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Evidence for developmental programming in cattle

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‘Developmental programming’

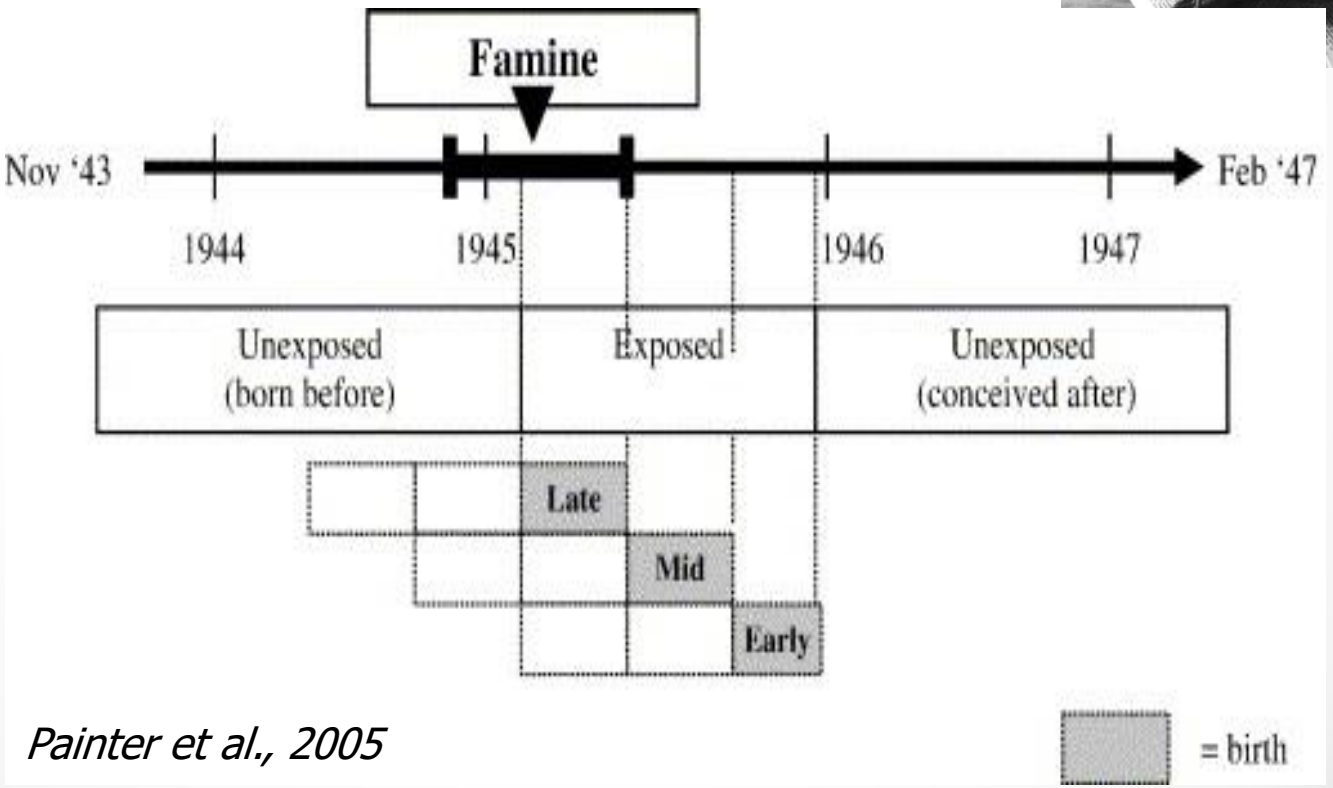
Stimuli during critical period of early development

Permanent changes in physiology / metabolism

Short and long-term health consequences

Introduction

- Dutch famine cohort study
  - hungerwinter WWII



Painter et al., 2005

Introduction

Nulliparous heifers

Bred at ± 15 months

Large part of body growth during first gestation

Dairy cows

Inseminated < 100 DIM

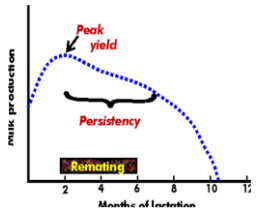
Produce large amounts of milk while being pregnant

Demanding in terms of energy and nutrients requirements

Introduction

HUMAN

- Undernourishment during pregnancy
- Energy restriction for embryo/fetus
- Placenta
- Birth weight
- Long-term health



CATTLE

- Growth/lactation during gestation
- Energy restriction for embryo/fetus
- Placenta
- Birth weight
- Long-term health and production

?

