

Feeding strategies of gestating sows for fetal and mammary gland growth

妊娠母猪胎儿和乳腺发育的饲喂策略

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Best selling car in China 中国最畅销汽车



2016 (2.0 L 120 HP)

Remarkable
changes! 显著变化!

1976 (1.1L 50 HP)



The Pig: High lean gain 猪：高瘦肉率

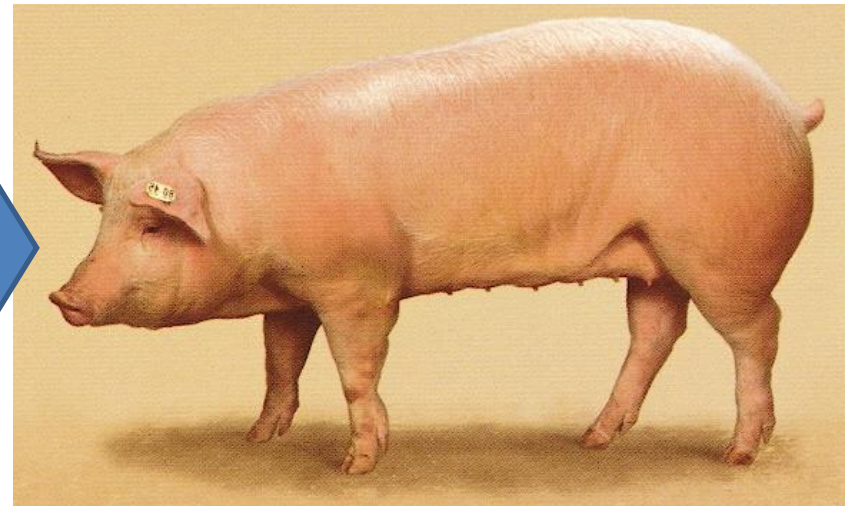
**Remarkable
changes! 显著变化!**

1950



W-F ADG 550 g; FG 3.5

2015



W-F ADG 700 g; FG 2.6

Current status of sows 母猪现状

- Sows have substantially been improved for high prolificacy during the last 50 years.
- 在过去50年里，母猪的高繁殖能力获得本质性地改善。

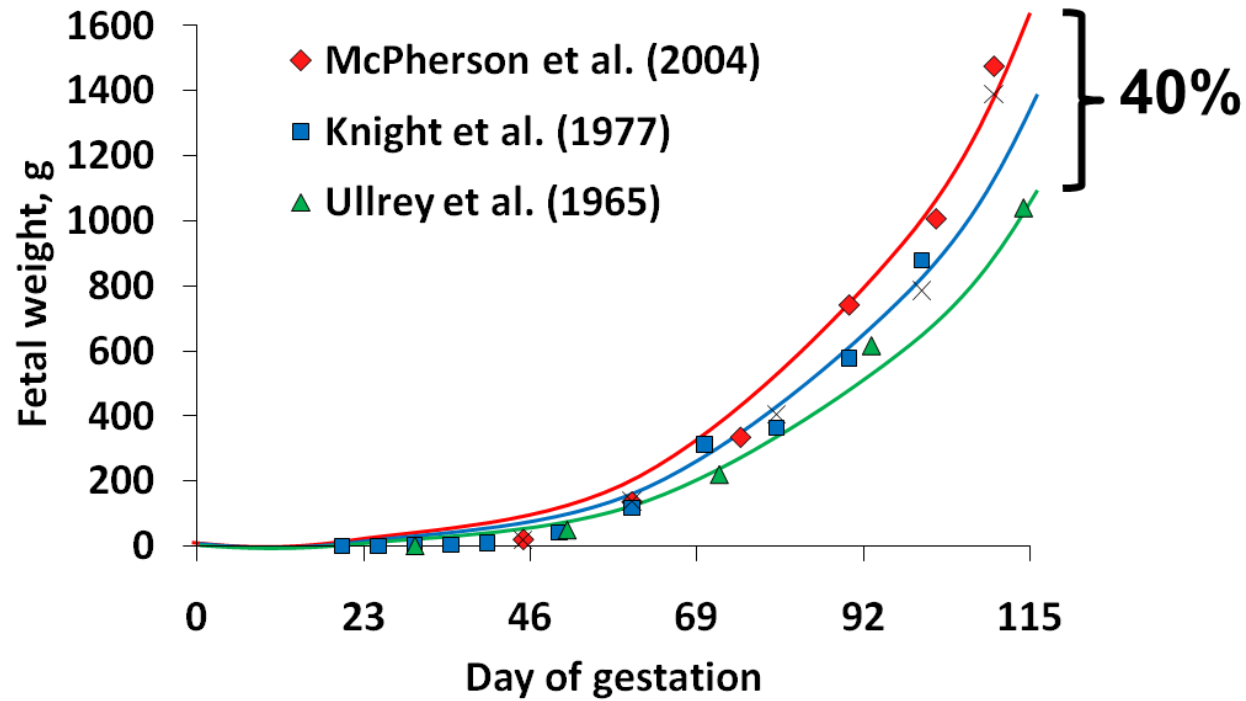


According to PIC, genetic potential:
25 PSY in 2000
30 PSY in 2015

NASS-USDA. 2010. <http://quickstats.nass.usda.gov>

Current status of sows 母猪现状

- Each fetus grows faster than before!
- 每个胎儿的生长速度比以前快！



McPherson et al., 2004. J Anim Sci. 82:2534-2540

Current status of sows 母猪现状

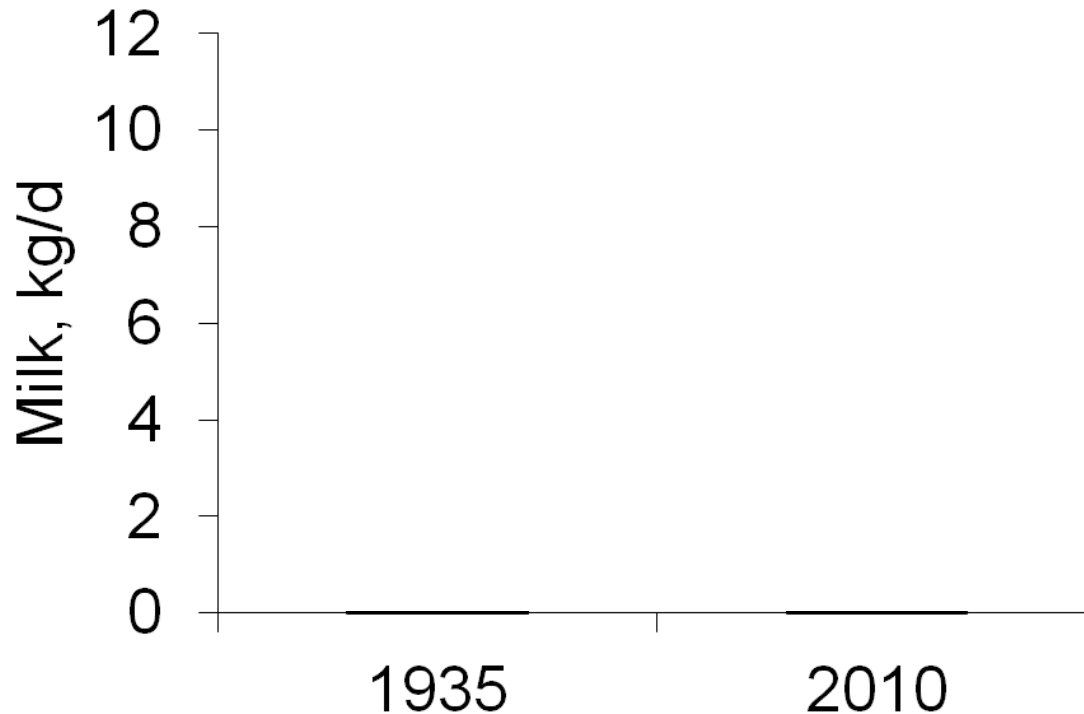
Thus, the pregnant sows today produce more and faster growing fetuses compared with those in the past!

因此，与过去相比，怀孕母猪生产出更多且生长更快的胎儿！



Current status of sows 母猪现状

- Produce more milk than before!
- 产奶比之前更多！



J Nutr 1935. 9:311-322; *J Anim Sci* 2011. 89:2462–2471

Current status of sows 母猪现状

- Probably produce more than dairy cows!
- 产奶量有可能比奶牛还多!



11 kg milk/180 kg BW

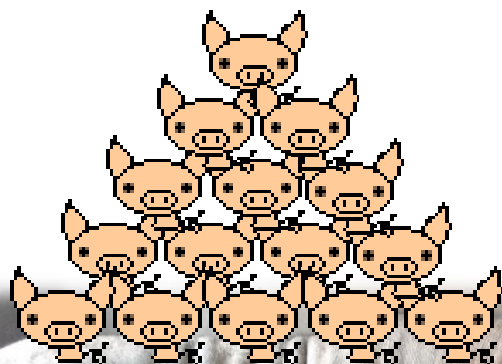
vs.



45 kg milk/900 kg BW

Current status of sows 母猪现状

Enough?
足够?



Thus, the sows today produce more and faster growing fetuses, and produce more milk compared with sows in the past!

因此，今天的母猪和过去相比，胎儿数更多，生长速度更快，且产奶量也更大。

Current status of sows 母猪现状

The sows now are different from the sows in the past!
现在的母猪和过去的母猪真是有很大不同。



Topics of my talk today... 今天我谈论的话题...

I will talk about
challenges and opportunities
in sow feeding during pregnancy.
我将探讨喂养孕期母猪的机会和挑战。

- Q: Has our feeding program evolved as well?**
我们的喂食程序也改进了吗?
- Q: Are we feeding sows adequately today?**
我们今天给母猪喂足了吗?

