Arch. Tierz., Dummerstorf **50** (2007) 5, 476-486

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Effect of Birth Weight and Sex on Pre-Weaning Growth Rate of Piglets

Abstract

A study was conducted to find out the effect of birth weight and sex on growth rate of piglets in pre-weaning period. A total of 466 piglets from 48 litters of multiparous sows (Landrace) were involved in the experiment. Using a clustering approach piglets were assigned into three birth weight groups (Heavy (H), Intermediate (I), Light (L)). For the analysis of growth performance, pigs were weighed every 7 days until weaning at 28 days of age and average daily gain (ADG) was calculated. During lactation, body weight of L piglets was 5.5-fold increased, whereas the increase in I and H piglets were only 4.7-fold and 3.4-fold, respectively. Piglets of L group were significantly lighter at all studied ages compared to piglets of I and H group. The highest ADG was noted in the second week for all three groups; thereafter it decreased in H and L piglets (24% and 17%, respectively). The average birth weight of piglets was positively and significantly correlated with body weight at days 7, 14, 21 and 28. Sex did not affect significantly the ADG of the investigated animals during the four weeks of lactation. The present results indicate that neither milk production after the second week of lactation nor consumption of creep feed are sufficient enough to cover nutrition needs of fast growing piglets. There's still a lack of optimization of nutrition in pre-weaning period especially for heavier piglets with their higher growth potential.

Key Words: piglets, barrow, gilts, birth weight, pre-weaning growth rate

Zusammenfassung

Titel der Arbeit: **Einfluss von Geburtsgewicht und Geschlecht auf die Gewichtszunahme von Ferkeln bis zum Absetzen**

Bei 466 Ferkeln aus 48 Würfen von schwedischen Landrassesauen wurde der Einfluss des Geburtsgewichtes und des Geschlechtes auf die Gewichtszunahme bis zum Absetzen am 28. Lebenstag geprüft. Die Ferkel wurden nach ihrem Geburtsgewicht in die Gruppen schwer (H), mittel (I) und leicht (L) eingeteilt, jeden 7. Tag gewogen und am 28. Lebenstag abgesetzt. Die durchschnittliche tägliche Gewichtszunahme wurde errechnet. Während der Säugezeit erhöhte sich das Körpergewicht der L Ferkel um das 5,5-fache, während das der I und H Tiere um das 4,7 bzw. 3,4-fache zunahm. Die L Tiere waren bei jedem der Wiegetage leichter als die I und H Tiere. Tiere in allen drei Gruppen erreichten ihre höchste Gewichtszunahme in der 2. Lebenswoche, die in den Folgewochen aber bei H und L um 24% bzw. 17% zurückging. Das Geburtsgewicht war signifikant positiv mit dem Körpergewicht am 7., 14. und 28. Tag korreliert. Ein Geschlechtereinfluss auf die tägliche Gewichtszunahme konnte nicht nachgewiesen werden. Es wird geschlussfolgert, dass nach der 2. Lebenswoche sowohl die Milchleistung der Sauen als auch das aufgenommene Futter nicht ausreichten um den wachsenden Nährstoffbedarf der Ferkel zu decken. Diese Aussage trifft vor allem für schwere Ferkel zu.

Schlüsselwörter: Schwein, Ferkel, Kastrat, Jungsau, Geburtsgewicht, Gewichtszunahme vor dem Absetzen

Introduction

One of the goals in pig selection programs is to increase the size and number of litters produced per sow before culling. Increase in litter size is associated with lower body weight of piglets at birth. However, the birth weight of piglets is not related only to the litter size (LEENHOUWERS et al., 1999); it depends on several factors such as genotype (RITTER et al., 1992; FALKENBERG and HAMMER, 1994;

