Production of Superior Pigs by Injecting the Sows with Gonadotropin Prior to Mating

Debby Jacqueline Jochebed Rayer[1),a], Hera Maheshwari[1)], Muladno[2)] and Wasmen Manalu[1),*]

[1)]Department of Anatomy, Physiology and Pharmacology, Faculty of Veterinary Medicine, Bogor Agricultural University, Jalan Agatis, Darmaga, Bogor 16680, Indonesia
[2)]Department of Animal Production and Technology, Faculty of Animal Husbandry, Bogor Agricultural University, Jalan Agatis, Darmaga, Bogor 16680, Indonesia
[a]Permanent address: Department of Biology, Faculty of Mathematics and Natural Science, Manado State University, Tataaran Tondano, Manado, North Sulawesi, Indonesia
***Corresponding author: Department of Anatomy, Physiology and Pharmacology, Faculty of Veterinary Medicine, Bogor Agricultural Universiy, Jalan Agatis, Darmaga, Bogor 16680, Indonesia.**
Telephone number 62+8158848829.
Corresponding author email : wasmenmanalu@ymail.com

Abstract. An experiment was conducted to produce superior pigs with improved growth phenotypes and survival during postnatal growth by injecting the sows with gonadotropin prior to mating. The experiment consisted of 2 stages. In the first stage, 12 sows were divided into 2 groups i.e., sows injected with NaCl0.95% as a control (NSO) and sows injected with PG600 (SO) prior to mating. Parameters measured were growth phenotypes and survival at birth and during pre-weaning period. In the second stage, 24 of weaned pigs (age 8 weeks) from the first stage were selected (6 males and 6 females from NSO group and 6 males and 6 females from SO group) to be used for measurement of growth performance. The experimental pigs were raised and observed until the age of 28 weeks (7 month). The body weights were measured monthly. The results of the experiment showed that improvement of uterine environment by gonadotropin injection of the sows prior to mating dramatically improved birth weight with a very homogenous birth weight within litter size. Improved birth weight and within-litter variation of birth weight improved pre-weaning growth performance and survival that finally dramatically increased weaning weight and total weight of weaned pigs per sow. After weaning, pigs born to SO sows grew faster and had around 10 kg higher body weight as compared to control at the age of 7 month. It was concluded that superior pigs could be produced by improving endogenous secretion of pregnant hormone during pregnancy.

Key words: Birth weight, growth phenotypes, survival, prenatal growth, postnatal growth

Abstrak. Penelitian ini dilakukan untuk menghasilkan anak-anak babi unggul dengan fenotipe pertumbuhan dan daya hidup yang lebih baik selama pertumbuhan pascalahir dengan cara menyuntik induk babi dengan gonadotropin sebelum pengawinan. Penelitian terdiri atas dua tahapan. Penelitian tahap pertama, 12 ekor induk babi dikelompokkan ke dalam 2 kelompok, 1) kelompok kontrol, yaitu induk yang disuntik dengan NaCl 0.95% (NSO) dan 2) kelompok yang disuntik dengan PG600 sebelum pengawinan (SO). Parameter yang diukur ialah fenotipe pertumbuhan dan daya hidup anak pada saat lahir dan selama periode prasapih. Tahap kedua, 24 anak babi lepas sapih dari percobaan tahap pertama (umur 8 minggu) dipilih (6 jantan dan 6 betinadari kelompok NSOdan 6 jantan dan 6 betina dari kelompok SO) untuk digunakan dalam pengukuran kinerja pertumbuhan pascasapih. Babi percobaan dibesarkan dan diamati sampai umur 28 minggu (7 bulan). Bobot badan diukur setiap bulan. Hasil penelitian menunjukkan bahwa perbaikan lingkungan uterus dengan cara penyuntikan induk dengan gonadotropin sebelum pengawinan secara dramatis memperbaiki bobot lahir anak dengan bobot lahir per induk yang lebih seragam. Perbaikan bobot lahir dan keseragaman bobot lahir memperbaiki kinerja pertumbuhan prasapih dan kelangsungan hidup anak yang pada akhirnya secara dramatis meningkatkan bobot sapih dan total bobot anak yang disapih per ekor induk. Setelah penyapihan, anak babi yang dilahirkan oleh induk yang disuntik gonadotropin tumbuh lebih cepat dengan bobot badan yang lebih tinggi sekitar 10 kg dibandingkan dengan kontrol pada umur 7 bulan. Disimpulkan bahwa anak babi unggul dapat dihasilkan melalui perbaikan sekresi endogen hormon kebuntingan selama kebuntingan.