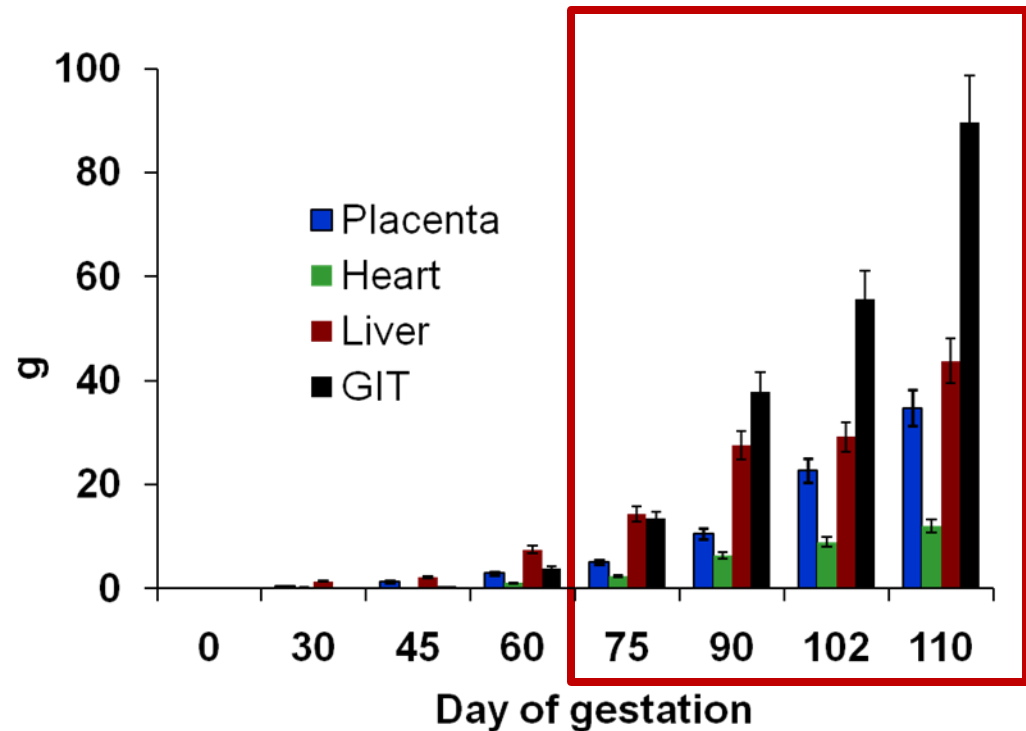
Pregnancy 妊娠

Two big changes occur during gestation!
妊娠期发生两大变化!



Pregnancy 妊娠

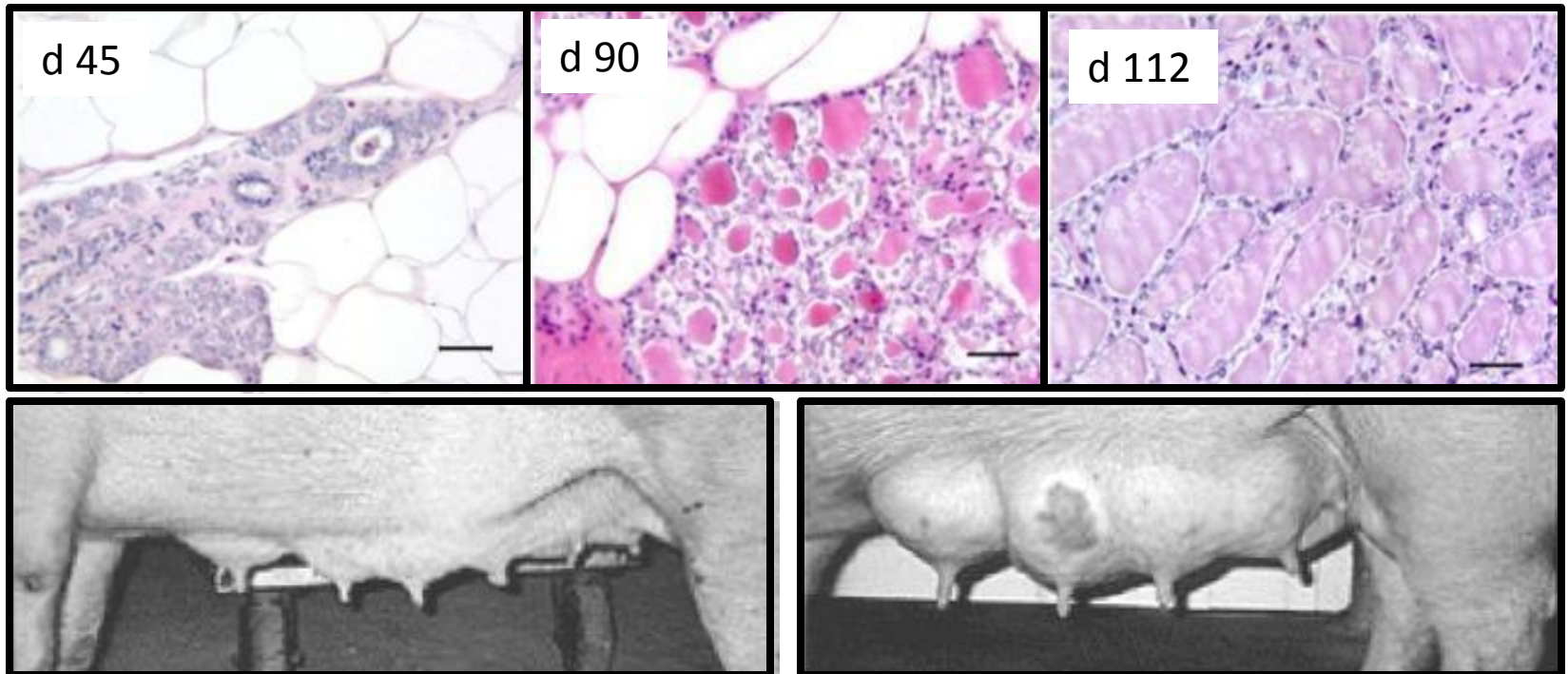
- Fetal growth occurs mostly during late gestation.
胎儿生长主要发生在妊娠后期。



McPherson et al., 2004. *J Anim Sci.* 82:2534-2540

Pregnancy 妊娠

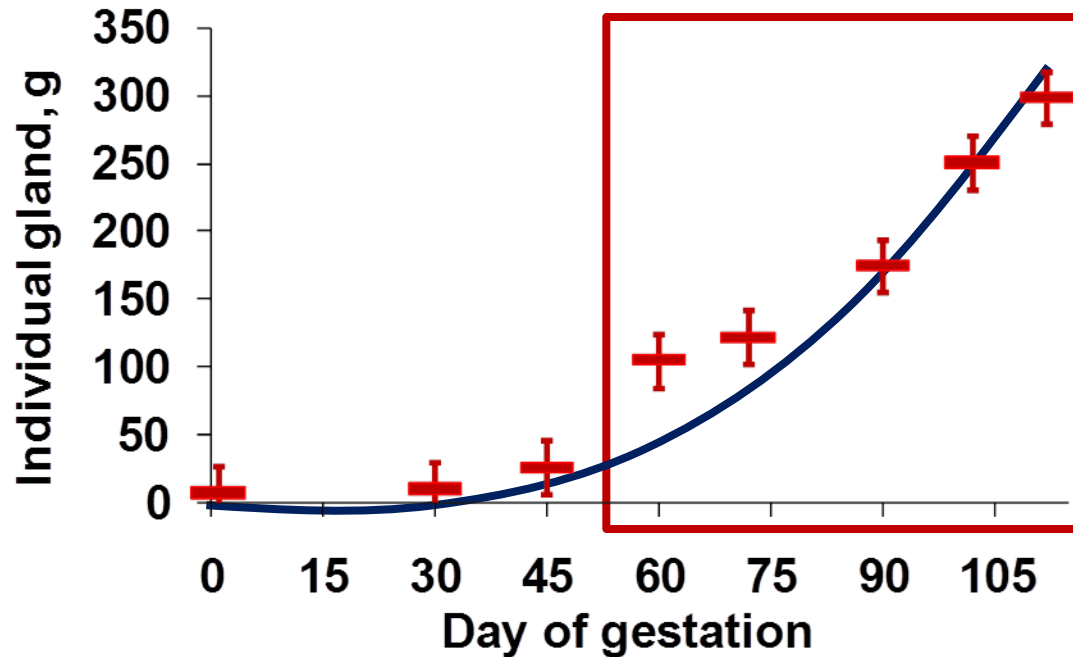
- Mammary growth occurs mostly during late gestation. 乳腺生长主要发生在妊娠后期。



Ji et al., 2006. J Anim Sci. 84:579-587

Pregnancy 妊娠

- Mammary growth occurs mostly during late gestation. 乳腺生长主要发生在妊娠后期。



Ji et al., 2006. J Anim Sci. 84:579-587

Pregnancy 妊娠

Thus, two big changes occur during **LATE** gestation!
因此，两大变化发生在妊娠后期。



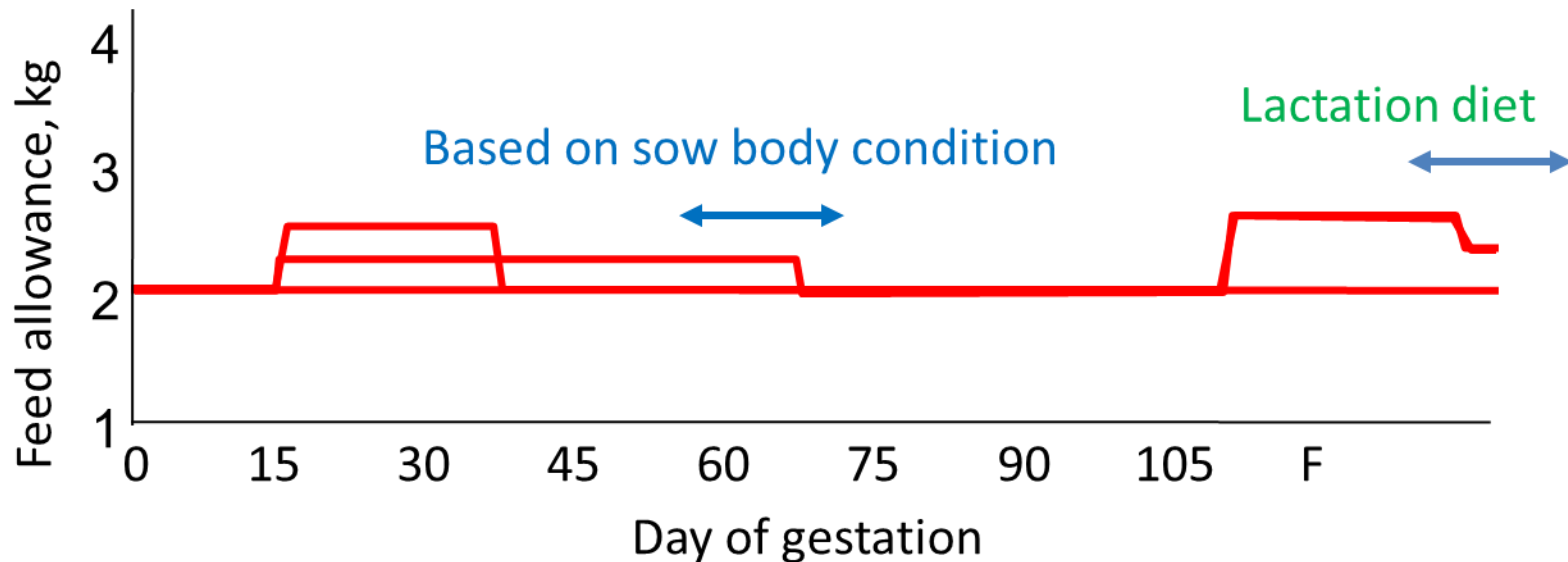
Pregnancy: Challenges 妊娠：挑战

Therefore, insufficient feeding of sows during late gestation can causes problems...

