高产母猪终身生产效率最大化的饲养和营养方案

Precision nutrition and feeding of highly prolific sows

Peter Kappel Theil

Professor

Lactation physiology and monogastric nutrition

Department of Animal Science

Aarhus University

Denmark

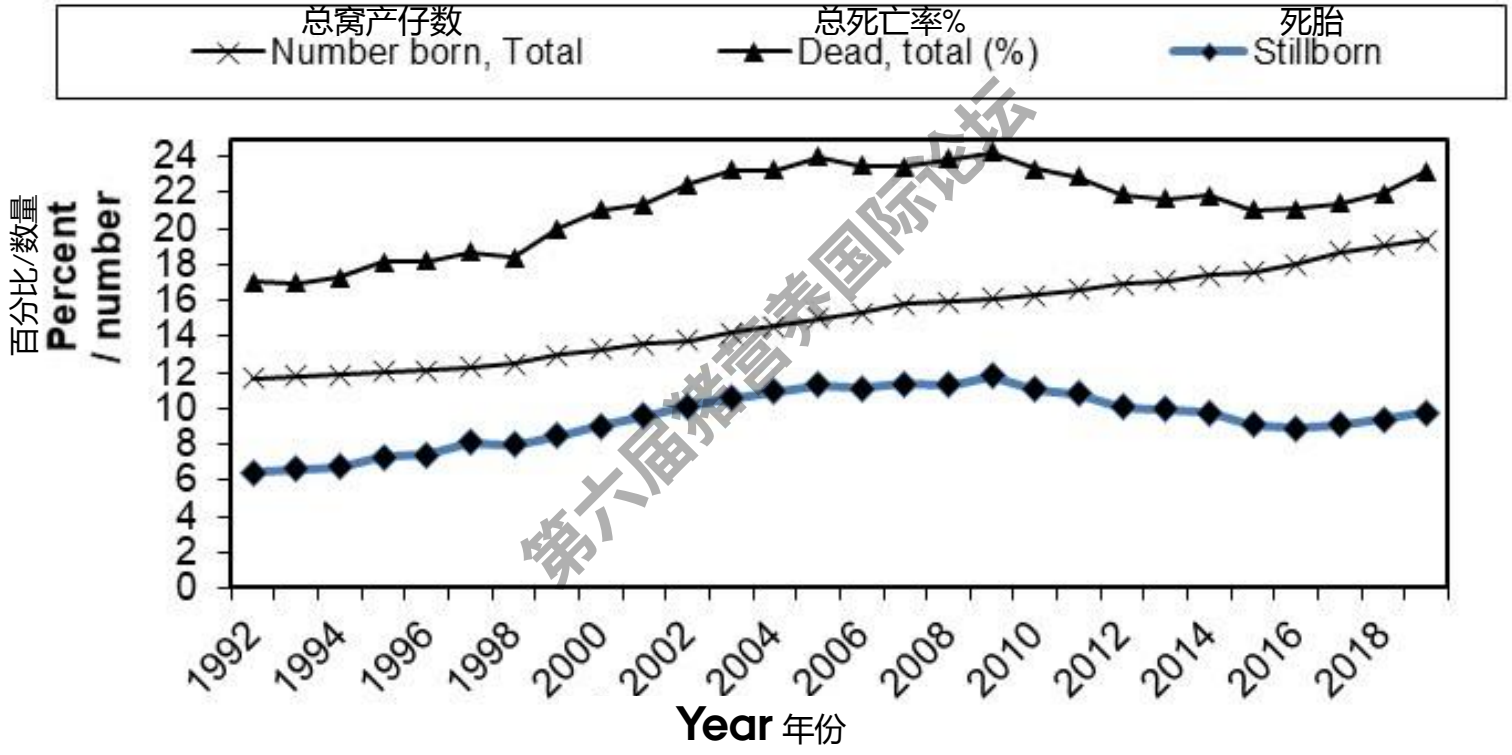
主要内容 Agenda

- *饲养妊娠早期母猪以恢复背膘 Feeding early gestating sows to restore back fat*
- *饲养妊娠后期母猪以达到最大化乳腺生长 Feeding late gestating sows to maximize mammary growth*
- *饲养围产期过渡母猪以达到最大化仔猪存活率 Feeding transition sows to maximize piglet survival*
- *饲养哺乳母猪以达到最大化产奶量 Feeding lactating sows to maximize milk production*
- *实现母猪的高饲料效率 Achieving high feed efficiency of sows*

由于遗传选择母猪的繁殖力变化迅速
Sow productivity change rapidly due to genetic selection

丹麦的窝产仔数和仔猪死亡率情况

Development in litter size and piglet mortality in DK

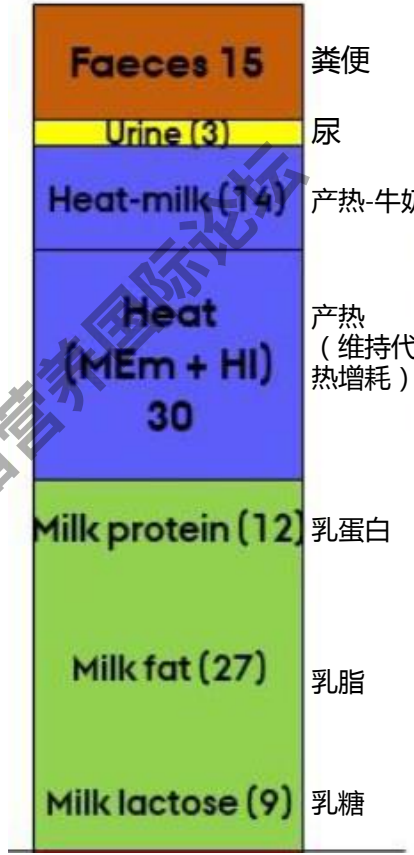


哺乳母猪的能量利用 Fuels and energy utilization in lactating sows

碳水化合物
Carbohydrates

蛋白质
Protein

脂肪Fat



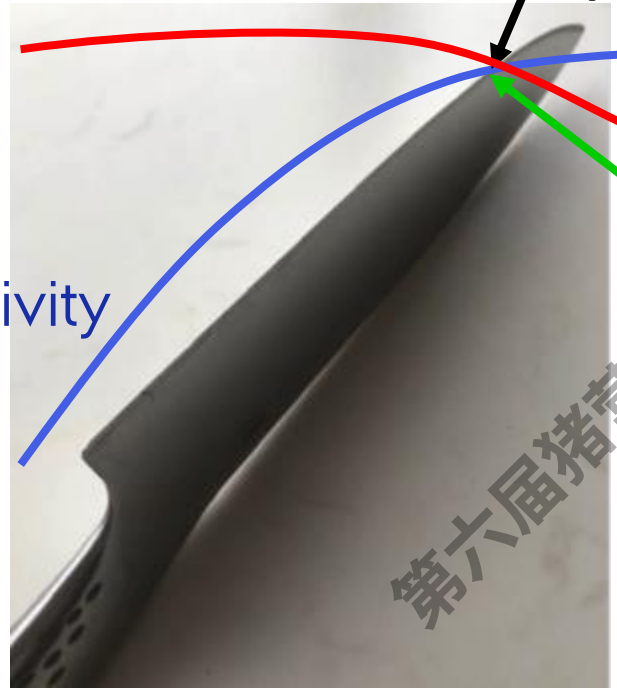
(Theil et al., 2020)

