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Effect of Sows' Post-Farrowing Husbandry Methods on Preweaning Piglets' Mortality Rate: A Case Study in Central Macedonia, Greece

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Abstract

The present paper studies the husbandry practices of sows and how they affect the mortality rate of preweaning piglets. The research took place in pig farms located in the Region of Central Macedonia, Greece and was based on a questionnaire created specifically for the needs of this research. The questionnaire included three sections of questions related to reproductive, zootechnical and nutritional parameters of pig breeding. The results showed that the pig farms in the study area could be classified into four Clusters: a) low-efficiency pig farms characterized by a limited improvement effort, b) low-efficiency pig farms characterized by a potent improvement effort, c) relatively high-efficiency pig farms characterized by an average improvement effort with emphasis on nutrition and d) relatively high efficiency pig farms characterized by an average improvement effort with emphasis on reproduction. The first conclusion that emerged is that the use of technology is essential for the timely detection of sows' reproductive problems. The second conclusion is that the use of proper husbandry methods can reduce stress and increase the fertility rate of sows. In addition, the presence of well-trained personnel for the care and supervision of animals is essential. Also, special attention must be taken for the nutrition of the sows, in order to avoid reproductive problems. In conclusion, it can be said that increasing the productivity of sows can be achieved by protecting the welfare of sows and piglets using appropriate husbandry practices.

Keywords: sow; husbandry methods; piglet; preweaning mortality.

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1. Introduction

In modern pig farming the litter size is one of the most important factors that determine the success of pig farming. Thus, today there is a constant effort to increase the piglets' litter size, mainly through the proper management of animals [1]. The survival rate of piglets until weaning seems to be mainly influenced by factors associated with the proper management of the sow [2]. These management factors concern the animal husbandry, breeding and nutrition of sows. Proper management of the sow, which affects her pre- and post-partum behavior, is crucial to ensure normal reproductive activity, as abnormalities in the expression of these behaviors adversely affect productivity [3]. The most important factors that determine the reproductive performance of sows are the increased interval between weaning and the next parturition, and the number of liveborn piglets, and therefore should be studied extensively to improve the management of pig farming [4]. In addition, the main goal of modern techniques used in the reproductive management of sows is to increase their reproductive efficiency [5]. Maternal characteristics and behavior of the sow, such as responding promptly to the piglets' needs, producing maternal sounds, facilitating the piglets' access to the nipples, and avoiding squeezing, are influenced by the sow 's management [6]. Improper handling of the sow results in stress, which has adverse effects on their health and productivity [7]. A characteristic negative effect is the insufficient production of colostrum which leads to a reduction in the number of surviving piglets [8]. Furthermore, the breeding conditions should be suitable so as not to cause heat-stress to the sows, reducing thus their productivity [9]. Proper zootechnical management also results in the reduction of losses in piglets due to starvation, asphyxia and crushing [10]. Additionally, nutrition is one of the most important factors that help sows and piglets to maximize their genetic potential while helping to achieve satisfactory productivity [11]. Also, the ration of sows is as one of the dominant factors that affects the proper growth of piglets during pregnancy and weight of piglets at birth, as well as the adequate production of colostrum and milk [8]. Proper nutrition of sows during pregnancy appears to increase colostrum production and to reduce piglet mortality until weaning [12]. The timely intake of a sufficient amount of colostrum from newborn piglets results in a significant reduction in their mortality, especially in large litters [13]. In addition, increased feed consumption beyond the maintenance needs has no effect on the live weight of piglets from birth to weaning and the weight of the litter and causes great weight loss of sows during lactation [14]. Furthermore, the applied feeding system must be suitable for each productive phase of the sow's life, promoting animals' welfare [15]. Finally, there is the possibility of using an electronic system that monitors whether the animal is fed normally or insufficiently [16] which is very important because in this way we can constantly monitor the feeding condition of the animals and we can intervene immediately before a problem arises. So, the aim of the present study was to study the effect of sows' post-farrowing husbandry methods on preweaning piglets' mortality rate.

2. Materials and Methods

2.1. Type of Research

The data collection was conducted using a questionnaire created specifically for the needs of the current research. This questionnaire consisted of three sections of questions which covered reproductive, zootechnical and nutritional parameters of pig farming and was completed with a personal interview of the participating pig

farmers.

