Open Journal of Veterinary Medicine, 2026, 16(5), 57-65
https://www.scirp.org/journal/ojvm
ISSN Online: 2165-3364
ISSN Print: 2165-3356

# Impact of Prefarrow Macro Mineral and Vitamin Supplementation on Sow Livability

**Mark Knauer[1], Jerry Purvis[2], Sara Hough[3], Jon Bergstrom[3], Kristina Hairr[4], Mary Battrell[4]**

[1]Department of Animal Sciences, North Carolina State University, Raleigh, NC, USA
[2]Purvis Farms, Robbins, NC, USA
[3]dsm-firmenich, Plainsboro, NJ, USA
[4]Murphy Family Ventures, Wallace, NC, USA
Email: mtknauer@ncsu.edu

**How to cite this paper:** Knauer, M., Purvis, J., Hough, S., Bergstrom, J., Hairr, K. and Battrell, M. (2026) Impact of Prefarrow Macro Mineral and Vitamin Supplementation on Sow Livability. *Open Journal of Veterinary Medicine*, **16**, 57-65.
https://doi.org/10.4236/ojvm.2026.165005

**Received:** May 1, 2026
**Accepted:** May 27, 2026
**Published:** May 30, 2026



## Abstract

The objective was to investigate the impact of prefarrow macro mineral and vitamin supplementation on sow livability. In Study A, sows (n = 321) were randomly allocated in a 2 × 2 factorial design. Treatments consisted of two top dressed supplements administered from day 110 of gestation until farrowing: 1) 50 g of dicalcium phosphate (18.5% phosphorus) and 2) extra vitamins. In Study B, sows (n = 415) were either top dressed from day 109 of gestation until farrowing with both 50 g of dicalcium phosphate (18.5% phosphorus) and extra vitamins, or received no extra supplementation. Control diets met or exceeded NRC (2012) recommendations. Sows were classified as having lived from day 109 or 110 of gestation until weaning or not. Chi-square tests were used to determine whether the two categorical variables were related. In Study A, sow mortality was lower ($P < 0.05$) for sows top dressed with both dicalcium phosphate and extra vitamins compared to Control sows or those top dressed with dicalcium phosphate alone (1.3% vs. 9.0% and 9.1%, respectively). Mortality for sows receiving only extra vitamins (5.6%) did not differ ($P > 0.05$) from the other treatments. In Study B, sows receiving the combination of dicalcium phosphate and extra vitamins tended ($P = 0.07$) to have lower mortality than Control sows (3.9% vs. 8.1%). When combining data from Studies A and B, sows top dressed with both dicalcium phosphate and extra vitamins had lower ($P < 0.01$) mortality than the Control sows (3.2% vs. 8.4%). Across both studies, sows receiving the combination of extra macro minerals and vitamins had fewer ($P < 0.05$) prolapses (1.1% vs. 3.8%), which was primarily driven by a reduction ($P < 0.01$) in rectal prolapses (0% vs. 2.4%). First parity sows supplemented with the combination had lower ($P < 0.01$) mortality than the Control group (0% vs. 10.4%). In summary, the combination of extra macro mineral and vitamin supplementation enhanced sow livability.

**Keywords**

Mineral, Mortality, Sow, Vitamin

## 1. Introduction

Sow mortality levels have continued to impact US pig farmers for multiple decades [1] [2]. Poor sow livability is problematic for farmers as it is both an economic and a well-being concern. Hence, management strategies are needed to mitigate current sow mortality levels.

Investigation of nutritional techniques to enhance sow livability are warranted. Improvements to maternal line genetics and sow management practices have rapidly increased litter sizes [1] [2]. However, sow nutrition recommendations, for a multitude of nutrients, have not changed this century [3] [4]. Therefore, the objective of the current study was to investigate the impact of prefarrow macro mineral and vitamin supplementation on sow health and well-being.

