Pre-farrowing feeding strategies for hyper-prolific sows

A.V. Strathe and T. S. Bruun

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Think Piglet – Health & Nutrition

Copenhagen 21-22 September 2023

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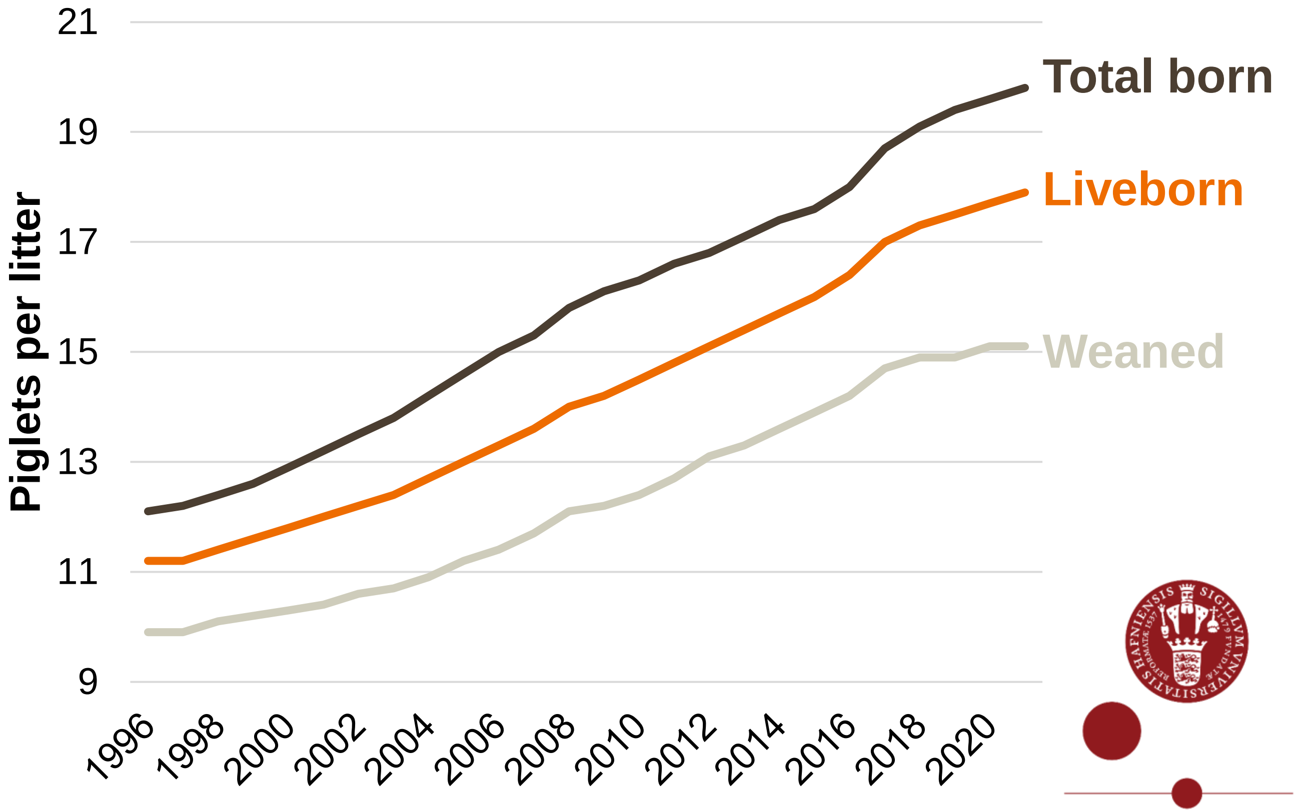
Photo: SEGES Innovation

Introduction

- Increasing litter size ⇨ lower average piglet birth weight
  (Hansen, 2022; Rutherford et al., 2013; Riddersholm et al., 2021; Smit et al., 2013; Langendijk et al. 2023)

- Piglet mortality increases when piglet birth weight decreases
  (Rutherford et al., 2013)



National Danish averages from 1996 to 2021

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Introduction

Contents lists available at ScienceDirect

Animal
The international journal of animal biosciences

Review: Targeted nutrition in gestating sows: opportunities to enhance sow performance and piglet vitality

P. Langendijk*, M. Fleuren, G. Page

Trouw Nutrition R&D, Stationsstraat 77, Amersfoort, The Netherlands

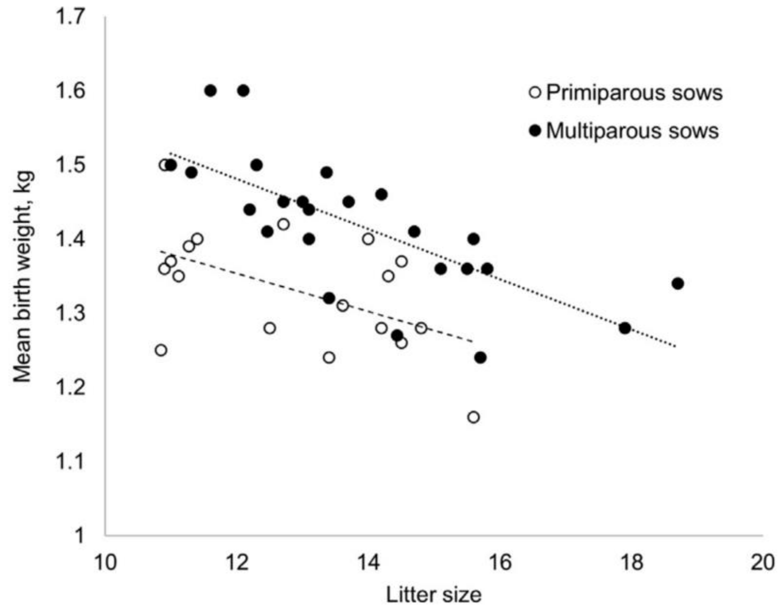

Fig. 2. Meta-analysis of mean piglet birth weight in relation to sow parity and litter size (total born). Data were obtained from 43 peer-reviewed papers published after 2000. After correction for parity and litter size, standard deviation of residual birth weight was 66 g.

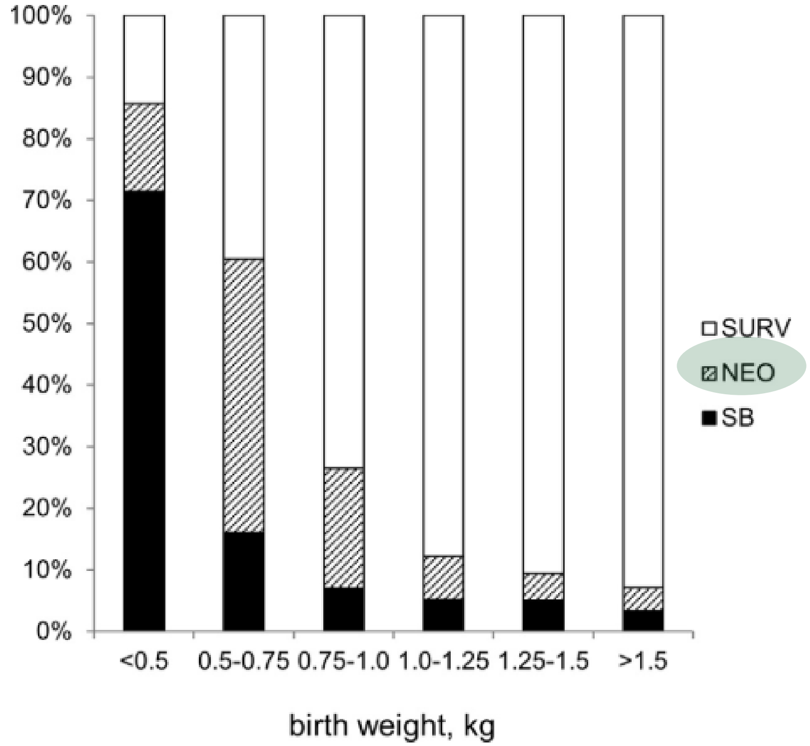

Fig. 1. (A) Perinatal and prewean mortality in relation to birth weight. Percentage of piglets in each birth weight class that survived to weaning (SURV = survivors), died after birth (NEO = neonatal mortality), or were stillborn (SB). (B) Effect of an increase in mean birth weight of a population on number of stillborn (SB), number of piglets that die preweaning (PWM = prewean mortality), and number of piglets weaned, per litter. Number of mortalities were obtained by simulating a change in the mean birth weight of a normally distributed population, and then calculating the mortality rate based on the association between number of piglets in each birth weight class and mortality rate in Fig. 1B.

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Aim

… To summarize most recent research (especially Danish) in feeding of gestating and transition sows to recommend dietary interventions that can improve sow productivity in terms of piglet birth weight, farrowing performance and colostrum production …

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Overview on gestation and pre-farrowing periods
Timeframes with natural overlays

- Weaning-to-estrus-interval (follicle quality and numbers)
- Entire gestation period i.e. day 0-114 (covers all growth aspects)
- Early gestation i.e. day 0-50 (maternal growth, implantation and placental growth)
- Mid gestation i.e. day 30-85 (maternal growth, placental and fetal growth)
- Late gestation i.e. day 65-110 (maternal growth, fetal and udder growth)
- Transition period i.e. day 110-post farrowing (fetal and udder growth and farrowing performance)
- Conclusion and perspectives

SEGES INNOVATION

Weaning-to-estrus interval
Can feeding make more even sized follicles at mating?

Glycemic diets (e.g. dextrose, lactose, sucrose)
→ ↑ blood glucose and insulin
→ ↑ IGF-1 in blood
→ ↑ Progesterone → more even sized follicles
→ ↑ LH surges at weaning → ↑ ovulation rate

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	Diet*							p-value†		
	CON	DEX	SUC	LAC	DL	SL	DSBP	Diet	Period‡	Day§
Insulin										
Number of sows	9	7	8	10	9	8	7			
Number of profiles	27	19	20	28	25	23	20			
Basal (μU/ml)	8.7 ± 0.6	8.8 ± 0.5	9.8 ± 0.5	8.0 ± 0.5	9.4 ± 0.5	9.6 ± 0.5	8.9 ± 0.5	0.04	0.01	–
Maximum (μU/ml)	38.0 ± 4.5[a]	47.8 ± 5.0[ab]	43.5 ± 4.9[ab]	42.7 ± 4.4[ab]	56.9 ± 4.6[b]	56.1 ± 4.7[b]	45.4 ± 4.9[ab]	<0.001	–	–
Increase after feeding (μU/ml)	29.2 ± 4.5[a]	39.0 ± 5.0[ab]	33.7 ± 4.9[ab]	34.4 ± 4.4[ab]	47.7 ± 4.6[b]	46.2 ± 4.7[b]	36.6 ± 4.9[ab]	<0.01	–	–
Mean (μU/ml)	16.4 ± 0.9[ab]	19.0 ± 1.0[abc]	17.9 ± 1.0[abc]	15.9 ± 0.9[a]	19.6 ± 0.9[c]	19.1 ± 0.9[bc]	18.4 ± 1.0[abc]	<0.01	<0.01	–

Journal of Animal Physiology and Animal Nutrition
DOI: 10.1111/j.1439-0396.2011.01171.x

ORIGINAL ARTICLE

Effects of dietary carbohydrate sources on plasma glucose, insulin and IGF-I levels in multiparous sows