因此，母猪在妊娠后期喂养不足，可能会导致问题...

Pregnancy: Challenges 妊娠：挑战

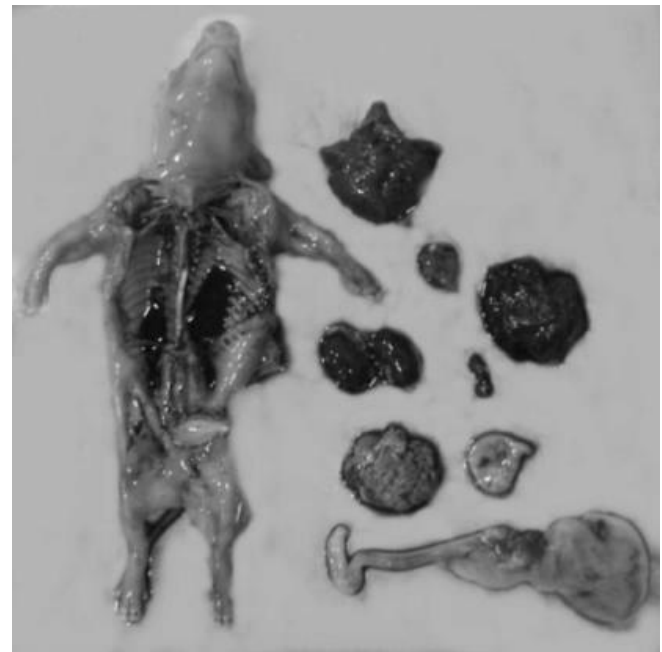
Then, how do we feed sows during gestation?
那么，如何在妊娠期喂养母猪呢？



Pregnancy: Challenges

妊娠：挑战

Fetal growth 胎儿生长

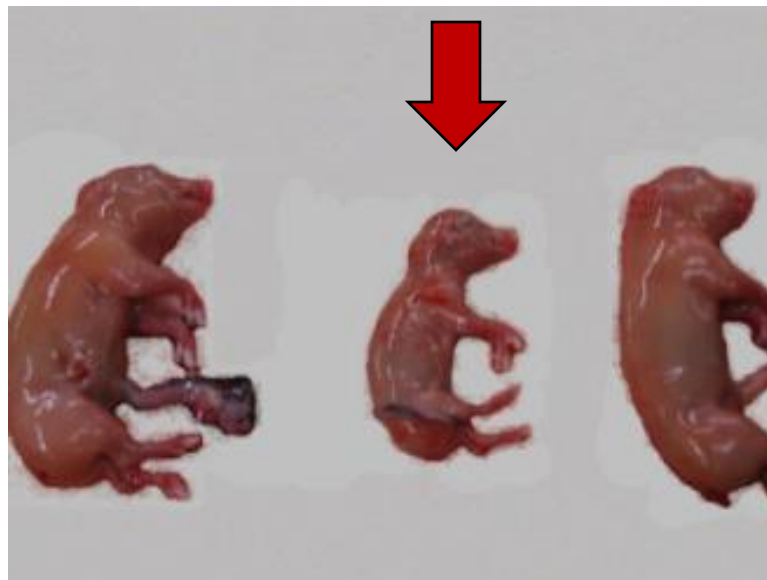


McPherson et al., 2004. J Anim Sci. 82:2534-2540

Pregnancy: Challenges

妊娠：挑战

Fetus on d 60 胎儿60天

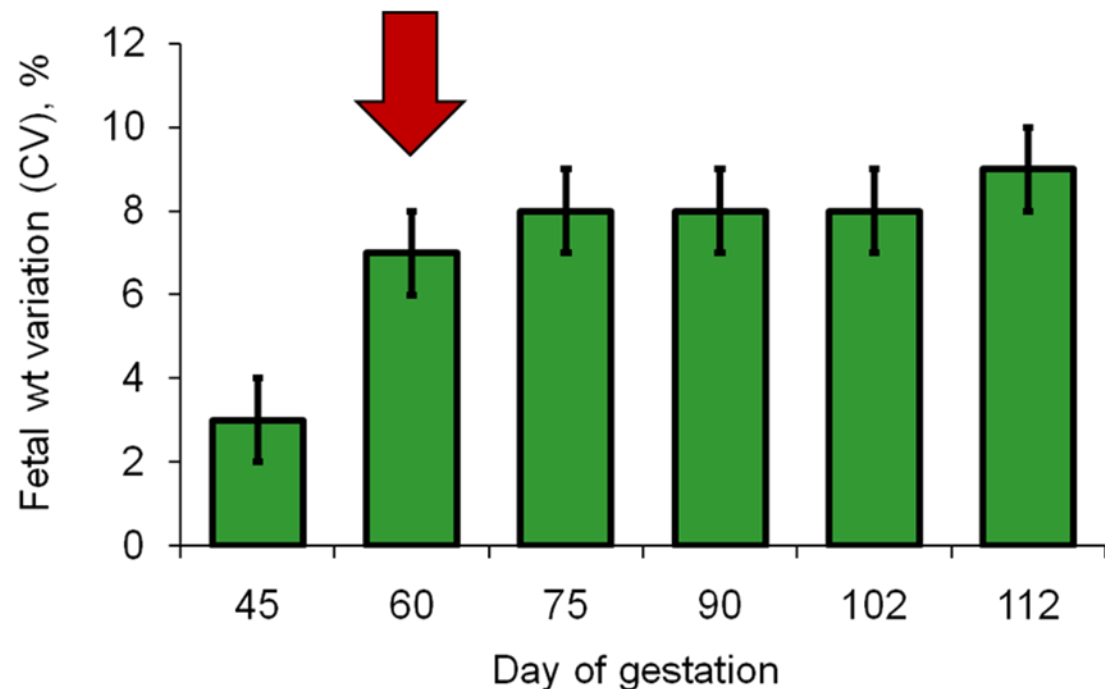
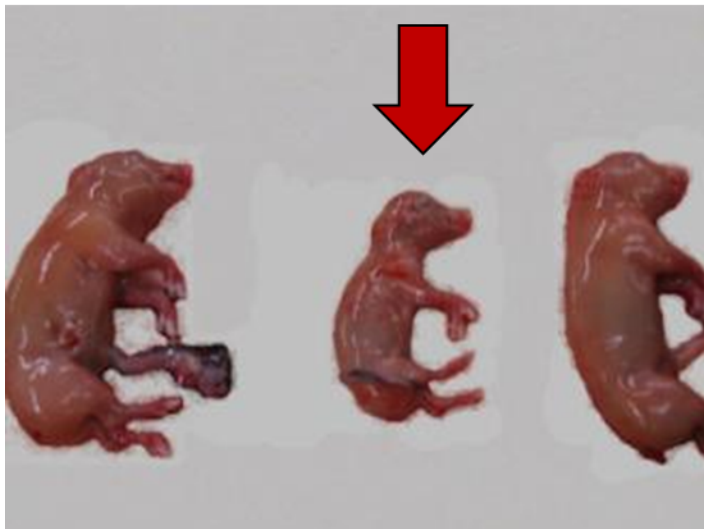


Kim et al., 2009. J Anim Sci. 87:E123-E132

Pregnancy: Challenges 妊娠：挑战

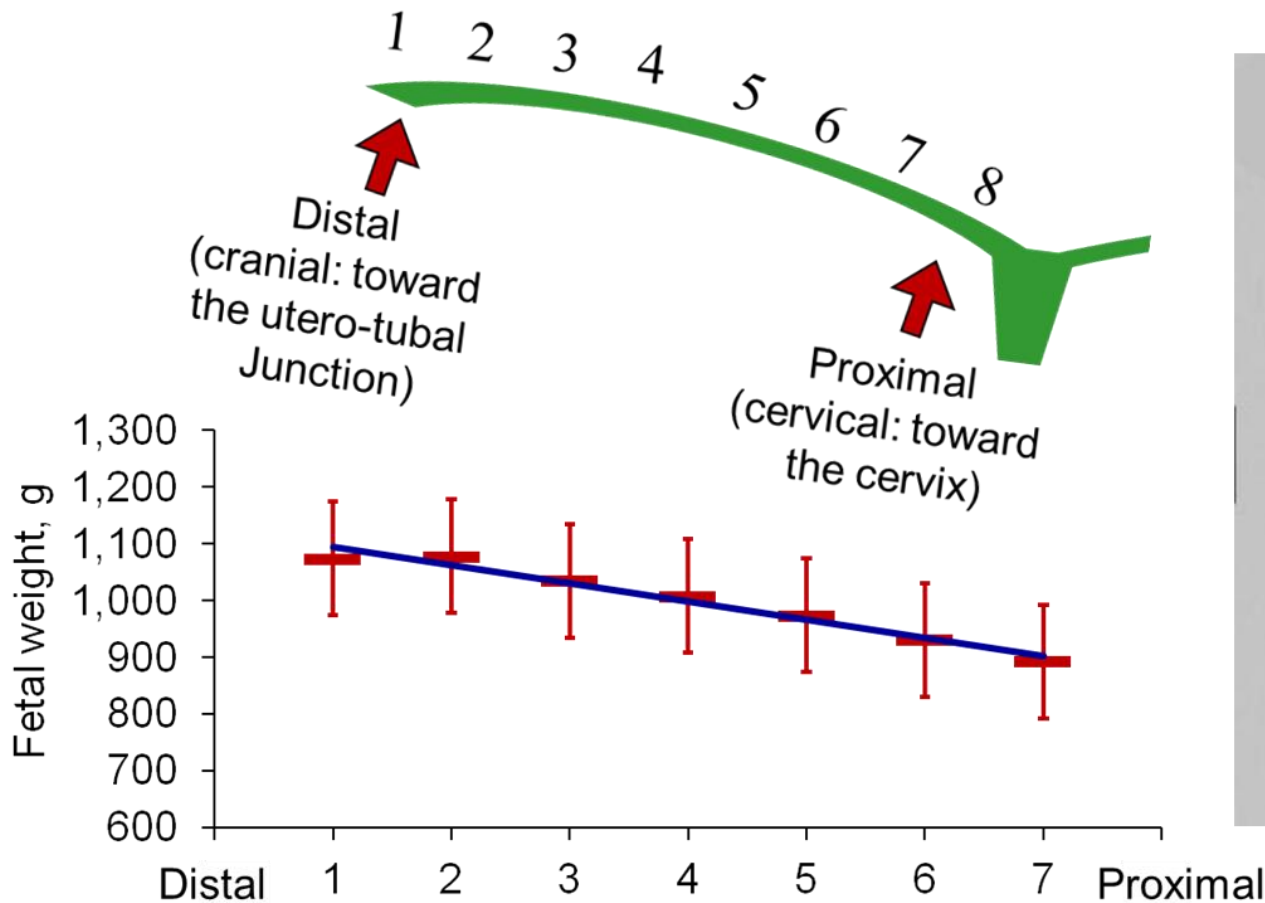
Insufficient nutrient supply to support the growth of all fetuses during late gestation?

