UDC 636.424.082/57.087.01
DOI 10.56407/bs.agrarian/1.2023.64

Ukrainian Black Sea Region Agrarian Science
Vol. 27, No. 1

Analysis of long-term dynamics of reproductive characteristics of sows of the large white breed

Olexander Kramarenko*

PhD in Agriculture
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0002-2635-526X

Serhii Luhovyi

Doctor of Agriculture
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0001-6505-8105

Olena Yulevich

PhD in Technical Sciences
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0003-1594-0700

Serhii Kramarenko

Doctor of Biological Sciences
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0001-5658-1244

Abstract. In the field of pig breeding, the main goal is to increase the level of fertility and survival of piglets in order to maximize the size of the nest both at birth and at weaning per sow per year. The purpose of this study was to determine the features of the long-term dynamics of the main reproductive features of sows of the large white breed using time series analysis, as well as the role of climatic factors (primarily, temperature) in the manifestation of these dynamics. For the analysis, we used primary data on sows of the large white breed, which were kept in the conditions of Tavriyski svini LLC (Skadovsky district, Kherson region, Ukraine) during 2007-2017. The presence of a trend was determined using the Spearman rank correlation coefficient. In addition, autocorrelation coefficients were estimated for lags from 1 to 45 months. to detect the presence and duration of cycles. It was established that during the research period there was a negative trend in relation to the total number of piglets at birth and, conversely, a positive trend in relation to the average weight of one piglet at birth and weaning. In addition, pronounced cyclicity of changes was revealed for the time series of the average weight of one piglet at birth and the average weight of one piglet at weaning. It was established that a higher temperature in the winter months led to a decrease in the average weight of one piglet at birth, but contributed to an increase in the number of piglets at weaning. Significant temperature deviations from the optimum (in either direction) in March-May led to a decrease in the fertility of sows due to an increase in the number and proportion of stillborn piglets in the nest.

Article's History:
Received: 03.10.2022
Revised: 19.12.2022
Accepted: 28.02.2023

Suggested Citation:
Kramarenko, O., Luhovyi, S., Yulevich, O., & Kramarenko, S. (2023). Analysis of long-term dynamics of reproductive characteristics of sows of the large white breed. *Ukrainian Black Sea Region Agrarian Science*, 27(1), 64-73. doi: 10.56407/bs.agrarian/1.2023.64.

*Corresponding author

Finally, higher summer temperatures contributed to an increase in the number of stillborn piglets, and there was a tendency for the mean birth weight of one piglet to decrease with increasing air temperatures in summer. Thus, the role of three processes was established in the formation of features of long-term dynamics of reproductive characteristics of sows: a) long-term trend; b) cyclic processes; c) random seasonal fluctuations associated with the reaction of animals to heat stress

Keywords: trend; cycle; nest size; live weight of piglets at birth and weaning; heat stress

INTRODUCTION

Since the beginning of the 1990s, the main goal of the pig industry has been to increase the reproductive performance of sows (primarily, the level of multiple fertility) in order to maximize the size of the litter both at birth and at weaning per sow per year (Biermann *et al.*, 2014). At the same time, it has been repeatedly proven that the reproductive characteristics of sows are significantly influenced by environmental factors, such as air temperature (Tantasuparuk *et al.*, 2000; Suriyasomboon *et al.*, 2006; Amavizca-Nazar *et al.*, 2019), relative air humidity and temperature-humidity index (THI) (Suriyasomboon *et al.*, 2006; Tummaruk *et al.*, 2010), photoperiod (Chokoe & Siebrits, 2009), season of the year (Tantasuparuk *et al.*, 2000; Tummaruk *et al.*, 2010) etc.

High temperatures play a particularly important role, since pigs are characterized by a low transpiration rate, which prevents their thermoregulation and maintenance of the temperature regime within the limits that ensure a normal level of productivity. Pigs use thermoregulation to maintain their body temperature within their thermal comfort zone (18°C to 20°C). Thus, if the ambient temperature exceeds 25°C, the animals will be subjected to heat stress (Wegner *et al.*, 2014).

According to (Tast *et al.*, 2002), in the body of pigs, with an increase in temperature, the synthesis of prolactin by the pituitary gland, which is necessary to increase the secretory activity of the corpora lutea, is inhibited approximately on the 30th day of puberty. This can cause interruption of the normal course of pregnancy and irregular sexual cycle of sows.

At the same time, the temperature regime and THI are reflected differently on the reproductive function of sows and the survival of piglets. Increasing the values of these indicators during mating had a positive effect on the fertility of sows, but similar conditions during farrowing, on the contrary, had negative consequences (Wegner *et al.*, 2014).

In addition, a probable joint effect of year and season of farrowing on the size of the nest and the total weight of the nest and individual piglets at birth and weaning was established (Ek *et al.*, 2016; Thiengpimol *et al.*, 2017). These results may indicate that it is not so much the calendar year or the calendar month of the year that is important, but the features of the climatic characteristics of a certain farrowing year/season/month and, first of all, their deviation from the optimal value at which the reproductive functions of sows can be realized as much as possible.

On the other hand, non-random components of temporal variability (for example, trend and/or cycles) may manifest on different time scales exceeding one year. In this case, elements of time series analysis (TSA) may serve as the most suitable methods.

TSA has previously been used to create stochastic models for short-term prediction of milk production in dairy cows (Deluyker *et al.*, 1990) and ewes (Macciotta *et al.*, 2000). In addition, in the work of R.M. Lark *et al.* (1999) showed that TSA can be used to describe the pattern of milk yield variability in the first 48 days of lactation among healthy cows and animals with ketosis. And in the work of E.A. Goodall *et al.* (1993) based on TSA methods, a mathematical model was built for predicting the incidence of fasciolosis in cattle.