J. G. M. Wientjes, N. M. Soede, F. Aarsse, B. F. A. Laurenssen, R. E. Koopmanschap, H. van den Brand and B. Kemp

Department of Animal Sciences, Adaptation Physiology Group, Wageningen University, Wageningen, The Netherlands

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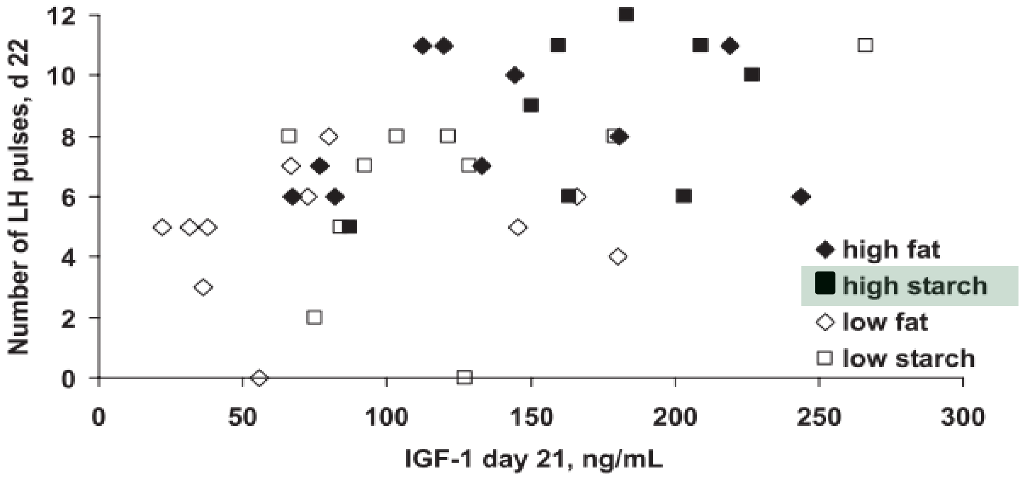

Reprod. Nutr. Dev. 41 (2001) 27–39 27
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Original article

In primiparous sows, plasma insulin-like growth factor-I can be affected by lactational feed intake and dietary energy source and is associated with luteinizing hormone

Henry VAN DEN BRAND[a*], Armelle PRUNIER[b], Nicoline M. SOEDE[a], Bas KEMP[a]

Feeding sows during the weaning-to-estrus interval

Can glycemic diets make more uniform piglets at birth?

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Animal Reproduction Science 91 (2006) 353–358

ANIMAL REPRODUCTION SCIENCE

www.elsevier.com/locate/anireprosci

Short communication

Supplementation of dextrose to the diet during the weaning to estrus interval affects subsequent variation in within-litter piglet birth weight

H. Van den Brand*, N.M. Soede, B. Kemp

Adaptation Physiology Group, Wageningen Institute of Animal Sciences, Wageningen University and Research Centre (WUR), P.O. Box 338, Wageningen 6700 AH, The Netherlands

Reprod Dom Anim **44**, 884–888 (2009); doi: 10.1111/j.1439-0531.2008.01106.x
ISSN 0936-6768

Effects of Dextrose Plus Lactose in the Sows Diet on Subsequent Reproductive Performance and within Litter Birth Weight Variation

H van den Brand[1], LCM van Enckevort[2], EM van der Hoeven[3] and B Kemp[1]

[1] *Adaptation Physiology Group, Wageningen University, Wageningen;* [2] *Denkavit Nederland B... ;* [3] *An... Group, Wageningen University, Wageningen, The Netherlands*

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doi:10.1017/S1751731113000566

animal

Insulin-stimulating diets during the weaning-to-estrus interval do not improve fetal and placental development and uniformity in high-prolific multiparous sows

J. G. M. Wientjes, N. M. Soede†, B. F.A. Laurenssen, R. E. Koopmanschap, H. van den Brand and B. Kemp

Wageningen University, Department of Animal Sciences, Adaptation Physiology Group, PO Box 338, 6700AH Wageningen, The Netherlands

Livestock Science 144 (2012) 218–229

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Livestock Science

journal homepage: www.elsevier.com/locate/livsci

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Piglet uniformity and mortality in large organic litters: Effects of parity and pre-mating diet composition

J.G.M. Wientjes [a], N.M. Soede [a,*], C.M.C. van der Peet-Schwering [b], H. van den Brand [a], B. Kem

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[b] Wageningen UR Livestock Research, P.O. Box 65, 8200AB, Lelystad, The Netherlands

Reprod Dom Anim **44**, 884–888 (2009); doi: 10.1111/j.1439-0531.2008.01106.x
ISSN 0936-6768

Effects of Dextrose Plus Lactose in the Sows Diet on Subsequent Reproductive Performance and within Litter Birth Weight Variation

H van den Brand[1], LCM van Enckevort[2], EM van der Hoeven[3] and B Kemp[1]

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Weaning-to-estrus interval
Research with hyper-prolific sows

- Sows supplemented with 400 g dextrose or fructose in WEI
  - Exp. 1: Effects on follicle development at mating

Weaning-to-estrus interval
Research with hyper-prolific sows

- Sows supplemented with 400 g dextrose or fructose in WEI
  - Exp. 2: Effects on embryo development at day 8 post mating → more even distribution of embryos between uterine horns (preliminary results)

Weaning-to-estrus interval
Research with hyper-prolific sows

- Sows supplemented with 400 g dextrose or fructose in WEI
  - Exp. 2: Effects on embryo development at day 8 post mating → more even distribution of embryos between uterine horns (preliminary results)
  - Exp. 3: Effect on piglet birth weight and within-litter variation

Weaning-to-estrus interval
Research with hyper-prolific sows

- Sow … with 400 g dextrose or fructose in WEI
  - Exp … post mating → more even distribution of em…
  - Ex…

Will we get a positive effect on litter uniformity if feeding a glycemic diet already from 7-14 days before weaning?

Overview on gestation and pre-farrowing periods
Timeframes with natural overlays

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- Conclusion and perspectives

SEGES INNOVATION

Possibilities to affect average piglet birth weight
Omega-3 fatty acids throughout gestation

- Omega-3 fatty acids may potentially increase birth weight (Tanghe et al., 2013; Jin et al., 2017; Papadopoulus et al., 2008)
  - The possible mechanism is the inhibitory effect of omega-3 on of PGF2α secretion from the endometrium (Tanghe and De Smet, 2013)
  - May serve as a protective mechanism for both the oocyte and embryo (Roszkos et al. 2020)

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Litter size, piglet birth weight and proportion of liveborn piglets weighing below 800 g and 100 g from sows (n=227) fed either a standard diet throughout previous lactation and gestation (Group 1) or identical diets supplemented with 250 mg/kg algae extract (Group 2) containing 48 mg/kg of docosahexaenoic acid (DHA) (Bruun et al. 2022)

Item	Group 1	Group 2	P-value
Liveborn piglets per litter	18.6	18.6	-
Stillborn piglets per litter	1.1	1.2	-
Average birth weight of liveborn, g	1.36	1.34	0.361
Proportion of liveborn <800 g, %	5.89	6.53	0.379
Proportion of liveborn <800 g, %	14.9	16.5	0.140

SEGES INNOVATION

Possibilities to affect average piglet birth weight
Omega-3 fatty acids throughout gestation

- Numerical differences in plasma cytokines of sows 7 days pre-partum (n=45)
  - Lower TNF-α (pro-inflammatory cytokine)
  - Higher IL-10 (anti-inflammatory cytokine)
- Colostrum composition was unaffected by diet except for tendency for higher DHA content

Possibilities to affect average piglet birth weight
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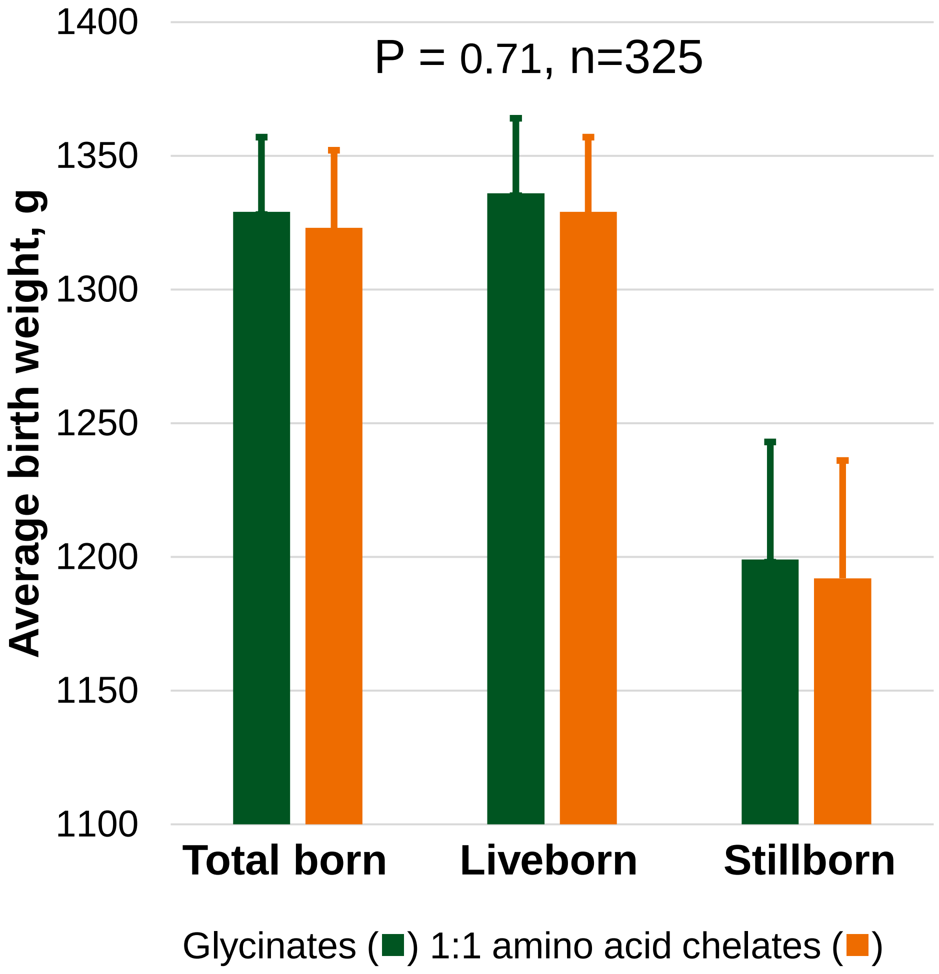
- Colostrum composition was unaffected by diet except for tendency for higher DHA content

Results might be an indication of the dose of DHA being too low

Combining with other research results, omega-3 should be supplied in g/kg rather than mg/kg

