BIOLOGICAL POTENTIAL OF FECUNDITY OF SOWS

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Abstract

The profitability of pig production considerably depends on the number of born alive and fostered piglets. The development regarding the number of piglets born for German Landrace (DL), Large White (DE) and Pietrain (PI) in Germany during 1980 – 2006 is limited (DL: 10,4 – 11,0; DE: 11,0 – 11,0; PI: 10,2 – 10,0). Comparing international data, variations between 10.2 to 13.6 piglets born alive are observed. Reproductive performance in sows is mainly determined by (1) the number of ovulated follicles and fertilized oocytes, (2) the divvy of surviving embryos and fetuses, and (3) the morphological and functional performance of the uterus to support fetal development up to birth. The question whether the ovary and/or uterus are limiting factors can be answered as followed. The pool of ovarian follicles is not the limiting one, although only about 0.5 % of oocytes present in the ovary are ovulated during the sows' lifetime. Selection for ovulation rate increases the number of ovulating follicles, but not of piglets born alive. Limiting is the uterine capacity. This physical, biochemical and morphological limitation of the uterus include space, nutrients, gas exchange and surface of the placenta. Although a relationship exists between uterine dimension and the number of fetuses/piglets, uterine length alone is not a prerequisite of higher uterine capacity. Placental efficiency (indicating how much gram fetus is supported by one gram placenta) and the degree of placental blood supply appear to be essentially for litter size. At present, the (really) assumed potential of fecundity is 15.0 piglets born alive, 2.4 litters/year, <10 % losses and 32.5 piglets per sow/year (compared to current data of 11.1, 2.26, 13.8 and 21.5; respectively).

Key Words: Pig, fecundity, ovulation, uterus

The objective of modern pig breeding is to exhaust the genetic potential in reproduction performance of sows regarding to litter size and number of weaned piglets per litter. It is necessary to realize a high number of vital born piglets, uniform bodyweights of newborn and weaned piglets and long living high performance sows. Profitability of piglet production depends on litter size very high (LAWRENCE, 1993). Regarding reproduction performance the comparison between modern pig races and still excistent different kinds of wild pigs (Pekari, Babirusa, European Wild Pig) is very interesting. The litter size of wild pigs is limited between 1 until 3 offsprings. This situation demonstrates the high potential of reproduction performance of modern breeds. In the other hand in the last 100 years the litter size sows in USA is increased from 7 to 8 piglets (HAMMOND, 1914) to 8 to 9 in the all registrated pig farms. In dam lines the litter size was increase until 10 to 11 piglets (VONNAHME et al., 2002). This progress is not very high. Also the development in litter size, number of newborn piglets per litter of German sows is in the same level. In the years 1970 until 2007 progress of reproduction performance in Landrace-, Large White or Pietrain-sows was very low (Table 1). An international comparison shows high differences in reproduction performance between different countries. Comparing international data, variations between 10.2 to 13.6 piglets born alive are observed.

Table 1. Development of reproductive performance for pig breeds German Landrace (DL), German Larg White (DE) and Pietrain (PI) in Germany (Source, ZDS)

year	German Landrace		Large White		Pietrain	
	Alive born piglets/	Weaned piglets	Alive born piglets	Weaned piglets	Alive born piglets	Weaned piglets
1980	10,4	9,6	11,0	10,0	10,2	9,3
1990	10,3	9,7	10,5	9,9	10,1	9,3
2000	10,4	9,6	10,4	9,5	10,0	9,3
2005	10,9	10,0	10,7	10,0	9,9	9,2
2007	11,2	10,2	11,4	10,7	10,0	8,9

The highest data are 13.6 alive born piglets per litter registrated in Denmark (SLOTH and BERTELSEN, 2007). Compared to results of 25% best farms of Germany the differences to results of Danish farms are between 1.6 to 1.8 piglets per litter. Generally, regarding to high performance piglet production it is interesting to know what are the biological potentials of fecundity of sows.

Are ovary and uterus limited factors?

