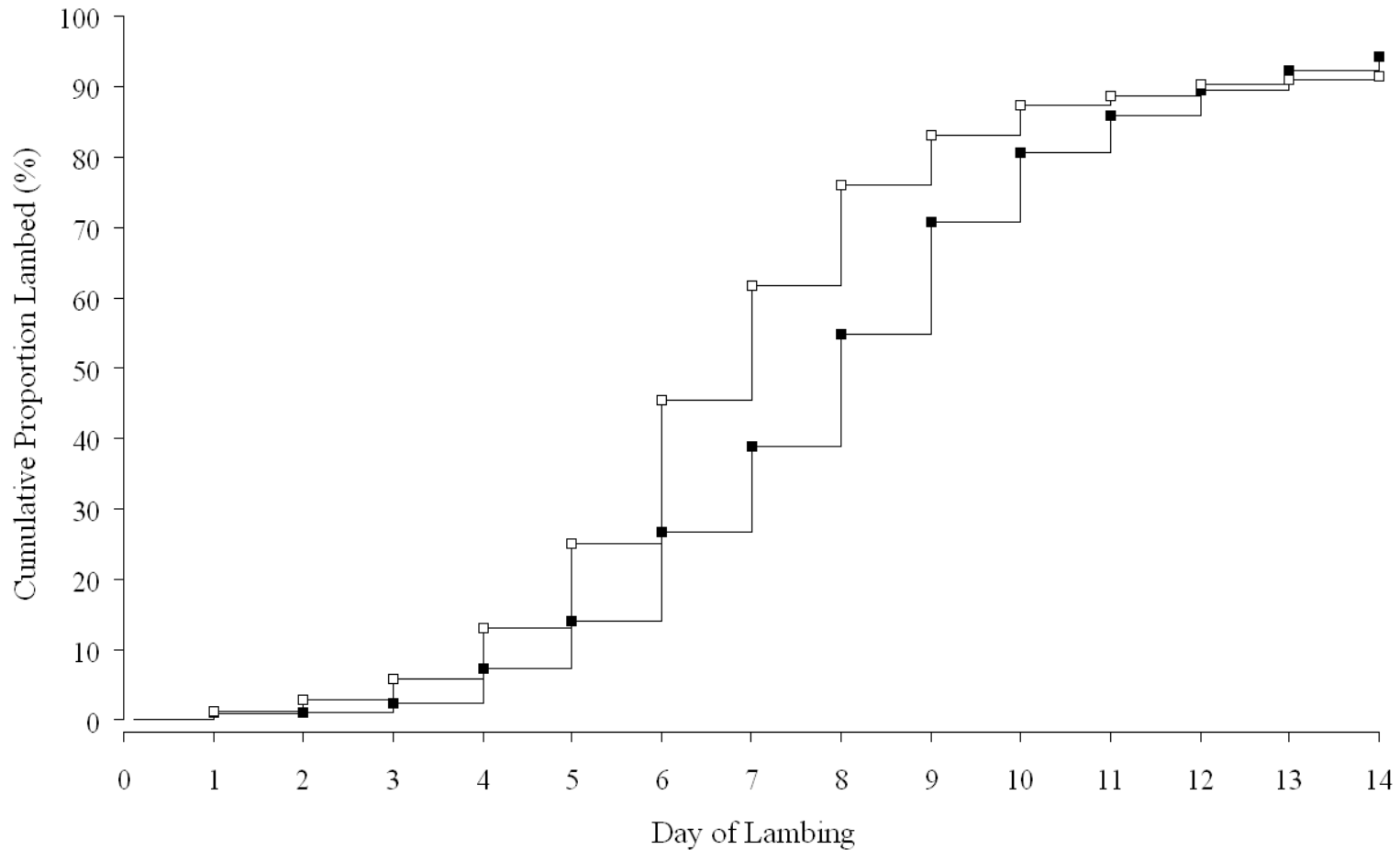
# Blood Omega-6



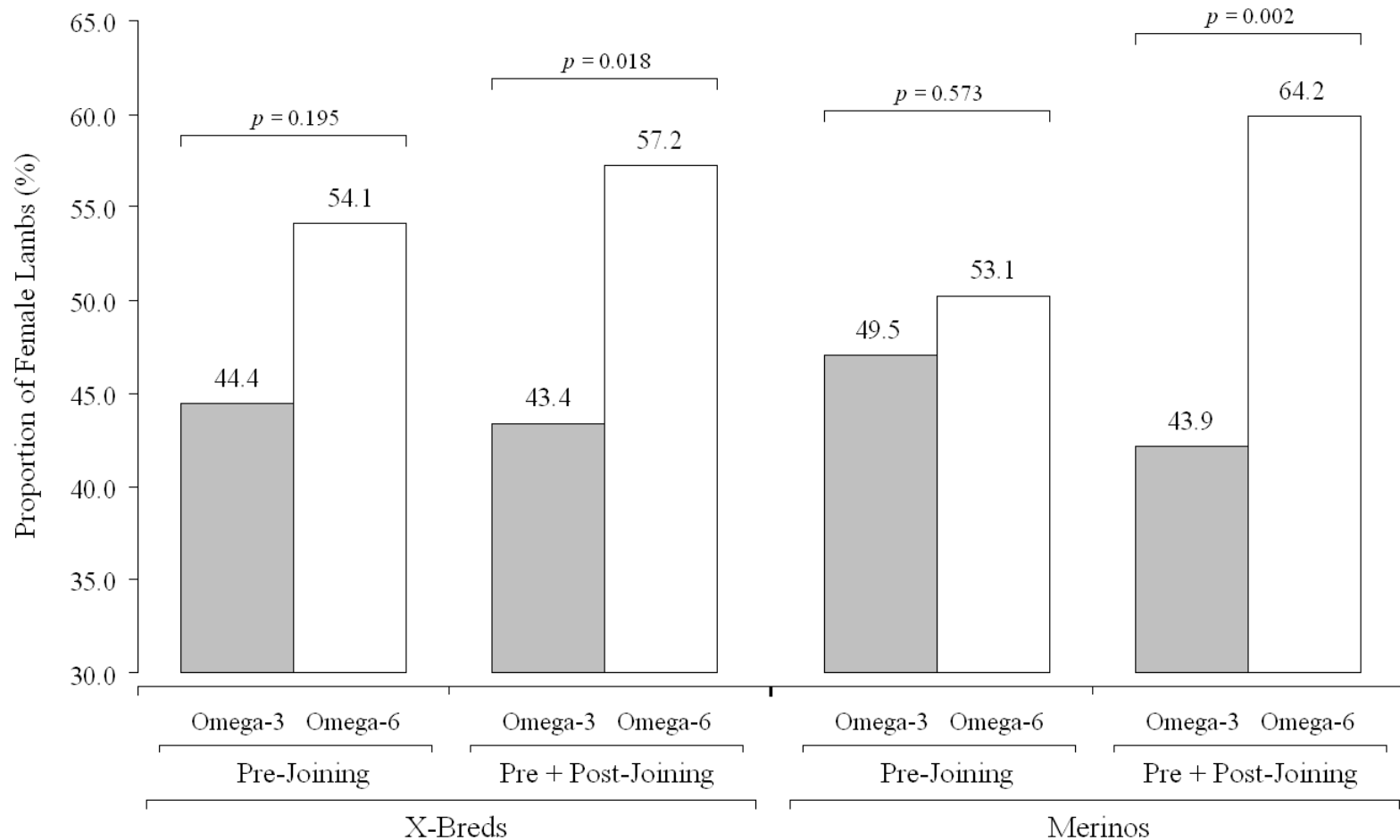
# Time to Oestrus



# Time of Lambing