Possibilities to affect average piglet birth weight

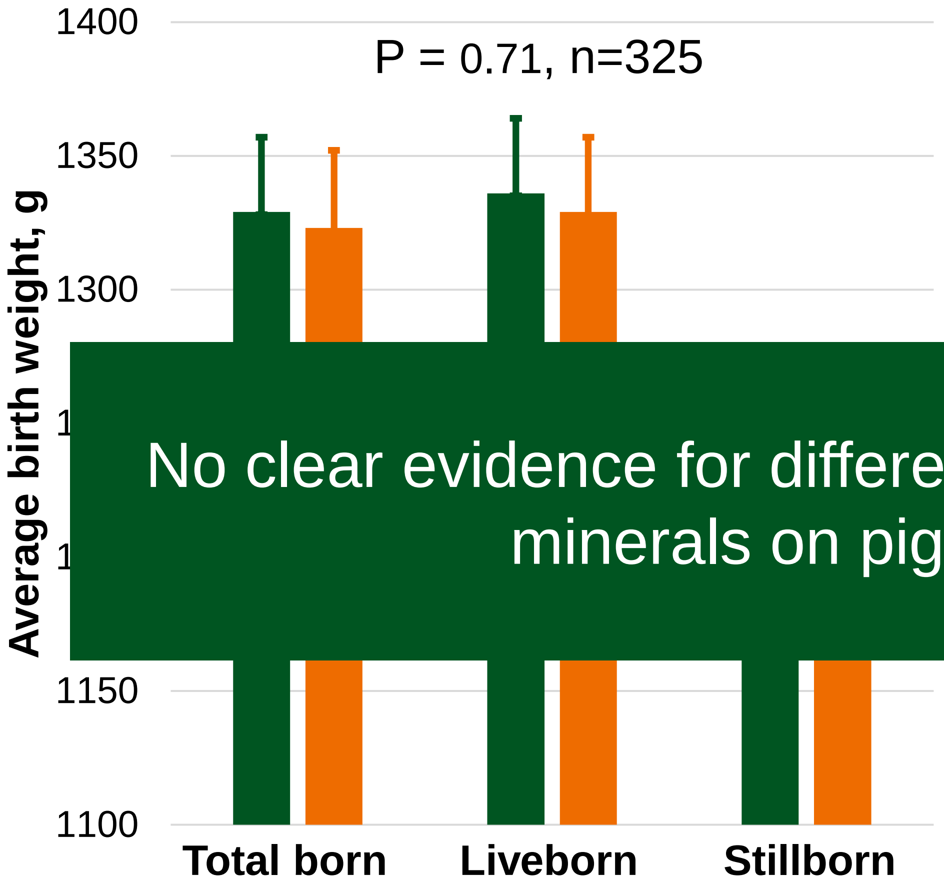
Effect of different types of organic trace minerals (Zn, Cu, Mn)



Reference: Bruun et al. (unpublished)

Possibilities to affect average piglet birth weight

Effect of different types of organic trace minerals (Zn, Cu, Mn)



Glycinates (■) 1:1 amino acid chelates (■)

No clear evidence for differences between sources of organic trace minerals on piglet birth weight and vitality

Reference: Bruun et al. (unpublished)

Reference: Strathe et al. (in preperation)

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Possibilities to affect piglet birth weight throughout gestation

Dietary lysine and protein do not affect litter size (n = 431)

Reference: Bruun et al. (unpublished)

Possibilities to affect piglet birth weight throughout gestation

Dietary lysine and protein do not affect piglet birth weight

Reference: Bruun et al. (unpublished)

Possibilities to affect piglet birth weight throughout gestation

Dietary lysine and protein have major impact on sow weight gain

Controlling sow weight development without effects on piglet birth weight is possible

Use of high lysine/protein diets for gestating sows should be avoided

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Reference: Bruun et al. (unpublished)

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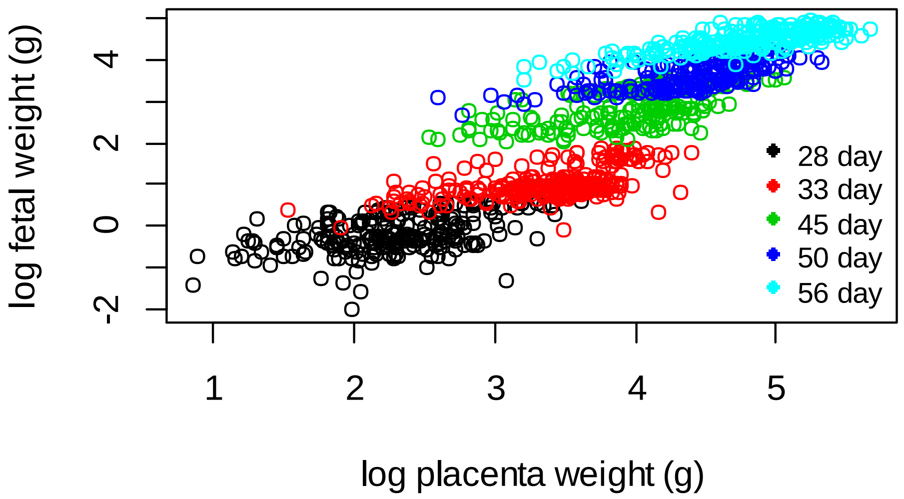
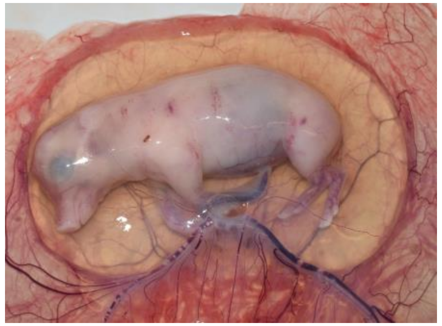
SEGES INNOVATION

Feeding in early gestation
Variation in weight of foetuses is seen already at day 28

Characteristics of fetuses at different gestational days.

	Day 28	Day 33	Day 45	Day 50	Day 56	SEM	*P*-value
Live fetuses	28.2	28.1	22.9	25.9	24.1	2.06	0.2157
Dead fetuses	3.4	1.9	2.4	3.3	1.1	0.94	0.3435
Litter weight, g	25.3[a]	81.2[a]	452.8[a]	1021.2[b]	2175.3[c]	115	<0.001
Male fetuses, %	–	–	47.6	46.0	49.8	4.00	0.7757
Average fetal weight, g	0.88[a]	2.91[a]	20.7[b]	37.7[b]	92.0[c]	4.35	<0.001
Within-litter variation in fetal weight, g	0.18[a]	0.49[ab]	2.87[bc]	5.05[c]	12.2[d]	0.68	<0.001
Within-litter CV in fetal weight, %	21.3[a]	16.4[b]	14.0[b]	12.8[b]	14.1[b]	1.76	<0.05





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Fetal and placental development in early gestation of hyper-prolific sows

Kimmie K. Lyderik [a], Esben Østrup [a], Thomas S. Bruun [b], Charlotte Amdi [a], Anja V. Strathe [a,*]
[a] Department of Veterinary and Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, Grønnegårdsvej 3, 1870, Frederiksberg, Denmark
[b] SEGES Danish Innovation, Agro Food Park 15, 8200, Aarhus N, Denmark

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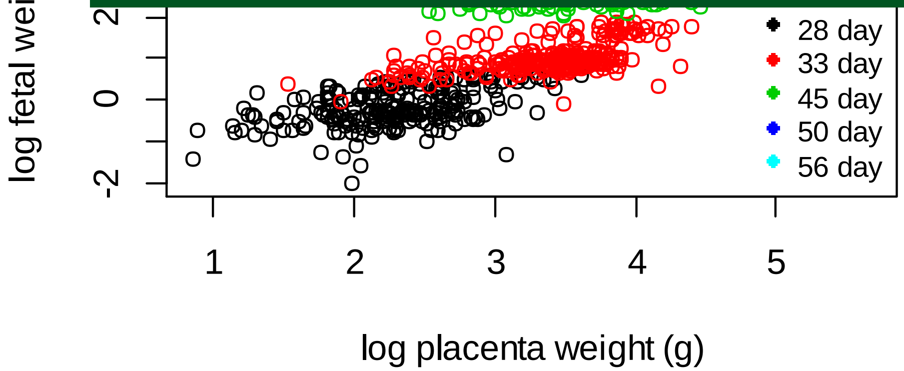
Within-lit[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]0.001
Within-lit[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]0.05

Nutritional prevention of high within-litter variation should start very early in gestation or before mating



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[b] SEGES Danish Innovation, Agro Food Park 15, 8200, Aarhus N, Denmark

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Feeding in early gestation

Feeding different nutrients the first 45-50 days of gestation

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Contents lists available at ScienceDirect

Animal Reproduction Science

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Effect of increasing dietary methionine-to-lysine ratio during early gestation on fetal development and piglet birth weight

Thomas Sønderby Bruun[a], Esben Østrup[b], Kimmie Kyed Lyderik[b], Jacob Dall[c], Anja Varmløse Strathe[b,*]

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[c] Vilofoss, Ballesvej 2, 7000 Fredericia, Denmark

Effect of feeding sows a combination of extra vitamin B2, vitamin B6, vitamin B12 and folic acid during the first 45 days of gestation on piglet birthweight

T.S. Bruun[a], K.K. Lyderik[c], J. Dall[b] and A.V. Strathe[c*]

[a]SEGES Innovation, Agro Food Park 15, 8200 Aarhus N, Denmark
[b]Vilofoss, Ballesvej 2, 7000 Fredericia, Denmark
[c]Department of Veterinary and Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, Grønnegårdsvej 2, 1870 Frederiksberg, Denmark

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Feeding in early gestation

Feeding different nutrients the first 45-50 days of gestation

The effect of dietary omega-3 fatty acid supplementation on fetal growth, piglet birth weight and plasma fatty acid concentrations, using docosahexaenoic acid in early gestation in sows

Thomas S Bruun[a], Anja H Madsen[b], Emilie R Handberg[b], Jacob Dall[c], Søren K Jensen[d], Esben Østrup[b], Anja V Strathe[b*]

- Fewer piglets below 800 g in DHA group (2.3 vs. 1.8 piglet)
- More omega-3 fatty acid in plasma of sows in DHA group
- Only numerical differences in piglet birth weight
- No effect on within-litter variation in birth weight

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Effect of feeding vitamin C, organic zinc and organic selenium during early gestation on fetal development and piglet birth weight

T.S. Bruun[b], E. Østrup[a], J. Dall[c], J. Lykkesfeldt[a], A.V. Strathe[a]

- Sows fed antioxidants had higher anti-oxidative capacity
- Sows fed antioxidants had lower level of free radical (BH2)
- Only numerical differences in piglet birth weight
- No effect on within-litter variation in birth weight

Feeding in early gestation

Arginine for gestating sows

+ Arg in early gestation -> improved placental angiogenesis[1]

+ Arg in early gestation -> improved water transport by placenta[2]

+ Arg in early gestation -> larger fetuses[3]

+ Arg in late gestation -> tendency for higher litter birth weight[3]

[1]Elmetwally et al. 2022; [2]Zhu et al. 2021; [3]Costa et al. 2019, [4]Hong et al. 2020;

Feeding in early gestation
Arginine for gestating sows

in early gestation -> improved placental angiogenesis[1]

Best effect of arginine is seen when fed day 14 to 28 of gestation

Effects are seen in sows with litter size below 14 piglets

Will arginine have a beneficial effect on hyper-prolific sows???

