

Assessment of hemoglobin concentration in relation to sow reproductive stage and parity

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Summary

The study objective was to determine if sows are anemic at any reproductive stage or parity. Hemoglobin concentrations were determined for 2683 sows from 11 farms. The overall trend was for hemoglobin concentrations to peak during mid-gestation and reach a nadir in early lactation when most (74.2%) sows were anemic.

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Resumen - Evaluación de la concentración de hemoglobina en relación con la etapa reproductiva de la cerda y la paridad

El objetivo del estudio fue determinar si las cerdas están anémicas en cualquier etapa reproductiva o paridad. Se determinaron las concentraciones de hemoglobina para 2683 cerdas de 11 granjas. La tendencia general fue que las concentraciones de hemoglobina alcanzaron su punto máximo durante la mitad de la gestación y alcanzaron su punto más bajo en la lactancia temprana cuando la mayoría de las cerdas (74.2%) estaban anémicas.

Résumé - Évaluation de la concentration d'hémoglobine en lien avec le stade de reproduction et la parité de truies

L'objectif de la présente étude était de déterminer si les truies sont anémiques à n'importe lequel des stades de reproduction ou de parité. Les concentrations d'hémoglobine furent déterminées chez 2683 truies provenant de 11 fermes. La tendance générale était que les concentrations d'hémoglobine atteignaient un pic durant la mi-gestation et un nadir au début de la lactation lorsque la plupart (74.2%) des truies étaient anémiques.

Iron deficiency anemia in neonatal pigs is a major limitation for optimal health and performance. To correct this deficiency, and resultant anemia, iron injections are given early in the piglet's life.¹⁻⁴ In contrast, the prevalence of anemia in sows has not been widely studied. Advances in genetic and reproductive research has led to highly prolific sows, which have a high nutritional demand to support the growth and development of large and frequent litters. While iron and other trace minerals are commonly present in excess in sow diets, the absorption capacity may not allow for optimal levels of iron to be maintained throughout a sow's lifetime. This potentially leads to conditions such as iron deficiency anemia.⁵⁻⁷ Results from one study showed that hemoglobin (Hb) concentrations in sows decreased with

age, thereby, supporting the concept that iron demands are greater than the quantity absorbed from a sow's diet.⁸

Attempts to manipulate the iron concentrations in sows to reduce anemia in piglets have been largely unsuccessful.⁵⁻⁷ This lack of response in the progeny was likely due to the controlled transfer of iron in the endometrium.⁹ Another study reported that low Hb concentrations in sows may impact the incidence of stillborn piglets.¹⁰ While reports on this topic were inconsistent with at least one study finding no correlation between sows' Hb concentrations and stillbirth occurrence,⁸ a recent investigation found that sows with Hb concentrations below 10 g/dL had significantly more stillborn piglets (1.7 stillborn/litter) compared to non-anemic sows (1.1 stillborn/litter).¹¹

Therefore, the present study was designed to evaluate Hb concentrations in sows of different parities and at various reproductive stages. The overall goal was to determine if sows are anemic at any reproductive stage or parity.

Materials and methods

All animals were raised and managed on commercial farms in North Carolina (n = 7 farms) and Indiana (n = 4 farms). The genetic lines of the sows were proprietary. Each farm was Pork Quality Assurance Plus certified and followed the animal care standards of the National Pork Board.¹² An Institutional Animal Care and Use Committee protocol was not required.

The study was a cross-sectional design including 2683 sows from 11 farms which ranged in size from 2400 to 4000 sows/farm. All animals included were normal, productive sows

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from the general population of each farm. Approximately 250 blood samples were collected from each farm representing 10 sows/parity/reproductive stage (Table 1). Reproductive stages were defined as early (approximately 25-35 days), mid (approximately 50-70 days), and late (approximately 100 or more days) gestation, and early (< 7 days postpartum) and late (> 14 days postpartum) lactation. Parity groups were 0 (gilts), 1, 2, 3, and ≥ 4 .

The Hb concentrations were measured on the farms using a HemoCue Hb 201+ (HemoCue America).⁴ Previous studies demonstrated that this instrument was reliable²; however, it may overestimate the Hb concentrations by 4%.¹ Blood samples were taken from the ear veins of sows,^{1,8} and loaded into disposable microcuvettes via capillary action. The microcuvette was placed in the HemoCue Hb 201+ and the resulting Hb concentration displayed and recorded within 60 seconds.