Reproduction performance depends on three main connections:

1. Relation between number of ovulated follicles and number of fertilized oozytes,
2. share of survived embryos and fetuses and
3. morphological and functional performance of uterus regarding safety development of fetuses until partus.

In front of this background following question requires an answer: Are the oyary and /or the uterus limited factors?

Generally, in pigs there is a large pool of follicles and oozytes, about 500.000 follicles (GOSDEN und TELFER, 1987). Therefore the ovary appears not the limited factor. Nevertheless only maximum 0,5% of existed "reserve of oozytes" will be a fertilized oocyte. Further, only 60-70% of ovulated oozytes will develop to born alive piglets (POPE and FIRST, 1985).

Generally there are possibilities for influence the number of ovulations, and following to increase the litter size. There are possibilities like stimulation of ovarian function by breeding selection. Although a stimulation of follicle growth by exogenous gonadotrophins as superovulation with eCG can increase the number of follicles for ovulation until 30-60%, but the number of intact and living embryos and following the potential litter size can increase only a littler bit, about 0 until 40% (BAZER et al., 1969; BRÜSSOW and KÖNIG, 1990).

Additionally, the individual variations are very high and the volume of variation is not predictable. Therefore it is not practicable to use hormonal induced superovulation for higher piglet production.

A breeding selection for high ovulation rate is possible, the heritability (h2) of this mark is about 0,10 until 0,15 (CUNNINGHAM et al., 1979; LAMBERSON et al., 1991; HANENBERG et al., 2001; ROSENDO et al., 2007). For example, the result of an experiment for breedig selection for number of corpora lutea (CL) during über 11 generations was an increasing of CL beginning from 14,0 to 20,5 CL (+ 6,5). The number fetuses at 50th day of gestation was increased from 10,8 to 13,6 (+ 2,8), the number of born alive piglets was increased only from 9,9 to 10,7 (+ 0,8; JOHNSON et al., 1999). Even though the breeding success in number of ovulations about a lot of generations was 10 to 28 % (1,5 to 3,9 CL), the litter size could be increased only a little bit (8 to 10 %) (CUNNINGHAM et al., 1979; JOHNSON et al., 1981; KELLY et al., 1988; LAMBERSON et al., 1991; RUIZ-FLORES and JOHNSON, 2001). The conclusion is, selection for ovulation rate increases the number of ovulating follicles, the ovary is not the limited factor for total potential of oocytes but not of piglets born alive.

Only during the first days of pregnancy you can observe a relation between increased number of ovulations and increased number of embryos/fetuses (FREKING et al., 2007). This fact could confirmed in own scientific experiments (Figure 1, Table 2). These results are the reason for next conclusion: Limiting is the uterine capacity. The capacity of uterus is the ability of this organ to take in only a limited number of embryos/fetuses and to save the development of them during gestation until partus (FENTON et al., 1970; CHRISTENSON et al., 1987). This physical, biochemical and morphological limitation of the uterus include space, nutrients, gas exchange and surface of the placenta.

Figure 1: Relationship between the number of ovulations and number of embryos or fetuses on days 30 and 80 of pregnancy in modern Landrace sows (n=84)