Kata kunci: Bobot lahir, fenotipe pertumbuhan, daya hidup, pertumbuhan prenatal, pertumbuhan pascalahir

Introduction

In mammalian animals, production is determined by the success of reproduction to produce offspring either as a finisher or parent stock. The major limitation of production is the lower birth weight and low survival of the offspring. Low birth weight and higher variation of within-litter birth weight in piglets correlates well with the decreased survival and lower postnatal growth rates (Milligan et al., 2002; Quiniou et al., 2002). Birth weight is the final result of a complex process of prenatal growth and development in the uterus during the whole pregnancy (Foxcroft et al., 2009, 2006). The growth and development of embryo and fetus during pregnancy is determined by the growth and development of uterus and placenta (Fowden et al., 2008, Spencer and Bazer, 2004) and utero-placental vascularity (Reynolds and Redmer, 1995) that will affect the supply of nutrient and oxygen for the growing fetus (Fowden et al., 2006). Complex hormones and local factors control the growth and development of the uterus and placenta (Fowden et al., 2005) that will determine fetal growth and development.

Estrogen and progesterone are the key hormones in controlling uterine growth and development in mammalian animals. During estrous cycle, estrogen is synthesized by the growing follicles and later, after ovulation, progesterone is synthesized and secreted by the corpus luteum and by the placenta after placentation (Ash and Heap, 1975; Flowers et al., 1991; Przała et al., 1985). These hormones initiated the histological changes in the uterus in preparation for implantation and the growth and development of uterus and embryo in the beginning of pregnancy followed by the growth and development of fetus and the placenta until parturition (Gray et al., 2001; Spencer and Bazer, 2004, 2002; Spencer et al., 2004). Low uterus and placental growth will limit the growth and development of embryo and fetus and finally decreases birth weight and neonatal vitality (Ohtaki et al., 2012).

In polytocus animals, the increased number of growing follicles and corpus luteum and the number of fetus in the uterus is not linear with the increased secretion of pregnant hormones. There is an indication of lower ratio of pregnant hormones per fetus during pregnancy that is related to the lower birth weight with the increased litter size. Therefore, improved secretion of pregnant hormones during pregnancy could improve the preparation of uterus for implantation and for uterine growth and development to support prenatal growth.

Previous research shows that intra-vaginal supplementation of estradiol and progesterone improves embryo development (Chlopek et al., 2008) and exogenous supplementation of progesterone and estrogen improves placental development (Dalton and Knight, 1983) that finally supports an optimal prenatal growth. Improvement of endogenous secretion of pregnant hormones by injecting the sows with gonadotropin such as FSH, LH, PMSG and HCG prior to mating shows positive effects on uterine and fetal growth and development during pregnancy (Mege et al., 2007) that finally improves birth weight, postnatal growth performances and survival of the offspring (Lapian et al., 2013; Mege et al., 2006).

This experiment was designed to study the effects of improved endogenous secretion of pregnant hormones by gonadotropin injections of the sows prior to mating on prenatal growth and development of the fetus as would be reflected in the growth phenotypes of the pigs at birth. The effects of improvement in prenatal growth and development of the fetus were evaluated on growth and survival of the offspring after birth to maturity.