母猪营养是一种微妙的平衡 Sow nutrition is a delicate balance

动物需要量 Animal Requirement

生产力损失
Loss of
productivity

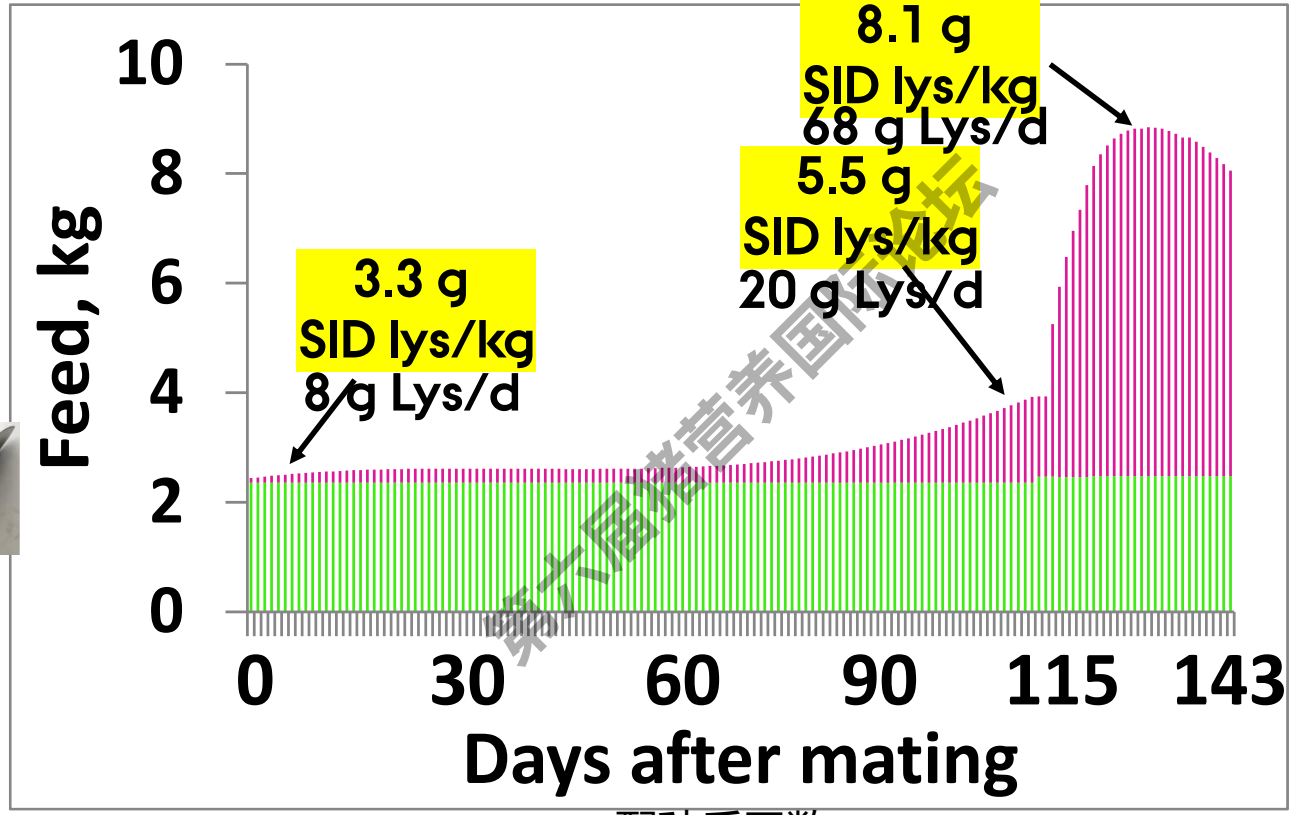
饲料效率损失
Loss of
feed efficiency



养猪生产对气候和环境的影响最小 Minimal impact of swine production on climate and environment

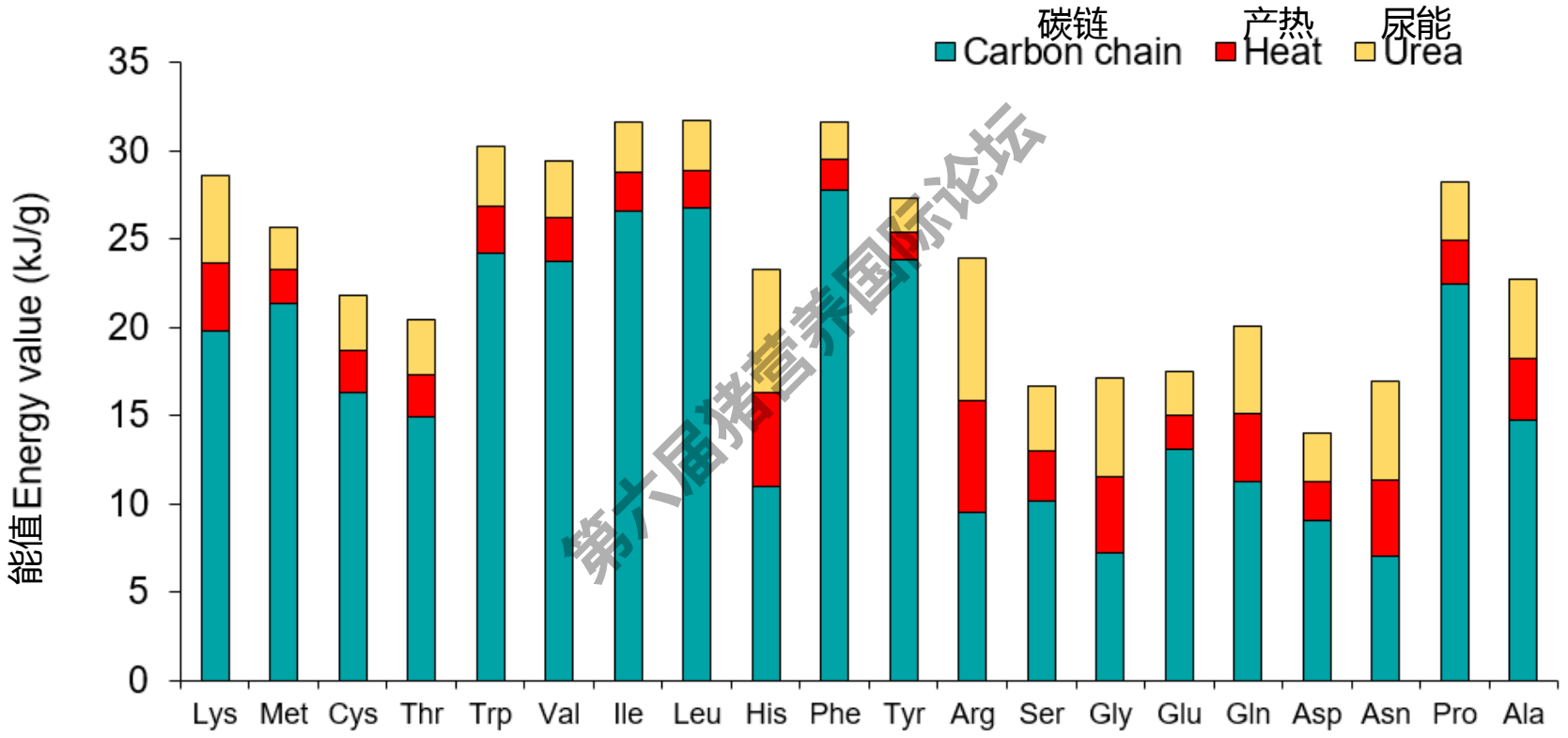
增加日粮营养浓度 Increasing dietary concentration of nutrient (g/kg)

妊娠和哺乳母猪最佳饲喂策略 Optimal feeding strategy for gestating and lactating sows



(Modified after Feyera & Theil, 2017; Feyera et al., 2020)

过量氨基酸的净能值（哺乳动物中）
NET ENERGY VALUES OF EXCESS AMINO ACIDS (IN MAMMALS)



多胎次妊娠母猪背膘需要恢复
Back fat needs to be restored in multiparous gestating sows

泌乳Lactation

体脂 Body fat
12 kg ↓

(Hojgaard et al., 2019, Wisbech et al., 2020)

妊娠Gestation

体脂Body fat
374 g/d ↑

体蛋白Body protein
129 g/d ↑

饲料过剩 Excess feed d 0-30

体脂 Body fat: 11.2 kg ↑

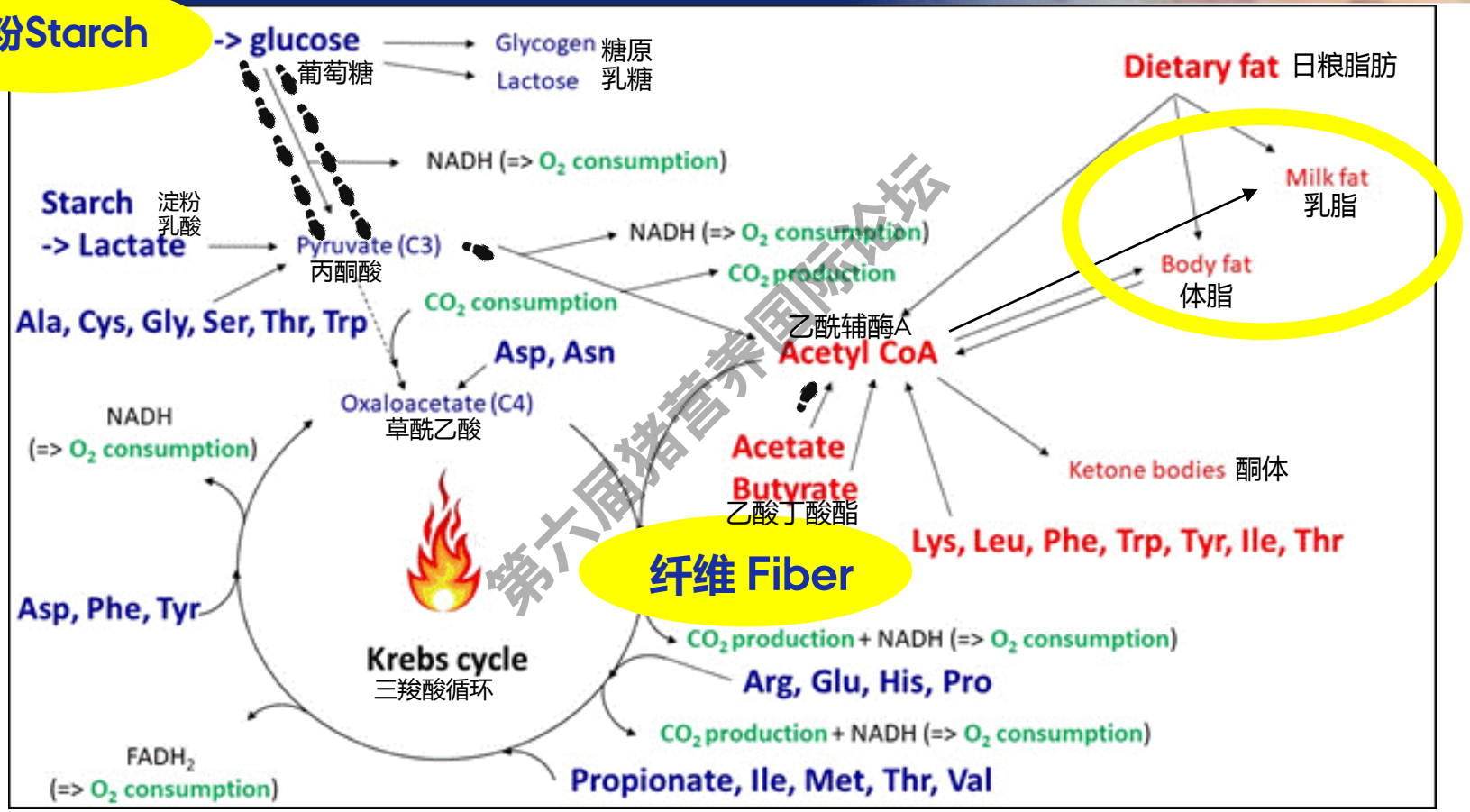
体蛋白 Body protein: 3.9 kg ↑

额外饲料需要 Extra feed needed:

47kg/头/年 47 kg/sow/year

36t/群/年 36 t/herd/year (~3 %)!

细胞内的能量代谢 ENERGY METABOLISM IN CELLS



(Theil et al., 2020, Wisbech et al., 2022)

如何有效恢复背膘？How may back fat be restored efficiently?

增加日粮纤维含量= > 降低产热 Increased dietary fiber content => reduces heat production

- 纤维减少身体活动 Fiber reduces physical activity (Rijnen et al., 2003)
- 纤维增加脂肪沉积 Fiber increases fat retention (Wisbech et al., 2022)
- 淀粉- > 脂肪：1/3的碳以二氧化碳形式损失 Starch -> Fat: 1/3 of the carbons are lost as CO_2

(Theil et al., 2020)

在妊娠早期使用低蛋白日粮 Use low dietary protein in early gestation

- 阶段饲喂 Phase feeding (< 3 g SID lys/kg) d 0-30
- 或在整个妊娠期间双料饲喂 Or two-component feeding throughout gestation

体况恢复需要的饲料 Feed needed to restore lost body condition

恢复1mm损失的背膘需要21-29kg饲料　21-29 kg of feed is needed to restore 1 mm lost backfat

恢复1kg损失体重需要1.9kg饲料　1.9 kg of feed is needed to restore 1 kg of lost body weight

(Wisbech et al., 2022)

赖氨酸供应对妊娠后期的影响 Impact of lysine supply in late gestation

使用同位素标记86-104d需要量 Requirement using isotopes d 86-104: 17.4 g SID Lys/d

(Samuel et al., 2012)

每天24gSID赖氨酸时乳产品达到最大 Maximal colostrum yield achieved at 24 g SID Lys/d

(增加饲料水平的剂量反应 Dose response with increasing feed levels)

(Feyera et al., 2021)

每天26gSID赖氨酸与18g相比，乳腺实质肿块增加44% 26 vs 18 g SID Lys/d increased mammary parenchymal mass 44%

(Farmer et al., 2022)

分娩时的生理和营养 PHYSIOLOGY AND NUTRITION AT ONSET OF FARROWING

-12 -> -1 h

筑巢 Nest-building

(身体活动Physical activity)

0 -> +7 h

分娩 Farrowing

(子宫收缩Uterine contractions)

0 -> +24 h

初乳 Colostrum

生产 Production

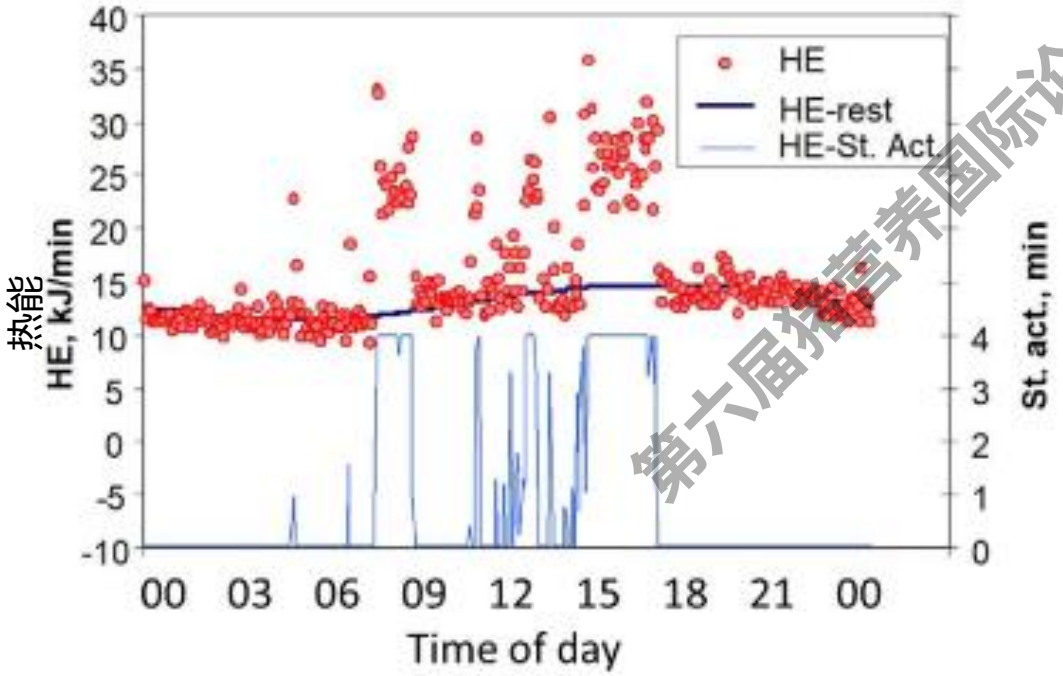
葡萄糖是分娩当天的限制性因素

Glucose is a limiting factor at the day of farrowing

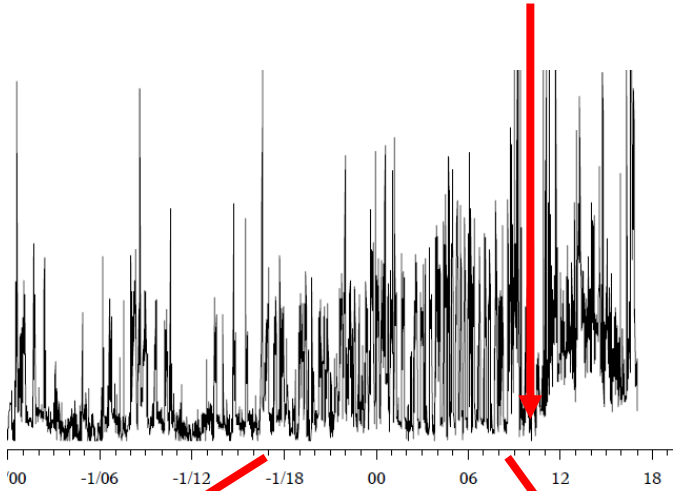
(Theil et al., 2022)