+ Arg in early gest

[1]Elmetwally et al. 2022; [2]Zhu et al. 2021; [3]Hong et al. 2020; [4]Costa et al. 2019

Overview on gestation and pre-farrowing periods
Timeframes with natural overlays

- Weaning-to-estrus-interval (follicle quality and numbers)
- Entire gestation period i.e. day 0-114 (covers all growth aspects)
- Early gestation i.e. day 0-50 (maternal growth, implantation and placental growth)
- Mid gestation i.e. day 30-85 (maternal growth, placental and fetal growth)
- Late gestation i.e. day 75-110 (maternal growth, fetal and udder growth)
- Transition period i.e. day 110-post farrowing (fetal and udder growth and farrowing performance)
- Conclusion and perspectives

SEGES INNOVATION

Feeding in mid gestation
Overlooked but might be the missing link

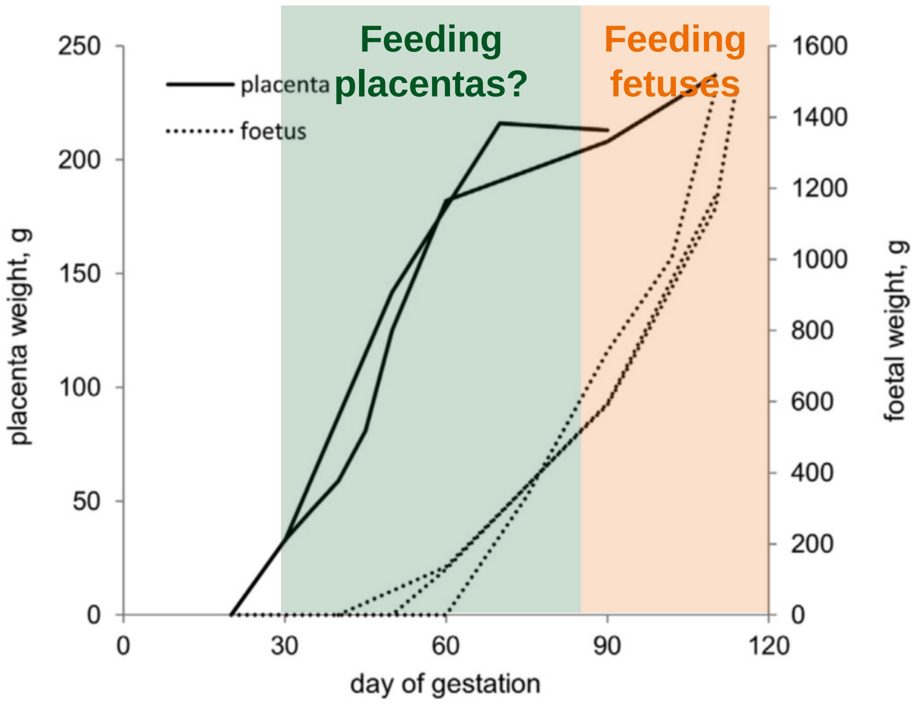

Fig. 5. Growth of pig foetal and placenta tissue in gestation. Based on Tarraf and Knight, 1995; Wu et al., 1999; Wu et al., 2005; McPherson et al., 2004).

Contents lists available at ScienceDirect

Animal

The international journal of animal biosciences

ELSEVIER

Review: Targeted nutrition in gestating sows: opportunities to enhance sow performance and piglet vitality

P. Langendijk *, M. Fleuren, G. Page

Trouw Nutrition R&D, Stationsstraat 77, Amersfoort, The Netherlands

Do we have the right approach?

Is the importance of placental growth underestimated?

SEGES INNOVATION

Feeding in mid gestation

Overlooked but might be the missing link

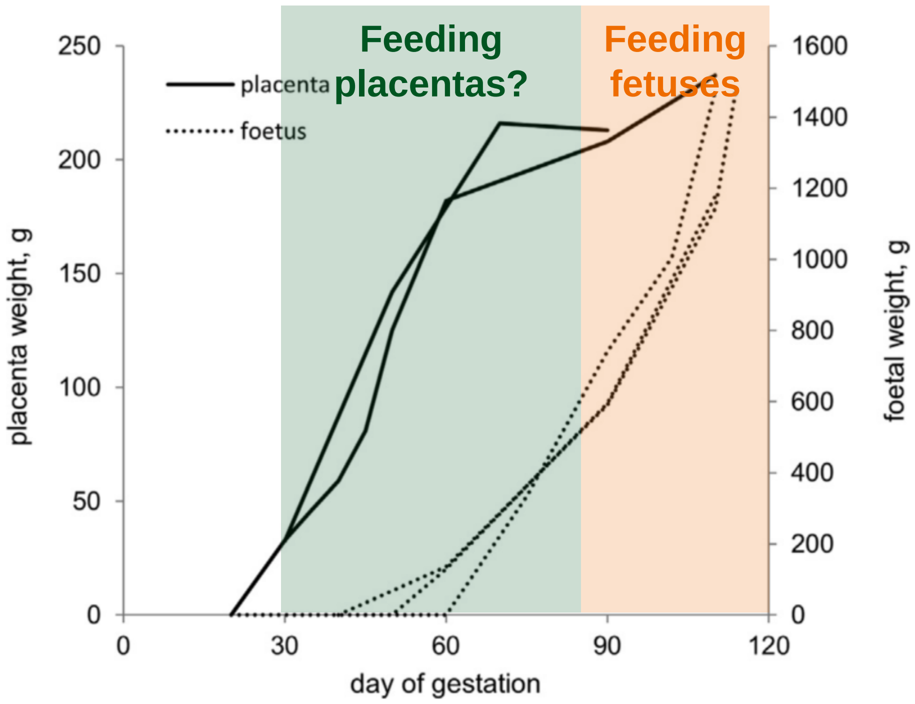

Fig. 5. Growth of pig foetal and placenta tissue in gestation. Based on Tarraf and Knight, 1995; Wu et al., 1999; Wu et al., 2005; McPherson et al., 2004).

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Review: Targeted nutrition in gestating sows: opportunities to enhance sow performance and piglet vitality

P. Langendijk *, M. Fleuren, G. Page

Trouw Nutrition R&D, Stationsstraat 77, Amersfoort, The Netherlands

New Danish research will (hopefully) provide answers

Different feeding levels from day 28 to 84 of gestation +/- bump feeding from day 84-114 of gestation

SEGES INNOVATION

Mid gestation
Can we improve feed utilization?

- Most gestating sows are only fed one time per day
- Can feed utilization be improved if dividing the daily ration into more meals?

Meals	1	2	3
8.00	2150g	1075g	717g
15.00		1075g	717g
20.00			717g

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SEGES INNOVATION

Possibilities to affect piglet birth weight in late gestation
Increasing feed or protein allowance has only marginal effects

Effect of increasing feed allowance 4 weeks before farrowing in hyper-prolific sows (n = 1138) fed one meal per day using ESF (Sørensen, 2012)

Feed allowance, kg	2.4	3.3	4.2
SID Lysine per day, g	8.6	11.9	15.1
Total born per litter, no.	17.9	18.0	18.0
Birth weight, kg	1.31[b]	1.34[a]	1.35[a]

[a,b] $P < 0.005$

SEGES INNOVATION

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a,b $P < 0.005$

Effect of increasing feed allowance and protein level 4 weeks before farrowing in hyper-prolific sows (n = 405) fed one meal per day using ESF (Sørensen & Krogsdahl, 2018)

Feed allowance, kg	3.3	3.8
SID Lysine per day, g	14.7	23.2
Total born per litter, no.	21.0	20.8
Birth weight, kg	1.28[NS]	1.29[NS]

NS $P = 0.659$

SEGES INNOVATION

Possibilities to affect piglet birth weight in late gestation
Increasing feed or protein allowance has only marginal effects

Effect of increasing feed allowance 4 weeks before farrowing in hyper-prolific sows (n = 1138) fed one meal per day using ESF (Sørensen, 2012)

Feed allowance, kg	2.4	3.3	4.
SID Lysine per day, g	8.6		
Total l			
B			

a,b

Results along with results from Greiner et al. (2016) raise the question whether bump-feeding actually works??

Or whether late gestation is actually too late….

Effe ... ore farrowing in hyper-prol ... day using ESF (Sørensen & Krogsdahl, 2018)

Fee ... nce, kg	3.3	3.8
SID Lysine per day, g	14.7	23.2
Total born per litter, no.	21.0	20.8
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SEGES INNOVATION

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SEGES INNOVATION

Transition feeding

The sow has a high energy requirement during farrowing

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Energy and lysine requirements and balances of sows during transition and lactation: A factorial approach☆

Takele Feyera, Peter Kappel Theil*

Department of Animal Science, Aarhus University Foulum, Blichers Alle 20, P.O. Box 50, DK-8830 Tjele, Denmark

