Delayed development in Large White Purebred piglets as compared to Crossbreds with Meishan, born in the Same Litter

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Session 11- Physiological limits of performance due to disproportionate tissue growth

Outline

1. Introduction

2. Definition of criteria of maturity in LW PB

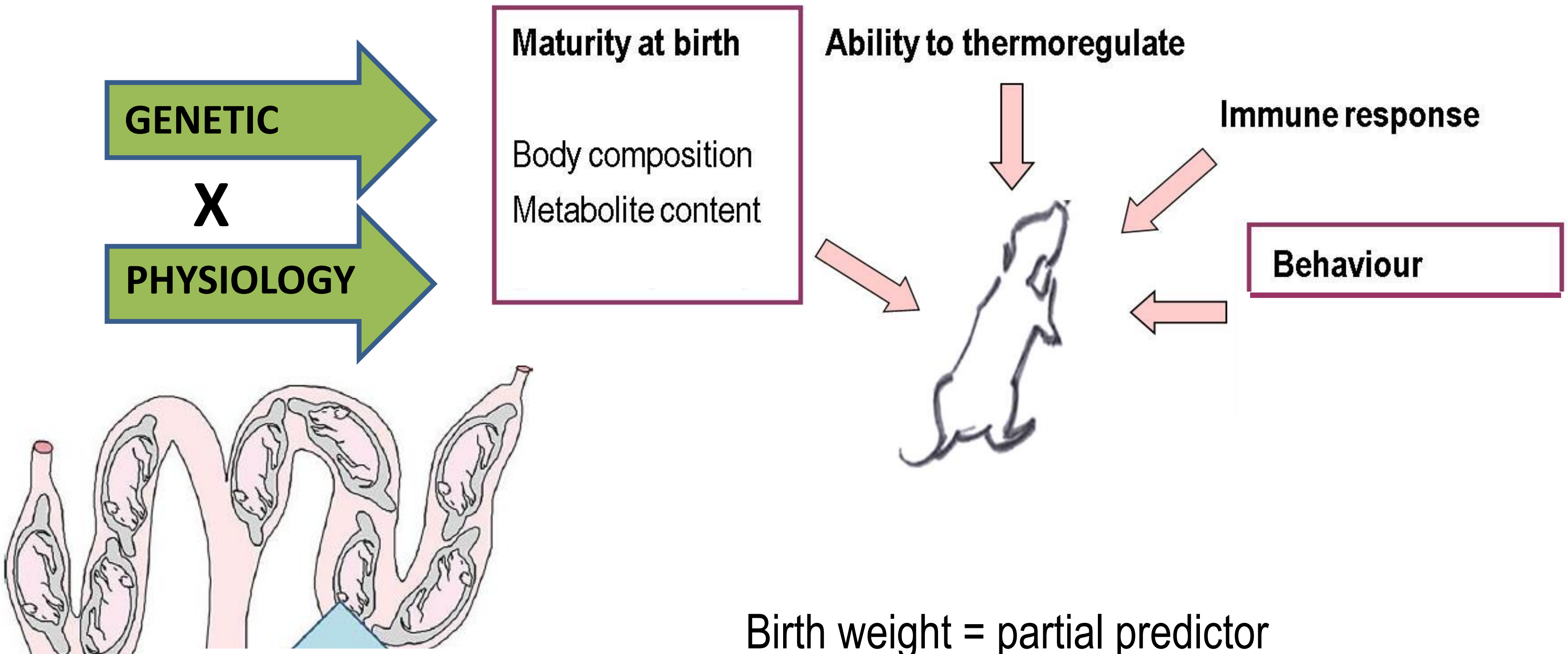
3. Experimental results – crossbreeding design
   - 110d dvp in utero
   - 90d dvp in utero

4. Uterine environment
   Placenta features

5. Conclusion

Concept of maturity at birth

Characteristics of newborn piglet influencing survival and growth



Ashworth et al., 2001

Birth weight = partial predictor

Level of maturity at birth = major determinant of early survival

Maturity *and* disproportionate dvp

Pre-maturity affects the dvpt of numerous organs

- BMI and PI
- Ratios of bone length to body length
- Ratios of organ weights to body weight
- Ratios of brain weight to organs' weights

Bauer *et al.*, 1998; Vallet et Freking, 2006

Objective use of allometric patterns of dvp to indirectly estimate level of maturity in contrasting fetal genotypes

⇨ Biometrics indicators of maturity

Chronology of development

Tissues Maturation process

Mecanisms influenced by maternal genetics

Mecanisms more specific to the fetal genotype

90 d

114 d Farrowing

Major changes in composition of the pig occur near parturition ***Brooks and Davis 1969***

Increased cortisol plasmatic rate → HPA axis

Storage of glycogen in liver and muscles → Carbohydrate metabolism

- ↗ organs weights
- ↗ placental vascularity

Genetic selection responsible for reduced level of maturity in newborn piglets

1. Association of phenotypes with breeding values

Leenhouwers et al., 2001

H0: litters with different genetic merit for piglet survival differ in late fetal development (111d dvp)

Higher genetic merit for survival ⇔ shorter body length

heavier liver, adrenals, small intestine

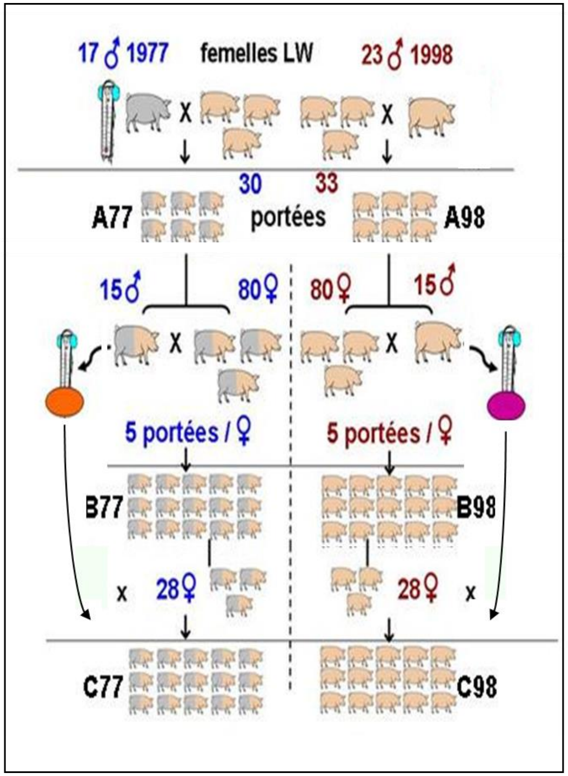
higher percentage of carcass fat

⬂ placental weight and within-litter variation in placental weight

⬀ placental efficiency

2. Genetic trends estimated with use of frozen semen

Canario et al. 2007



G98 as compared to G77

- Carcass : less DM, protein and energy, %fat unchanged
- Liver: weights 16% less relative to piglet weight, contains less glycogen (-24%), no diff in G6Pase activity
- LD muscle : [ ] Prot, DNA, RNA, glycogen content ident. but ratio RNA/prot (growth potential) higher in G98

Evolution of body composition and energetic reserves
negative trend on protein contents BUT positive trend in capacity for proteic synthesis
Selection: Difference in muscle growth potential favorable to G98 piglets, expresses after birth

Maturity at birth for selective breeding?

Issue: reducing piglet losses (20%)

Survival in lactation is lowly heritable
Genetic selection against stillbirth efficient, but ≠ genetic determinism from that of losses during lactation *Huby et al., 2003; Roehe et al 2010*

Objectives

- quantify contributions of piglet and dam genetics to maturity at birth
- define alternative strategy to reduce piglet mortality, through increased maturity at birth

SIZE OF MATERNAL EFFECTS ON DEVELOPMENT?

DIRECT EFFECTS

Meishan

Large White

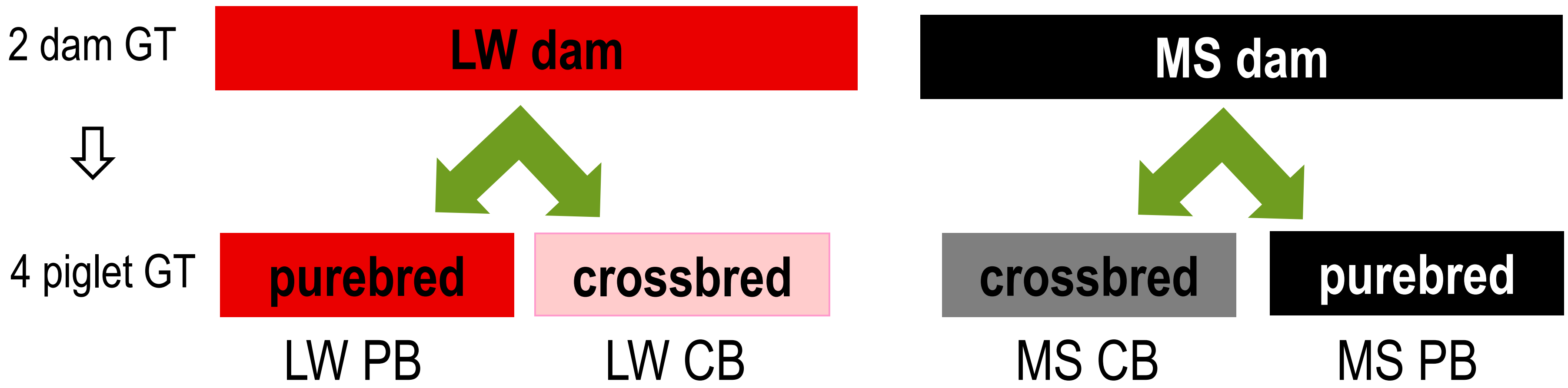
Meishan

Large White

Le Dividich et al., 1991 ; Herpin et al., 1996 ; Wilson et al., 1998

Genetic design

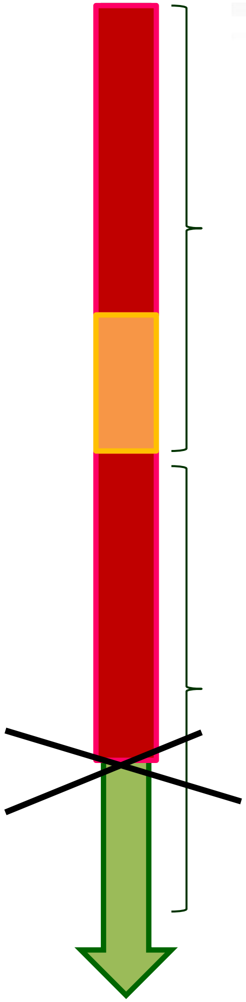
Mixture of semen from the 2 breeds



1. Differences between Piglet genetic types (GT)
   ie., PB *versus* CB within dam GT
2. Interaction of Dam envt with Piglet performance

Experimental design

Lactation: individual pen 2.8 x 2.5 m²
no intervention at farrowing, no adoption
⇨ sow's investment in raising of its progeny



