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METAL, SWORDS, AND BIRDS.
A MYTH SPANNING TIME, PLACE, AND CULTURES

Abstract: During the late 1950s, a discovery of precipitates interpreted as nitrides in the structure of Iron Age iron objects led to the forming of a hypothesis, in which deliberate nitriding of iron in the distant past was implied. The allegedly purposeful introduction of nitrogen to form compounds with iron was linked to the *Þiðriks saga*. There, in a fragment devoted to the making of the sword Mimming, Velent the smith feeds domestic fowl with filings from a ground down blade, which he later picks up from the birds' droppings and reforges into a new weapon of superior quality and performance. Bafflingly, this seemingly unbelievable story appears in faraway lands, in different time periods. The paper presents the context and circumstances of the occurrence of this myth and provides a technological commentary.

Keywords: iron nitriding, swords, Velent the smith, Iron Age, Middle Ages

The myth in question consists of a procedure, in which chunks or filings of iron are passed through fowl's digestive tracts. From the bird droppings, the pieces of metal are picked and reforged into a material of superb quality, which could be used to make a blade fit for fabulous deeds. Versions of this curious and quite a persistent story are found in historical sources of a very broad chronological and cultural range, achieving a legendary status and becoming widespread by the mid-11th century.

The *Þiðriks saga* was compiled in Norway in the 13th century, but it contains some early contents from (mostly) German and Scandinavian traditions. It has much to tell concerning a few famous swords, Mimming among them, whose making is described here in detail. First, Velent the smith made an unnamed sword in seven days, and tested it for the king who ordered the weapon, by cutting a piece of felt carried downstream by a river. Claiming it not to be a finished product yet, „Velent went to the smithy and took a file and filed the sword down to dust. He took the filings and mixed them with meal, and then he took poultry[1], starved them for three days, and took the meal and gave it to the birds to eat. Then he took the birds' droppings and brought them to the forge and worked out all the soft parts of the iron; and from it he made a sword which was not as big as the first one [...]. Then Velent went to his smithy and filed the sword to pieces [again – P. K.], and carried out the same process as he had done before. And when three weeks were passed, Velent had made a shining sword, inlaid with gold and with a fair hilt... It was of convenient size, although those he had made before were longer"[2].

Poetic and oral traditions figure to some extent in Al-Biruni's (Abū Rayḥān Muḥammad ibn Aḥmad Al-Bīrūnī) chapter on iron in his *Kitāb al-jamāhir fī-maʿrifat al-jawāhir* (*Sum of Knowledge about Precious Stones*), written probably between 1041–1050: „A Hundhali poet said: »Be content [...] of pure iron that has suffered long working and the stomach of a hungry bird.« [...] this means that this iron is cut up and heated until it becomes like hot coals, and is thrown to the ostrich so that the dross may be removed in its stomach. The ostrich will then excrete it pure and in the proper state to have swords struck from it, and to be ground and polished. Those who have witnessed ostriches swallow the heated iron assert that it does not linger in their stomachs; rather they excrete it immediately. I have also heard concerning *shāburqān* [„hard"/„male" iron – bloomery (direct process) steel – P. K.], from a number of sources, that the Russians and Slavs would cut it into small pieces, work it into a powder, feed it to ducks, and then wash it out from their dung. They repeat this action many times, and then they weld it together after immersing it in the fire, and they forge their swords from it"[3].

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[1] Geese and hens in an alternative version – cf. Bertelsen (ed.) 1905-1911, 99.

[2] Davidson 1994, 159-160; Hall 1995, 197-201.

[3] Hoyland and Gilmour 2006, 150 [250].

Fig. 1. Man feeding horseshoes and nails to an ostrich. The Queen Mary Psalter, 1310-1320, London, British Library, Ms Royal 2B vii, fol. 114.