In the study of M. van Straten *et al.* (2008) quantified changes in daily body weight of high-yielding dairy cows during the first 120 days of lactation. As a result, the presence of 7-day and 21-day cycles of changes in live weight was revealed. At the same time, the connection between the latter and the activity of the ovaries suggests that they had a physiological origin and are also related to the estrous cycle.

Also, TSA has already been used repeatedly in pig breeding, for example, when analyzing the incidence of mycobacteriosis in pigs (Carpenter & Hird, 1986), echinococcosis (Adachi & Makita, 2017), ascariasis (Goodall *et al.*, 1991) and other diseases, including reproductive porcine respiratory syndrome (Arruda *et al.*, 2018). In addition, based on the analysis of sound signals using TSA, an automated online procedure for recognizing and localizing the sounds of a sick pig's cough was developed, which allowed early diagnosis of sick animals (Exadaktylos *et al.*, 2008). TSA was also used to analyze physiological processes in the body of pigs, for example, jaw movement and tissue deformation (Liu *et al.*, 2004).

Thus, the main goal of this study was to determine the features (presence of a trend and/or cyclicity) in the analysis of long-term dynamics of the main reproductive characteristics of sows of the large white breed using TSA, as well as the role of climatic factors in the manifestation of these dynamics.

MATERIALS AND METHODS

For the analysis, primary data on sows of the large white breed (BBP) were used, which were kept in the conditions of "Tavriyski Swyni" LLC (Skadovsky district, Kherson region, Ukraine). In total, data on 860 farrowings from 312 sows during January 2007 – July 2017 were used.

The following reproductive traits were recorded for each farrowing: total number of piglets at birth (TNB), multiparity (NBA), number of stillborn piglets (NSB), proportion of stillborn piglets (FSB), average weight per piglet at birth (AWPB), number of piglets at birth weanings (NW), piglet mortality from birth to weaning (PWM) and average piglet weight at weaning (AWPW).

All sow farrowing dates were recoded using the year/month of farrowing (YMF Code) format, so a code of "1" was assigned to sows that farrowed during January 2007 and a code of "127" to sows that farrowed during July 2017

A trend in the ACP is considered a statistically probable increase (or, conversely, a decrease) of the characteristic under investigation during the time interval under consideration against the background of minor fluctuations caused by both endo- and exogenous factors. Changes in the magnitude of the characteristic during the time interval may, in addition, be not just random in nature, but contain a relatively regular alternation of increase and decrease. The autocorrelation coefficient (AR) is used to determine the presence of such cyclicity in the time series. The autocorrelation coefficient is an estimate of the pairwise correlation coefficient between the values of the original time series and the same values, but shifted by a certain number of time intervals (in this case, the single time interval was one month), which is called lag. If the estimate of the autocorrelation coefficient (for a certain lag *k*) is likely to exceed zero, it is assumed that the original time series and the same time series, but shifted by *k* time intervals, coincide, that is, cyclicity occurs (Wakchaure *et al.*, 2010).

The first important characteristic of the time series, for which the presence of non-random fluctuations is proven, is the first value of the lag, at which positive estimates of the AR coefficient gradually turn into negative estimates (*k*1). The values of *k*1 correspond to the moment when the time series moves from the zero value (that is, the arithmetic mean for all values of the time series) to the largest or, conversely, the smallest.

The second important characteristic of the time series is the first value of the lag, at which the lowest negative estimates of the AR coefficient (*k*2) are achieved. The value of *k*2 corresponds to the moment when the time series passes through a complete cycle – from the zero value to the largest (or smallest) and again to zero. Thus, this value is equal to half the duration of a complete cycle (Chatfield, 2003).

The presence of a trend was determined using Spearman's rank correlation coefficient (*Rs*) for estimates calculated on the basis of the method of least squares (LSE – least squares estimates) of the main reproductive characteristics of BBP sows. The General Linear Model (GLM) was used to calculate LS-estimates:

$$Y_{ijk} = \mu + P_i + YMF\ Code_j + e_{ijk}, \qquad (1)$$

where Y_{ijk} – a sign of reproduction; μ – the overall average value; *Pi* – the fixed effect of the ith farrowing (*i*=1, 2, ..., 10); $YMF\ Code_j$ – fixed effect of the jth code "year/month of farrowing" (*j*=1, 2, ..., 127); e_{ijk} – an error.

All calculations were performed using the "General Linear Model" module of the MINITAB Release 13.1 software package (MINITAB Inc. 2000).

For traits for which the null hypothesis regarding the absence of a trend was rejected with a significance level of $P<0.05$, the LS-estimates calculated according to model (1) were subsequently adjusted (ie, detrended) using the formula:

$$LSE_{adj} = LSE - (a + b \cdot YMF\ Code), \qquad (2)$$

where LSE_{adj} – the adjusted LS score; *LSE* – LS-estimate obtained on the basis of model (1); *a*, *b* – linear regression coefficients.

The presence of a non-random component of time series variability was assessed using estimates of autocorrelation coefficients for lags from 1 to 45 months. using the "Time Series Analysis" module of the STATISTICA v. application program package. 6.0 (StatSoft Inc.).

To explain the patterns of temporal variability of LS-estimates of the reproductive traits of the studied sows, three climate indicators were used for each calendar month of the year: average monthly air temperature (AMT), deviation from the long-term average temperature (DAT) and absolute deviation from the long-term average temperature (ADAT). All temperature values were obtained for the weather station located in the city of Kherson and were listed in the archive for the years 2007...2017 (Meteopost..., n.d.).