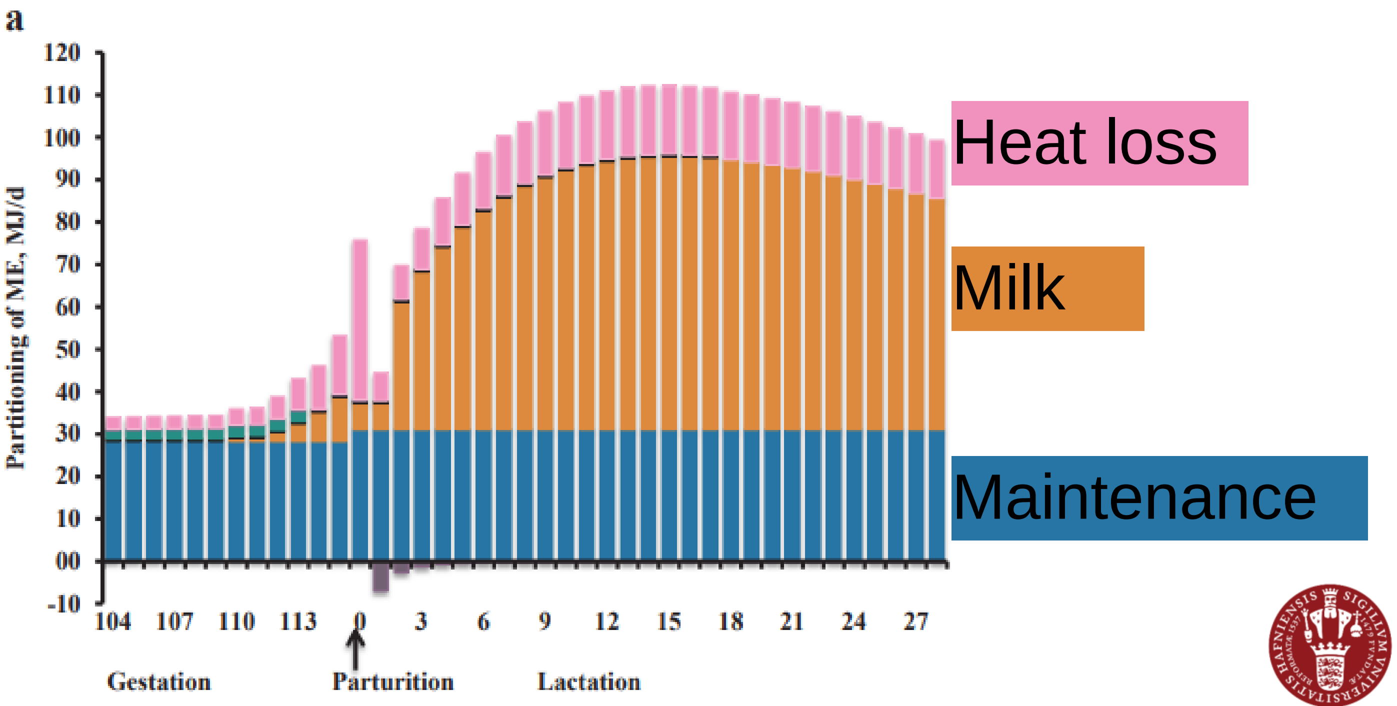


Photo: Rasmus Bendix, Bendix Production

Transition feeding to improve the farrowing process

Frequent feedings

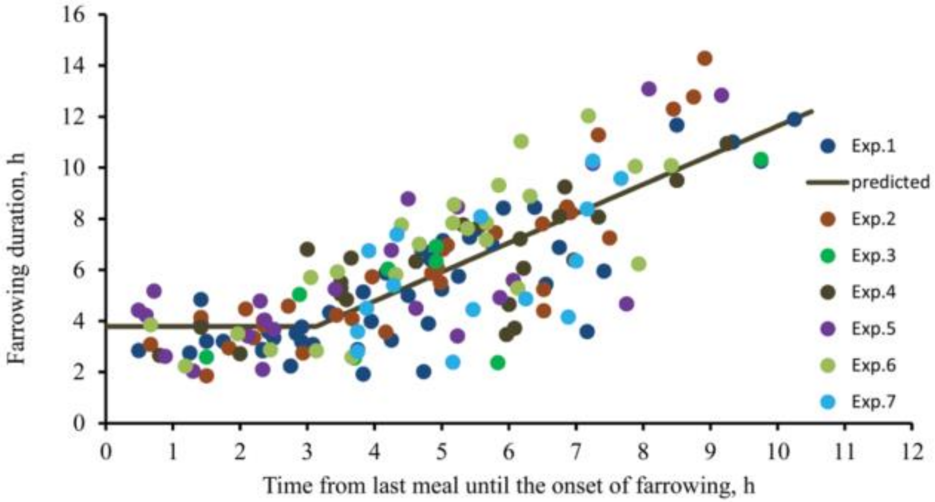


Figure 1. The relation between time from last meal until the onset of farrowing and farrowing duration. In Exp. 1, sows received 2 daily meals and in Exp. 2 through 7, sows received 3 daily meals. The solid circles with different colors indicate individual sows studied in 7 previous experiments, whereas the solid line indicate predicted values (data from study-1).

Impact of sow energy status during farrowing on farrowing kinetics, frequency of stillborn piglets, and farrowing assistance[1]

Takele Feyera, Trine Friis Pedersen, Uffe Krogh, Leslie Foldager, and Peter Kappel Theil[2]

Department of Animal Science, Aarhus University, Foulum, Dk-8830 Tjele, Denmark.

J. Anim. Sci. 2018.96:2320–2331
doi: 10.1093/jas/sky141

Transition feeding to improve the farrowing process

Frequent feedings

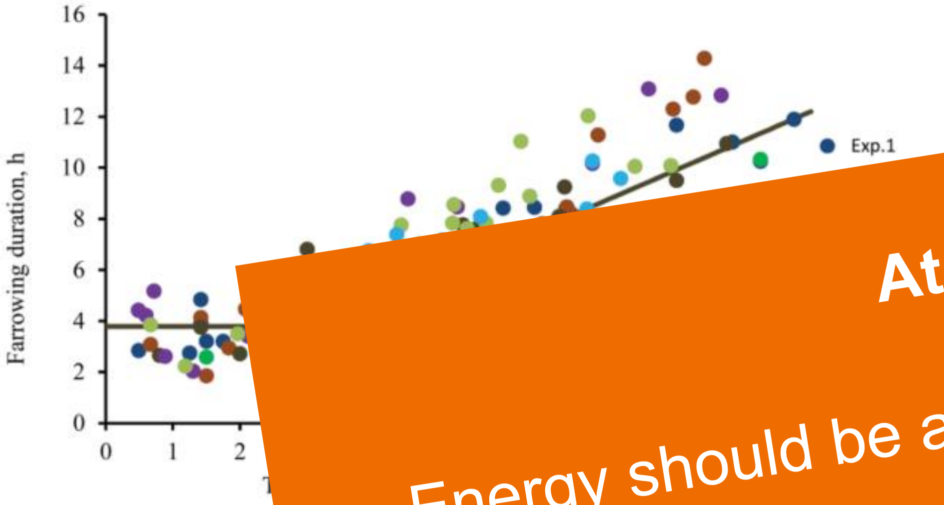


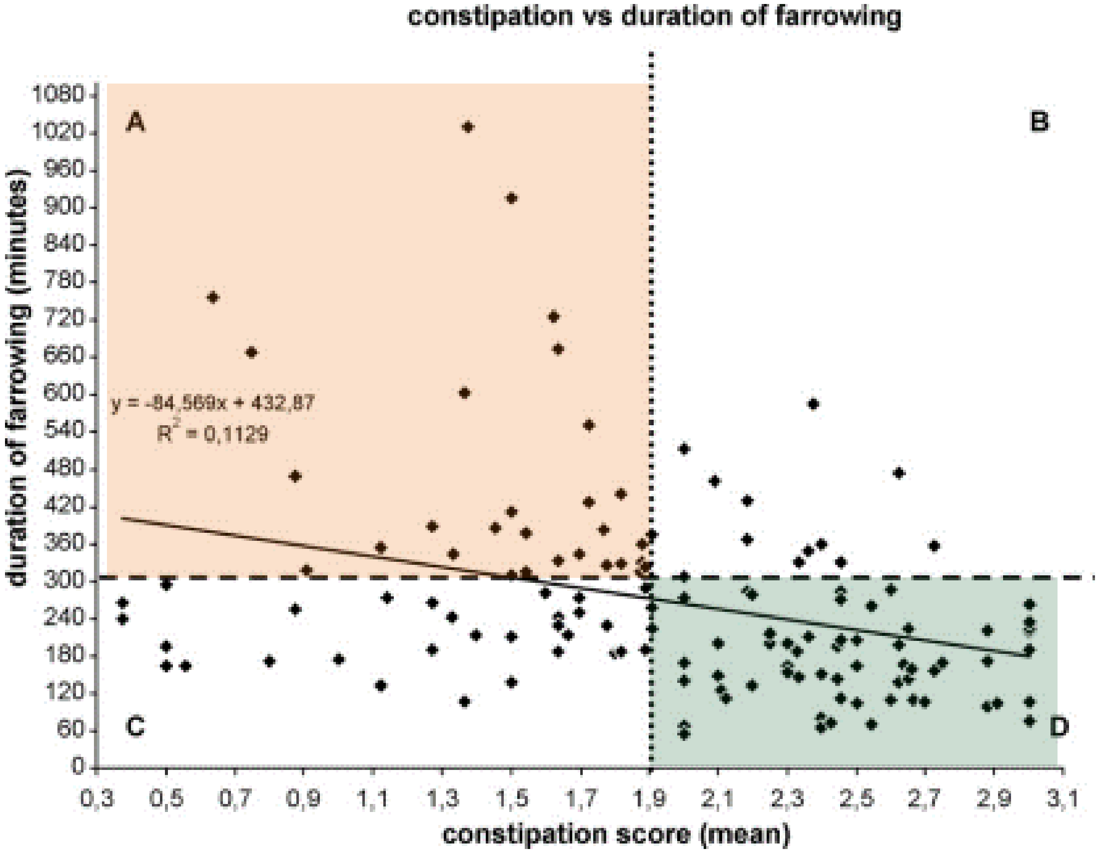
Figure 1. The rela ... the onset of farrowing and farr ... xp. 1, sows received 2 daily meals and in Exp. 2 th ... 7, sows received 3 daily meals. The solid circles with different colors indicate individual sows studied in 7 previous experiments, whereas the solid line indicate predicted values (data from study-1).

At least 3 meals per day

Energy should be available around the clock (starch + fibers)

...oup.com.
...nim. Sci. 2018.96:2320–2331
doi: 10.1093/jas/sky141

Transition feeding
Effect of constipation in sows at farrowing



Contents lists available at ScienceDirect

Animal Reproduction Science

journal homepage: www.elsevier.com/locate/anireprosci

Environmental and sow-related factors affecting the duration of farrowing

Claudio Oliviero*, Mari Heinonen, Anna Valros, Olli Peltoniemi

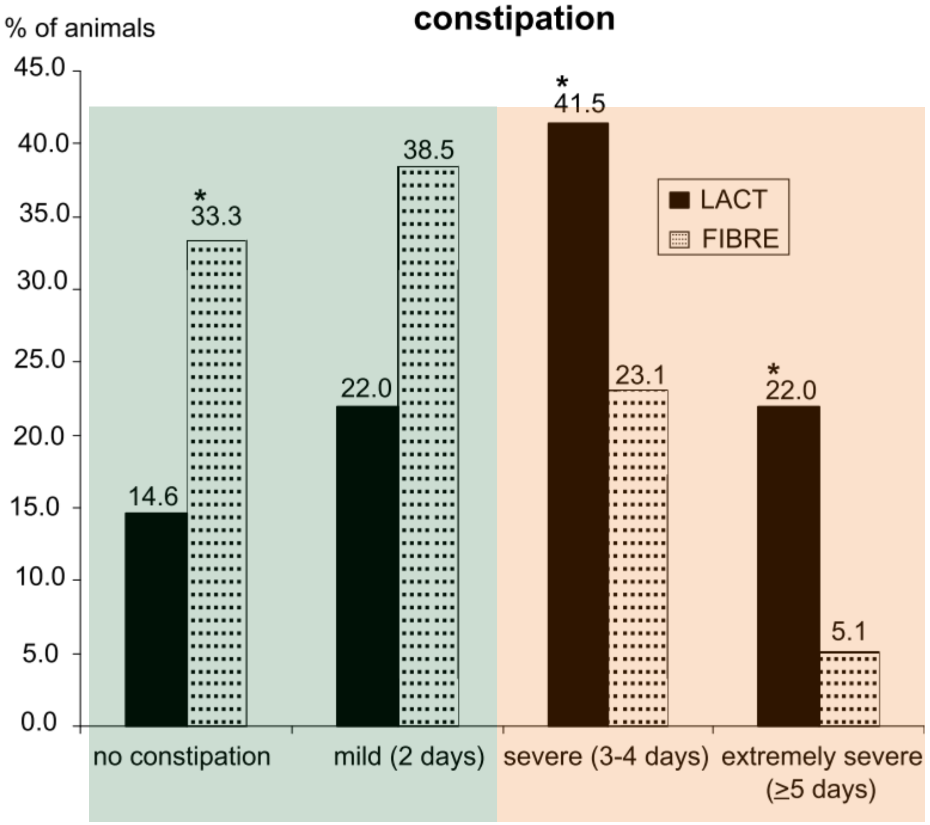
↑ Constipation (low score)

⇩

↑ farrowing duration

Improving the farrowing process

Fiber sources in the transition and/or lactation feed is a ”must”




Research in Veterinary Science 86 (2009) 314–319

Contents lists available at ScienceDirect

Research in Veterinary Science

journal homepage: www.elsevier.com/locate/rvsc

Feeding sows with high fibre diet around farrowing and early lactation: Impact on intestinal activity, energy balance related parameters and litter performance

Claudio Oliviero [a,*], Teija Kokkonen [b], Mari Heinonen [a], Satu Sankari [c], Olli Peltoniemi [a]

[a] Department of Production Animal Medicine, Faculty of Veterinary Medicine, University of Helsinki, Pohjoinen Pikatie 800, 04920 Saarentaus, Finland
[b] Department of Basic Veterinary Science, Faculty of Veterinary Medicine, University of Helsinki, P.O. Box 66, 00014 Helsinki, Finland
[c] Department of Equine and Small Animal Medicine, Faculty of Veterinary Medicine, University of Helsinki, P.O. Box 66, 00014 Helsinki, Finland

SEGES INNOVATION

Improving the farrowing process

Fiber sources in the transition period

Item	Control	Treatment	SEM[1]	*P*-value
Number of sows	310	334		
Number of nurse sows	52	56		
Number of total born piglets	18.4	18.1	0.29	0.38
Number of live-born piglets	16.8	16.9	0.25	0.78
Number of weaned piglets	14.2	14.4	0.23	0.66
Stillborn piglets, % of total born	8.8[a]	6.6[b]	0.47	<0.001
Preweaning mortality, % of total born	14.6	13.7	0.68	0.21
Overall mortality, % total born	22.3[a]	19.9[b]	0.71	0.004
Causes of preweaning piglet mortality, % of total born				
Crushing	4.7	5.0		0.41
Low birth weight	3.2	3.6		0.24
Poor viability at birth	2.8[a]	1.5[b]		<0.001
Unidentified	2.3	1.9		0.20
Starvation	0.8	1.0		0.36
Joint infection	0.5	0.5		0.91
Diarrhea	0.7[a]	0.3[b]		0.004

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]The largest SEM.

