

Graded levels of phytic acid in diets for Atlantic salmon (*Salmo salar* L.) and description of hyper dense vertebrae

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(2006) Hyper dense vertebrae and mineral content in Atlantic salmon (*Salmo salar* L.) fed diets with graded levels of phytic acid. *Aquaculture* 261: 603-614

Background

- Increased use of plant based ingredients in fish feed
- Anti nutritional effectors like phytic acid
- Phytic acid binds to minerals
- Minerals are important in strengthening of bone
- Correct mineral supply is essential for avoiding development of skeletal malformations

Materials and methods

- Atlantic salmon n=672, with start weight 36.5 +/-0.1 gram
- 12 tanks 0,5m diameter (300 L)
- Temperature 12°C
- Continuous light on tank edge
- Experimental duration: 8 weeks
- 6 experimental feeds (D1 to D6) produced by Fortek, Ås, Norway
- Containing levels of phytic acid: 0; 1,0; 2,1; 4,7; 10,0 and 20,7 g IP6 kg⁻¹, analysed levels).

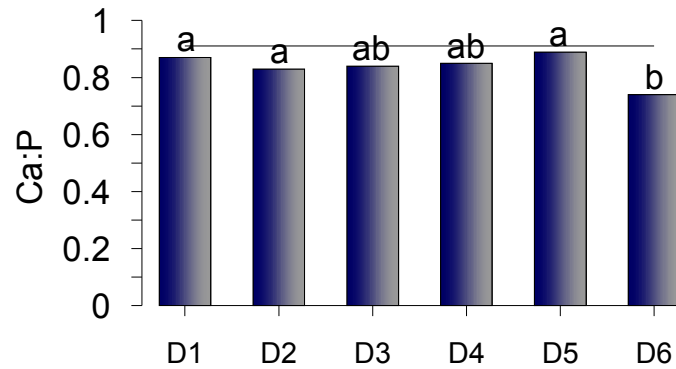
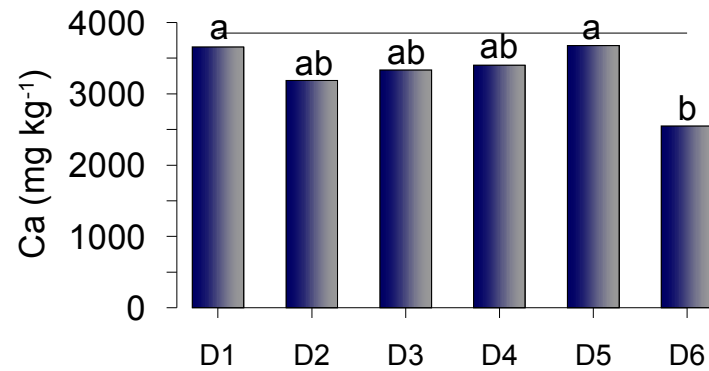
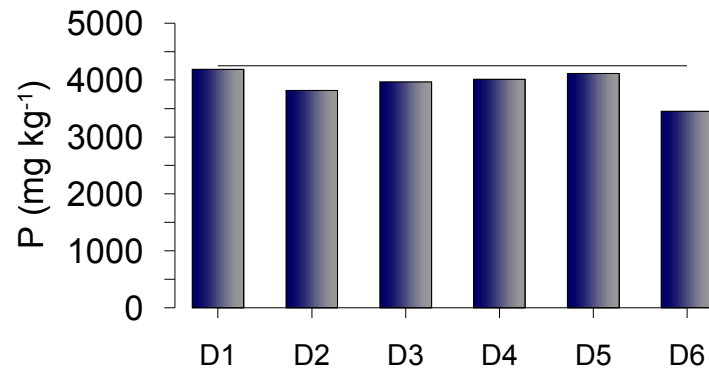
Diet formulation and analysed and calculated chemical composition.

