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Milk and meat production

Dietary L-arginine supply during early gestation promotes myofiber hyperplasia

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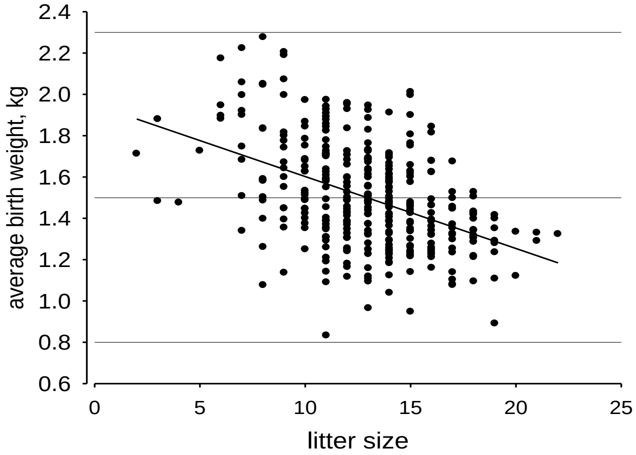
Known relationships

- Litter size is negatively correlated with average litter birth weight

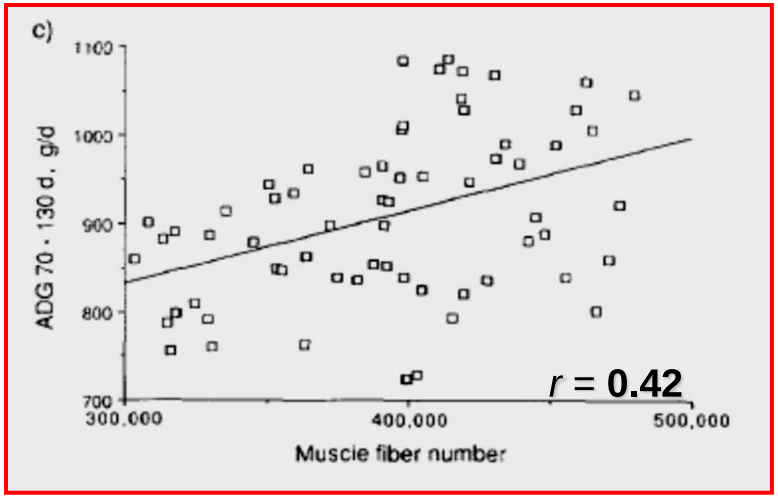


- Birth weight is negatively correlated with
  - survival rate in the first week after birth
  - postnatal growth
  - carcass leanness
  - some meat quality traits

myofiber number
myofiber size

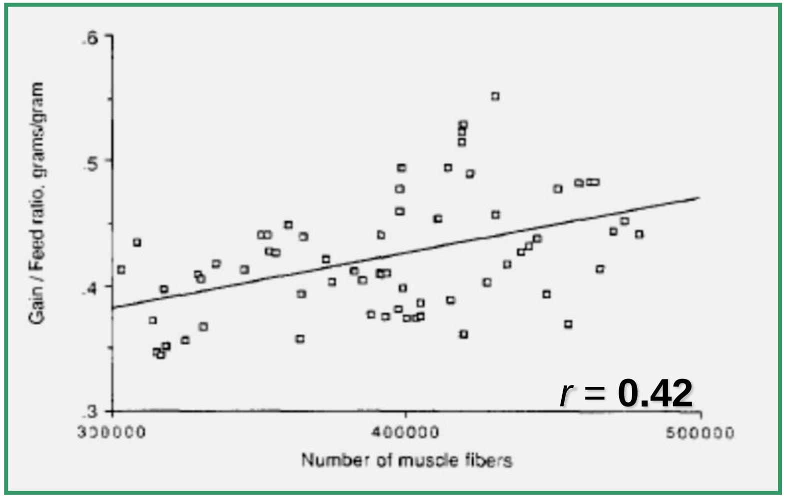
Total myofiber number (TFN)

ADG vs. TFN



Dwyer et al. 1993
J. Anim. Sci. 1993. 71:3339-3343

G/F vs. TFN



Dwyer et al. 1993
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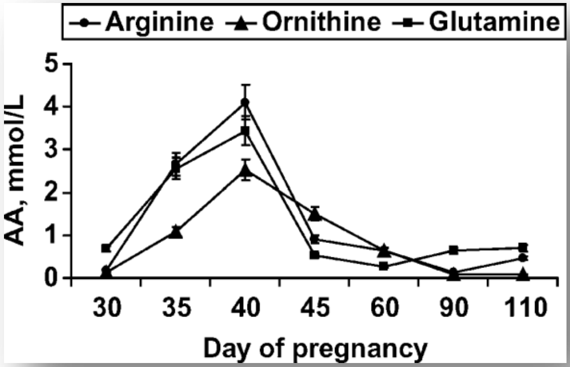
Arginine ↔ Prenatal development

