

# Effects of a reduced dose of injected iron on health, iron status and growth of suckling piglets with access to iron enriched soil

S. Thanner, A. Gutzwiller

Agroscope, 1725 Posieux, Switzerland

## Summary

The effects of the recommended dose of 200 mg iron and of half that dose injected on the first day of life on health, iron status and performance during the 4 week suckling period were studied in 2'123 piglets. All piglets received creep feed and soil which was supplemented with 14 g iron per kg. Neither mortality nor the prevalence of arthritis, meningitis and foot abscess (each disease affecting about 1% of the piglets) differed between the two groups. The low dose of 100 mg iron decreased blood haemoglobin concentration at weaning ( $110 \pm 19$  vs.  $120 \pm 15$  g/l), but did not affect growth rate.

**Keywords:** piglet, iron, arthritis, health, haemoglobin

## Einfluss der Injektion einer reduzierten Eisendosis auf Gesundheit, Eisenstatus und Wachstum von Saugferkeln mit Angebot von Wühlerde

An 2'123 Saugferkeln wurde untersucht, welche Auswirkungen die Injektion der empfohlenen Dosis von 200 mg Eisen bzw. der halben Dosis am ersten Lebens- tag auf den Gesundheitszustand, den Eisenstatus und das Wachstum während der vierwöchigen Säugezeit hatte. Allen Ferkeln wurde ein Ferkelbeifutter und mit 14 g Eisen pro kg angereicherte Wühlerde angeboten. Die unterschiedliche Eisendosierung beeinflusste weder die Sterblichkeit noch die Prävalenz an Arthritis, Meningitis und Panaritium, an denen je rund 1 % der Ferkel erkrankte. Die Injektion von 100 mg Eisen reduzierte die Hämoglobinwerte zum Zeitpunkt des Absetzens ( $110 \pm 19$  gegenüber  $120 \pm 15$  g/l), zeigte aber keinen Einfluss auf das Wachstum der Ferkel.

**Schlüsselwörter:** Ferkel, Eisen, Arthritis, Gesundheit, Hämoglobin

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## Introduction

Pigs are born with only about 50 mg iron reserves and have to retain 20 mg of iron per kg body weight gain in order to maintain a physiological iron status (NRC, 2012). Milk contains little iron, and piglets raised indoors do not have access to soil as a natural iron source. To avoid iron deficiency anaemia, iron has to be administered to newborn piglets. The injection of iron at the generally recommended dose of 200 mg prevents the development of iron deficiency, but temporarily increases the serum iron concentration up to 50 times above the physiological level (Knight et al., 1983). This short-term iron overload increases the susceptibility of piglets

to bacterial infections, as is the case in humans (Barry et al., 1977; Bullen et al., 2000, 2006). Serum of piglets injected with 200 mg iron enhanced the growth of *E. coli* added *in vitro* compared to the serum of piglets injected with 100 mg iron (Knight et al., 1983). Moreover, iron injection has been associated with an increased prevalence of infectious arthritis in piglets (Holmgren, 1996; Rantzer et al., 2010; Hartmann, 2017). The objective of the present study was to test the hypothesis that the injection of half the recommended dose of iron reduces the prevalence of infectious arthritis and meningitis, both caused by haematogenous infection, usually involving streptococci (Gottschalk, 2012). Foot abscess, often caused by streptococci, was also recorded because

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environmental risk factors for that local infection, such as abrasive flooring and wet conditions, are the same as for arthritis (Gardner et al., 1990; Zoric et al., 2008, 2009).

## Animals, Material and Methods

### Animals and management

In the study which had been approved by the Veterinary office of the Kanton Freiburg (approval no. 25414), piglets born in the course of one year in the Large White pig herd of the research institute Agroscope were used. The herd had a high health status (SGD status A), i.e. it was free from enzootic pneumonia, *actinobacillus pleuropneumoniae* pneumonia, rhinitis atrophicans, brachyspira dysentery, pediculosis and sarcoptic mange. The gilts and sows were vaccinated using the vaccines Porcilis Porcoli DF® (MSD animal health, Lucerne, Switzerland) and Circovac® (Merial, Lyons, France) as recommended by the manufacturers to increase the colostral antibody titres against enterotoxigenic E. coli and porcine circovirus 2. A few days before farrowing the sows were transferred batch-wise in groups of 8 to 12 animals into one of the three stables of the farrowing unit which had been cleaned, disinfected and left empty for at least one week. Each farrowing pen with 6 m<sup>2</sup> concrete floor and 1.2 m<sup>2</sup> slatted metal floor was equipped with an insulated heated piglet nest (Krieger AG, Ruswil, Switzerland) with a plastic floor of 0.52 m<sup>2</sup>. Each day 1 kg of straw as nesting material and as bulk feed was provided, and 2 kg wood shavings were strewn on the floor. Farrowing was induced using prostaglandin in sows which had not farrowed by day 117 of pregnancy. Within the first 24 hours after birth the piglets were identified using consecutive-