A suspicion arises that animals became a sacrifice in the name of science and for the sake of technical progress, not to say: human curiosity. The strive for knowledge pushed some people to attempt to acquire knowledge empirically. A report written already in the year 650 refers to ostriches said to be like camels (Greek *stroutokmelo* – „ostrich-camel," Persian *ushturmurgh* – „camel-bird," Turkish *devekuşu* – „camel-bird"[4], probably due to their sheer size), and capable of swallowing iron. Such ostriches were sent as a tribute by Tokharistan to China (Fig. 1). Al-Jahiz (Abū ʿUthman ʿAmr ibn Baḥr al-Kinānī al-Baṣrī) in his *Kitāb al-Ḥayawān* (*Book of Animals*) written in the 1st half of the 9th century, relates an experiment that had been told to him. Two scholars threw small heated bits of metal, which were consumed by an ostrich with relish. Hungry for more knowledge and wanting to learn whether the bird was able to digest the metal, they gave it red-hot scissors, which the ignorant ostrich ate as well. The sharp tool pierced its neck, killing it in the process. Al-Jahiz concludes that this marked the end of the experiment, as the two scientists got their answer. The legend of iron-digesting birds persisted in Europe as well. In the 13th century *On animals* (*De animalibus*), its author Albertus Magnus describes experiments he carried personally, during which he spread pieces of iron before a number of ostriches. Unfortunately, even though they were keen on consuming stones and broken bones, they did not find the metal palatable[5].

Despite the saddening and tragic fate of poultry or fowl, this paper primarily addresses its potential as bio-machines producing iron or weapons of far above-average quality. Indeed, ancient Arabic lore accorded specific properties to certain anatomical parts of the ostrich. A belief existed that the blade of an iron sword or a dagger, having stayed in the bird's gizzard, was unalterable and unbreakable[6]. A 14th century author Muḥamraad Ibn Manglī even argues that this very fact was demonstrated by means of experimentation[7]. Albeit with reservations, a process of manufacturing such a steel in i.a. Damascus was also described in early modern Europe by the Italian Renaissance master craftsman Vannoccio Biringuccio in his *De la Pirotechnia* (*About pyrotechnics*) published in 1540: „they file it, knead it with a certain meal, make little cakes of it, and feed these to geese. They collect the dung of these geese when they wish, shrink it with fire, and convert it into steel. I do not much believe this, but I think that whatever they do is by virtue of the tempering [quenching – P. K.], if not by virtue of the iron itself"[8].

All in all, these stories are rather bizarre and puzzling. If taken into consideration seriously, what could have been the purpose and effect of such a treatment? Biruni seems to suggest that the passing of chunks of hot iron through the digestive system of an ostrich led to the removal of slag or dross. The whole procedure was believed to give a purer and harder metal. Édouard Salin saw this as a plausible result. His assessment was made after a practical