- In early pregnancy, arginine and ornithine level elevated in porcine amniotic and allantoic fluid

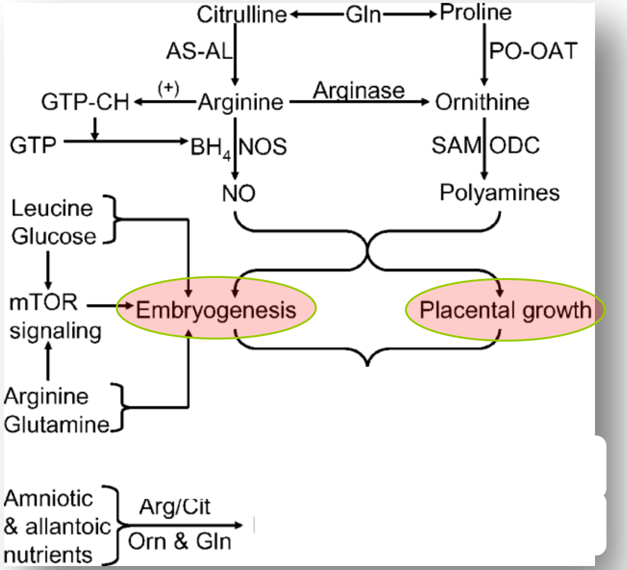


Wu et al. 2006

- Associated with a high syntheses rate of nitric oxide and polyamine in the porcine placenta