## 2. Materials and Methods

### 2.1. Study A

Sows (n = 321), within a 3600 sow commercial farm in eastern North Carolina were used. Females consisted of PIC maternal genetics. In lactation, sows were housed in individual farrowing stalls with ad libitum access to water. Farrowing rooms were mechanically ventilated. Prefarrow, sows were hand fed 2.27 kg of a lactation diet containing 0.85% total calcium and 0.57% total phosphorus. After farrowing, sows were fed ad libitum. The lactation diet met or exceeded the National Research Council's recommendations [4]. In late gestation, sows were randomly assigned within parity to one of four treatments in a 2 × 2 factorial design. Treatments consisted of two top dressed supplements administered from day 110 of gestation until farrowing: 1) 50 g of dicalcium phosphate (FEEDPHOS®, Southeastern Minerals, Inc., Bainbridge, USA; minimum 18.5% phosphorus and minimum 20% calcium) and 2) extra vitamins (dsm-firmenich, Plainsboro, USA; **Table 1**). Top dress supplements were added to the sow's daily feed allotment while in her farrowing stall. Sow body condition was measured at day 110 of gestation using the Knauer sow caliper [5]. Sows that had not farrowed by day 114 of gestation were induced with 1 ml of prostaglandin $F_{2\alpha}$ (Lutalyse®, Zoetis Inc., Kalamazoo, USA). Farm staff assisted sows during farrowing at their discretion. Piglets were weaned at approximately 22 days of age.

**Table 1.** Total daily vitamin levels fed prefarrow for Study A and Study B.

| Vitamin† | Study A | | Study B | |
|---|---|---|---|---|
| | Control | Extra Vitamins | Control | Extra Vitamins |
| Biotin, mg | 0.6 | 2.4 | 1.3 | 3.1 |

**Continued**

| | | | | |
|---|---|---|---|---|
| Folic acid, mg | 3.7 | 16.0 | 9.2 | 21.5 |
| Menadione, mg | 10.0 | 23.0 | 9.7 | 22.6 |
| Niacin, mg | 75 | 198 | 92 | 215 |
| Pantothenic acid, mg | 62 | 165 | 76 | 179 |
| Pyridoxine, mg | 7.5 | 24 | 12.3 | 29 |
| Riboflavin, mg | 17.5 | 45 | 20.5 | 48 |
| Thiamine, mg | 5 | 13 | 6 | 14 |
| Vitamin A, IU | 19,994 | 54,081 | 25,509 | 59,597 |
| Vitamin B12, mg | 0.08 | 0.19 | 0.08 | 0.19 |
| Vitamin D3, IU | 4498 | 9271 | 3573 | 8345 |
| HyD®, mg | 0.085 | 0.085 | - | - |
| Total vitamin D3, IU | 7897 | 12,670 | 3573 | 8345 |
| Vitamin E, IU | 150 | 491 | 256 | 597 |

†Total vitamin levels fed from day 110 of gestation until farrowing in Study A and from day 109 of gestation until farrowing in Study B, HyD® (dsm-firmenich, Plainsboro, NJ USA), Total vitamin D3 = provided 3400 IU of 25-OH-$D_3$ from HyD® in Study A.

Farm staff classified sow mortality causes. Mortality codes included difficulty farrowing, failing to farrow, lame, prolapse, and other.

## 2.2. Study B

Sows (n = 415) within a 3600 sow commercial farm (within a different production system than Study A) in eastern North Carolina were used. Females consisted of PIC maternal genetics. In lactation, sows were housed in individual farrowing stalls with ad libitum access to water. Farrowing rooms were naturally ventilated. Prefarrow, sows were fed 1.82 kg of a lactation diet containing 0.90% total calcium and 0.58% total phosphorus. After farrowing, sows were fed ad libitum. The lactation diet met or exceeded the National Research Council's recommendations [4]. In late gestation, sows were randomly assigned to one of two treatments. Sows were either top dressed from day 109 of gestation until farrowing with 50 g of dicalcium phosphate and extra vitamins (**Table 1**) or received no extra supplementation. The top dress supplement was formulated the same as those used in Study A and added to the sow's daily feed allotment while in her farrowing stall. Sow body condition was monitored using the Knauer sow caliper [5]. Sows were not induced to farrow. Farm staff assisted sows during farrowing at their discretion. Piglets were weaned at approximately 21 days of age.

