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EFFECTS OF THE PHOTOPERIODICITY ON THE REPRODUCTION IN SOW. II-EFFECTS ON THE REPRODUCTIVE HORMONAL SYSTEM

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Abstract

The research was conducted on a breed of adult sow in different physiological states, originated from a northern EU area, during the period of adaptation in a temperate (Romanian) area. The animals were in different physiological status: gilts and sows, estrous, pregnancy or lactation. They were determined the blood plasma levels of main hormones involved in the reproductive function [17-β estradiol, progesterone, follicle stimulating hormone (FSH), luteinizing hormone (LH) and melatonin] in the days of the solstices and equinoxes. Plasma levels of 17-β estradiol for gilts and sows during the first day of the estrous showed minimal values in March, 20^th^, increased in June 21^st^, reaching a maximal values in September, 22^nd^, and then decreased again. The LH mean values (assayed in the first day of estrous period) were highest during the maximum photophase (June, 21^st^) and lowest in September, 22^nd^ in gilts, while in sows, the higher levels of plasma LH were found during the day of spring equinox and summer solstice and the lowest levels in September, 22^nd^ (as in gilts). Plasma progesterone of the 25-day-pregnant gilts and sows presented the highest values during the period of maximum scotophase (December, 21^st^), significantly higher by comparing to the other three analyzed photoperiods. Plasma progesterone of pregnant gilts was lower vs. pregnant sows for every analyzed photoperiod. The maximum amounts of melatonin blood values were found in December 21^st^, the lowest in June 21^st^ and intermediate values in the two solstices. For all the assayed photoperiods, melatonin contents in midnight samplings were nearer to those taken at midday. Almost every time, the melatonin values in lactant sows were lower vs. in pregnant sows.

Key words*: *17β-estradiol, progesterone, follicle stimulating hormone (FSH), luteinizing hormone (LH), melatonin, photoperiodicity, sows.

INTRODUCTION

Reproductive photoperiodicity of the sow shows a number of features related to breed physiological status, age or parity. Sensibility of the pig to different photoperiods is discussed in relation to reproductive parameters by commercial farmers. Seasonal infertility of sows for example, has a multiple causes (temperature, level of nutrition, genetic background), but this factorial complex is completed by photoperiodism. It is possible that the seasonal early disruption of pregnancy to be mediated by decreased progesterone concentrations leading to underdeveloped embryos at the time of recognition of pregnancy. This seasonal decrease in progesterone appears to be under the influence of seasonally changing melatonin secretion (Tast, 2002). Bassett *et al.* (2001, cited by Chokoe and Siebrits, 2009) found that melatonin implants were able to prevent seasonal anestrous In regions with large variation in day length during the year, the importance of photoperiod and light intensity during photo- and scotophase may be greater than the effect of high ambient temperature. (Gaustand *et al*., 2004). Transfer of animals from a region of large differences between the main photoperiods to another with low differences could involve significant modification of the reproductive hormonal system and of reproductive parameters. The purpose of this study was to identify the season effects on sow originating from a Northern EU area, during the period of adaptation in a Southern EU area.

