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COULD *KALEVIPOEG* HAVE BEEN HUMAN?

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The article is based on a graduate thesis by Martin Marek Mileiko delivered at the department of physics of the University of Tartu in 1994 (Mileiko 1994). The thesis aims to shed light on the application of physics to the areas commonly considered as very remote from physics. Mileiko's thesis received wide attention among scientists and was assigned the highest grade. As the results of the work have attracted further attention (see, e.g., Voolaid & Mileiko 1996, Voolaid 1998), the topic has been elaborated on even more. The following is but a fancy, a mind game which has nothing to do with reality, or folklore, for that matter. But why not play the game?

Kalevipoeg, in some regions also known as Sohn (Kreutzwald 1975: 28), the youngest son of Kalev and Linda, is the best known Old Estonian epic hero. Various natural monuments like furrows, beds, stones he arguably threw, etc. still bear witness to Kalevipoeg's adventures (Laugaste, et al. 1959)**.** As compared to humans, all these monuments are extremely large. The furrows are tens of metres deep and tens of kilometres long, the thrown stones weigh hundreds of tons. Judging by that Kalevipoeg must have been very large indeed. Could someone of that size be human? The national epic offers no explicit answer to that question. The only indication to his human origin is his intimate relations with mortal*Saarepiiga* [The Isle Maiden] (Kreutzwald 1975: 54). The present work will make an attempt to find out whether Kalevipoeg could have been human, on the presumption that Kalevipoeg did really exist and that the aforementioned natural monuments are connected to him. We will pose a hypothesis that Kalevipoeg was an extremely large and strong person and will put the hypothesis to test.

THE METHOD

Firstly, let us determine Kalevipoeg's height. For that we simply consider the length of his beds, as a bed is generally as long as the

person who sleeps in it. There are several natural monuments in Estonia, called the beds of Kalevipoeg, which length is e.g. 85 m at Alatskivi, or 40 m near Lake Saadjärv (Kirt 1988). The length of other similar monuments is approximately the same. In order to simplify the estimation we will consider the length of a bed 100 metres and equal it with the height, L_K, of Kalevipoeg.

Could a man of this stature have performed all the feats commonly attributed to Kalevipoeg?

To solve this problem we have to examine the feats of Kalevipoeg (the casting of huge rocks and carrying a load of boards from Pskov), as there are quite a few references to that in legends. On the basis of the estimated height of Kalevipoeg we should be able to determine whether a 100 metres tall human could have performed such deeds. If he could, we have reason to believe that Kalevipoeg was human, if not, he must have been of non-human origin.

Our estimation is based on a method called scaling (Marion 1996). Namely, the qualities of a body, like muscular strength, are related to the so-called characteristic dimension. The dimension of a body can be called characteristic, if it functions as a means for describing the body as a whole. For example, the characteristic dimension of a cube is the length of its side, the characteristic dimension of a circle is its radius, etc. The characteristic dimension of an ordinary human is therefore its height, L_l, and the characteristic dimension of Kalevipoeg is his height, L_K.

The larger a person's characteristic dimension, the stronger he is, as muscular strength depends on the cross section area of a muscle. The larger the area, the more myofibrils the muscle contains. A taller man with proportionally developed body has thicker arms with stronger muscles.

We will come to the value to be determined (the distance of the stone's cast or the weight of the carried load) by comparing the abilities of a normal human to these of Kalevipoeg. Disregarding the physical and mathematical details of the problem, we will hereby apply the terms derived in the graduation paper (Mileiko 1994), which allow us estimate the distance, x_K, of Kalevipoeg's stone's throw:

$$x_K = \frac{L^3{}_K}{L_I^3} \cdot \frac{m}{M} \cdot x_I \quad (1),$$

where m is the mass of the body thrown by an ordinary man, M is the mass of a body cast by Kalevipoeg and x_I is the distance of a body thrown by an ordinary man.