Farm staff classified sow mortality causes. Mortality codes included difficulty farrowing, lame, prolapse, sudden death, and unknown.

### 2.3. Statistical Analysis

All data analyzed were categorical in nature. Sows were classified as having lived from day 109 or 110 of gestation until weaning or not. Further, sows were categorized as having died within seven days of farrowing (early lactation) or having died in middle or late lactation (day eight of lactation until weaning). Chi-square tests were exclusively used to determine if two categorical variables were related.

## 3. Results

Sow mortality across the lactation period was 6.2% and 6.0% for Study A and Study B, respectively. Average number of piglets born alive, stillborn piglets, and mummies per litter were 14.9, 0.9, and 0.5 for Study A, and 15.3, 1.5, and 0.5 for Study B. Average sow parity was 3.1 and 3.2 for Study A and Study B, respectively. Within both studies, treatments did not differ ($P \geq 0.33$) for average sow parity or sow caliper score.

Sow livability differed ($P < 0.05$) in Study A and tended ($P = 0.07$) to differ in Study B. In Study A, sow mortality was lower ($P < 0.05$) for sows top dressed with both dicalcium phosphate and extra vitamins compared to Control sows or those top dressed with dicalcium phosphate alone (Figure 1). Mortality for sows receiving only extra vitamins did not differ ($P > 0.05$) from the other treatments. In Study B, sows receiving the combination of dicalcium phosphate and extra vitamins tended ($P = 0.07$) to have lower mortality than Control sows (3.9% vs. 8.1%).

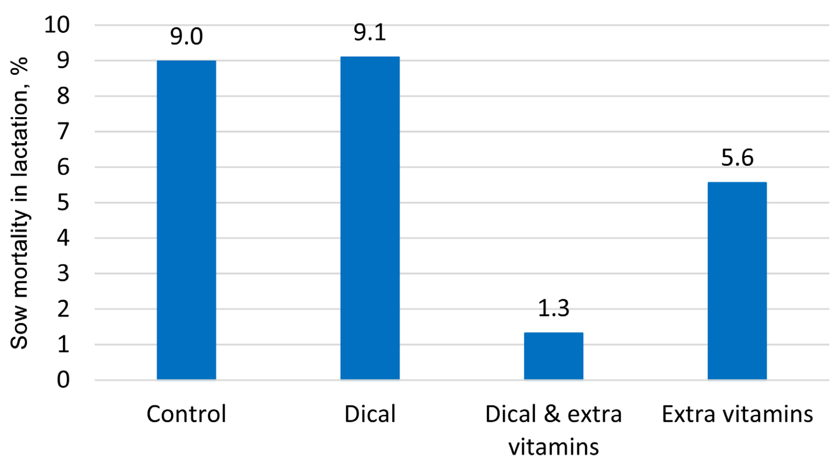


**Figure 1.** Study A, sow mortality was lower ($P < 0.05$) for sows top dressed (from day 110 of gestation until farrowing) with both 50 g of dicalcium phosphate and extra vitamins compared to Control sows or those top dressed with dicalcium phosphate alone. Mortality for sows receiving only extra vitamins did not differ ($P > 0.05$) from the other treatments.

When combining data from Studies A and B, sows top dressed with both dicalcium phosphate and extra vitamins had lower mortality than the Control sows ($P < 0.01$; Figure 2). Farm recorded mortality codes are presented in Table 2. Across both studies, sows receiving the combination of extra macro minerals and vitamins had fewer prolapses ($P < 0.05$), which was primarily driven by a reduction in rectal prolapses ($P < 0.01$; Figure 3). First parity sows supplemented with the combination had significantly lower mortality than the Control group (0% vs. 10.4%, $P < 0.01$).