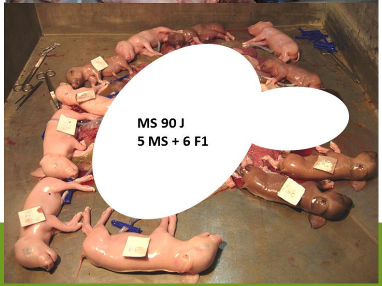
1st gestation - Parity 1

STUDY 1 Lactation performance
Newborn piglet growth

2nd gestation - Parity 2

90 d dvp
110d dvp

STUDY 2 Physiological basis of prenatal development – late gestation



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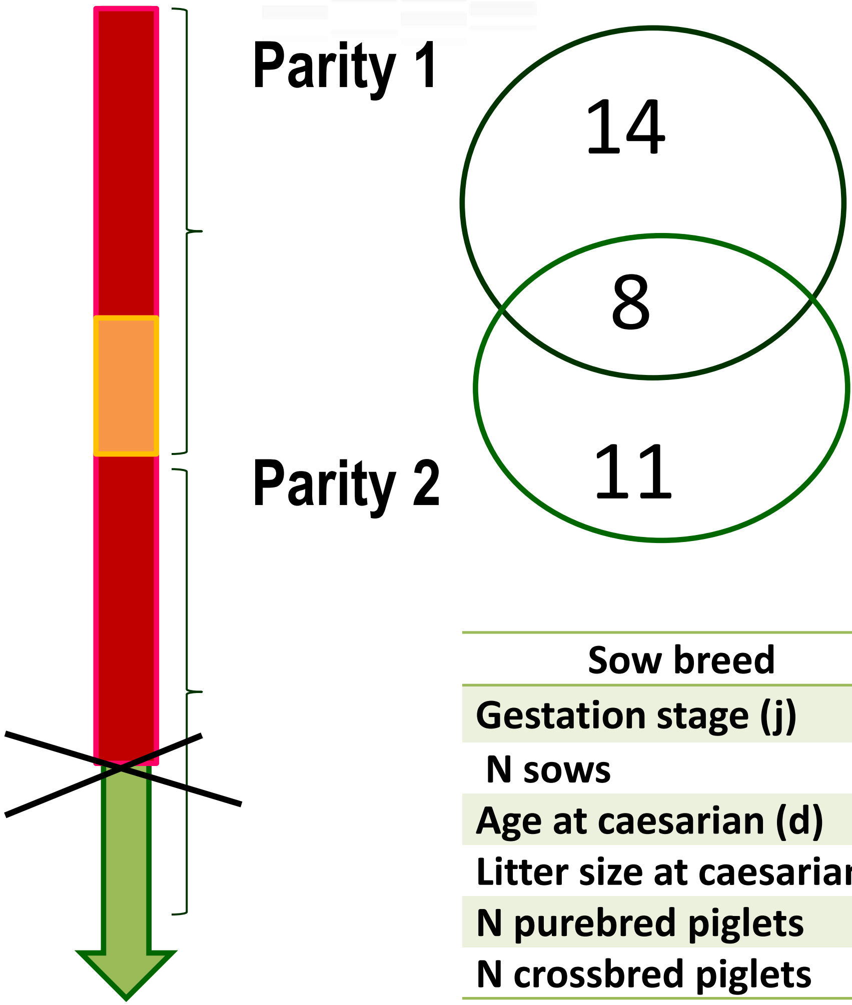
SOWS UNDER STUDY

Litters with >= 2 crossbreds + 2 purebreds



	LW	MS
N sows	12	10
Litter size farrowing	14.8 (2.9)	13.6 (2.7)
Min-Max Litter size	12 - 22	9 - 17
N purebred piglets	102	69
N crossbred piglets	76	67

Sow breed	**LW**		**MS**	
Gestation stage (j)	90	110	90	110
N sows	6	3	7	3
Age at caesarian (d)	553 (23)	559 (11)	527 (21)	536 (11)
Litter size at caesarian	16.5	19.2	15.1	13.6
N purebred piglets	78	49	31	16
N crossbred piglets	23	10	77	28

2. Identification of biometric markers of maturity in the newborn

What makes a difference bw purebred LW dead before and after 24h of extra-uterine life?

Dead1 : Piglets dead between birth and 24 h of age
Dead2 : Piglets dead between 24h and one week of age

Reason for death: weak or crushed by the sow

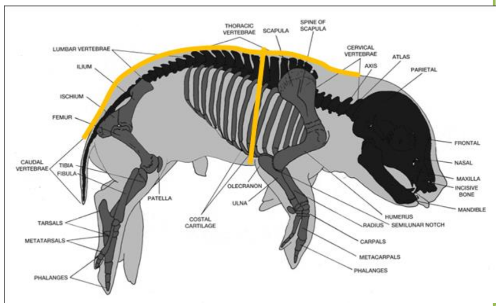
H0: Dead 1 less mature than Dead2

Small sample

Estimates

1. With adjustment for Body shape
2. With adjustment for age at death, i.e., not to confound with « normal » dvpt

1. Body development



	LSM of Dead 1 (SE)	LSM of Dead 2 (SE)	p-value	P-value Adj. Age
BIRTH				
BW (kg)	0.773 0.079	0.950 0.090	0.12	
BL (cm)	20.86 0.79	22.28 0.90	0.19	
BMI x 1000	1.77 0.11	1.86 0.13	ns	
PI x 1000	0.086 0.006	0.084 0.008	ns	
DEATH				
BW (kg)	0.788 0.097	1.009 0.110	0.11	ns
BL (cm)	21.29 0.75	21.87 0.85	ns	ns
BMI x 1000	1.71 0.11	2.02 0.13	0.06 °	ns
PI x 1000	0.081 0.005	0.092 0.006	0.12	ns
Body_width / BL	0.325 0.009	0.364 0.010	0.07 °	0.05

BW = body weight
BL = body length

Same body shape at birth

Mass indexes ⇔ dvpt Body width ⇔ maturity

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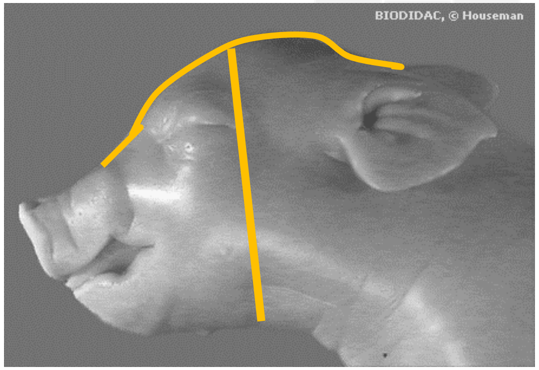
2. Head measures

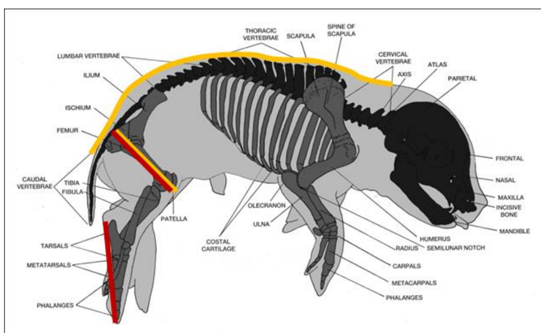


	LSM of Dead 1 (SE)		LSM of Dead 2 (SE)		p-value	P-value Adj. Age
Head_W / Head_L	0.595	0.024	0.545	0.029	0.15	ns

Similar results when adjusted for BW† or BL

Head dvpt not connected to level of maturity

3. Bone development



	LSM of Dead 1 (SE)		LSM of Dead 2 (SE)		p-value	BW† effect	P-value Adj. Age
Femur_L / BL	0.222	0.007	0.244	0.008	0.05	0.03	0.12
Feet_L / Femur_L	1.242	0.051	1.107	0.056	0.09	0.11	ns

Dvpt of femur relative to BL depended linearly on BW at death

Femur length relative to BL ⇔ maturity

Feet/Femur length ratio ⇔ overall dvpt

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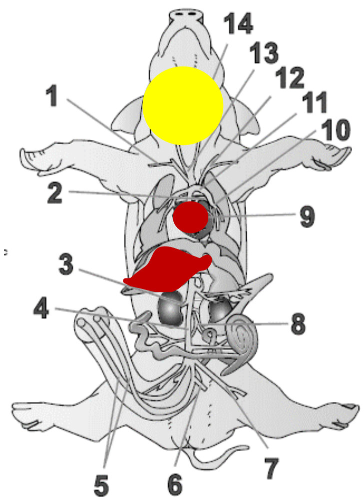
4. Organ development

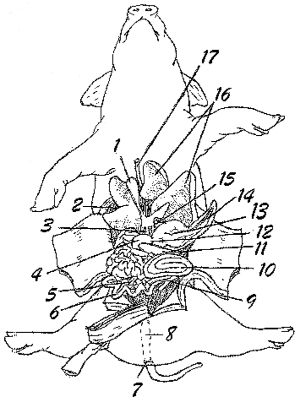


	LSM of Dead 1 (SE)	LSM of Dead 2 (SE)	p-value	BW†	P-value Adj. Age
Brain W (g)	25.93 1.18	22.10 1.04	0.05	<0.001	0.05
Heart_W (g)	7.68 0.42	9.05 0.47	0.03	<0.0001	ns
Liver_W (g)	27.00 2.35	28.14 2.61	ns	<0.001	ns
Small Intestine_W	35.69 4.43	37.89 4.86	ns	<0.0001	ns
Large Intestine_W	6.53 0.60	6.46 0.66	ns	<0.01	ns

Lower brain weight relative to BW ⇔ maturity

Lack of discrepancy according to liver weight unexpected

5. Relative internal development



	LSM of Dead 1 (SE)	LSM of Dead 2 (SE)	p-value	p-value Adj. Age
Brain_W / Liver_W	1.17 0.13	0.82 0.11	0.06	ns
Brain_W / Heart_W	3.75 0.28	2.41 0.24	0.005	0.05
Brain_W / Small Intestine_W	0.95 0.13	0.65 0.11	0.11	ns
Brain_W / Large Intestine_W	5.76 0.49	4.07 0.42	0.02	0.12
Brain_W / Kidneys_W	3.95 0.33	2.64 0.28	0.01	0.06

Lower ratios of brain weight to heart and kidneys ⇔ higher maturity

What makes a difference bw purebred LW dead before and after 24h of extra-uterine life?

Indicators of maturity

- **Abdominal circumference** relative to BL; (thermoregulatory surface and nutritional state)

- **Femoral length** relative to body length

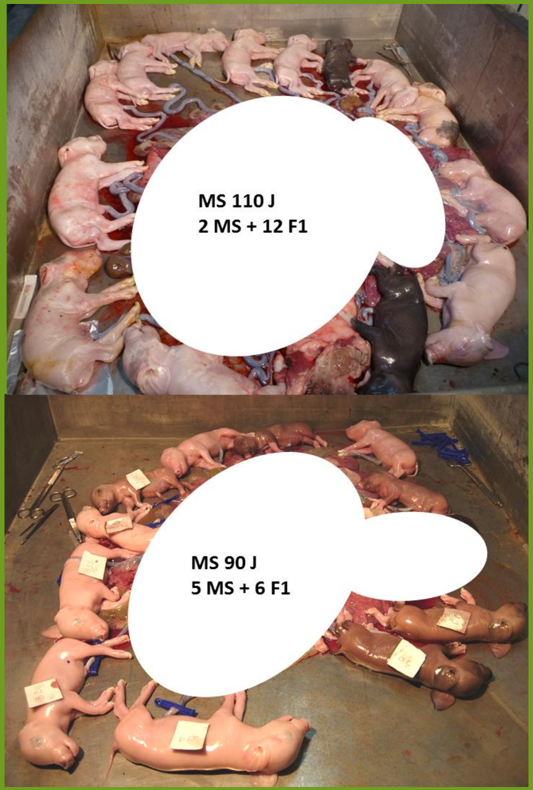
- **Brain weight** in proportion to body weight
- **Symmetry of organ dvpt** relative to brain dvp

Higher maturity

- Larger body
- Longer femoral bone
- Lower ratio of brain weight to other organs weight

⇨ Results to be confirmed at larger scale, within the LW population

3. Late fetal development



Estimating allometric development

Huxley's equation (1932)

Organs' allometric growth

Organ weight = cst x Fetal weight $^{a/c}$

a: organ growth **c: fetal growth**

log (Organ weight) = log cst + a/c log (Fetal weight)

⇧

allometric coefficient

slope = 1 proportional dvp

slope > 1 organ growth superior to that of the fetal growth

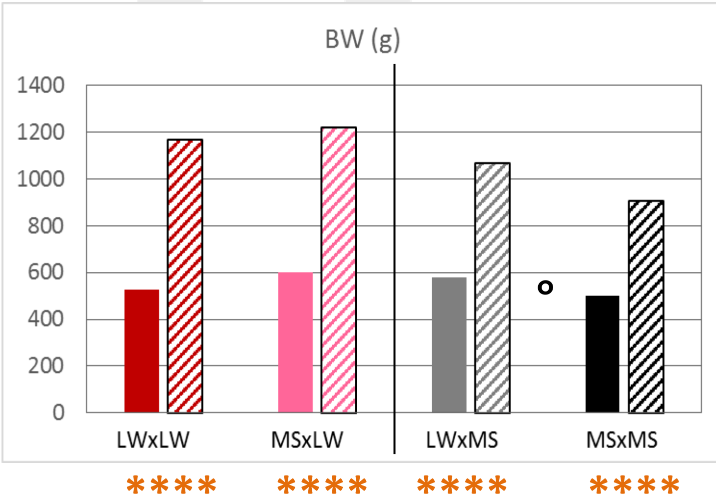
slope < 1 delay in organ growth relative to fetal growth SPARING

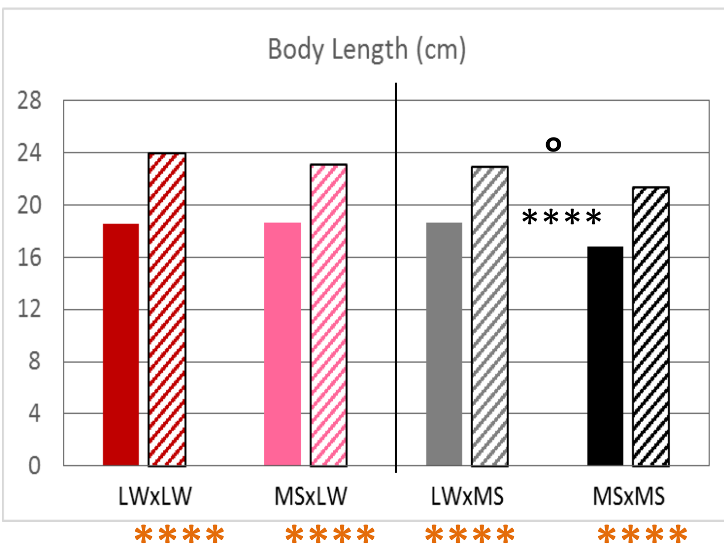
- ❑ Comparison of slopes bw piglet GT

  H0: are the allometric relationships similar between PB and CB?