Materials and Methods

The experiment was conducted in commercial pig farmer in Kalasey, Kecamatan Pineleng,

Minahasa Regency, North Sulawesi Province, Indonesia. The experimental sows used were 36 sows of Landrace breed with body weight range of 100-120 kg. Gonadotropins used to stimulate endogenous secretion of pregnant hormones were PMSG and HCG (PG 600,Intervet,The Netherlands) and for estrus synchronization was used prostaglandin (Lutalyse, Intervet, The Netherlands). The experimental sows were maintained in individual cage and were fed twice a day with commercial feed and water was available ad libitum.

The experiment consisted of 2 stages. In the first stage, 12 sows were injected with 1 ml prostaglandin (PGF2α) twice with 14 days interval to synchronize estrous cycle. At the second prostaglandin injection, or 3 days prior to estrous, the experimental sows were divided into 2 groups; each group consisted of 6 sows. The first group was injected intramuscularly with NaCl 0.95% and used as a control (NSO). The second group was injected intramuscularly with PG 600 with a dosage of 400/200 IU (SO). The experimental sows exhibiting estrous behavior were mated naturally by mixing them with selected boars. The experimental sows were maintained in individual cages during pregnancy, parturition and lactation. Parameters measured were birth weight of live born pigs and weekly body weight until weaning. Body length, fore leg height, and hind leg height at birth and at weaning were also measured.

In the second stage, 24 of weaned pigs (age of 8 weeks) from the first stage were selected to be used for measurement of growth performance during post-weaning period. Twelve of the best performed pigs (6 males and 6 females) born to NSO sows and twelve of the best performed pigs (6 males and 6 females) born to SO sows were selected. The experimental pigs were raised and observed until the age of 28 weeks (7 month). During this observation, body weights were measured monthly. The differences between parameters measured in both experimental groups were subject to analysis of variance.

Results and Discussion

The results of this experiment showed that pigs born to SO sows had 31.09% higher birth weights as compared to those born to NSO sows (Table 1). Pigs born to SO sows had a more homogenous birth weight with a very small within-litter variation (7.27%) as compared those born to NSO (21.26%). In addition, sows injected with PMSG and HCG prior to mating had a dramatically higher total live birth pigs per sow (increased by 54.68%) as compared to NSO sows (Table 1). Within-litter variation of total live birth pigs per sow in SO pigs was very low i.e., 3.92% while in NSO pigs was 20.16%. Pigs born to SO sows also had 6.56% higher body length as compared to those born to NSO sows with a more homogenous body length and lower within-litter variation (4.18%vs.8.58%)($P<0.05$). Fore leg heights of pigs born to SO sows were higher

Table 1. Body weight, total weight of live born pigs per sow, body length, fore leg height, and hind leg height at birth in pigs born to NSO and SO sows.

Parameters	Group	
	NSO[c]	SO[d]
Birth weight (kg/pig)	1.19±0.12[b]	1.56±0.07[a]
Total weight of live born pigs per sow (kg/pig)	11.65±2.08[b]	18.02±1.49[a]
Body length at birth (cm)	31.04±1.64[b]	33.08±1.17[a]
Fore leg height at birth (cm)	11.59±1.07[b]	12.93±1.12[a]
Hind leg height at birth (cm)	12.78±1.20[b]	14.90±1.28[a]

[a,b] Values bearing different superscripts within row are significantly different ($P<0.05$)
[c]NSO are control sows without PMSG and HCG injection prior to mating
[d]SO are PMSG and HCG-injected sows prior to mating

by 11.56% as compared to those born to NSO sows with within-litter variation of 4.33 and 7.83%, respectively (P<0.05). Hind leg heights of pigs born to SO sows were higher by 16.59% as compared to those born to NSO sows with within-litter variation of 5.21 and 7.70%, respectively (P<0.05).

The improved growth phenotypes of pigs born to SO sows in the present experiment are related to the improved prenatal growth due to the improved uterine and placental environment. Our previous results show that injection of the sows with PMSG and HCG significantly improves endogenous secretion of estrogen, progesterone and thyroxin in pregnant sows that finally improves uterine and placental growth and development and prenatal growth of the fetus that eventually improves birth weight and survival of the offspring (Mege et al., 2006, 2007). Improved growth and development of the uterus during pregnancy will determine fetal birth weight (Foxcroft et al., 2009, 2006) through the improvement of uterine and placental growth and development (Fowden et al., 2008, Spencer and Bazer, 2004), and utero-placental vascularity (Reynolds and Redmer, 1995) that will affect the supply of nutrient and oxygen to support the optimum growth of fetuses (Fowden et al., 2006).