LEENHOUWERS et al., 1999), folicular development (EGERSZEGI et al., 2001), parity (QUINIOU et al., 2002) and placental size (BIENSEN et al., 1999). Birth weight is important for piglet survival and postnatal growth. Indeed, many authors report that only low percentage of piglets with low birth weight (i.e. less than 0.8 kg) survive up to weaning (FALKENBERG and HAMMER, 1994; QUINIOU et al., 2002). Moreover, piglets of low birth weight have a lower weaning weight, lower growth rate and they need more feed between birth and slaughter (KISNER et al., 1995; GONYOU et al., 1998; WOLTER and ELLIS, 2001).
The growth potential of a suckling pig may be limited by several factors such as teat position (ZSCHORLICH and RITTER, 1984a, 1984b; PUPPE et al., 1993), composition of milk and amount of milk protein (NOBLET and ETIENNE, 1989), establishment of lactation and successful nursing (VALROS et al., 2002) and piglets transfer (ZSCHORLICH and RITTER, 1984a; LANGHAMMER, 1989, ZSCHORLICH, 1989; FALKENBERG and ZSCHORLICH, 1990; RITTER and ZSCHORLICH, 1990). Heavier piglets are able to remove more milk from anterior mammary glands of lactating sows and consequently grow faster than lighter piglets (KING et al., 1997). Due to changes of the amount and composition of sow milk during the second week of lactation, it is evident that sow milk becomes one of the major limiting factors. Milk energy output by high producing sows was shown to change in satisfying the energy needs of piglets beyond about day 7 of lactation (BOYD et al., 1995).
The observation indicating that the difference between the need and the supply increases with the proceeding lactation, prompted us to test the effect of different birth weights on pre-weaning growth patterns. Assuming that the piglets with high birth weight are more affected by inadequate nutritional milk supply and have consequently slower growth rates, we wanted to find out to what extent the birth weight could influence the growth rate. Following our hypothesis, the present investigation concentrated on the role of birth weight on pre-weaning growth rate pattern of suckling piglets.

Material and Methods

A total of 466 piglets from 48 litters of multiparous sows (Landrace) from the Pig Research Centre (Faculty of Agriculture, University of Maribor, Slovenia) were involved in the experiment. During gestation, sows were group housed on straw and fed twice daily (7:00 h and 15:00 h). During the first 12 weeks of gestation, sows were offered 2 kg/day, and during the last 4 weeks 3 kg/day.
This study was carried out according to the Slovenian Law Regulating the Protection of Animals (1999).

Sows and piglet management

Ten days before the expected day of parturition, sows were moved into individual farrowing pens (1.8 m x 2.5 m = 4.5 m^2 including 1.98 m^2 of plastic-coated perforated floor). Pens had solid wooden side walls and were equipped with a sow feeder (0.45 m x 0.35 m) and a nipple drinker. During the lactation, sows were fed up to 6.5 kg/day twice daily (7:00 h and 16:00 h) a diet with 12.9 MJ ME/kg and at least 15% of protein. Sows had *ad libitum* access to water.

Piglets had a specific nipple drinker and a special pen area (1.1 m x 0.45 m) with an automatic, thermostatically controlled heating plate with a cover fitted with a 150 W infrared heating lamp. Within the cover, the temperature was maintained at 32°C, whereas outside it was regulated at 18-22°C by the ventilation system. Pens were cleaned twice per day, simultaneously with the manual feed distribution. All pens were washed and disinfected between each replicate. We avoided any additional noise, and therefore the noise level in the farrowing room could be considered as normal. Natural light was combined with artificial one (14 h long period of the light and 10 h of darkness).

Cross-fostering was not applied in any of these litters. At birth, teeth were clipped and tails were docked. Each piglet was also marked individually with an ear tattoo and received an iron injection. Males were castrated at approximately 6 days of age. During lactation, piglets had free access to water. At 10 days of age, they were offered "pre-starter" creep feed *ad libitum*.

Data collection and statistical analysis

Piglets were individually weighed at birth and on days 7, 14, 21 and 28 using an electronic balance having the accuracy ± 0.1 g. On the basis of birth weight (BW), piglets were assigned within a litter as Heavy (H), Intermediate (I) or Light (L) weight group, using the clustering approach and program SPSS for Windows (1989-2003). Cluster analysis was performed using K-Means cluster analysis procedure. It attempts to identify relatively homogenous groups of cases based on selected characteristics. In our case, the K-Means cluster analysis was limited to birth weight, as a continuous data.