营养供给不足能支撑所有胎儿在妊娠后期的生长？



Kim et al., 2009. J Anim Sci. 87:E123-E132

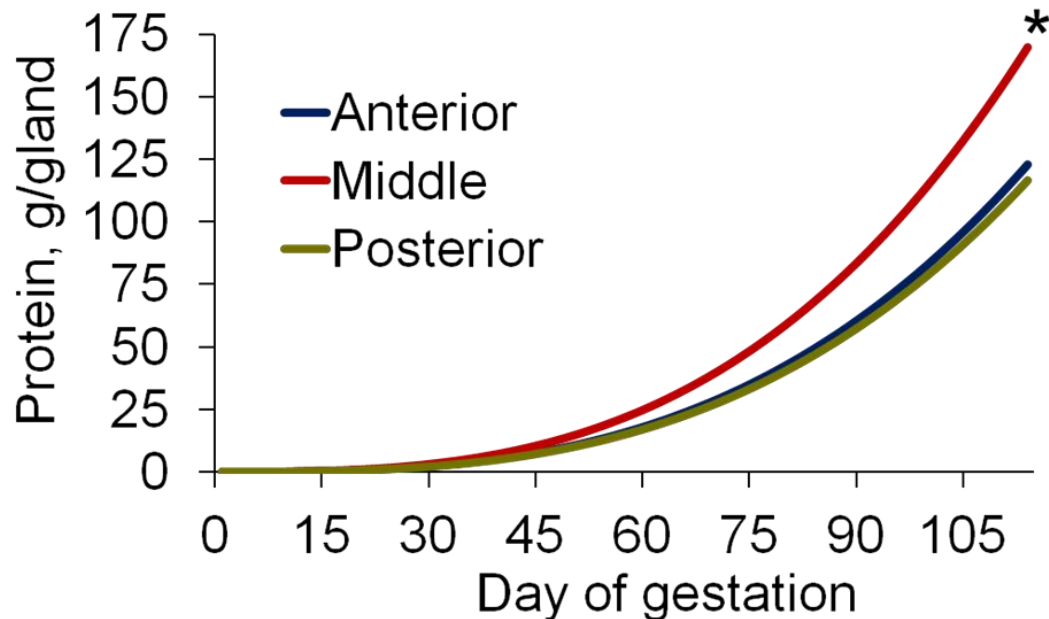
Pregnancy: Challenges 妊娠：挑战



Kim et al., 2009. *J Anim Sci.* 87:E123-E132

Pregnancy: Challenges 妊娠：挑战

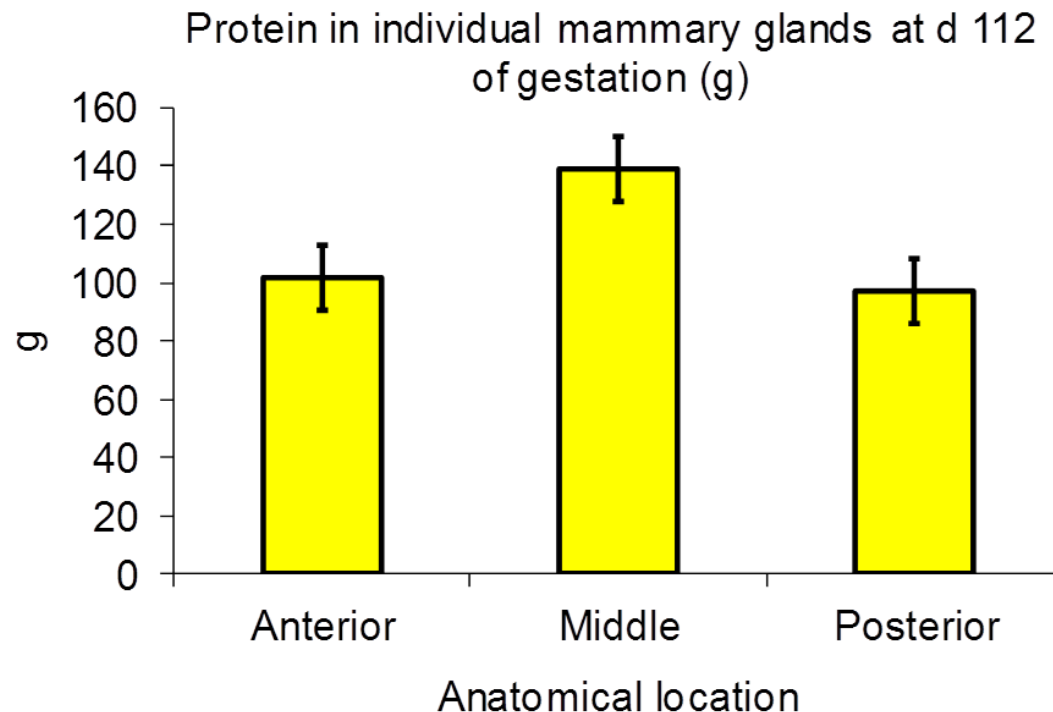
Insufficient nutrient supply to support the growth of all mammary glands during late gestation?
营养供给不足能支撑所有乳腺在妊娠后期的生长吗？



Amino Acids 2009. 37:89-95; J Anim Sci 2006. 84:579-587

Pregnancy: Challenges 妊娠：挑战

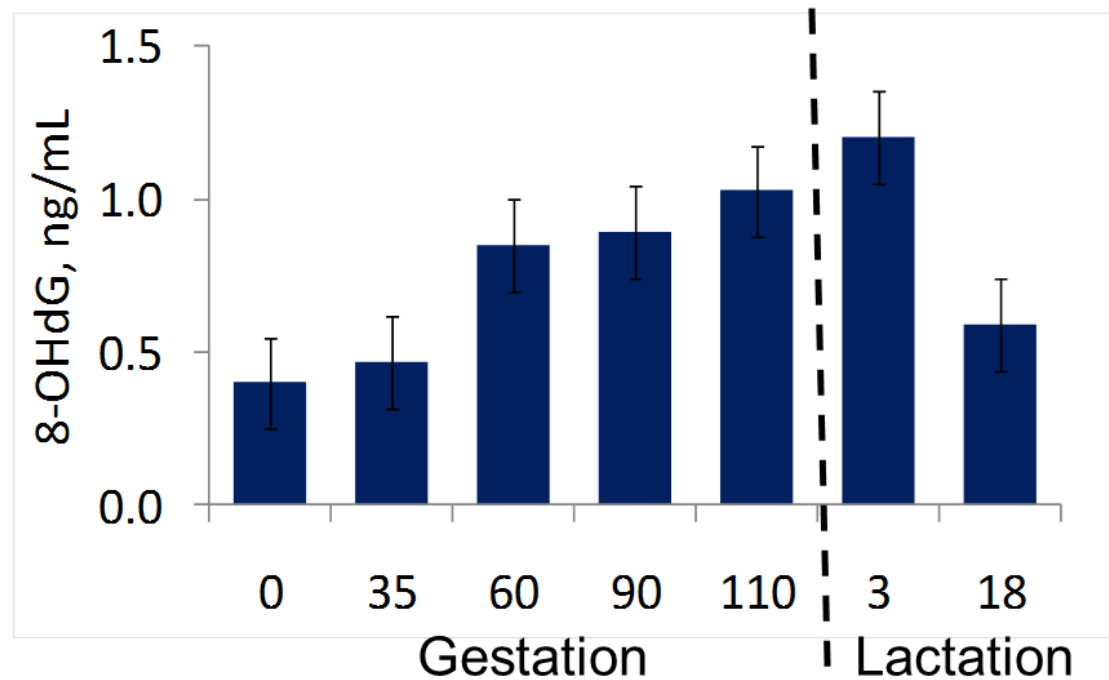
Insufficient nutrient supply to support the growth of all mammary glands during late gestation?
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Pregnancy: Challenges 妊娠：挑战

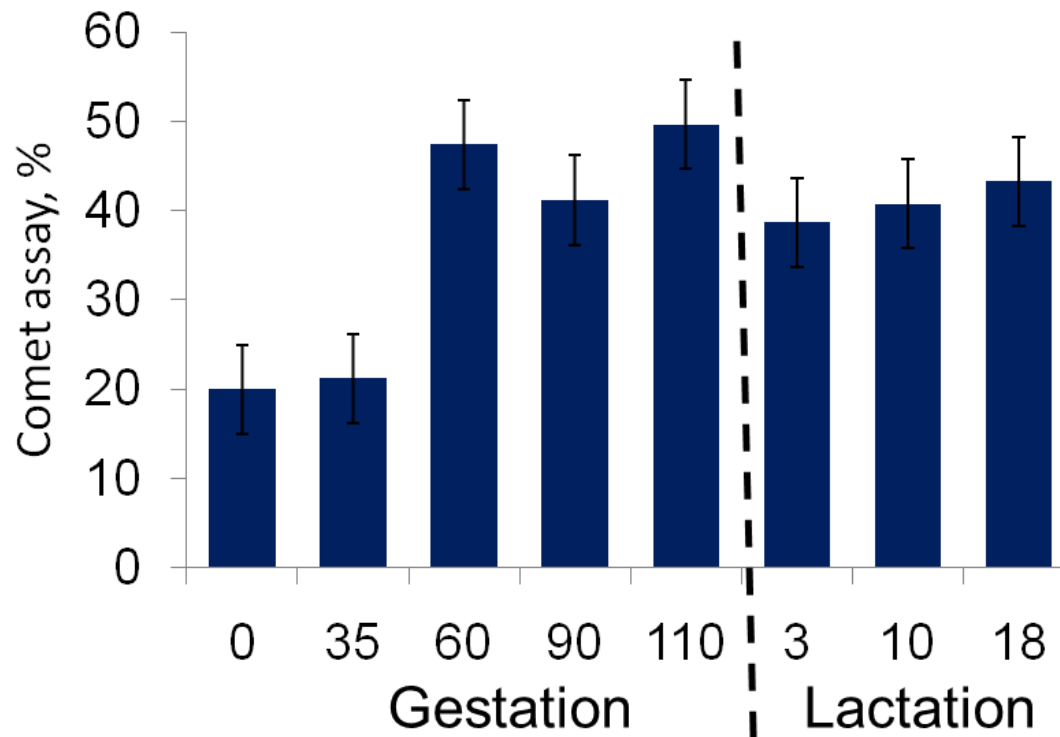
Oxidative damage to DNA increases during perinatal period
围产期DNA氧化损伤增加