Studies

PLACENTA

PRENATAL

birth size

metabolism

POSTNATAL

growth

fertility

LACTATION

Studies

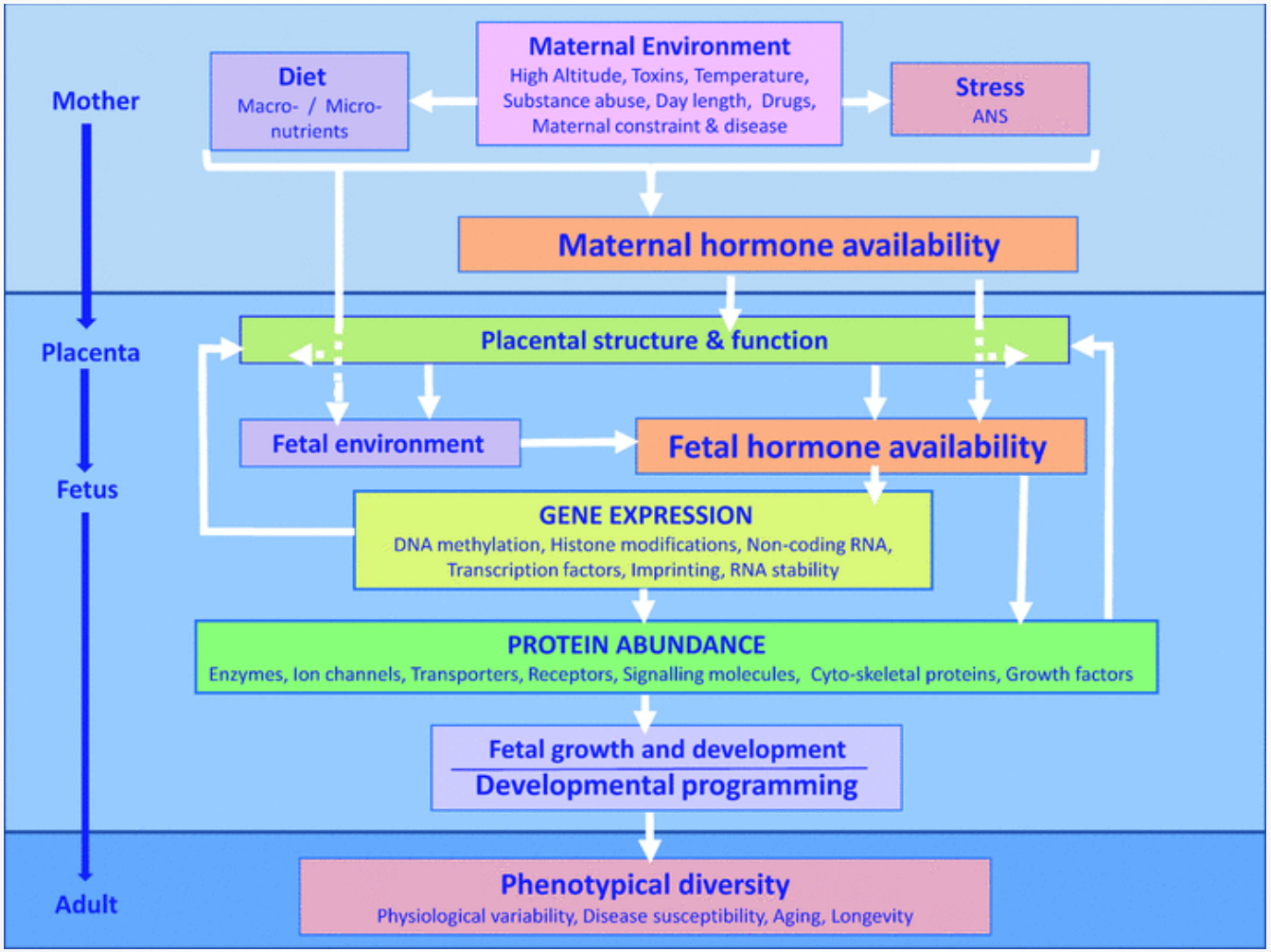
PLACENTA

PRENATAL

POSTNATAL

LACTATION

Placental development



Fowden & Forhead, 2009

Placental development

- Aim: assess effect of maternal body growth/ milk yield on placental development

- Expelled fetal membranes
  - maternal growth: BB heifers ↔ BB cows
  - maternal lactation: HF heifers ↔ HF cows

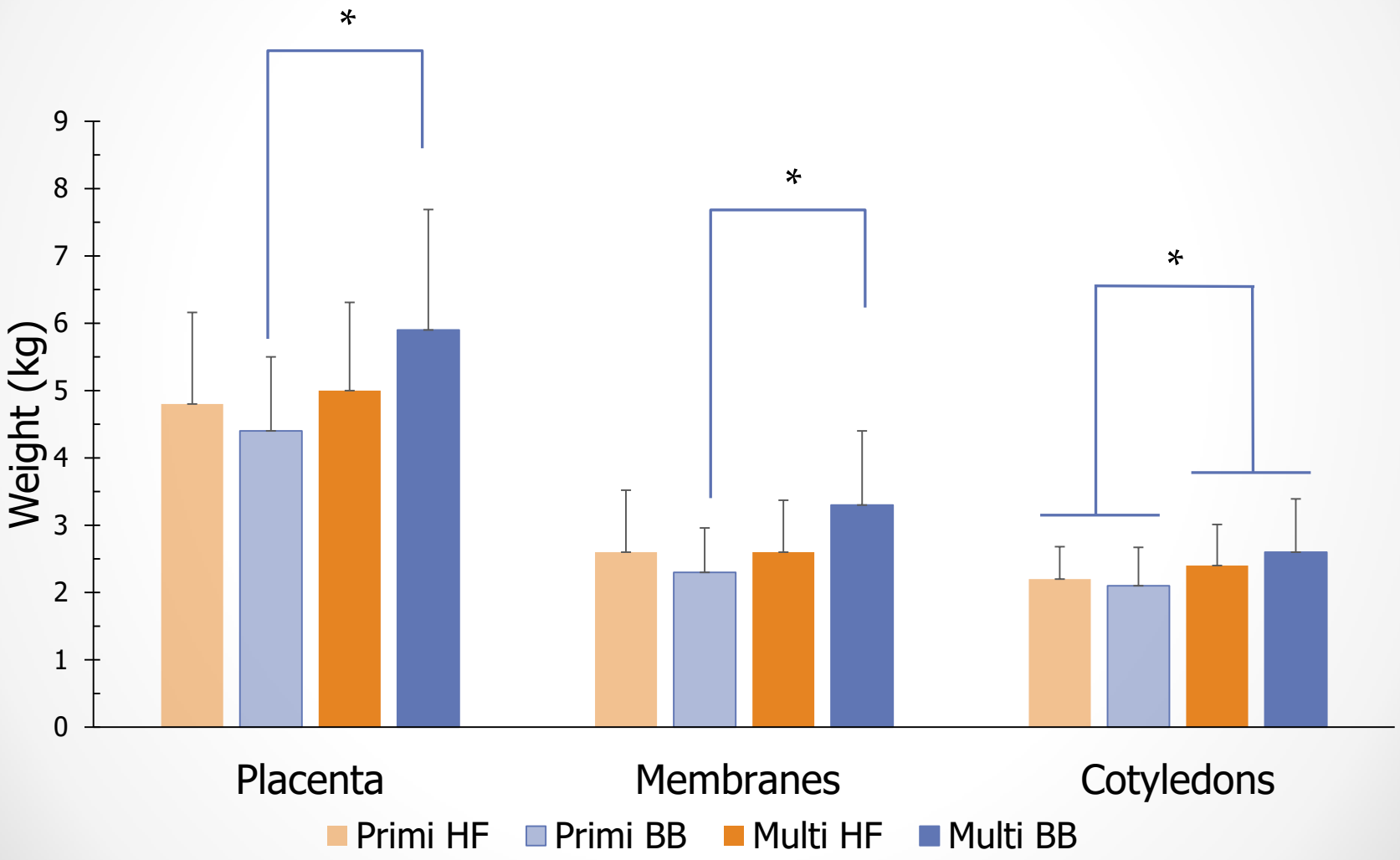
Van Eetvelde et al., 2016

Placental development

- Expelled fetal membranes
  - weight of membranes and cotyledons
  - cotyledon number
  - cotyledonary surface area
    - ⇒ exchange mother - calf