- Key role in angiogenesis

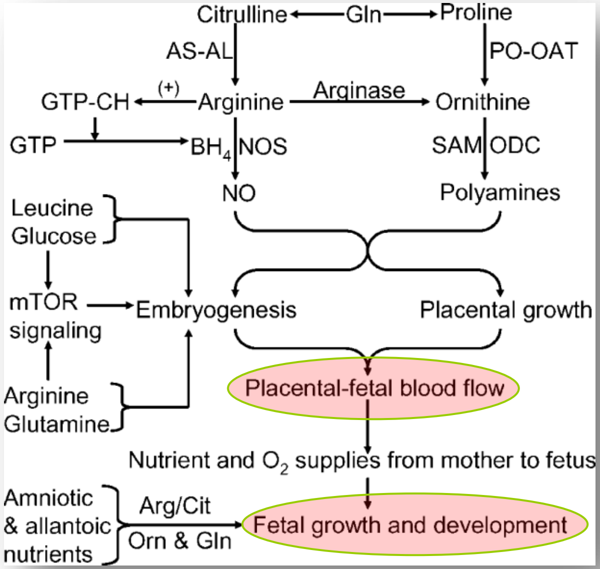
  = placental and embryonic development



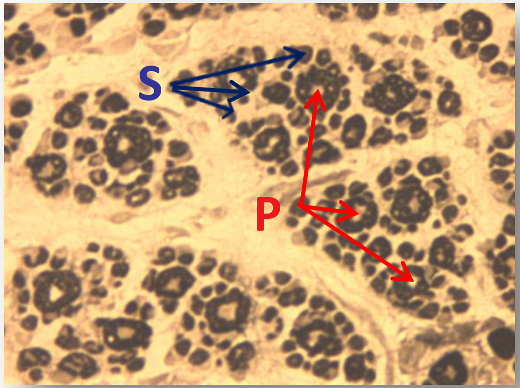
Wu et al. 2006

ARGININE ↔ MYOGENESIS

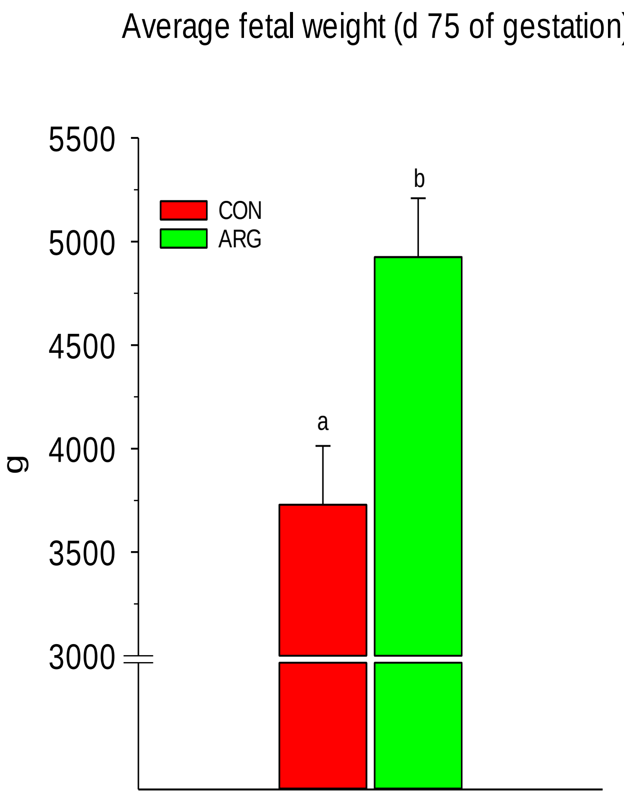
- Improved placental-fetal blood flow = improved fetal development
- Increased litter size without impact of birth weight
- Impact on muscle development?

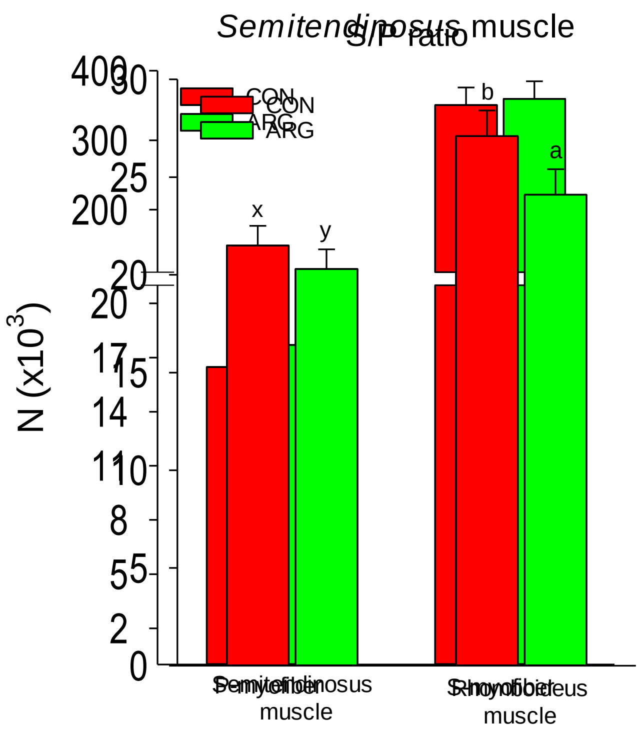


Wu et al. 2006



Dietary manipulation of myofiber development





Animal (2010), **4:10**, pp 1680–1687

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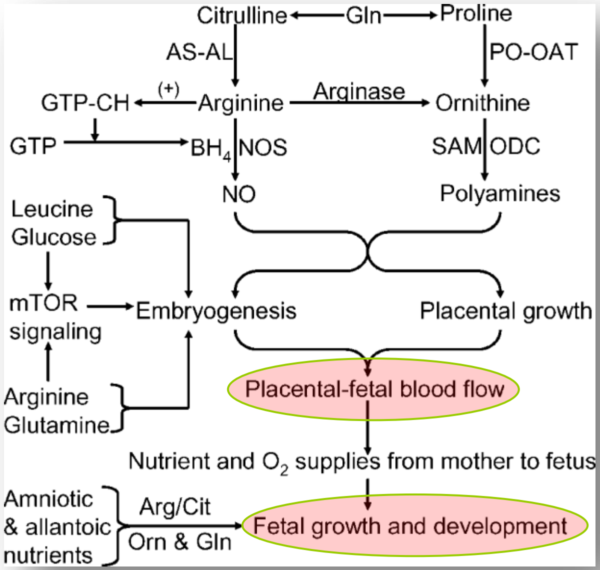
ARGININE ↔ MYOGENESIS

- Improved placental-fetal blood flow
  = improved fetal development

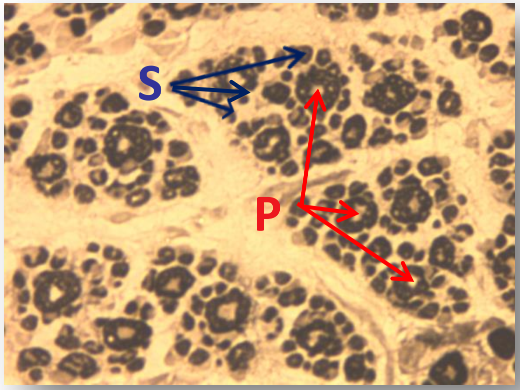
- Increased litter size without impact of birth weight

