

HET EFFECT VAN EEN VERKORTE DRACHTDUUR OP DE LACTATIECURVE BIJ EERSTEKALFS HOLSTEIN VAARZEN.

Nederlandse samenvatting

Gezien recente ontwikkelingen binnen de Nederlandse melkveehouderij rondom de milieu wetgeving, meer specifiek de fosfaatrechten is er een sterk hernieuwde belangstelling in de opfok van jongvee. Het aanhouden van een minimaal aantal stuks jongvee als vervangingsvee is een belangrijke strategie om het aantal fosfaatrechten op het bedrijf zo optimaal mogelijk te benutten. Daarnaast neemt jongvee opfok ongeveer 20% van de totale productiekost van melk voor zich.

In veel landen is de melkproductie over de loop van de laatste 50 jaar verdubbeld, door een combinatie van genetisch selectie en verbetering van het management van melkvee. Het productieve leven van een vaars start bij het voor de eerste maal drachtig worden en succesvol afkalven. Het vroegtijdig kalven of een abortus heeft een belangrijke invloed op het productieve leven van de vaarzen. Veel van de fundamentele fysiologische principes over het opstarten van de melkproductie in relatie met de hormonale veranderingen die gepaard gaan met het vorderen van de dracht zijn reeds lange tijd gekend. Echter, reeds in 1931 werden er meldingen gemaakt over vaarzen die reeds na 120 dagen dracht melk produceerden (Asdell, 1931). Over de loop van de jaren is de genetisch aanleg om melk te geven gewijzigd en worden vanuit de praktijk meldingen gemaakt over het succesvol initiëren van de melkproductie voor het bereiken van een normale drachtduur. Echter recente gegevens om deze anecdotische waarnemingen te ondersteunen zijn afwezig.

Het doel van deze studie was het analyseren van een bestaande dataset van melkproductiegegevens van Europese melkveebedrijven om een idee te krijgen over:

1. Het aantal dieren dat per bedrijf een lactatie start na een abnormaal korte drachtlengte en het kwantificeren van het effect daarvan op de melkproductie.
2. Het in beeld brengen van de melkproductie van vaarzen met een extreem korte drachtlengte (< 243 dagen).

26 In de periode 2013 tot en met 2018 werd data verzameld van 100 melkveebedrijven die uitgerust waren
27 met automatische melkmeting. De drachtduur werd berekend per dier en onderverdeeld in categorieën
28 op basis van kwantielen (0-1%, 1-5%, 5-25% en 25-75%). Een langere drachtduur als normaal (kwantiel
29 75-100%) werd in deze studie niet meegenomen. Finaal werden 2 135 210 melkingen bij 10 698 eerste
30 lactatie dieren geselecteerd voor verdere analyse op 94 bedrijven. Na het elimineren van lactaties met
31 minder als 10 lactatiedagen werd een Milkbot lactatiecurve analyse uitgevoerd naar de methodologie
32 beschreven in Hostens et al. (2012). De verschillen in lactatiecurve parameters tussen de verschillende
33 drachtduur categorieën is weergegeven in Tabel 2. De meeste verschillen in lactatie curve parameters
34 kunnen gezien worden tussen de categorieën 0-1%, 1-5% enerzijds en de 5-25%, 25-75% anderzijds.
35 Een verschil van 718 ± 154 kg in de M305d productie kan geobserveerd worden tussen de 0-1% en 25-
36 75% categorieën. Het verschil kan voornamelijk toegeschreven worden aan een lagere piekgift bij de 0-
37 1% (27.2 ± 0.66 kg melk/koe vs 30.1 ± 0.40 kg melk/koe) die slechts deels gecompenseerd wordt door
38 een hogere persistentie (decay 0.00123 ± 0.0000582 versus 0.00138 ± 0.0000248).
39 Verder werd de dataset geanalyseerd naar melkgifte na extreem korte drachtduur. In dit geval werd de
40 maximale drachtduur op 210 dagen geplaatst. Van de 10 698 lactaties werden 15 lactaties (dier
41 prevalentie - $15 / 10698 : 0.14\%$) gevonden op 12 bedrijven (bedrijf prevalentie - $12/94 : 12.8\%$) met
42 een drachtduur korter als 210 dagen. Deze lactatiecurves werden individueel gevisualiseerd in figuur 1.
43 Acht van de 15 vaarzen bleven ook langer als 120 dagen in productie. Daarnaast werden de
44 vruchtbaarheidsgegevens van deze dieren opgezocht en weergegeven in tabel 1. Zes van de 15 dieren
45 hadden een natuurlijke dekking als laatste bevruchting, 8 werden geïnsemineerd met kunstmatige
46 inseminatie en 1 dier werd drachtig na embryo transfer.
47 Samenvattend kan gesteld worden dat in deze observationele studie melkproductie verliezen van $718 \pm$
48 154 kg gezien worden in 305d productie van vaarzen met een drachtduur van minder als 243 dagen
49 vergeleken met het gemiddelde (276-283 dagen). In deze studie werd het verschil veroorzaakt door een
50 lagere piekproductie die deels gecompenseerd werd door een hogere persistentie. De melkproductie
51 verliezen zijn opmerkelijk lager (maximaal 90%) vergeleken met oudere observaties van Swanson