For the analysis of growth performance, pigs were weighed every 7 days, from birth to the end of lactation, and average daily gain (ADG) was calculated. Over the following periods: from birth to day 7, 7 to 14 days, 14 to 21 days, 21 to 28 days, and from birth to 28 days.

Data were analyzed using the GLM procedure of SPSS for Windows. The statistical model included effects of birth weight group (Light, Intermediate, Heavy) and sex (gilts, barrows). Values in the tables are presented as mean ± standard deviation. Multiple comparisons of the observed means were based on the Duncan Post Hoc test. Using the SPSS for Windows, Pearson′s correlation coefficients were estimated between parity, litter size, birth weight and weaning weight of piglets. In addition, Pearson’s correlation coefficients were estimated also between birth weight and growth variables.

Results

Sow and litter performance during lactation

Results of sows’ performance and litter characteristics during lactation are presented in Figures 1 to 3 and in Table 1. Up to the 6^{th} parity, litter size statistically increased from 9.1 to approximately 12.9 (p = 0.0001) of born alive piglets. Thereafter, a decline of born alive piglets per litter was noticed (Fig. 1).

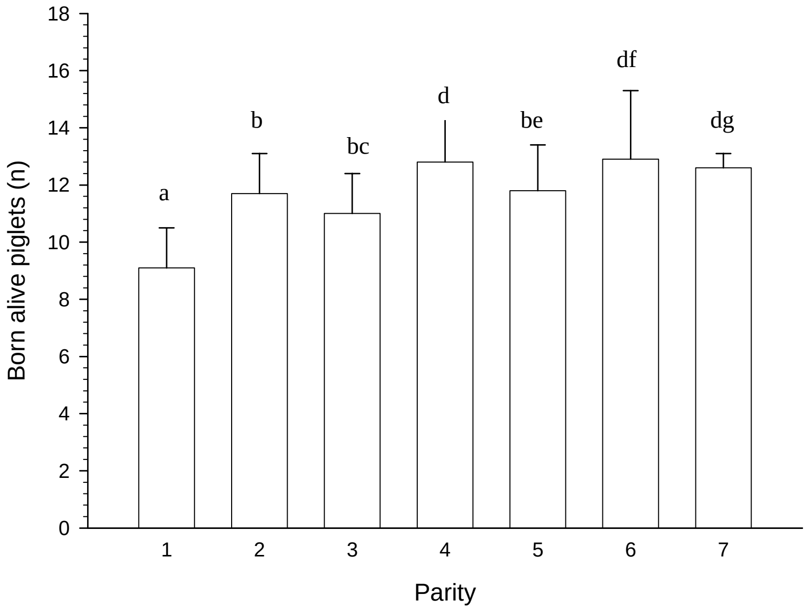

Fig. 1: Changes in the number of piglets born alive per litter over seven parities (Änderungen der Anzahl von lebend geborenen Ferkeln per Wurf über sieben Abferkelungen)
Values signed with different letters ([a, b, c, d, e, f, g]) are statistically different ($p < 0.05$)

A similar pattern was observed for number of weaned and stillborn piglets per litter with relation to parity (Fig. 2). Up to the 4th parity, number of weaned piglets statistically increased from 8.7 to approximately 12 ($p = 0.0001$) of weaned piglets. Thereafter, a significant decline in number of weaned piglets per litter was observed ($p \leq 0.001$).