筑巢，身体活动和产热 Nest building, physical activity and heat production

站立活动使母猪产热翻倍 Standing activity doubles the heat production of sows (Theil, 2022)



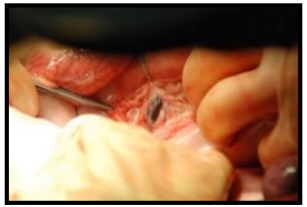
开始分娩 Start of farrowing

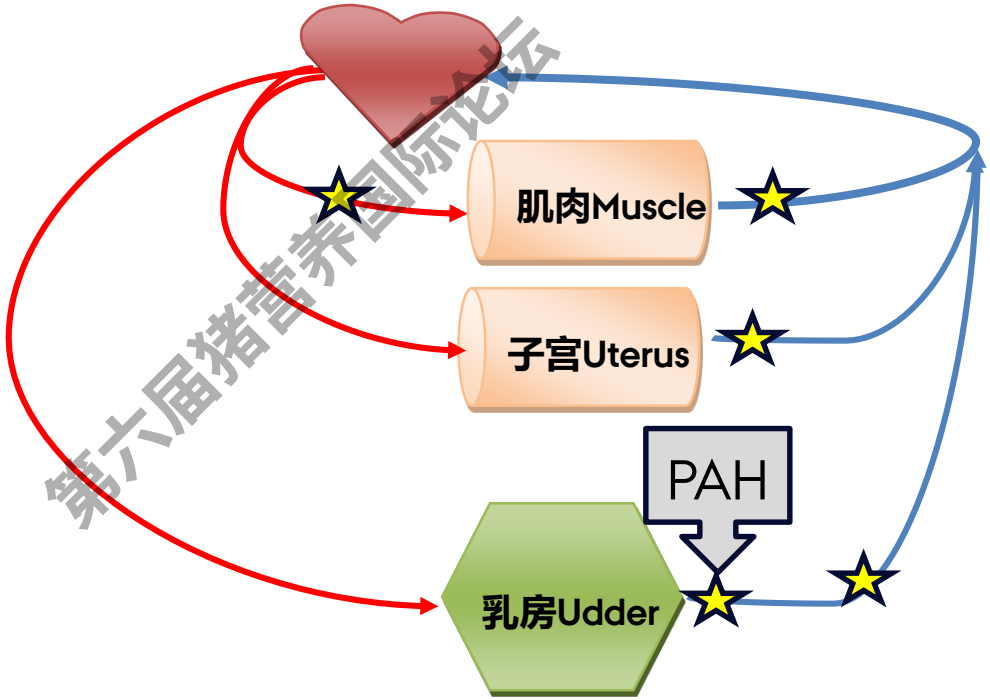


15h筑巢15 h of nest building

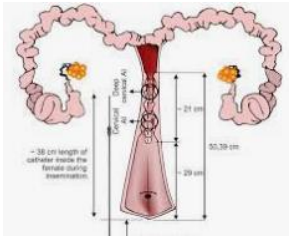
多导管母猪（器官水平）Multicatheterised sows (Organ level)

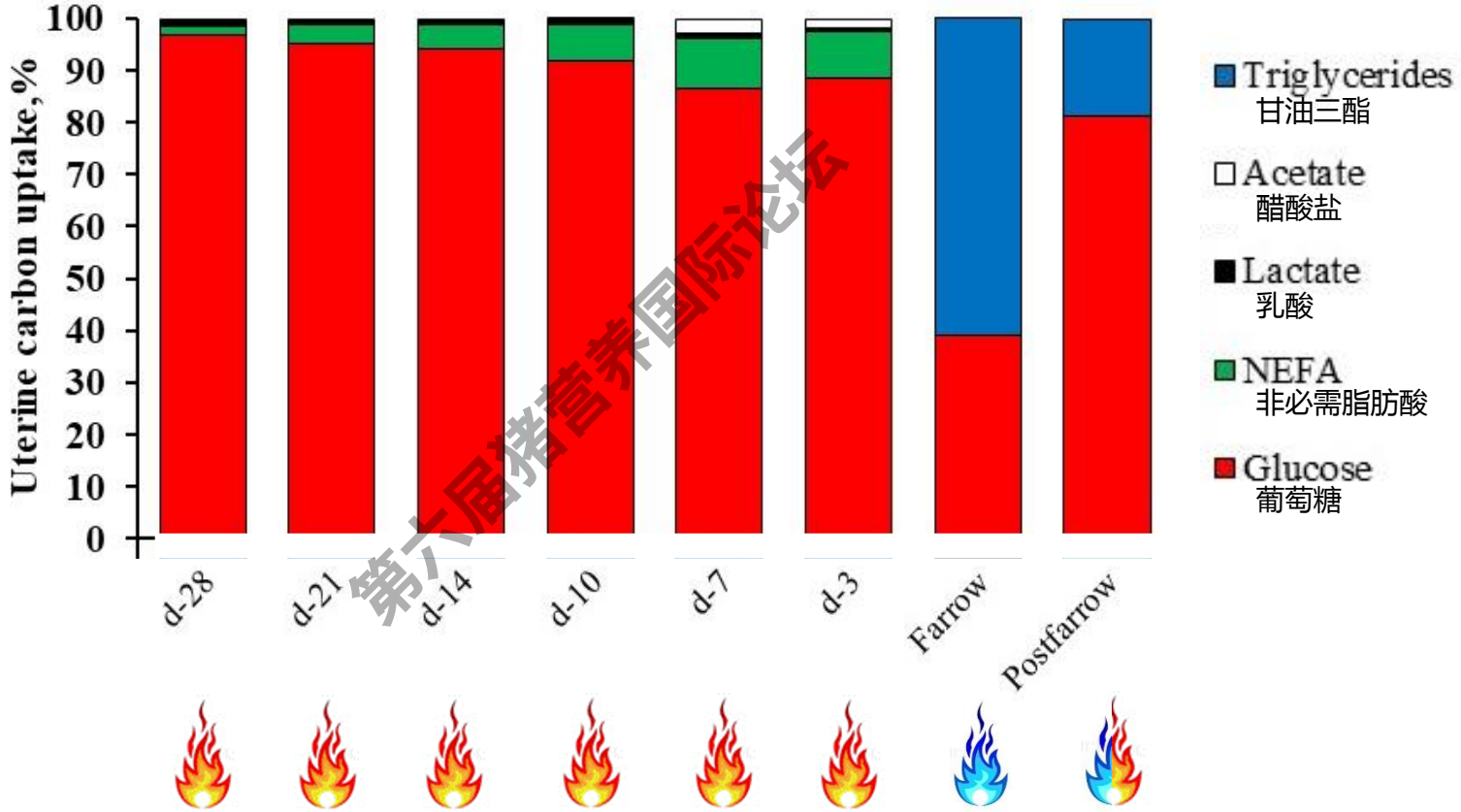
子宫和乳腺代谢 Uterus and mammary metabolism





哪些代谢物在子宫中用作燃料 ？
Which metabolites are used as fuel in the uterus?





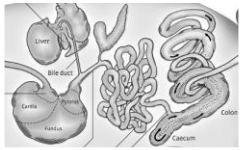
(Theil et al., 2020)

分娩时各器官间葡萄糖的优先次序
Prioritization of glucose at farrowing among organs

380 g

胃肠道GI-tract

(门静脉portal vein)

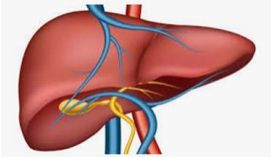


150 g

(肝脏中糖原储存库Glycogen-depot in liver)

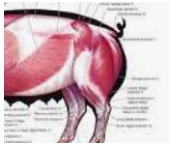
净通量+Net flux

15 g



-Net flux

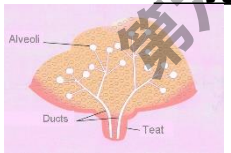
-Net flux



1. 肌肉Muscles

Ox.

300 g 糖原库 Glycogen depot



2. 乳腺Mammary

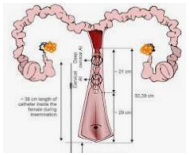
Ox.

270 g 乳糖Lactose

乳脂 Milk fat

3. 子宫Uterus

Ox.



200 g (?)

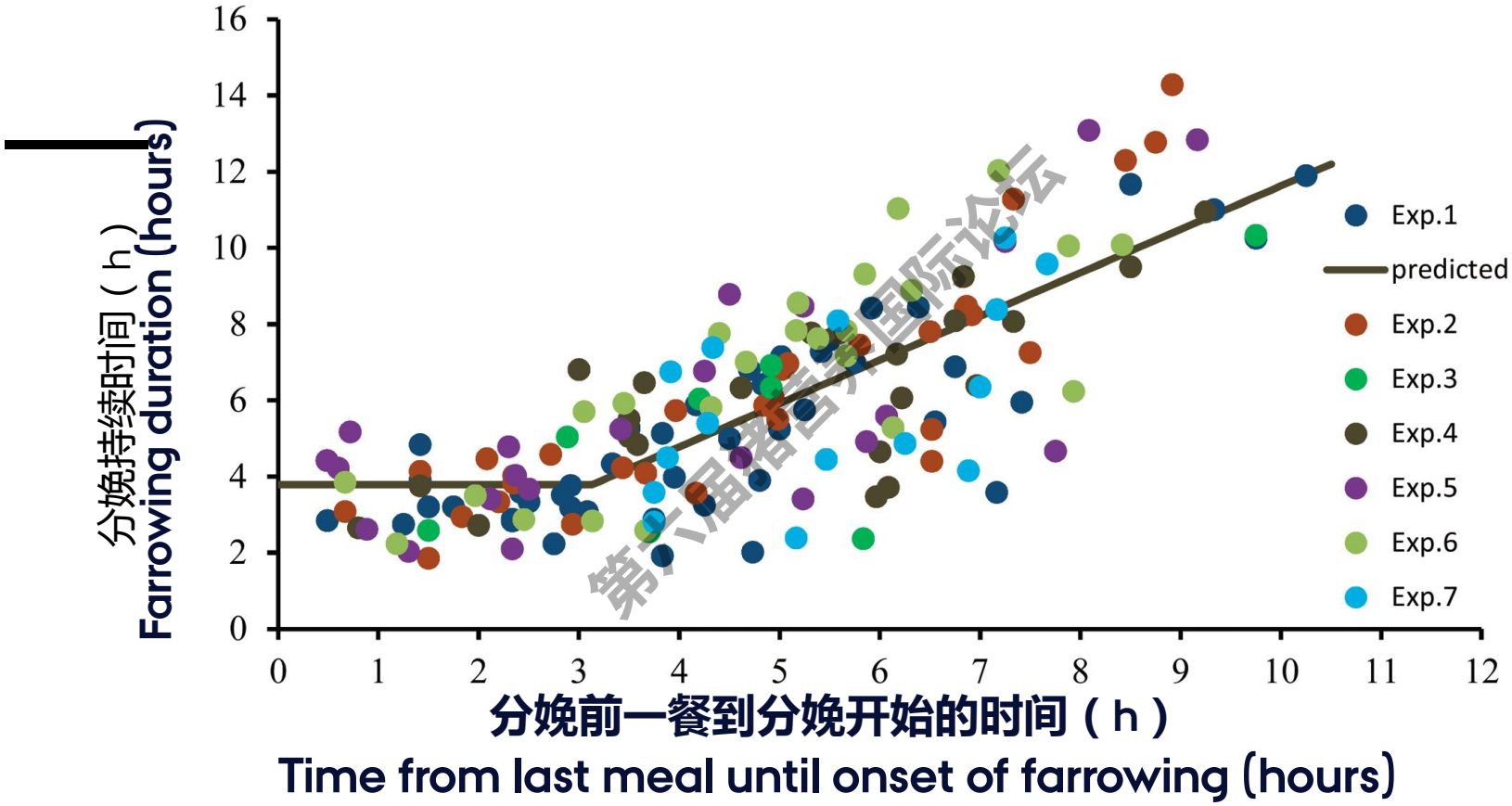
肝脏 Liver

(Ox.)