Van Eetvelde et al., 2016

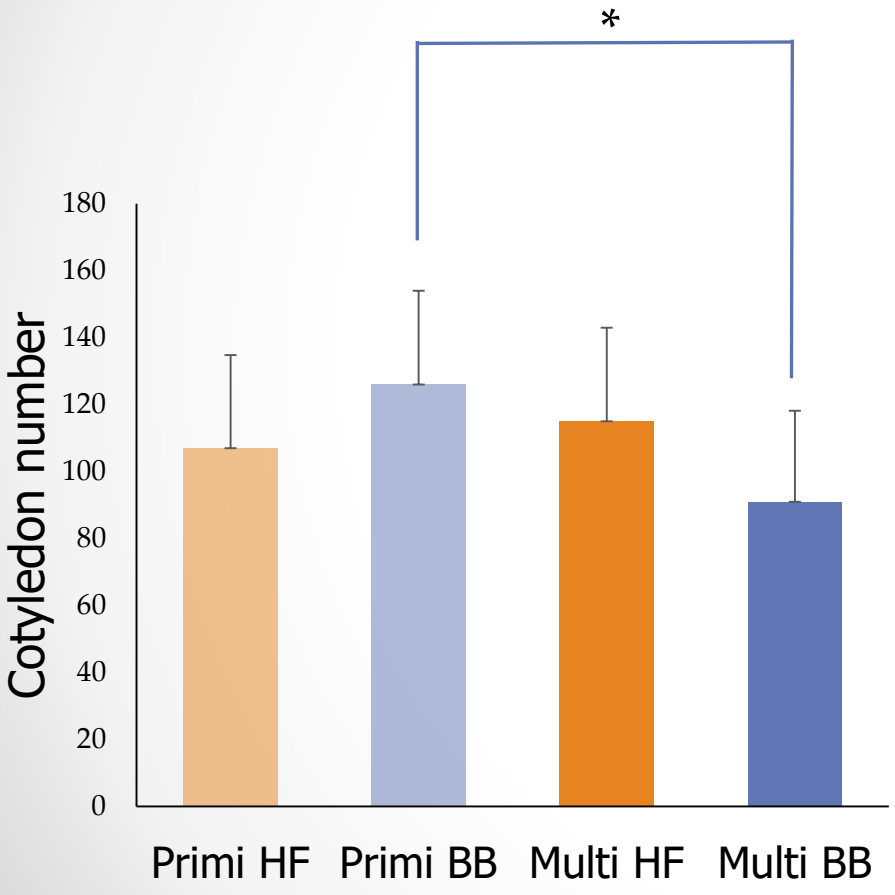
Placental development



- * P<0.05

Van Eetvelde et al., 2016

Placental development



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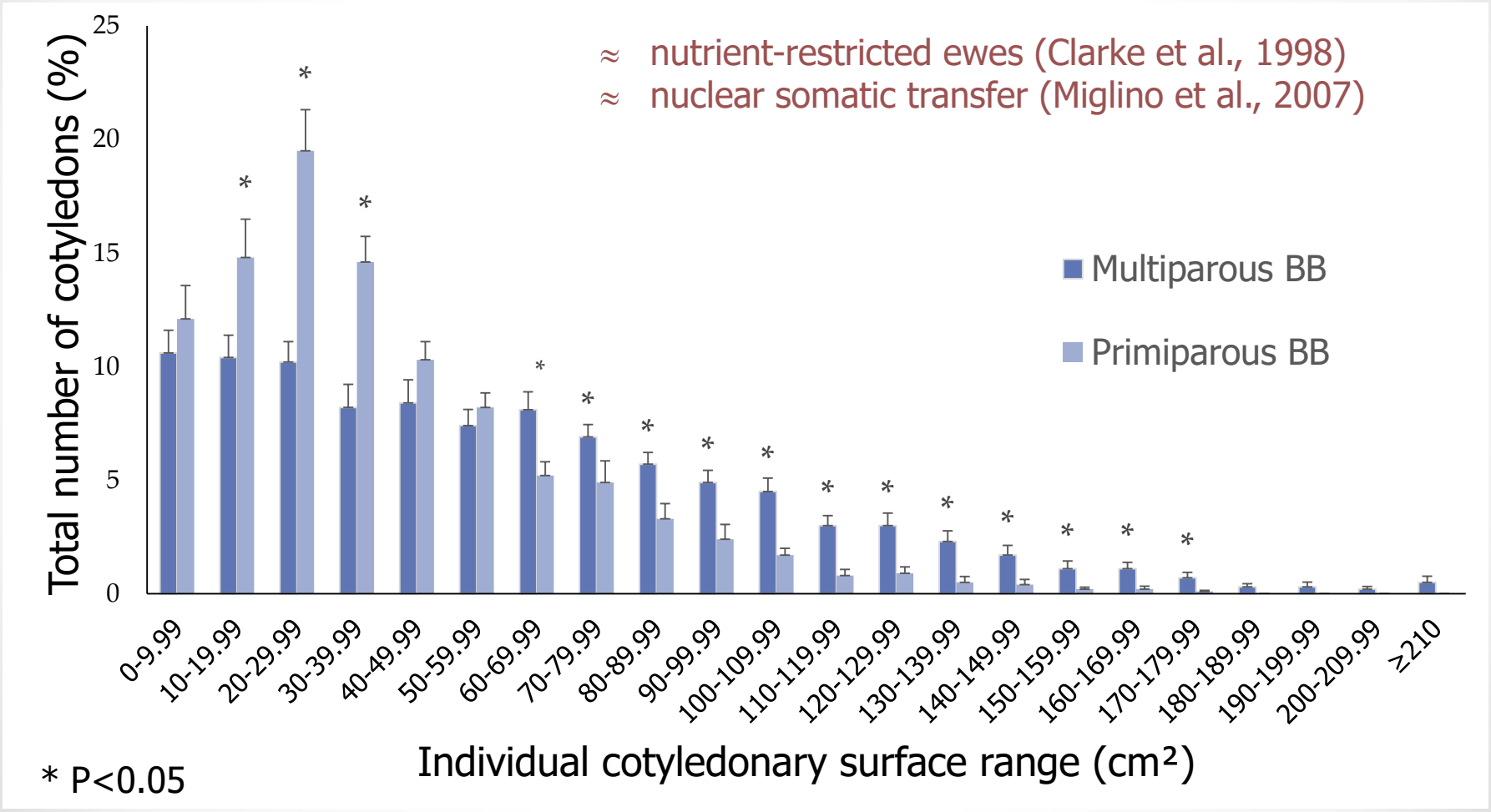
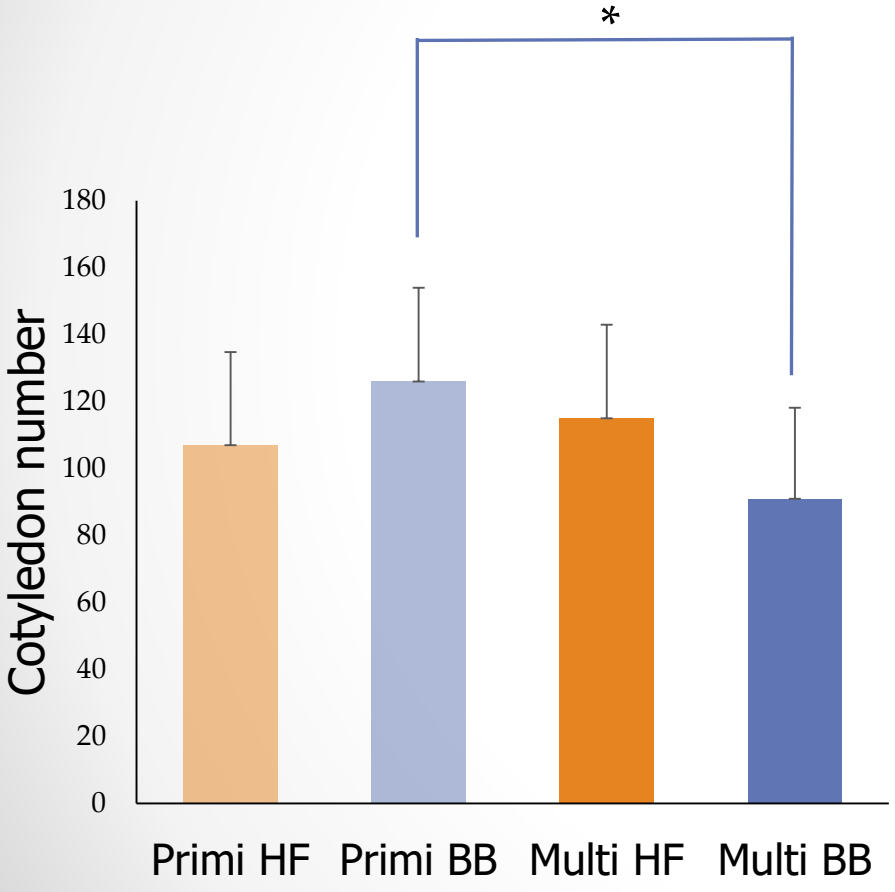
Van Eetvelde et al., 2016