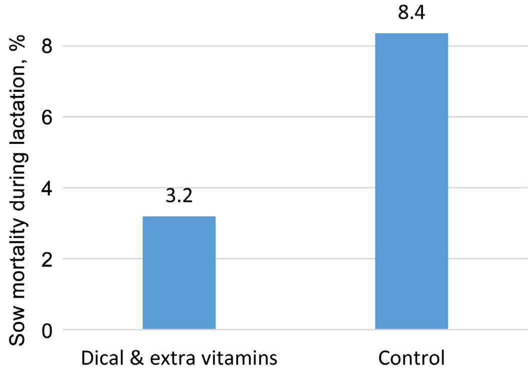


Figure 2. Combining data from Studies A and B, sows top dressed (from day 109 or 110 of gestation) with both 50 g of dicalcium phosphate and extra vitamins had lower ($P < 0.01$) mortality than the Control sows.

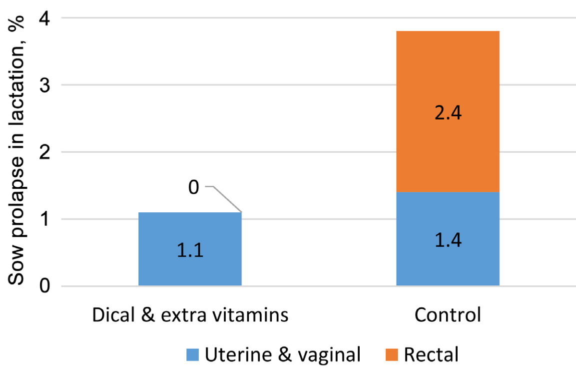


Figure 3. Across Study A and Study B, sows receiving the combination of extra dicalcium phosphate and vitamins had fewer ($P < 0.05$) prolapses, which was primarily driven by a reduction ($P < 0.01$) in rectal prolapses.

Table 2. Farm recorded lactation mortality codes for Study A and Study B.

| Study[†] | n | Difficulty farrowing | Failing to farrow | Lame | Uterine/vaginal prolapse | Rectal prolapse | Other | Sudden death |
|---|---|---|---|---|---|---|---|---|
| Study A | | | | | | | | |
| Control | 78 | 2 | | 2 | | 1 | 2 | - |
| Dical | 77 | | 1 | | 3 | | 3 | - |
| Extra vitamins | 90 | 3 | 1 | | | | 1 | - |
| Dical & extra vitamins | 76 | 1 | | | | | | - |
| Study B | | | | | | | | |
| Control | 209 | 3 | - | 1 | 4 | 6 | - | 3 |
| Dical & extra vitamins | 206 | 1 | - | 1 | 3 | | - | 3 |

[†]Top dressed supplements administered daily from day 109 or 110 of gestation until farrowing, Dical = 50 g of dicalcium phosphate (18.5% phosphorus).

Again analyzing the combined data from Studies A and B, Figure 4 illustrates the timing of sow mortality during lactation. No differences (P = 0.79) were observed in early lactation between sows receiving the combination of extra macro minerals and vitamins with the control group (3.2% vs. 4.6%, respectively). However, in middle and late lactation, sows top dressed with the combination exhibited lower (P < 0.01) sow mortality rates (0% vs. 3.9%).