ly numbered ear tags and received an iron injection. For each litter a new disposable injection needle (0.8 × 15 mm) was used. The umbilical cord was neither shortened nor disinfected. The canine teeth were not trimmed. At the age of 1 to 2 weeks, the male piglets were castrated under isoflurane anaesthesia 15 minutes after receiving 2 mg meloxicam intramuscularly (Metacam®, Boehringer, Basel, Switzerland). From the second week of life on, creep feed containing 150 mg/kg iron and a commercially available iron sulfate fortified soil containing 14 g iron per kg were constantly available. The piglets were batch-wise weaned at the age of 26 ± 3 days.

### Experimental design and protocol

The piglets with even ear tag numbers (group H) received the high (200 mg), those with odd numbers (group L) received the low (100 mg) dose of iron injected into the thigh muscles (Ferriphor 200® and Ferriphor 100®, containing per ml 200 and 100 mg iron as Fe (III) hydroxide dextran plus 5 mg phenol, Dr. E. Graeb AG, Bern, Switzerland).

Piglets dying within the first 24 hours after birth were excluded from the study.

The animal caretakers were instructed by the attending veterinarian to recognize the clinical signs of arthritis (lameness, swelling of one or several joints), meningitis (ataxia, rigidity of the neck and back, nystagmus, inability to rise, paddling movements) and foot abscess (lameness, swelling of the coronary band). Animals showing signs of one of these diseases were treated with penicillin (Duplocillin®, MSD, Lucerne, Switzerland). The diagnoses and treatments were noted. The piglets were weighed within 24 hours after birth and at weaning. In addition, the body weight of 57 piglets H and of 58 piglets L was recorded 6 weeks after weaning. At weaning, blood of 50 piglets H and 50 siblings of these piglets of the same sex and a similar BW belonging to group L was collected from an ear vein into heparinized capillaries for haemoglobin analysis using the Huma Meter Hbplus® (HUMAN diagnostics Worldwide, Wiesbaden, Germany).

### Statistical analysis

The data were statistically analyzed using the t-test and Fisher's exact test. Means and standard deviations are used to characterize the continuous variables.

## Results

After eliminating the data of the piglets dying within the first 24 hours after birth, 1'061 and 1'062 piglets, which had received 200 and 100 mg iron respectively, were included in the study. The experimental parameters

**Table 1:** The prevalence of arthritis, meningitis and foot abscess, mortality, haemoglobin and growth in piglets which had received either 200 mg (H) or 100 mg (L) iron by injection.

	H (200 mg)	L (100 mg)	<i>p</i>
Piglets included, n <sup>1</sup>	1061	1062	
Arthritis prevalence, %	1.32	0.66	0.13
Meningitis prevalence, %	0.75	0.94	0.80
Foot abscess prevalence, %	1.41	0.94	0.30
Mortality, %	10.9	11.0	0.95
Haemoglobin, g/L	120 ± 15	110 ± 19	0.004
Birth weight of all studied piglets, kg	1.51 ± 0.35	1.49 ± 0.35	0.48
Birth weight of weaned piglets, kg	1.53 ± 0.34	1.53 ± 0.34	0.96
Age at weaning, days	25.6 ± 3.6	25.5 ± 3.2	0.64
Body weight at weaning, kg	7.29 ± 2.20	7.14 ± 1.99	0.20
Growth rate, suckling period, g/day	224 ± 74	220 ± 68	0.24
Post-weaning growth rate, g/day <sup>2</sup>	357 ± 101	368 ± 89	0.54

*p* = probability of error

<sup>1</sup> piglets dying within the first 24 hours after birth were not included in the study

<sup>2</sup> daily weight gain of 57 piglets H and of 58 piglets L during the first 6 weeks after weaning