2.2. Sampling

The research was carried out on pig farms in the Region of Central Macedonia, Greece. The pig-farm size ranged from a few (<10) to 1,100 sows. The research did not include extremely small holdings having less than ten (10) sows because these are not essentially commercial-type farms. The research used the Method of Random Stratified Sampling. The sampling was based on data received from the Ministry of Rural Development and Food of Greece. According to these data, in the Region of Central Macedonia there are 290 pig farms having more than ten (10) sows. The sample-size was 36 questionnaires, covered the 12.4% of the total pig-farms and was sufficient according to the literature [17-18]. The calculation of the minimum sample-size was done according to the recommendations of relevant studies [17-18] and using the type:

$$n = \frac{p\,(100-p)\,z^2}{E^2}$$

where:

n: is the minimum sample size; p: is the "hypothetical" proportion in the population; z: is the critical value of the normal distribution; E: is the maximum tolerable error level.

2.3. Questionnaire structure

The data were collected using a questionnaire with a personal interview of the pig farmers. The research was based on a questionnaire consisting of 3 sections, 5 subsections and a total of 18 questions and 56 sub-questions. The first subsection was entitled "Farm capacity" and contained questions about the number of boars and sows, the breeding method used, the educational level of workers involved in breeding processes and who supervised the breeding program. Subsequently, the second subsection was entitled "Reproduction", which contained indicative questions related to the total number of births per sow per year, the number of piglets at birth and the number of weaned piglets and the reasons for removing sows from breeding. The third subsection, entitled "Hygiene", contained questions concerning the breeding biosecurity, the frequency of veterinary care and the use of medicines during parturition. This was followed by the fourth subsection entitled "Facilities and Infrastructures", which included questions about the type of pig-farming, the area of the sows' cell with and without piglets, the material of the cages, the type of machinery used and how loud was the noise caused by them. The last subsection was entitled "Nutrition and Feeds" and had questions about the amount of feed consumed according to the production phase of the sow, the control of the feeding level of the sows, the type of feeds used and the frequency of feeding according to sows' productive phase.

2.4. Data analysis

The statistical analysis performed using the statistical package NCSS (Number Cruncher Statistical Systems).

Four statistical methods of analysis were used. The first method was the Descriptive Statistics, which helps us to present simply, concisely and effectively the data (Table 1). The second method was the Factor Analysis (Table 2), which helps us to group the initial data into a smaller number of independent variables that did not pre-exist. This processing can reveal more useful structures of the original data which may not have been obvious at first. The method of Principal Component Analysis (PCA) with rotation (Varimax) was applied to create the new Factors from the initial data. In order to determine the Factors, the eigenvalue size was used and those that had an eigenvalue greater than 1.00 were selected. Additionally, Factor loadings expressed the correlations between Variables and Factors, while rotation was done in order to correlate Variables with Factors. The third method was Hierarchical Cluster Analysis, which enables us to proceed with sequential consolidations of observations in order to achieve their grouping. In this method we begin from the individual observations, that is, initially there are as many groups as there are observations. The most similar observations are grouped first and then the new groups are grouped according to the similarity between them. These subgroups are joined sequentially resulting in a single group at the end. The selection of the final number of clusters is made from the produced Dendrogram (Figure 1). Finally, the study of possible significant differences between the produced Clusters was done using One-way ANOVA with $P<0.05$ (Table 3).

3. Results

3.1. Descriptive Statistics

The Table 1 describes the variables used in the research. These variables selected from the initial data using the method of Principal Component Analysis.

Table 1: Descriptive Statistics of variables used for Cluster Analysis

Variable	Mean	SD*	Min	Max
Number of live born piglets per sow per year	28.28	1.77	24.00	32.00
Number of weaned piglets per sow per year	25.11	1.8	21.00	28.00
Keeping details related to reproduction **	2.03	0.99	1.00	4.00
Number of parturitions per sow per year	2.25	0.13	1.91	2.49
Number of piglets at parturition	13.87	0.83	12.00	15.00
Number of live piglets at parturition	12.59	0.77	11.43	14.29
Litter size at weaning	11.17	0.63	10.02	13.33
Average weight of piglets at birth (kg)	1.09	0.15	0.80	1.45
Percentage of replacement of sows (%)	14.78	6.81	8.00	34.00
Maximum feed per piglet in lactation (kg)	0.44	0.19	0.25	1.10
Type of reproduction ***	2.36	0.9	1.00	3.00

*SD: Standard Deviation

** Scale: 1 to 5 (where: 1 = Always; 2 = Very frequently; 3 = Frequently; 4 = Rarely; 5 = Never)

*** Scale: 1 to 3 (where: 1 = Natural Mating; 2 = Artificial Insemination; 3 = Both)

3.2. Factor Analysis

The Table 2 shows the correlations between Variables and Factors (after rotation). The choice of the three Factors was made for eigenvalues greater than 1.00.