<i>Formulation g kg⁻¹</i>	D1	D2	D3	D4	D5	D6
Constant ingredients	1000	997.9	995.9	991.7	983.5	967.0
Sodium phytate	0	2.1	4.1	8.3	16.5	33
<i>Chemical composition g kg⁻¹</i>						
IP6 ³	0	1.0	2.1	4.7	10	20.7
IP5 ³	n.d.	n.d.	n.d.	0.5	1.1	2.0
<i>Minerals, mg kg⁻¹</i>						
Phosphorus (P)	16183	16586	16925	18007	19589	22547
<i>Digestible P</i>	<i>6182</i>	<i>5589</i>	<i>5941</i>	<i>5870</i>	<i>6288</i>	<i>8748</i>
Magnesium (Mg)	1632	1634	1629	1644	1644	1600
<i>Digestible Mg</i>	<i>857</i>	<i>770</i>	<i>772</i>	<i>658</i>	<i>442</i>	<i>373</i>
Zinc (Zn)	94	97	93	91	90	89
<i>Digestible Zn</i>	<i>40</i>	<i>38</i>	<i>31</i>	<i>26</i>	<i>25</i>	<i>23</i>

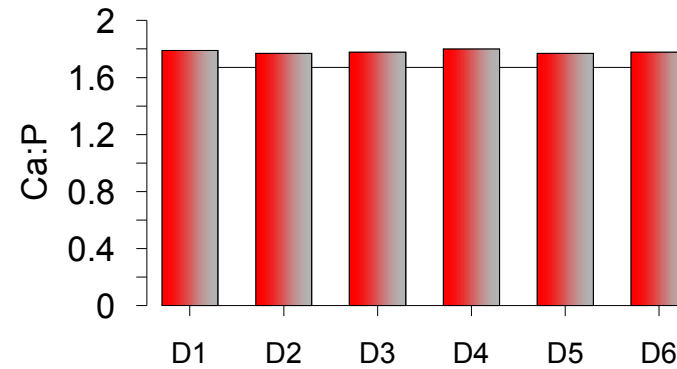
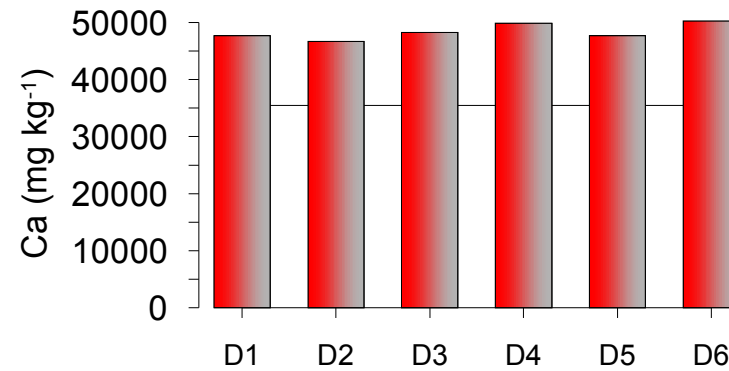
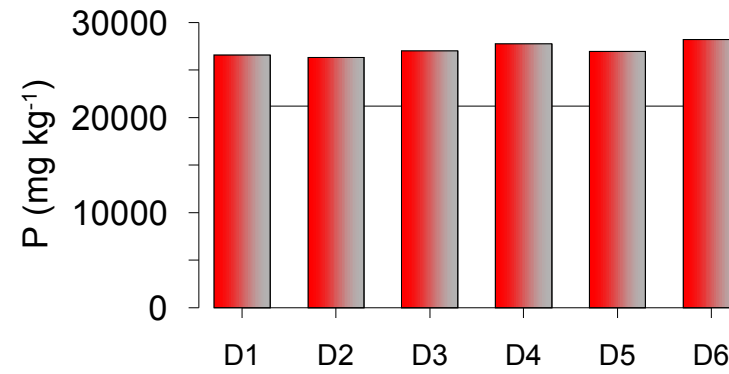
Feed intake and growth

- A content of phytic acid up to 4,7 g IP6 kg⁻¹ (D4) had no effect on feed intake nor growth
- Higher contents resulted in a reduced feed intake and in reduced growth
- The content of phytic acid in the feed affected the digestibility of nitrogen and lipid, and of magnesium and zinc, but not the digestibility of starch, ash and phosphorus