糖原库 Glycogen depot

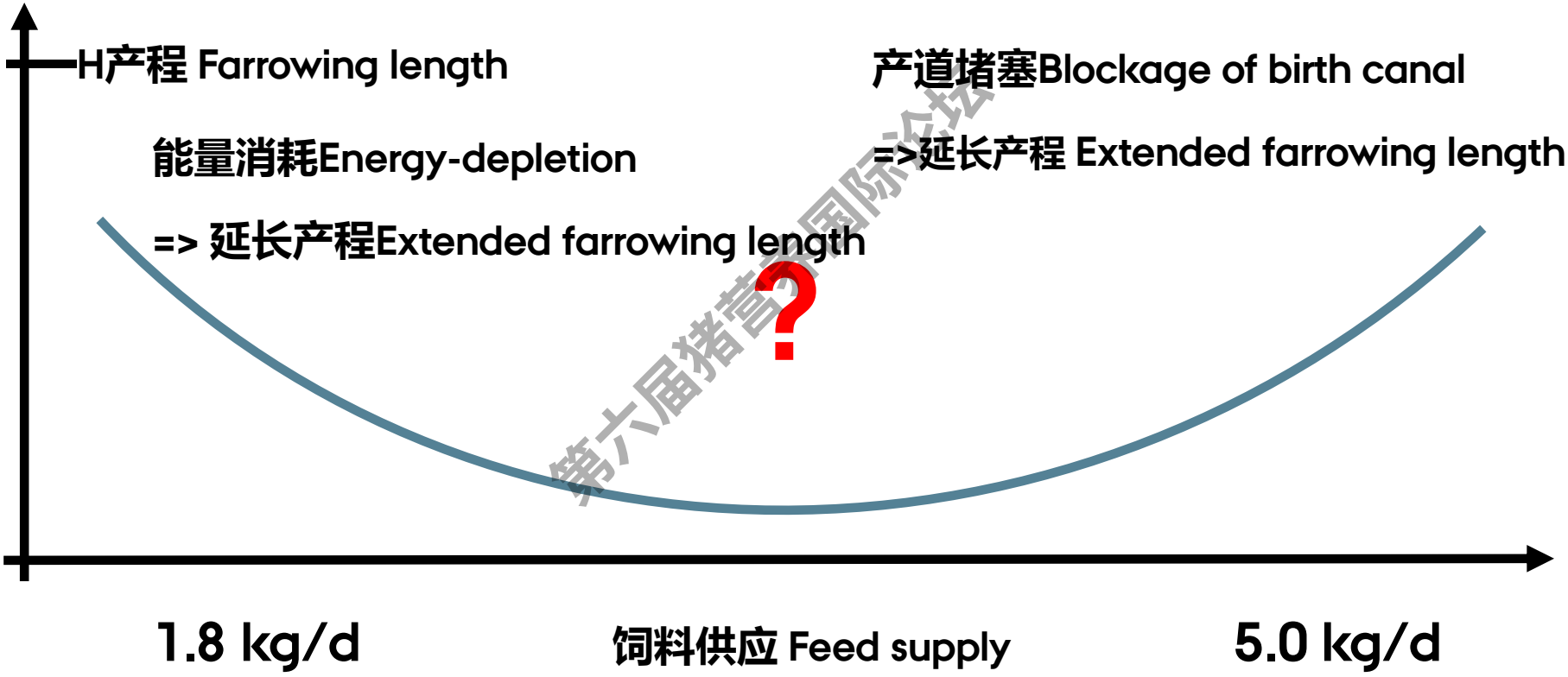
(脂肪合成Fat synthesis)

分娩前一餐和分娩持续时间
TIMING OF LAST MEAL AND FARROWING DURATION

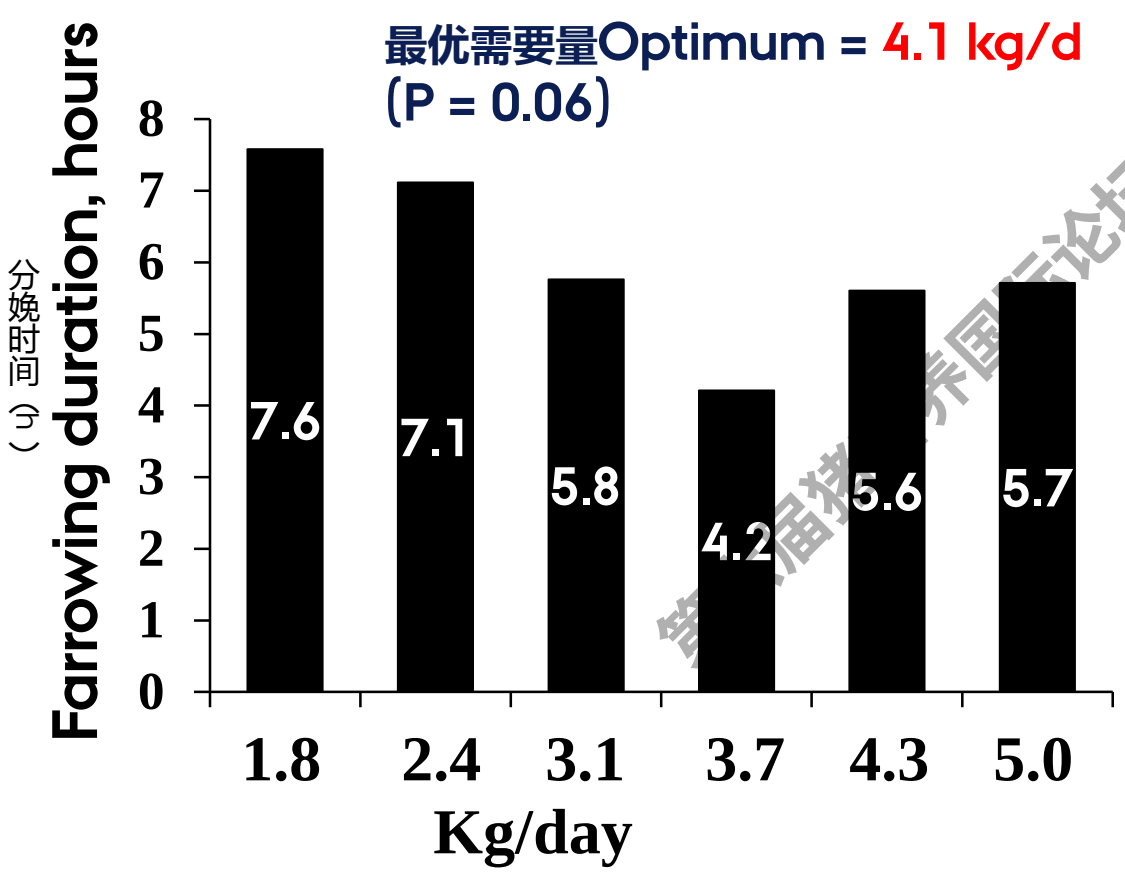


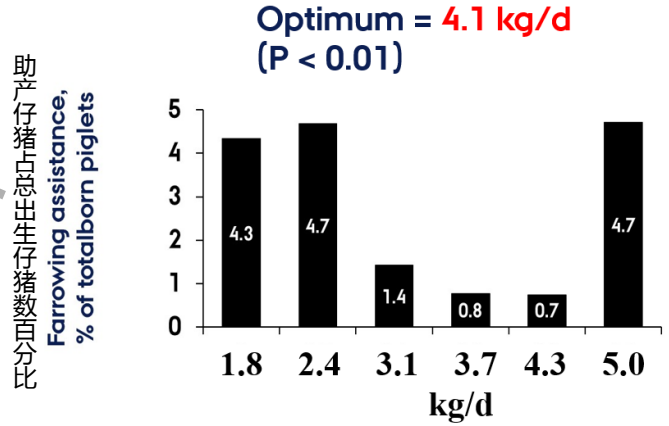
(Feyera et al., 2018)

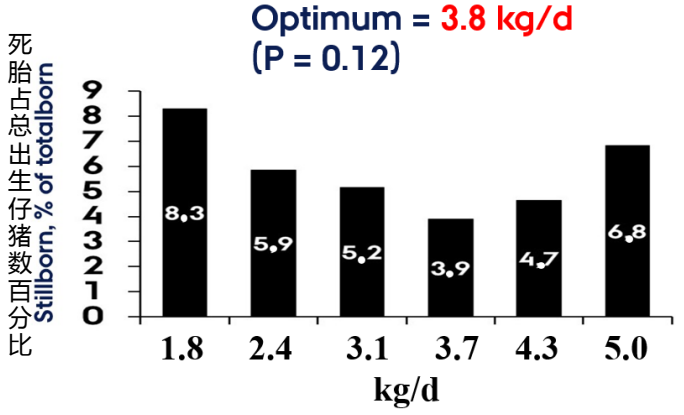
饲料供应对分娩时间的影响
EXPECTED IMPACT OF FEED SUPPLY ON FARROWING DURATION



分娩时的最优饲料需要量
AMOUNT OF FEED NEEDED TO OPTIMIZE THE FARROWING PROCESS

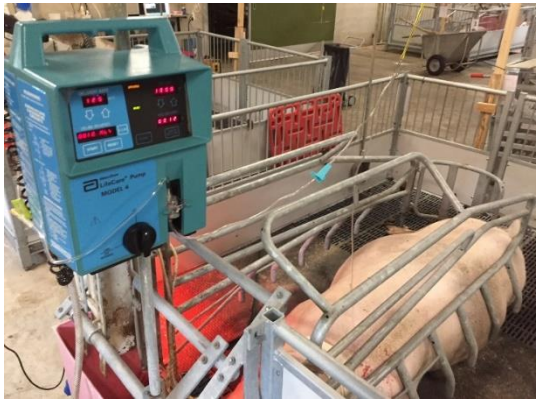






Feyera et al. (2021)

