A case of anaemia in a neonatal warthog (*Phacochoerus aethiopicus*) and evaluation of serum-soluble iron in warthogs

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ABSTRACT

A 38-day-old male warthog (*Phacochoerus aethiopicus*) with marked anaemia (haematocrit = 14 %) presented to the Denver Zoological Gardens hospital with ataxia, tachypnoea, suspected stunted growth and cardiomegaly. The piglet demonstrated some features consistent with both iron deficiency anaemia and autoimmune haemolytic anaemia. Serum-soluble iron was below the level of detection (<8.96 μmol/ℓ). Iron deficiency anaemia is a well recognised entity in domestic swine reared on concrete and denied access to soil. Fifteen captive warthogs were subsequently evaluated for serum soluble iron content (mean = 21.62 ± 4.36 μmol/ℓ) as well as 5 neonatal warthog piglets that required hand-rearing. Only 1 of 5 neonatal warthog piglets had measurable serum soluble iron (9.50 μmol/ℓ). These data suggest that warthogs are similar to domestic swine and are born with low iron stores. Some form of iron supplementation should be considered for captive neonatal warthog piglets, especially if they are reared on concrete.

Key words: anaemia, autoimmune haemolytic anaemia, iron deficiency, *Phacochoerus aethiopicus,* warthog.

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In 1991 the Denver Zoological Gardens acquired a pair of warthogs (*Phacochoerus aethiopicus*); a 1-year-old female captive born in the U.S. and a 1-year-old male captive born in Europe. The warthog diet at the Denver Zoo consists of grain, which is supplemented with ferrous sulphate, and produce. In February 1995, 2 piglets were born in a 44.5 m^2 indoor holding stall with a concrete slab floor.

A 38-day-old, 4.34-kg male warthog piglet presented to the zoo hospital with apparent stunted growth (appeared to be half the size of a litter mate), ataxia and tachypnoea. Blood was collected for a haemogram. The piglet demonstrated marked anaemia with a haematocrit of 14 %. It did not appear to be icteric and had a total bilirubin of 0.41 mg/dℓ. The anaemia was characterised by a mixed-cell population with large polychromatic spherocytes (thought to be reticulocytes) and microcytic hypochromic red cells. There were also 187 nucleated red blood cells per 100 white blood cells. Ventrodorsal and right lateral thoracic radiographs taken at initial presentation revealed an increased cardiac silhouette. The working diagnosis was a congenital heart defect leading to cardiomegaly.

The following day an ultrasound was performed which demonstrated generalised heart enlargement, contractility within expected values and no evidence of congenital defects. Aetiologies now considered included iron-deficiency anaemia and autoimmune haemolytic anaemia (AIHA). The piglet was treated with 100 mg iron dextran (Vedco, St Joseph, Missouri) administered i.m. repeated at 41 and 48 days of age and again with 300 mg at 109 days of age for possible iron-deficiency anaemia. To cover the possibility of AIHA, it was also given 5 mg dexamethasone (Phoenix Pharmaceutical, St Joseph, Missouri) administered i.m. at 41 days of age and continued q 48 h for 3 treatments and then changed to oral prednisolone (Goldline Laboratories, Fort Lauderdale, Florida) at 1.25 mg q 12 h. The piglet recovered and the dosage was gradually reduced and discontinued 3 weeks later.

Subsequent to this case, 15 warthogs were bled randomly to determine serum-soluble iron content and haematocrits.

To determine a reference range for serum-soluble iron in captive warthogs, blood samples were collected opportunistically on 15 separate occasions from 1 adult warthog and 14 juvenile warthogs. The mean age was 1.05 ± 0.46-year-old (range 0.75–2.5). Blood samples were collected following immobilisation with xylazine (Vedco, St Joseph, Missouri) and tiletamine and zolazepam HCL (Telazol®, Fort Dodge Laboratories, Fort Dodge, Iowa). Sera for mineral analysis were stored at –70 °C and later sent on dry ice overnight to the laboratory. The serum-soluble iron content was determined by inductively-coupled plasma atomic emission spectrometry[9]. Blood for haemograms was collected in EDTA tubes (Capiject™ T-MQK, Terumo Medical Corp., Elkton, Maryland). The haematocrit (HCT) was determined using the micro-haematocrit method[6]. The mean serum-soluble iron content for the adult and juvenile warthogs was 21.62 ± 4.36 μmol/ℓ (range 0.66–1.69) (Table 1). The laboratory level of detection was >8.96 μmol/ℓ. The mean HCT was 42.2 ± 4.4 % (range 36–50). In addition, 5 abandoned neonatal warthogs were bled when presented to the hospital for hand-rearing. Four of these piglets were below the level of laboratory detection (includes the case report piglet) and 1 was just barely detectable (9.50 μmol/ℓ).