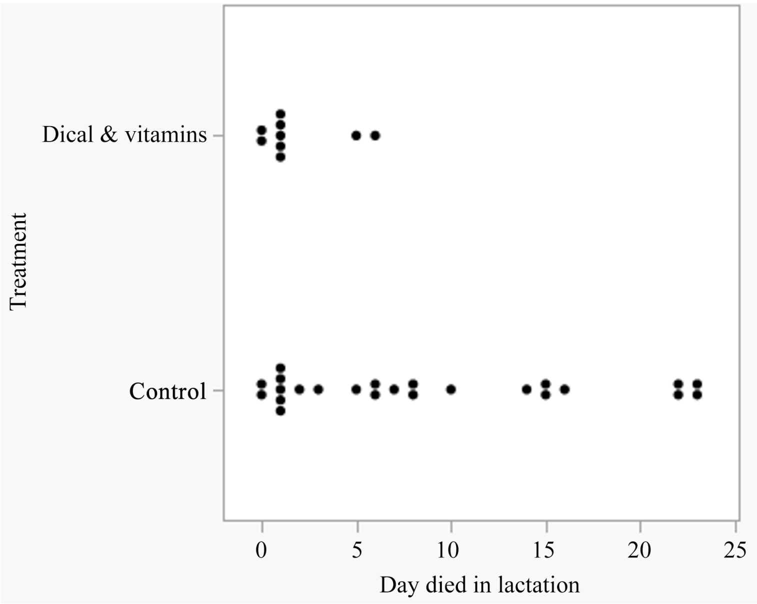


Figure 4. Timing of sow mortality during lactation for Control sows and sows top dressed (from day 109 or 110 of gestation) with both 50 g of dicalcium phosphate and extra vitamins. No differences (P = 0.79) were observed in early lactation between sows receiving the combination of extra macro minerals and vitamins with the control group (3.2% vs. 4.6%, respectively). However, in middle and late lactation, sows top dressed with the combination exhibited lower (P < 0.01) sow mortality rates (0% vs. 3.9%).

## 4. Discussion

Oxidative stress (an imbalance between free radicals and antioxidants in the body) leads to cell and tissue damage, which can impair sow health and reproductive performance. Primiparous females are reported to experience higher levels of oxidative stress than multiparous sows [6]. Further, previous research [7] indicated that antioxidant nutrient levels (specifically vitamins A and E) reach their lowest points during late gestation and early lactation. In the current study, prefarrow macro mineral and vitamin supplementation was particularly beneficial for the livability of primiparous sows. Taken together, these findings suggest that providing extra antioxidant supplementation beyond NRC (2012) requirements may improve the health and livability of first parity females reared under commercial conditions.

Several studies suggest supplementation of antioxidants, around the time of farrowing, may enhance sow livability. In late gestation, [8] supplemented sows with 1.05 g of vitamin C and 500 IU of vitamin E, twice weekly, from day 87 of gestation until farrowing. Sows supplemented with these vitamins had numerically lower ($P = 0.11$) mortality from sudden death and prolapse when compared to Control sows (3.0% vs. 6.0%). Further, the supplementation tended ($P = 0.08$) to reduce the number of sows that died at or before farrowing. Hence, extra antioxidant support in late gestation may help sows survive until farrowing. In lactation, [9] fed 0.45 kg of a top dress supplement for five days beginning at farrowing house entry, and 0.23 kg of the same supplement from day six until weaning. The 0.45 kg supplement contained 67% beet pulp, 18% wheat bran, enzymes (phytase and xylanase), vitamin C (754 mg), vitamin D (14,617 IU), and vitamin E (465 IU). The authors reported the lactation supplement numerically ($P = 0.15$) reduced sow mortality when compared to controls (1.3% vs. 4.0%). Similarly, [10] top dressed ImmuFend® (TechMix, LLC, Stewart, USA), a propriety blend of zinc and vitamins C, E, B12, B1, K, A, and D, from day 105 of gestation until five days post-farrowing or until weaning. The authors reported that sows receiving ImmuFend® tended ($P = 0.10$) to have lower mortality when compared to controls (3.9% vs. 6.0%). Collectively, these studies support the concept that timely supplementation of antioxidants can improve sow livability.