The Hb data was analyzed using an analysis of variance, with state, farm, parity, and stage as the independent variables (Statistix 10, Analytical Software). A significant interaction between parity and stage was present. Means were compared with Tukey's honest significant difference test. Using < 10 g/dL as the cutoff for anemia,¹¹ sows were classified as anemic or non-anemic. For each category (parity and reproductive stage), the percentage of anemic animals was determined and compared with Chi-square tests.

Results

Due to the significant interaction between parity and reproductive stage, it was not possible to separate the effects of these variables (Figure 1). The Hb concentrations typically were lower ($P = .04$) in early and late lactation than at other stages of reproduction regardless of parity. Gilts (1st pregnancy) had higher ($P = .04$) Hb concentrations than other parities of sows in mid-gestation. In general, it was evident that parity 0, 1, and 2 animals had higher Hb concentrations than parity 3 and ≥ 4 animals during gestation; however, these differences were not evident during lactation. The overall trend was for Hb concentrations to peak during mid-gestation, then be lower in late gestation and reach a nadir in early lactation.

All but one farm in North Carolina had similar, overall Hb concentrations (Figure 2). These concentrations were consistently less

Table 1: Numbers of sows (n = 2683) sampled by reproductive stage and parity

Parity	Reproductive Stage				
	Early Gestation	Mid Gestation	Late Gestation	Early Lactation	Late Lactation
0	105	108	109	103	106
1	110	107	104	97	103
2	105	109	110	110	107
3	110	110	110	110	100
≥ 4	110	110	110	110	110
Total	540	544	543	530	526

than 10 g/dL. In contrast, the four farms in Indiana had greater ($P = .01$) Hb concentrations than all the North Carolina farms. No differences were evident among the four Indiana farms.

Cumulatively, 1333 (49.7%) of the 2683 sows tested were anemic using a < 10 g/dL cutoff for sow anemia.¹¹ When evaluated by parity, 206 (38.8%) of 531 gilts tested below this cutoff, while parity ≥ 4 sows had 321 (58.4%) of 550 sows considered anemic. Of all gilts and sows tested, more sows were anemic ($P = .01$) during early or late lactation (74.2% and 67.3%, respectively) than during early, mid or late gestation (30.9%, 29.6%, 47.6%, respectively).

Discussion

This method of Hb assessment provided a quick and inexpensive method for on-farm use. It was previously shown² that values obtained from the HemoCue Hb 201+ correlate well with laboratory results with a 97% sensitivity and 100% specificity in the diagnosis of anemia (< 8.0 g/dL) and Hb measurements of 2.7 to 11.2 g/dL.