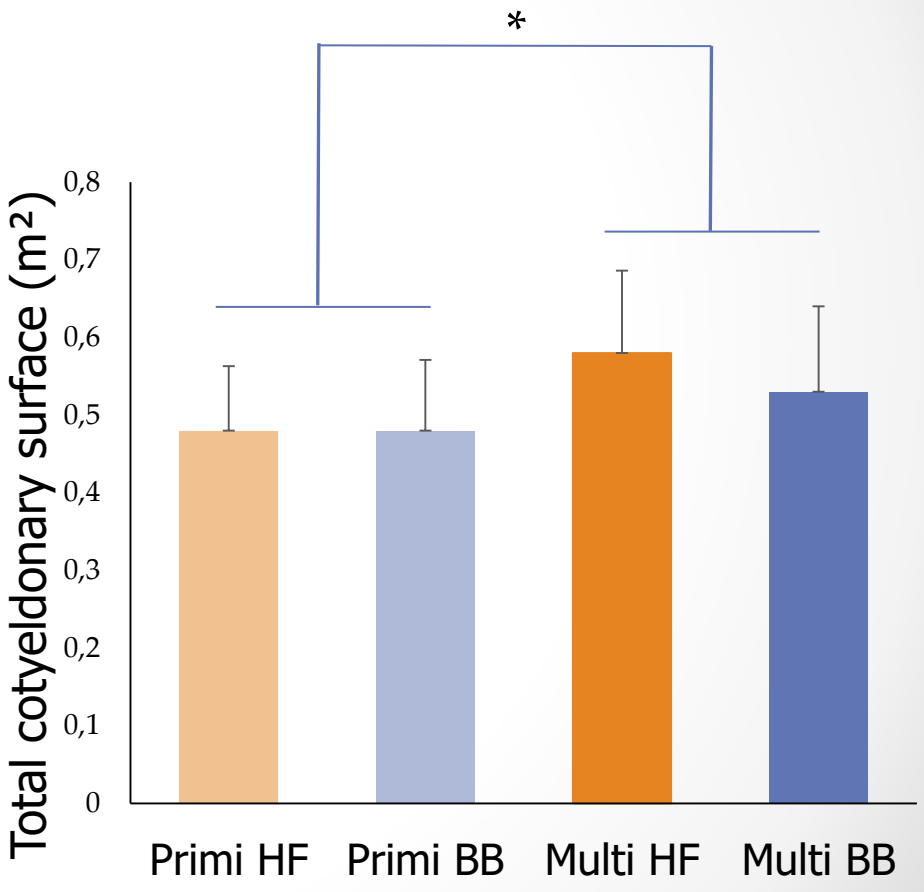
Placental development



Van Eetvelde et al., 2016

Placental development





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Van Eetvelde et al., 2016

Placental development

- Compensation mechanisms of the placenta
  - early gestation: developing more cotyledons
    - survival of pregnancy
  - late gestation: expansion of cotyledonary surface
    - increasing nutrient demand of fetus