While previous research has implicated nutrition in the occurrence of prolapse across various species, a recent study connected prefarrow sow nutrition to pelvic organ prolapse. A North American study [11] evaluating 53 swine farms across 26 production systems found that farms with high pelvic organ prolapse rates fed diets with higher standardized total tract digestibility (STTD) of phosphorus (0.49% vs. 0.39%) and a narrower analyzed calcium to STTD phosphorus ratio (1.7 vs. 2.2). This relationship between mineral balance and prolapse is mirrored in other species as well. In buffalo, researchers noted lower serum calcium and phosphorus levels in prolapsed females compared to healthy counterparts [12] [13]. Nutritional interventions in sheep, specifically an injection of vitamins A, D, and E, reduced the incidence of vaginal prolapse in breeding ewes [14]. This trend extends to human medicine, where a systematic review linked pelvic organ prolapse with lower serum vitamin D (25-OH-$D_3$) levels [15]. Collectively, these cross species findings suggest that calcium and/or phosphorus metabolism are perhaps key components in the prolapse etiology.

The results concerning prolapse are further supported by a genomic study investigating the genetic architecture of the condition in sows. Specifically, [16] aimed to confirm the association between genetics and sow prolapse while identifying genomic regions and candidate genes linked to the disorder. The authors reported that genes on several chromosomes (1, 3, 7, 10, 12, and 14) were associated with sow prolapse. Candidate genes included those related to bone mineral density, bone strength, calcium homeostasis, and blood calcium levels, among other biological processes. Therefore, the reduction in sow prolapse incidence achieved by feeding higher levels of calcium, phosphorus, and vitamin D appears biologically plausible.

The interpretation of the current results is subject to several limitations. While sow livability improved across two production systems with distinct diets, the dicalcium phosphate and extra vitamin top dress program may require adaptation for diets outside the studied range. Furthermore, because the specific treatments from Study A were not replicated in Study B, their individual performance in different environments remains unknown. Consequently, caution is advised when interpreting results for treatments that were not repeated across both studies.

Given the hyperprolificacy of modern maternal genotypes, [17] and [18] recommended that the swine industry work to better understand the micro and macro nutrient requirements of modern sow genotypes in commercial environments. This statement is well supported by the results of the current study, as we observed that increased prefarrow nutritional support enhanced sow livability. Future studies should work to identify specific micro nutrients that impact sow health and livability. However, whether concepts from the current study can be implemented into existing diets remains in question. Hence, further investigation into the micro nutrient requirements of the modern sow under commercial conditions remains essential.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

[1] Knauer, M.T. and Hostetler, C.E. (2013) US Swine Industry Productivity Analysis, 2005 to 2010. *Journal of Swine Health and Production*, **21**, 248-252. https://doi.org/10.54846/jshap/776

[2] Meta Farms (2025) Production Analysis Summary for U.S. Pork Industry: 2020-2024. National Pork Board: Des Moines, IA, USA. https://porkcheckoff.org/wp-content/uploads/2025/10/MetaFarms-2024-Production-Analysis-NPB-Final.pdf

[3] NRC (1998) Nutrient Requirements of Swine. 10th Edition, The National Academies Press.

[4] NRC (2012) Nutrient Requirements of Swine. 11th Edition, The National Academies Press.

[5] Knauer, M.T. and Baitinger, D.J. (2015) The Sow Body Condition Caliper. *Applied Engineering in Agriculture*, **31**, 175-178. https://doi.org/10.13031/aea.31.10632

[6] Breuer, S.A. (2022) Oxidative Stress Variation and Its Relationship to Genetics and Reproductive Performance in a Commercial Swine Breeding Herd. M.S. Thesis, Iowa State University. https://dr.lib.iastate.edu/server/api/core/bitstreams/c09595c1-a6df-4684-b10c-915e1fadc99d/content

[7] Berchieri-Ronchi, C.B., Kim, S.W., Zhao, Y., Correa, C.R., *et al.* (2011) Oxidative Stress Status of Highly Prolific Sows during Gestation and Lactation. *Animal*, **5**, 1774-1779. https://doi.org/10.1017/s1751731111000772