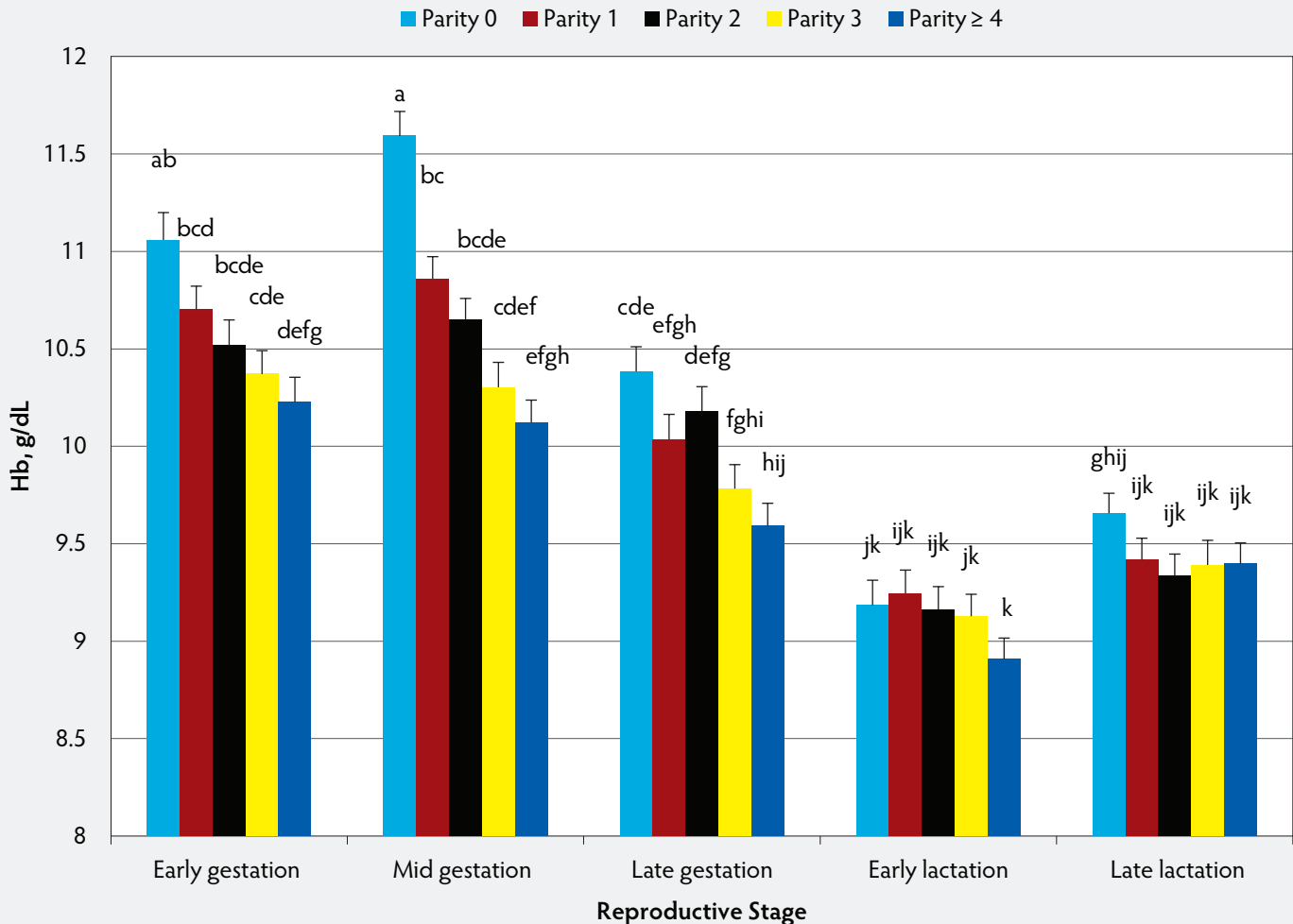
These data raise the question of how anemia impacts sow health and reproduction over time. For example, if a sow is anemic in mid-gestation, is she more likely to become more anemic by early lactation? While not evaluated in this cross-sectional study, a previous cohort study demonstrated that with each successive parity, the Hb concentrations decreased and did not recover to values observed as gilts or first parity sows.⁸ Severe anemia could lead to reproductive issues or sow death,^{13,14} and an increase in the number of stillborn pigs.¹¹

Feeding high levels of iron to sows during late gestation^{6,15} or parenteral injections of iron dextran to gestating sows failed to increase placental transfer of iron to fetuses.¹⁶ However, there have been few attempts to increase the Hb concentrations and the hematological status of sows. Regardless of the Hb status of sows in gestation, it is apparent that the sows become anemic in lactation.

The difference between the farm locations was unexpected. While precise feed analyses were not available, the difference may be explained, at least in part, by the inclusion levels of phytase in the diets. Indiana farms included a higher level of phytase (1250 FTU/kg) in the sow diets than North Carolina farms (750 FTU/kg). Since phytates form insoluble complexes with several minerals including iron, the increased phytase possibly contributed to greater Hb concentrations in the Indiana farms. Phytases increase the release of phosphate and other minerals, such as iron, from phytates,¹⁷ and the phytases may enhance iron absorption from 0.6% to 42% in cereal meals.¹⁸ Therefore, the different phytase levels among farms in the two states may have contributed to the differences in Hb concentrations.

Generally, while the results demonstrated that Hb concentrations varied among sows, a considerable number (49.7%) would be considered anemic based on the cutoff of 10 g/dL suggested in a previous study.¹¹ Trends can be observed in the data with mean Hb declining in a stepwise fashion as sows age. This supports a potential link between anemia and stillbirth occurrence as a higher occurrence of stillbirths are often observed in higher parity sows.

Figure 1: Mean (SEM) hemoglobin (Hb) concentrations in gilts and sows at various stages of reproduction. Bars with different superscripts differ ($P = .04$).



While further study is necessary, iron supplementation at critical periods or at the onset of anemia may be required to sustain a sow at higher reproductive performance levels. The critical limit of Hb concentrations for the gilt or sow to be considered anemic is unknown at this time. It was previously stated that Hb concentrations between 10 and 16 g/dL were considered normal.⁸ Based on the present results, it is evident that most (74.2%) sows are anemic in lactation and that higher parity sows (parity 3 and ≥ 4) are more likely to have reduced Hb concentrations in late gestation. The precise influence of sow anemia on the long-term reproductive performance and longevity of sows requires further study.