- ❑ Comparison of 90-110d dvp slopes: pattern of speed of organ dvpt

1. Late body development in utero





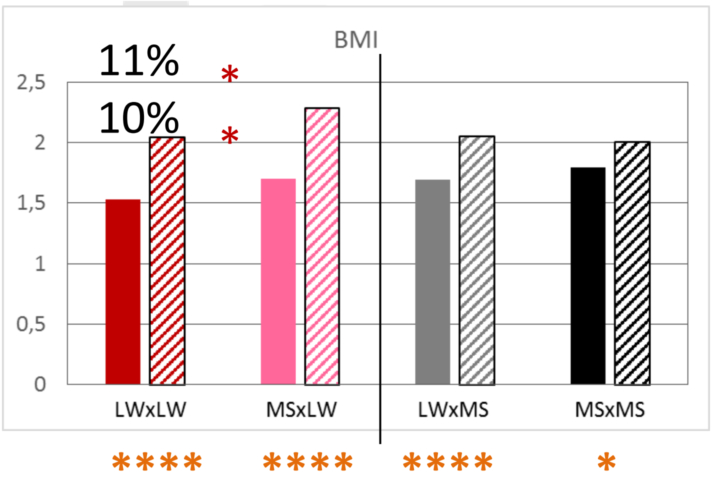
90 d dvp 110 d dvp

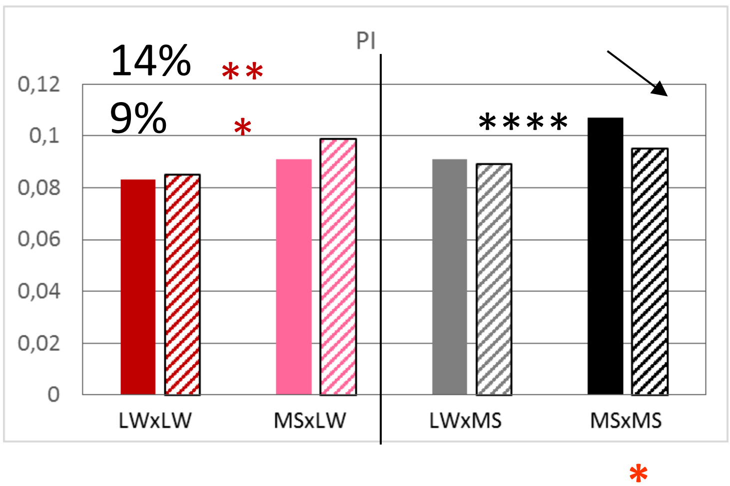
❖ LW sows: PB and CB fetuses do not differ in BW and body length

❖ MS sows : CB fetuses tended to grow faster than PB at 90d dvp – paternal genetic effects

⇨ comparison in proportion to BW or BL

° P<0.10; **** P<0.0001

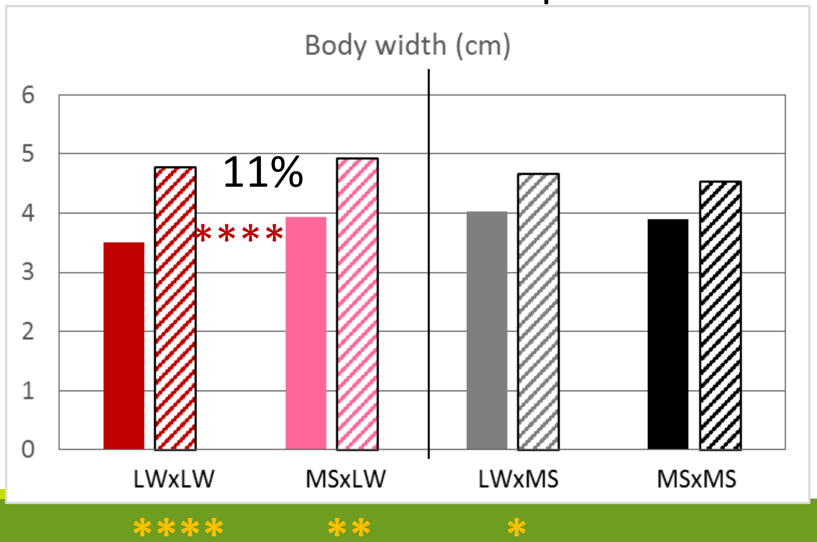




- LW sows : Higher Mass indexes in CB than PB
- MS sows: Higher PI in PB than CB d90 dvp=> better nutritional level in utero

MS PB: increasing BW at the expense of BL d110 dvp

H0: plateau reached for body length before birth



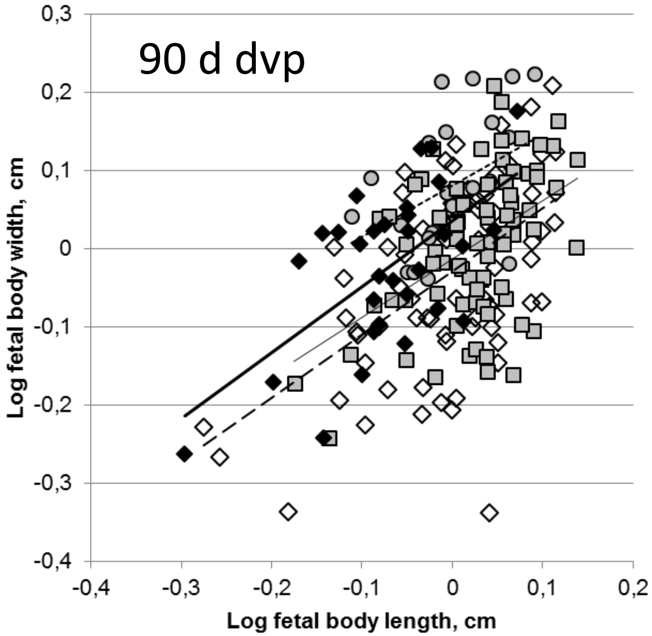
- LW sows:

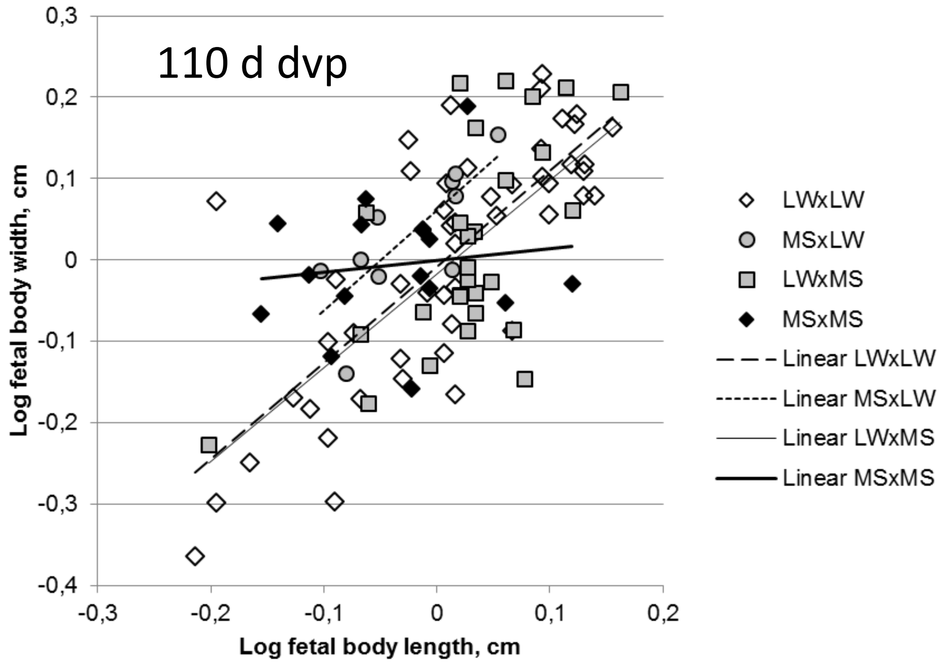
Thinner thorax in PB 90d dvp

D110 dvp: no diff. => compensation

* P<0.05 ; ** P<0.01 ; **** P<0.0001

Body width to body length





Comparison of linear slopes

Allometric coefficient	LWxLW	MSxLW	LWxMS	MSxMS	LWxLW vs MSxLW	MSxMS vs LWxMS
Age (d)	lsmean	lsmean	lsmean	lsmean	Prob(D=0)	Prob(D=0)
90	0.83 ± 0.13 °	0.76 ± 0.40	0.85 ± 0.16	0.73 ± 0.22 °		
110	1.17 ± 0.14	1.33 ± 0.54	1.08 ± 0.23	0.08 ± 0.32		0,008

° P<0.10

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BODY MASS

- LW PB: high body dvp from 90d to 110d and less dvlped than CB according to BMI - PI
- MS: more harmonious growth rate relative to BL

BODY WIDTH

	LWxLW	MSxLW	LWxMS	MSxMS
90 to 110	⇗	⇗	⇗	⇨
speed	⇗ >1	⇨ 1	⇨ 1	⇘ 0
Full dvpt	no	no	no	90d dvp

More heterogeneous dvp within MS dam

Higher growth potential in fetuses born from LW sows? Accelerated (disproportionate) dvp of LW PB in late gestation to compensate delayed growth

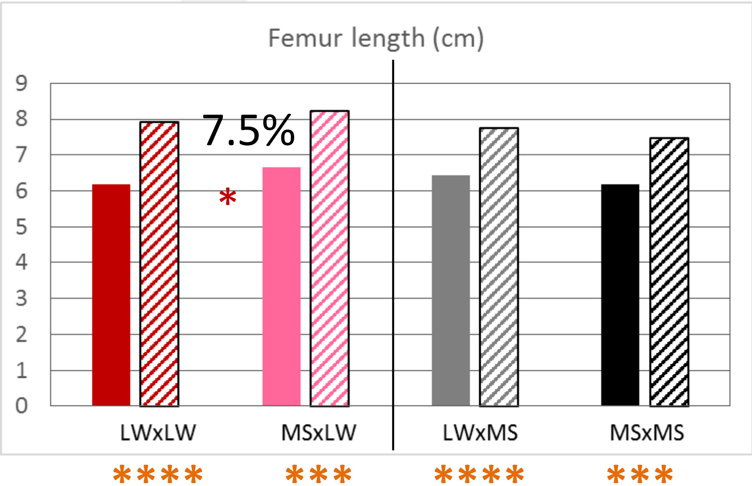
CCL BODY DVP

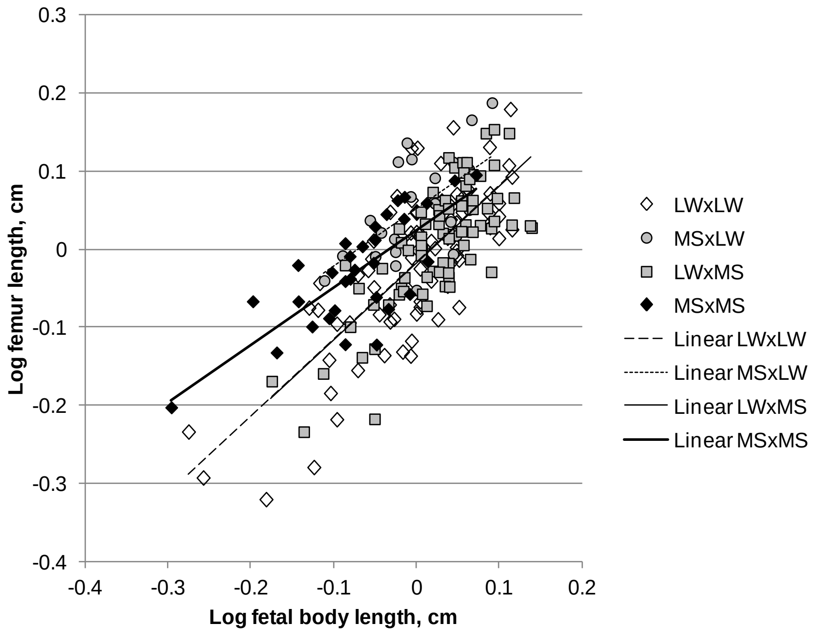
Mean dvp in progress bw d90 and d110 dvp in both MS and LW sows