~350 and ~700 g fiber additive per day for 7+7 days

Dietary supplement rich in fiber fed to late gestating sows during transition reduces rate of stillborn piglets[1]

T. Feyera,* C. K. Højgaard,† J. Vinther,† T. S. Bruun,† and P. K. Theil*[2]

*Department of Animal Science, Aarhus University Foulum, DK-8830 Tjele, Denmark; and †SEGES Danish Pig Research Centre, DK-1609, Copenhagen, Denmark

J. Anim. Sci. 2017.95:5430–5438
doi:10.2527/jas2017.2110

SEGES INNOVATION

Transition feeding
Effect of fibre rich and protein reduced transition diet

Research in Veterinary Science 86 (2009) 314–319

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Research in Veterinary Science

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Claudio Oliviero [a,*], Teija Kokkonen [b], Mari Heinonen [a], Satu Sankari [c], Olli Peltoniemi [a]

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Table 2
Causes of piglet mortality (from birth to day 5 of life) after post-mortem examination in the two treatments (41 litters, 21 LACT and 20 FIBRE)

Cause of mortality	*n*	%	LACT piglet (*n*)	FIBRE piglet (*n*)	*P* value
Stillborn	50	34.5	26	24	>0.05

Improving the farrowing process
Combining the effects of fibers and feed allowance

3 meals per day 0530h, 1130h and 2300h

Only 3rd-7th parity sows included

Group 1:  2.8 kg

Group 2:  3.8 kg

Group 3:  3.8 kg

78.6% wheat
6.6% sugar beet
4.5 % oat hulls
5.0 % cake flour

Reference: Højgaard et al. (2022)

Improving the farrowing process
Combining the effects of fibers and feed allowance

3 meals per day 0530h, 1130h and 2300h

Only 3rd-7th parity sows included

Group 1:  2.8 kg // 357 g SID CP/day // 499 g fibre/day

Group 2:  3.8 kg 3.8 kg // 474 g SID CP/day // 665 g fiber/day

Group 3:  3.8 kg // 422 g SID CP/day // 667 g fiber/day

78.6% wheat
6.6% sugar beet
4.5 % oat hulls
5.0 % cake flour

SEGES INNOVATION

Reference: Højgaard et al. (2022)

Improving the farrowing process
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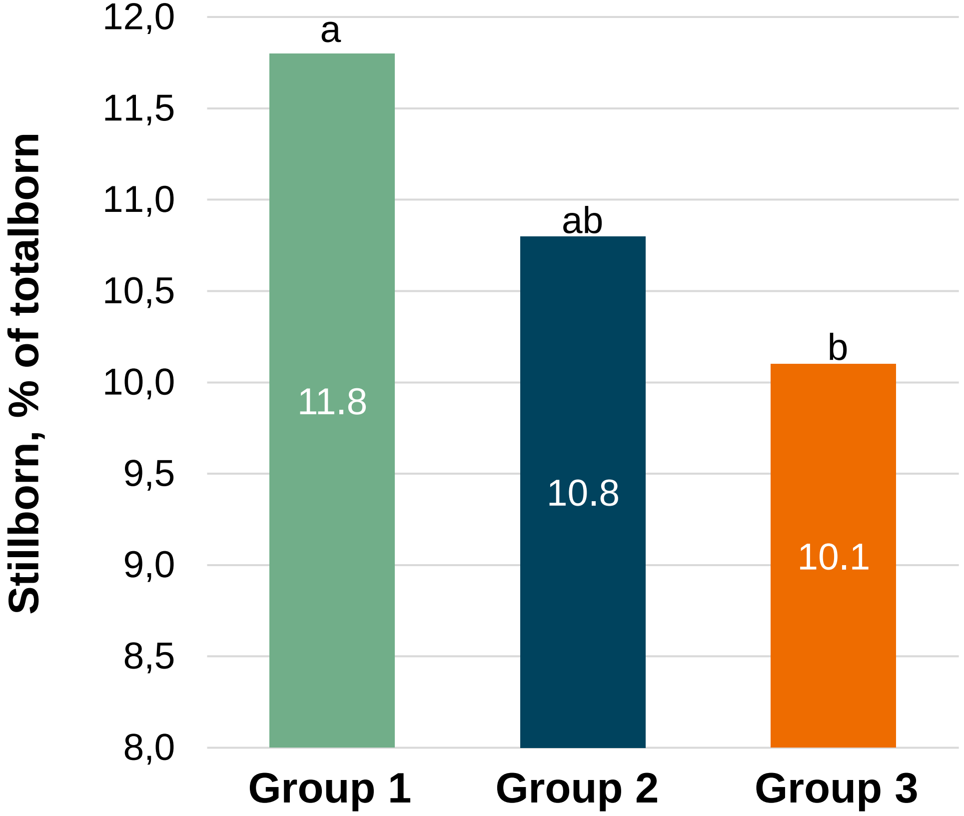

^{a,b} $P < 0.03$

SEGES INNOVATION

Reference: Højgaard et al. (2022)

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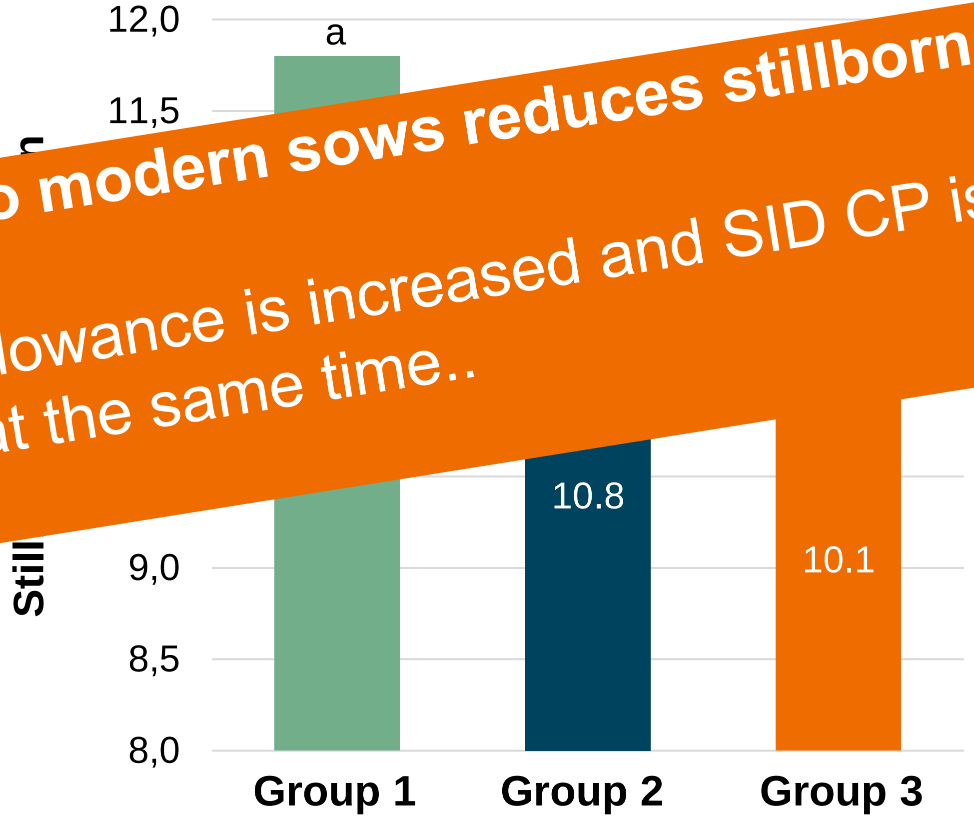


Increasing feed allowance to modern sows reduces stillborn

Especially when daily fiber allowance is increased and SID CP is reduced at the same time..

^{a,b} P < 0.03

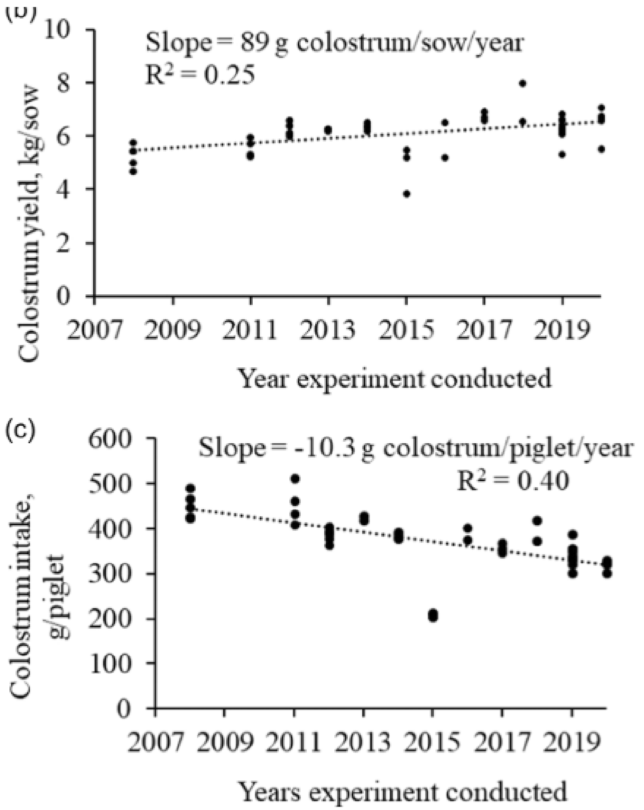
Reference: Højgaard et al. (2022)