52 (1970) met maximale verliezen om en bij de 68%. Verder werden op 12.8% van de 94 bedrijven, 15
53 dieren gevonden met een drachtduur lager als 210 dagen waarbij weldegelijk een lactatiecurve kon
54 geconstrueerd worden. Echter, het aantal dieren per bedrijf ligt opvallend lager, 0.14% van de eerste
55 kalfsdieren. In 6 van de 15 gevonden lactaties met extreem korte drachtduur werd een natuurlijke
56 dekking als laatste inseminatie genoteerd. Mogelijks werden deze ten onrechte door de veehouder
57 beschouwd als dekking en was het dier reeds drachtig van een vroegere inseminatie of dekking. Gebruik
58 makende van de management gegevens van de veehouder kon dit slechts in 1 geval (dier 3) bevestigd
59 worden.

60 Concluderend toonde deze studie aan dat op ongeveer 13% van de onderzochte bedrijven in uiterst
61 zeldzame gevallen (8/10698: 0.075% van de dieren) een lactatie van minder als 210 dagen drachtduur
62 leidt tot een melkproductie die langer als 120 dagen in lactatie blijft duren. Ondanks de aangetoonde
63 verschillen in deze studie vertoont de lactatiecurve van sommige van de onderzochte lactaties na
64 extreem korte dracht een normaal fysiologisch patroon.

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67 Interpretative Summary: Lactation Performances In Heifers Following Abortion Or Short Gestation.

68 *By Monica Probo et al.*

69

Lactation Performances In Heifers Following Short versus Normal Gestation Length

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INTRODUCTION

In many countries, milk yield per cow has more than doubled in the last 40 years, mainly due to rapid progress in management first, and in genetics then (Oltenu and Broom, 2010). Looking at the literature, it appears that many of the fundamentals of milking process for successful lactation have been understood (Akers, 2017); moreover, the advent of sensitive assays to measure concentrations of mammogenic, lactogenic, and galactopoietic hormones and, subsequently, growth factors in blood, milk, and tissues, has allowed creation of multiple hypotheses to explain mammary cell proliferation and regulation of function (Akers, 2017). However, some of the principles that have been identified when cows produced markedly less milk may not be still valid for the high-producing cows of today (Akers, 2017), and some mechanisms regarding physiology of lactation are still unexplored.

The initiation of milk secretion in cattle is usually thought to follow the termination of pregnancy; still, it has long been known that cows may begin to secrete milk also previous to the time of parturition (Turner, 1931), so that the practice of pre-partum milking in dairy cows has been investigated as a means to shorten calving intervals and enhance milk production (Pennington and Malven, 1985; Malven et al. 1987; Greene et al. 1988; Grummer et al. 2000; Bowers et al. 2006). For decades, researchers also focused on the hormonal induction of lactation, from the first successful induction in a goat (Frank and Rosenbloom, 1915) until the development of a short-term protocol that ensures

94 induction of lactation in most treated cows and heifers (Collier et al., 1975; Kensinger et al., 1979; Byatt
95 et al., 1994; Magliaro et al., 2004). Induced lactation of non pregnant cows can represent an alternative
96 management to avoid culling of high-producing cows with low fertility thus increasing profits (Magliaro
97 et al., 2004), while the induction of lactation in young heifers can provide also a tool to collect milk
98 before a normal lactation for early testing of transgenic animals as possible mammary bioreactors (Ball
99 et al., 2000; Kaiser et al., 2017). Nevertheless, the average milk yield per lactation hormonally-induced
100 is about 90% in cows (Mellado et al., 2011) and 60-70% in heifers (Fulkerson, 1978) of an equivalent
101 post calving lactation, and the use of hormones for lactation induction is legally forbidden in most of
102 the countries because of concerns regarding consumer safety and presence of hormones in milk (Jewell,
103 2002).