Only the MS PB seemed to reach optimal width before birth

2. Bone development

90d dvp





		LWxLW	MSxLW	LWxMS	MSxMS	LWxLW vs MSxLW	MSxMS vs LWxMS
	Age (d)	lsmean	lsmean	lsmean	lsmean	Prob(D=0)	Prob(D=0)
Femur_L	90	1.00 ± 0.08	0.55 ± 0.25 °	0.92 ± 0.10	0.83 ± 0.14 *	0,08	
	110	1.10 ± 0.08	1.25 ± 0.33	1.09 ± 0.15	0.29 ± 0.19		0,0006

Slow-downed dvp of femur relative to whole body in MS PB

° P<0.10; * P<0.05

FEMUR LENGTH

	LWxLW	MSxLW	LWxMS	MSxMS
90 to 110	⇗	⇗	⇗	⇗
speed	⇨ 1	⇗ >1	⇨ 1	⇨ 0.3
Full dvpt	No	No	No	110d

MS and LW sows: Deviations in speed of dvpt bw CB and PB

CCL BONE DVP

Maximum femur length achieved in MS PB relative to birth requirements and breed potential

CCL EXTERNAL DVP

Fast external dvp at the end of gestation on all measures (but body width in MS sows) with some accelerating/compensatory growth in order to reach a full physical state of dvp at birth

MS PB fetuses achieved full body size dvp before birth

3. Organ development

Important organs' growth bw 90 and 110d dvp (except spleen)

Intra-LW: diff on organs essential for maturity

Priority of dvp: spleen > heart-liver-kidneys > brain- gastrointestinal tract

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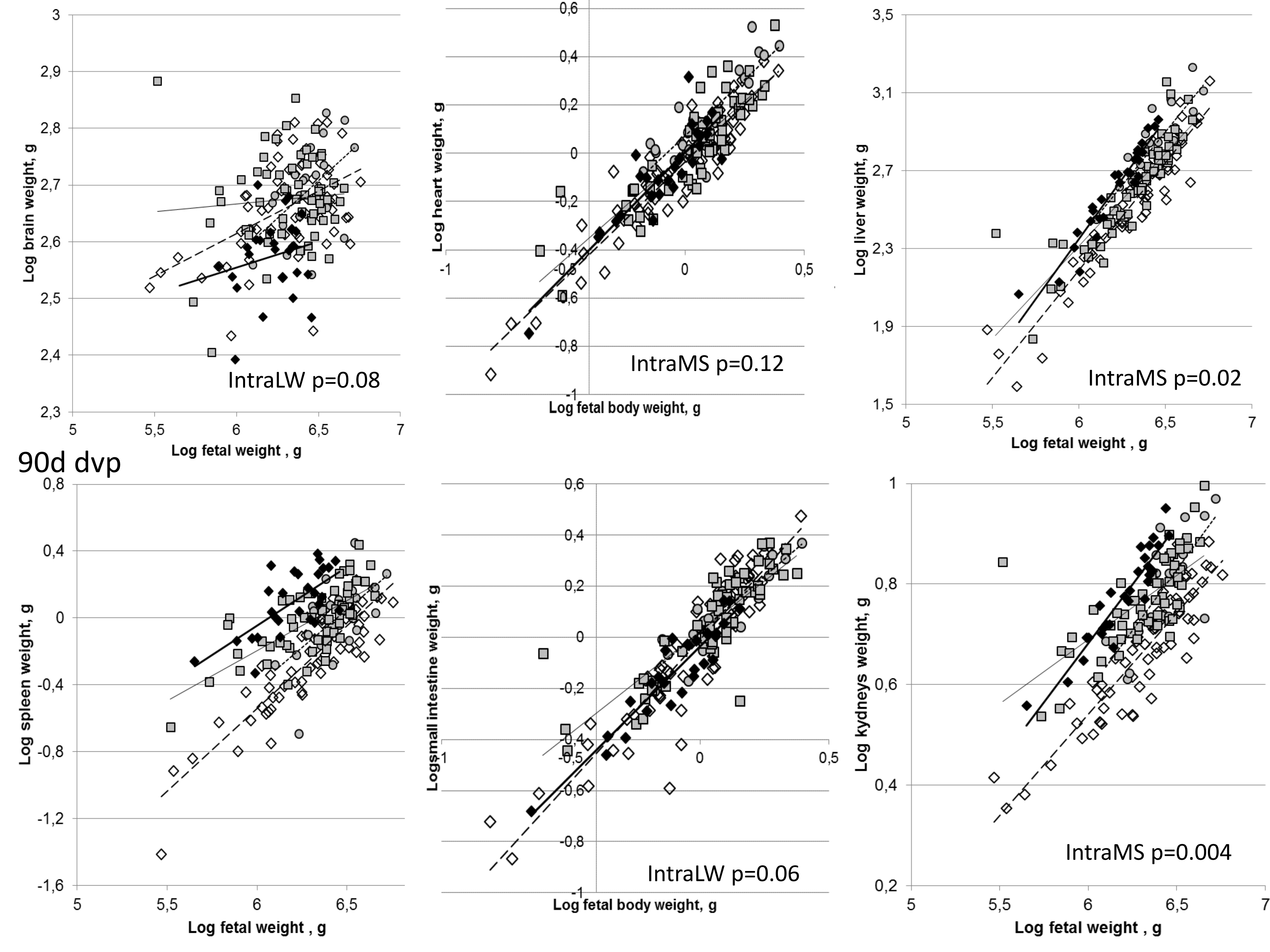


Log brain weight, g
Log fetal weight , g
IntraLW p=0.08
Log heart weight, g
Log fetal body weight, g
IntraMS p=0.12
Log liver weight, g
Log fetal weight , g
IntraMS p=0.02
90d dvp
Log spleen weight, g
Log fetal weight , g
Logsmall intestine weight, g
Log fetal body weight, g
IntraLW p=0.06
Log kydneys weight, g
Log fetal weight , g
IntraMS p=0.004

		LWxLW	MSxLW	LWxMS	MSxMS	LWxLW vs MSxLW	MSxMS vs LWxMS
	Age (d)	lsmean	lsmean	lsmean	lsmean	Prob(D=0)	Prob(D=0)
Brain W (g)	90	0.16 ± 0.03	0.34 ± 0.10	0.11 ± 0.04	0.25 ± 0.09	0.08	0.13
	110	0.18 ± 0.04	0.26 ± 0.12	0.15 ± 0.05	0.10 ± 0.49		
Heart W (g)	90	0.95 ± 0.05	0.92 ± 0.16	0.86 ± 0.07	1.06 ± 0.11		0.12
	110	1.00 ± 0.06	0.94 ± 0.20	1.01 ± 0.09	1.02 ± 0.24		
Liver W (g)	90	1.05 ± 0.05	1.03 ± 0.15	0.89 ± 0.06 ****	1.19 ± 0.11		0.02
	110	1.14 ± 0.06	0.98 ± 0.20	1.37 ± 0.08	0.90 ± 0.24		0.06
Spleen W (g)	90	1.08 ± 0.07 *	0.99 ± 0.20	0.71 ± 0.08	0.72 ± 0.14		
	110	0.85 ± 0.08	0.94 ± 0.25	0.67 ± 0.11	1.00 ± 0.31		
Small Intestine W (g)	90	1.11 ± 0.06	0.78 ± 0.17 °	0.84 ± 0.07 °	0.95 ± 0.12 °	0.06	
	110	1.07 ± 0.07	1.26 ± 0.21	1.04 ± 0.09	0.45 ± 0.26		0.03
Kidneys W (g)	90	0.99 ± 0.06	0.97 ± 0.17	0.63 ± 0.07	1.04 ± 0.12		0.01
	110	0.88 ± 0.07	0.70 ± 0.22	0.81 ± 0.09	0.63 ± 0.32		

° P<0.10; * P<0.05 ; **** P<0.0001

ORGAN WEIGHTS

Negative allometry + decreased speed <=> full dvp for birth

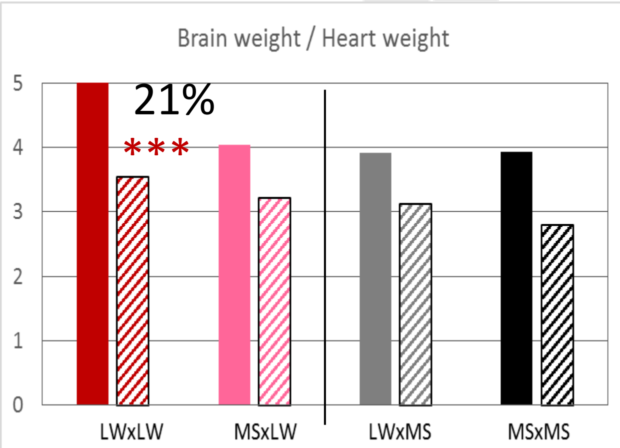
	LWxLW	MSxLW	LWxMS	MSxMS
90 to 110	⇗ all	⇗ but spleen	⇗ but spleen	⇗ but spleen
Speed	⇨ 1 heart liver small Intestine Kidneys ⇘ <1 spleen	⇨ 1 heart liver spleen ⇨ <1 Kidneys ⇗ >1 small intestine	⇨ 1 heart ⇨ <1 spleen kidneys ⇗ >1 liver ⇗1 small intestine	⇨ 1 heart liver spleen ⇘ 0.6 kidneys ⇘ 0.5 small intestine
Full dvpt	Spleen 110d	Spleen 90d Kidneys 110d	Spleen 90d Kidneys 110d	Spleen 90d Kidneys 110d Small Intestine 110d

MS dam: more heterogeneous state of dvp at 110d

CCL ORGANS DVP

Large organ dvp in late gestation at constant speed and proportionally to whole body dvp on organs decisive for maturity: heart, liver, spleen, kidneys

4. Relative internal development



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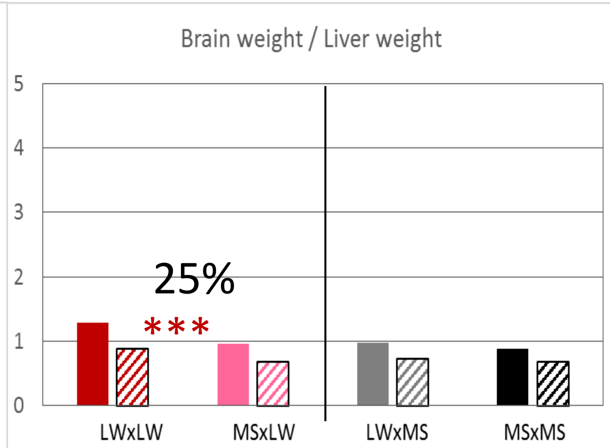