The stone-throwing hypothesis

The estimation of the distance of a stone cast by Kalevipoeg is based on one of his longest known stone throws, described in the legend about the stone of Painuva (Laugaste et al 1959):

Once again Kalevipoeg visited Finland. The Evil One had come to Viru [Estonia] *to spite him and throw stones in front of the seagoing ships. Kalevipoeg had seen Old Nick from Cape Porkkala in Finland and thrown a huge rock at him, which had landed near Mohn, the tip of Cape Turbuneem, right under the Evil One's nose without actually hitting him.*

Geologists have estimated the volume of Painuva stone at 340 cubic metres. The density of the rock being 2.800 kg/m^3 (granite), we will find that its mass is M ~ 1.000 tons. We will calculate the throwing potential of a human on the basis of grenade throwing, which was a popular sports during the Soviet time and resembles stone throwing. Stronger men used to throw grenade (m = 0.7 kg) to the distance of ca 80 metres. To simplify the calculation, we will determine the distance of grenade throwing at x_I = 100 m and the characteristic dimension of a human L_I = 2 m. The characteristic dimension of Kalevipoeg L_K = 100 m.

The estimated distance of stone's throw from the formula (1) indicates that had Kalevipoeg been human he would have cast the rock to the approximate distance of 10 m. Which is considerably less than the geographical distance between Cape Porkkala and Cape Turbuneem, which is approximately 80 km.

How tall should have been a human Kalevipoeg to be able to throw a rock so far? We will find this height also with the help of the formula (1), assuming that x_K = 80 km. The result is approximately

2 km. Consequently, the stone's cast reveals that a man who slept in Kalevipoeg's bed could not have been able to throw the rock as far as Kalevipoeg.

The boards-bringing hypothesis

Secondly, we can test our hypothesis on the basis of a legend describing how Kalevipoeg brought boards from Pskov (Laugaste et al 1959)**:**

Once Kalevipoeg forded through Lake Peipus, carrying seven hundred boards on his back, and cursed that the damned water wetted his dick.

Again we will estimate the value of Kalevipoeg's capacity on the basis of the formula derived in the thesis (Mileiko 1994)**:**

$$M = \frac{L_K^2}{L_I^2} \cdot m \qquad (2),$$

where M is the mass of Kalevipoeg's load and m is the mass load of an ordinary human.

We will equal the mass load of an ordinary man with a mass of a larger backpack, as according to the legend the load was not too heavy: *The load of boards was not too large / Nor was it too small, / Just the size of a man's waist* (Kreutzwald 1975: 135). Thus, let us assume m = 30 kg, which is a proper weight for a hiker's backpack. Calculations using the formula (2) indicate that Kalevipoeg could carry approximate 75 tons of boards across Lake Peipus.

However, according to the legend (Laugaste et al 1959), his load consisted of 700 boards with particular dimensions:

The boards were not thick
Somewhere over three inches,
Nor were they wide
Somewhere over two feet
Nor were they long
Somewhere over three fathoms
(Kreutzwald 1975: 135).

Thus, a board was approx. 0.08 m thick, ca 0.6 m wide and ca 21 m long. Considering the density of wood to be equal to 700 kg/m^3, the load must have weighed ca 500 tons. But a load like that must have been beyond the powers of a 100 m tall human Kalevipoeg. According to the formula (2), Kalevipoeg should have been at least 300 metres tall to be able to carry such a load. However, legends tell that Kalevipoeg could carry even heavier loads: some ancient accounts reveal that Kalevipoeg has carried a load of nearly 1700 boards. Regretfully, the accounts mention nothing of the size of the boards in the load, which makes it impossible for us to estimate the weight of the load.

WHY KALEVIPOEG COULD NOT HAVE BEEN HUMAN

The examples might suggest that the human Kalevipoeg must have been much taller than 100 m. But a human body can never reach the height of 100 metres, not to mention even taller heights. There are at least two reasons for it:

Firstly, the bones of a man of this height would crush under the weight of his body, as the mass of body is proportional to the cube of the characteristic length, L_I, while the strength of human bones is proportional to $L_I^{0.66}$ (Kane & Sternheim 1978). Calculation shows that the mass of a 100 m tall giant exerts nearly 200 times higher pressure on his bones than in case of a man of 2 metres. Therefore, the bones of such a tall man would collapse under his body weight and splinter.

Secondly, a man of his stature would have suffered under excessive heating, as his skin surface area would be too small to remove the heat emitted from such a huge body. The amount of heat produced by the body is proportional to the cube of the characteristic length, while the amount of heat emitted through the skin is proportional to the square of the characteristic length (Marion 1996). Consequently, the body of a 100 metre tall giant emits 50 times less heat than an ordinary person, which leads to overheating.

To sum up, we might claim that Kalevipoeg, who might have slept in the natural beds, that can still be seen in different parts of Estonia, could not have been of human origin. His muscles and bones

must have been made of altogether different material than the muscles and bones of ordinary humans.

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