104 Rearing heifers represents about 20% of total milk production costs (Donovan et al., 1986; Fetrow,
105 1988), and the return on the investment allocated from birth to first lactation is commonly not fully
106 recovered until at least the end of first lactation (Bach, 2011). As consequence, productive life of heifers
107 is an important factor in determining profits of dairy enterprises (Bach, 2011). Pregnancy losses would
108 still allow heifers to start their first lactation if they are sufficiently far advanced in pregnancy, but the
109 exact time point when this is possible is unknown. Scattered through the earlier literature on milk
110 secretion are reports on lactation in suckled virgin heifers (Turner, 1931) and in heifers milked as early
111 as 120 days of first pregnancy (Asdell, 1931). The secretory activity of the mammary gland during the
112 first pregnancy in heifers is of considerable interest, as the growth of the mammary glands during the
113 first pregnancy is remarkable (Turner, 1931). Early studies on mammary development in cattle showed
114 that the histological development of the mammary gland from early gestation to near parturition is a
115 progressively continuous process, more nearly exponential than linear, with marked developmental
116 changes only in late pregnancy (Kwong, 1940; Feldman, 1961; Cowie, 1971); most of the rapid increase
117 in udder weight and in growth of the duct system occurs after the fifth month of pregnancy (Hammond,
118 1927). In pregnant heifers, serum concentrations of α -lactalbumin (i.e. a whey protein that plays a
119 central role in milk production) become detectable only in the last trimester of gestation, with modest

increases until just before calving, when concentrations markedly increase (Akers, 2017). This pattern mirrors a 2-stage onset of lactogenesis, with a modest increase in milk component biosynthesis in the last month before calving followed by a marked increase just before and after calving (McFadden et al., 1987). Despite decades of research, little is known regarding physiologic temporal limits for initiation of lactation in pregnant non-lactating cattle. In a research from Swanson (1970), lactations of cows following abnormal mean gestation lengths of 263, 246 and 242 days were compared with normal lactations by the same cows, and reductions to 87%, 73% and 68% of the normal mature-equivalent lactations were registered, respectively. To the best of our knowledge, the effect of short gestation or abortion on lactation performances in heifers is unknown. Therefore, the objective of this study was to evaluate the lactation performances in heifers following short gestation or abortion, by comparison with lactation in heifers after normal gestation length.

MATERIALS AND METHODS

Observational dataset

The observational data were collected using an automated data collection system using a wide variety of herd management software programs as described by Hermans et al. (2019). All herds were located in Belgium, France, Italy, the Netherlands and Germany. Data from a wide range of physiological cow-life events were collected, including birth and calving events, reproduction events (insemination, pregnancy checks, abortions), milking events were combined into one event base dataset.

Definition of gestation length

Throughout the study, a pregnancy was defined as the last insemination and subsequent calving within a range of 150-279 days. The upper limit was set as mean + 2 times the StDev after initial exploration of the gestation length. Given the focus of the current study, no further exploration of long gestation lengths was done in the current study.

Statistical analysis and visualization

144 First, lactation curve parameters scale, ramp and decay were estimated using the Milkbot model
145 (Ehrlich, 2011) and derived m305, peak yield (PEAK) and time to peak (TIMEPEAK) production
146 were compared between different gestation length categories. Animals were categorized to one of 3
147 categories based on quantiles 0-5%, 5-25% and 25-75% (DAYSPREGNANTQUANTILE). For each
148 of the outcome variables, a multi-level mixed model was built taking into account a random effect of
149 the herd (1 | HerdId), fixed effects month (MONTH) and year (YEAR) of calving and age at first
150 calving (AFC) as covariate using the lmer() function from the *lme4* package. Model fit of the nested
151 models was compared to a baseline model only including the random effect using the anova() function.
152 Least square means and contrasts were computed for each of the DAYSPREGNANTQUANTILEs
153 using the lsmeans() function from the *lsmeans* package. Significance and tendency levels were
154 determined at $P < 0.05$ and $0.10 < P < 0.05$, respectively. The data analysis was made publicly available
155 through a central code repository at <https://github.com/Bovi-analytics/probo-et-al-2019>.