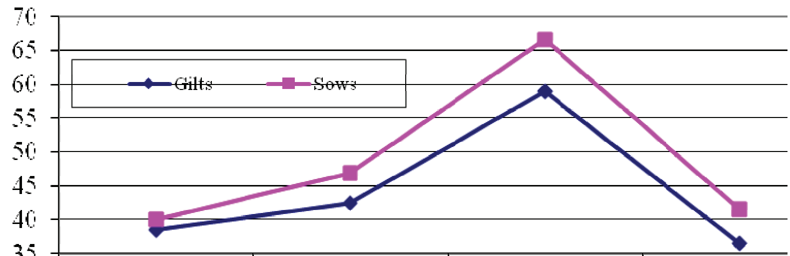
MATERIAL AND METHODS

Researches were performed on a crossbred of Yorkshire (♀)×Landrace (♂) gilts and sows sourced from Denmark, belonging to a commercial piggery from Southern Romania. The animals were in different physiological states: pregnancy (the 25th day from artificial insemination), lactation or oestrous (first day of post-weaning oestrous). Each animal was individually labelled. The animals were fed 40% from *ad libitum* (9.5 – 10 kg/day) during the oestrous period, 50% from *ad libitum* during the first third of pregnancy period and *ad libitum* during the rest of pregnancy and lactation periods. The animals were housed in stables whose mean temperatures were 25°C (71.6 – 77.0°F) for the all monitored periods, under natural light conditions, and they had free access to water. Blood was sampled by vein puncture of *V. jugularis or Vena saphena medialis*. Each sample (approximately 8 mL) was drawn into a 10 mL syringe and immediately emptied into 15 mL plastic tubes containing 150 µL EDTA solution (250 mg/mL). Blood samples were assayed for the 17-β estradiol, FSH, LH, progesterone and melatonin contents. The blood was sampled at the equinox days (2013, Sept., 22nd, and 2014, Mars, 20th), at maximum photophase day (2013, Dec., 21st) and at maximum scotophase day (2014, June, 21st), every time at 8:30 to avoid the circadian influences, except for melatonin, to whose analyses the blood was sampled to times a day: midnight and midday. Samples were analyzed by the electro-chemiliminescence assay (ECLIA) using a COBASe 411 analyzer and using pig 17-β estradiol, progesterone, FSH, LH commercial lyophilized antisera extracted from porcine plasma provided by Abnova, and melatonin ELISA kit provided by Elabscience. The results were statistically analyzed using a commercial ANOVA software and the significance was established for P<0.05. The post hoc Tukey test was performed to find the statistical significance between the photoperiods inside the same category of sows. The results are presented as mean ± standard error of mean ($\bar{X} \pm s_{\bar{x}}$).

RESULTS AND DISCUSSION

Regarding the 17-β estradiol in the first day of post-weaning oestrous gilts and sows, they were found seasonal and parity differences, with maximal values in Sept., 22nd for both gilts (P = 0.0029) and sows (P= 0.0298), but with less maximal values in gilts (58.9 pg·mL^{-1}) and a higher maximal value in sows (66.6 pg·mL^{-1}, fig. 1).

Figure 1. The plasma 17-β estradiol levels of the first day of the post-weaning estrous (in pg·mL^{-1}) in gilts and sows during the main photoperiods of the year



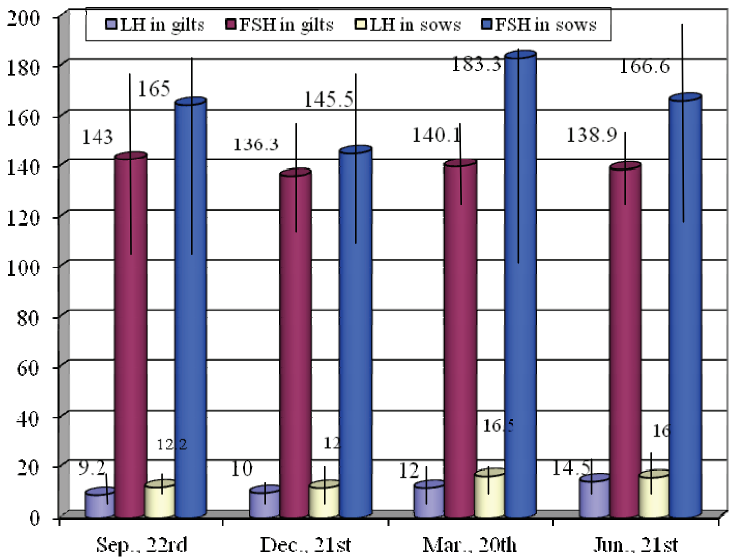
	March, 20th	June, 21st	Sept., 22nd	Dec., 21st
Gilts	38.5	42.5	58.9	36.5
Sows	40	46.9	66.6	41.5

Notice: each mean is the result of 5 or 6 samples.