Improved prenatal growth and birth weight in pigs born to SO sows finally improves postnatal growth performances and survival of the offspring until weaning and maturity. Pigs born to SO sows had faster growth rates during pre-weaning period as compared to those born to NSO sows (Table 2) as was indicated by the higher slope of the growth rate regression (Figure 1). Predicted growth rates of the pigs born to SO and NSO sows were 1.80 and 1.54 kg/week, respectively. The ranges of pre-weaning growth rates of pigs born to SO sows were 250.34 to 263.61 g/pig/day, while those of pigs born to NSO sows were 181.63 to 240.20 g/pig/day. With the faster growth rate, pigs born to SO sows had 21.14% higher weaning weight as compared to those born to NSO sows with more homogenous within-litter weaning weight (1.97 and 7.40%, respectively, in pigs born to SO and NSO sows) (P<0.05).

During pre-weaning growth, pigs born to SO sows had a dramatically lower mortality (9.07% vs. 36.75%) with automatically higher survival rate (90.93% vs. 63.25%) (P<0.05). The improved

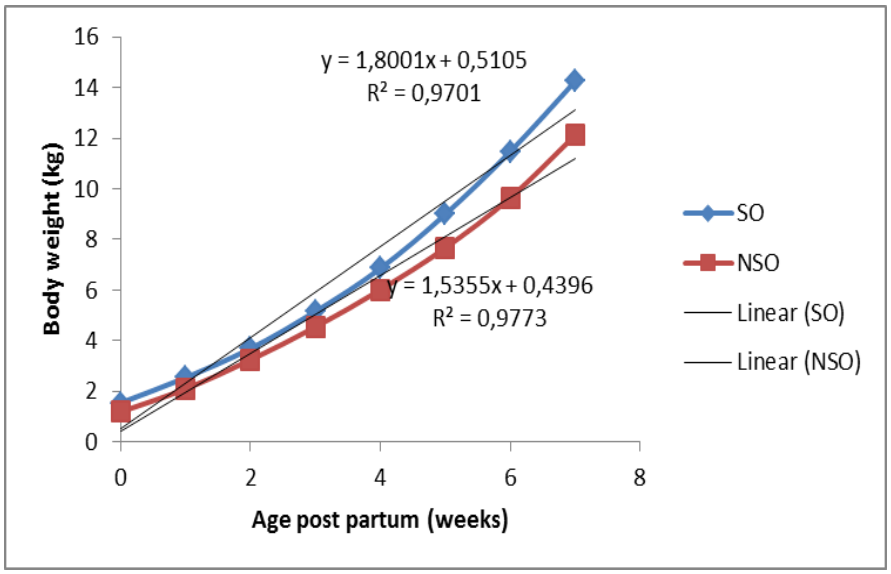

Figure 1. Preweaning growth of pigs born to NSO and SO sows

birth weight, pre-weaning survival and pre-weaning growth rate finally improved total productivity of the sows as was indicated by the increased total weight of weaned pigs per sow in SO sows by 21% as compared to NSO sows (Table 2).

The higher increase in weaning body weights were not contributed only by the higher body lengths and leg heights. Body length, fore leg height and hind leg height and their growth during pre-weaning period in NSO and SO pigs were not different statistically, even though the growth of the SO pigs was constantly above those of NSO pigs. The rate of body length growth during pre-weaning period in pigs born to SO sows ranged from 0.35 to 0.64 cm/pig/day while in those born to NSO sows ranged from 0.35 to 0.61 cm/pig/day. Predicted body length growth rates of the pigs born to SO and NSO sows were 3.37 and 3.34 cm/pig/week, respectively. The rate of fore leg height growth during pre-weaning period in pigs born to SO sows ranged from 0.24 to 0.36 cm/pig/day while in those born to NSO sows ranged from 0.21 to 0.34 cm/pig/day. Predicted fore-leg growth rates of the pigs born to SO and NSO sows were 2.16 and 2.02 cm/pig/week, respectively. The growth rate of hind leg in pigs born to SO sows ranged from 0.25 to 0.39 cm/pig/day, while in those born to NSO sows ranged from 0.24 to 0.35 cm/pig/day. Predicted hind leg growth rates of the pigs born to SO and NSO sows were 2.23 and 2.18 cm/pig/week, respectively.