156

157 **RESULTS**

158 *Descriptive data analysis*

159 The dataset consisted of 8,175,067 milkings on 100 herds on which data was collected from 26,448
160 animals calving between January 2013 until December 2018. An average of 192 calvings per year was
161 recorded (IQR 83 - 215). After filtering out all first lactation animals, 2,135,210 milkings from 10,698
162 animals on 94 farms remained for further analysis.

163 *Individual lactation curves*

164 In order to identify extreme short gestation lengths, the original dataset was mined using a cut-off of
165 maximum 210 days gestation length. Next, a minimum of 10 days in milk was required for the individual
166 lactation curve exploration. Of the 10,698 lactations, 15 lactations (animal prevalence - 15 / 10698 :
167 0.14%) on 12 herds (herd prevalence - 12/94 : 12.8%) were found with a gestation period shorter than
168 210 days. Each of these 15 individual lactation curves were individually plotted (Figure 1.) and their
169 reproductive history was illustrated in Table 1. Six out of 15 animals had a natural service, 8 had an
170 artificial insemination and one heifer became pregnant after embryo transfer.

171 *Lactation curve parameters*

172 The result of the lactation curve analysis is reported in Table 2. The M305 production was lowest in
173 the 0-1% group (7740 ± 132 kg), followed by the 1-25% (8138 ± 119 kg) and 25-75% (8235 ± 115 kg)
174 group. Each of the lactation curve parameters were different between the 0-1% and 25-75% group with
175 subtle contrasts between the middle 1-25% and 25-75% group for scale.

176

177 **DISCUSSION**

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Table 1. List of reproduction events from 15 animals with short gestation lengths (<210 days).

Animal	Birth Date	Number of Services	Type of Service	Insemination Date	Pregnancy Check Date	Reported Calving Date	Expected Insemination Date	Gestation Length	Remarks
1	3/17/2014	1	NS ¹	7/16/2015	10/21/2015	12/22/2015	3/15/2015	159	
2	6/1/2011	1	NS	2/19/2013		8/1/2013	10/23/2012	163	
3	10/13/2013	3	NS	9/4/2015	10/2/2016	3/29/2016	6/21/2015	207	
4	7/22/2013	1	AI ²	10/1/2014	12/5/2014	3/16/2015	6/7/2014	166	
5	8/3/2014	1	AI	9/30/2015	10/30/2015	3/11/2016	6/3/2015	163	
6	3/17/2014	1	NS	7/16/2015	10/21/2015	12/22/2015	3/15/2015	159	
7	9/18/2013	1	NS	5/25/2016	11/30/2016	12/4/2016	2/26/2016	193	
8	10/30/2013	1	NS	8/12/2015	1/28/2016	2/8/2016	5/2/2015	180	
9	3/17/2016	1	AI	4/13/2017	6/13/2017	11/7/2017	1/29/2017	208	Abort - 11/7/2017
10	6/26/2015	1	AI	11/8/2016		5/11/2017	8/2/2016	184	
11	4/2/2017	1	ET ³	7/3/2018	8/1/2018	12/20/2018	3/13/2018	170	
12	6/23/2016	1	AI	12/18/2017	4/30/2018	5/28/2018	8/19/2017	161	Heat - 12/17/17
13	5/11/2015	1	AI	12/21/2016		5/28/2017	8/19/2016	158	
14	1/9/2016	1	AI	7/18/2017	10/13/2017	1/31/2018	4/24/2017	197	
15	7/31/2017	1	AI	6/15/2018	11/16/2018	12/9/2018	3/2/2018	177	

NS¹ = Natural service, AI² = Artificial insemination, ET³ = Embryo transfer

Table 2. The effect of gestation length on Milkbot lactation curve parameters in first parity cows split by quantile of gestation length.

Parameter	DAYSPREGNANTQUANTILE			
	0-1%	1-5%	5-25%	25-75%
M305, kg/305d	7519 ± 189 ^{a1}	7795 ± 136 ^a	8140 ± 119 ^b	8238 ± 115 ^{bc}
Scale	30.7 ± 0.75 ^a	32.3 ± 0.53 ^a	34.0 ± 0.46 ^b	34.4 ± 0.44 ^{bc}
Ramp	29.2 ± 0.35 ^{ab}	29.2 ± 0.21 ^a	28.9 ± 0.13 ^{ab}	28.7 ± 0.14 ^b
Decay	0.00123 ± 0.0000582 ^a	0.00130 ± 0.0000355 ^a	0.00137 ± 0.0000270 ^b	0.00138 ± 0.0000248 ^b
Time to peak (days)	81.5 ± 1.96 ^a	80.7 ± 1.18 ^{ab}	77.9 ± 0.87 ^{ac}	77.4 ± 0.78 ^{ac}
Peak yield (kg)	27.2 ± 0.66 ^a	28.3 ± 0.47 ^a	29.7 ± 0.41 ^b	30.1 ± 0.40 ^c

¹Different superscripts indicate significant differences between categories at $P < 0.05$.