[8] Knauer, M. (2023) PSIV-2 Impact of Vitamins C and E on Sow Mortality and Stillborn Rate. *Journal of Animal Science*, **101**, 352-353. https://doi.org/10.1093/jas/skad341.400

[9] Nickell, S.J., Rush, C., McKilligan, D., Tauer, S. and Cline, P.M. (2023) 35 High Fiber Top Dress Effects on Sows during Farrowing and Lactation. *Journal of Animal Science*, **101**, 252. https://doi.org/10.1093/jas/skad341.286

[10] Bohr, A., Reever, A., Burton, B., Guzman, J.E., McKilligan, D., Coulson, K., *et al.* (2025) Effect of Antioxidant Supplementation in Sows Pre-Farrow and during Lactation on Sow and Piglet Performance. *AASV Annual Meeting*, San Francisco, 1-4 March 2025, 248. https://doi.org/10.54846/am2025/88

[11] Kociemba, L., Vier, C.M., Canavate, S., Diaz, A., Diaz, J.A.C., Weger, K., *et al.* (2024) 283 Identification of New or Existing Risk Factors Associated with the Development of Sow Pelvic Organ Prolapse. *Journal of Animal Science*, **102**, 177-178. https://doi.org/10.1093/jas/skae102.197

[12] Ahmed, S., Ahmad, I., Lodhi, L.A., Ahmad, N. and Samad, H.A. (2005) Clinical, Haematological and Serum Macro Mineral Contents in Buffaloes with Genital Prolapse. *Pakistan Veterinary Journal*, **25**, 167-170. https://www.pvj.com.pk/pdf-files/25_4/167-170.pdf

[13] Akhtar, M.S., Lodhi, L.A., Ahmad, I., Qureshi, Z.I. and Muhammad, G. (2008) Serum Concentrations of Calcium, Phosphorus and Magnesium in Pregnant Nili-Ravi Buffaloes with or without Vaginal Prolapse in Irrigated and Rain Fed Areas of Punjab, Pakistan. *Pakistan Veterinary Journal*, **28**, 107-110. https://pvj.com.pk/pdf-files/28_3/107-110.pdf

[14] Allott, B.S., Dittmer, K.E., Kenyon, A.G. and Elder, P.A. (2020) Preliminary Investigation of the Effect of Treating Sheep during Pregnancy with a Vitamin A, D, E Formulation on the Incidence of Vaginal Prolapse. *New Zealand Veterinary Journal*, **68**, 193-197. https://doi.org/10.1080/00480169.2019.1696719

[15] Kurniawati, E.M., Rahmawati, N.A. and Widyasari, A. (2023) Differences between 25-Hydroxyvitamin D Levels in Patients with Pelvic Organ Prolapse and Non-Pelvic Organ Prolapse: A Systematic Review. *Journal of Obstetrics and Gynaecology Canada*, **45**, Article 102198. https://doi.org/10.1016/j.jogc.2023.102198

[16] Bhatia, V., Stevens, T., Derks, M.F.L., Dunkelberger, J., Knol, E.F., Ross, J.W., *et al.* (2023) Identification of the Genetic Basis of Sow Pelvic Organ Prolapse. *Frontiers in Genetics*, **14**, Article 1154713. https://doi.org/10.3389/fgene.2023.1154713

[17] Knauer, M. (2023) 84 Dead Sows Do Not Rear Piglets. *Journal of Animal Science*, **101**, 193-194. https://doi.org/10.1093/jas/skad341.214

[18] McClellan, K.A., Acosta, J., Lawrence, B., Hough, S., Bergstrom, J., Weaver, M., *et al.* (2025) Feeding a Nutrient Enriched Diet to Late Gestating Sows across Consecutive Cycles Improves Micronutrient Status, Farrowing Duration, and Prolificacy. *Translational Animal Science*, **9**, txaf155. https://doi.org/10.1093/tas/txaf155