Primary fibers serve as a scaffold for the formation of secondary fibers

Greater number primary fibers = greater number of secondary fibers



Wu et al. 2006



Bérard and Bee 2010

Hypothesis

Based on the association between dietary arginine supply, the extent of placental vascularization, the fetal nutrient supply and muscle development 2 working hypothesis were formulated:

- Hypothesis 1:
  - *Supplementing L-arginine to an early gestational diet of the dams would promote hyperplasia leading to an increased number of myofibers in their offspring at birth*.
- Hypothesis 2:
  - *L-arginine is especially efficient in piglets suffering from IUGR*.

Experimental design

Animals:

- Intact sows (**I**; litter size: > 15; naturally **crowded**)
- OL sows (**OL**; unilaterally oviduct ligated; **uncrowded**)

All sows (n = 10) were at the beginning of the experiment in their fifth parity

Diets:

- Control (**C**; 100 g/d alanine from d 14 to 28 of gestation)
- Arginine (**Arg**; 25 g/d arginine from d 14 to 28 of gestation)

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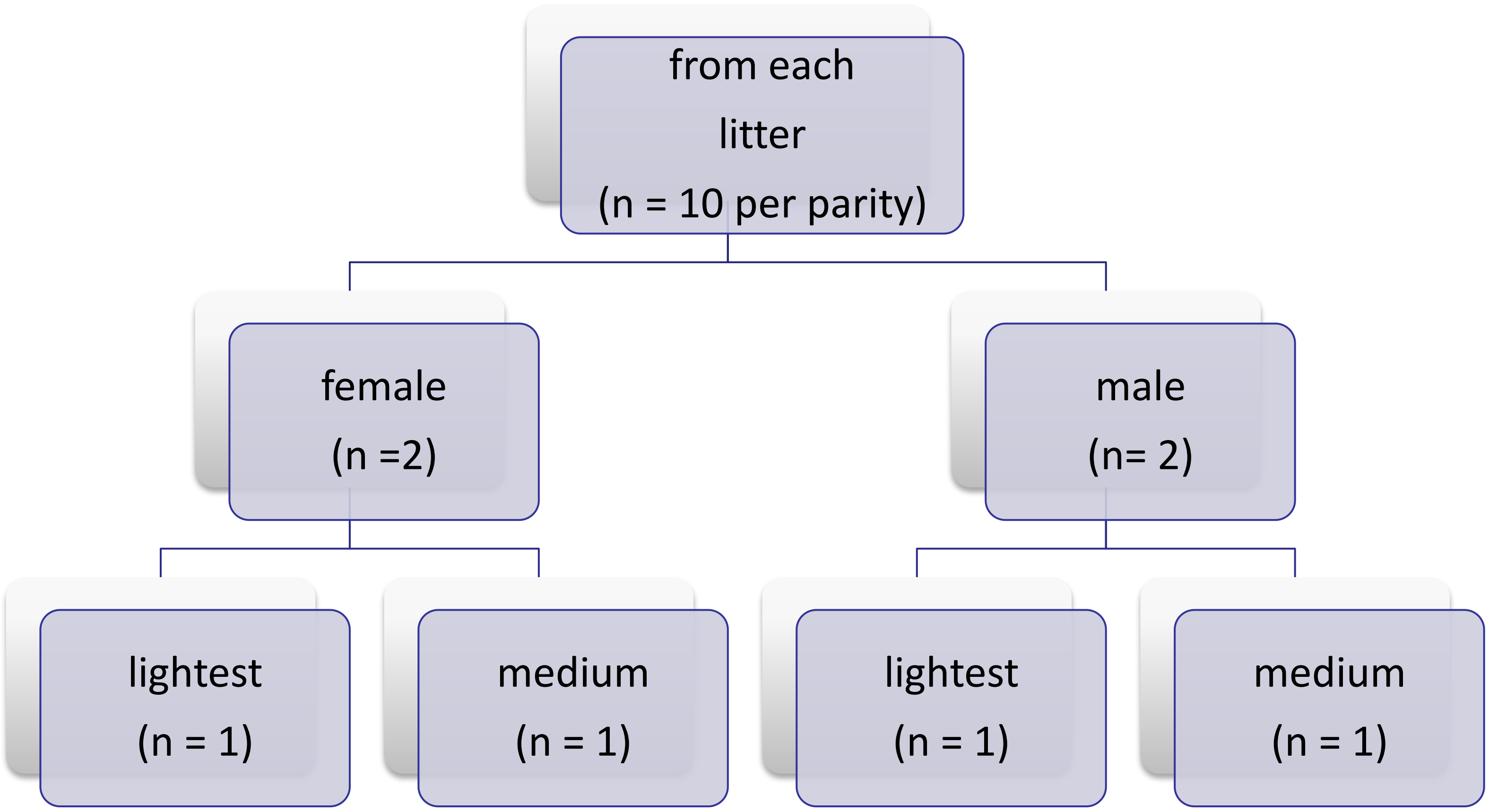
Selection criteria at farrowing