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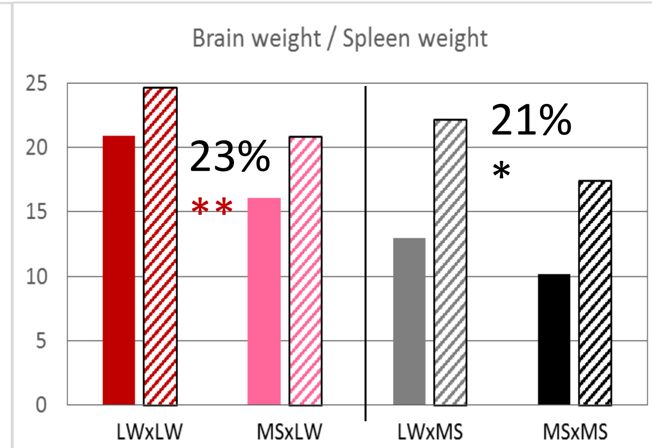

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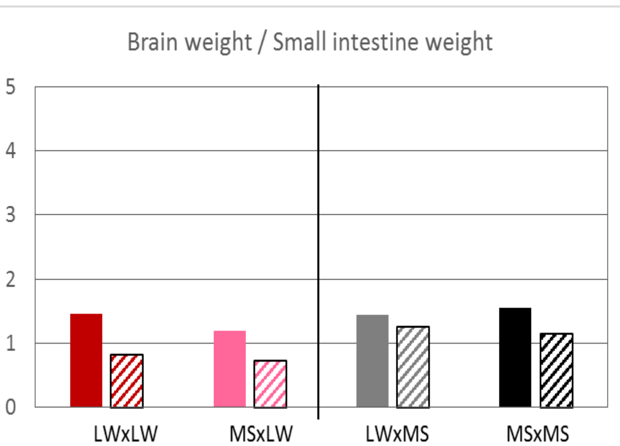

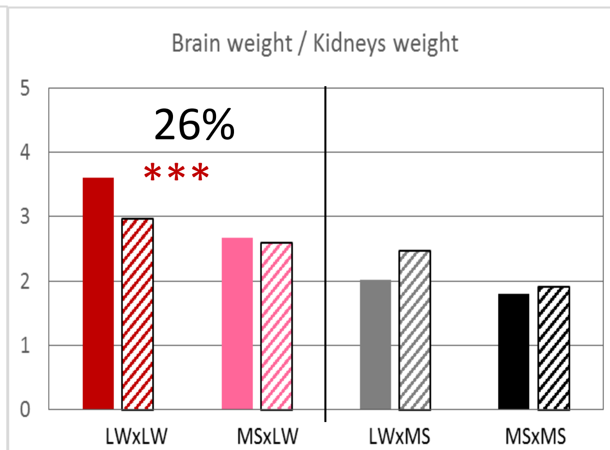

Trends 90-110d:

⬂ Ratio relative to heart + liver in LW PB : gain of maturity

⬀ Ratio relative to spleen in MS PB + CB: brain growth and zero growth of the spleen

- Delayed heart, liver, kidneys dvp relative to brain in LW PB ⇔ lack of maturity
- Faster brain dvp relative to spleen in MS at 110 than 90d ⇔ mature size of spleen

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CCL RELATIVE ORGANS DVP

Sparing at the advantage of brain growth in LW PB

Conclusions – Fetal late development

How far do we get from the full dvpt necessary at birth?

1. External morphology and bone dvp

Dvpt of CB LW superior to that of PB LW at both stages of dvp
Within-MS dam: PB display greater dvp than CB

Body became wider in LW PB

Delay in femoral dvp of the MS CB was compensated   Dvp of MS PB most complete

2. Internal dvp

- Brain dvpt relative to organ dvpt: sparing effect in LW PB,
  disadvantageous as compared to LW CB
- Discrepancies in speed of dvpt within MS and LW maternal environment:

Full dvp is a matter of priorities of dvp

Maternal and paternal Influences in MS and LW uterine environment

❖MS sows: lower capacity to ensure homogeneous dvp of their fetuses, in the case of this crossbreeding

⇨ HERE Growth of CB fetuses superior to that of PB fetuses
BUT higher maturity achieved at birth in PB according to:

1/ PI

2/ body width

3/ femur length

4/ spleen 90d small intestine + kidneys 110d

❖LW sows: heterogeneous dvp within the litter

⇨ Similar growth in CB and PB fetuses
but lower maturity at birth in PB according to:

1/ BMI, PI 110d and body width + femur length 90d

2/ heart, liver, kidneys 90d

3/ brain dvp at the expense of other organ dvpt

Conclusions – Fetal late development

- Original design but complicate to implement - limited sample size 110d dvp

- Differences on traits decisive for late development :

  brain, liver (glycogene storage), spleen and heart
  Le Dividich *et al*., 1991 ; Leenhouwers *et al*., 2002 ; Foxcroft *et al*., 2006

- Within a common environment, fetuses of different genetic types had the capacity to develop differently, with combination of heterosis, direct and maternal additive effects

  ⇨ Genetics has a strong impact on intra-uterin growth

Indirect non-invasive indicators of maturity

- ➢ Body width to body length
- ➢ Femur length to body length

Conclusions – Fetal late development

The analysis of allometric dvp revealed novel predictors of maturity

- Proportional growth with whole body dvp not necessarily recommended
- Disproportionate dvp may have positive impact on full dvp
  when acts as compensatory growth
- Negative allometry with decelerating dvp: maturity at birth

MS breed = good model to understand perinatal development and explain delay of maturity in the LW PB

LW PB *vs* MS PB

Allometric differences

		MS	LW
BWidth	110	DISP 0	PROP
Femur	110	DISP<<1	PROP
Spleen	90	DISP<1	PROP
Small Intestine	110	DISP<<1	PROP

PROP = proportional
DISP = disproportional

LW PB *vs* LW CB

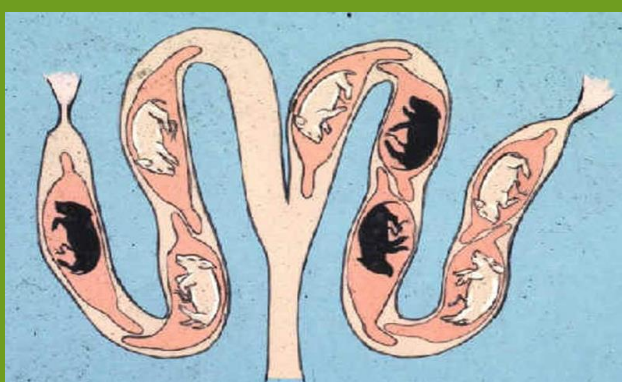
Allometric differences

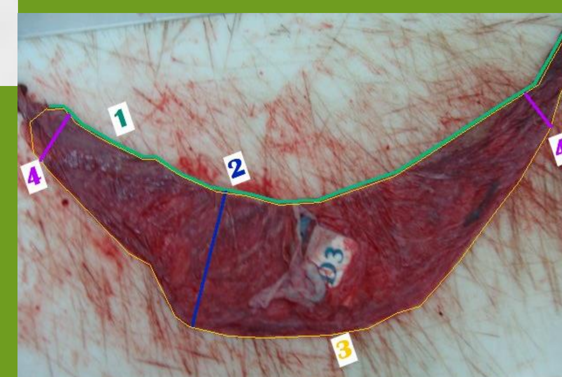
		LW CB	LW PB
Femur	90	DISP<1	PROP
Brain	90	DISP<1	PROP
Small Intestine	90	DISP<1	PROP

PROP = proportional
DISP = disproportional

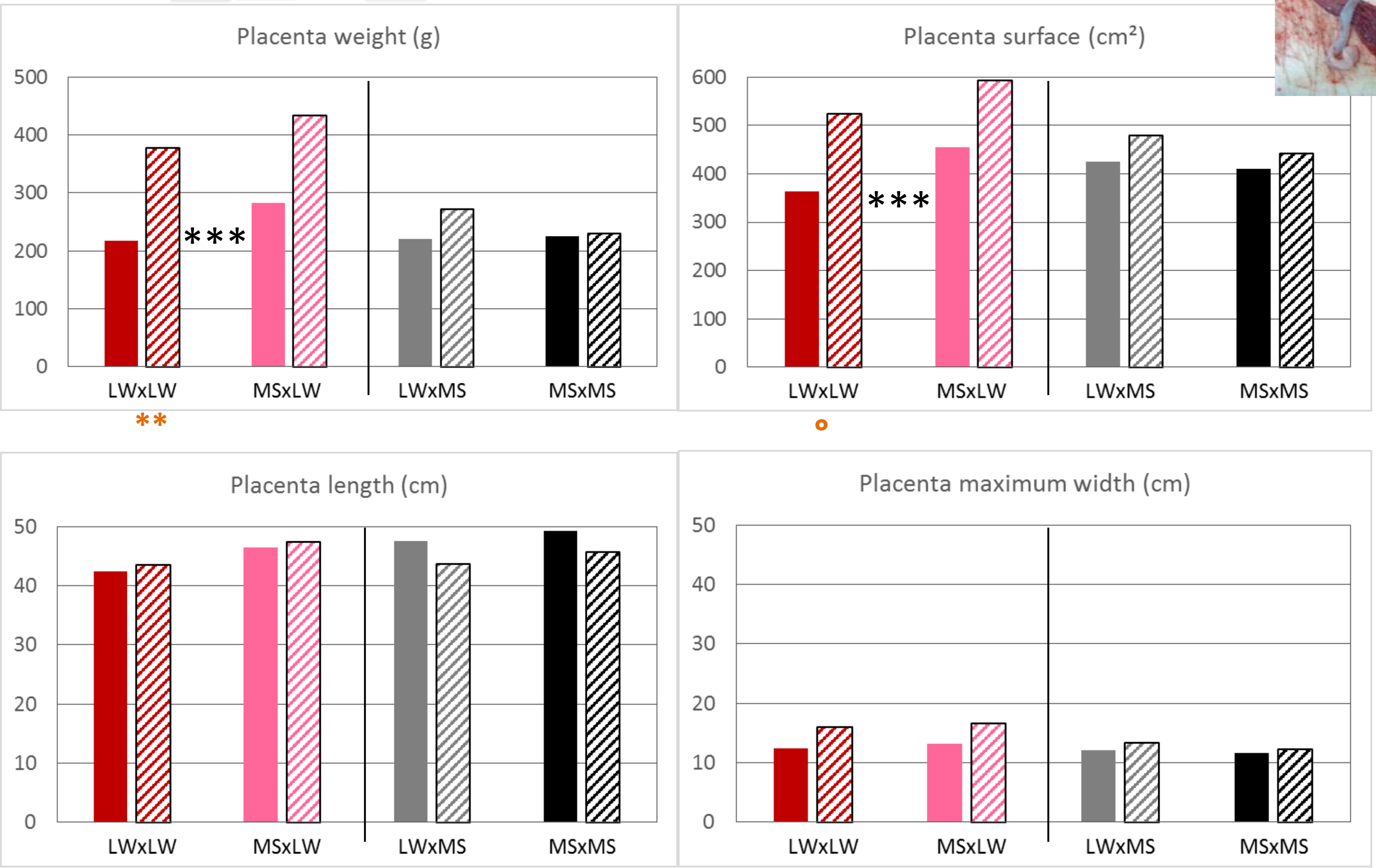
Proportionality in late fetal dvp is not synonymous of maturity at birth