4 Viré 1993, 828.
5 Buquet 2013.

6 Viré 1993, 830.
7 Buquet 2013.
8 Smith and Gnudi (eds.) 1990, 70.

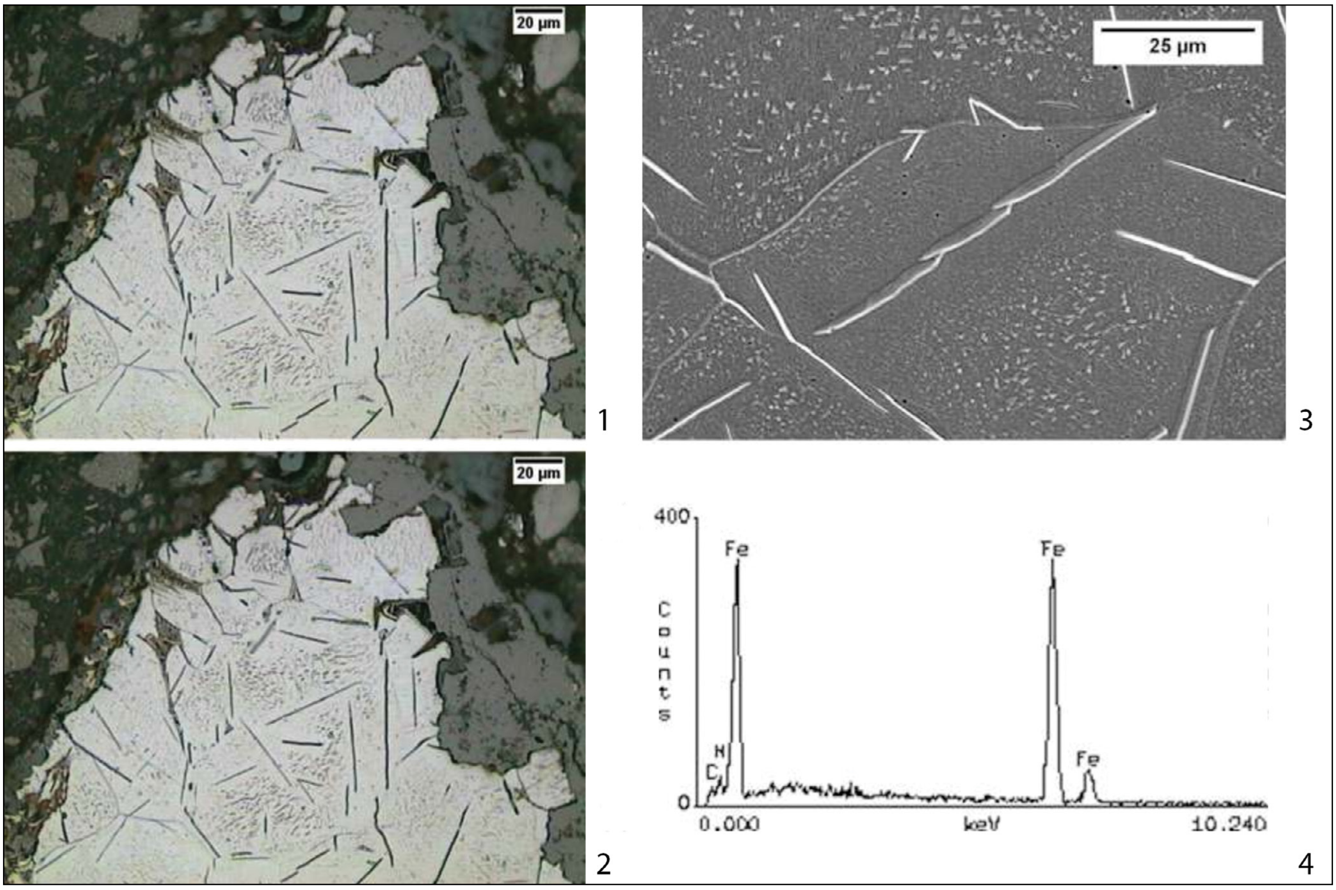

Fig. 2. Microstructure of a sword from Kamieńczyk – ferrite with nitride (?) precipitates in the weapons' edges: 1–2 – optical microscopy; 3 – SEM morphology; 4 – EDX spectrum of a needle. After Kędzierski et al. 2010, Figs. 4, 5.

experiment he carried with a duck. He gives no further details, though[9]. Carl J. Ballhausen gave an opinion that since fowl liked to peck at bright particles of a certain size, they could devour tiny bits of metal lying around a smithy. If they were further encouraged to repeat this action, the content of their stomachs could be removed afterwards and sorted for later use. The author goes on to say that a poultry breeder, whose birds had access to the yard of a ferro-alloy factory, confirmed that the stomach content of his birds consisted almost entirely of bright metals and slag particles of rather uniform size[10]. Considered was a possibility of mixing small pieces of soft iron and pig iron produced by chance in the hearth of the smithy, which could be forge-welded while wrapped in an iron sheet and repeatedly folded and reforged in a fashion similar to „the old Japanese procedure for the preparation of Damascene-type blades". The repetition of this operation could be due to problems with obtaining a mixture of the correct proportions of both components[11].

Some interpretations by modern scholars suggest that apart from the purification of metal by slag removal, the digestive process introduced nitrogen to the metal, which was a hardening agent[12]. Many iron artefacts coming from cremation burials, which were examined metallographically, were found to contain nitrogen in the form of dark shorter and longer needles of iron nitrides, present mainly in the outer areas of specimens in the zones with the largest ferrite grains[13]. Contrary to this belief, Vagn Fabritius Buchwald suggests that these precipitates in historic iron alloys are not nitrides, but misidentified phosphides[14]. As most recent studies evidence, these needle-like structures might as well contain arsenic[15]. In the worst case, all of the above possibilities may be true.