According to Guthrie *et al.* (1972), total serum estrogen in sows begins to increase three days before estrous (10-28 pg·mL^{-1}), which coincide with the time of lowest progesterone levels, and reached maximum values of about 38 pg·mL^{-1} two or one day before estrous. In our research, the plasma 17-β estradiol levels of the first day of estrous were found increased from Mars, 20th to June, 21st, reaching the maximal values during the autumnal equinox day (Sept., 22nd). This slow increase of the plasma 17-β estradiol from spring to summer could be assigned to a slow stimulatory effect of the increasing photoperiod. The same explanation for the evolution of estrogen levels from March to September. Almond and Dial (1990) reported a 17-β estradiol level of 10-19 pg·mL^{-1} in anestrous sows. Estradiol-17β and progesterone blood changes were found according to breed and feeding system: Lee *et al.* (2013) investigated the changes of serum progesterone and estradiol-17b in sows of Landrace (L), Yorkshire (Y) and F1 (L × Y) fed by two ways methods, a conventional method and 3 days-flushing feed before estrous. In conventional feeding, serum progesterone and estradiol-17b levels were significantly ($p<0.01$) higher in F1 than in L and Y. In the case of flushing method, almost of hormonal levels were a little higher than that of conventional methods. The authors concluded that more studies about hormonal changes in sows according to seasonal and nutritional factors should be needed.

Plasma LH levels assayed for the first day of the estrous cycle ranged between 9.2 and 14.5 ng·mL^{-1} in gilts and between 12.0 and 16.5 ng·mL^{-1} in sows along the whole analyzed photoperiodicity (Fig. 2). The LH average values of gilts were highest in the moment of maximum photophase (in June) and lowest in September, while in sows, the higher levels of plasma LH belong to sows which were in oestrous during the days of spring equinox and summer solstice. Statistical analysis revealed significant seasonal differences for both gilts ($P = 0.033$) and sows ($P = 0.019$). Mean annual values of LH were 11.42 ng·mL^{-1} in gilts and 14.17 ng·mL^{-1} in sows.

Fig. 2. Comparative blood plasma LH and FSH levels in gilts and sows in the first day of post-weaning estrous, for the main photoperiods of the year (ng·mL^{-1})



Guthrie *et al.* (1972), reported that LH concentration was significantly greater during pregnancy (3.12 ng·mL^{-1}) than during the early follicular phase (1.02 ng·mL^{-1}).

Mean annual values of FSH were 139.5 ng·mL^{-1} in gilts and 165.1 ng·mL^{-1} in sows, higher in sows vs. gilts for every one of the four analyzed photoperiods. In sows, highest values of FSH were found in the equinox days ($P = 0.0082$ when calculated by comparing to the lowest value, found in December). For gilts, they were no significant differences between the four analyzed photoperiods. Studies relieve a period of seasonal abortion in pig, focused on the August, September and October (Wrathall *et al*, 1986). Smits and Almond (1991) found that frequency of LH pulses and LH pulse amplitude were higher in pregnant gilts during January and February compared to August and September. Luteinizing hormone secretion is known to be affected by seasonal variation (low in summer and high in winter) in the domestic pig (Peltoniemi *et al*., 1997) and this seasonal variation appears to be controlled by photoperiodism through melatonin secretion (Bassett *et al*., 2001; Tast *et al*., 2001, cited by Chokoe and Siebrits, 2009).

Chokoe and Siebrits (2009) hypothesized that reduced daylight will improve estrous expectancy rates of sows seven days after weaning, non-return rate, farrowing rates and litter size. They found that the supply of constant 10 h photoperiod had no effect on the proportion of sows that were served within seven days or served after seven days, neither on the number of sows that returned to service. There was no seasonal effect on the proportion of sows served or on the proportion that returned to service.

Peltoniemi *et al*. (2000) links the blood LH level variations by the phenomenon of seasonal abortion in sows. According to Peltoniemi *et al*. (2000), the endocrinological mechanism of seasonal disruption of pregnancy is yet to be determined. However, they found that LH is reduced in the summer–autumn period. These changes in LH secretion may exert a progesterone-mediated detrimental effect on the capability of embryos to produce adequate embryonic signaling. This may lead to a seasonal disruption of pregnancy and a return to estrous 25–30 days after mating.

Plasma progesterone presented the highest values in both pregnant gilts and pregnant sows during the maximum scotophase period (December), significantly higher by comparing to the other three analyzed photoperiods. Minimal values were found in June and September, and intermediates values in March (Table 1).

Table 1. The plasma level of progesterone (in $ng \cdot mL^{-1}$) in pregnant gilts and sows during the main photoperiods of the year

Item	Sep., 22^{nd}	Dec., 21^{st}	Mars, 20^{th}	June, 21^{st}	P
Gilts (25^{th} day of pregnancy)	32.2± 6.8	36.9± 6.0	33.0± 7.5	28.0± 8.9	0.033
Sows (25^{th} day of pregnancy)	36.0± 8.8	46.5± 6.1	36.3± 7.0	38.9± 9.0	0.019

Notice: each mean is the result of 5 or 6 samples.