The increased postnatal growth performances of pigs born to SO sows are related to the improved birth weight and more homogenous birth weight since low birth weight and higher variation of within-litter birth weight in piglets correlates well with decreased survival and lower postnatal growth rates (Milligan et al., 2002; Quiniou et al., 2002) and important risk factors for pre-weaning mortality are birth weight and within-litter variation in birth weight (Roehe and Kalm, 2000; Tuchscherer et al., 2000). Improvement of uterine environment during pregnancy by injecting the sows with PMSG and HCG prior to mating improves prenatal growth and birth weight that finally improves pre-weaning growth and survival. The increased weaning weight in pigs born to SO sows could be related to the muscular development attached to the skeleton, since the body length and leg heights of the pigs born to SO and NSO sows were not statistically different. Postnatal and post-weaning growth rates are strongly affected by the number of myocytes in the muscle (Foxcroft et al., 2006, 2009) that finally affects meat quality and tenderness.

With the better birth weight and pre-weaning growth performance, the growth performances

Table 2. Pre-weaning growth rate, mortality, weaning weight, morphometri and total weight of weaned pigs per sow in pigs born to NSO and SO sows.

Parameters	Group	
	NSO[c]	SO[d]
Pre-weaning mortality (%)	36.75±21.22[a]	9.70±15.5[b]
Pre-weaning growth rate (g/d)	215.32±17.41[b]	259.26±4.81[a]
Weaning weight (kg/pig)	11.78±0.87[b]	14.27±0.28[a]
Total weight of weaned pigs per sow (kg)	91.97±12.64[b]	111.2±1.49[a]
Body length at weaning (cm)	45.23±1.29[a]	48.85±1.58[a]
Fore leg height at weaning (cm)	22.04±2.68[a]	24.51±1.14[a]
Hind leg height at weaning (cm)	23.81±2.43[a]	26.43±1.45[a]

[a,b] Values bearing different superscripts within row are significantly different (P<0.05)
[c]NSO are control sows without PMSG and HCG injection prior to mating
[d]SO are PMSG and HCG-injected sows prior to mating

of the grower pigs to finishing were tested. In general, the results showed that there was no difference in weekly body weights and growth rates between female and male pigs either born to SO or NSO sows, even though there was a numerically higher growth rate of male pigs as compared to female pigs. However, pigs born to SO sows showed a significant higher growth rate after weaning to finishing ($P<0.05$) (Figure 2). The growth rate during post-weaning period in pigs born to SO sows was 5.26 kg per month and for pigs born to NSO sows was 4.50 kg/month. At the age of 8 weeks postpartum, pigs born to SO sows had post-weaning weight of 18.93 kg while those pigs born to NSO sows only 15.81 kg (Table 2). At the age of 28 weeks postpartum, pigs born to SO sows had body weight of 123.94 kg while pigs born to NSO sows only reached body weight 113.43 kg. There was almost 10 kg difference in slaughter weight between pigs born to SO sows and NSO sows. If the total pigs succeeded to slaughter age were around 10, the difference in total weight pig produced by a SO sow will be around 100 kg. This increased sows' productivity could be significant in improving income for the farmer and in general in improving meat production per sow. The results of this experiment strongly showed that pigs born to SO sows constantly had higher growth rate during post-weaning period. The improved growth rate during pre-weaning period in the SO pigs is not only contributed by the increased milk production during lactation (Lapian et al., 2013) since the higher growth rates are constantly observed during post-weaning growth in pigs born to SO sows. It means that the improved uterine environment improves the growth phenotype of the offspring during prenatal growth during pregnancy. The increased post-weaning growth performances of pigs born to SO sows are related to the improved growth phenotypes during fetal growth and development during pregnancy that are reflected in an optimum birth weight and more homogenous birth weight within-litter. Low birth weight and higher variation of within-litter birth weight correlates well with decreased survival and lower postnatal growth rates (Milligan et al., 2002; Quiniou et al., 2002). Macro- and micro-environments of the uterus and placenta (nutritional, hormonal and local factors) are assumed to function as epigenetic factors that affect genetic expression of certain phenotype that could affect the expression of the gene during future life (Fowden et al., 2008; Foxcroft et al., 2009, 2006).