Van Eetvelde et al., 2016

Studies

PLACENTA

PRENATAL

POSTNATAL

LACTATION

Studies

birth weight

± 1500 calves

metabolism

± 500 calves

growth & fertility

± 100 heifers

lactation

74 heifers

Studies

PLACENTA

PRENATAL

POSTNATAL

LACTATION

Birth weight

- Aim: assess effect of maternal body growth/ milk yield on fetal development

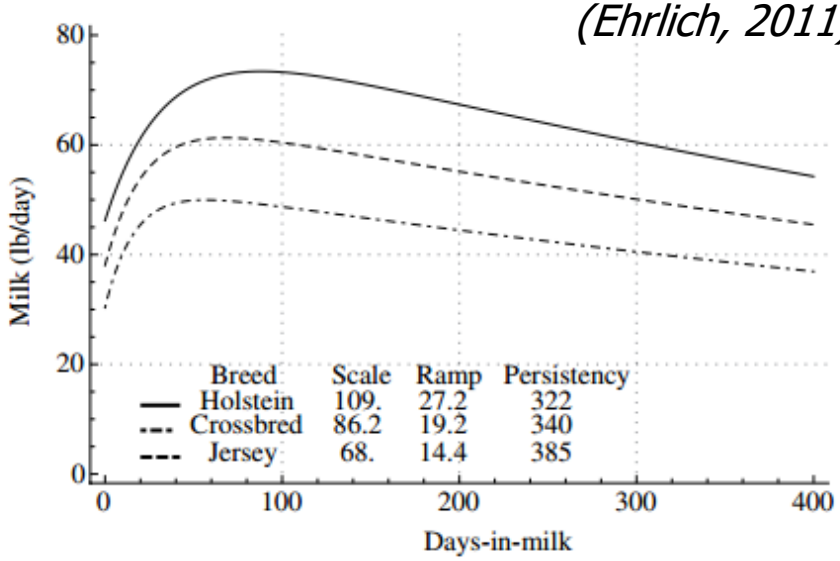
- Birth weight of 1,594 HF calves
  - 540 primiparous dams
  - 1,054 multiparous dams

Kamal et al., 2014

Birth weight

- Maternal factors:
  - parity / age
  - body measurements / body condition
  - lactation features (Milkbot)
    - during gestation
      - 6,193 kg milk
      - 446 kg glucose
      - 217 kg proteins

(Ehrlich, 2011)