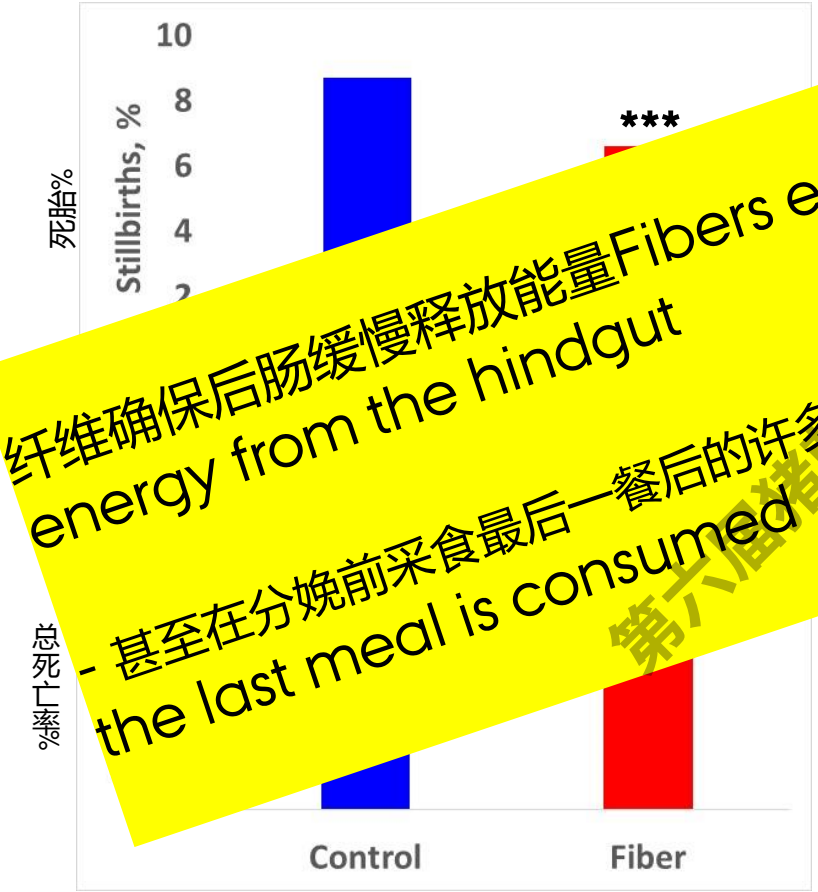
注入葡萄糖以确保分娩过程的能量
GLUCOSE INFUSED TO ENSURE ENERGY FOR FARROWING PROCESS

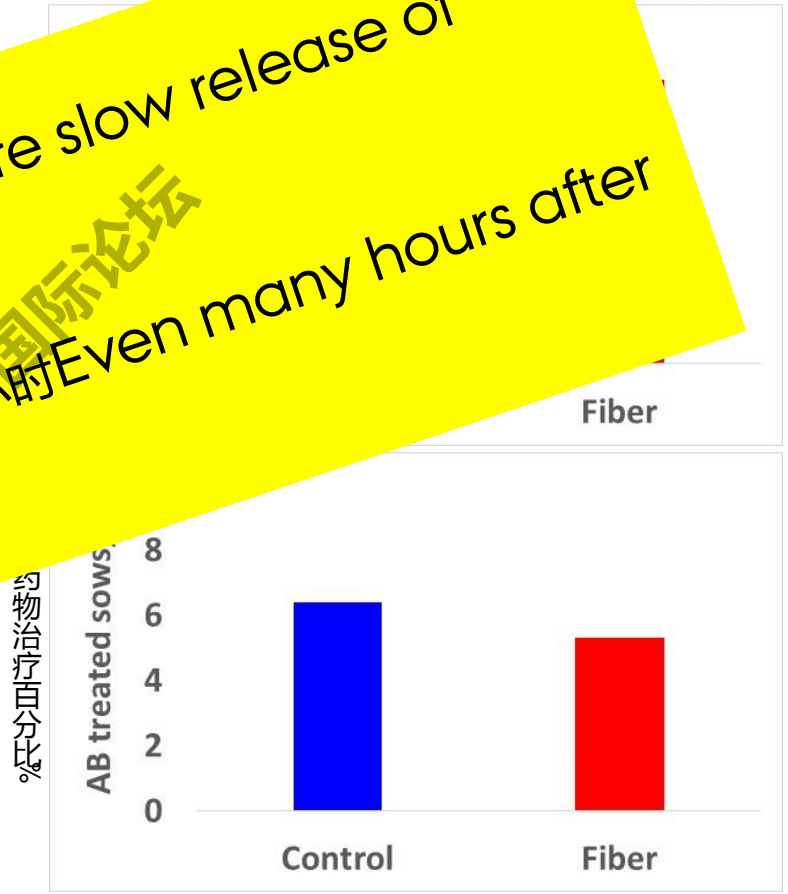


筑巢和分娩期间注入300g葡萄糖
300 g glucose infused during nest building and farrowing
母猪饲喂1次/天，3.3kg/天
Sows were fed 1 meal/day, 3.3 Kg/day)

死胎率 Stillbirth rate: 16.1-> 7.4% (P < 0.05)
助产 Farrowing assistance: 21 -> 9% (P = 0.01)
血浆葡萄糖下降 Plasma glucose dropped!: 5.53 -> 5.09 mM (P 0.03)
初乳产量 Colostrum yield: 6.7 -> 7.1 kg (N. S.)

分娩前最后两周补充纤维
FIBER SUPPLEMENTATION THE LAST 2 WEEKS BE... ...WING





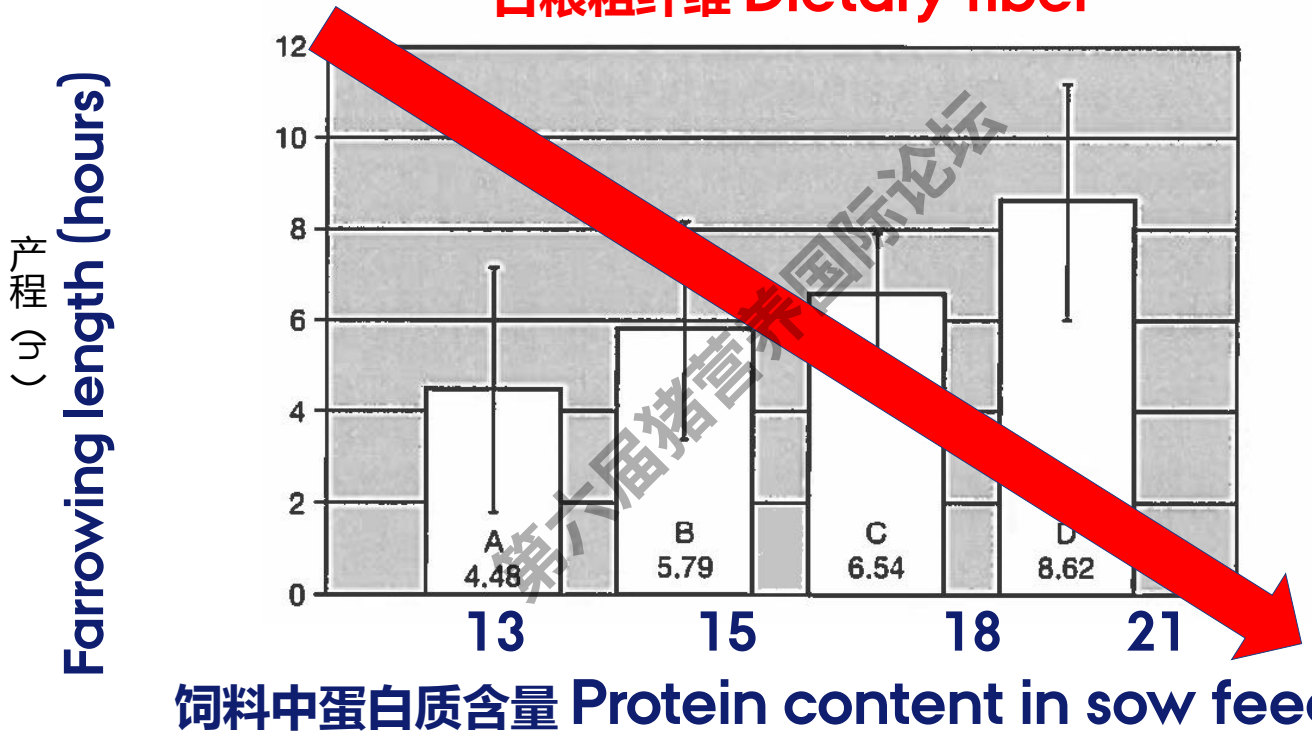
纤维确保后肠缓慢释放能量Fibers ensure slow release of energy from the hindgut

- 甚至在分娩前采食最后一餐后的许多个小时Even many hours after the last meal is consumed

Bruun et al. (2015)

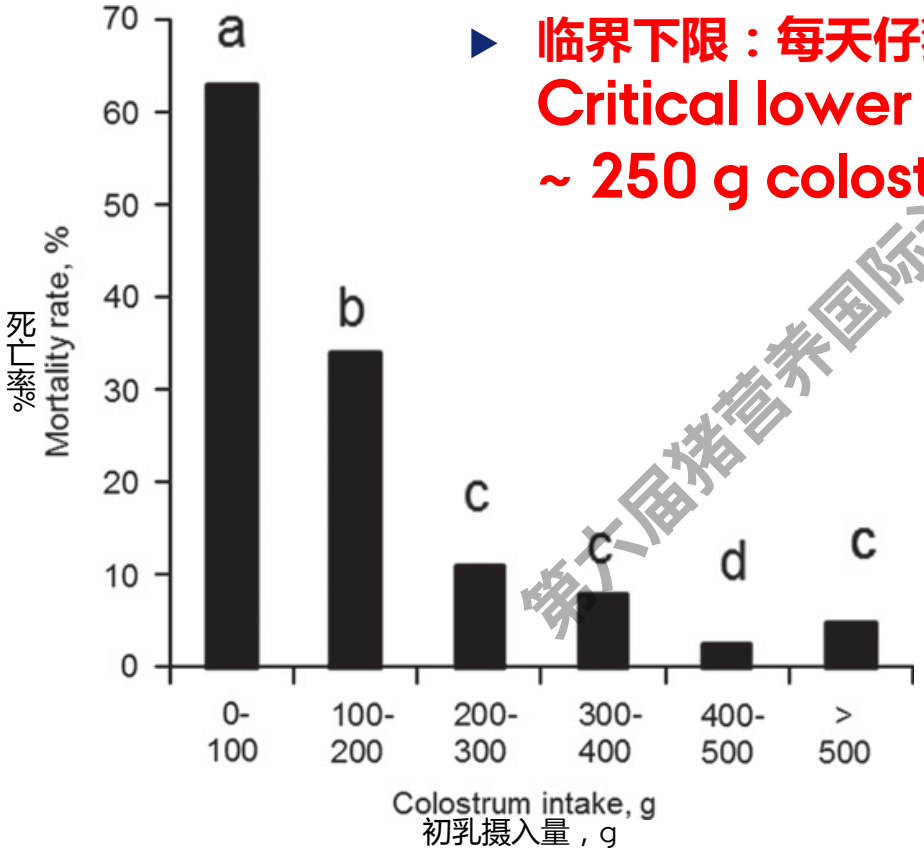
产程和饲料粗蛋白质？
Farrowing length and crude protein in sow feed?