According to Guthrie *et al*. (1972): the mean progesterone concentration in pig ranges from 16.1 $ng \cdot mL^{-1}$ of blood plasma to 1 $ng \cdot mL^{-1}$ or less before estrous, remains less during estrous and increases to a peak value of 35.4 $ng \cdot mL^{-1}$ during pregnancy. Peak plasma values of progesterone in December, 21^{st} seem to be a consequence of pregnancy installation in September rather than an influence of photoperiodicity.

Wrathall *et al*. (1986) found that seasonal differences in progesterone concentrations were evident, with the concentrations rising from the lowest values in August, September and October (as in our research) but to a peak in March (not in December). Their findings are pertinent to the pathophysiology of the autumn abortion syndrome and other seasonal reproductive problems in sows.

Plasma values of melatonin for the blood sampled in the midnight showed maximal values in Dec., 21^{st} and minimal values in June, 21^{st} (Table 2). The two solstices presented intermediate melatonin values, between winter equinox and summer equinox, for the two physiological states of sows, lactant and pregnant, and for the two times of sampling.

Melatonin content of the blood sampled at Dec. 21^{st} midnight vs. midday was 1.17 higher in lactant sows and 1.22 higher in pregnant sows. These differences were a bit lower in June, 21^{st}: 1.05 and, respectively, 1.06. The plasma melatonin ranges we found in our research are in agreement with Andersson (2001) results (according to Andersson, in gilts, plasma levels of melatonin ranges between 2.6 pg·mL^{-1} in daytime and 26 pg·mL^{-1} in nighttime), excepting the differences between daytime and nighttime: ten times higher in nighttime vs. daytime, but no detail is given about the season of sampling.

The same author suggests there is a genetic background involved in melatonin secretion. Seasonal variations in melatonin secretion bind the hormone levels to the phenomenon of seasonal infertility in pig. Seasonal infertility in sows has been documented to be a result of high temperature.

One of the reasons pigs are vulnerable to elevated ambient temperature is their inability to lose heat by evaporation. High ambient temperatures limit pig production (Bloemhof *et al*., 2012). There is no consensus regarding the factors that impact seasonal infertility. However, some traits involved are heat stress, genetic background and photoperiod (Love *et al*., 1993). It has been shown that pigs adjust their circadian melatonin secretion according to changes in photoperiod (Tast *et al*., 2002).

Bassett *et al.* (2001, cited by Chokoe and Siebrits, 2009) found that melatonin implants which were inserted at the spring equinox were able to prevent seasonal anestrous, thus providing further support for the contention that the duration of the daily photoperiod is the primary determinant of the reproductive seasonality.

Table 2. The plasma level of melatonin ($\bar{X} \pm s_{\bar{x}}$, in pg·mL^{-1}) in lactating and pregnant sows in the main photoperiods of the year

Item	Time of sampling	Sep., 22nd	Dec., 21st	Mars, 20th	June, 21st	P
Lactant sows	Midday	4.0±0.10	20.4±0.45	4.04±0.00	1.05±0.00	0.033
	Midnight	4.49±0.98	24.0±0.40	4.98±0.65	1.11±0.04	0.020
Pregnant sows	Midday	4.35±0.19	23.96±0.50	5.19±0.05	1.15±0.05	0.019
	Midnight	5.05±1.09	26.9±3.33	5.55±0.65	1.22±0.22	0.009

Notice: each $\bar{X} \pm s_{\bar{x}}$ is the results of 5 or 6 samples.

Apparently contradicting findings were observed by Kermabon *et al*. (1995) who showed that a long light duration (16 h/day) had a detrimental influence on the return to estrous after weaning, while a higher proportion of sows exposed to a short day length (8 h/day) exhibited estrous shortly after weaning. Gaustad *et al*. (2004) reported that litter size was lower after service during natural long photoperiod than during the rest of the year for both, gilts and sows from a Northern and a Southern region in Norway.

CONCLUSION

Landrace x Yorkshire sows are subject of reproductive hormone level changes during adaptation in temperate zone, according to the seasonal photoperiodicity and different physiological states, which can be taken into account in the commercial management of this species.

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