It has been reported that serum ferritin alone or in combination with serum iron-binding capacity are best for determining an iron deficiency or response to iron therapy[17]. These tests correlate well with the non-haem iron in the liver and the reticuloendothelial system[17]. Only serum-soluble iron was evaluated in this study. This procedure still appeared to be adequate to demonstrate that neonatal warthogs are born with low serum iron levels.

Anaemia is defined as a deficiency in the number of red blood cells and the oxygen carrying moiety haemoglobin[14]. There are 3 basic pathological mechanisms for anaemia: haemorrhage, increased red blood cell destruction and decreased production of erythrocytes[14,16]. Frequent causes for anaemia in neonatal large animals

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Table 1: **Signalment, serum-soluble iron content** (μmol/ℓ) **and haematocrits** (HCT %) **from 15 warthog serum samples** (7 males, 8 females)**. Mean age was 1.05 ± 0.46 years** (range 0.75–2.5)**, mean serum-soluble iron content was 21.62 ± 4.36 μmol/ℓ** (range 11.83–30.29) **and mean haematocrit was 42.2 ± 4.4 %** (range 36–50)**.**

Sex	Age (y)	Iron (μmol/ℓ)	HCT (%)
Male	2.5	21.86	39
Male	0.75	18.91	48
Female	0.92	22.76	44
Female	1.3	19.89	50
Female	0.75	30.29	41
Female	1.08	16.31	47
Male	1.0	27.60	41
Female	1.33	22.76	43
Female	1.33	21.68	42
Male	0.81	21.69	37
Female	0.81	21.69	38
Male	0.81	19.00	38
Female	0.81	24.19	48
Male	0.75	23.84	36
Male	0.75	11.83	41
Mean ± SD	1.05 ± 0.46	21.62 ± 4.36	42.2 ± 4.4

include; haemorrhage, blood-sucking parasites, neonatal isoerythrolysis, haemolytic anaemias due to drugs, vaccines, infections (parasites, bacteria, viral), or secondary to immune-mediated processes and chronic infections[16]. Other causes for non-immune-based anaemias in large animals due to oxidative injury to the red blood cell are Heinz body anaemia from drugs such as phenothiazines, methylene blue or plants such as onions or members of the *Brassica* family[16]. Certain lymphoid neoplasms have also been associated with anaemia[16]. An experimentally induced macrocytic anaemia from vitamin B_{12} and folate deficiency has been produced in swine[16].

Several causes for anaemia were considered unlikely in the neonatal warthog piglet in this case report. There was no evidence of haemorrhage, infection, chronic disease, parasites or neoplasia. Neonatal isoerythrolysis was considered, but thought to be unlikely because it usually occurs in the first few days of life in domestic species[16]. The 2 remaining likely possibilities were iron-deficiency anaemia and autoimmune haemolytic anaemia. Iron-deficiency anaemia has been well described in swine but cases of haemolytic anaemia are rare[8,14].

Approximately two-thirds of an animal's iron is associated with haemoglobin, 4 g in a 70 kg human[2,3,4,5,14]. The remaining one-third can be found as ferritin, haemosiderin, myoglobin, or associated with several enzymes[2,7]. For haemoglobin production, transferrin transports iron to receptor sites located on the membranes of erythroblasts in the bone marrow where it is presented to mitochondria for haem synthesis[6]. Haem contains 4 iron porphyrin groups which are combined with a globin protein unit to form haemoglobin[15].

At birth the domestic piglet has a high haematocrit but it rapidly falls by approximately 30 % in the 1st week[8]. Blood volume, including erythrocytes, rapidly expands during this period[3]. Hepatic iron in the newborn domestic piglet is only sufficient to maintain haematopoesis for the 1st 2–3 weeks of life[14]. Domestic piglets aged 10–54 days old have a HCT 25.5 ± 27 % and reticulocyte count at birth of 0.6 ± 0.1 %[18]. The 14 % haematocrit and 18.7 % reticulocyte count from the warthog piglet in this case report would be consistent with a marked regenerative anaemia when compared with domestic swine and warthog values[1,11].