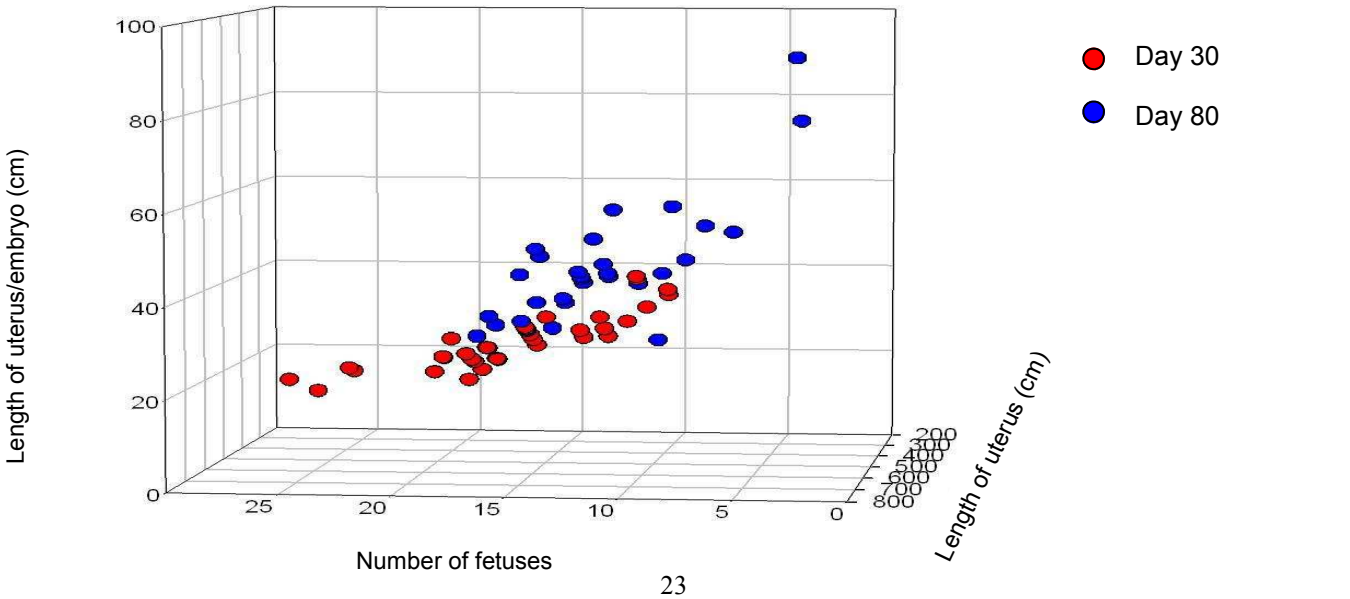


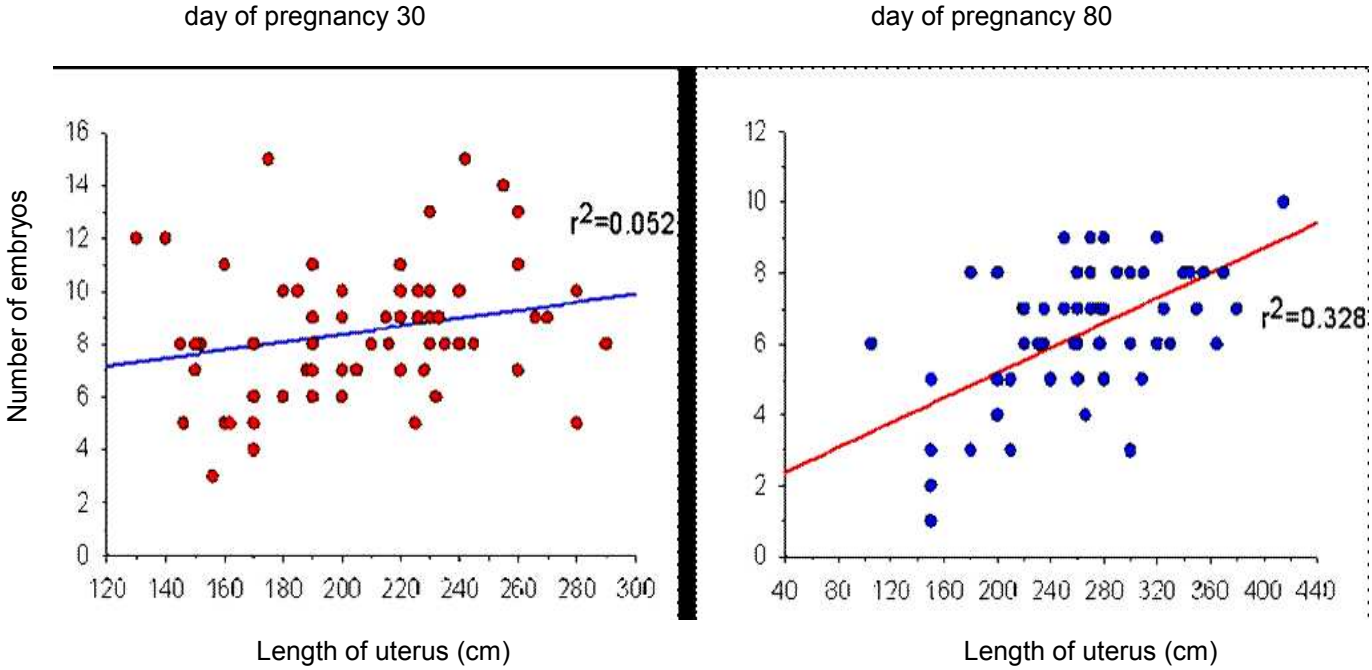
Table 2. Relationship between the number of ovulations and number of embryos or fetuses on days 30 and 80 of pregnancy in modern Landrace sows (n=84)