Table 2: Correlations between variables and factors (after rotation)

Variable	Factor 1*	Factor 2*	Factor 3*
Number of live born piglets per sow per year	**0.702467**	-0.458957	0.134724
Number of weaned piglets per sow per year	**0.833504**	-0.405157	-0.034085
Keeping details related to reproduction **	**-0.628208**	0.163234	-0.368376
Number of parturitions per sow per year	**0.915635**	0.347484	0.130069
Number of piglets at parturition	0.064491	**-0.620331**	0.114700
Number of live piglets at parturition	-0.108523	**-0.893786**	0.023025
Litter size at weaning	0.177192	**-0.844501**	-0.167264
Average weight of piglets at birth (kg)	0.071766	-0.20068	**-0.696098**
Percentage of replacement of sows (%)	0.174198	-0.068933	**0.750917**
Maximum feed per piglet in lactation (kg)	-0.050305	0.268483	**-0.790567**
Type of reproduction ***	0.339084	0.114433	**0.627965**

* Eigenvalues of Factors after Rotation (Varimax Rotation): Eigenvalue of Factor 1: 2.622; Eigenvalue of Factor 2: 2.651; Eigenvalue of Factor 3: 1.348. Bartlett Test=484.41 and P=0.000000

** Scale: 1 to 5 (where: 1 = Always; 2 = Very frequently; 3 = Frequently; 4 = Rarely; 5 = Never)

*** Scale: 1 to 3 (where: 1 = Natural Mating; 2 = Artificial Insemination; 3 = Both)

3.2.1. Description of the Factors

The Factor 1 (Table 2) is related to the annual reproductive capacity of sows which is a key factor in the viability of the pig farm and has a high eigenvalue (2.622). The Factor 1 includes three quantitative variables relating to the Total number of live born piglets per sow per year, the Total number of weaned piglets per sow per year, and the Average number of parturitions per sow per year and a qualitative variable related to Breeding. The Factor 2 (Table 2) is related to the litter size, which largely determines the productivity of the pig farm and has a high eigenvalue (2.651). Additionally, the Factor 2 includes three quantitative variables related to the Total number of piglets at parturition, the Total number of live piglets at parturition and the Litter size at weaning. The Factor 3 (Table 2) is related to the management of the pig farm, which affects all factors related to productivity and has a high eigenvalue (1.348). Furthermore, the Factor 3 includes three quantitative variables concerning the Rate of replacement of sows by young animals, the Maximum amount of feed per piglet at lactation and the Average weight of piglets at birth, and a qualitative variable which is the Breeding type.

3.3. Hierarchical Cluster Analysis

The Hierarchical Cluster Analysis was performed with the Factors that emerged from the Factor Analysis. From

the Dendrogram (Figure 1) we can conclude that there are four (4) Clusters: C1, C2, C3 and C4.