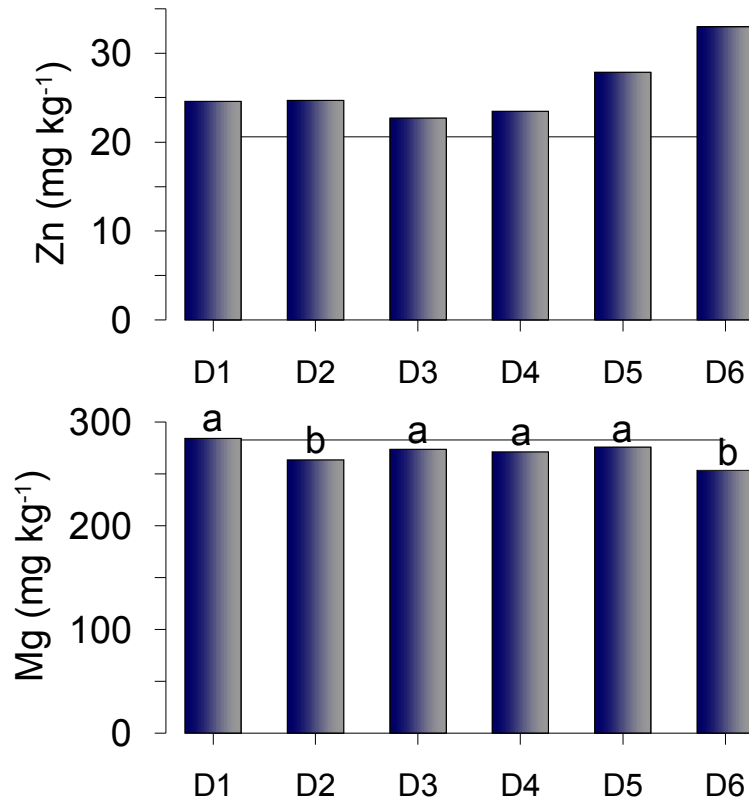
Whole body



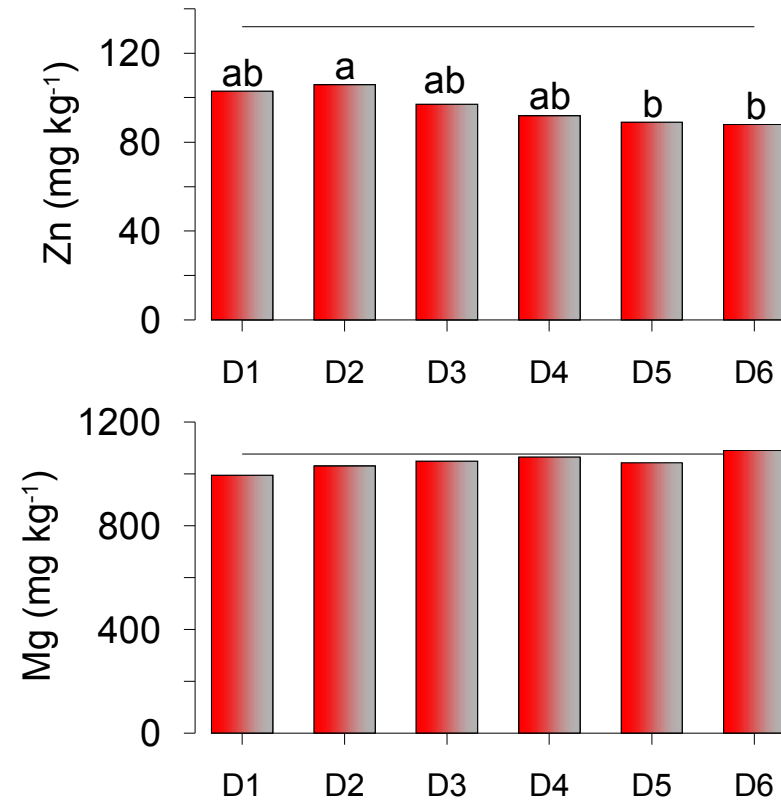
Vertebral column



Whole body

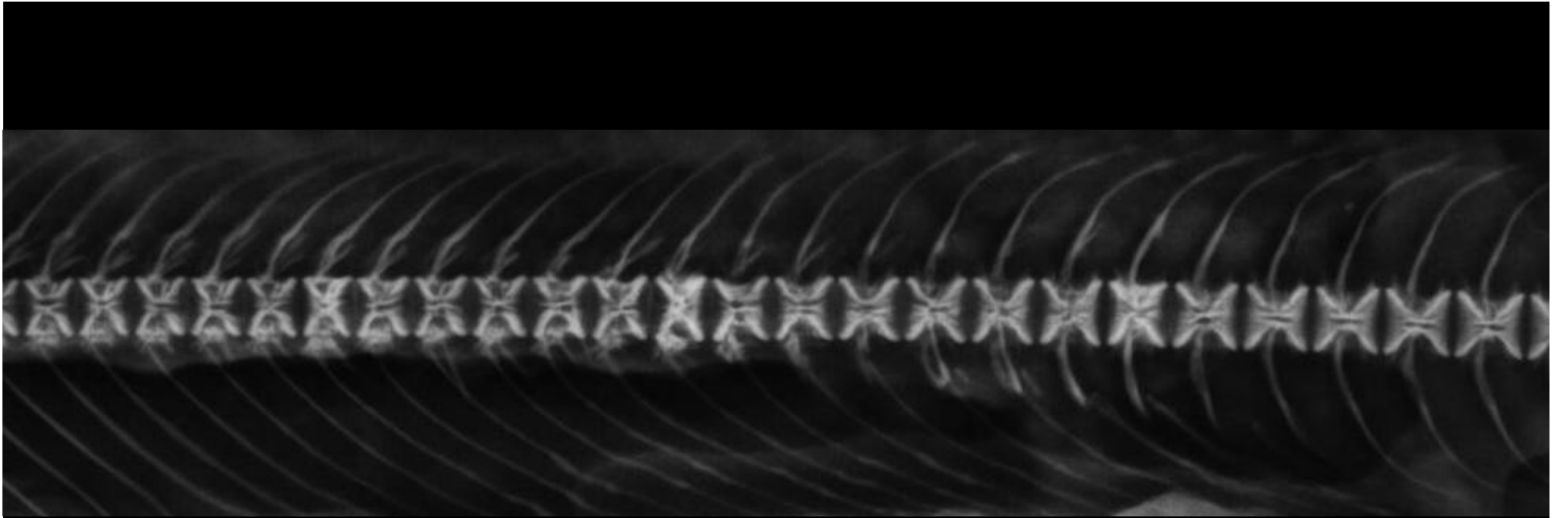


Vertebral column