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182

183 **FIGURES**

184

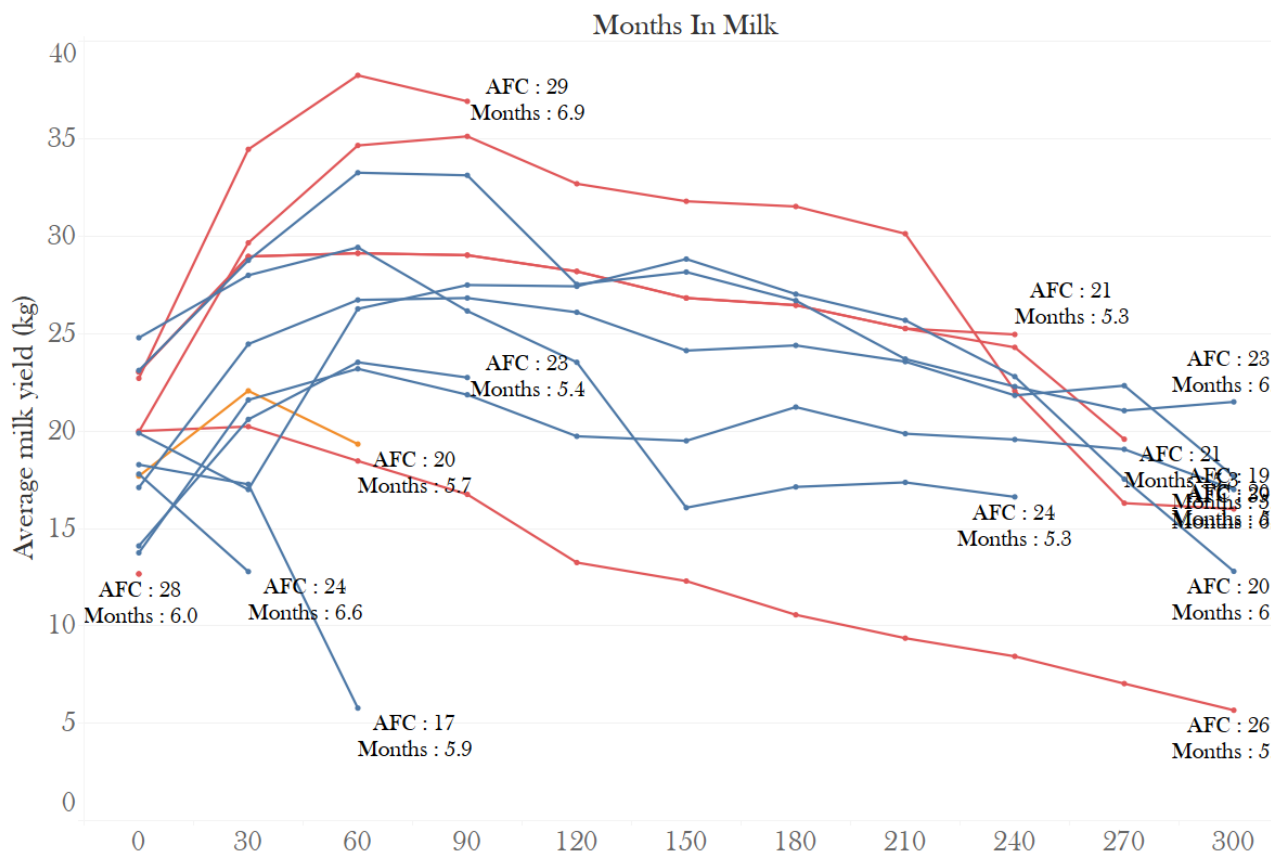


Figure 1. Individual lactation curves of first parity animals with gestation length less than 210 days and minimum of 10 days in milk (blue lines = Artificial insemination, red lines = Natural service, orange = Embryo transfer).

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