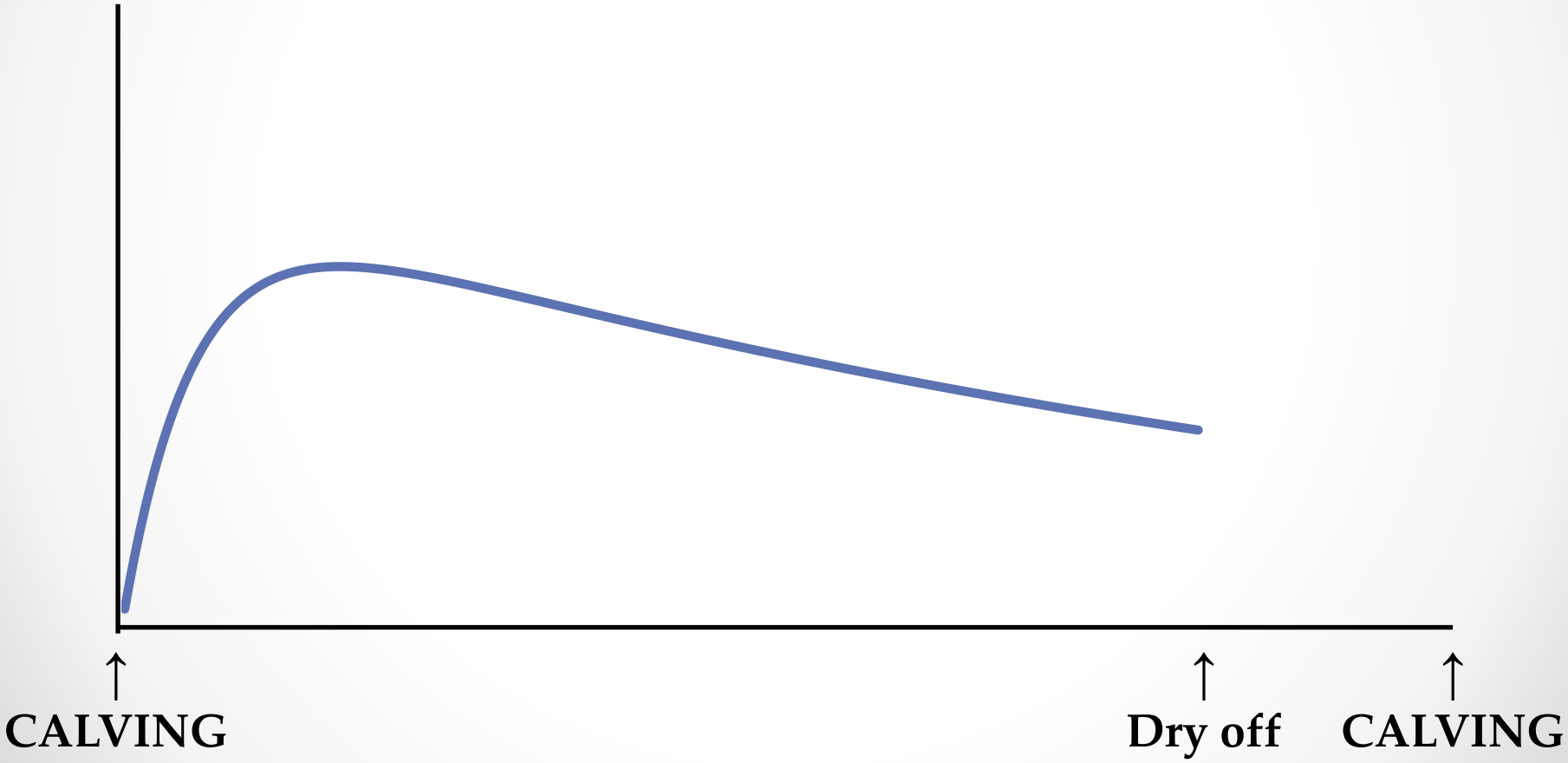
Kamal et al., 2014

Birth weight

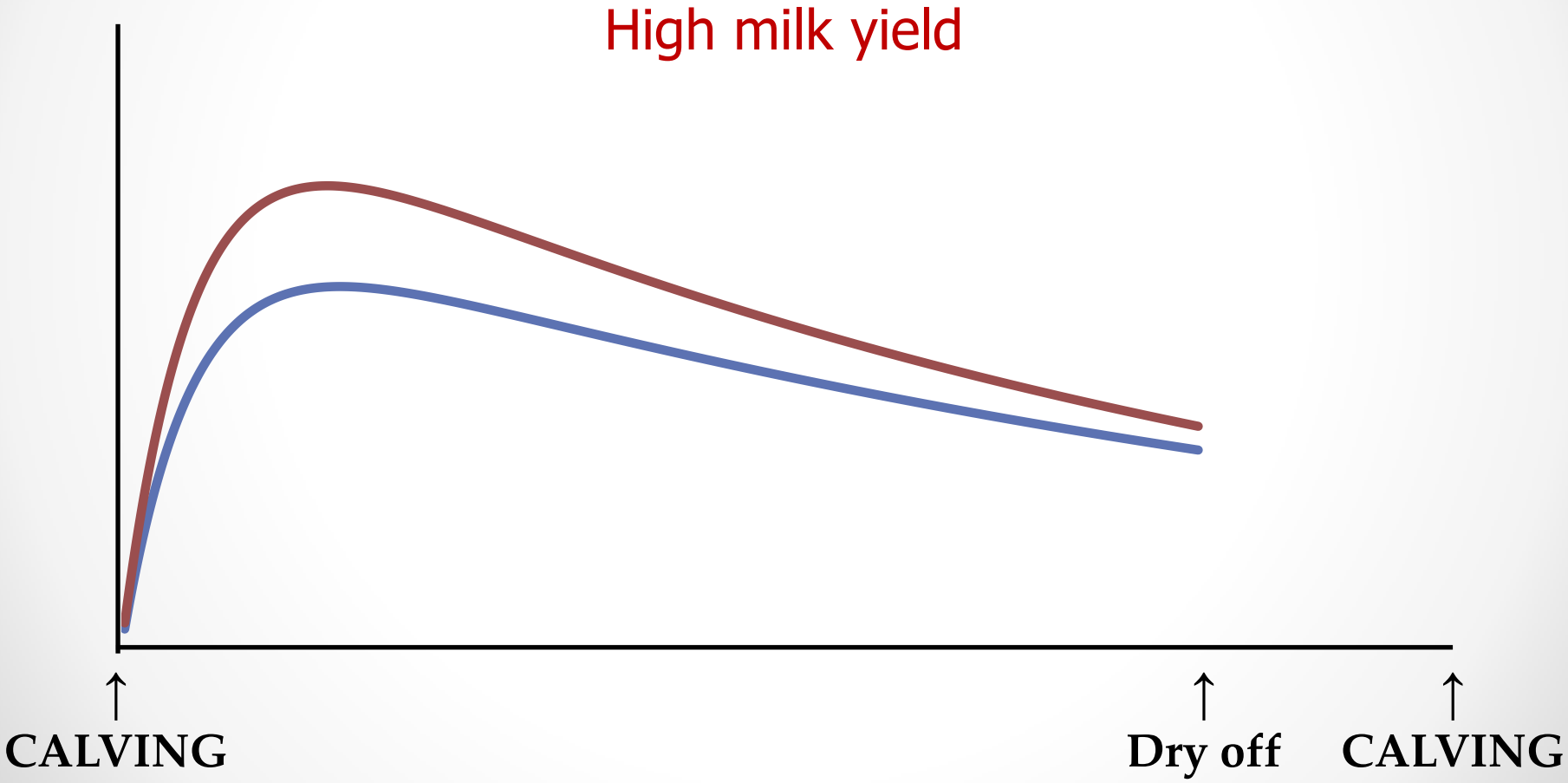
- Birth weight ↓:
  - female calves
  - primiparous dams
    - younger age at calving
  - multiparous dams
    - higher milk yield of dam during gestation
    - shorter dry period

Kamal et al., 2014

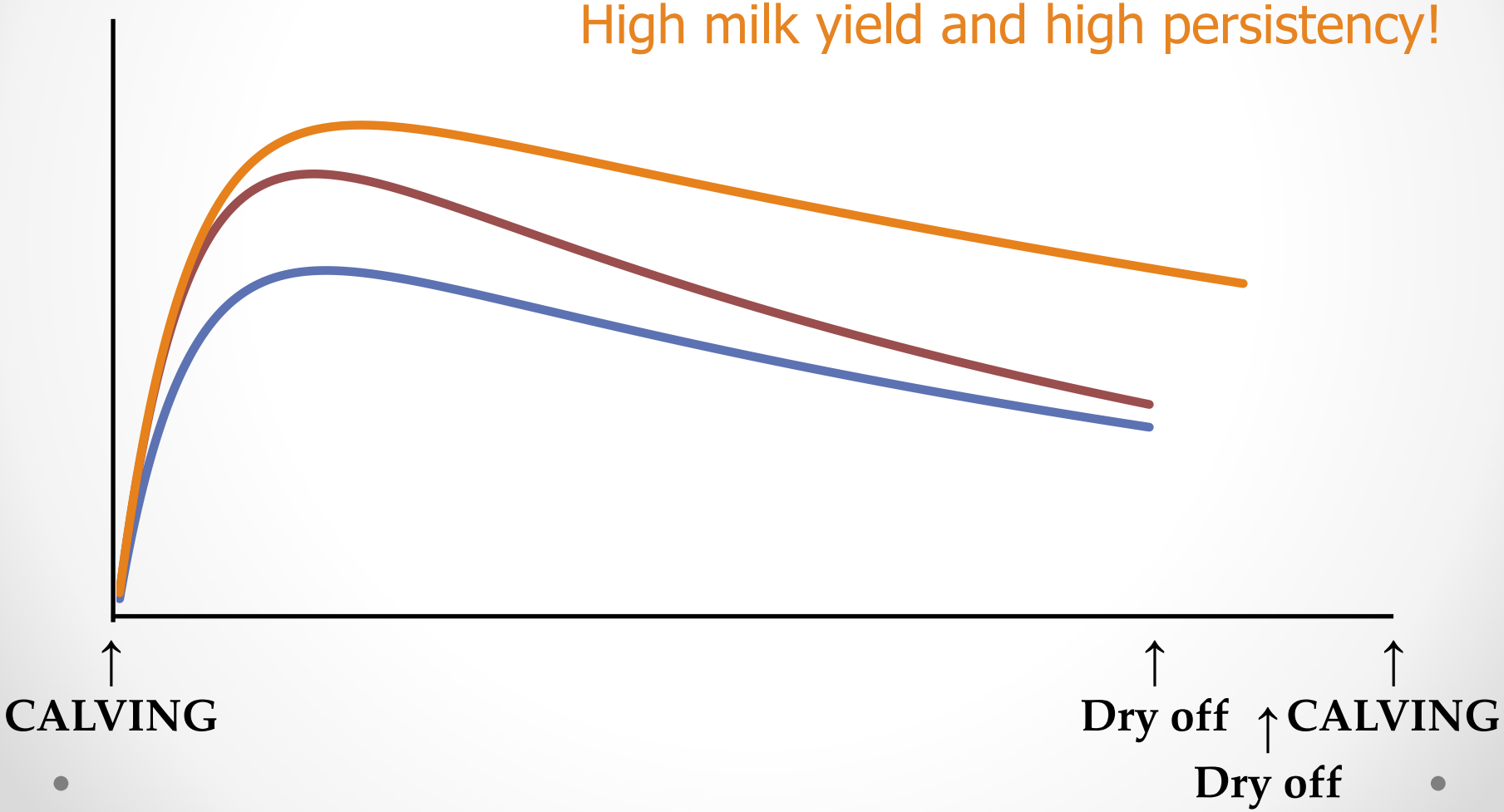
Birth weight



Birth weight



Birth weight



Calf metabolism

- Aim: assess effect of maternal body growth/ milk yield on metabolism calf

- 481 HF calves
  - basal glucose/insulin levels
  - glucose stimulation (150 mg/ kg BW)