In domestic swine iron-deficiency anaemia typically develops in 2–4 weeks and becomes clinically evident at 6 weeks of age[6,7]. Newborn domestic piglets have approximately 50 mg total body iron[5]. Piglets require 7–16 mg of dietary iron each day while sow milk contains approximately 1 mg of iron per litre of milk[5,12]. Iron-deficiency anaemia is usually characterised as a hypoproliferative anaemia that is microcytic and hypochromic[5,10,14]. Low iron content of sow milk and the lack of access to dietary iron from soil when animals are raised on concrete, makes rapidly growing piglets especially susceptible to iron-deficiency anaemia[8,10,14]. Iron deficiency is not a common disease, except in humans and swine[7]. It is suspected that warthog milk is probably similar to that of domestic swine and is deficient in iron. Piglets will start rooting in soil (a source for iron) on about the 3rd and 4th days of life[6]. If piglets are raised on concrete with no access to supplementary iron they may become severely anaemic, stunted, lethargic and some may even die[6]. At necropsy domestic piglets dying from iron-deficiency anaemia often have a dilated cardiomyopathy, pericardial effusion, pulmonary oedema and splenomegaly[8].

At the Denver Zoo, warthog piglets are born in late January to April at a time when they are kept indoors, due to cold weather, in a 44.5 m^2 indoor holding stall with a concrete slab floor. It is common practice for domestic swine in total confinement facilities to be housed on concrete. As a matter of routine, piglets are administered 100 mg of iron dextran during the 1st few days of birth[5].

Evaluation of serum-soluble iron content from the case report warthog piglet revealed the level to be below detection (<8.96 μmol/ℓ). Normal serum iron levels for newborn domestic piglets has been reported to be 12.54–14.34 μmol/ℓ, while adult levels range from 17.92 to 26.88 μmol/ℓ[13]. Why the litter mate appeared unaffected is unknown. It was not handled for examination and blood sampling because of concerns that the sow might injure or abandon it.

Arguments can also be made in the case report for AIHA as an aetiology. Many of the clinical signs of AIHA are similar to iron-deficiency anaemia, including pallor, fatigue, depression, anorexia, tachypnoea, tachycardia, hepatomegaly, splenomegaly and variable icterus[5,16]. In AIHA, blood smears typically show increased reticulocytes and nucleated red blood cells, macrocytosis and hypochromia (as opposed to the hypoproliferative pattern normally observed in iron deficiency)[5,10,16]. The marked regenerative response and high reticulocyte count in this case are characteristic responses to AIHA[6]. The serological diagnosis of AHIA requires a Coomb's test using species-specific reagents[18]. The piglet's age, undetectable serum-soluble iron content, clinical signs, and susceptibility of swine to iron deficiency as well as the presence of microcytosis and hypochromia support a diagnosis of iron-deficiency anaemia. A bone marrow sample stained for iron may have been helpful in establishing a definitive diagnosis, but unfortunately this procedure was not performed. The piglet responded favourably to an injection of iron dextran and a course of corticosteroids.

Because several litters of warthogs have been raised at the Denver Zoo, we were able to randomly sample and evaluate several warthogs for iron to help develop a species baseline and compare it to domestic swine. The mean value for

Table 2: **Signalment and serum-soluble iron content** (μmol/ℓ) **from 5 neonatal warthog piglets. Level of detection was 8.96 μmol/ℓ.**

Sex	Age (days)	Iron (μmol/ℓ)
Male[a]	46	<8.96
Female[b]	1	<8.96
Male[b]	1	<8.96
Male[c]	2	<8.96
Female[c]	2	9.50

serum-soluble iron from 15 warthog samples was 21.62 ± 4.36 μmol/ℓ (Table 1). This fits within the range reported for domestic swine (11.83–30.29 μmol/ℓ)[13]. The relative frequency for serum-soluble iron in warthogs also had a similar frequency distribution to that of domestic swine (n = 264) analysed by the same laboratory (The Animal Health Diagnostic Laboratory, Michigan State University, East Lansing, Michigan, pers. comm., 1999). Neonatal domestic piglets have been reported to have a serum iron range of 12.54–14.34 μmol/ℓ[13]. In addition to the piglet in this report, 4 orphaned warthog piglets with no known pathology had significantly low serum-soluble iron levels (3, <8.96 μmol/ℓ, and 1, 9.50 μmol/ℓ) (Table 2). It is believed that these data demonstrate that warthog piglets are born with low systemic iron stores and without supplementation may be susceptible to the development of iron-deficiency anaemia.