Zhao et al., 2013. J Anim Sci. 91:5848-5858

Pregnancy: Challenges 妊娠：挑战

Oxidative damage to DNA increases during perinatal period
围产期DNA氧化损伤增加

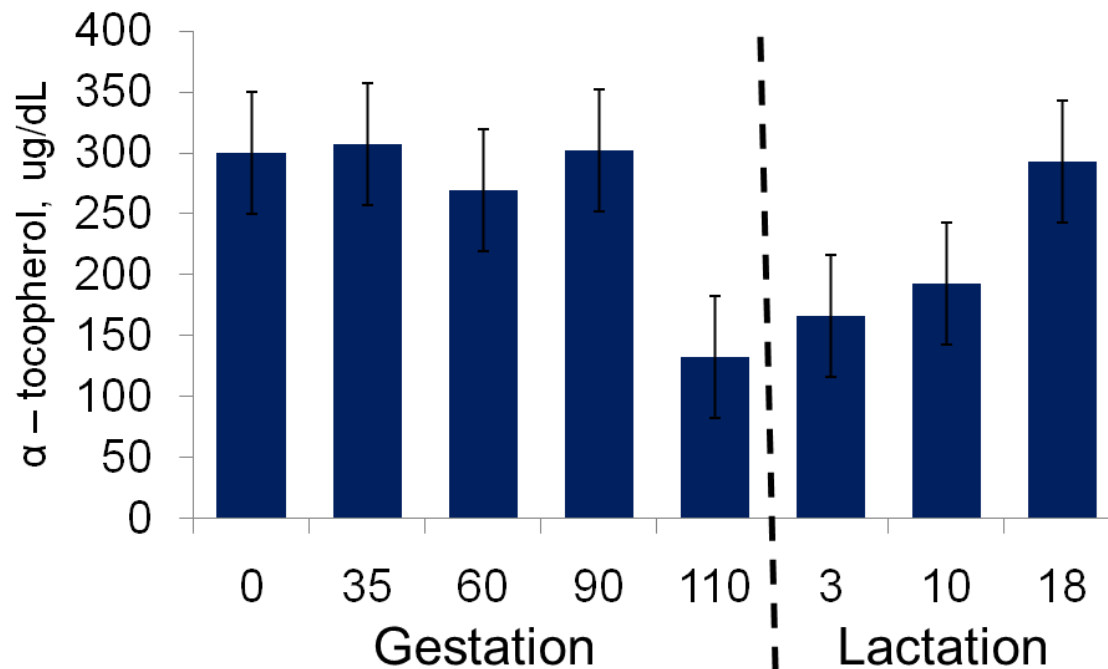


Animal 2011. 5:1774-1779

Pregnancy: Challenges 妊娠：挑战

With increased oxidative stress, antioxidant availability reduces during perinatal period

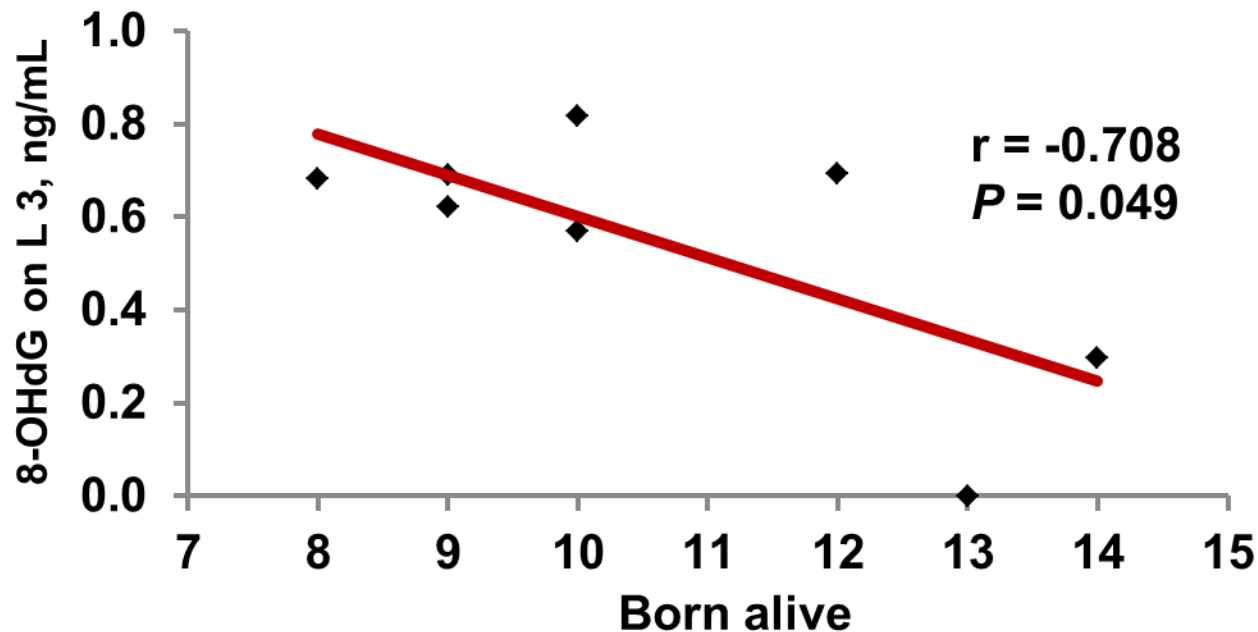
随着氧化应激的增加，围产期抗氧化能力降低



Animal 2011. 5:1774-1779

Pregnancy: Challenges 妊娠：挑战

Increased oxidative stress is negatively correlated to reproductive performance of sows
氧化应激增加与母猪繁殖性能呈负相关



Zhao et al., 2013. J Anim Sci. 91:5848-5858

Pregnancy: Challenges 妊娠：挑战

These problems are partly due to insufficient nutrient supply to sows during late gestation.

这些问题部分是由于妊娠后期母猪营养供给不足所致。

- **Failing nutritional supports for fetal and mammary growth** 没有足够的母猪营养支持胎儿和乳房的生长
- **Causing metabolic burdens to sows** 引起母猪的代谢负担

Suggestions! 建议!

Phase feeding or top dressing additional proteins during late gestation

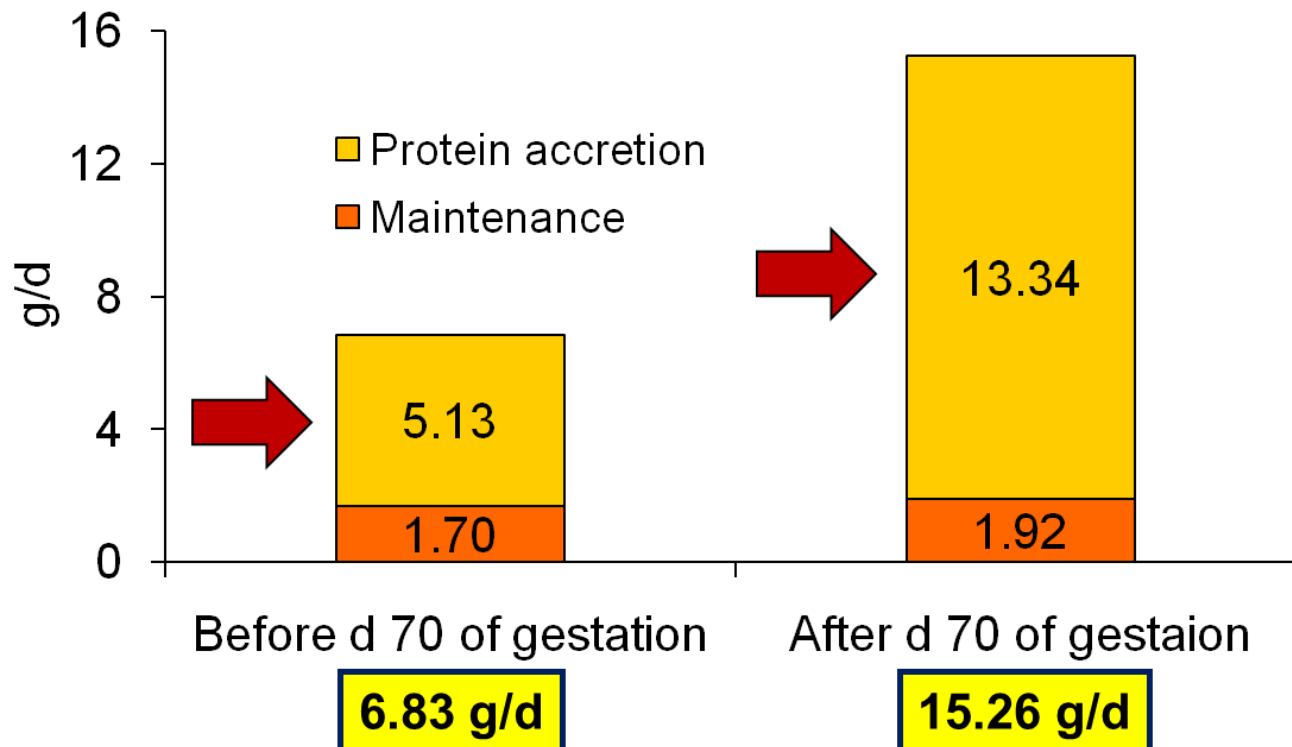
妊娠晚期进行阶段性喂养或补饲额外蛋白质

Why? 为什么?