SEGES INNOVATION

Colostrum

Photo: Rasmus Bendix, Bendix Production

Colostrum production



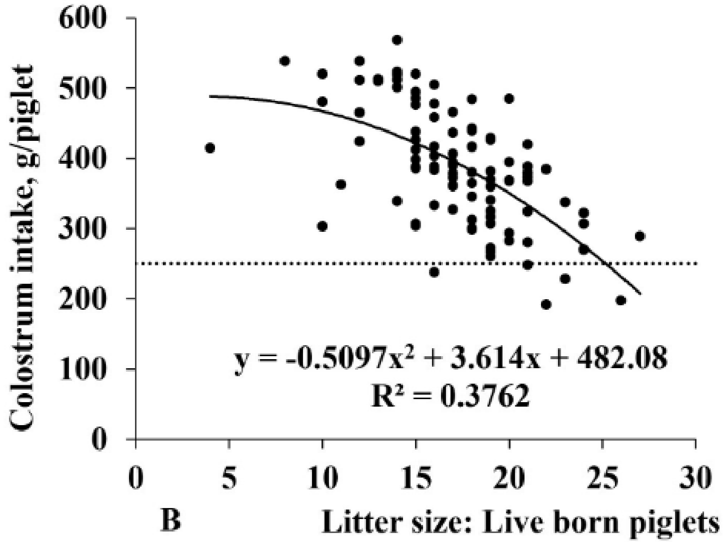
Received: 14 January 2022 | Accepted: 5 April 2022
DOI: 10.1002/mrd.23571

Molecular Reproduction Development

REVIEW ARTICLE

Feeding the modern sow to sustain high productivity

Peter K. Theil[1] | Uffe Krogh[1,2] | Thomas S. Bruun[2] | Takele Feyera[1]



Journal of Animal Science, 2022, **100**, 1–15
https://doi.org/10.1093/jas/skac176
Advance access publication 16 June 2022
Board Invited Reviews

Review: Physiology and nutrition of late gestating and transition sows

Peter Kappel Theil,[†,1] Chantal Farmer,[‡] and Takele Feyera[†]
[†]Department of Animal Science, Aarhus University, DK-8830 Tjele, Denmark
[‡]Sherbrooke R & D Centre, Agriculture and Agri-Food Canada, Sherbrooke, QC J1M 0C8, Canada

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Transition feeding

Effect of fiber and fat source on colostrum production

	CON[z]			ALF[z]			SPB[z]		
	PFAD[y]	SOYO[y]	C8TG[y]	PFAD	SOYO	C8TG	PFAD	SOYO	C8TG
Gross energy (MJ kg^{-1} DM^{-1})	18.1	18.0	18.4	18.6	18.5	18.6	17.8	18.4	17.6
Nonstarch polysaccharides[x]	128 (24)	129 (27)	130 (26)	175 (42)	172 (41)	176 (41)	162 (32)	163 (24)	158 (25)
Klason lignin	14	17	18	23	27	20	39	39	40
Dietary fiber	142	146	148	199	199	196	200	202	198
Fatty acid (g × kg DM^{-1})	48	48	41	59	57	47	53	51	43
Medium-chain (C8 to C14)	1	0	15	1	0	16	1	0	19
Long-chain (C16 to C22)	47	48	26	58	56	31	53	50	24
Saturated fatty acids	20	11	23	27	15	27	23	12	26
Monounsaturated fatty acids	13	11	5	18	14	7	15	11	4
Polyunsaturated fatty acids	14	26	13	15	28	13	15	27	12

[z]Low fiber content (CON), sugar beet pulp (SBP) and alfalfa meal (ALF).
[y]Soybean oil (SOYO), palm fatty acid distillate (PFAD) and trioctanoate (C8TG).
[x]Numbers in parentheses are contents of soluble non-starch polysaccharides.

Colostrum production in sows fed different sources of fiber and fat during late gestation

Uffe Krogh[1], Thomas S. Bruun[2], Charlotte Amdi[3], Christine Flummer[1], Jesper Poulsen[2,4], and Peter K. Theil[1,5]

Transition feeding
Effect of fiber and fat source on colostrum production

No effect of fat and fiber on colostrum yield

	Fiber			Fat				*P* values	
	CON[z]	ALF[z]	SBP[z]	PFAD[y]	SOYO[y]	C8TG[y]	SEM[x]	Fiber	Fat
Fat (%)									
0 h	5.0	4.7	5.2	5.0	5.3	4.6	0.33	0.43	0.27
12 h	4.7	4.9	5.4	5.2	5.3	4.6	0.68	0.69	0.67
24 h	6.8	5.9	6.9	5.7	7.5	6.4	0.77	0.55	0.17
36 h	8.0	8.1	9.2	7.8*b*	10.1*a*	7.4*b*	0.72	0.32	0.01
Protein (%)									
0 h	17.8	17.3	17.7	17.7	18.0	17.0	0.80	0.86	0.59
12 h	11.5	12.3	13.1	11.8	12.9	12.1	0.90	0.35	0.58
24 h	7.3	8.4	10.0	8.1	9.8	7.7	1.01	0.10	0.20
36 h	6.6	8.2	7.0	7.2	7.7	6.9	1.24	0.10	0.55
Lactose (%)									
0 h	3.5	3.5	3.5	3.5	3.5	3.6	0.07	0.94	0.26
12 h	4.2*a*	4.0*ab*	3.9*b*	4.0	4.0	4.0	0.10	0.03	0.84
24 h	4.6*a*	4.4*ab*	4.2*b*	4.5	4.2	4.5	0.11	0.04	0.10
36 h	4.7*a*	4.4*b*	4.6*ab*	4.6	4.5	4.7	0.19	0.04	0.33
Dry matter (%)									
0 h	27.5	26.4	26.8	27.2	27.3	26.2	0.72	0.46	0.45
12 h	21.4	22.1	23.3	21.9	23.2	21.6	0.73	0.11	0.18
24 h	19.9*b*	19.5*b*	22.4*a*	19.0*b*	23.0*a*	19.9*b*	0.81	0.001	<0.001
36 h	19.8	21.1	21.3	19.9*b*	22.9*a*	19.5*b*	1.35	0.28	0.004

[z]Low fiber content (CON), sugar beet pulp (SBP) and alfalfa meal (ALF).
[y]Soybean oil (SOYO), palm fatty acid distillate (PFAD) and trioctanoate (C8TG).

Colostrum production in sows fed different sources of fiber and fat during late gestation

Uffe Krogh[1], Thomas S. Bruun[2], Charlotte Amdi[3], Christine Flummer[1], Jesper Poulsen[2,4], and Peter K. Theil[1,5]

Transition feeding
Effect of fiber source on colostrum production

Journal of Animal Science, 2021, Vol. 99, No. 9, 1–12

https://doi.org/10.1093/jas/skab247
Advance Access publication August 22, 2021
Received: 30 June 2021 and **Accepted:** 19 August 2021
Non Ruminant Nutrition

NON RUMINANT NUTRITION

Impact of four fiber-rich supplements on nutrient digestibility, colostrum production, and farrowing performance in sows

Takele Feyera,† Liang Hu,†,1 Maria Eskildsen,† Thomas S. Bruun,‡ and Peter K. Theil,†,2

			Dietary fiber supplements[1]			
Ingredients	Gestation diet	Lactation diet	Mixed fiber	Sugar beet pulp	Palm kernel expellers	Soy hulls
Lignin	17.2	19.0	91.2	73.0	124	58.1
Soluble NSP[2]	31.7	26.8	101	220	66.0	126
Insoluble NSP[2]	80.5	94.9	255	318	449	554
Total NSP[2]	112	122	356	538	515	680
Dietary fiber	129	141	447	611	640	738

UNIVERSITY OF COPENHAGEN

Transition feeding
Effect of fiber source on colostrum production

Journal of Animal Science, 2021, Vol. 99, No. 9, 1–12
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Ingredients	Gestation diet	Lactation diet	Dietary fiber supplements[1] Mixed fiber	Sugar beet pulp	Palm kernel expellers	Soy hulls
Lignin	17.2	19.0	91.2	73.0	124	58.1
Soluble NSP[2]	31.7	26.8	101	220	66.0	126
Insoluble NSP[2]	80.5	94.9	255	318	449	554
Total NSP[2]	112	122	356	538	515	680
Dietary fiber	129	141	447	611	640	738

Item	Dietary fiber (DF) source[1] MF	SBP	PKE	SH
Concentrations, %				
Fat	6.23	6.89	6.17	6.41
Protein	10.4	11.4	10.6	11.0
Lactose	4.10	3.98	4.07	4.03
DM	21.6[b]	23.1[a]	21.5[b]	22.1[ab]
Outputs, g				
Fat	378	422	340	377
Protein	798	835	668	818
Lactose	264	258	229	257
DM	1,457[a]	1,566[a]	1,269[b]	1,540[a]
Colostrum yield, kg	6.73	6.72	5.82	6.57
Gross energy, MJ	38.5	40.4	32.6	38.7

Focussing on daily output vs. concentrations is important

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Transition feeding
Effect of protein to ME ratio on colostrum production

	HE-FP	HE-IP	LE-FP	LE-IP	SEM	*P*-value
Day 108-farrow						
Energy intake, MJ ME/day	42.2^{a}	43.3^{a}	33.9^{b}	33.9^{b}	1.48	$<$ 0.001
Protein intake, g SID/day	427^{ac}	475^{a}	348^{b}	384^{bc}	15.7	$<$ 0.001
Protein intake, g/kg	125^{d}	141^{b}	128^{c}	147^{a}	0.22	$<$ 0.001
Lysine intake, g SID/day	17.6^{ac}	19.3^{a}	14.3^{b}	15.6^{bc}	0.64	$<$ 0.001
Lysine intake, g/kg	5.17^{d}	5.73^{b}	5.26^{c}	5.98^{a}	0.008	$<$ 0.001
Protein to ME ratio	10.14^{d}	10.99^{b}	10.28^{c}	11.35^{a}	0.01	$<$ 0.001
Colostrum yield, kg/sow						
0–12 h[1]	3.7	3.5	4.0	3.8	0.4	0.80
12–24 h[1]	2.6	2.7	2.5	2.7	0.2	0.83
0–24 h[1]	6.3	6.2	6.4	6.5	0.6	0.97
Fat, g/100 g						
0 h	4.7^{AB}	5.0^{AB}	3.9^{B}	5.4^{A}	0.42	0.08
12 h	5.4	5.3	6.1	5.7	0.7	0.87
24 h	7.4	7.5	6.1	6.3	0.7	0.38

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Impact of dietary protein to energy ratio and two different energy levels fed during late gestation on plasma metabolites and colostrum production in sows