A few hours of exposure to dilute hydrochloric acid present in a bird's stomach might dissolve a little slag near the surface, but any more than a minimal effect cannot be expected. A hammer-welding process of filings small enough to benefit in any way from such a process is well beyond possible, although, in fact the only logical

[9] Salin 1957, 96, note 1.
[10] Ballhausen 1956.
[11] Davidson 1954, 194.

[12] Needham 1964, 43ff.
[13] Coghlan 1956-1957; Piaskowski 1959; Piaskowski 1961; Piaskowski 1962; Bhardwaj 1979, 160-165; Biborski et al. 1982; Biborski et al. 1997; Pleiner 2006, 66, 70, 101, 197, 242; addressed in: Kędzierski et al. 2010, 271; Fig. 2; in general, nitrogen tends to concentrate in weld-lines – Rubinson 2010, 39-42.
[14] Buchwald 2005, 120, 171-172; cf. Doan and Goldstein 1969.
[15] Föll (n.d.), 282.

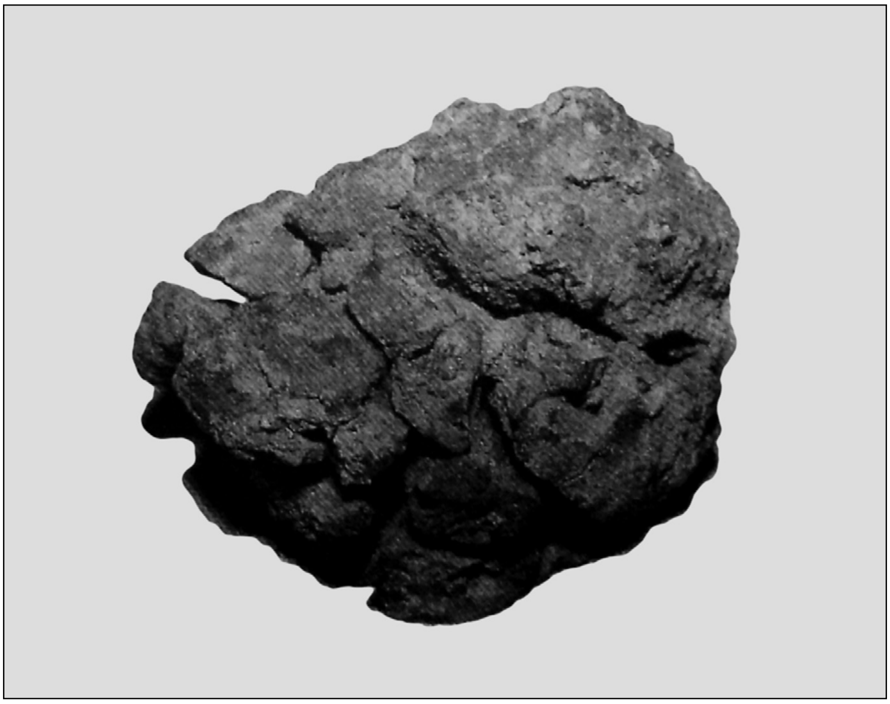

Fig. 3. Corroded remains of an egg-shaped (c. 5 cm wide) crucible steel ingot found near the 9th-10th c. steel-making workshop at Merv, measuring c. 5 cm across. After Hoyland and Gilmour 2006, Fig. 14.

way would be to try to do this in some metal wrappings. In any case, this unlikely process would only re-introduce as much if not more slag than removed by the bird's digestive tracts[16]. Remelting of such a fine material would also prove pointless – because of the amount of surface energy of the whole batch, it would be lost due to burning (oxidation). Only a crucible could provide an atmosphere devoid of oxygen that would make it possible to consolidate the material into a single workable piece.