# Sex Ratio of Lambs

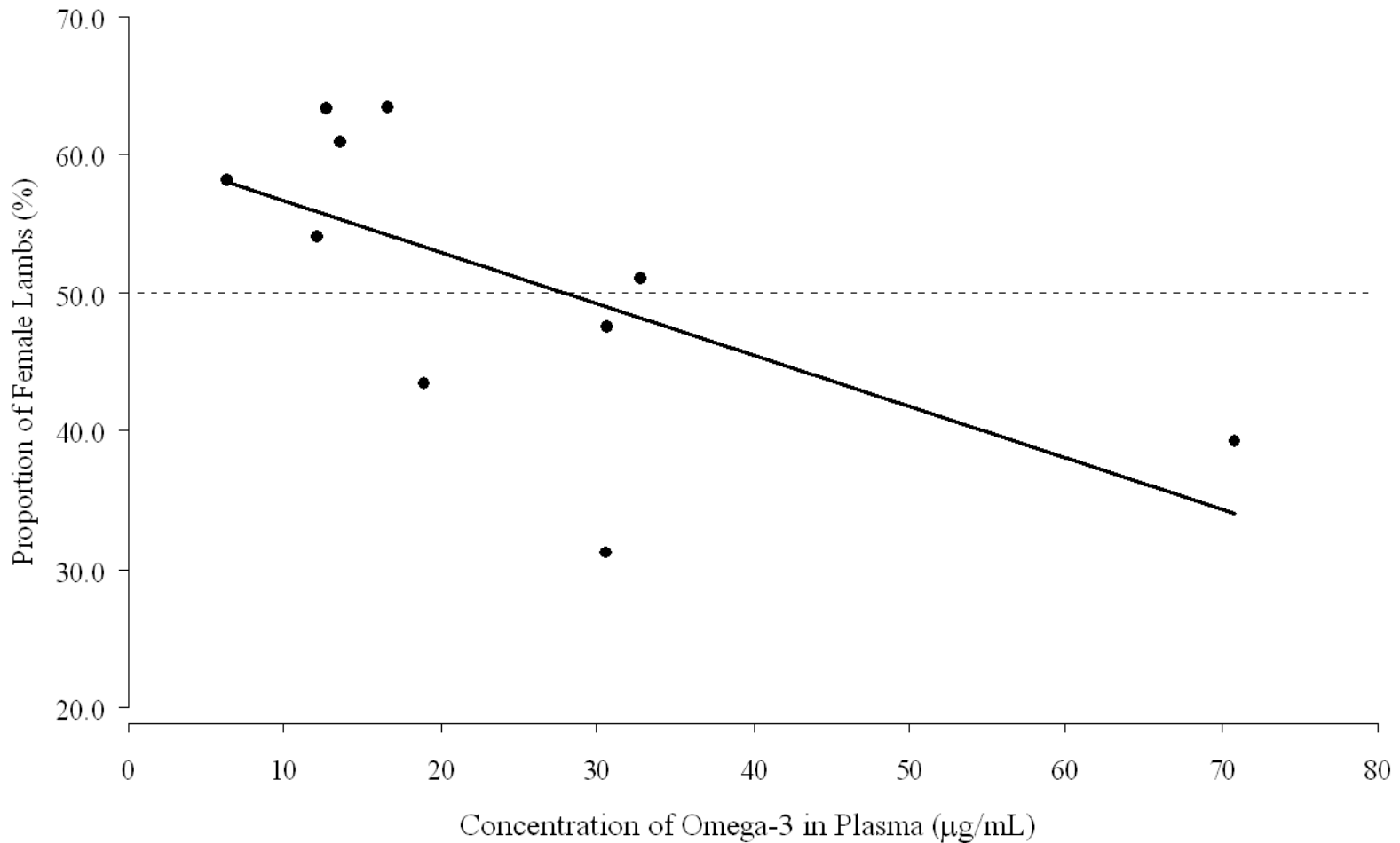


# Sex Ratio Breed Differences

- Merinos
  - Larger effect when fed pre- and post-joining
- X-Breds
  - Larger effect in singles than twins
- Greatest effect in singles fed pre- and post joining (21% more females)