Nutritional strategy for gestating sows

妊娠母猪的营养策略

The true ileal digestible lysine needs of gilts before and after d 70 of gestation (g/d)



J Anim Sci 2009. 87:E123-E132; *Rev Brasil de Zootecnia* 2010. 39:303-310

Nutritional strategy for gestating sows

妊娠母猪的营养策略

Procedures used to calculate requirements: 需求测定程序

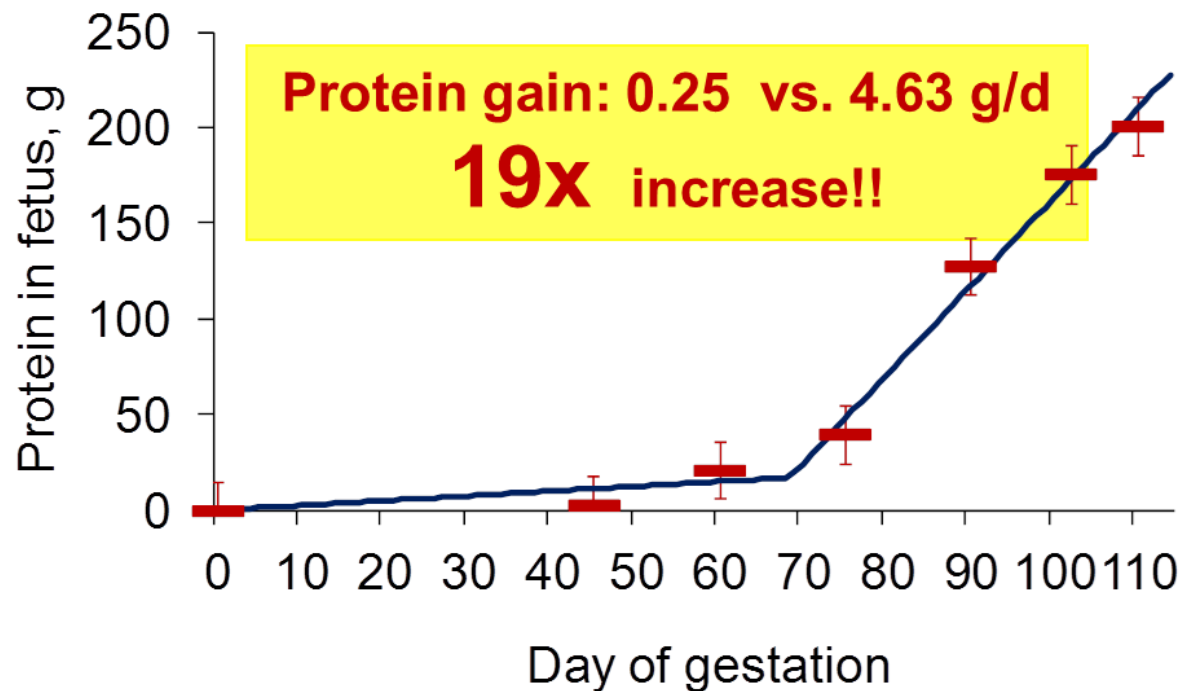
1. Fetal tissues were obtained (carcass, GIT, liver, etc) on different days of gestation. 采集妊娠不同时期的胎儿组织（胴体，消化道，肝脏等）
2. Composition of nutrients (protein, amino acids, fat, etc) in these tissues were measured. 测定了这些组织的营养成分（蛋白质、氨基酸、脂肪等）。
3. Changes in the amount and composition were determined during different stages of gestation. 在妊娠的不同阶段的组织的组成和含量的变化进行了测定。
4. So all values presenting here is based on actual nutrients accreted in tissues. So I can call them similar to **TID values**. 所以所有的价值呈现是基于实际营养增生组织。因此我可以称它们类似于真实回肠消化值。
5. Same for mammary glands and maternal body. 同样适用于乳腺和母体。

Kim et al., 2009. J Anim Sci. 87:E123-E132

Nutritional strategy for gestating sows

妊娠母猪的营养策略

- Protein accretion in fetuses mostly occurs during late gestation. 胎儿的蛋白质沉积主要发生在妊娠晚期



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Nutritional strategy for gestating sows

妊娠母猪的营养策略

- Protein accretion in fetuses mostly occurs during late gestation. 胎儿的蛋白质沉积主要发生在妊娠晚期

| AA, mg/d | d 0 to 70 | d 70 to F | Fold increase |
|----------|-----------|-----------|---------------|
| Lys | 19 | 283 | 15 |
| Thr | 10 | 162 | 16 |
| Trp | 3 | 56 | 19 |
| Met | 6 | 92 | 15 |
| Val | 13 | 211 | 16 |
| Leu | 20 | 332 | 17 |
| Ile | 9 | 142 | 16 |
| Arg | 16 | 317 | 20 |

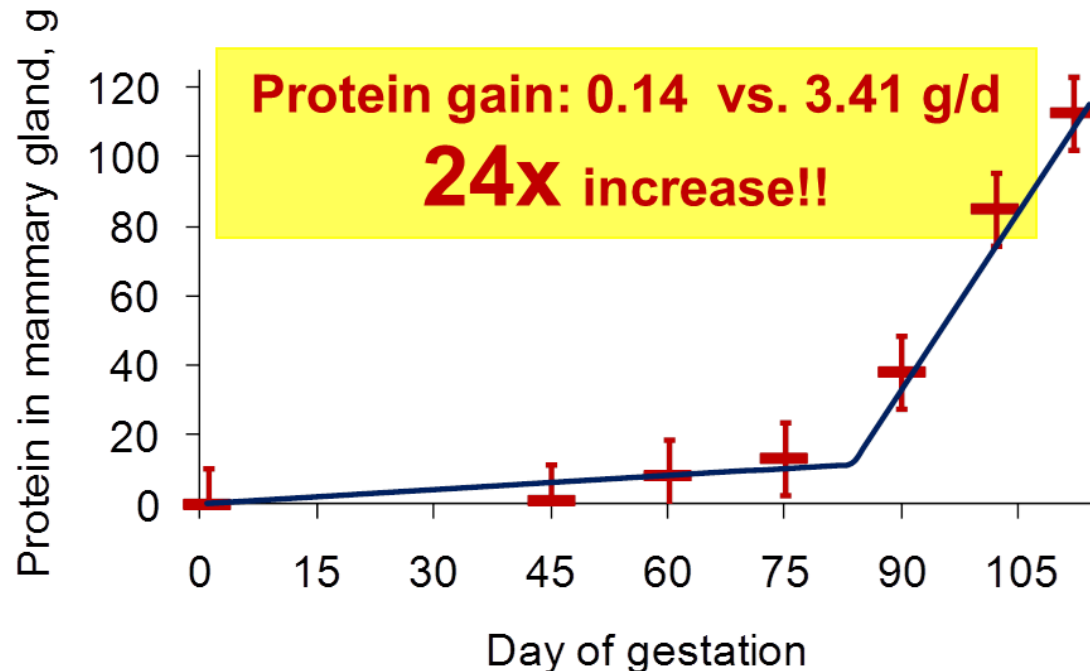
(BW at d 110: 1.47kg)

Kim et al., 2009. J Anim Sci. 87:E123-E132

Nutritional strategy for gestating sows

妊娠母猪的营养策略

- Protein accretion in mammary glands mostly occurs during late gestation. 乳腺的蛋白质沉积主要发生在妊娠后期。



Kim and Wu. 2009. Amino Acids. 37:89-95

Nutritional strategy for gestating sows

妊娠母猪的营养策略

- Protein accretion in mammary glands mostly occurs during late gestation. 乳腺的蛋白质沉积主要发生在妊娠后期。

| AA, mg/d | d 0 to 70 | d 70 to F | Fold increase |
|----------|-----------|-----------|---------------|
| Lys | 11 | 256 | 23 |
| Thr | 6 | 145 | 24 |
| Trp | 2 | 40 | 20 |
| Met | 3 | 68 | 23 |
| Val | 8 | 194 | 24 |
| Leu | 12 | 286 | 24 |
| Ile | 6 | 141 | 24 |
| Arg | 9 | 209 | 23 |

(Wt at d 110: 300 g)

Kim and Wu. 2009. Amino Acids. 37:89-95

Nutritional strategy for gestating sows

妊娠母猪的营养策略

Ideal protein 理想蛋白值

| AA | d 0 to 70 | d 70 to farrowing |
|-----|-----------|-------------------|
| Lys | 100.0 | 100.0 |
| Thr | 79.0 | 71.2 |
| Trp | 14.6 | 16.0 |
| Met | 25.2 | 27.1 |
| Val | 65.0 | 66.4 |
| Leu | 88.3 | 95.3 |
| Ile | 58.6 | 55.5 |
| Phe | 50.1 | 51.8 |
| Arg | 89.3 | 97.9 |
| His | 35.9 | 35.5 |

Kim et al., 2009. J Anim Sci. 87:E123-E132

Nutritional strategy for gestating sows

妊娠母猪的营养策略

KIM MODEL FOR GESTATING SOWS



| | | |
|---------------------------|------|-------|
| Sow BW at breeding | 160 | |
| Sow BW gain | 40 | |
| Fetus (n) | 14 | |
| Mammary gland (n) | 17 | |
| Suggested AA Requirements | | |
| Gestation | 0-70 | 70-F |
| Lys | 3.69 | 12.18 |
| Thr | 3.60 | 8.75 |
| Trp | 0.67 | 2.16 |
| Met | 0.97 | 3.45 |
| Val | 2.42 | 8.60 |
| Leu | 3.12 | 12.42 |
| Ile | 2.31 | 6.82 |
| Arg | 3.13 | 11.54 |

Kim et al., 2010. Rev Brasil de Zootecnia. 39:303-310

Nutritional strategy for gestating sows

妊娠母猪的营养策略

KIM MODEL FOR GESTATING SOWS

By the number of fetuses

| Fetus # | 70 to farrowing | | | |
|---------|-----------------|-------|-------|-------|
| | 6 | 9 | 12 | 15 |
| Lys | 15.05 | 15.09 | 15.13 | 15.17 |
| Thr | 10.92 | 10.88 | 10.83 | 10.79 |
| Trp | 2.27 | 2.34 | 2.42 | 2.50 |
| Met | 3.94 | 4.02 | 4.10 | 4.18 |
| Val | 9.59 | 9.78 | 9.96 | 10.15 |
| Leu | 13.58 | 13.93 | 14.28 | 14.64 |
| Ile | 8.42 | 8.41 | 8.41 | 8.40 |
| Arg | 14.58 | 14.68 | 14.77 | 14.87 |

Kim et al., 2010. Rev Brasil de Zootecnia. 39:303-310

Nutritional strategy for gestating sows

妊娠母猪的营养策略

KIM MODEL FOR GESTATING SOWS

By the number of MG

| MG # | 70 to farrowing | | | |
|------|-----------------|-------|-------|-------|
| | 12 | 14 | 16 | 18 |
| Lys | 14.74 | 15.13 | 15.52 | 15.90 |
| Thr | 10.63 | 10.83 | 11.04 | 11.25 |
| Trp | 2.35 | 2.42 | 2.48 | 2.55 |
| Met | 3.99 | 4.10 | 4.20 | 4.31 |
| Val | 9.64 | 9.96 | 10.28 | 10.60 |
| Leu | 13.81 | 14.28 | 14.76 | 15.23 |
| Ile | 8.19 | 8.41 | 8.62 | 8.84 |
| Arg | 14.49 | 14.77 | 15.06 | 15.34 |

Kim et al., 2010. Rev Brasil de Zootecnia. 39:303-310

Nutritional strategy for gestating sows

妊娠母猪的营养策略

- In feeding sows with 30 PSY, different **quantity** and **quality** of nutrients (especially amino acids, antioxidants, etc.) are needed depending on
 - # of fetuses and mammary glands during late gestation (**phase feeding or topdressing**)
- 在喂养PSY为30的母猪时，需要不同数量和质量的营养物质（尤其是氨基酸，抗氧化剂等），
 - 而且取决于在妊娠晚期胎儿和乳腺的数量（阶段喂养或补饲）