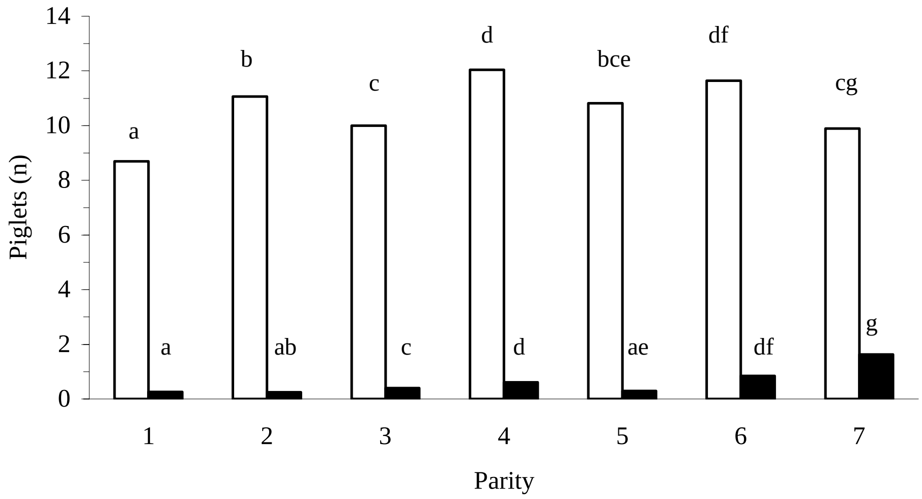

Fig. 2: Changes in the number of weaned and stillborn piglets per litter in relation to parity (Änderungen der Anzahl vom abgesetzten (□) und totgeborenen (■) Ferkel per Wurf in Beziehung zur Zahl der Abferklungen)
Values signed with different letters ([a, b, c, d, e, f, g]) are statistically different between parities for each trait ($p < 0.05$)

The number of stillborn piglets per litter increased from 0.26 at parity 1 up to 1.6 at parity 7 (p = 0.0001).
Relationships between subsequent parity, litter characteristics, birth weight and weaned weight were estimated with Pearson´s correlation coefficients (Tab. 1).

Table 1
Pearson's correlation coefficients between litter characteristics (Korrelationskoeffizienten nach Pearson zwischen Wurfmerkmalen)

Trait	P	LP	SP	WP	BW	WW
Parity (P)	1	0.397**	0.222**	0.277**	-0.164**	-0.175**
Number of piglets born alive (LP)		1	0.220**	0.815**	-0.060	-0.317**
Number of stillborn piglets (SP)			1	0.143**	-0.304**	-0.237**
Number of weaned piglets (WP)				1	0.091*	-0.232**
Birth weight (BW)					1	0.294**
Weaning weight (WW)						1

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed)

Parity was moderately, but significantly positively ($p \leq 0.01$) correlated to the number of born alive piglets (r = 0.397), stillborn piglets (r = 0.222) and with the number of weaned piglets (r = 0.277). These correlations were weak, especially in comparison to relationships between litter size properties. For example, the number of live born piglets was highly correlated with the number of weaned piglets (r = 0.815, $p \leq 0.01$). With increasing subsequent parity increase the litter size, but decrease the piglets birth weight (r = -0.164, $p \leq 0.01$) and weight at weaning (r = -0.175, $p \leq 0.01$). Number of stillborn piglets is in a negative correlation with piglets birth weight (r = -0.304, $p \leq 0.01$) and with piglets weight at weaning (r = -0.237, $p \leq 0.01$).

Table 2
Effects of birth weight and sex on pig body weight from birth to weaning (Einfluss des Geburtsgewichts und Geschlechts auf das Körpergewicht des Ferkels von der Geburt bis zum Absetzen)

Trait	Group	Birth weight (BW)			Sex (S)		*P*-values	
	Group (n=466)	Light (n=151)	Intermediate (n=258)	Heavy (n=57)	Gilt (n=233)	Barrow (n=233)	BW	S
BW (kg)								
Birth	1.63 ± 0.40^a	1.22 ± 0.19^a	1.71 ± 0.17^b	2.40 ± 0.22^c	1.63 ± 0.40	1.63 ± 0.41	0.0001	0.630
Day 7	2.97 ± 0.63^b	2.68 ± 0.74^a	3.03 ± 0.55^b	3.43 ± 0.55^c	2.94 ± 0.67	2.96 ± 0.64	0.0001	0.815
Day 14	4.67 ± 1.13^c	4.06 ± 1.06^a	4.78 ± 1.03^b	5.78 ± 1.48^c	4.70 ± 1.23	4.54 ± 1.13	0.0001	0.116
Day 21	6.04 ± 1.40^d	5.11 ± 1.30^a	6.29 ± 1.33^b	7.01 ± 1.42^c	6.05 ± 1.44	5.87 ± 1.50	0.0001	0.170
Day 28	7.67 ± 1.65^e	6.68 ± 1.68^a	7.98 ± 1.56^b	8.23 ± 1.89^b	7.65 ± 1.74	7.51 ± 1.77	0.0001	0.239