The influence of these climatic parameters on the variability of the reproductive traits of BVP sows was assessed using the Spearman rank correlation coefficient separately for each season of the year: winter (December-February), spring (March-May), summer (June-August) and autumn (September-November).

All procedures were carried out in accordance with the ethical considerations regarding the involvement of animals according to the recommendations of ARRIVE (n.d.). The authors of this study assure compliance with all ethical standards in research involving animals.

RESULTS

Presence of a trend. Probable estimates of Spearman's rank correlation coefficient were found only for three reproductive traits of WBP sows, namely TNB (*Rs*=-0.214; *P*=0.016), AWPB (*Rs*=0.607; *P*<0.001) and AWPW (*Rs*=0.345; *P*<0.001). Thus, there was a negative time trend for TNB and a positive time trend for AWPB and AWPW during the study period (ie, January 2007 to July 2017). Accordingly, only LS-adjusted scores (LSE_{adj}) of these traits calculated using formula (2) were used in further analysis.

Previously, in the work of Southwood & Kennedy (1991), a probable positive trend was established in relation to NW (0.051±0.021 piglets/year) of first-born piglets of the landrace breed during 1977-1987. A probable, but negative trend was found when analyzing the signs of reproduction of BBP and Landrace sows on two farms in Nebraska (USA) during 1988-1994 – for NBA it was 0.09-0.11 piglets, and for litter weight – 0.29...0.80 kg in a 6-month period (ten Napel & Johnson, 1997).

In this study, LS scores for TNB decreased by 0.0085±0.0035 piglets per month, i.e., by 0.10 piglets/year. For AWPB and AWPW, in contrast, LS estimates increased by 0.0032±0.0004 and 0.0246±0.0058 kg/month, respectively, that is, by 0.038 and 0.295 kg/year.

Presence of cyclicity. It was established that for TNB (detrend series) and PWM, the nature of the dynamics of the time series was characterized by a random alternation of positive and negative LS-estimates, which are completely stochastic in nature (Fig. 1; Fig. 2).

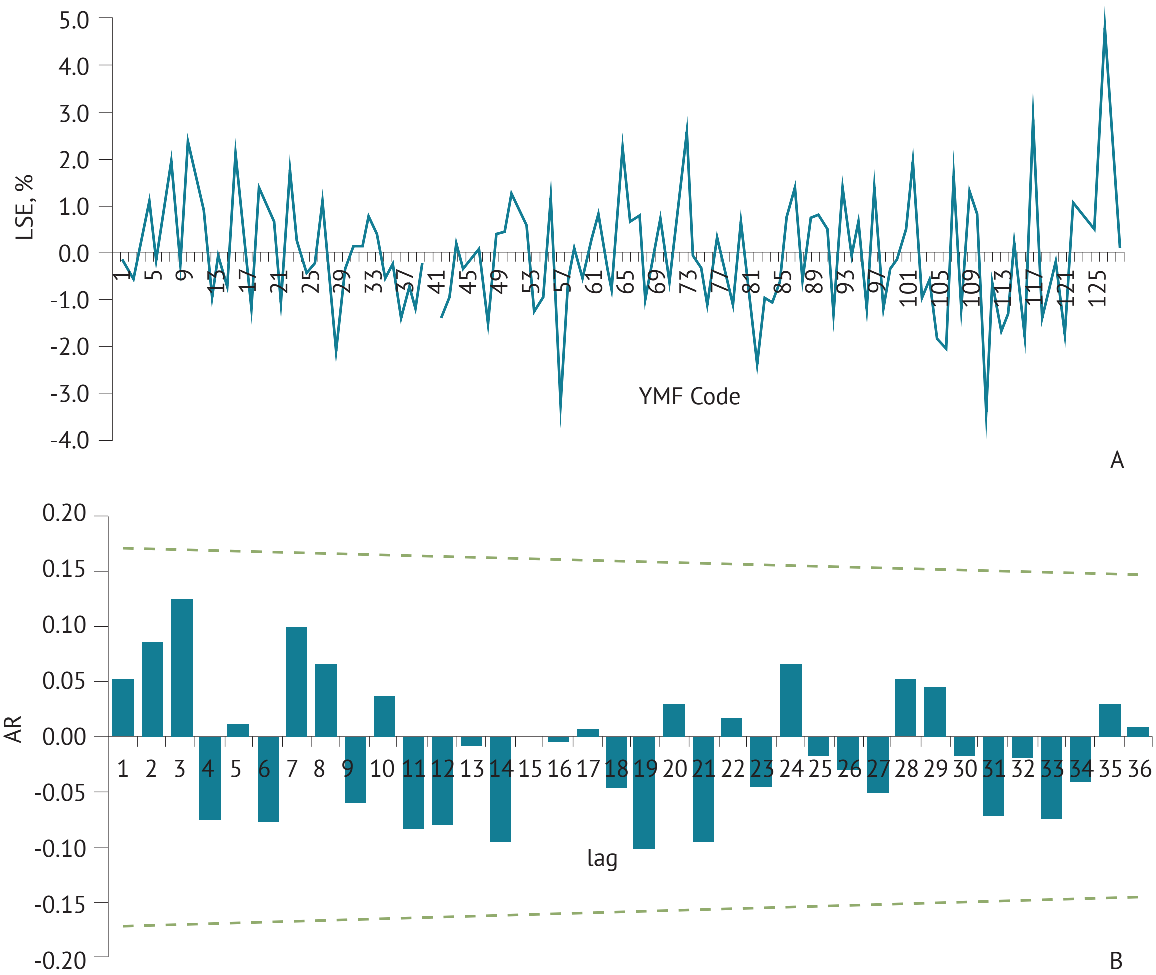

Figure 1*. (A) Detrended time series of LS estimates of the total number of piglets at birth from January 2007 to July 2017; (B) Estimates of the autocorrelation coefficient (AR) of the LS estimates of the total number of piglets at birth*