日粮粗纤维 Dietary fiber



(Tydlitat et al., 2008)

初乳对仔猪存活的重要性
Importance of colostrum for piglet survival



- **临界下限：每天仔猪250g初乳**

Critical lower limit:

~ 250 g colostrum/piglet

Quesnel et al., (2012)

初乳期间（0-24h）乳腺的吸收和输出
Mammary uptake and output during colostrum ...-24 h)

乳腺吸收450g碳M~

约94%初乳在出生1头仔猪后产生 ~94% of colostrum is produced after 1. piglet is born

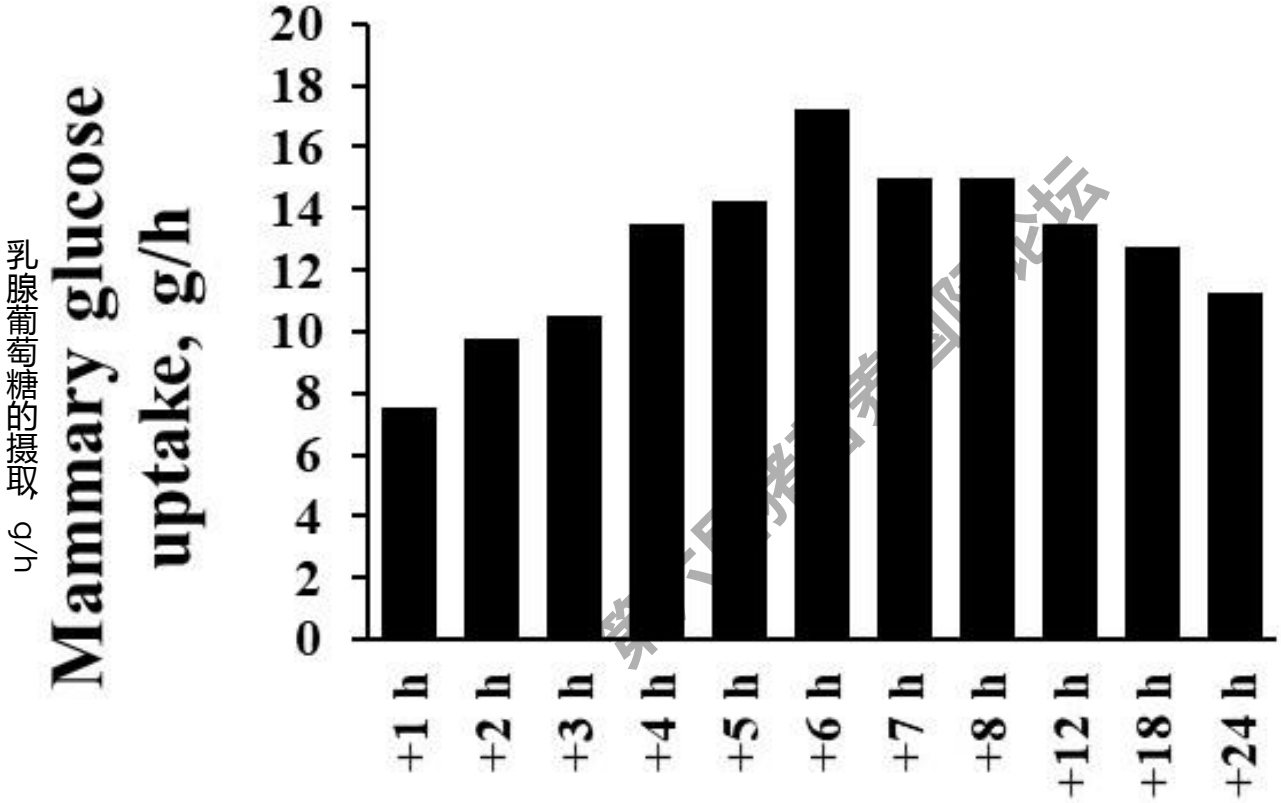
如果母猪饲喂纤维，那么在此之前会产生一些脂肪 But some fat is produced before, if sows are fed fiber!

...Mihai Curtasy)

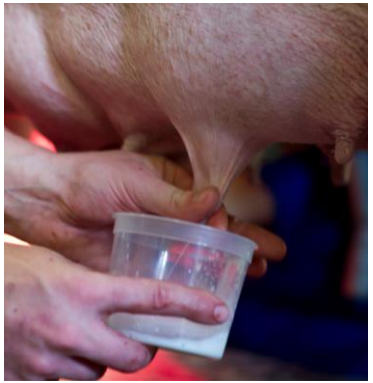
初乳产出48(...utput 480 g Carbon

(Feyera et al., 2019)

初乳合成随着仔猪的数量增加而增加
Colostrum synthesis increases as more piglets reach the udder



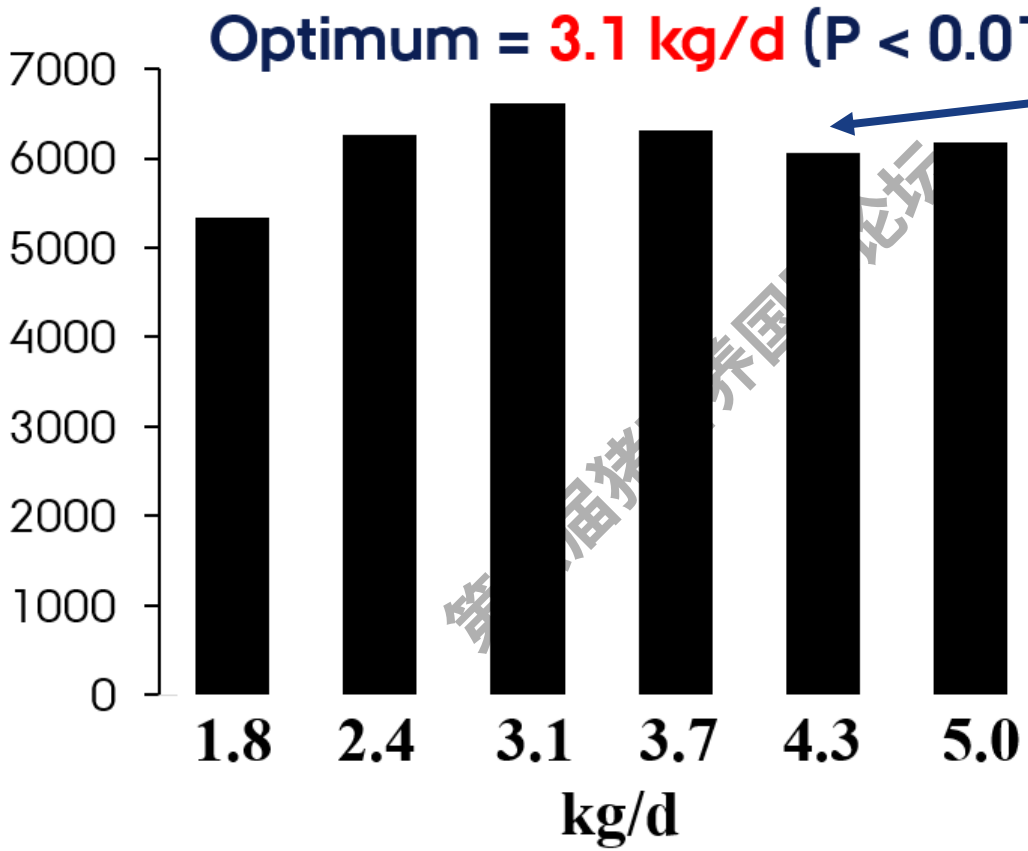
葡萄糖 Glucose



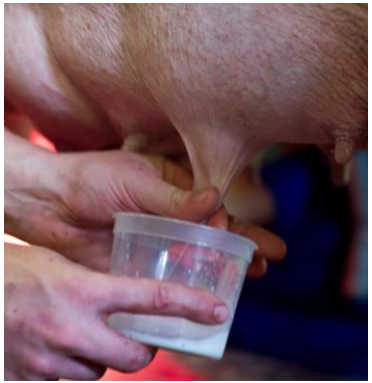
(Photo: Mihai Curtasy)

(Theil et al., 2022)

最佳产奶量的饲料需要量
AMOUNT OF FEED NEEDED TO OPTIMIZE COLOSTRUM YIELD



蛋白质氧化
Protein oxidation?



(Photo: Mihai Curtasy)

(Feyera et al., 2021)

分娩前的饲料供应 FEED SUPPLY PRIOR TO FARROWING?

快速分娩Rapid farrowing:

~4.0 Kg/day

折中？A compromise?

(~3.5 Kg/d)

最大生产力？
Maximal productivity?
(通过优化饲料成分
by optimising feed
composition)

最大产奶量
Maximal colostrum yield:

~3.1 Kg/day

一些可增加产奶量的纤维源
SOME FIBER SOURCES SEEMS TO INCREASE COLOSTRUM YIELD

Dietary fiber and colostrum production (Theil et al., 2014)
日粮纤维和初乳的产生

		配种	体增重（g/头仔猪）weight gain (g/piglet)	
甜菜浆	33% DF - suger beet pulp	Mating- > d 108	135	
果胶渣	35% DF - pectin residue	Mating-> d 108	131	
马铃薯浆	40% DF - potato pulp	Mating-> d 108	71	
低纤维浓缩物	17% DF - Low fiber Contr.	Mating-> d 108	96	

(Krogh et al., 2015)

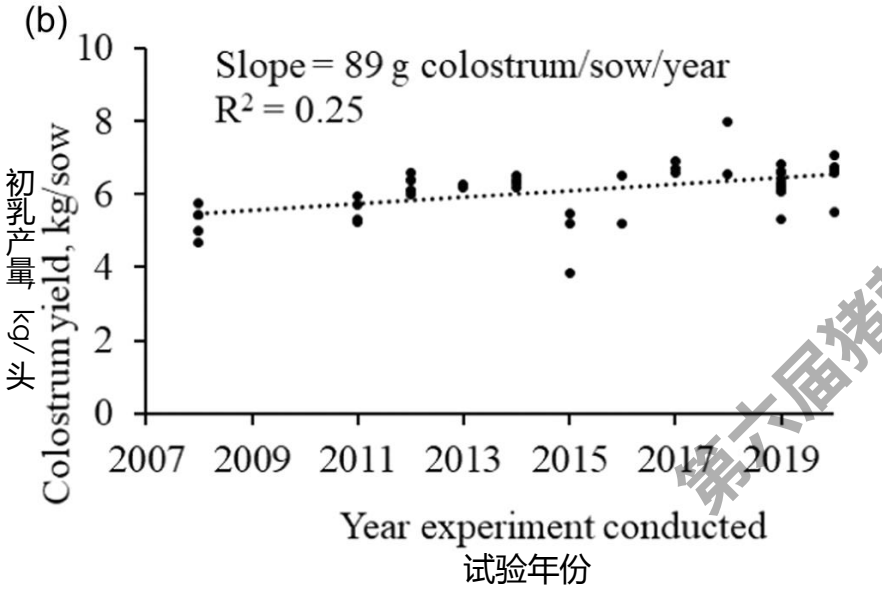
		分娩	
甜菜浆	20% DF - suger beet pulp	d 105 -> parturition	101
苜蓿	20% DF - alfalfa	d 105 -> parturition	90
低纤维浓缩物	15% DF – Low fiber Contr.	d 105 -> parturition	85

(Loisel et al., 2013)

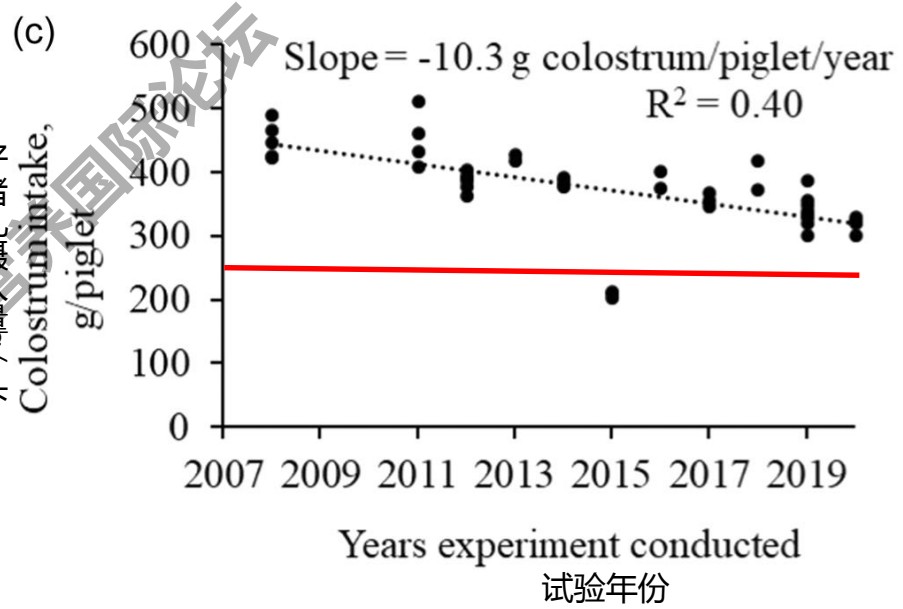
甜菜浆	23% DF - SBP, Sunflow, soyH	d 106 -> parturition	76
低纤维浓缩物	13% DF – Low fiber Contr.	d 106 -> parturition	85

2008-2020产初乳的进展
Advances in colostrum production from 2008 -> 2020

母猪初乳产量
Sow colostrum yield: 20% ↑



仔猪初乳摄入量
Piglet colostrum intake: 28% ↓



窝产仔数（活产）Litter size (liveborn): 48% ↑

(Theil et al., 2022)

丹麦新的推荐饲喂方案 New recommended feeding curve in DK

配种84d-分娩：3.3kg/d（在分娩前无下降，如果在分娩前最后几天达到4.0kg/d会更好）

D 84-farrow: 3.3 kg/d (no drop before farrowing!