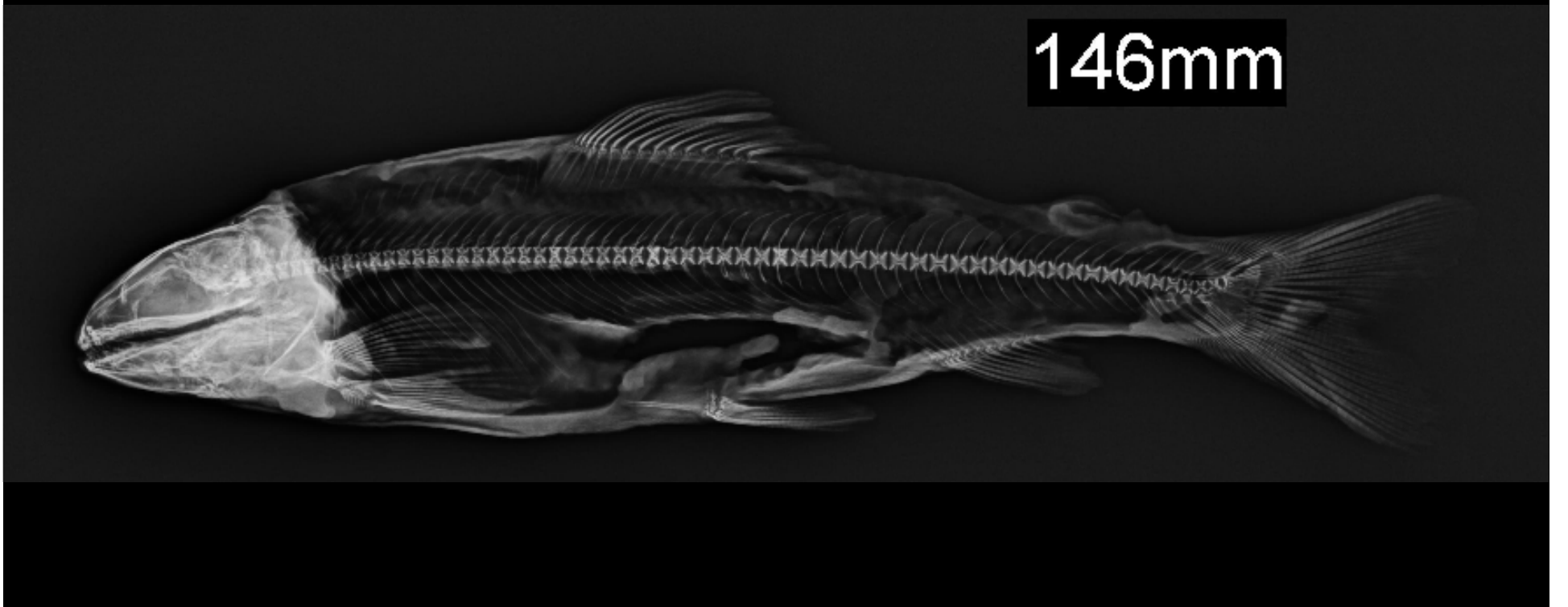


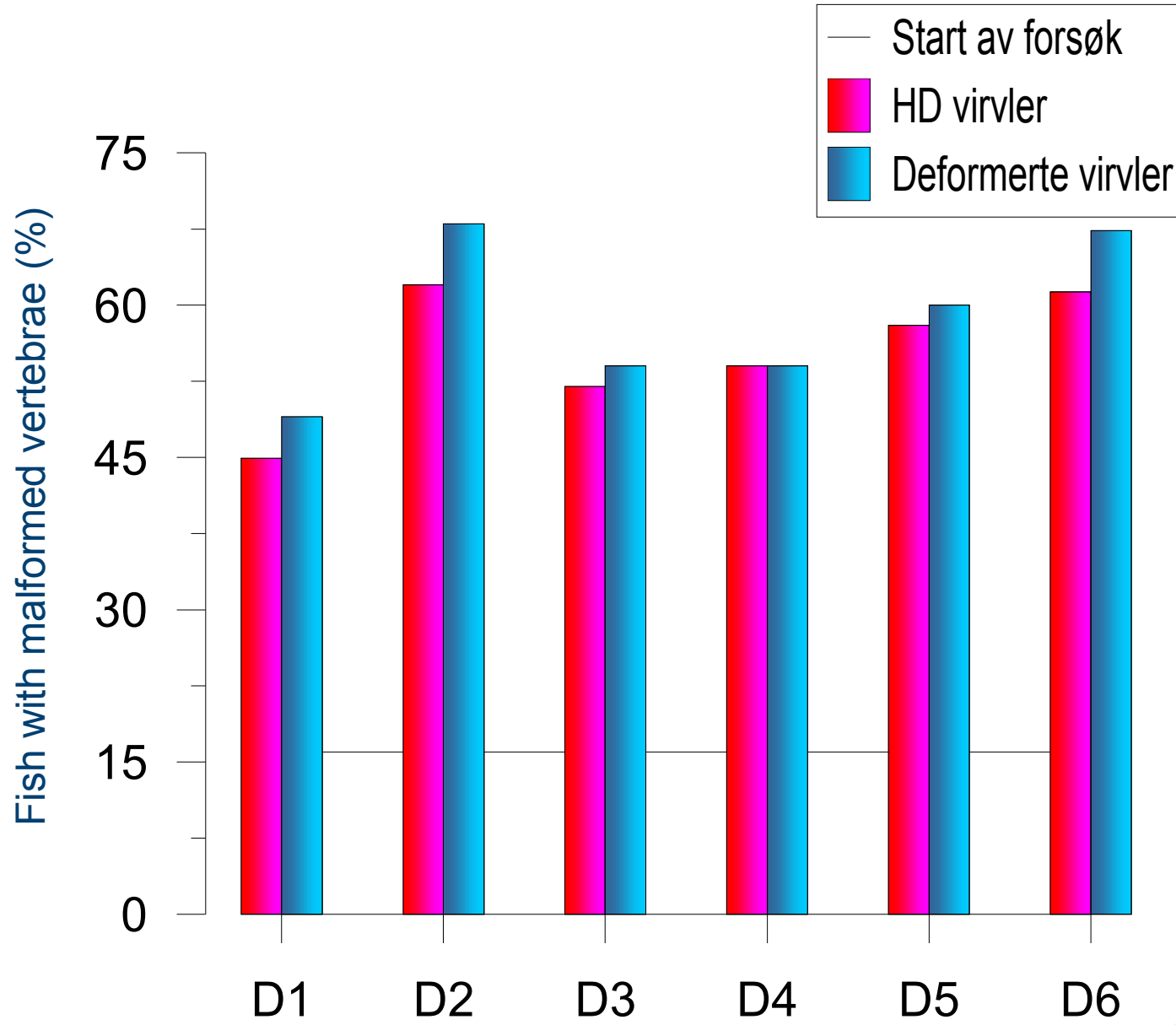
Zinc and magnesium

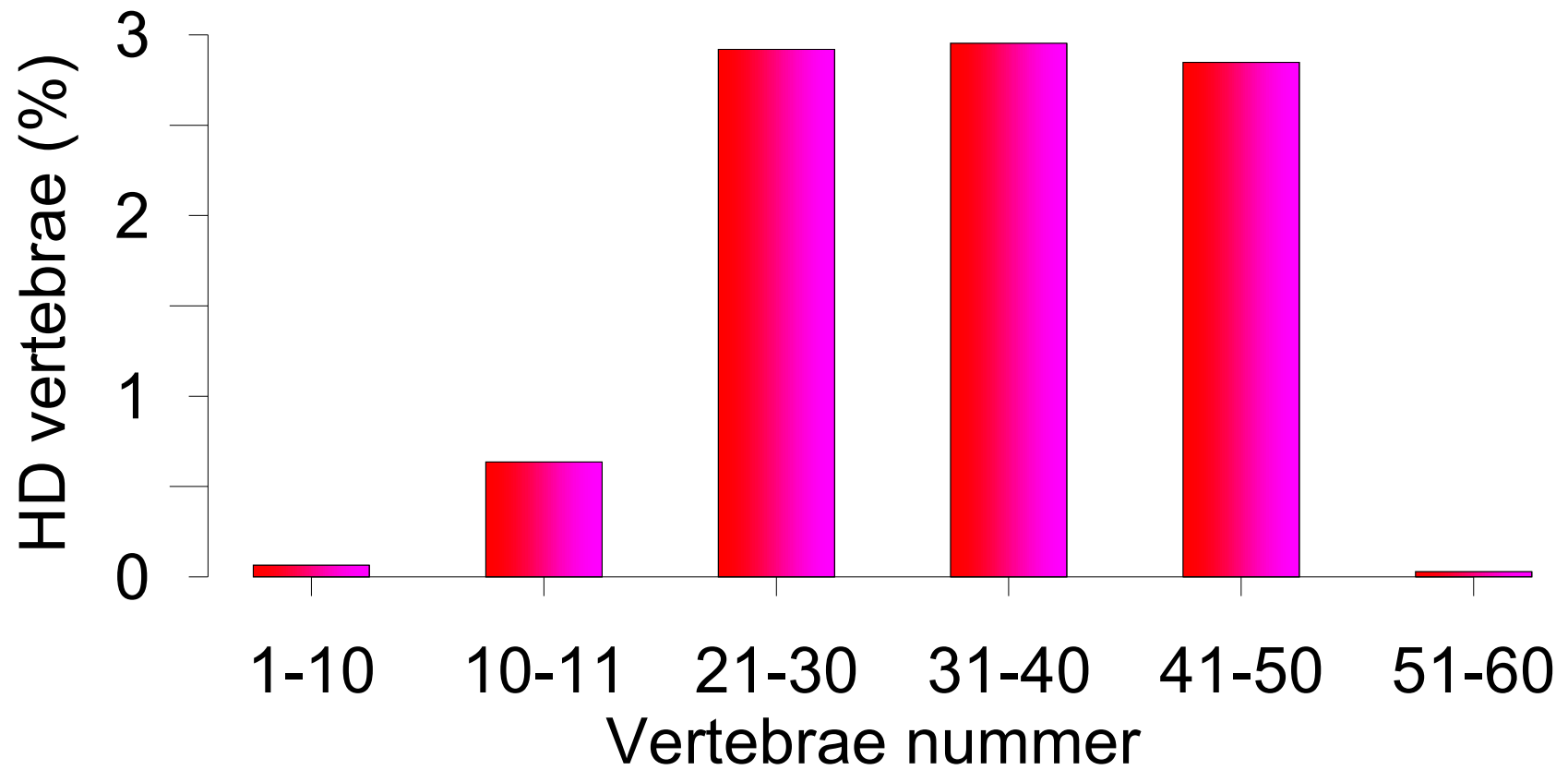
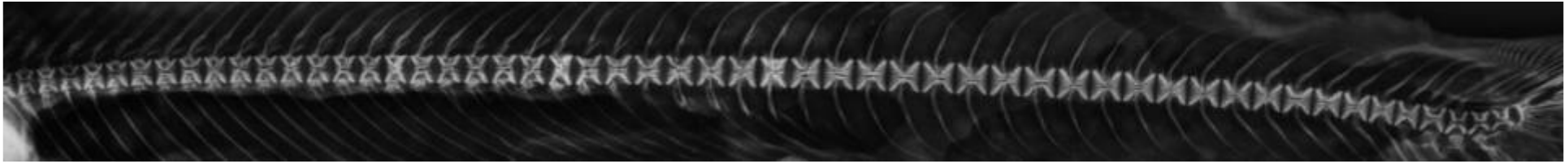
- The fish had at the start of the experiment a rather low level of zinc (20,6 mg kg⁻¹)
- There was no effect of reduced zinc digestibility on the whole body content of zinc, while the vertebral column showed a reduced content of zinc
- A reduced digestibility of magnesium resulted in a reduced whole body content of magnesium, but no change in the vertebral column