Trait	day 30	day 80
Number of fetuses	17.0 ± 4.5a	12.3 ± 3.5b
Length of uterus (cm)	412 ± 63a	511 ± 113b
Length of uterus/embryo (cm)	25.8 ± 7.0a	44.5 ± 13.7b

Uterus capacity depends on genotype of sow. Special experiments with the additional transfer of 13 to 15 embryos in inseminated sows demonstrates this fact (RAMPACEK et al., 1975). In the uterus of crossbred sows (Duroc x Yorkshire) a higher number of embryos (24,2) was found compared to purebred parenteral animals (19,6 ; 19,5). DAVIS et al., (1987) have found a longer uterus in Duroc-sows compared to Yorkshire- sows (411 cm vs. 375), although the number of embryos was lower (9.9 vs. 10.5). In literature differences are confirmed in development of length and weight of uterus during early pregnancy between Hungarian breed Mangaliza and German Landrace (BRÜSSOW et al., 2004). Mangaliza sows have significant lower fecundity then German Landrace sows. The length of uterus of Mangaliza sows was shorter then the length of uterus of German Landrace sows (124 ±5 vs. 188 ± 8cm) significantly ($p<0,01$). In comparison to German Landrace there was no measurable growth of uterus during first 24 days of gestation. The increasing of weight of uterus started later.

Although a relation between length of uterus (capacity of space) and number of fetuses/piglets excist, the length of uterus is not the single precondition for higher capacity of uterus (VALLET et al., 2002). There are publications which demonstrate sows with low length and weight of uterus but with higher capacity of uterus (GAMA and JOHNSON, 1993). Nevertheless a minimum of space for embryos is necessary. WU et al.(1989) have found, each fetus until 50 days old needs about 36 cm length of uterus. The relation between length of uterus, length of uterus/ fetus and number of embryos/fetuses in Landrace-sows in different times of pregnancy is illustrated in Figure 2.

Figure 2: Relationship between uterus length, uterus length/fetus and the number of embryos or fetuses in Landrace sows on day 30 and 80 of pregnancy



Good developed placentas are very important for high litter size and high bodyweigth of piglets. An underdeveloped placenta in early pregnancy (day 20 to 30) has a high influence on growth and survival of fetuses. In time 30th day of pregnancy until end of pregnancy the capacity of uterus influence the prenatal losses (KNIGHT et al., 1977; JOHNSON et al., 1999). In comparison to a selection for number of ovulations a selection for capacity of uterus together with higher weigths of placentas realized a increased number of fetuses/uterushorn about 0,8. In the other hand in sows after selection for number of ovulations the capacity of uterus was reduced about 1.1 fetuses per uterushorn (FREKING et al., 2007).