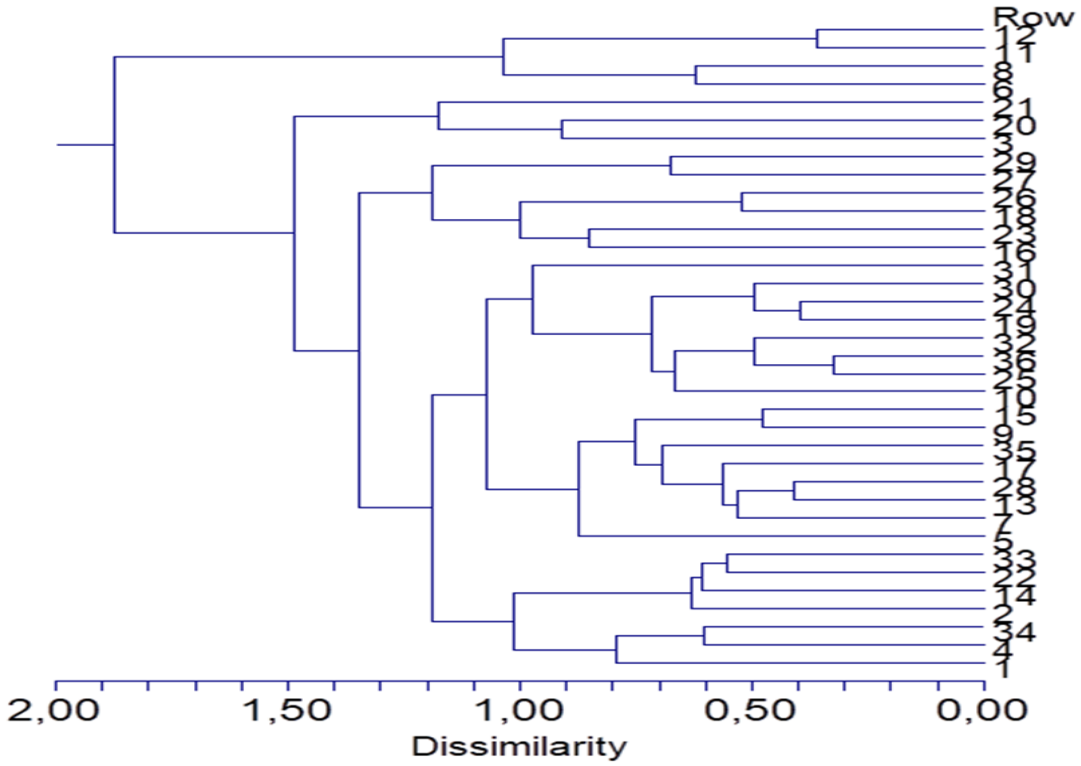

Figure 1: Dendrogram

3.4. Comparisons between the four Clusters

The Table 3 shows the comparisons between the four Clusters resulting from the Dendrogram (Figure 1).

Table 3: Comparison between the four Clusters

	C1* (n=4)	C2* (n=3)	C3* (n=22)	C4* (n=7)	P
Number of live born piglets per sow per year	25.75^{a}	26.00^{a}	28.68^{b}	29.43^{b}	<0.0001
Number of weaned piglets per sow per year	22.25^{a}	23.00^{a}	25.50^{b}	26.43^{b}	<0.0001
Keeping details related to reproduction **	3.75^{a}	1.67^{bc}	2.04^{b}	1.14^{c}	<0.0001
Number of parturitions per sow per year	2.06^{a}	2.17^{ab}	2.24^{b}	2.41^{c}	<0.0001
Number of piglets at parturition	13.32^{a}	13.01^{a}	14.27^{b}	13.29^{a}	<0.0001
Number of live piglets at parturition	12.53^{ab}	11.99^{a}	12.80^{b}	12.19^{ab}	<0.0001
Litter size at weaning	10.79^{a}	10.62^{a}	11.38^{b}	10.95^{ab}	<0.0001
Average weight of piglets at birth (kg)	1.06	1.05	1.10	1.09	<0.0001
Percentage of replacement of sows (%)	9.51^{a}	21.33^{b}	14.45^{ab}	16.03^{ab}	<0.0001
Maximum feed per piglet in lactation (kg)	0.46^{a}	0.47^{a}	0.44^{ab}	0.38^{b}	<0.0001

* Means with different exponents on the same line have statistically significant difference.

** Scale: 1 to 5 (where: 1 = Always; 2 = Very frequently; 3 = Frequently; 4 = Rarely; 5 = Never)

3.4.1. Description of Clusters

Cluster 1 consists of low productivity pig farms with little effort for improvement. Cluster 1 (Table 3) contains 11.1% of the sample and concerns pig farms which are characterized by a low Total number of liveborn piglets per sow per year, low Total number of weaned piglets per sow per year, and low Total number of piglets at parturition. These parameters indicate that these are low-productivity pig farms which, however, make small efforts for improvement as shown by the increased adherence to detailed breeding data. In addition, Cluster 2 consists of low-productivity pig farms with a strong effort for improvement. Cluster 2 (Table 3) contains 8.33% of the sample and includes pig farms which have a low Total number of liveborn piglets per sow per year, low Total number of weaned piglets per sow per year, low number of parturitions per sow per year, and high percentage of replacement of sows by young animals. These parameters indicate that Cluster 2 includes low-productivity pig farms that make significant improvement efforts. Furthermore, Cluster 3 consists of relatively high productivity pig farms with a medium improvement effort giving emphasis on nutrition. The Cluster 3 (Table 3) contains 61.1% of the sample and consists of pig farms which are characterized by a high Total number of liveborn piglets per sow per year, high Total number of weaned piglets per sow per year, high Number of piglets at parturition, and high Number of weaned piglets per sow per year. Additionally, there is a medium size feed intake per piglet in lactation, and a medium size percentage of replacement of sows by young animals. These parameters show that these pig farms have relatively high productivity and medium intensity effort to improve, mainly through nutrition. In addition, Cluster 4 consists of relatively high productivity pig farms with a medium effort for improvement giving emphasis on reproduction. Cluster 4 (Table 3) contains 19.4% of the sample and consists of pig farms having a high Total number of liveborn piglets per sow per year, high Total number of weaned piglets per sow per year, high Number of parturitions per sow per year, and low feed consumption per piglet in lactation. The above shows that these are pig farms with relatively high productivity and medium intensity effort to improve mainly through breeding management.