Notes*: the dashed line marks the 95% confidence interval of the autocorrelation coefficient*

Source*: author's development*

On the other hand, for AWPB and AWPW, the periods of increase and decrease of LS-estimates replaced each other with a certain regularity. For example, probable positive estimates of the autocorrelation coefficient for AWPB were noted for lags of 1…8, 10…12, and 15 months, while probable negative ones were found for lags of 30, 33, and 36 months. (Fig. 3A).

For the time series of LS estimates for AWPB, the value of *k*1 was 21…23 months, and the value of *k*2 was 41…42 months. (Fig. 3A). Thus, the time interval of a complete cycle of increase and decrease of LS-estimates for AWPB was approximately 82…84 months, i.e., 6.8…7.0 years.

For AWPW, probable positive estimates of the autocorrelation coefficient were noted for lags of 1, 2, and 5 months, while probable negative ones were noted for lags of 16, 18, and 19 months. (Fig. 3B). Thus, estimates of *k*1 and *k*2 for this time series were 9 and 18 months, respectively. The time interval of a complete cycle of increase and decrease of LS-estimates for AWPW was approximately 36 months, that is, 3 years.

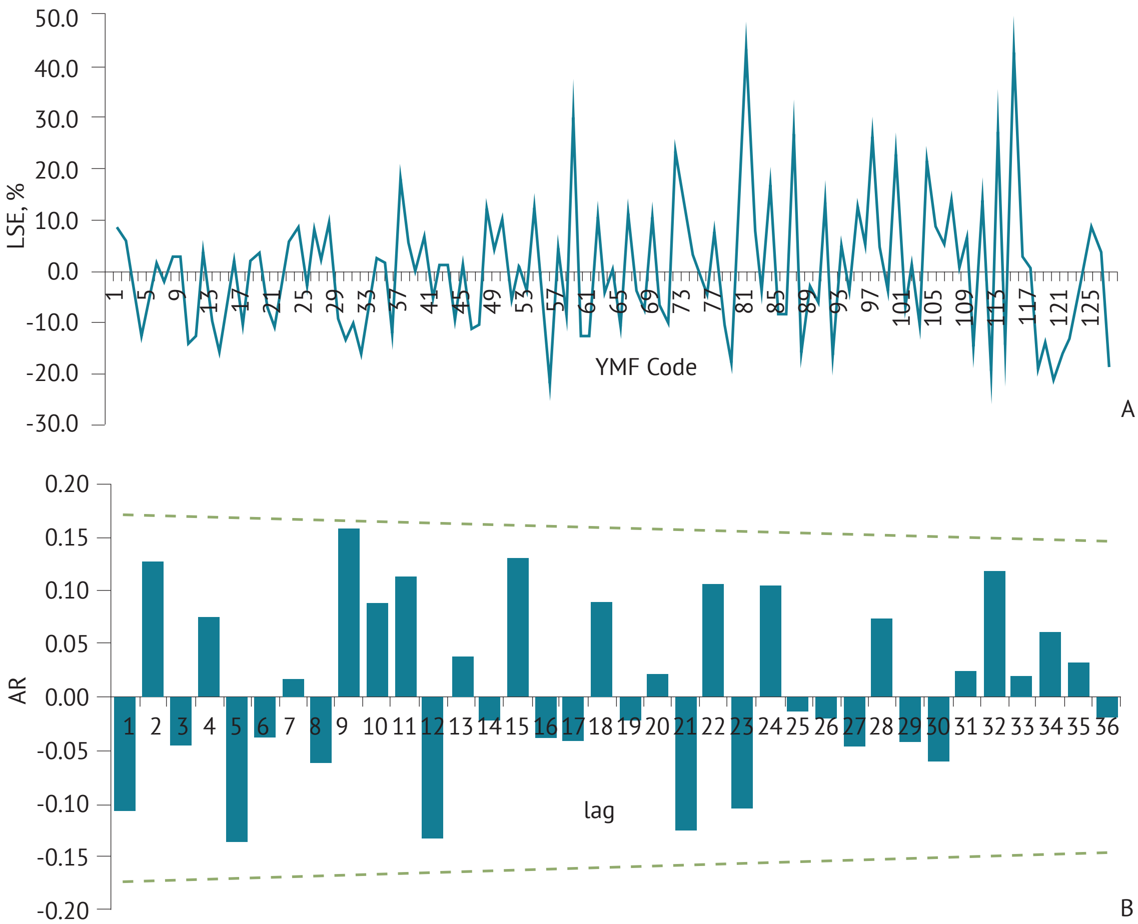

Figure 2. *(A) Time series of LS estimates of piglet mortality from birth to weaning from January 2007 to July 2017; (B) Autocorrelation coefficient (AR) estimates of LS estimates of piglet mortality from birth to weaning*

Notes*: the dashed line marks the 95% confidence interval of the autocorrelation coefficient*

Source*: author's development*

Similar, more or less pronounced fluctuations were previously noted in the analysis of temporal variability (in the format month/year of farrowing) of the main reproductive characteristics (abortion rate, TNB, NBA, NW) of crossbred sows BBP × Landrace (Scanlan *et al.*, 2019). For cattle, such cycles can take 5-7 years (Wakchaure *et al.*, 2011). For the rest of the signs that were included in the analysis (NBA, NSB, FSB and NW), probable positive estimates of the autocorrelation coefficient were noted most often for very small lags (1-2 months), which may indicate the presence of a certain "inertia" of the formation mechanisms reproductive properties of BBP sows, the level of which can be maintained for another 1-2 months. after the influence of factors of endo- or exogenous nature on them.