# Omega-3 in Blood and Sex Ratio



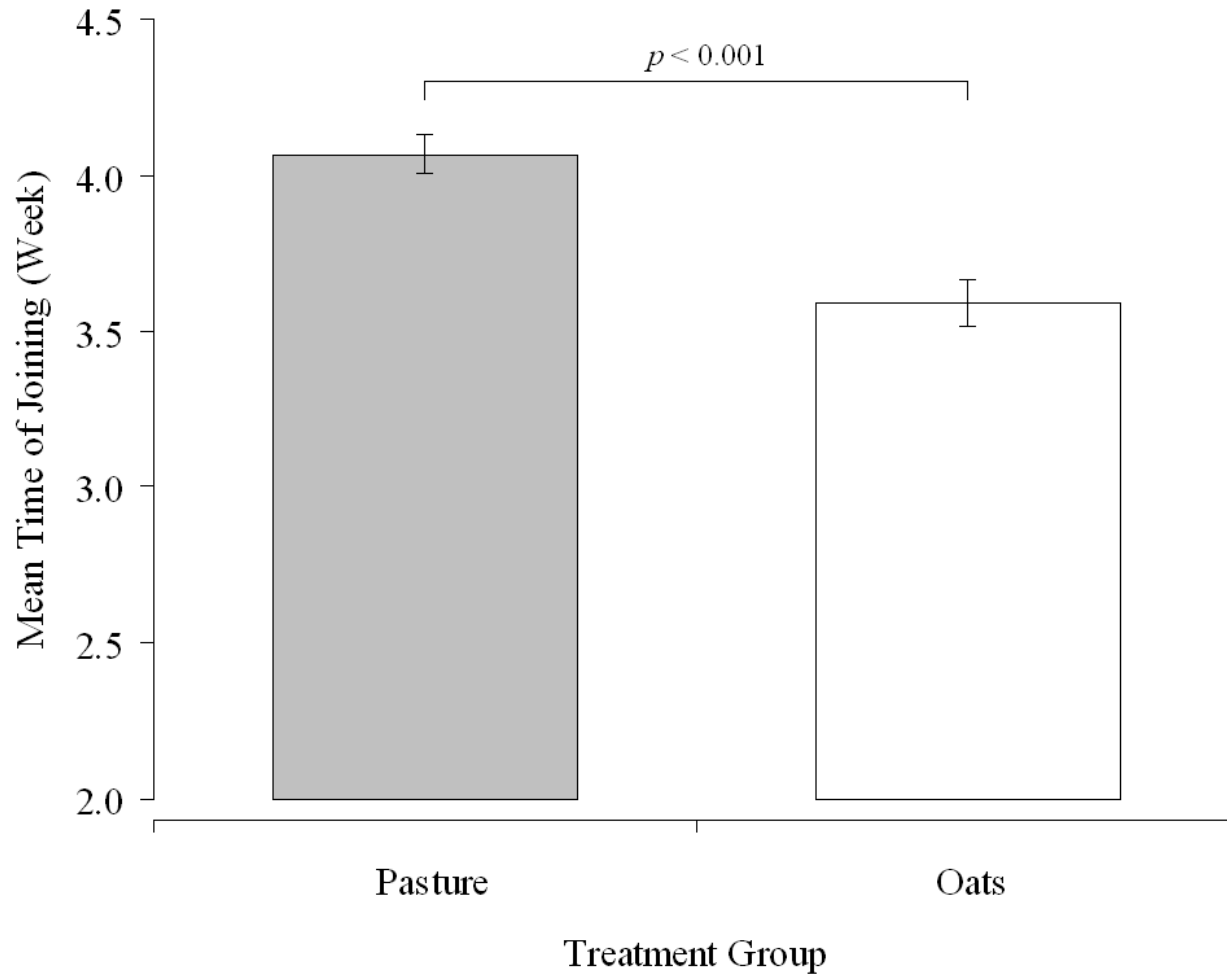
# Outcomes

- Ewes fed Oats/CSM (high in omega-6) had:
  - more omega-6/less omega-3 in plasma
  - increased PG response to oxytocin
  - shorter time to oestrus
  - approximately 10-15% more female lambs

# Where to?

- Overall lamb survival and production
- Lamb metabolism
- Health attributes of meat
- More on-farm studies