Kamal et al., 2015

Calf metabolism

- ↑ basal insulin levels:
  - female calves
  - multiparous dams
    - higher milk yield of dam during gestation
    - longer dry period

Kamal et al., 2014

Prenatal development

- Effect of high maternal milk yield / dry period
  - on birth weigh
  - on glucose and insulin metabolism of calf

- Further research necessary:
  - metabolic state of the dam?
  - long-term consequences for the offspring?

Kamal et al., 2014

Birth season

- Born during 'hotter' months
  - larger cotyledonary surface of placenta
  - lower birth weights
  - lower insulin levels in newborn calves

- Decreased nutrient supply during end of gestation?

Kamal et al., 2014 and 2015; Van Eetvelde et al., 2016

Studies

PLACENTA

PRENATAL

POSTNATAL

LACTATION

Body growth

Intra Uterine Growth Retardation

↓

SGA infants

↓ insulin levels

↓

catch-up growth

reduced insulin sensitivity at early age

↓

longterm health risks

associated with high insulin levels

Hales et al., 1991; Barker et al., 1993; Ibanez et al., 1998

Body growth

- Hypothesis:
  - catch-up growth in cattle
    - associated with low insulin at birth
    - can lead to adiposity/ health problems in later life

Van Eetvelde, unpublished data

Body growth

- 3 groups (daily growth during first 6 months)
  - slow: <750 g/day (n=6)
  - moderate: 750-950 g/day (n=40)
  - fast: >950 g/day (n=5)

	Growth rate			
	slow	**moderate**	**fast**	**P-value**
Birth weight (kg)	39 ± 1.8	39 ± 4.6	42 ± 2.2	0.32
Glucose (mMol/L)	6.5 ± 0.70	6.0 ± 0.60	5.9 ± 0.81	0.16
Insulin (mU/L)	12.9 ± 9.10	7.2 ± 4.76	4.4 ± 2.39	0.08

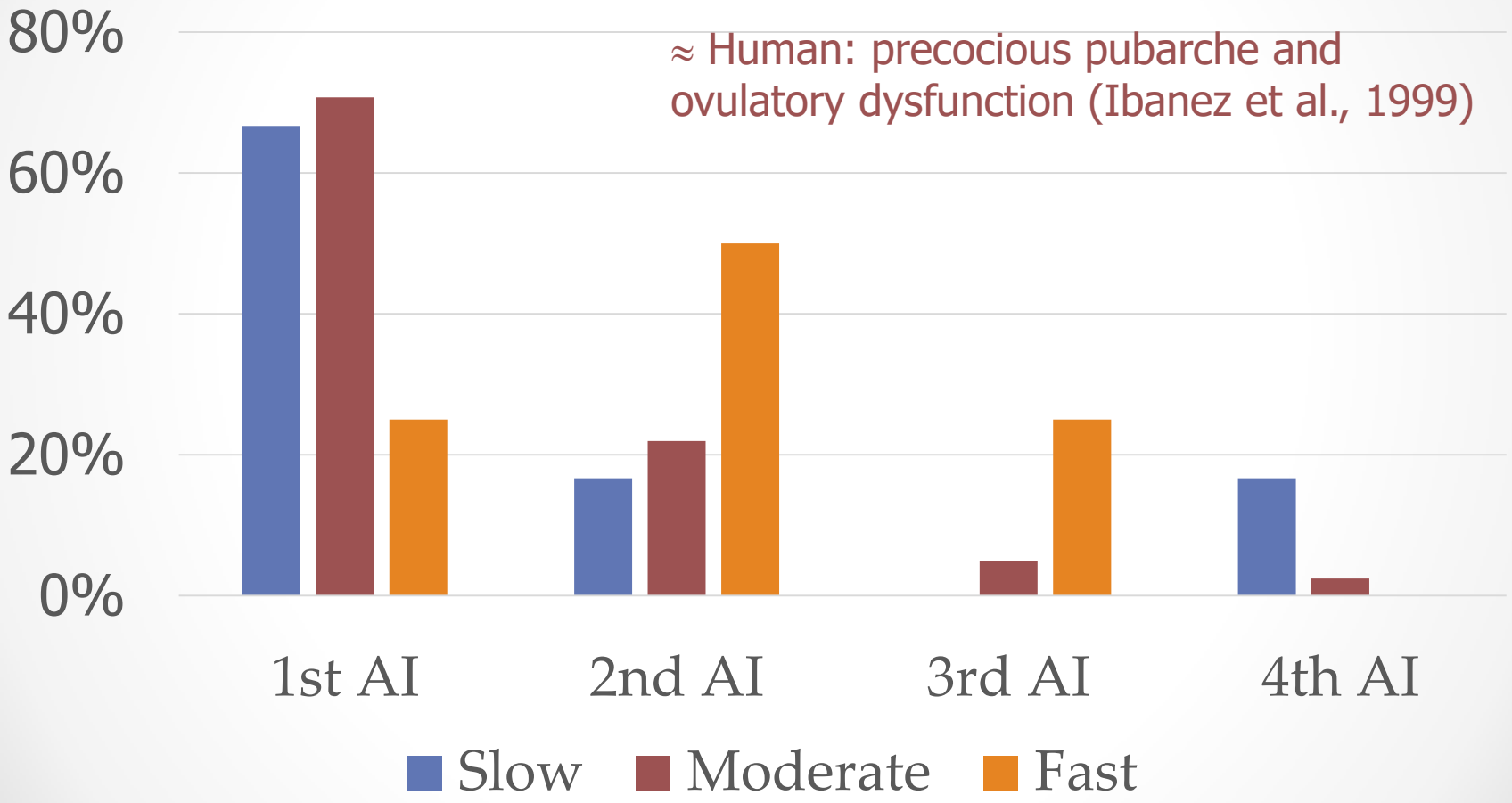
Van Eetvelde, unpublished data

Body growth

	Growth rate			
	slow	moderate	fast	P-value
FIRST AI				
Age (d)	445 ± 38	454 ± 51	455 ± 30	0.91
Weight (kg)	378 ± 29[a]	414 ± 41[a]	473 ± 45[b]	0.003
CONCEPTION				
Age (d)	480 ± 88	474 ± 69	528 ± 58	0.36
Weight (kg)	406 ± 82[a]	425 ± 45[a]	506 ± 41[b]	0.007