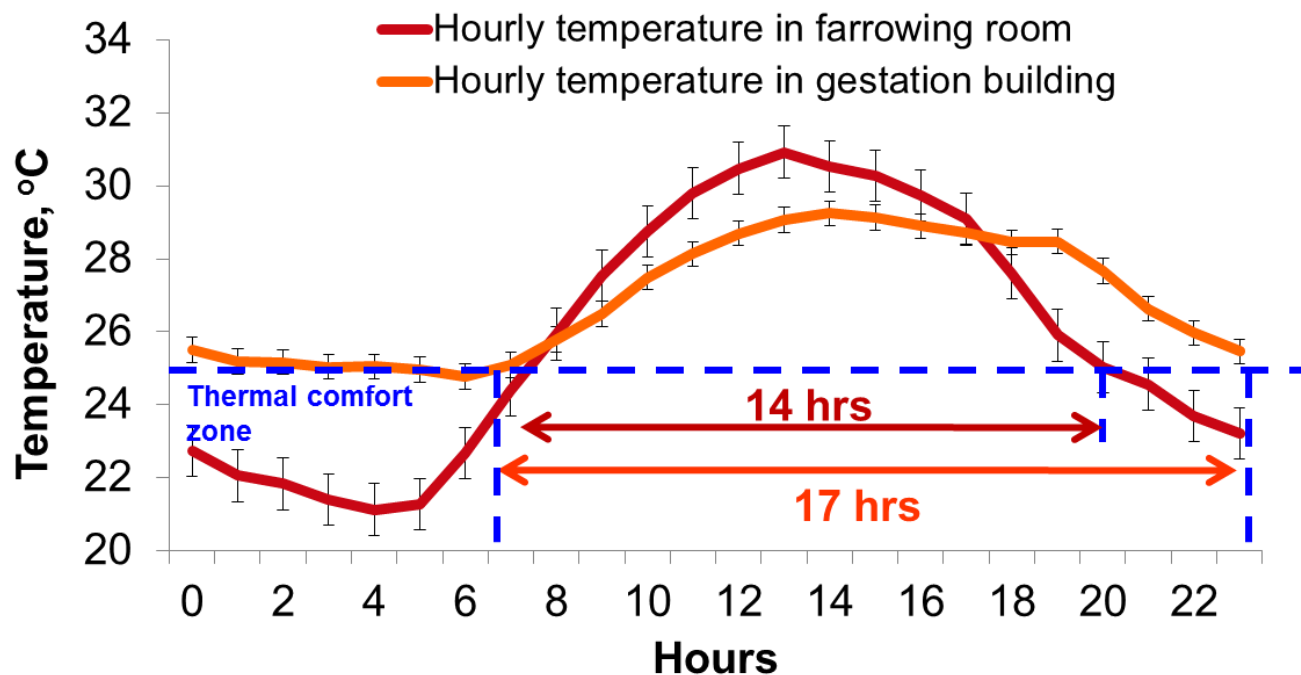
Others to consider 其他考虑因素

- Some other factors to consider for sow management.
- 母猪管理需要考虑的一些其他因素



Others to consider: Heat stress 热应激

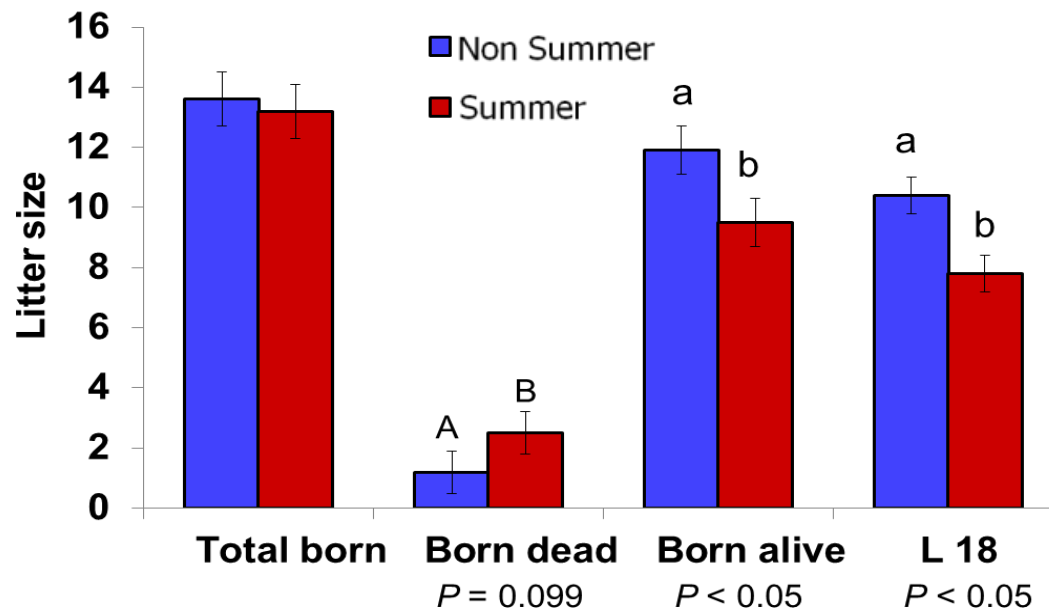
- Hyperthermal stress 高温应激
 - Summer in North Carolina



Zhao et al., 2013. J Anim Sci. 91:5848-5858

Others to consider: Heat stress 热应激

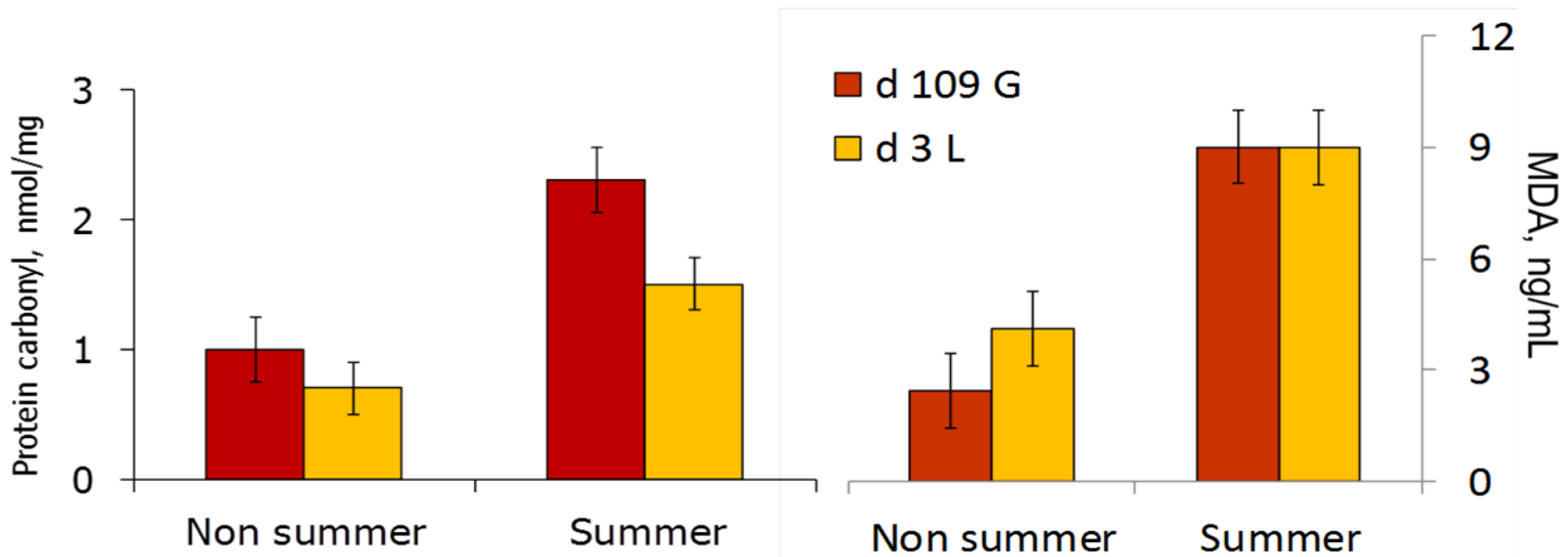
- Heat stress during perinatal period affects maternal nutrition and neonatal growth. 围产期热应激影响母猪营养需求及胎儿生长发育。



Zhao et al., 2013. *J Anim Sci.* 91:5848-5858

Others to consider: Heat stress 热应激

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Zhao et al., 2013. *J Anim Sci.* 91:5848-5858