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Data and sample collection and analysis

Collection of data and samples at birth

- Litter size
- BtW of all piglets born

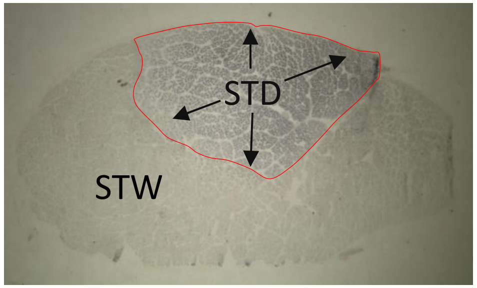
<u>From the selected newborn piglets</u>

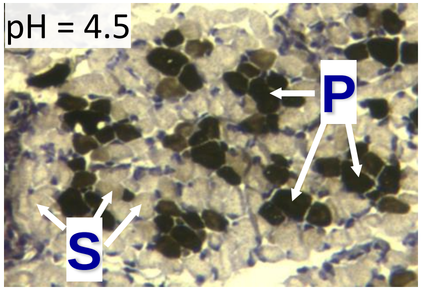
- Weight of the heart, kidney, liver, lung and spleen
- Weight of the brain
- Weight of the semitendinosus and psoas major

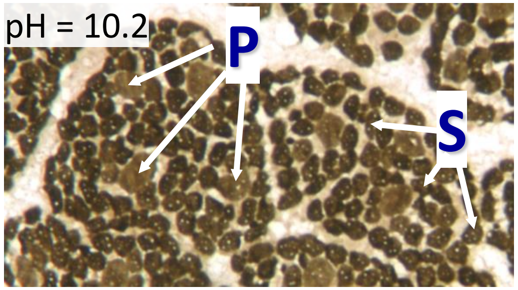
Histological analyses in the semitendinosus

(mATPase staining after pre-incubation at pH 4.5 and 10.2)

- CSA
- Number of P- and S-fibers
- S/P ratio
- TNF







RT-PCR analysis

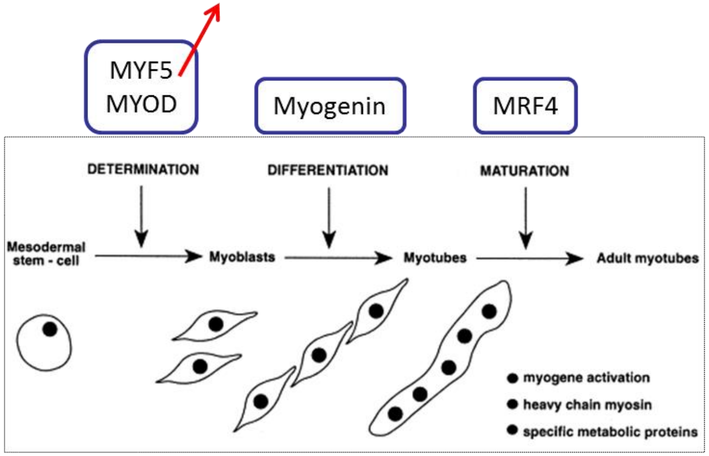
Transcript expression of

- myogenic factor 5 (***MYF5)***
- myogenic differentiation factor ***(MYOD)***
- myogenin ***(MYOG)***
- muscle-specific regulatory factor 4 ***(MRF4)***

- myostatin (***MSTN)***

- AMP-activated protein kinase catalytic subunit alpha-2 ***(PRKAA2)***

- insulin growth factor 2 (***IGF2)***
- insulin growth factor binding protein 5 ***(IGFBP5)***