In conclusion it can be stated that a neonatal warthog piglet was successfully treated for marked anaemia. It was never definitively established whether the aetiology was iron-deficiency anaemia or autoimmune haemolytic anaemia. The data from this report indicate that like domestic swine, warthogs may be susceptible to iron-deficiency anaemia. If warthog piglets are reared on concrete it is important that they be provided with a supplementary iron source. Although iron injections may give a quicker rise in serum-soluble iron, providing piglets with fresh soil is also effective and may be preferable because of the risk of injury or rejection.

REFERENCES

1. Anonymous 1996 *Phacochoerus aethiopicus*/Cape wart hog. In Flesness N (ed.). *ISIS physiological data reference values.* ISIS, Apple Valley, Minnesota: 606
2. Bhagavan N V 1992 Iron metabolism. In Bhagavan N V (ed.). *Medical biochemistry.* Jones and Bartlett Publishers, Boston: 709–711
3. Guyton A C 1991 In Guyton A C (ed.) *Textbook of medical physiology* (8th edn). W B Saunders, Philadelphia
4. Hendrix T R 1980 Iron. In Mountcastle V B (ed.) *Medical physiology* (14th edn). C V Mosby, St Louis: 1282–1283
5. Jain N C 1986 Hematology of the pig. In Jain N C (ed.) *Schlam's veterinary hematology* (4th edn). Lea & Febiger, Philadelphia
6. Jain N C 1993 In Jain N C (ed.) *Essentials of veterinary hematology.* Lea & Febiger, Philadelphia
7. Jones T C, Hunt R D, King N W 1997 Nutritional deficiencies. In Jones T C, Hunt R D, King N W (eds) *Veterinary pathology* (6th edn). Williams & Wilkins, Baltimore: 804–805
8. Leman A D, Straw B E, Mengeling W L, D'Allaire S, Taylor D J 1992 In Leman, A D, Straw B E, Mengeling W L, D'Allaire S, Taylor D J (eds) *Diseases of swine* (7th edn). Iowa State University Press, Ames
9. Melton L A, Tracy M L, Möller G 1990 Screening trace elements and electrolytes in serum by inductively-coupled plasma emission spectrometry. *Clinical Chemistry* 36: 247–250
10. Meyer D J, Harvey J W 1998 Evaluation of erythrocyte disorders. In Meyer D J, Harvey J W (eds) *Veterinary laboratory medicine.* W B Saunders, Philadelphia: 43–82
11. Miller E R, Ullrey D E, Ackerman I, Schmidt D A, Lueke R W, Hoefer J A 1961 Swine hematology from birth to maturity. II. Erythrocyte population, size, and hemoglobin concentration. *Journal of Animal Science* 20: 890–897
12. National Research Council 1988 *Nutrient requirements of swine.* National Academy Press, Washington DC
13. Puls R 1994 Iron: pigs. In Puls R (ed.) *Vitamin levels in animal health: diagnostic data and bibliographies* (2nd edn). Sherpa International, Clearbrook, British Columbia: 141–142
14. Radostits O M, Blood D C, Gay C C 1994 In Radostits O M, Blood D C, Gay C C (eds) *Veterinary medicine* (8th edn). Baillière Tindall, Philadelphia
15. Randall D 1988. Exchange of gases. In Eckert R (ed.). *Animal physiology: mechanisms and adaptations* (3rd edn). W H Freeman, New York: 475–478
16. Smith B P 1996 Diseases of the hematopoietic and hemolymphatic systems. In Smith B P (ed.) *Large animal internal medicine.* Mosby-Yearbook, St Louis
17. Smith J E, Moore K, Boyinton D, Pollman D S, Schoneweiss D 1984 Serum ferritin and total iron-binding capacity to estimate iron storage in pigs. *Veterinary Pathology* 21: 597–600
18. Tumbleson M E, Schmidt D A 1986 Hematology and clinical chemistry. In Leman A D, Straw B E, Mengeling W L, D'Allaire S, Taylor D J (eds) *Diseases of swine* (6th edn). Iowa State University Press, Ames: 31