4. Interactions within the uterin environment - placentae and fetuses relative developments





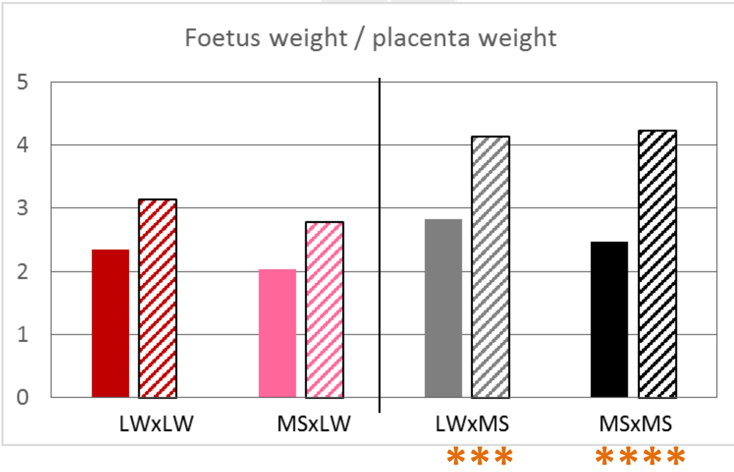
Placenta features

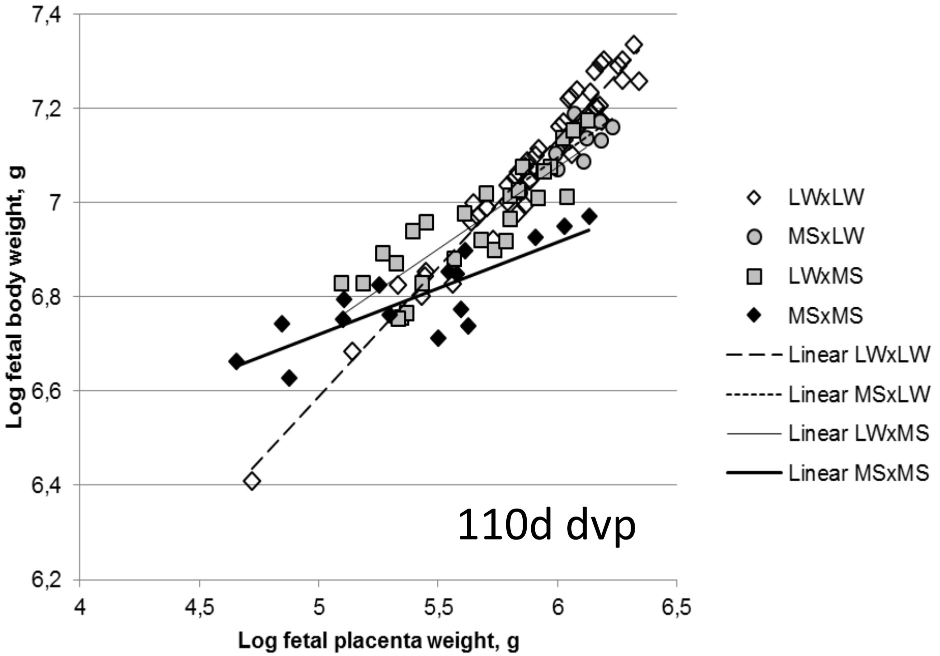


Dimensions of placenta fixed at 90d in MS sows

Variability in placenta features intra-LW in favour of the CB

Placenta efficiency





90-110d dvp: Gain of PE in MS sows

Higher PE in MS sows than LW sows - Large MS maternal additive effects on PE

H0: increased PE ⇨ stimulate maturation process and favours late fetal growth

		LWxLW	MSxLW	LWxMS	MSxMS	LWxLW vs MSxLW	MSxMS vs LWxMS
	Age (d)	lsmean	lsmean	lsmean	lsmean	Prob(D=0)	Prob(D=0)
BW/placentaW	90	0.56 ± 0.06	0.40 ± 0.15	0.52 ± 0.09	0.21 ± 0.12		
	110	0.55 ± 0.08	0.59 ± 0.56	0.37 ± 0.13	0.20 ± 0.12		0.04

Negative allometry on body growth relative to placenta growth

		LWxLW	MSxLW	LWxMS	MSxMS	LWxLW vs MSxLW	MSxMS vs LWxMS
	Age (d)	lsmean	lsmean	lsmean	lsmean	Prob(D=0)	Prob(D=0)
plaWidth/plaLength	90	0.50 ± 0.10 b	0.38 ± 0.17	-0.15 ± 0.11 c	-0.08 ± 0.20		
	110	0.13 ± 0.13	0.42 ± 0.57	0.39 ± 0.16	0.16 ± 0.17		
plaSurf/placentaW	90	0.62 ± 0.10 b	0.67 ± 0.29 a	0.46 ± 0.12	0.53 ± 0.22		
	110	0.26 ± 0.11	-0.08 ± 0.36	0.54 ± 0.19	1.09 ± 0.52		

- ❖ No association bw placenta width and length in MS PB
- ❖ Negative allometry on placenta width relative to placenta length in other fetal GT

- ❖ No clear difference between DAM breeds in allometry of placenta dvp

- ❖ LW sows: Stronger negative allometry on the relative dimensions of placenta at 110d than at 90d dvp => increasing placental weight
  => H0: lack of placental efficiency

CONCLUSION Fetal-Placenta dvp

Placental dvp follows body growth in LW PB at the expense of placenta efficiency

Conclusion

Fine characterization of the Maturation process in late gestation

Genetics to improve maturity at birth

No direct solution (producing CB not profitable)

Use of external metric ratios / allometric relations ⇨ genetic parameters?

e.g. body width , femoral length

Many direct effects on dvp ⇨ direct and maternal components on lactation growth traits

Maturity at birth depends on genetic effects and interactions with the maternal envt

Perspectives

Different processes of fœtal development in MS and LW maternal envt

- use of unoccupied space Vonnahme et al 2002

- Impact of *in utero* environment on allometric dvpt of organs?
- Relevance of external metric ratios to assess internal dvp
- Connexions of allometric dvp with functional maturity of several organs
- In progress: genomic analyses
- Bridging the gap between fetus and piglet performance

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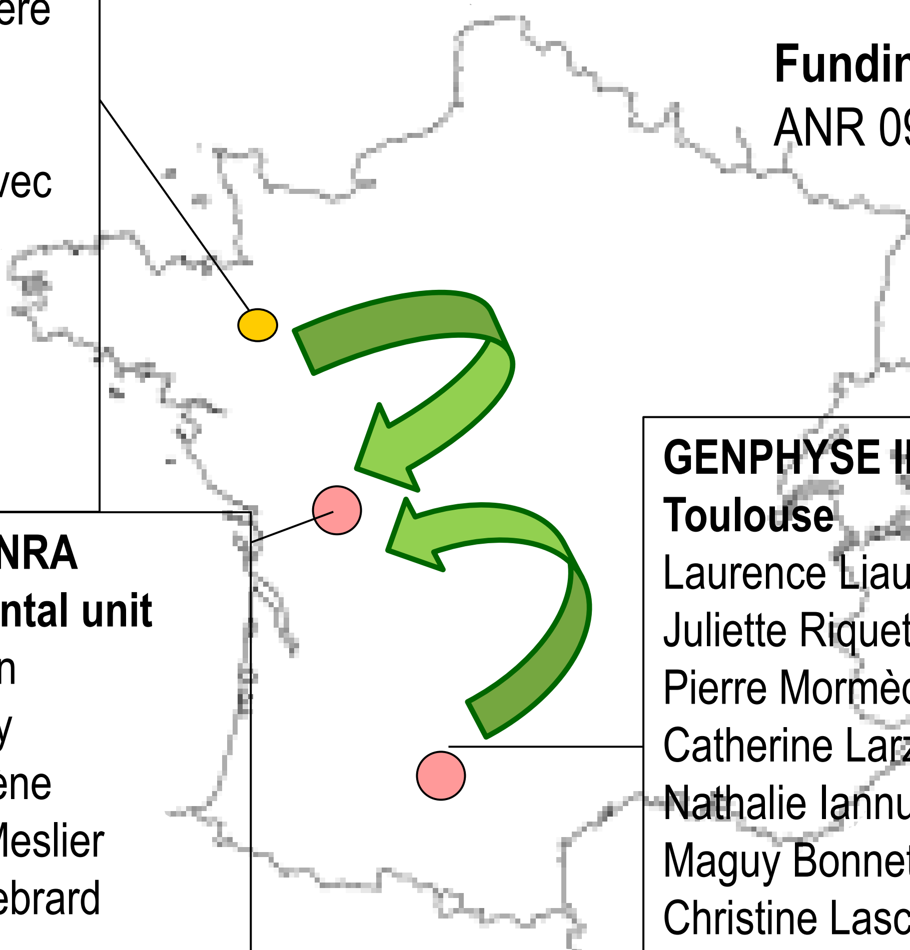

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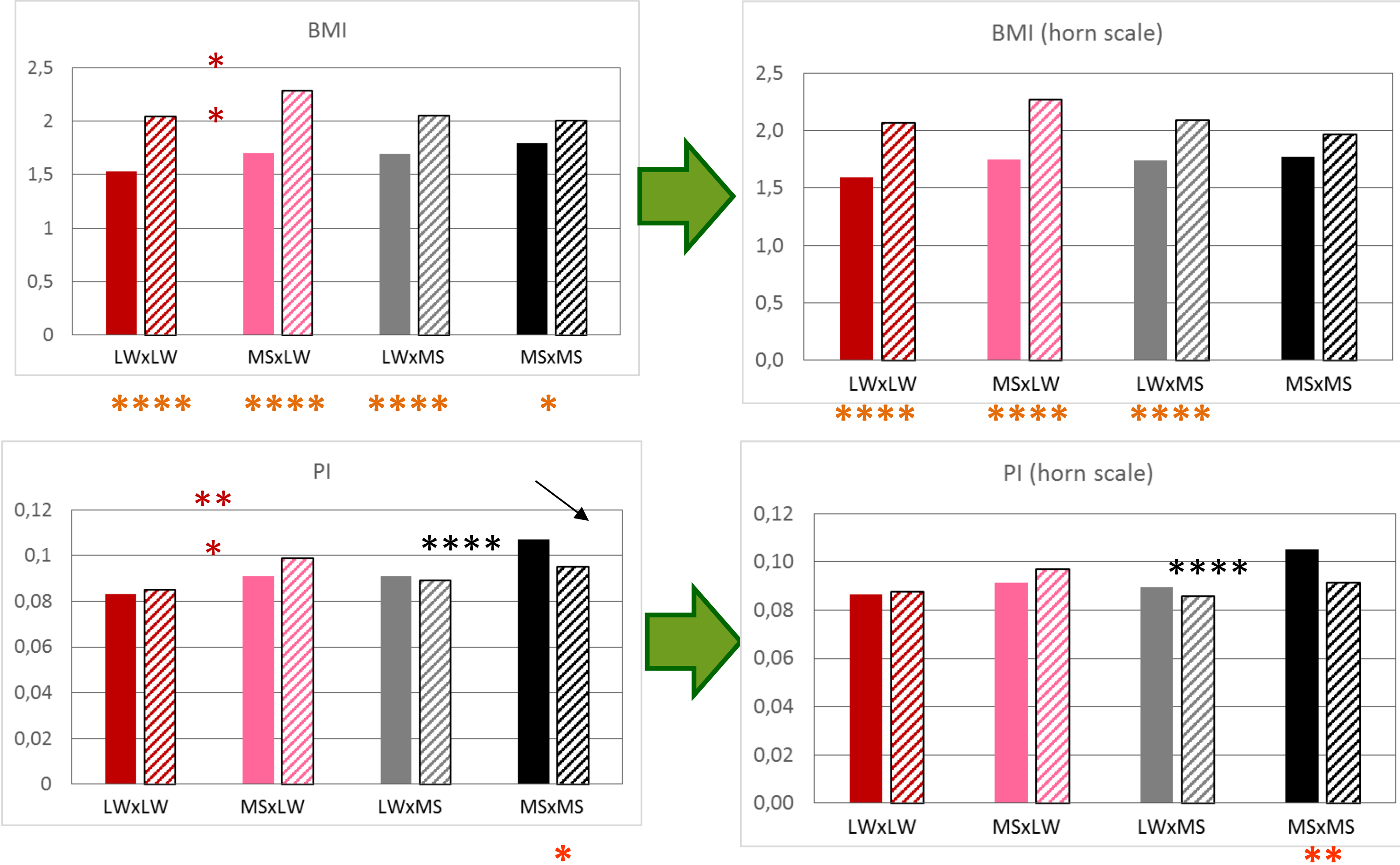
BMI
2,5
2
1,5
1
0,5
0
LWxLW
MSxLW
LWxMS
MSxMS
BMI (horn scale)
2,5
2,0
1,5
1,0
0,5
0,0
LWxLW
MSxLW
LWxMS
MSxMS
PI
0,12
0,1
0,08
0,06
0,04
0,02
0
LWxLW
MSxLW
LWxMS
MSxMS
PI (horn scale)
0,12
0,10
0,08
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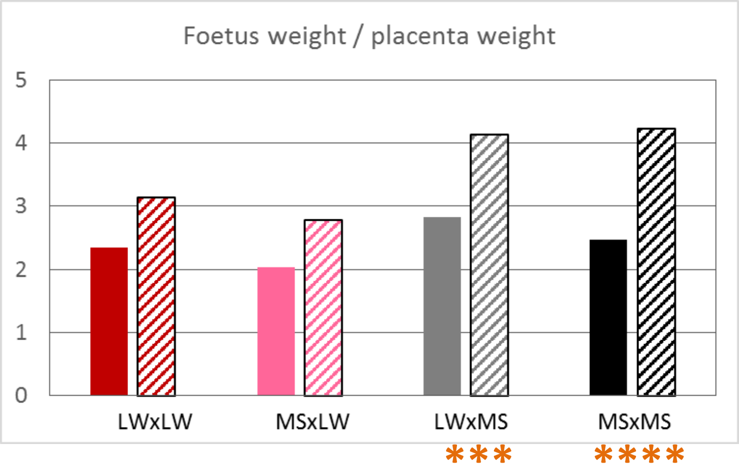
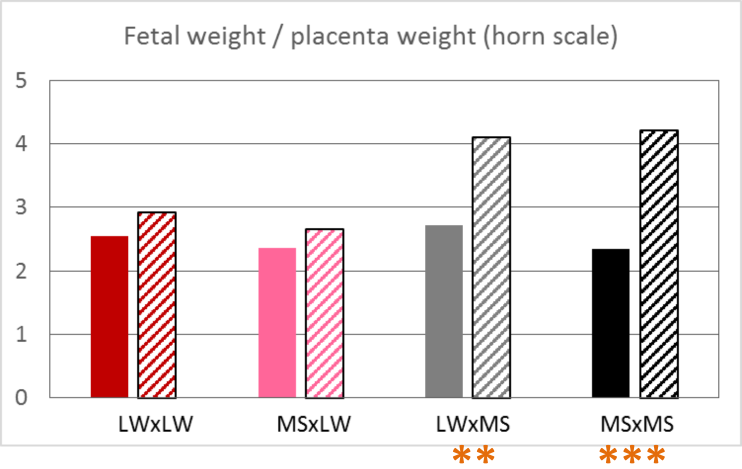
0,02
0,00
LWxLW
MSxLW
LWxMS
MSxMS