www.sciencedirect.com

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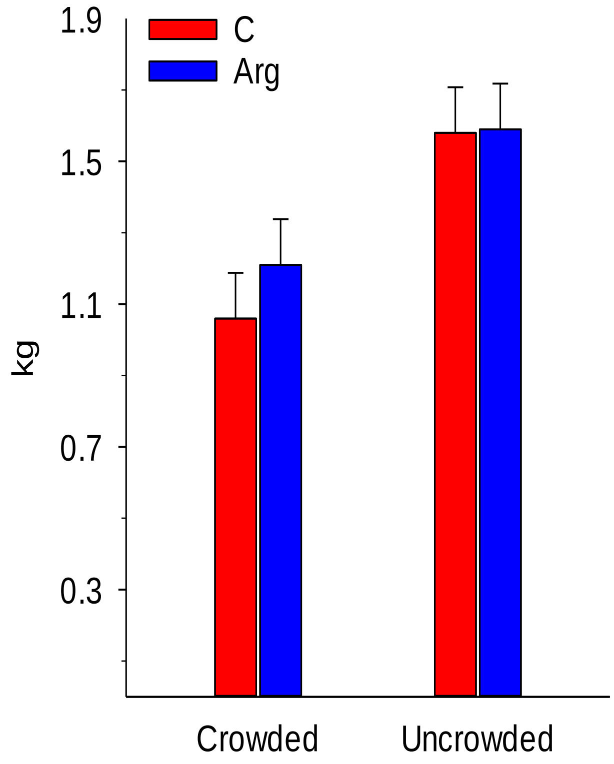
Results

Litter characteristics

	Crowded		Uncrowded			*P*-values		
Trait	C	Arg	C	Arg	SEM	IUC	DIET	IUC x DIET
Litter size, n								
Total born	15.5	15.3	10.5	11.9	1.71	0.26	0.72	0.66
Born alive	13.1	14.5	9.1	10.3	1.49	0.23	0.46	0.96
Birth weight, kg								
Total born	1.22	1.48	1.57	1.51	0.068	0.28	0.21	0.13
Born alive	1.24	1.50	1.59	1.53	0.068	0.28	0.22	0.13
STD	0.24	0.25	0.18	0.14	0.056	0.41	0.87	0.63