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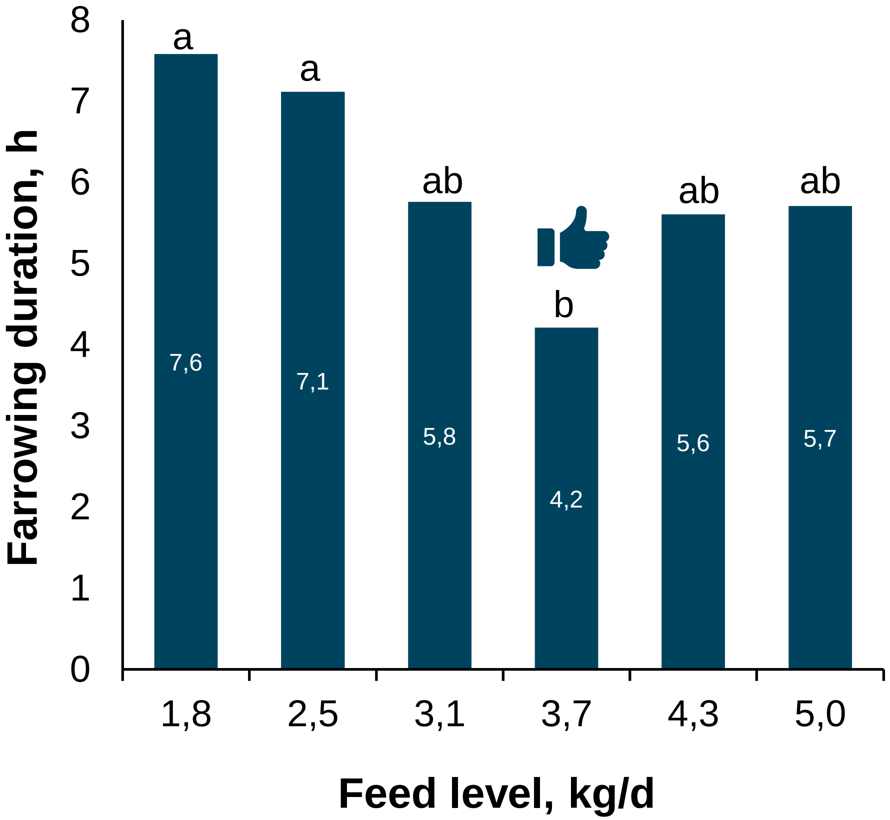
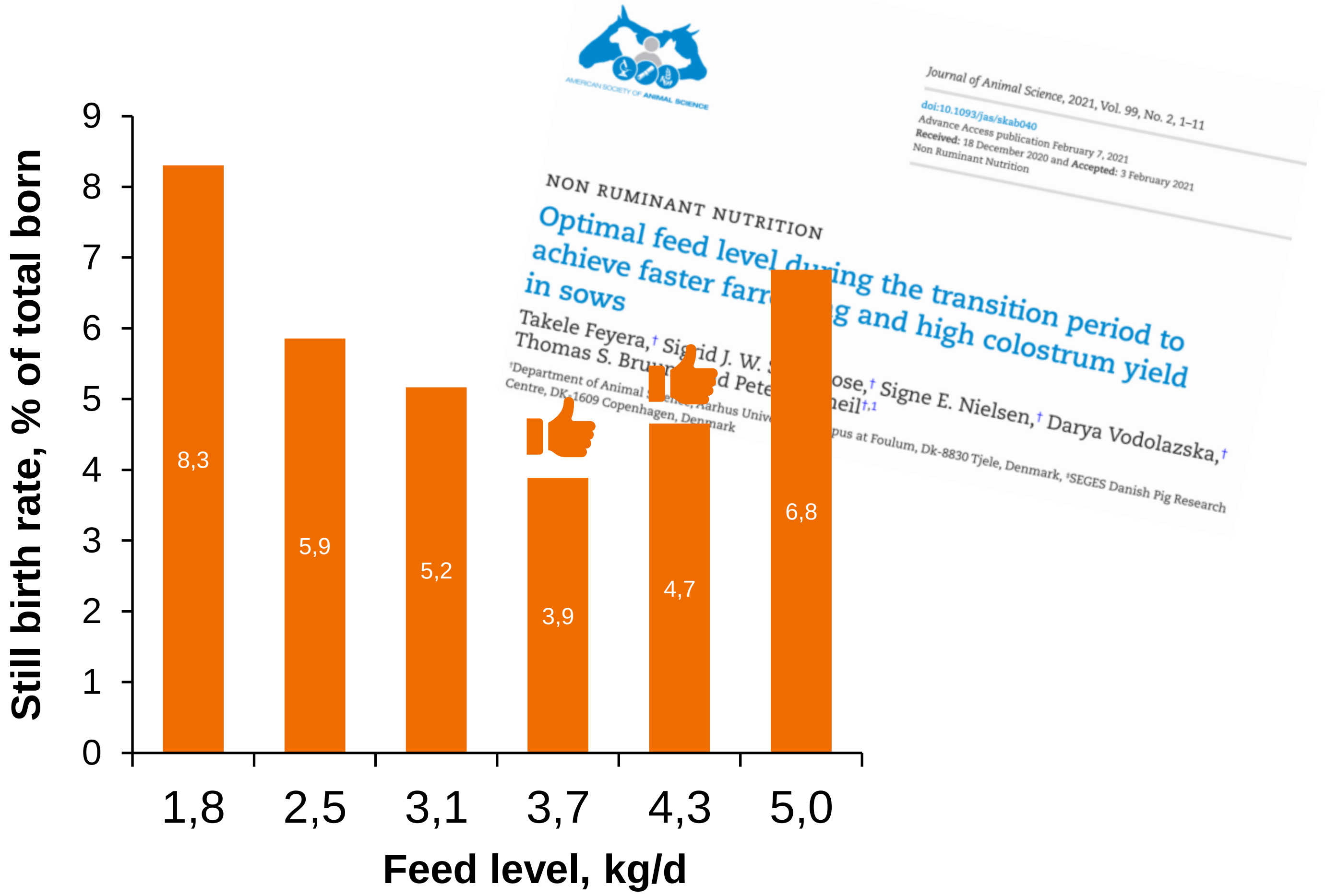
High protein:ME ratio
→ Tendency ↑ colostral fat concentration at start farrowing
→ No effect on protein secretion

Photo: Rasmus Bendix, Bendix Production

Improving the farrowing process

Selecting the optimal feeding level the last week of gestation

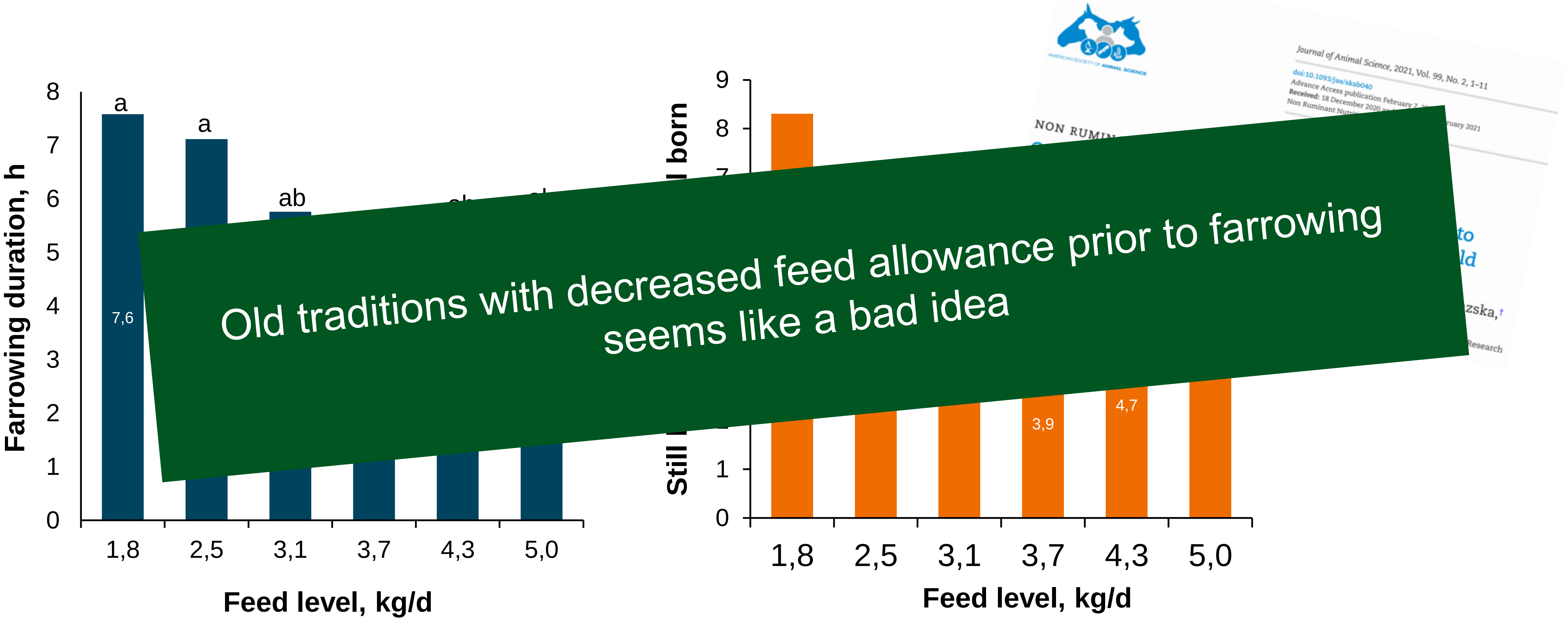




SEGES INNOVATION

Improving the farrowing process

Selecting the optimal feeding level the last week of gestation



Old traditions with decreased feed allowance prior to farrowing seems like a bad idea

SEGES INNOVATION

Transition feeding

Effect of feed allowance on colostrum production

Item	Feed level (FL), kg/d					
	1.8	2.4	3.1	3.7	4.3	5.0
CY 0 to 24 h, kg/sow	5.33[b]	6.26[a]	6.62[a]	6.32[a]	6.06[ab]	6.17[a]
Piglet colostrum intake 0 to 24 h, g	302	321	333	350	341	357

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Non Ruminant Nutrition

NON RUMINANT NUTRITION

Optimal feed level during the transition period to achieve faster farrowing and high colostrum yield in sows

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A feed reduction prior to farrowing can decrease colostrum production

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Overview on gestation and pre-farrowing periods

Timeframes with natural overlays

- Weaning-to-estrus-interval (follicle quality and numbers)
- Entire gestation period i.e. day 0-114 (covers all growth aspects)
- Early gestation i.e. day 0-50 (maternal growth, implantation and placental growth)
- Mid gestation i.e. day 30-85 (maternal growth, placental and fetal growth)
- Late gestation i.e. day 75-110 (maternal growth, fetal and udder growth)
- Transition period i.e. day 110-post farrowing (fetal and udder growth and farrowing performance)
- Conclusion and perspectives

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Conclusions

- **Piglet birth weight and within-litter variation**
  - Glycemic diets affect number of total born in hyper-prolific sows
- **Feeding in gestation**
  - Omega-3 fatty acids show potential to improve piglet birth weight and sow health
  - No negative effect of low Lys/protein diet on piglet birth weight
- **Farrowing process**
  - Use of soluble fiber to avoid constipation
  - No feed reduction prior to farrowing (3.5-4.0 kg/day)
- **Colostrum production**
  - Feed reductions should be avoided (≥2.4 kg/day)

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Perspectives
Future research in pre-farrowing nutrition of sows

Feeding during weaning-to-estrus interval and previous lactation

Glycemic diets may need more attention (fed at the last part of lactation and WEI?)

→ Effect on follicle maturation and piglet birth weight

Mid gestation lacks attention…

→ Importance of nutrition on placental development and birth weight

More studies on functional AA

→ Possible effects of arginine need to be revisited in hyper-prolific sows

Health status and welfare of the sow

→ Impact of nutrition on e.g. oxidative stress and inflammatory status

→ Long term effect on piglet birth weight and sow longevity

Carry-over effects from transition feeding to lactation performance

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Questions

Photo: Rasmus Bendix, Bendix Production