Impact of in utero space restriction on placenta dvpt





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Estimating heterosis effects Dickerson's equations (1969, 1973)

- **HETEROSIS effect** (UC) = ½ x (MS x LW + LW x MS – LW x LW – MS X MS)

Positive heterosis effects ⇔ hybrid vigour

$$\text{Mean heterosis (\%)} = \frac{\text{Heterosis effect}}{\frac{1}{2}(\text{LWxLW+MSxMS})} \times 100$$

- **DIRECT additive effects** (UC) = ½ x (LW x LW – MS X MS + LW x MS – MS x LW)

$$\text{Direct effects (\%)} = \frac{\text{Direct effect}}{\frac{1}{2}(\text{LWxLW+MSxMS})} \times 100$$

- **MATERNAL additive effects** (UC) = ½ x (MS x LW - LW x MS)

$$\text{Maternal effects (\%)} = \frac{\text{Maternal effect}}{\frac{1}{2}(\text{LWxLW+MSxMS})} \times 100$$

Sire x Dam

LW PB *vs* LW CB

Mean differences

	Stage dvp	PB / CB
BMI	90-110	-
PI	90-110	-
BWidth	90	-
Femur	90	-
Heart	90	-
Liver	90	-
Spleen	90	-
Kidneys	90	-

→ Higher brain / organ ratios

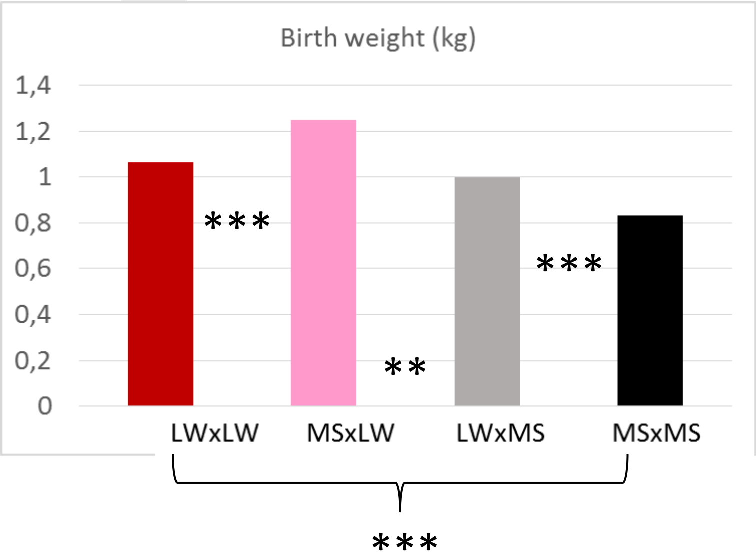
Allometric differences

		LW CB	**LW PB**
Femur	90	DISP<1	PROP
Brain	90	DISP<1	PROP
Small Intestine	90	DISP<1	PROP

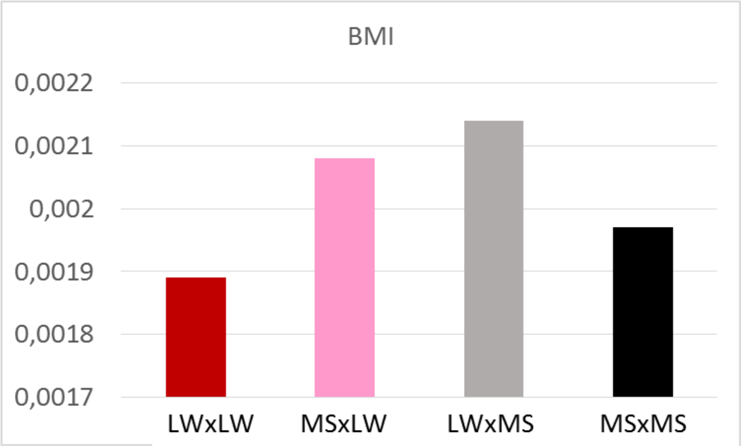
PROP = proportional
DISP = disproportional

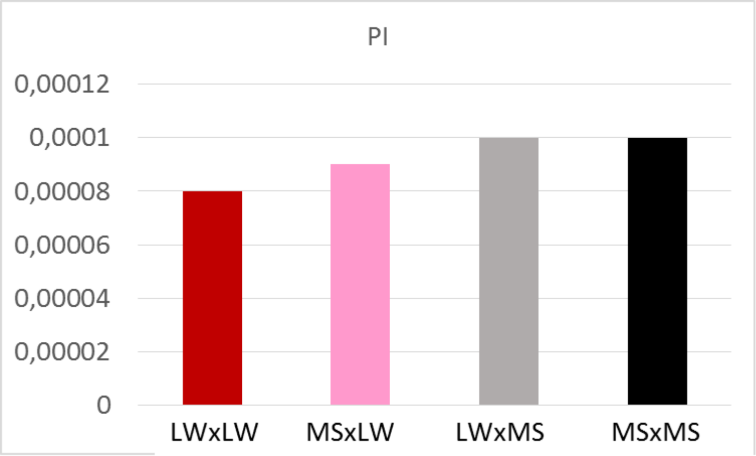
Proportionality in late fetal dvp is not synonymous of maturity at birth

Piglet characteristics at birth



within-breed: crossbred were heavier than purebreds but their body mass indexes were not diff.





* P<0.05 ; ** P<0.01 ; *** P<0.001 ; **** P<0.0001

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LW and MS sows' reproductive characteristics

PARITY 2	LW			MS			Diff LW-MS	
CEASARIAN	90d	110d	pdiff	90d	110d	pdiff	pdiff	
	LSM	LSM		LSM	LSM		90d	110d
Age	565	572		527	524		**0.003**	**0.009**
Body weight	261.0	284.7	°	188.1	188.7		**<.0001**	**<.0001**
us_mean	22.6	22.2		48.2	46.1		**<.0001**	**0.0001**
N_corpus lutea	23.5	28.3	°	19.7	23.3		**0.09**	0.12
Horns-weight	3799	6746	****	2803	3838	°	**0.04**	**0.0005**
Horns-weight adj.	3772	6702	***	2831	3867	°	ns	**0.06**

70 to 100kg diff in BW between the 2 breeds at 90d and 110d gestation

- More corpus lutea produced in LW than MS sows
- Almost doubled weight of uterine horns in LW from 90d to 110d of gestation, not in MS sows

Large uterine growth in late gestation - same survival rate 73% in both breeds

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° P<0.10; * P<0.05 ; **** P<0.0001

INTRA-UTERINE COMPETITION

Different processes of fœtal development in MS and LW maternal envt - use of unoccupied space Vonnahme et al 2002

Relationships with prenatal survival and uterine crowding?

	Stade	Nfoetus	Survival	Location
BW	GT <0,0001	GT 0,02	0,03	GT 0,0003
BMI	GT <0,0001	GT 0,0002		GT <0,0001
PI	GT 0,003	GT 0,15	0,17	GT 0,06
PLA_weight	GT 0,0003			GT 0,03
PLA efficiency	GT 0,0004			
Body length	GT <0,0001	0,03	0,07	0,04

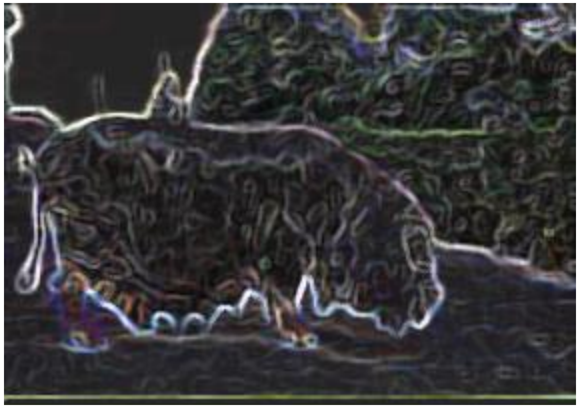
Placenta efficiency not influenced by intra-horn density

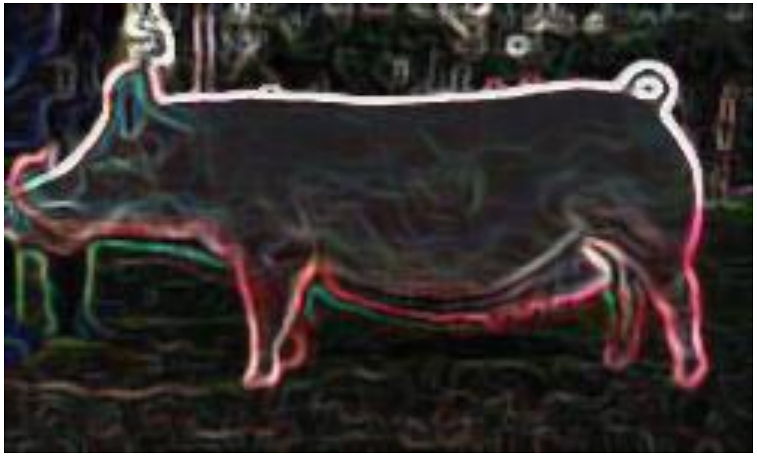
Location in the horn impacts on fetal dvpt but not placenta efficiency

Fetal dvpt depends also on its uterine close envt, not only on maternal features and genetics, direct genetics and heterosis effects! Strong interactions

Models at UTERINE HORN level, including interactions of fœtus GT with N_fetuses, N_purebreds, N_Males, Horn_location (3 levels), Survival within the horn + horn_weight (default)

1. Contrast between LW and MS sows and between piglet genotypes in lactation performance





Differences of Meishan from European (LW) breeds

1. Elements from the old litterature

- Higher embryo survival and uterine capacity
- More prolific, superiority of 3 to 4 piglets / litter
- Better progeny survival during lactation

- Higher homogeneity of piglet weights within the litter
- Higher piglet maturity at birth
- Better milk production

Bidanel et al., 1989; White et al., 1993; Haley et al., 1995, Le Dividich et al, 1991; Herpin et al, 1993

Influence of genetic components on maternal abilities ?
Possible strategies to use MS genes to improve performance in French pig populations?