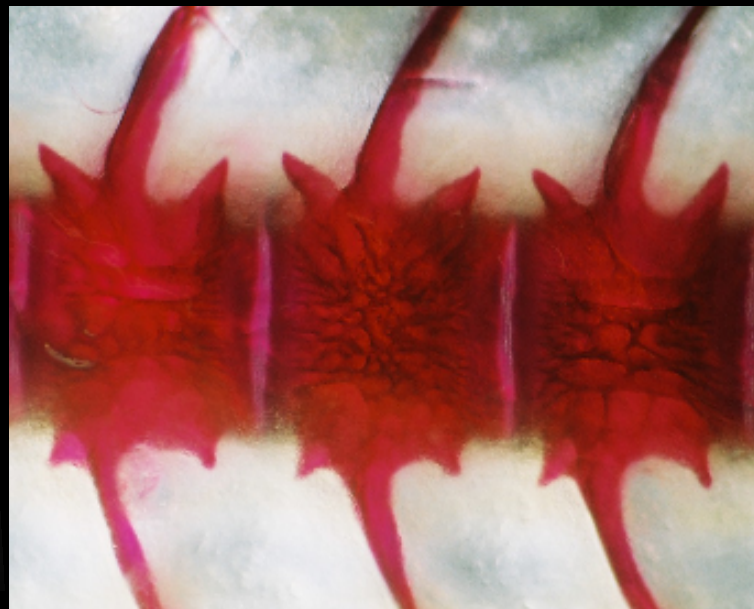
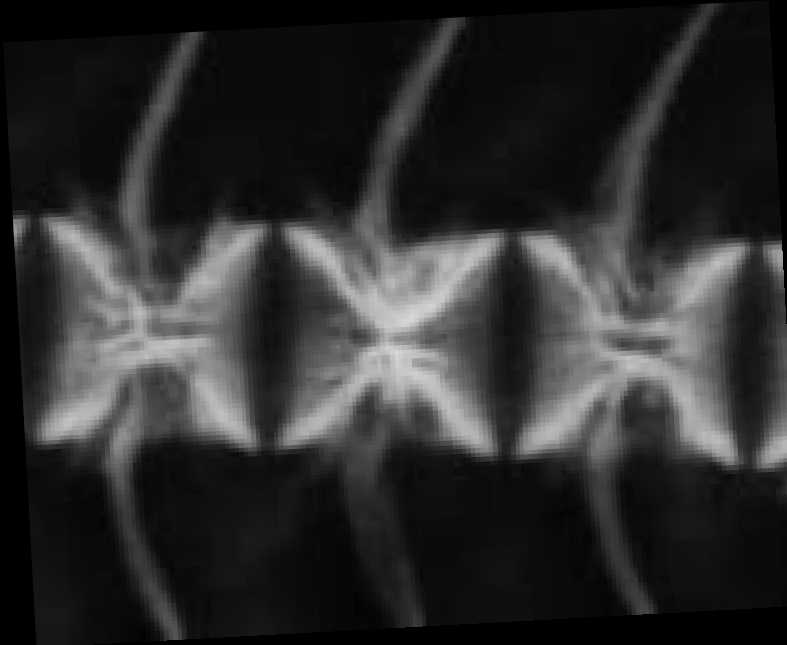