The idea of nitridation was brought about also due to the presence of nitric dung. Under high temperatures, nitrogen reacts with iron and produces hard nitrides, which precipitate when oversaturated. Intentional nitridation as a method of steel hardening is applied in modern industry and – regardless of the method used – it always requires a prolonged exposure in an ammonia medium at high temperatures. This is conducted in special furnaces. Leaving aside Buchwald's opinion, nitrogen can only penetrate iron from the air-blast when smelting or during the burning of a (funeral) pyre, and appears in the form of needles only when the cooling rates of metal are low (annealing)[17]. Very little to no hardening effect of the alleged nitrides has been observed so far in archaeological artefacts[18]. Thereupon, there is no archaeometallurgical evidence of purposeful iron nitridation.

As pointed out by Robert Hoyland and Brian Gilmour, the different stories corrupted in transmission to varying extent could point to a particular sort of secondary iron processing of Central Asian origin. Some memory of it was carried into Europe during the widespread migrations in the middle of the first millennium AD and later brought back by the Vikings when their long distance routes to the Caliphate were established. Small pieces of both soft and hard iron together with other ingredients were fired and melted in a crucible to produce *fūlādh* – crucible steel. The resulting material was pure (as alluded to by different Arabic authors), in the sense that most of the slag had been removed in the liquid phase, and the resulting alloy was highly carburised (very hard). Some of the products came out of the furnace in the form of eggs (Fig. 3), which were made into swords and other artefacts. Another, Chinese version of the story may be a parallel corrupted account that travelled from Tokharistan. It was a successor state to Bactria and part of Transoxiana, a region which was historically known as an important producer of crucible steel, as confirmed by archaeological surveys. The confusion of exotic egg-shaped steel ingots with exotic birds should be understandable. This possibly led to the emergence of such a popular and long lasting myth connecting metal, birds, and swords[19].

[16] Hoyland and Gilmour 2006, 159.

[17] Pleiner 2006, 70; cf. Jack 1951.

[18] Tylecote 1986, 193; Scott 1990, 16, 19; Kędzierski et al. 2010, 271.

[19] Hoyland and Gilmour 2006, 158-161.

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Streszczenie

Metal, miecze i ptaki. Długowiekowy mit rozprzestrzeniony na wielu terytoriach i w różnych kulturach

Zabieg metalurgiczny, którego zapis odnaleźć można w różnoczasowych źródłach pisanych (europejskich, arabskich, chińskich), dotyczy karmienia ptaków drobinami żelaza, które po opuszczeniu układu pokarmowego zwierząt łączono w jeden kęs metalu, mający dawać głownie mieczowe doskonałej jakości. Kolejne przekazy źródłowe informują o różnych, zwykle inspirowanych przez człowieka, okolicznościach konsumowania przez ptaki kawałków czy przedmiotów żelaznych oraz o konsekwencjach tych działań. Wśród nich znajdowały się także opinie o korzystnej przemianie metalu i walorach powstałych z niego wyrobów.

W piśmiennictwie naukowym zaproponowano kilka koncepcji ewentualnej popłatności takiej procedury. Pierwsza dotyczy oczyszczania metalu z wtrąceń żużla i zendry w wyniku działania kwasów żołądkowych. Druga sugeruje możliwości mieszania ze sobą drobin miękkiego żelaza i żeliwa, które po dalszej obróbce dać mogły dobrą jakościowo stal wysokowęglową. Trzecia zakłada nasycenie metalu azotem. Każda z tych hipotez jest wysoce spekulatywna. Co prawda, publikacje archeometalurgiczne raportują obecność faz azotkowych w wyrobach żelaznych, wśród nich także mieczy z epoki żelaza, jest ona jednak rezultatem procesów zachodzących w zupełnie odmiennych warunkach ciśnieniowo-temperaturowych, niestanowiących w tym przypadku intencjonalnego zabiegu azotowania. Istnieje także możliwość, że związki te są błędnie rozpoznanymi fosforkami żelaza.

Mit o mieczach kutych z kawałeczków metalu, które przeszły przez ptasi układ trawienny, może mieć swoje źródło w produkcji stali tyglowej pochodzącej z Azji Środkowej oraz Półwyspu Indyjskiego, którą wytwarzano, przetapiając w tyglach kawałki żelaza z dodatkiem materiałów węglonośnych. Z uzyskanego tym sposobem, często jajowatego, wlewka kuto głownie znakomitej broni białej.