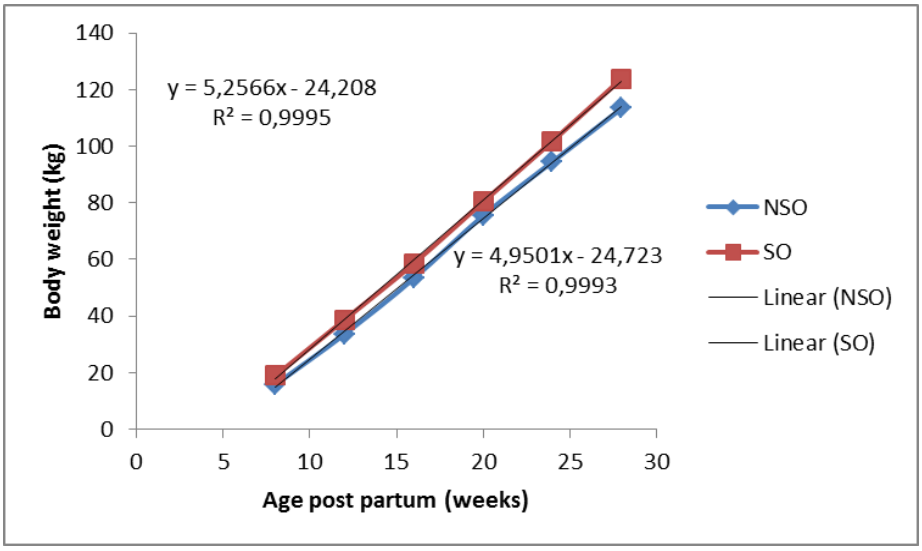

Figure 2. The growth of pigs born to NSO and SO sows during post-weaning period

Improved endogenous secretion of maternal estrogen and progesterone by stimulating the growth and development of follicles and corpora luteal by injection of the sows with exogenous gonadotropin such as FSH, PMSG or HCG prior to mating increases the uterine and placental growth and development and the growth of the embryo and fetus (Mege et al., 2007) and finally improves birth weight and postnatal growth performances and survival of the offspring (Lapian et al., 2013; Mege et al., 2006). Pigs born to super-ovulated sows reached the slaughter weight (95 kg) 2 weeks faster than those born to control sows with a better carcass and meta qualities (Lapian et al., 2013).

Conclusion

Improved uterine environment during pregnancy could improve growth phenotype expression that finally improves postnatal growth and survival of the offspring. Injection of the sows prior to mating could produce superior offspring that could be used a finisher or parent stocks.

Acknowledgement

This study was sponsored by doctoral scholarship provided by the BPPS of the Directorate General of Higher Education, Ministry of Education and Culture of the Republic of Indonesia to DJJR.

References

Ash RW and RB Heap. 1975. Oestrogen, progesterone and corticosteroid concentrations in peripheral plasma of sows during pregnancy, parturition, lactation and after weaning. J Endocrinol. 64:141-154.

Chłopek J, P Gilun, A Tabecka-Lonczyńska, M Koziorowski and S Stefańczyk-Krzymowska. 2008. The effect of intravaginal application of estradiol and progesterone on porcine embryo development. Pol. J. Vet. Sci. 11:287-93.