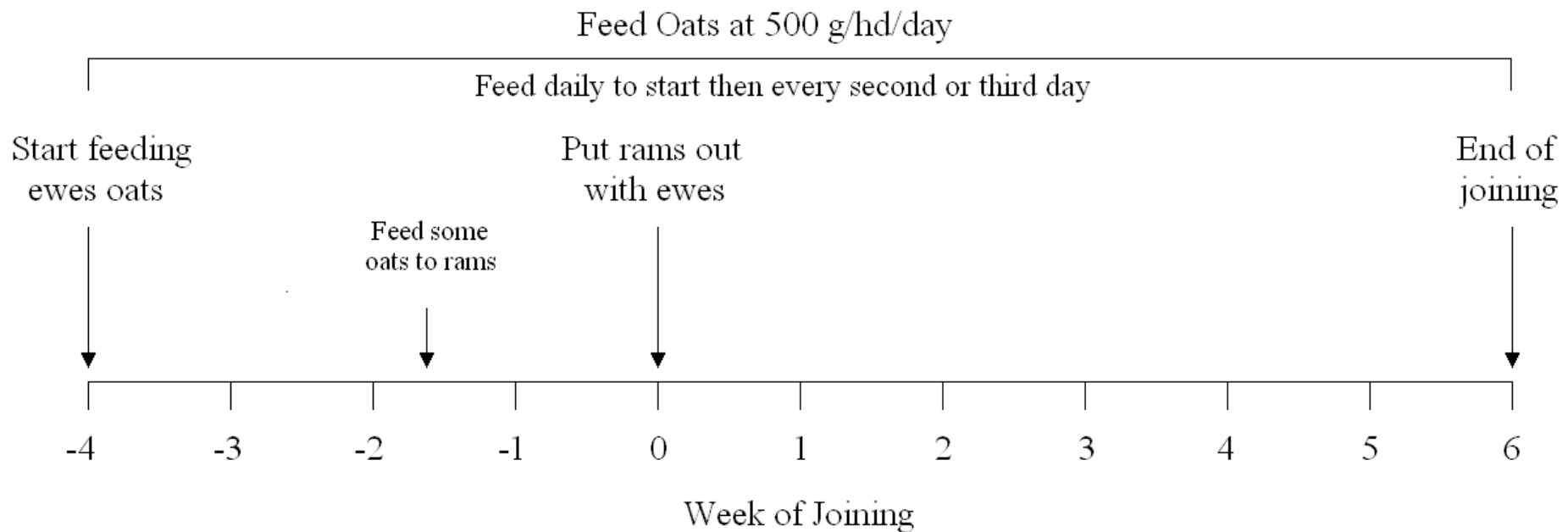
# On-farm Study



# Reproduction Outcomes

Reproduction Measure	Omega-3 (Pasture)	Omega-6 (Oats)	<i>p</i> -value
Proportion of ewes pregnant (%)	89.4	87.5	0.479
Mean foetal number			
<i>For ewes pregnant</i>	1.06 (± 0.02)	1.22 (± 0.03)	< 0.001
<i>For all ewes</i>	0.95 (± 0.02)	1.06 (± 0.03)	0.009

# Practicalities – What do we think works?



# In Summary

**Omega-3**

**Silage**



**More Males**

**Omega-6**

**Oats/Cottonseed Meal**



**More Females**

**Grain for Girls?**

# Acknowledgements

- WWAI: Greg Clark, Steven Huckell, Michael Loiterton, Rex Edis, John Moore, Craig Lihou, Patricia O' Keeffe
- John Piltz, Craig Rodham, Geoff Casburn, Peter Hawkins, Jamie Ayton, Greg Scott
- CSU: Brian Alston, Tony Hobbs, Brad Kelk, John Broster, Steph Knott
- Students: Alex Doulman, Simone Vincent, Bryanna Beattie, Vanessa Farrall, Emma Hand (CSU)  
Natalie Bignell (Sydney Uni)
- Paul Meggison (Ausfarm Nutrition)
- On-farm collaborators
- Meat and Livestock Australia



# References

- **Austad SN**, and Sunquist, ME (1986). Sex-ratio manipulation in the common opossum. *Nature* **324**, 58-60.
- **Clayton EH**, et al. (2007). Long-chain omega-3 polyunsaturated fatty acids in the treatment of psychiatric illnesses in children and adolescents. *Acta Neuropsych* **19**, 92-103.
- **Fountain ED**, et al. (2008). Effects of diets enriched in omega-3 and omega-6 polyunsaturated fatty acids on offspring sex-ratio and maternal behavior in mice. *Biol Reprod* **78**, 211-217.
- **Green MP**, et al. (2008). Nutritional skewing of conceptus sex in sheep: effects of a maternal diet enriched in rumen-protected polyunsaturated fatty acids (PUFA). *Reprod Biol Endocrinol* **6**, 21.
- **Horrobin DF**, and Bennett, CN (1999). Depression and bipolar disorder: relationships to impaired fatty acid and phospholipid metabolism and to diabetes, cardiovascular disease, immunological abnormalities, cancer, ageing and osteoporosis. Possible candidate genes. *Prostaglandins Leukot Essent Fatty Acids* **60**, 217-234.
- **Simopoulos AP** (1999). Essential fatty acids in health and chronic disease. *Am J Clin Nutr* **70**, S560-S569.