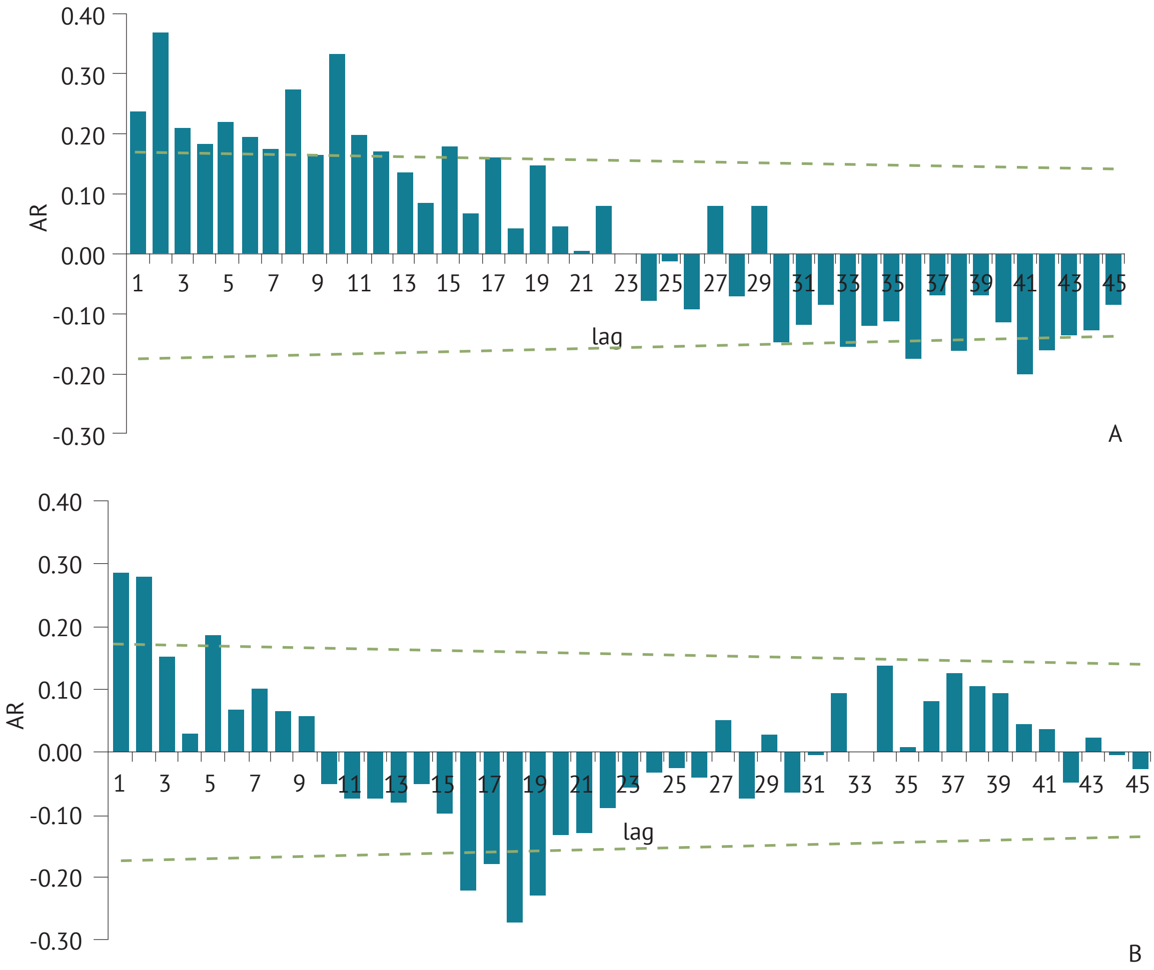

Figure 3. *(A) Estimates of the autocorrelation coefficient (AR) of the detrended time series of LS-estimates of the average birth weight of one piglet; (B) Estimates of the autocorrelation coefficient (AR) of the detrended time series of LS estimates of the average weight of one piglet at weaning*

Notes*: the dashed line marks the 95% confidence interval of the autocorrelation coefficient*

Source*: author's development*

On the other hand, short cycles correspond to the duration of the seasons of the year (during which meteorological characteristics are relatively constant), and thus environmental conditions (primarily air temperature) are able to influence the processes of formation of reproductive characteristics of sows.

Influence of air temperature. It was found that for farrowings in the winter months, there were probable relationships between the following parameters of temperature and reproductive traits of sows: AMT and AWPB (*Rs*=-0.377; *n*=32; *P*=0.033), DAT and AWPB (*Rs*=-0.364; *n*=32; *P*=0.040), AMT and NW (*Rs*=0.353; *n*=32; *P*=0.047), DAT and NW (*Rs*=0.447; *n*=32; *P*=0.010). Thus, a higher temperature in the winter months led to a decrease in the average weight of piglets at birth, but contributed to an increase in the size of the nest at weaning.

For farrowings in the spring months, a significant effect of ADAT was found on NBA (*Rs*=-0.393; *n*=31; *P*=0.029), NSB (*Rs*=0.438; *n*=31; *P*=0.013) and FSB (*Rs*=0.530; *n*=31; *P*=0.002). Thus, significant temperature deviations from the optimum (in either direction) in March-May led to a decrease in the fertility of sows due to an increase in the number and share of stillborn piglets in the nest.