Others to consider: Social stress

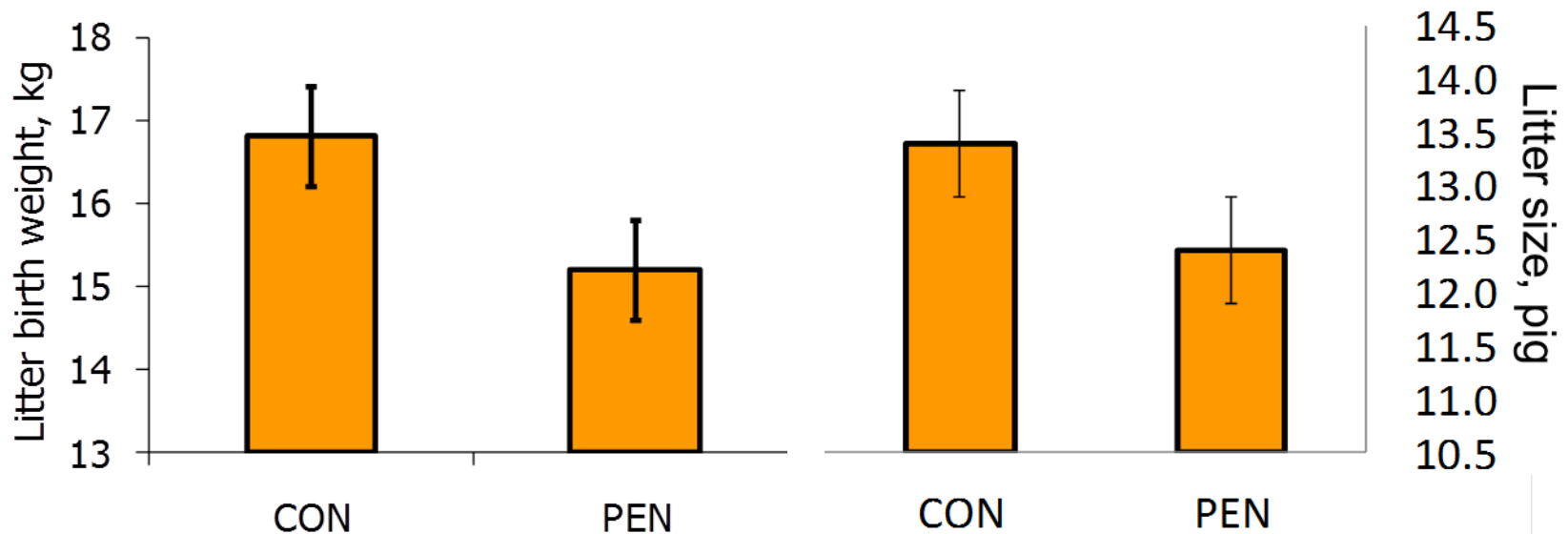
社群应激



Others to consider: Social stress

社群应急

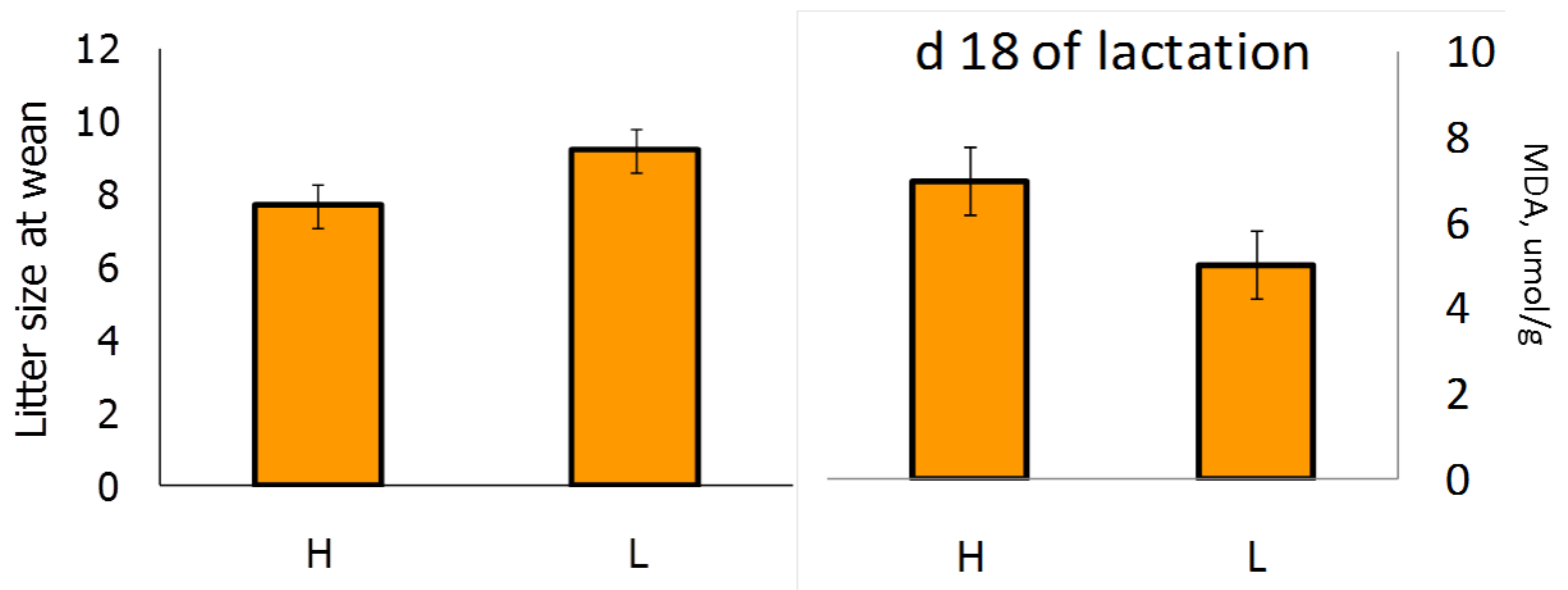
- Sows in small pens during gestation had reduced reproductive performance compared with sows in gestation stalls. 妊娠期的母猪在小围栏里的繁殖能力低于在单个妊娠栏。



Zhao et al., 2013. *J Anim Sci.* 91:5848-5858

Others to consider: Social stress 社群压力

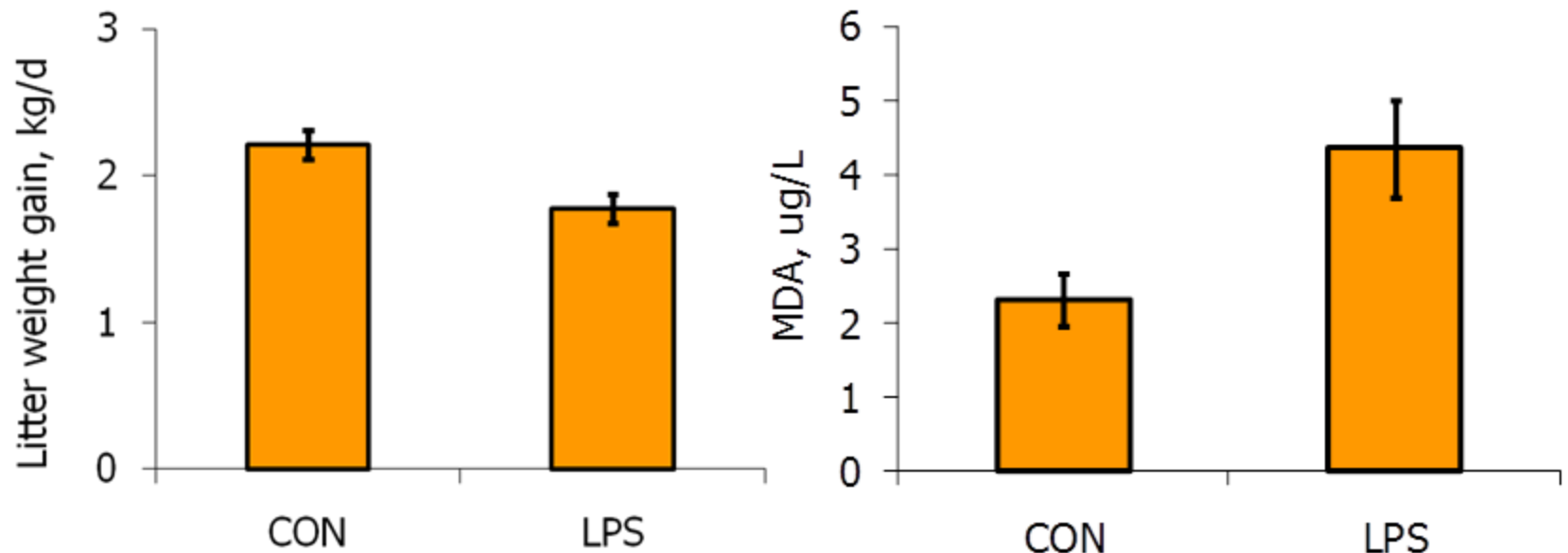
- Aggressive sows in small pens can get higher oxidative stress. 活跃性强的母猪在小围栏能够获得更高的氧化应激。



Zhao et al., 2013. *J Anim Sci.* 91:5848-5858

Others to consider: Endotoxin 内毒素

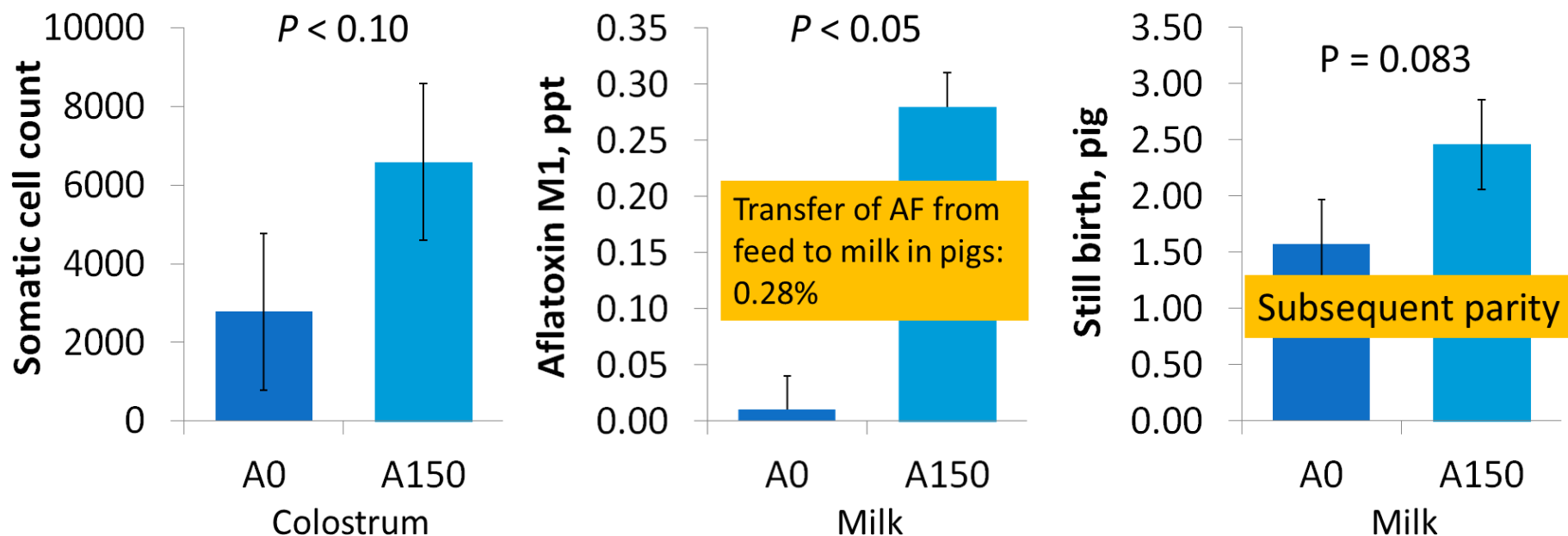
- Endotoxin stress during perinatal period affects maternal nutrition and neonatal growth (4 x 30 μg LPS/kg BW). 围产期内毒素应激影响妊娠母猪营养和胎儿生长。



Kim et al., Rev Brasil de Zootecnia 2010. 39:303-310

Others to consider: Mycotoxins 真菌毒素

- Low MT cause problems by damaging MG, fetal health, and reproductive outcome. 低剂量的霉菌毒素就可以破坏乳腺，胎儿健康和繁殖结果。



Weaver et al., 2017. Unpublished

Conclusion 结论

- In feeding sows with 30 PSY 在喂养PSY为30的母猪时
 - Increased requirements for nutrients (especially protein/amino acids, antioxidants, minerals, and vitamins) during late gestation: phase feeding or topdressing of 'Sow Pak' (?) 在妊娠晚期，营养需求增加（尤其是蛋白质/氨基酸、抗氧化剂、矿物质和维生素）：阶段饲喂或补饲母猪营养包
 - Consider avoiding heat stress, social stress, endotoxin stress, mycotoxin stress in sow management. 在母猪管理的时候，要考虑到避免热应激，社群应激，内毒素应激和霉菌毒素应激。

Thank you!

Thoughts? Questions?