Differences of Meishan from European (LW) breeds

2. Elements from a recent study

MS ♀ x LW♂	LW ♀x MS ♂
↓	↓

F1 MS x LW piglets

Advantage of Meishan sows for prolificacy
is out of date

No difference in stillbirth, remarquably low

Large White produced larger litters and heavier piglets who grew faster

No diff in litter size at weaning (11 vs 12.2)

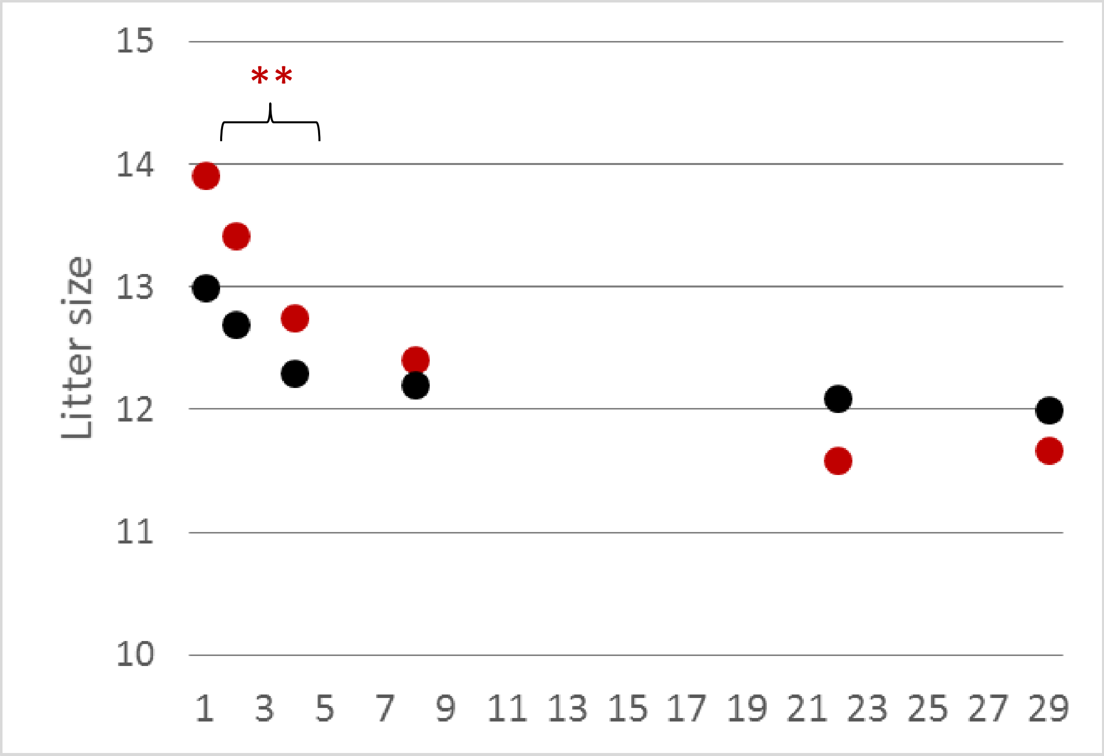
Meishan kept their advantage on the
ability to produce and raise more homogeneous litters

SD farrowing: 190 vs 280 g

SD 3wks lactation: 900 g vs 1.5 kg

Canario et al., 2008

3. Elements from the current study



LW vs MS Breed differences

No diff in Litter Size bw the 2 breeds lactation through

	LWxLW	LWxMS	MSxLW	MSxMS
Mortality 3d	**21%**	7%	0%	2%

Mortality affects LW purebred piglets

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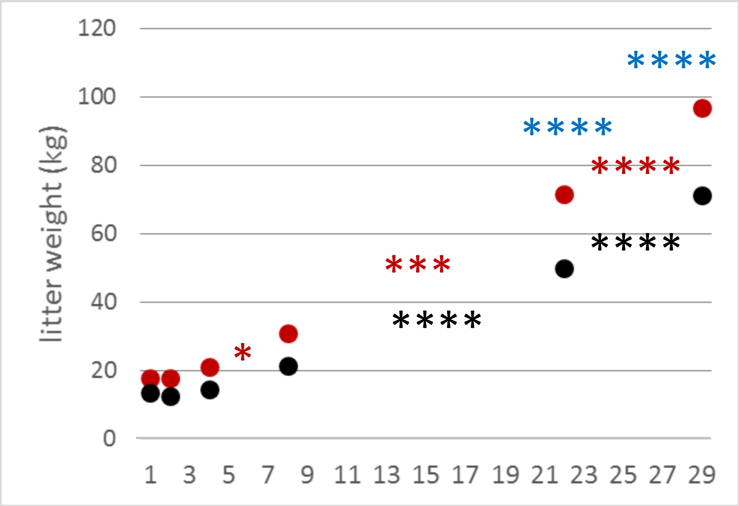
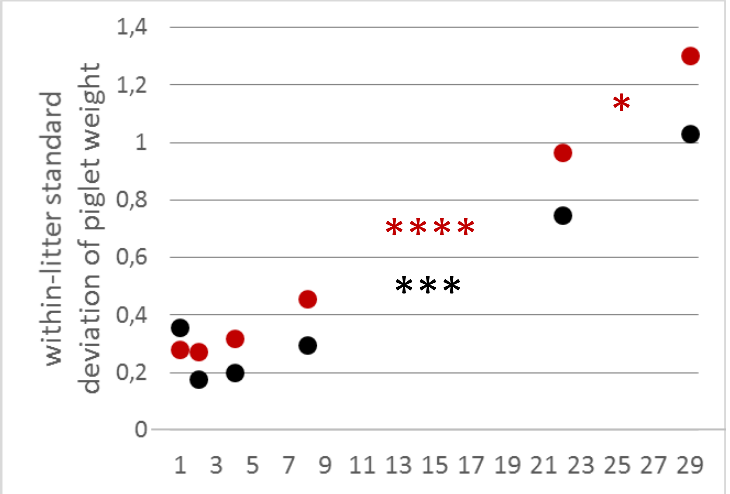
** P<0,01

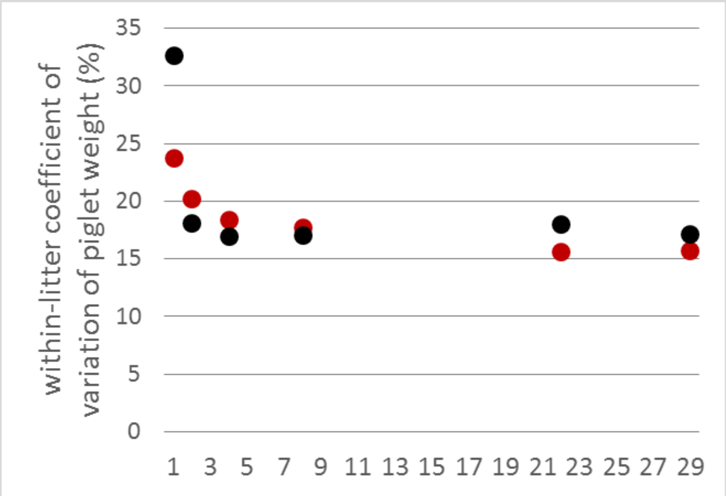
Sow's piglet production

LW vs **MS** Breed differences



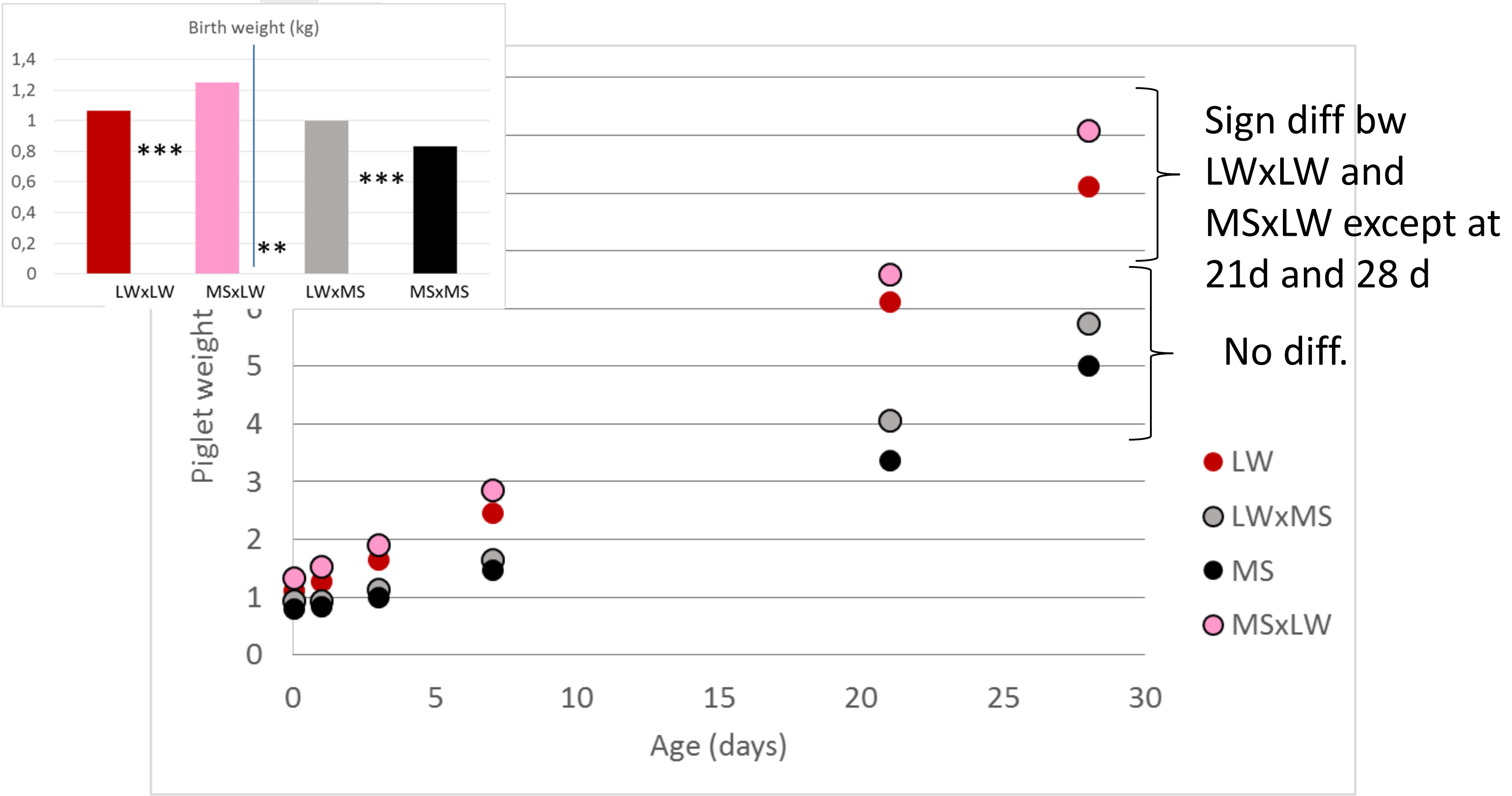
The 2 breeds produced litters equally homogeneous in piglet weights





* P<0.05 ; ** P<0.01 ; *** P<0.001 ; **** P<0.0001

Piglet individual growth



- ❖ LW sows: Higher growth of CB as compared to their PB littermates
- ❖ MS sows: homogeneous growth among the litter

Summary – postnatal growth

- MS and LW sows raised litters of similar homogeneity

In comparison to Canario et al (2008): slightly more homogeneous in LW and conversely more heterogeneous in MS

- Sows had the capacity to raise their litter homogeneously although composed from 2 different genetics

  ⇨ marked maternal effects

- Higher paternal influence on piglet growth in LW sows, in favour of CB

  ⇨ heterosis effects

Do the lower growth of LW PB in comparison to LW CB find explanation in a lower level of maturity at birth?

❑ MS breed = good model to understand perinatal development and explain delay of maturity in the LW PB

LW PB *vs* MS PB

Mean differences

	Stage dvp	MS / LW
BMI	90	+
PI	90	+
Spleen	90	+
Kydneys	90	+
Brain	110	-

Not many diffs bw the 2 most contrasted fetal genotypes

Allometric differences

		MS	**LW**
BWidth	110	DISP 0	PROP
Femur	110	DISP<<1	PROP
Spleen	90	DISP<1	PROP
Small Intestine	110	DISP<<1	PROP

PROP = proportional
DISP = disproportional

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LW PB *vs* LW CB

Mean differences

	Stage dvp	PB / CB
BMI	90-110	-
PI	90-110	-
BWidth	90	-
Femur	90	-
Heart	90	-
Liver	90	-
Spleen	90	-
Kidneys	90	-

→ Higher brain / organ ratios

Allometric differences

		LW CB	**LW PB**
Femur	90	DISP<1	PROP
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