Dalton DL and JW Knight. 1983. Effects of exogenous progesterone and estrone on conceptus development in swine. J. Anim. Sci. 56:1354-1361.

Flowers B, TC Cantley, MJ Martin and BN Day. 1991. Episodic secretion of gonadotrophins and ovarian steroids in jugular and utero-ovarian vein plasma during the follicular phase of the oestrous cycle in gilts. J. Reprod. Fertil. 91:101-112.

Fowden AL, AJ Forhead, PM Coan and GJ Burton. 2008. The placenta and intrauterine programming. J. Neuroendocrinol. 20:439–450.

Fowden AL, DA Giussani and AJ Forhead. 2005. Endocrine and metabolic programming during intrauterine development. Early Hum. Dev. 81:723–734.

Fowden AL, JW Ward, FPB Wooding, AJ Forhead and M Constancia. 2006. Programming placental nutrient transport capacity. J. Physiol. 572: 5–15.

Foxcroft GR, WT Dixon, MK Dyck, S Novak, JC Harding and FC Almeida. 2009. Prenatal programming of postnatal development in the pig. Soc. Reprod. Fertil. Suppl. 66:213-31.

Foxcroft GR, WT Dixon, S Novak, CT Putman, SC Townand and MDA Vinsky. 2006. The biological basis for prenatal programming of postnatal performance in pigs. J. Anim. Sci. 84: E105-E112.

Gray CA, GA Johnson, FF Bartol, BJ Tarleton, AA Wiley, FW Bazer and TE Spencer. 2001. Developmental biology of uterine glands. Biol. Reprod. 65:1311–1323.

Lapian MTR, PH Siagian, W Manalu and R Priyanto. 2013. Carcass qualities of finisher pig born to superovulated sows before mating. J. Veteriner. 14:350-357.

Mege RA, SH Nasution, N Kusumorini and W Manalu. 2007. Growth and development of the uterus and placenta of superovulated gilts. Hayati J. Biosciences. 14:1-6.

Mege RA, W Manalu, N Kusumorini and SH Nasution. 2006. Effect of superovulation on piglet production. Animal Production. 8:8-15.

Milligan BN, D Fraser and DL Kramer. 2002. Within-litter birth weight variation in the domestic pig and its relation to pre-weaning survival, weight gain, and variation in weaning weights. Livest. Prod. Sci. 76:181–191.

Ohtaki T, M Moriyoshi, KNakada, T Nakao and Y Sawamukai. 2012. Relationships among steroid hormone levels in newborn piglets, birth weight, placental weight, vitality of offspring and litter size. Anim. Sci. J. 83:644-649.

Przała J, A Grazul, T Wiesak, A Muszyńska and L Dusza. 1985. Steroid hormones and prolactin in porcine follicular fluid in estrous cycle and early pregnancy. Exp. Clin. Endocrinol. 86:291-296.

Quiniou N, J Dagorn and D Gaudre. 2002. Variation of piglets' birth weight and consequences on subsequent performance. Livest. Prod. Sci. 78:63–70.

Reynolds LP and DA Redmer. 1995. Utero-placental vascular development and placental function. J. Anim. Sci. 73:1839-1851.

Roehe R and E Kalm. 2000. Estimation of genetic and environmental risk factors associated with pre-weaning mortality in piglets using generalized linear mixed models. Anim. Sci. 70:227–240.

Spencer TE and FW Bazer. 2002. Biology of progesterone action during pregnancy recognition and maintenance of pregnancy. Front Biosci. 7:d1879–1898.

Spencer TE and FW Bazer. 2004. Uterine and placental factors regulating conceptus growth in domestic animals. J. Anim. Sci. 82:E4-E13.

Spencer TE, GA Johnson, RC Burghardt and FW Bazer. 2004. Progesterone and placental hormone actions on the uterus: Insights from domestic animals. Biol. Reprod. 71:2–10.

Tuchscherer M, B Puppe, A Tuchscherer and U Tiemann. 2000. Early identification of neonates at risk: Traits of newborn piglets with respect to survival. Theriogenology. 54:371–388.