[a, b, c, d, e] values in group column signed with different letters are statistically different between the day of age (p < 0.05); [a, b, c] values signed in other columns with different letters are statistically different within the same day of age (p < 0.05).

Effects of birth weight and sex on pre-weaned body weights of pigs

At weaning, body weight of L piglets was 5.5-fold increased during lactation (Tab. 2). On the contrary, body weight of I and H piglets increased by 4.7-fold and 3.4-fold, respectively. Piglets of the L group had significantly lowest body weight during all investigated periods, when compared to groups I and H ($p = 0.0001$). However, there were no significant weight differences between gilts and barrows during the nursing period.

Effects of birth weight and sex on pre-weaned daily gains of pigs

The ADG for the different periods is given in Table 3. It increased in all groups up to the second week.

Table 3
Effects of birth weight and sex on daily weight gain (ADG) from birth to weaning (Einfluss des Geburtsgewichts und des Geschlechts auf die tägliche Gewichtszunahme von der Geburt bis zum Absetzen)

		Birth weight (BW)			Sex (S)			
Trait	Group (n=466)	Light (n=151)	Intermediate (n=258)	Heavy (n=57)	Gilt (n=233)	Barrow (n=233)	BW	S
ADG (g/days)								
Week 1	207 ± 58^{a}	180 ± 31^{a}	218 ± 55^{b}	230 ± 114^{c}	210 ± 56	202 ± 61	0.001	0.227
Week 2	243 ± 103^{b}	234 ± 96^{a}	241 ± 97^{a}	290 ± 171^{a}	244 ± 11	239 ± 94	0.334	0.886
Week 3	231 ± 100^{bc}	206 ± 114^{a}	237 ± 88^{b}	262 ± 114^{c}	234 ± 11	225 ± 95	0.001	0.670
Week 4	222 ± 76^{d}	194 ± 72^{a}	234 ± 75^{b}	220 ± 90^{a}	220 ± 80	221 ± 75	0.039	0.888
Birth to weaning	216 ± 55	195 ± 57^{a}	225 ± 54^{b}	211 ± 67^{a}	215 ± 58	212 ± 58	0.004	0.929

$^{a, b, c, d}$ values in group column signed with different letters are statistically different within the day of age ($p < 0.05$); $^{a, b, c}$ values signed in other columns with different letters are statistically different within the same day of age ($p < 0.05$).

From birth to day 7, L piglets had 17-22% lower ADG when compared to I and H groups ($p = 0.001$). In the second week of lactation, no significant difference in ADG among three groups was observed ($p = 0.334$). In fact, ADG peaked in the second week in all groups and thereafter decreased (Fig. 3).
Despite of the highest ADG of H piglets in second week of lactation and subsequently decrease of ADG in third ($p = 0.851$) and fourth week ($p = 0.074$) of lactation the differences were not statistically significant. A possible explanation for this not significant detection of ADG differences is in a higher standard deviation of ADG of H piglets at all weeks of lactation in comparison to I and L piglets.
The most important decrease of ADG over the third and fourth week of lactation was observed for H and L piglets. In both groups, ADG decreased by 24% ($p = 0.851$) and 17% ($p = 0.319$), respectively, when compared to ADG observed during the 2nd week, whereas the corresponding reduction was only 3% in I piglets ($p = 0.946$). According to the statistical analyses, no significant difference in ADG ($p \geq 0.05$) between gilts and barrows was established during different weeks of lactation.