4. Discussion

The comparison of the means (Table 3) shows that Cluster 1 and Cluster 2 differ in terms of keeping records for breeding and replacement rate of sows. So, it turns out that the pig farms of Cluster 2 try to increase their productivity by keeping records regarding reproduction issues, so they immediately identify their breeding deficiencies and correct them, which is consistent with the findings of previous research [4] which showed that the possibility of using technology promotes the collection and combination of data to improve the productivity of pig farms. Thus, the most intense replacement of sows in Cluster 2 using records can help to increase pig farm efficiency, which is in line with a previous research [4] reported that intense discomfort in the sow who is unable to feed the piglets, resulting in reduced piglets' growth rate and increased mortality. In addition, according to a previous research [19], the limited availability of functional nipples has resulted in the decreasing survival of newborn piglets as the time needed to suckling each piglet increases. The Cluster 1 and Cluster 3

(Table 3) differ in their productivity with the farms in Cluster 3 being more efficient, as they are superior to Cluster 2 regarding the number of liveborn and weaned piglets per year, having a higher number of parturitions per year and a larger litter size at weaning and finally a larger number of piglets at parturition. The above-mentioned differences are probably due to the better management of the sow in terms of performing Artificial Insemination, ie to be done at the appropriate time when the sow is in estrus and to remain calm during the Artificial Insemination [20]. These results were in line with the results of a previous research [21] according to which the highest conception rates were observed when the sows were calm during Artificial Insemination, while the exact opposite results were observed when sows were anxious, and that more Artificial Inseminations during estrus leads to increased litter size. This may also be due to the immediacy of the colostrum intake from piglets, and is consistent with a previous research [8] which found that immediate colostrum intake from piglets is necessary because it is used for thermoregulation and growth and for uptake of antibodies by the sow. Also, according to the results of previous studies [22-24], great care should be taken in the management of animals, as there can be significant consequences such as injuries and inflammations that affect animals' productivity and welfare. The Cluster 1 and Cluster 4 (Table 3) differ, with the most efficient farms belonging to Cluster 4 and differing in the number of liveborn and weaned piglets per year, the average number of parturitions per year, in keeping records for breeding issues and the maximum amount of feed for the sow per piglet during lactation. Therefore, the high production in piglets is directly dependent on the parturitions per sow per year, as the more births take place the more piglets can be produced. This is in line with the findings of an earlier study [25] which found that the number of sows' previous births, ie their experience, was associated with reduced piglet mortality before weaning. Subsequently, the high number of births is the result of a combination of many reproductive management practices such as keeping regular breeding records, something which is consistent with the findings of a previous research [4] which found that data collection on zootechnical and breeding management methods of sows leads to a gradual increase in livestock productivity and farms' profitability. Also, the differences between Cluster 1 and Cluster 4 seem to be due to the appropriate nutritional program followed, in order to meet the nutritional needs of animals without wasting feed, providing gradually the appropriate amount of feed. A similar conclusion was reached by a recent study [14], which showed that increased feed intake during pregnancy had no effect on live weight of piglets and in addition resulted in greater weight loss of sows during lactation. The comparison between means (Table 3) shows that Cluster 2 and Cluster 3 differ in that Cluster 3 farms outperform yields, as they differ in the number of liveborn and weaned piglets per year, the total number of piglets at parturition, and the litter size at weaning. First, birth losses may be the result of dystocia, which increases birth time and piglet mortality, a result which is in line with recent studies [26-27], which showed that piglet losses may be reduced if during the critical periods of breeding (pregnancy, parturition, lactation) there is a thorough control of sows and constant adherence to good management practices. In addition, losses in pig farms of Cluster 2 during weaning appear to be due to insufficient colostrum intake [28]. According to previous research [29], adequate colostrum intake has a positive effect on piglet survival, increasing livestock productivity and that one of the factors causing piglets' death is diarrhea [12]. These losses seem to be due to the insufficient care of the sow to the piglets resulting in their crushing, while the phenomenon of starvation is frequent due to the lack of regular suckling of the piglets [30-31]. This result is consistent with the findings of previous research [6] which showed that the main causes of death of young piglets were starvation (34%) and crushing by sows (28%) and that the use of large amounts of straw reduced