Finally, for farrowings during the summer months, a significant effect of AMT was found on NSB (*Rs*=0.380; *n*=32; *P*=0.032) and AWPB (*Rs*=-0.346; *n*=32; *P*=0.052). Thus, a higher summer temperature contributed to an increase in the number of stillborn piglets, and, accordingly, there was a tendency for the average birth weight of piglets to decrease with increasing air temperature in summer. It is characteristic that, both in the winter months and in the summer, a significant increase in air temperature led to similar consequences – a decrease in the average weight of piglets at birth, which can be explained by the manifestation of heat stress of sows during farrowing.

DISCUSSION

In the study of Tantasuparuk *et al*. (2000) showed that air temperature in the first four weeks after mating of sows had a significant negative effect ($P<0.001$) on their litter size at farrowing – the number of piglets born decreased by 0.07 piglets as the maximum temperature increased during this 4-week period by 1°C.

Similar regularities were found in the work of Suriyasomboon *et al*. (2006) – high temperature and relative air humidity had a negative effect on sow nest size indicators. These results are consistent with the results of an experimental study (Omtvedt *et al*., 1971) in which it was shown that sows exposed to heat stress during late pregnancy gave birth to fewer live piglets and, accordingly, had more stillborn piglets in the litter. than sows kept at a comfortable temperature.

High temperature, high relative humidity, and/or high THI during brooding significantly reduced the total number of piglets in the nest. At the same time, this negative effect was manifested to a greater extent among gilts than among adult sows (Tummaruk *et al*., 2010).

Heat stress during the period from 7 days before successful insemination to 12 days after it had the greatest effect on the total number of piglets born. Therefore, the temperature regime during effective insemination of sows can be used as a reliable predictor of heat stress in commercial pig farms (Bloemhof *et al*., 2013).

In the work of Wegner *et al*. (2014) found that high values of air temperature and THI before farrowing led to a decrease in sow fertility (NBA). On the other hand, increased temperature and THI values after farrowing were associated with more piglets at weaning (NW). Piglet birth-to-weaning mortality (PWM) decreased significantly with increasing temperature and THI values after farrowing ($P<0.05$).

In the study of Brito *et al*. (2022) investigated the effect of heat waves (HW), defined as three consecutive days with ambient temperature ≥25°C and THI>74, on reproductive traits in sows. It was found that sows that were exposed to significant heat waves during farrowing gave birth to more mummified and stillborn piglets than sows that reproduced under optimal conditions.

According to the recently published results of a meta-analysis (Guo *et al*., 2018), conducted to identify the negative effects of heat stress on the reproductive functions of sows, it was established that heat stress, first of all, had a negative effect on the live weight gains of piglets from birth to weaning, but was manifested to a lesser extent on nest sizes and live weight of piglets at birth.

CONCLUSIONS

It was established that during 2007-2017 there was a negative trend in relation to TNB and, conversely, a positive trend in relation to AWPB and AWPW. LS estimates during this period decreased by 0.10 piglets/year for TNB, while for AWPB and AWPW, on the contrary, they increased by 0.038 and 0.295 kg/year, respectively. In addition, a somewhat pronounced cyclical nature of changes was found for AWPB and AWPW. The time interval of a complete cycle of increase and decrease of LS-estimates for AWPB was 6.8…7.0 years, and for AWPW – 3 years.

It was established that a higher temperature in the winter months led to a decrease in the average weight of piglets at birth, but contributed to an increase in the size of the nest at weaning. Significant temperature deviations from the optimum (in either direction) in March-May led to a decrease in the fertility of sows due to an increase in the number and proportion of stillborn piglets in the nest. Finally, higher summer temperatures contributed to an increase in the number of stillborn piglets, and, accordingly, there was a tendency for the average piglet weight at birth to decrease with increasing air temperature in summer. It was noted that a significant increase in air temperature both in winter and summer led to similar consequences - to a decrease in the average weight of piglets at birth, which can be explained by the manifestation of heat stress in sows during farrowing.

Thus, the role of three processes has been established in the formation of the features of the long-term dynamics of the reproductive characteristics of BBP sows: a) a long-term trend; b) cyclic processes; c) random seasonal fluctuations associated with the reaction of animals to heat stress. To the greatest extent, all these processes were manifested in the average weight of piglets both at birth and at weaning.

ACKNOWLEDGMENTS

The work was carried out within the framework of funding under the state budget of the Ministry of Education and Science of Ukraine (state registration number – 0121U109492).

CONFLICT OF INTEREST

None.

REFERENCES

[1] Adachi, Y., & Makita, K. (2017). Time series analysis based on two-part models for excessive zero count data to detect farm-level outbreaks of swine echinococcosis during meat inspections. *Preventive Veterinary Medicine*, 148, 49-57. doi: 10.1016/j.prevetmed.2017.10.001.

[2] Amavizca-Nazar, A., Montalvo-Corral, M., González-Rios, H., & Pinelli-Saavedra, A. (2019). Hot environment on reproductive performance, immunoglobulins, vitamin E, and vitamin A status in sows and their progeny under commercial husbandry. *Journal of Animal Science and Technology*, 61(6), 340-351. doi: 10.5187/jast.2019.61.6.340.

[3] ARRIVE guidelines. (n.d.). Retrieved from https://arriveguidelines.org/.