What is able to distinguish a sow with higher number of piglets. For example the race Meishan is wellknown. Sows of Meishan have 3 to 5 piglets alive per litter. These piglets are shorter and lighter then piglets of European sows and they need a smaller space in uterus. Meishan sows have a smaller placenta and have a higher efficiency of placenta BIENSEN et al. 1998; WILSON et al., 1999). The definition of efficiency of placenta (EP) is the quotient of weight of fetuses (g) and weight of placenta (g). The EP is the "degree of effectiveness" of placenta, it means, it shows how much gramme of fetus is supported be 1 gramme placenta. Additionally in Meishan the degree of supply with blood in placenta is important too. The number and the diameter of blood vessel are higher. Following in Meishan sows the density of blood vessels more then 100% higher then in Yorkshire sows and it is going to increase during pregnancy continuously (BIENSEN et al., 1998). A high density of blood vessels supports the transfer of nutrients to fetuses (REDMER et al., 2004). Especially that is advantage for small fetuses. It is guarantee for higher survival and following for higher reproduction performance.

A breeding selection for smaller and more efficiency placentas realizes higher litter sizes of course, but also maller bodyweight of newborn piglets (WILSON et al., 1999). Generally and hypothetical two ways for breeding selections are possible:

- Increasing of efficiency of placenta and "maximization" of number of piglets per litter. Following of that the weight of litter and the weight of each piglet will be degreased and the rearing losses can be increased.
- A smaller number of piglets per litter with more uniform litter weights and high vitality of piglets.

It is necessary to compare both ways and to weight up the disadvantages and advantages, because biological (different muscle growth and meat quality, health status, behaviour and s. e., QUINIOU et al., 2002; GONDRETA et al., 2005; REHFELD and KUHN, 2006) and technological parameters (housing system, climate, feed input a.s.e. BEAULIEU et al., 2006) have an influence on profit under specific production conditions.

For realization of these breeding ways a lot of researches are necessary.

Following topics are important for researches.

- Metabolic performance of uterus in different trimesters of pregnancy
- Blood and nutrients supply in fetuses in relations to fetal growth

Additionally, it is necessary to find genetic marks for uterine metabolic performance, for efficiency of placenta and for uterine/fetale supply of blood and nutrients, which are usabel for breeding selection.

Estimation of potential of fecundity in sows

What is he level of estimated potential of fecundity in modern bred sows? Generally it is difficult to determine the potential of reproduction performance, because there is a continuous dynamic for border of performance. Nevertheless with regard to realistic physiological parameters a prediction of performance development should be done (Table 3).

These estimations regard not the single animal, but the middle of population.

Primary the biological basis is the increasing of number piglets born alive per litter. It means the progress in reproduction performance is the result of reduced prenatal losses and reduced rearing losses during lactation with higher vital piglets.

Both biological processes need a optimizing of uterine environment and fetal-maternal-interactions.

The own estimations are based on relevant and realizable parameters like 25 ovulations, a fertilization rate of 80% at least of oocytes, embryonic/fetal losses of 20% and the number of death born piglets per litter should be lower than 1,0 piglet.

Regarding to actual biological and technological situations 2.4 litters per sow and year are possible generally. Following the reproduction performance can increase to the level of 32 to 33 piglets per sow and year.

Sometimes future higher reproduction performances of more than 41 weaned piglets per sow and year are published of some international breeding companies. These results could be possible in individual very high performance sows. For the middle of populations these numbers are speculative. These estimations are based on not seriously numbers of ovulations more than 35 in one estrus.

Regarding to these aims of reproduction performance in pigs it is interesting to analyze a breeding experiment with mouses (SPITSCHAK et al., 2007). It is a long time breeding selection experiment with more than 130 generations for fecundity, litter size and litter weight. In comparison to control group the animals of experimental group realized nearly 100% higher litter size (18 vs. 11) together with increased litter weight (29.9 vs. 19.9g). It would be interesting and hopeful to confirm similar tendencies in pigs. It requires a lot of intensive researches for a long time and very long time breeding selections.

Table 3. Actual reproductive data of German Landrace (ZDS 2007) and estimated reproductive potential (own estimation)

	Piglets born alive/ litter	Number of litters per year	Piglets losses (%)	Number of weaned piglets /sow and year
Actual data	11,1	2,26	13,8	21,1
Own estimation[1]	15,0	2,4	<10	32,5

[1] estimation: 25 ovulations; fertilization rate 80%; embryonic losses 20%, death born piglet per litter <1

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