the number of dead piglets [32-33]. Furthermore, the previous results are in line with the results of an earlier study [8], according to which the breeding system that will be applied in the parturition area affects the crushing rate of piglets and that is why in recent years alternative systems have been applied to which the initial restraint of the sow is followed by a phase with increased ability to move within the cell. The Table 3 shows that Cluster 2 and Cluster 4 do not differ in terms of keeping a detailed breeding record, while Cluster 1 and Cluster 4 differ in this area. The previous result shows that the pig farms of Cluster 2 having low-productivity keep breeding records with the same frequency as the farms of Cluster 4, so it turns out that the high-producing farms or the farms that try to increase their productivity are keeping breeding records. Keeping breeding records could help in better management of the pig farm and in planning the production activities, which is line with the results of previous research [4] which showed that keeping records results in achievement of production stability. There is also a difference in the maximum amount of feed given per piglet, which is probably due to the weaning system that is applied which lasts the minimum possible days (early weaning). In addition, the frequency of parturition is higher in Cluster 4, which may be due to the more adequate housing of sows during pregnancy, which reduces the chance of miscarriage and increases fertility [34]. According to the findings of recent studies [35-36], it seems that it is preferable for pregnant sows to be housed in groups and not individually, because this practice has a positive effect on the reproductive function and welfare of animals. The Cluster 3 and Cluster 4 having differences (Table 3) which lead to the conclusion that pig farms of Cluster 4 are more productive than farms of Cluster 3, as while the former produce more piglets during parturition, they have many losses during weaning, while the farms of Cluster 4 do not show significant losses from parturition to weaning. The losses during parturition may be due to the lack of trained staff who would supervise the parturition and provide help to newborn piglets such as cutting the umbilical cord, releasing it from the embryonic membranes, drying it from fluids and putting the piglet to the right position near the sow. According to the findings of relevant studies [37-38], the way sows and piglets are treated during the parturition period can affect the way they interact with each other, reducing losses. Cluster 3 farms also appear to have sows with increased rates of dystocia, which is consistent with the findings of a recent study [39] which showed that increasing the duration of parturition as well as the abnormal sows' body condition may increase losses in piglets. Furthermore, losses up to the weaning stage are probably due to incorrect temperatures, which is consistent with the findings of a recent study [8] according to which ambient temperature is one of the factors influencing piglet mortality. Subsequently, the losses may be due to the large size of the pens for sows and piglets, since according to an earlier study [40] it seems that in pig farming the appropriate size of the pens can reduce the mortality of piglets due to that the sows' movements are restricted, something which reduces the chance of crushing the piglets. Finally, the loss of piglets is likely to result from poor hygiene conditions in the farm, since according to the results of recent studies [8, 23, 41] it seems that the breeding conditions of sows largely determine the level of welfare, especially near the parturition as there is the possibility of negative effects on the growth and mortality of piglets.

5. Conclusions

Based on the results of the present study, significant conclusions were drawn concerning the husbandry methods of the sow that could increase the productivity of pig farms by reducing piglets' mortality rate. So, the conclusions that emerge are that the use of technology can help in the early detection of reproductive problems

of the sow, which will help in the immediate treatment of the problems resulting in better productive performance of animals. Another useful conclusion is that minimizing stress and keeping the sow calm during breeding periods through proper handling methods can lead to greater fertility of sows and reduced non-productive days increasing thus farms' productivity. In terms of nutrition, sows should be fed with the proper amounts of feed that will ensure the cover of their nutritional needs, because undernutrition can reduce the piglets' survival rate. Equally important is the way the sows are housed, as it disrupts the animals' welfare and affects the animals' behavior, and in particular the sows' behavior, leading to increases or decreases in the litters' size. In conclusion, it turns out that the proper handling of sows' post-farrowing husbandry methods by pig farmers leads to reduced preweaning piglets' mortality rate.

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