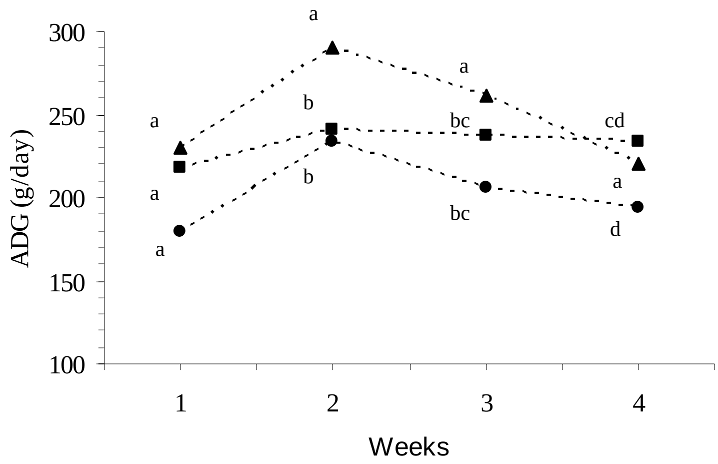

Fig. 3: Daily weight gain (ADG) of pigs from birth to weaning (● – light; ■ – intermediate; ▲- heavy) (Gewichtszunahme (ADG) von der Geburt bis zum Absetzen)
[a, b, c, d] values signed with different letters are statistically different within the same group of birth weight ($p < 0.05$)

The average birth weight was significantly positive correlated with body weight at day 7, 14, 21 and 28 (Tab. 4).

Table 4
Pearson's correlation coefficients between body weights (BW) at birth, 7, 14, 21 and 28 days of age and average daily gain (ADG) calculated between these ages (Korrelationskoeffizienten nach Pearson zwischen den Körpergewichten bei der Geburt, dem Alter von 7, 14, 21 und 28 Tagen und der durchschnittlichen täglichen Gewichtszunahme (ADG), berechnet für dieses Alter)

Trait	B	BW 7	BW 14	BW 21	BW 28	ADG B-7	ADG 7-14	ADG 14-21	ADG 21-28	ADG B-28
B	1	0.383**	0.404**	0.434**	0.331**	0.306**	0.097	0.171**	0.181**	0.135**
BW 7		1	0.651**	0.650**	0.581**	0.483**	0.637**	0.036	0.287**	0.524**
BW 14			1	0.892**	0.836**	0.476**	0.631**	0.513**	0.362**	0.785**
BW 21				1	0.913**	0.421**	0.591**	0.498**	0.455**	0.856**
BW 28					1	0.373**	0.529**	0.506**	0.633**	0.973**
ADG B-7						1	0.107*	0.183**	0.216**	0.340**
ADG 7-14							1	-0.127*	0.134*	0.535**
ADG 14-21								1	0.287**	0.488**
ADG 21-28									1	0.628**
ADG B-28										1

Birth weight (B); Body weight at d 7 (BW 7); Body weight at d 14 (BW 14); Body weight at d 21 (BW 21); Body weight at d 28 (BW 28); Daily gain birth to 7 d (DG B-7); Daily gain 7 d to 14 d (ADG 7-14); Daily gain 14 d to 21 d (ADG 14-21); Daily gain 21 d to 28 d (ADG 21-28); Daily gain birth to 28 d (ADG B-28);** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2 tailed).

The correlation coefficients ranged from 0.331 to 0.434. A significant positive correlation was also found between birth weight and ADG during first week of lactation ($r = 0.306$, $p \leq 0.01$). Body weights from day 7 to day 21 were much more closely related to the weaning weights. Compared to the body weights, daily gains of the first two weeks were much less effective in predicting of subsequent piglets' growth rate.

Discussion

The present study provides the evidence that the lightest or the heaviest piglets exhibit decreased growth rate during the third and fourth weeks of suckling period. At birth, the piglets possess low body fats stores (i.e. 1.5 to 2.5%) and therefore milk fat is the only source of energy until weaning at the age of 4 weeks (GERFAULT et al., 2000). Regarding this fact, we can conclude that ADG of piglets in pre-weaning period is mainly related to sow milk production and its contents.