Results

Birth weight of selected piglets



DIET, *P* = 0.07
IUC, ***P*** **< 0.01**
DIET x IUC *P* = 0.14

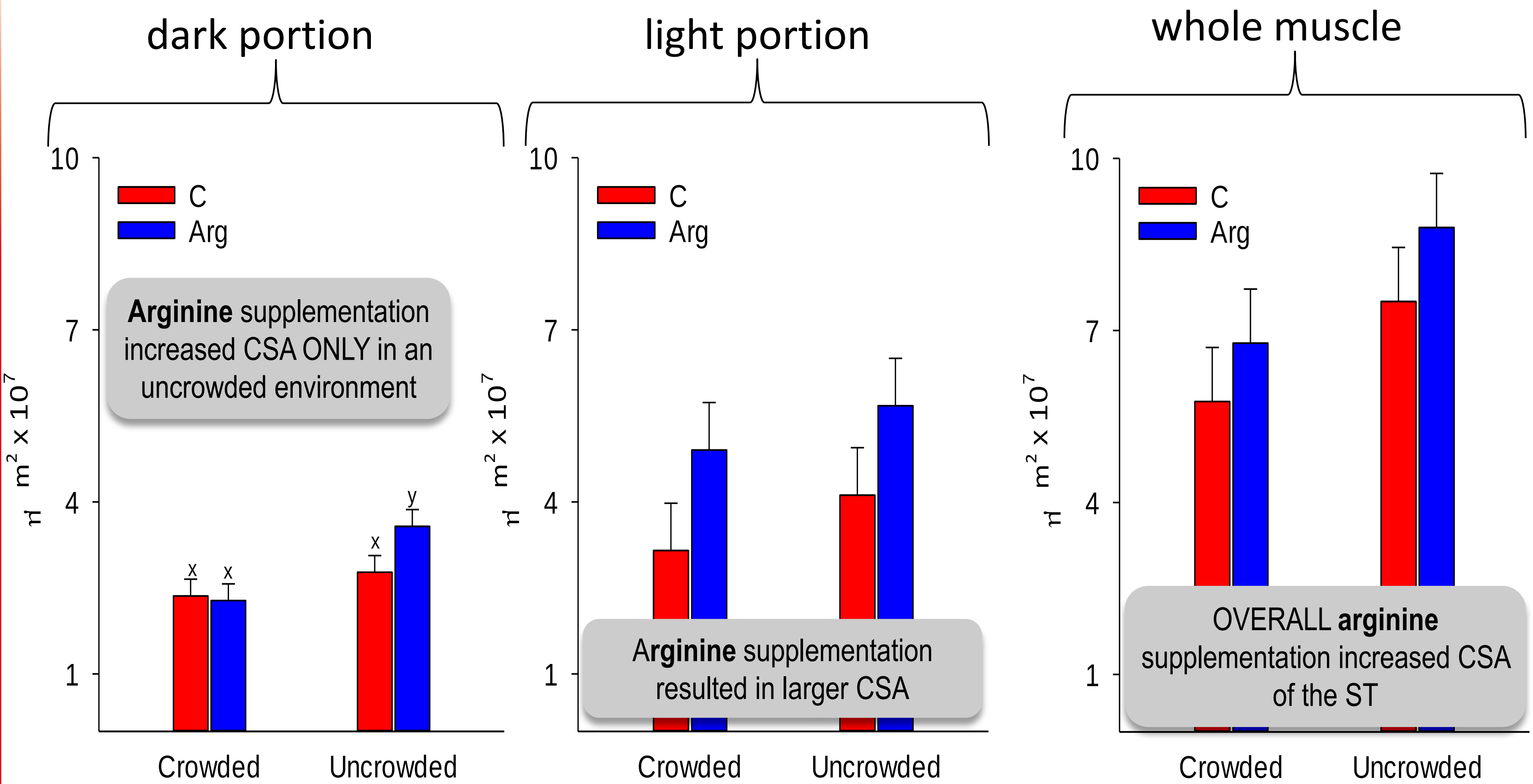
Results

Morphometric measures

Trait expressed	Crowded		Uncrowded			*P*-values		
in g/100 g birth weight	C	Arg	C	Arg	SEM	IUC	DIET	IUC x DIET
Heart	0.70	0.67	0.67	0.65	0.02	0.49	0.03	0.72
Liver	2.21	2.47	2.78	2.77	0.18	0.13	0.19	0.14
Spleen	0.10[b]	0.09[a]	0.09[ab]	0.09[ab]	0.01	0.67	0.18	0.02
Lung	1.47	1.39	1.31	1.27	0.11	0.36	0.25	0.76
Kidney	0.74	0.72	0.80	0.82	0.04	0.27	0.76	0.40
Brain	2.87	2.53	2.47	2.50	0.32	0.62	0.17	0.11
Brain:liver weight ratio	1.36	1.12	0.94	0.92	0.22	0.27	0.08	0.18
Semitendinosus	2.09	2.08	2.19	2.28	0.11	0.33	0.42	0.34
Psoas major	2.06	2.14	2.31	2.39	0.14	0.28	0.28	0.99

Results

Muscle area



dark portion	light portion	whole muscle
DIET, **P < 0.01**	DIET, **P < 0.01**	DIET, **P < 0.01**
IUC, P = 0.08	IUC, P = 0.24	IUC, P = 0.14
DIET x IUC **P < 0.01**	DIET x IUC P = 0.60	DIET x IUC P = 0.74

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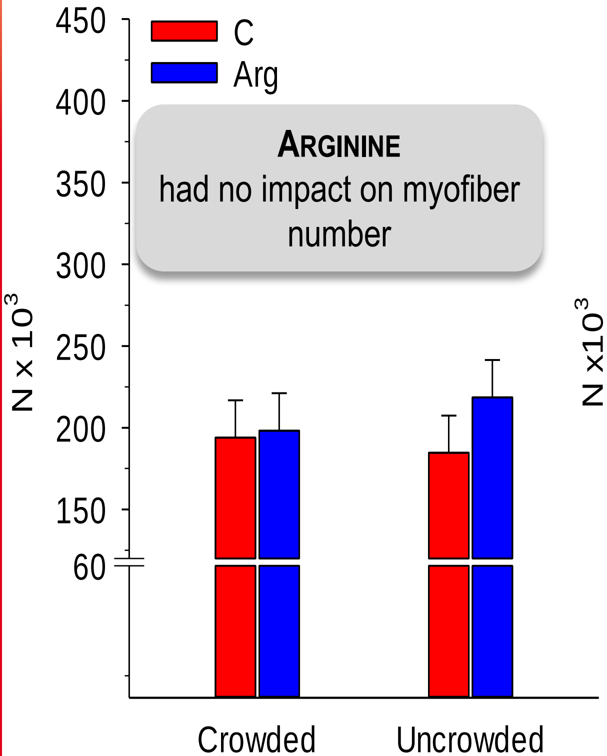
Results