Implications

Under the conditions of this study:

- Many sows are anemic during lactation regardless of parity.

- Higher parity sows are more likely to be anemic during gestation.
- Sow iron requirements during late gestation and lactation require more study.

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Conflict of Interest

One author (C. Olsen) is employed by Pharmacosmos, Inc. His role was limited to the review of the manuscript.

Disclaimer

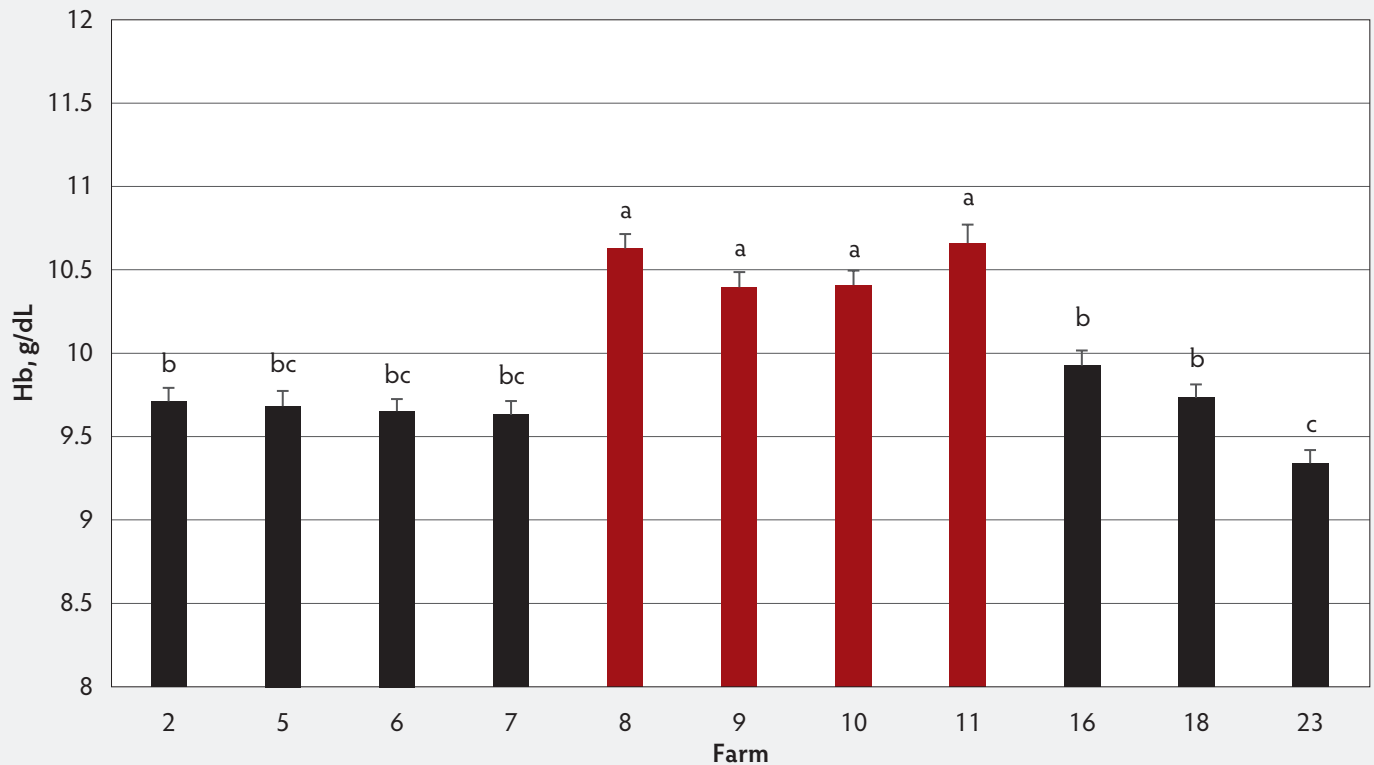
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Figure 2: Comparison of overall mean (SEM) hemoglobin (Hb) concentrations in gilts and sows on 11 farms. The red bars represent Indiana farms and the black bars represent North Carolina farms. Bars with different superscripts differ ($P = .01$).



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