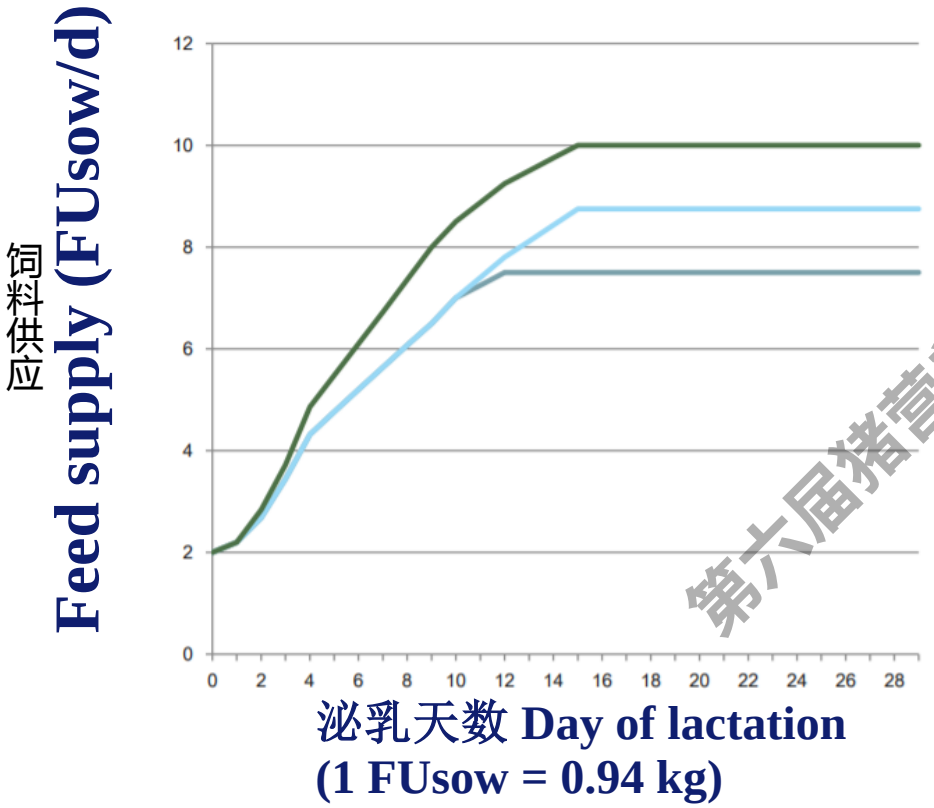
Most likely, up to 4.0 kg/d the last days would be even better)

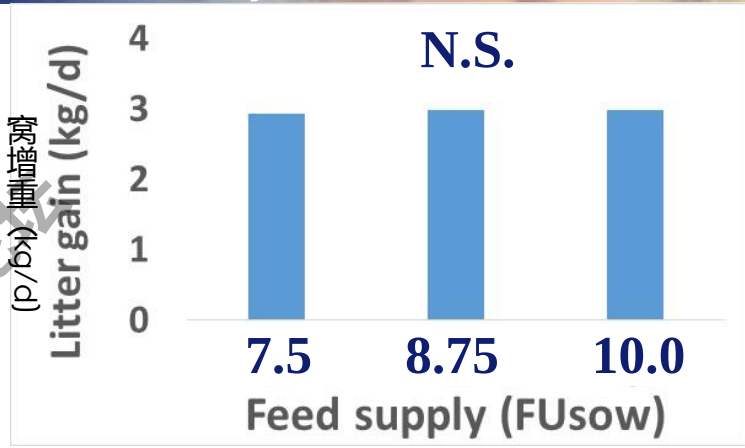
分娩前后每天约500-600g纤维 ~500 to 600 g fibre per day around parturition

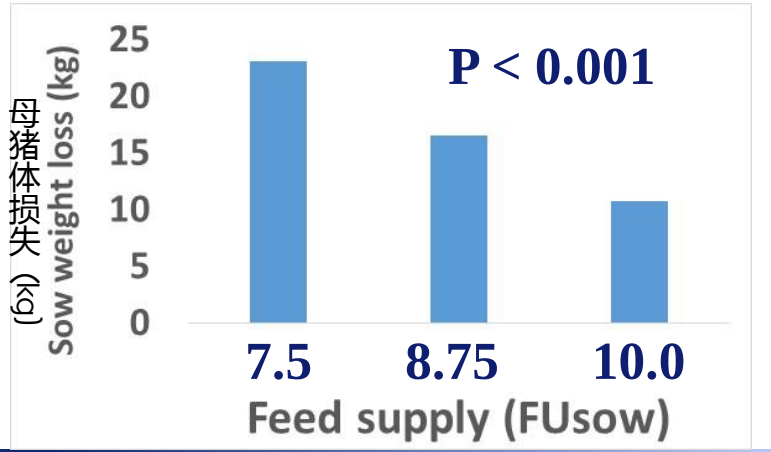
赖氨酸：17-24g SID/d?(目前正在研究中) Lysine: 17-24 g SID/d ??

(We are currently studying this)

3种饲喂方案-对窝重无影响（~产奶量）
3 feeding strategies – no impact on litter gain (~milk yield)





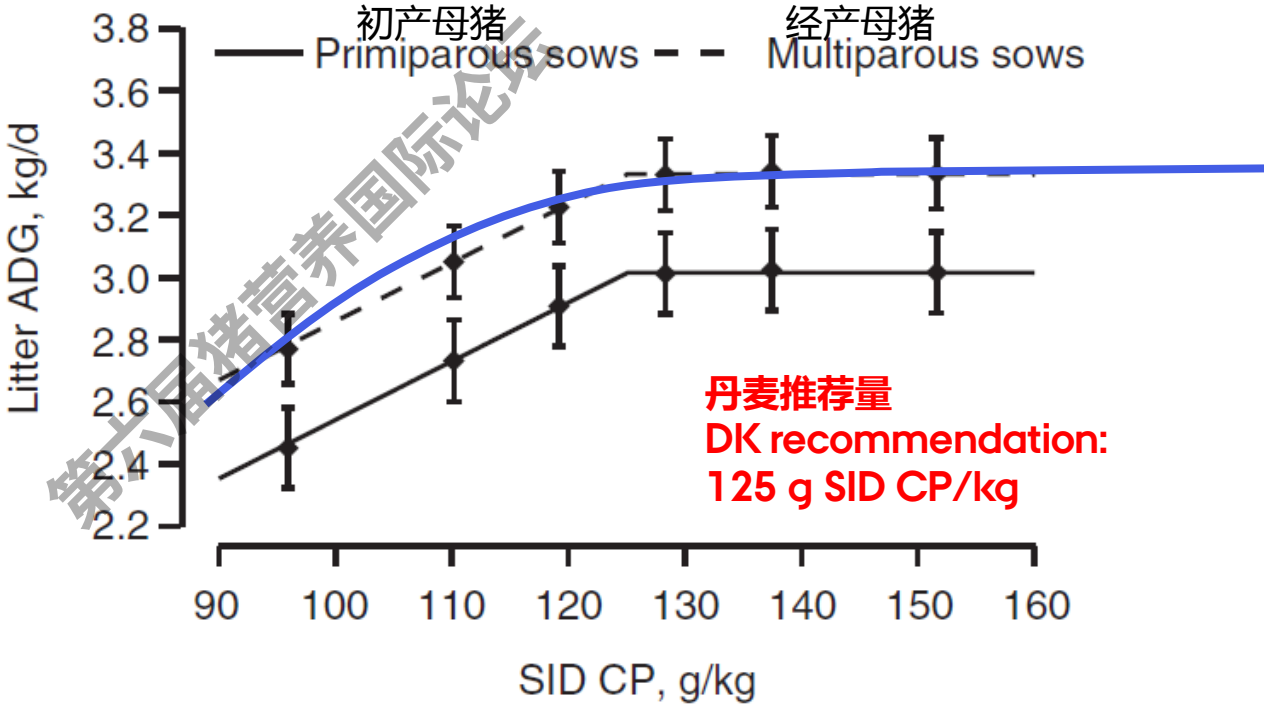


(Bruun et al., 2017)

日粮蛋白和母猪生产力Dietary protein and sow productivity

每窝日增重
~产奶量
Daily litter gain
~ milk yield

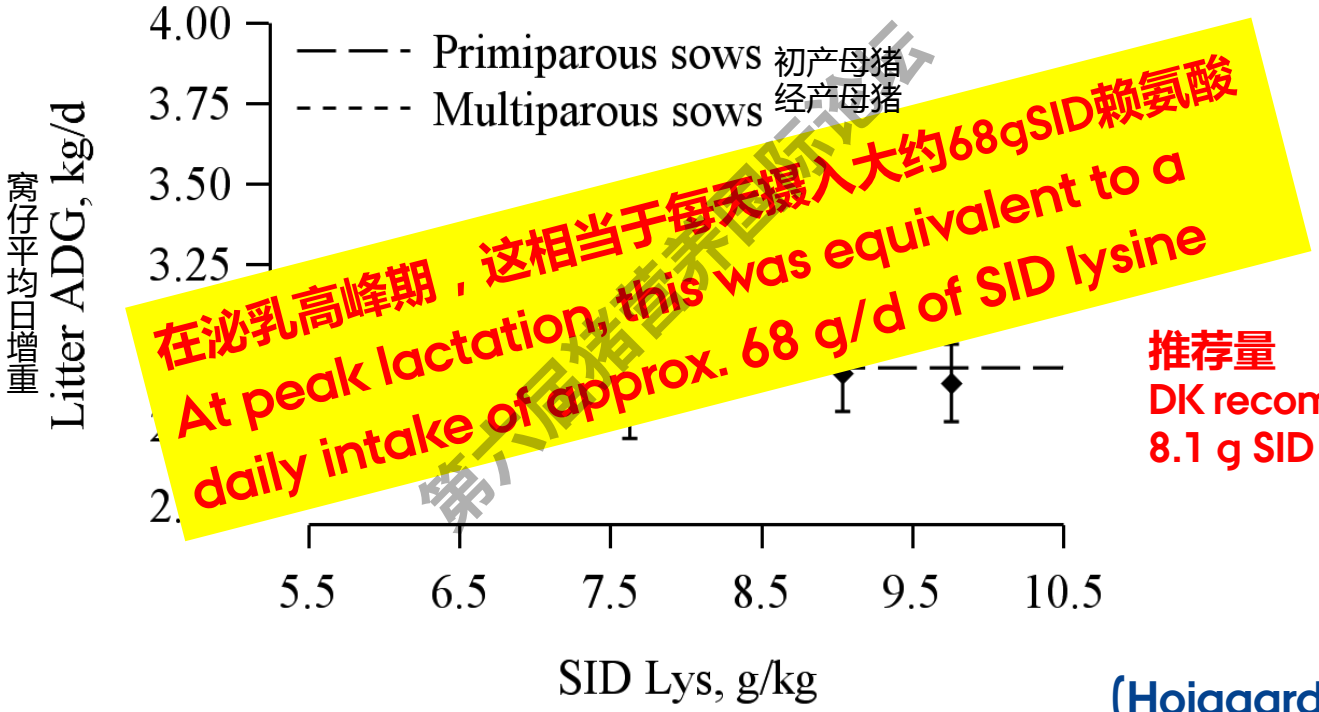
生产力损失
Loss of
productivity



(Hojgaard et al., 2019)

日粮赖氨酸可能限制产奶量 Dietary lysine may limit milk yield

最大窝增重~产奶量Maximal litter gain ~ milk yield



在泌乳高峰期，这相当于每天摄入大约68gSID赖氨酸
At peak lactation, this was equivalent to a daily intake of approx. 68 g/d of SID lysine

推荐量
DK recommendation:
8.1 g SID Lys/kg

(Hojgaard et al., 2019a)

怀孕料对产奶量的重要性 Importance of gestation feed on milk yield

有机母猪饲喂降低蛋白质的日粮（比丹麦对妊娠母猪的推荐量低31%）
Organic sows fed reduced dietary protein
(31% below DK recommendation for gestating sows)

⇒ 在接下来的哺乳期增加产奶量（ Eskildsen 等，未发表）Increased milk yield in the following lactation (Eskildsen et al., unpublished)

什么决定了饲料效率？ What determines feed efficiency?