In the present experiment, a higher ADG in the first week of lactation was observed in H and I than in L group. During this first week males were castrated. Their ADG was slightly lower (-8g/day) than in gilts and the difference was not statistically significant (p = 0.227). Similar negative difference in ADG between males and females (-4 g/day) was reported by JOHANSEN et al. (2004). These results confirm the previous study and indicate a temporary negative affect of surgical castration on a piglet ADG (KIELLY et al., 1999).

Increase of ADG was noted for all three groups of piglets in the second week of age, moreover it was the highest weekly value during pre-weaning period. This result can be explained by the fact, according to KING et al. (1997), that during the second week a normal sow milk production reaches its maximum and the suckling order is well established.

It is noteworthy that ADG of H and L piglets decreased during the third and fourth week of lactation by 24% and 17%, respectively. A maternally insufficient milk supply may be a good explanation for the lower ADG's in H piglets, but not only one in L piglets. Light piglets are physiologically immature and certainly their intestinal tract (TUCHSCHERER et al., 2000). Thus, they could have also a limited capacity of milk intake. Moreover, these piglets exhibit a lower growth potential because of lower number of muscle fibers formed prenatal (GONDRET et al., 2006; REHFELDT and KUHN, 2006).

These data cannot be explained without knowing the quantity of milk production per teat, teat order, as well as milk composition. However, a possible explanation of these findings could be that sow milk production and/or milk composition are unable to fulfil nutritional demands of piglets, especially in case of very intensive growth.

Another explanation is that the position of suckling piglets and their ADG is correlated with teats order. The relationships between ADG in lactation, birth weight and teats position are not completely understood. The general assumption is that the anterior teats are more productive than posterior (PUPPE et al., 1993; PLUSKE and WILLIAMS, 1996). We could speculate that H piglets suckled anterior teats with enough milk production, but with no adequate nutrition value for their growth potential. On the contrary, L piglets would thus be on posterior teats, which might produce less milk, and, therefore L piglets had lower ADG. Indeed, MASON et al. (2003) reported that anterior teat preference had high positive correlation with piglet relative weight over pre-weaning period. The suckling piglets on anterior teats had the highest ADG in comparison with those suckling posterior teats of the primiparous sows (ZSCHORLICH and RITTER, 1984b).

There are numerous papers describing almost a linear growth rate of piglets during the lactation (FALKENBERG and ZSCHORLICH, 1990; FRASER et al., 1994; KISNER et al., 1995; VALROS et al., 2002; WOLTER et al., 2002). Contrary to these findings, the present study demonstrates a non-linear growth model. The results indicated a pronounced decrease of ADG of H and L piglets during third and fourth weeks of lactation. In case of I pigs, we could observe a slight decrease (or standstill) (Fig. 3). Different technologies have been suggested to avoid this problem, such as cross fostering or litter size standardization (ZSCHORLICH, 1989; FALKENBERG and ZSCHORLICH, 1990; RITTER et al., 1992).

In the present study piglets were offered a creep feed diet at 10 days of age, but their consumption per litter was very low (approximately 50g/day). Regarding relatively high birth weights of all three groups of piglets in the present study, and their low amount of creep feed intake during lactation, we consider that creep feed had no significant effect on piglet growth rate in pre-weaning period, in agreement with results of ALGERS et al. (1990) and FRASER et al. (1994). One of the reason why a supplemental nutrition source such as creep feed to piglets has no effect on their growth performance is the high affinity bond between sow and piglets (HARRELL et al., 1993). Nevertheless, it is generally accepted that such feeding technology helps piglets to adapt the transition from milk to a solid feed, and thus promotes a more successful weaning (FRASER et al., 1994).

Contrary to many studies, the present study demonstrates a non-linear growth model of piglets during lactation. Namely during third and fourth week of lactation a sharp decrease of ADG of heavier piglets at birth was observed, whereas ADG remained constant in piglets with intermediate birth weight. Results of the present study suggest that milk production and composition after the second week of lactation, together with low consumption of creep feed, are not sufficient to meet nutritional needs especially of fast growing piglets.

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Received: 2006-06-12

Accepted: 2007-03-07

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