[4] Arruda, A. G., Vilalta, C., Puig, P., Perez, A., & Alba, A. (2018). Time-series analysis for porcine reproductive and respiratory syndrome in the United States. *PLoS One*, 13(4), e0195282. doi: 10.1371/journal.pone.0195282.

[5] Biermann, A.D.M., Pimentel, E.C.G., Tietze, M., Pinent, T., & König, S. (2014). Implementation of genetic evaluation and mating designs for the endangered local pig breed 'Bunte Bentheimer'. *Journal of Animal Breeding and Genetics*, 131(1), 36-45. doi: 10.1111/jbg.12041.

[6] Bloemhof, S., Mathur, P.K., Knol, E.F., & Van der Waaij, E.H. (2013). Effect of daily environmental temperature on farrowing rate and total born in dam line sows. *Journal of Animal Science*, 91(6), 2667-2679. doi: 10.2527/jas.2012-5902.

[7] Brito, A.A., da Silva, N.A.M., Alvarenga Dias, A.L.N., & Nascimento, M.R.B.D.M. (2022). Heat wave exposure impairs reproductive performance in primiparous sows and gilts in a tropical environment. *International Journal of Biometeorology*, 66, 2417-2424. doi: 10.1007/s00484-022-02365-4.

[8] Carpenter, T.E., & Hird, D.W. (1986). Time series analysis of mycobacteriosis in California slaughter swine. *Preventive Veterinary Medicine*, 3(6), 559-572. doi: 10.1016/0167-5877(86)90034-6.

[9] Chatfield, C. (2003). *The analysis of time series: Aan introduction*. Boca Raton, Florida: Chapman and Hall/CRC Press., 333 p.

[10] Chokoe, T.C., & Siebrits, F.K. (2009). Effects of season and regulated photoperiod on the reproductive performance of sows. *South African Journal of Animal Science*, 39(1), 45-54. doi: 10.4314/sajas.v39i1.43545.

[11] Deluyker, H.A., Shumway, R.H., Wecker, W.E., Azari, A.S., & Weaver, L.D. (1990). Modeling daily milk yield in hHolstein cows using time series analysis. *Journal of Dairy Science*, 73(2), 539-548. doi: 10.3168/jds.S0022-0302(90)78701-2.

[12] Ek, M., Segura, C., & Alzina, L. (2016). Effect of environmental factor on some litter traits of sows in the tropics Mexican. *Revista MVZ Córdoba*, 21(1), 5102-5111. doi: 10.21897/rmvz.21.

[13] Exadaktylos, V., Silva, M., Ferrari, S., Guarino, M., Taylor, C.J., Aerts, J.M., & Berckmans, D. (2008). Time-series analysis for online recognition and localization of sick pig (*Sus scrofa*) cough sounds. *The Journal of the Acoustical Society of America*, 124(6), 3803-3809. doi: 10.1121/1.2998780.

[14] Goodall, E.A., McLoughlin, E.M., Menzies, F.D., & McLlroy, S.G. (1991). Time series analysis of the prevalence of *Ascaris suum* infections in pigs using abattoir condemnation data. *Animal Science*, 53(3), 367-372. doi: 10.1017/S0003356100020389.

[15] Goodall, E.A., Menzies, F.D., & Taylor, S.M. (1993). A bivariate autoregressive model for estimation of prevalence of fasciolosis in cattle. *Animal Science*, 57(2), 221-226. doi: 10.1017/S0003356100006826.

[16] Guo, Z., Lv, L., Liu, D., & Fu, B. (2018). Effects of heat stress on piglet production/performance parameters. *Tropical Animal Health and Production*, 50(6), 1203-1208. doi: 10.1007/s11250-018-1633-4.

[17] Lark, R.M., Nielsen, B.L., & Mottram, T.T. (1999). A time series model of daily milk yields and its possible use for detection of a disease (ketosis). *Animal Science*, 69(3), 573-582. doi: 10.1017/S1357729800051420.

[18] Liu, Z.J., Green, J.R., Moore, C.A., & Herring, S.W. (2004). Time series analysis of jaw muscle contraction and tissue deformation during mastication in miniature pigs. *Journal of Oral Rehabilitation*, 31(1), 7-17. doi: 10.1111/j.1365-2842.2004.01156.x.

[19] Macciotta, N.P.P., Cappio-Borlino, A., & Pulina, G. (2000). Time series autoregressive integrated moving average modeling of test-day milk yields of dairy ewes. *Journal of Dairy Science*, 83(5), 1094-1103. doi: 10.3168/jds.S0022-0302(00)74974-5 .

[20] Weather archive in settlements of Ukraine from 2003Meteopost. Archive of meteorological data. (n.d.). Retrieved from https://meteopost.com/weather/archive/.: http://meteo.ua/ua/archive

[21] Omtvedt, I.T., Nelson, R.E., Edwards, R.L., Stephens, D.F., & Turman, E.J. (1971). Influence of heat stress during early, mid and late pregnancy of gilts. *Journal of Animal Science*, 32(2), 312-317. doi: 10.2527/jas1971.322312x.

[22] Scanlan, C.L., Putz, A.M., Gray, K.A., & Serão, N.V. (2019). Genetic analysis of reproductive performance in sows during porcine reproductive and respiratory syndrome (PRRS) and porcine epidemic diarrhea (PED) outbreaks. *Journal of Animal Science and Biotechnology*, 10(1), 1-12. doi: 10.1186/s40104-019-0330-0.

[23] Southwood, O.I., & Kennedy, B.W. (1991). Genetic and environmental trends for litter size in swine. *Journal of Animal Science*, 69(8), 3177-3182. doi: 10.2527/1991.6983177x.