生长猪：最大肉料比 Growing pigs: Maximizing Gain:Feed-ratio

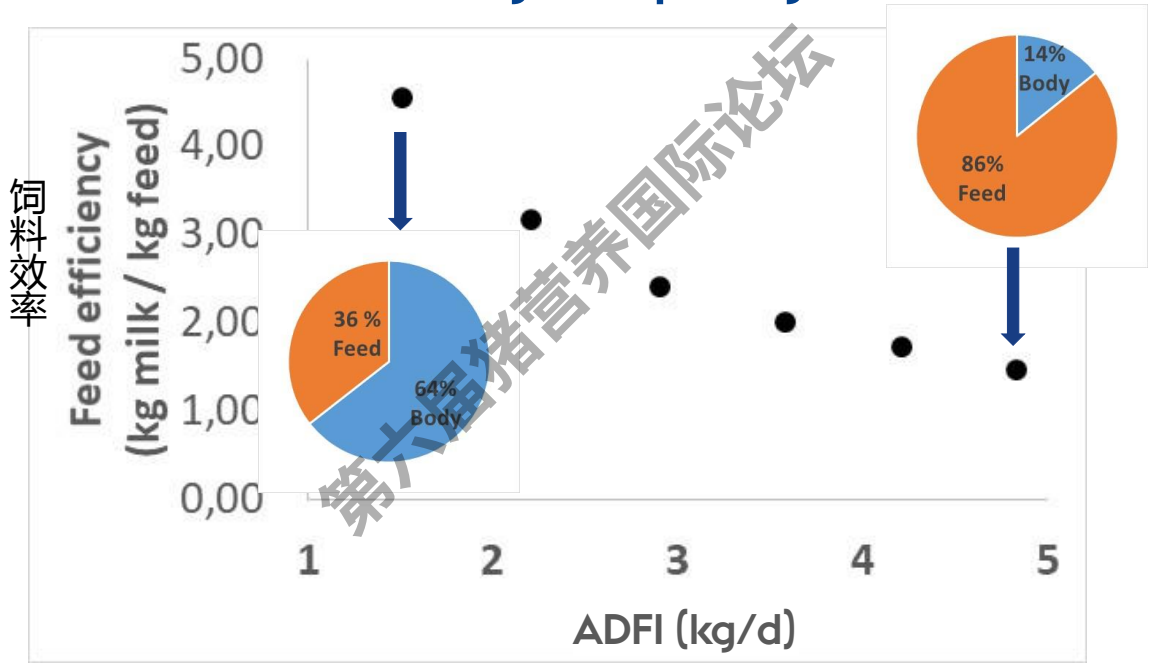
（或最小料肉比 Or Minimizing Feed:Gain-ratio）

哺乳母猪 Lactating sows?

泌乳母猪的饲料效率 Feed efficiency of lactating sows....

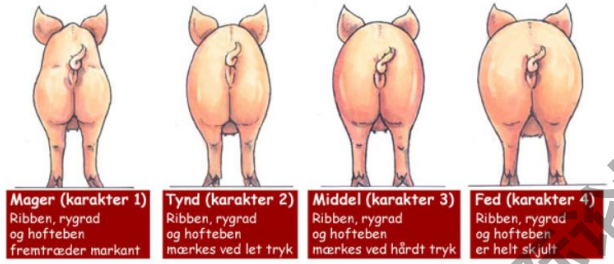
如果我们最大化每kg饲料转化的每kg奶

If we maximize kg milk per kg feed...



(modified from King and Dunkin, 1986)

产奶的高能效率 Energetic efficiencies for milk production



60%

母猪体况 Sow body

饲料Feed → 产奶 Milk yield

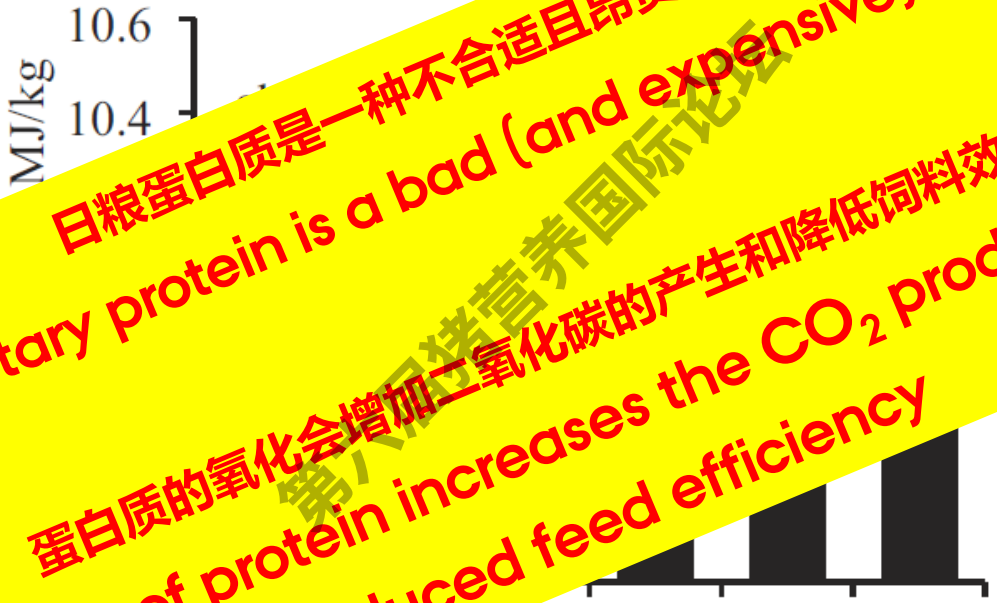
78%

(Theil et al., 2020)

日粮蛋白和饲料效率 Dietary protein and fe ency

饲喂增加日粮蛋白质的母猪每千克饲料的

NEc per kg feed in sows fed increasing



日粮蛋白质是一种不合适且昂贵的燃料

Dietary protein is a bad (and expensive) fuel

蛋白质的氧化会增加二氧化碳的产生和降低饲料效率

Oxidation of protein increases the CO_2 production and reduced feed efficiency

效率损失

Loss of feed efficiency

(Pedersen et al., 2019)

双料饲喂：改进方向
TWO-COMPONENT FEEDING: THE WAY FORWARD?

维持 Maintenance

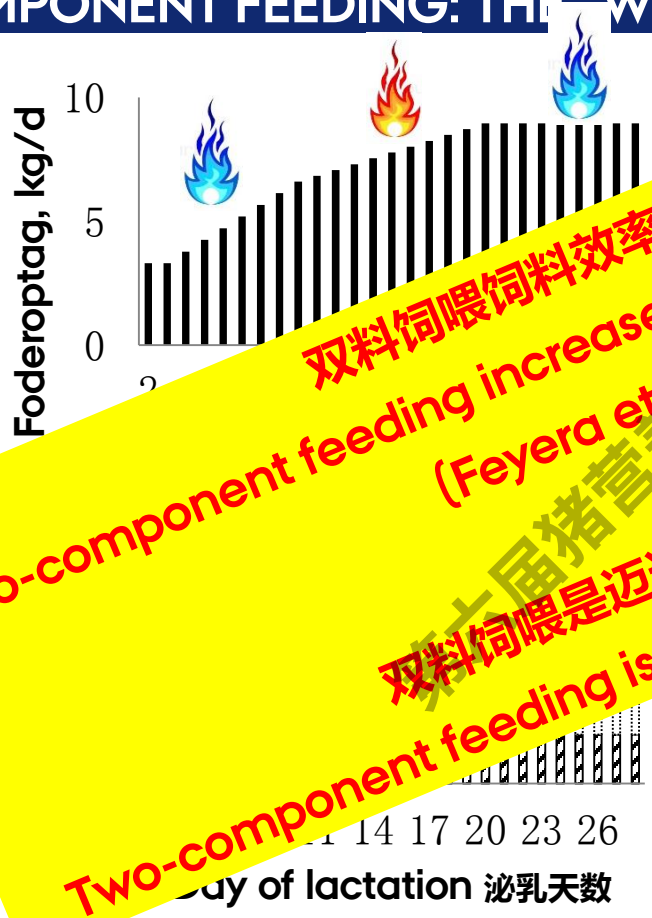
产奶 Milk production

能量 Energy

能量+营养 Energy + nutrients

双料饲喂：要走的路
TWO-COMPONENT FEEDING: THE "WAY TO GO" !

1-comp.



2-comp

Two-component feeding increased feed efficiency with >10% !!
(Feyera et al., 2020)

Two-component feeding is first step towards precision feeding

双料饲喂饲料效率增加 > 10%

双料饲喂是迈进精准饲喂的第一步

ilk yield: 13,3 kg/d

断奶重 Weaning weight: 8,0 kg

脂肪动员 Fat mobilisation: 10 kg

(Pedersen et al., 2016)

结论 CONCLUSIONS

- 在妊娠母猪恢复体况饲喂时避免过多的蛋白质沉积
  Avoid excess protein retention in gestation sows fed to gain lost body condition
- 能量不足会导致分娩问题（死产、助产）
  Insufficient energy causes farrowing problems (stillborn, assisted farrowings)
- 产初乳的最佳饲料供应量约为3.1kg/d, 但分娩时约4.0kg/d
  Optimal feed supply for colostrum is ~3.1 kg/d but 4.0 kg/d for farrowing
- 纤维有利于分娩和产乳性能 **Fibers are beneficial for farrowing and colostrum performance**
- 初乳产量—初乳摄入和仔猪存活的限制因素
  Colostrum yield – a limiting factor for colostrum intake and piglet survival
- 初乳主要是在分娩开始后产生 **Colostrum is mainly produced AFTER onset of parturition**
- 赖氨酸和蛋白质是影响产奶量和饲料效率的重要日粮因素
  Lysine and protein important dietary factors for milk yield & feed efficiency
- 产奶主要是饲料直接影响因素（高饲料效率）
  Milk should mainly be produced directly from feed (=> high feed efficiency)
- 太高活体重和蛋白质氧化会降低饲料效率
  Too high live weight and oxidation of protein reduces feed efficiency

日粮方案 Dietary strategies

妊娠 Gestation

- 根据体况0-30d饲料饲喂2.2-4.0kg/d
  Feed supply 2.2 – 4.0 kg/d (d 0-30) according to body condition
- 根据体况30-60d饲料饲喂2.0-2.8kg/d
  Feed supply 2.0 – 2.8 kg/d (d 30-60) according to body condition
- 60-84d推荐2.2kg/d, 84d-分娩推荐3.3kg/d
  Feed supply 2.2 kg/d (d 60-84) and 3.3 kg/d (d 84 until farrowing)
- 如果可能在分娩前最后几天供应4.0kg/d
  If possible, supply up to 4.0 kg/d the last days prior to parturition
- 丹麦推荐：4.0g SID赖氨酸/kg　DK recommendation: 4.0 g SID lys / kg

泌乳 Lactation

- 在泌乳高峰期（17d）饲料采食量增加到8.5kg/d
  Increase feed intake until reaching 8.5 kg/d at peak lactation (d 17)
- 丹麦推荐量：8.1g SID赖氨酸/kg　DK recommendation: 8.1 g SID lys / kg

感谢您的关注
Thank you for your attention ☺

联系方式Contact:
peter.theil@anis.au.dk