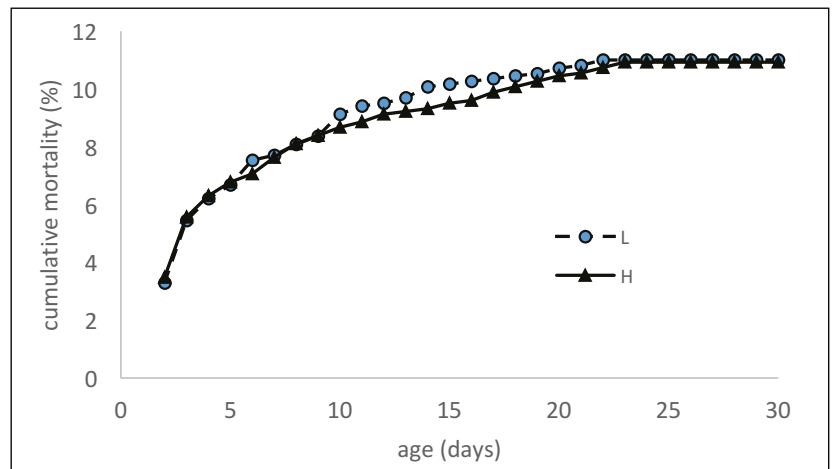
are shown in Table 1. Neither the prevalence of any single disease nor of the sum of the three diseases arthritis, meningitis and foot abscess differed significantly between groups H and L ( $p \geq 0.13$ ). Likewise, mortality did not differ between the two groups (Fig. 1;  $p = 0.95$ ). On the second and third day of life 117 piglets died, which represents 50% of the cumulative mortality. Compared to the piglets which had received the generally recommended dose of 200 mg iron, the piglets which had received the low iron dose had lower haemoglobin values (Fig. 2;  $p = 0.004$ ). The lower iron status of group L affected neither the pre-weaning nor the post-weaning growth rate ( $p \geq 0.24$ ).

## Discussion

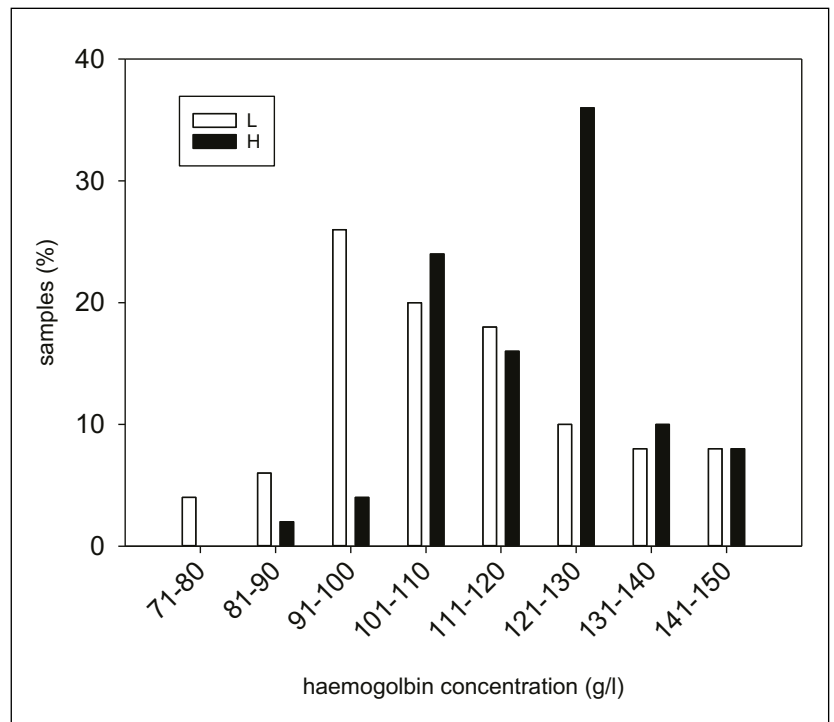
In former experiments reported by Holmgren (1996) and by Rantzer et al. (2010), arthritis prevalence decreased from 10% to 6% and from 18 to 8% when the injection of 200 mg iron was delayed from the first to the fifth day of life and from the first four days to the second week of life, respectively. When iron injection is delayed until several days after birth, the risk of iron overload and consequently the risk of septicemia and of arthritis decreases because of the higher serum concentration of the iron binding molecules transferrin and ferritin, which increases two- to threefold within the first few days after birth (Furugouri et al., 1983), and because of the higher body weight of the rapidly growing piglets.

In the present study the number of piglets treated for arthritis was twice as high in group H as in group L, but because of the low disease prevalence the statistical comparison has a low power. It was therefore not possible to verify the finding of Holmgren (1996) and of Rantzer et al. (2010) that a high dose of iron injected within a few days after birth increases the risk of infectious arthritis. The results of the present study neither confirm nor exclude the possibility that high doses of iron injected soon after birth increase the risk of arthritis, meningitis and foot abscess in suckling piglets. On the other hand, the present study shows that arthritis prevalence can be kept at a low level even when 200 mg iron are injected on the first day of life under the condition that other risk factors for disease such as insufficient colostrum intake, wet and abrasive flooring, and unhygienic iron injection (Nielsen et al., 1975; Zoric et al., 2008, 2009) do not play an important role.