[24] Suriyasomboon, A., Lundeheim, N., Kunavongkrit, A., & Einarsson, S. (2006). Effect of temperature and humidity on reproductive performance of crossbred sows in Thailand. *Theriogenology*, 65(3), 606-628. doi: 10.1016/j.theriogenology.2005.06.005.

[25] Tantasuparuk, W., Lundeheim, N., Dalin, A.M., Kunavongkrit, A., & Einarsson, S. (2000). Reproductive performance of purebred Landrace and Yorkshire sows in Thailand with special reference to seasonal influence and parity number. *Theriogenology*, 54(3), 481-496. doi: 10.1016/S0093-691X(00)00364-2).

[26] Tast, A., Peltoniemi, O.A.T., Virolainen, J.V., & Love, R.J. (2002). Early disruption of pregnancy as a manifestation of seasonal infertility in pigs. *Animal Reproduction Science*, 74(1-2), 75-86. doi: 10.1016/S0378-4320(02)00167-7.

[27] ten Napel, J., & Johnson, R. (1997). Genetic relationships among production traits and rebreeding performance. *Journal of Animal Science*, 75(1), 51-60. doi: 10.2527/1997.75151x.

[28] Thiengpimol, P., Tappreang, S., & Onarun, P. (2017). Reproductive performance of purebred and crossbred Landrace and Large White sows raised under thai commercial swine herd. *Science & Technology Asia*, 22(2), 16-22. doi: 10.14456/tijsat.2017.13.

[29] Tummaruk, P., Tantasuparuk, W., Techakumphu, M., & Kunavongkrit, A. (2010). Seasonal influences on the litter size at birth of pigs are more pronounced in the gilt than sow litters. *The Journal of Agricultural Science*, 148(4), 421-432. doi: 10.1017/S0021859610000110.

[30] van Straten, M., Shpigel, N. Y., & Friger, M. (2008). Analysis of daily body weight of high-producing dairy cows in the first one hundred twenty days of lactation and associations with ovarian inactivity. *Journal of Dairy Science*, 91(9), 3353-3362. doi: 10.3168/jds.2008-1020).

[31] Wakchaure, R. S., Sachdeva, G. K., & Gandhi, R. S. (2011). Studies on time series analysis of production and reproduction traits in Murrah buffaloes. *Indian Journal of Animal Research*, 45(3), 162-167. Retrieved from https://www.indianjournals.com/ijor.aspx?target=ijor:ijar1&volume=45&issue=3&article=002.

[32] Wakchaure, R.S., Sachdeva, G.K., Gandhi, R.S., Singh, A., & Gupta, J.P. (2010). Utility of time series analysis – a review. *Agricultural Reviews*, 31(3), 229-232.

[33] Wegner, K., Lambertz, C., Daş, G., Reiner, G., & Gauly, M. (2014). Climatic effects on sow fertility and piglet survival under influence of a moderate climate. *Animal*, 8(9), 1526-1533. doi: 10.1017/S1751731114001219.

Аналіз багаторічної динаміки відтворювальних ознак свиноматок великої білої породи

Олександр Сергійович Крамаренко

Кандидат сільськогосподарських наук
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0002-2635-526X

Сергій Іванович Луговий

Доктор сільськогосподарських наук
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0001-6505-8105

Олена Іванівна Юлевич

Кандидат технічних наук
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0003-1594-0700

Сергій Сергійович Крамаренко

Доктор біологічних наук
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0001-5658-1244

Анотація. В галузі свинарства головною метою є підвищення рівня багатоплідності та збереженості поросят для максимізації розмірів гнізда як при народженні, так і при відлученні в розрахунку на одну свиноматку за рік. Метою даного дослідження було визначення особливостей багаторічної динаміки головних ознак відтворення свиноматок великої білої породи за використання аналізу часових рядів, а також ролі кліматичних факторів (насамперед, температури) в прояві цієї динаміки. Для аналізу було використано первинні дані щодо свиноматок великої білої породи, які утримувалися в умовах ТОВ «Таврійські свині» (Скадовський район, Херсонська область, Україна) протягом 2007-2017 рр. Наявність тренду було визначено із використанням коефіцієнта рангової кореляції Спірмена. Крім того, було оцінено коефіцієнти автокореляції для лагів від 1 до 45 міс. для виявлення наявності та тривалості циклів. Встановлено, що протягом періоду дослідження мав місце негативний тренд у відношенні загальної кількості поросят при народженні та, навпаки, позитивний – у відношенні середньої маси одного поросяти при народженні та відлученні. Крім того, виявлено виражену циклічність змін для часових рядів середньої маси одного поросяти при народженні та середньої маси одного поросяти при відлученні. Встановлено, що більш висока температура в зимові місяці призводила до зниження середньої маси одного поросяти при народженні, проте сприяла підвищенню кількості поросят при відлученні. Значні відхилення температури від оптимальної (у будь-який бік) у березні-травні призводили до зниження багатоплідності свиноматок за рахунок підвищення кількості та частки мертвонароджених поросят у гнізді. Нарешті, більш висока літня температура сприяла підвищенню кількості мертвонароджених поросят і мала місце тенденція до зниження середньої маси одного поросяти при народженні при підвищенні температури повітря влітку. Таким чином, при формуванні особливостей багаторічної динаміки відтворювальних ознак свиноматок встановлено роль трьох процесів: а) довготривалого тренду; б) циклічних процесів; в) випадкових сезонних коливань, що пов’язані з реакцією тварин на тепловий стрес

Ключові слова: тренд; циклічність; розмір гнізда; жива маса поросят при народженні та відлученні; тепловий стрес