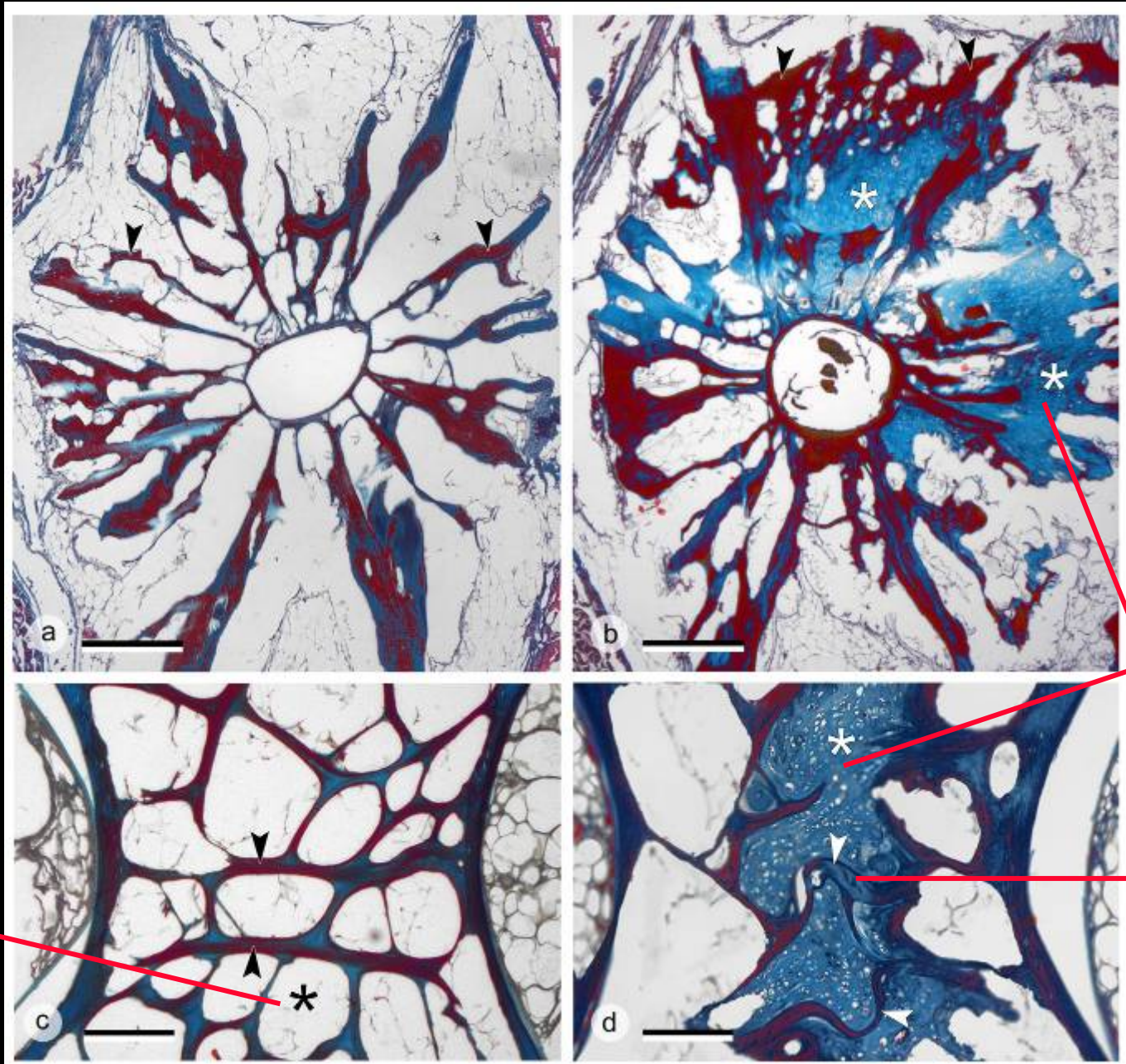
146mm











Ectopic cartilage

Distorted bone trabeculae

Adipose tissue

Control

HD vertebrae

Conclusions

- At the start: 16% of the fish had HD vertebrae
- At the end: 45 to 60% of the fish had HD vertebrae
- Tendency to a higher number of fish with increasing levels of phytic acids
- The fish had at the start a somewhat low level of zinc (20,6 mg kg⁻¹)
- A reduced content of zinc in the vertebral column with increasing levels of phytic acid in the feed

Conclusions

- The radiographic images show HD vertebrae as more radio dense than the surrounding vertebrae
- Bone staining show similar degree of staining of HD vertebrae and normal vertebrae, but the HD vertebrae have a denser trabecular network
- HD vertebrae was found mainly between the 30. and 50. vertebra (from front) and was found both in malformed vertebrae and in vertebrae with an otherwise normal shape

Conclusions

- Large bone trabeculae in non-altered vertebrae had a predominately anterior-posterior orientation whereas the numerous trabeculae of HD vertebrae appeared to be orientated in all directions
- The histological sections revealed that the increased radio density of HD vertebra not only relates to increased trabecular density but also to the ectopic presence of cartilage
- Cartilage in HD vertebra occupies bone marrow space which is taken by adipose tissue in non-altered developed salmon vertebrae

A close-up photograph of a fish's scales, showing a repeating pattern of red, star-shaped structures. The scales are arranged in a regular, overlapping grid. The red structures have a central point and several radiating arms, giving them a star-like appearance. The background is a light, mottled greenish-grey color.

Thank you for the attention!

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