Although the reduced amount of injected iron significantly reduced the haemoglobin concentration to  $110 \pm 19$  g/l, this value is not far below the haemoglobin values of  $113 \pm 16$  g measured in piglets which had received 200 mg iron by injection (Perri et al., 2015). The ingestion of iron fortified soil probably ameliorated the iron



**Figure 1:** Cumulative mortality from the second day of life until weaning in piglets which had received either 200 mg (H) or 100 mg (L) iron by injection.



**Figure 2:** Variation of the blood haemoglobin concentration at weaning in piglets which had received either 200 mg (H) or 100 mg (L) iron by injection.

status of piglets L and prevented a significant growth check, which is considered to be the most sensitive clinical indicator of iron deficiency anaemia in growing pigs (Suttle, 2010). Perri et al. (2015), who classified piglets in categories Hb > 110 g/l (normal iron status), Hb 90-110g/l (subclinical iron deficiency) and Hb < 90 g/l (anaemia), showed that the growth performance of piglets with a Hb concentration below 90 g/l is impaired. Since the injection of 100 mg iron results in a higher proportion of anaemic piglets which would show a clinical response to additional iron, the recommended dose of 200 mg of injected iron should not be lowered.

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In farms with a high arthritis prevalence in suckling piglets, the injection of 100 mg iron within the first days of life, followed by a second injection of 100 mg 1 to 2 weeks later, as recommended by Lipinski et al. (2010) and Starzynski et al. (2013) may be tested as part of a disease prevention strategy. The provision of iron enriched soil in addition to the iron provided by injection and the creep feed is recommended to reduce the proportion of iron deficient piglets.

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## Influence de l'injection d'une dose réduite de fer sur la santé, l'état nutritionnel en fer et la croissance de porcelets allaités recevant de la terre à fouiller

Le présent travail de recherche, mené avec 2'123 porcelets allaités, avait pour objectif d'étudier les effets de l'injection, le premier jour de vie, d'une dose recommandée de 200 mg de fer de même que de la moitié de cette dose sur l'état de santé, le statut ferrique et la croissance des porcelets pendant les quatre semaines d'allaitement. Tous les porcelets avaient en plus à disposition de la terre à fouiller enrichie de 14 g de fer par kg et d'un aliment complémentaire. Les différents dosages en fer n'ont influencé ni la mortalité ni la prévalence de l'arthrite, de la méningite et du panaris, chaque affection ayant touché environ 1% des porcelets. Les valeurs de l'hémoglobine au moment du sevrage étaient plus basses chez les porcelets qui avaient reçu 100 mg de fer ( $110 \pm 19$  contre  $120 \pm 15$  g/l), mais leur croissance n'a toutefois pas été influencée

## Influenza di un'iniezione di ferro ridotta su salute, stato del ferro e crescita nei lattonzoli ricevandi terra per grufolare

Sono stati eseguiti dei test su 2'123 lattonzoli per osservare gli effetti sulla salute, sul tenore di ferro e sulla crescita di iniezioni della dose raccomandata di 200 mg di ferro e della metà della dose. Le iniezioni sono state effettuate il primo giorno di vita e i lattonzoli osservati per un periodo di quattro settimane. A tutti i suinetti è stata data terra per grufolare con 14 g di ferro per kg e un alimento complementare. Le differenze nella dose non hanno avuto alcun un influsso né sulla mortalità né sulla prevalenza di artrite, meningite e pateruccio. Ciascuna di queste prevalenze ha toccato circa l'1% dei suinetti. I valori di emoglobina alla fine dello svezzamento erano più bassi nei suinetti che avevano ricevuto 100 mg di ferro ( $110 \pm 19$  rispetto al  $120 \pm 15$  g/l). La dose di ferro non ha invece influenzato la crescita.

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S. Thanner, A. Gutzwiller

## Corresponding author

Sophie Thanner  
 ETH Zürich, Animal Physiology  
 Institute of Agricultural Sciences  
 Postal address: Universitätstrasse 2/LFW B 58.1  
 Office: Universitätstrasse 2/LFW B 55.2  
 8092 Zürich, Switzerland  
 Telephone: +41 44 633 88 01  
 E-Mail: sophie.thanner@usys.ethz.ch