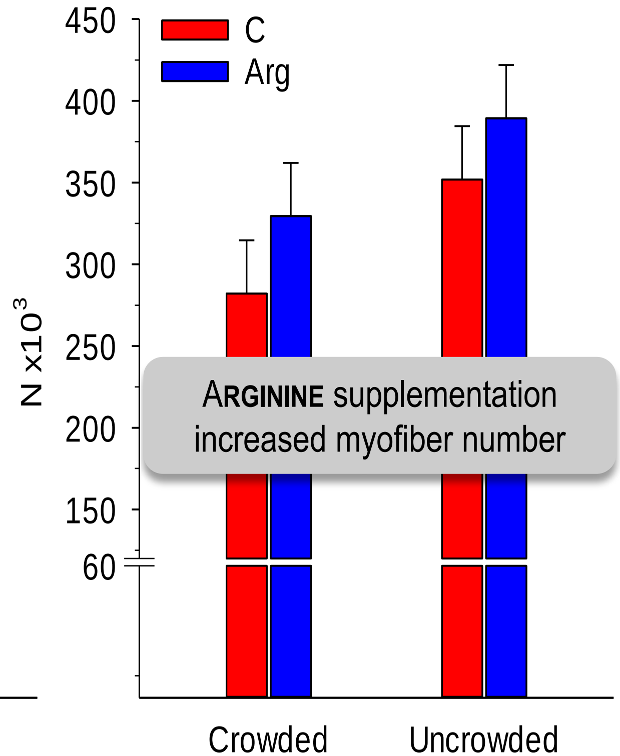
Myofiber number

dark portion



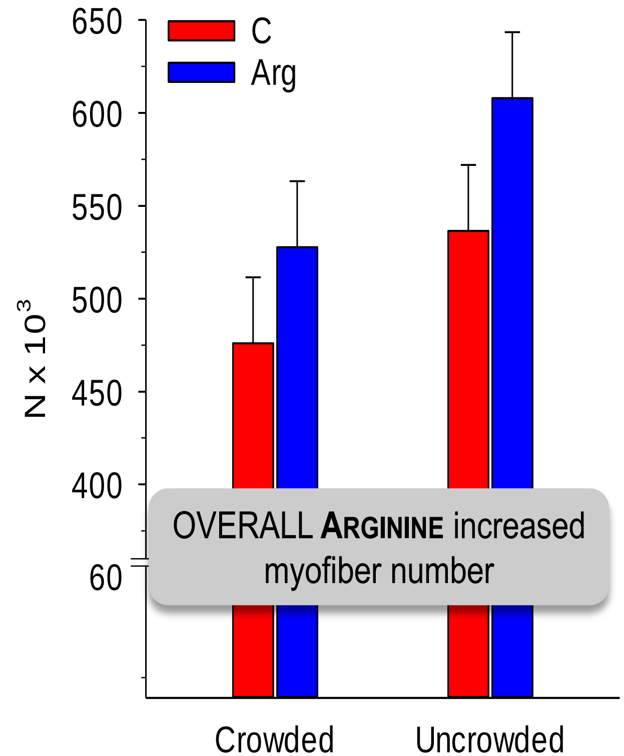
DIET, $P = 0.13$
IUC, $P = 0.88$
DIET x IUC $P = 0.23$

light portion



DIET, $\mathbf{P = 0.02}$
IUC, $P = 0.23$
DIET x IUC $P = 0.78$

whole muscle



DIET, $\mathbf{P < 0.01}$
IUC, $P = 0.24$
DIET x IUC $P = 0.23$

Results Gene expression of myogenesis-related genes

	Crowded		Uncrowded			*P*-values		
Trait	C	Arg	C	Arg	SEM	IUC	DIET	IUC x DIET
IGF2	2.36	1.55	0.91	1.70	0.555	0.487	0.967	0.950
IGFBP5	5.63	5.65	2.32	4.62	2.190	0.489	0.233	0.297
MSTN	1.60	1.64	0.46	0.98	1.754	0.351	0.232	0.110
MYF5	0.35	0.42	0.24	0.28	1.694	0.631	0.531	0.159
MYF6	0.58	0.65	1.18	0.98	0.576	0.623	0.859	0.631
MYOD1	2.36	1.84	0.68	0.48	2.143	0.223	0.340	0.418
MYOG	0.94	0.70	1.32	1.11	0.255	0.333	0.168	0.417
PRKAA2	0.72[b]	1.04b[b]	0.26[a]	0.15[a]	0.194	0.024	0.264	0.091

PRKAA2 (inhibitor of muscle protein synthesis) greater expression related to

- lower BtW
- lower muscle weight

Answer to hypothesis

Supplementing L-arginine early in gestation

- reduces the negative impacts of IUGR,
  - increased hyperplasia, birth weight and STM area.

- as muscle area increased more than TNF → prenatal myofiber hypertrophy

- not especially efficient in L-BtW piglets