Van Eetvelde, unpublished data

Body growth



Van Eetvelde, unpublished data

Body growth

	Growth rate			
	slow	moderate	fast	P-value
CALVING				
Age (d)	755 ± 87	739 ± 62	815 ± 67	0.15
Weight (kg)	627 ± 69[a]	616 ± 72[a]	734 ± 145[b]	0.045
BFT (mm)	16 ± 6.5	15 ± 5.3	24 ± 13.8	0.069

Van Eetvelde, unpublished data

Body growth

- FAST growing heifers
  - lower basal insulin levels at birth
  - larger body weight at calving
  - higher adiposity at calving

≈ Human catch-up growth

- Low fasting insulin levels in newborns
  - forecast of catch-up growth during early life?
    - consequences for fertility and health?

Van Eetvelde, unpublished data

Studies

PLACENTA

PRENATAL

POSTNATAL

LACTATION

1st lactation

- Aim: assess factors influencing first lactation milk yield

- 305-d milk yield of 74 HF heifers
  - maternal factors
  - environmental factors
  - heifers development

Van Eetvelde, unpublished data

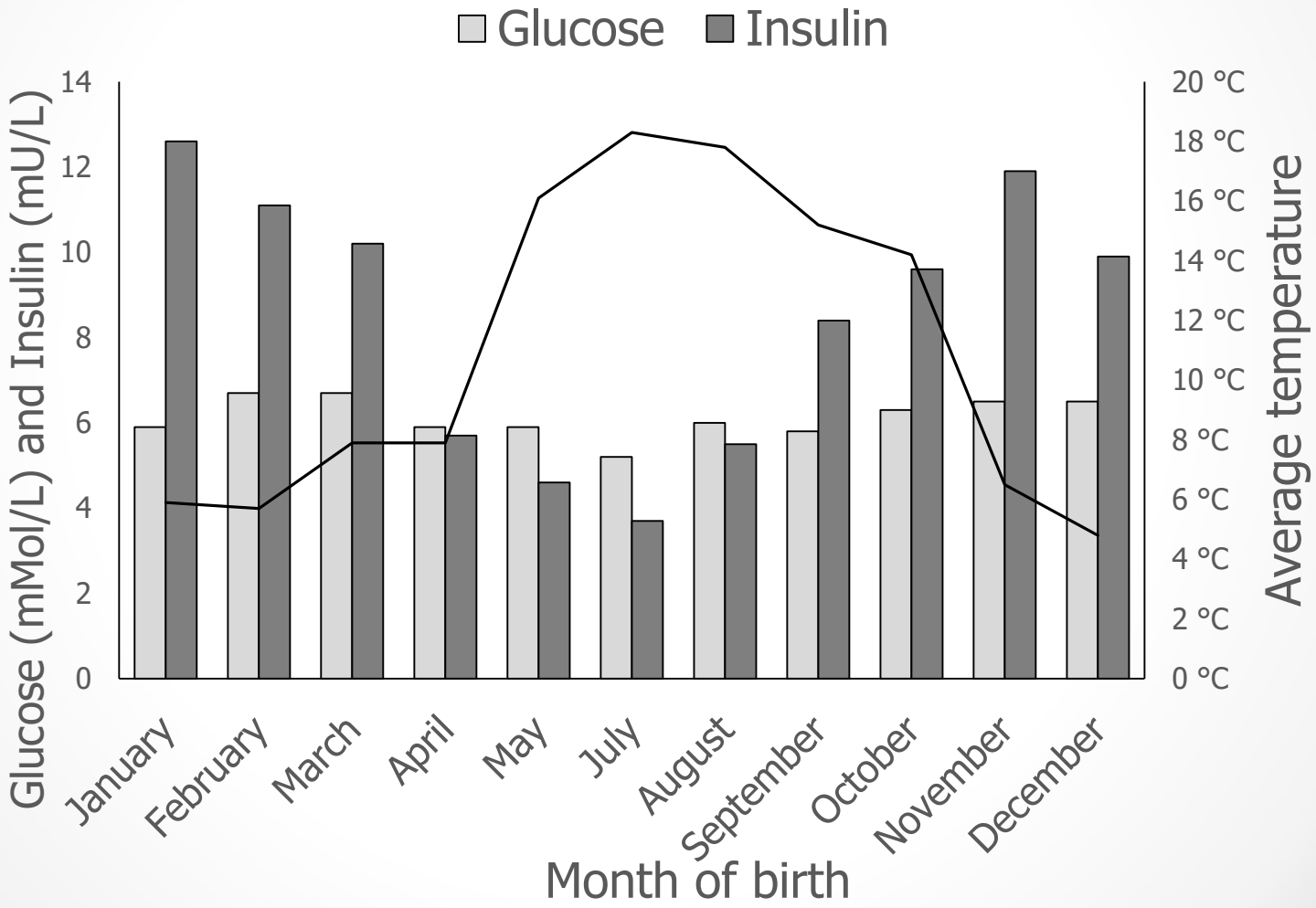
1st lactation

- ↓ first lactation milk yield associated with
  - younger age at first parturition
  - lower body weight at first parturition
  - birth during winter
    - nutrition?
    - photoperiod?
    - temperature?

Van Eetvelde, unpublished data

1st lactation

- Relation birth season – metabolism



Van Eetvelde, unpublished data

1st lactation

- Born during hotter months
  - ↓ basal insulin level

- Potential consequences:
  - Development of insulin resistance in early life?
  - Higher milk yield during first lactation?

Van Eetvelde, unpublished data

Conclusion

Environmental events during gestation

Impact on development (size and metabolism) of newborn dairy calves

Consequences for health and productivity

Conclusion

- Fundamental studies necessary to
  - decipher the underlying mechanisms
  - develop preventive and curative strategies to increase productivity, health and life expectancy in dairy cattle

Thank you!

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