

# Journal of Interdisciplinary Science Topics

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## Golden Fleece: A Heavy Task

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24/03/2013

### Abstract

Of the many infeasible creatures and relics in ancient Greek mythos, the Golden Fleece from Jason and the Argonauts has drawn much attention from historians as to what it represented in terms of politics, technology and religion. However, we will instead explore the scientific basis to the possibilities of the existence of a gold fleeced ram. This article specifically addresses the physical and biophysical aspects to this multidisciplinary problem.

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### Introduction

The ancient Greek tale of Jason and the Argonauts is one of the most famous and foundational in classical Greek history. In one of its oldest and most complete accounts, the 3rd century BC *Argonautica* by Apollonius Rhodius, the hero Jason quests across uncharted seas and overcomes impossible obstacles in order to obtain a legendary relic, with promise of his rightful crown. This relic, found in the land of Colchis (the eastern Caucasus), is none but the fleece of a ram with hair of gold. Although a golden fleeced ram borders on the ordinary among the many fanciful creatures and relics in the tales of ancient Greece, it is the fleece's representation of power that is at the heart of Jason's quest. However, if such a creature were to exist, it would raise a number of issues regarding physical, geochemical, biochemical, and evolutionary feasibility.

### Fleece Weight

The fleece of a ram, like the fur and hair of other mammals, is made primarily of keratin [1]. In comparison, the Golden Fleece will be modelled to have a primary composition of gold. In order to calculate the weight of the fleece, the density ratio of the constituent keratin and gold is assumed to be equal to that of the woollen and aurous (made of gold) wool. In essence, this is an assumption that there is the same volume of gold per volume of aurous wool as there is keratin per volume of ordinary wool. It can then be said that this ratio would be equal to the ratio of the fleece weights, as

shown in the equation below, since the volume components cancel.

$$\frac{\rho_{ker}}{\rho_{Au}} = \frac{m_{ker}}{m_{Au}}$$

Here,  $\rho_{ker}$  is the density of keratin, roughly 1280 to 1340 kg m<sup>-3</sup> [1], and  $\rho_{Au}$  is the density of gold, at 19320 kg m<sup>-3</sup> [2].  $m_{ker}$  and  $m_{Au}$  are the respective weights of a woolen and aurous fleece.

In the days of 3rd and 4th century BC Eastern Europe, sheep would certainly have looked rather different to today's industry-driven, highly modified stock. However, we cannot assume that the sheep used in civilised ancient Greek agriculture would be similar to purely feral or wild sheep, such as the Armenian mouflon [3]. A group of nomadic peoples, the Sarakatsan, originating from ancient Greek tribes, preserved the culture of ancient Greek shepherding in areas of the Baltics until the last century [4]. Ancient Greek agricultural rams are likely to have resembled those of the Sarakatsaniko sheep, which average 66 kg and have a mean wool weight of 3.5 kg.

Taking this wool weight as  $m_{ker}$  gives the Golden Fleece a weight of 50 to 53 kg. At the weight of a small person, the depictions of the Golden Fleece, being easily adorned on the shoulders of Jason and his companions, are surely inaccurate.

### Maximum Carry Weight

Regarding the poor animal itself, carrying such a heavy fleece during its whole life before maturation and eventual slaughter may cause issues regarding the biophysical limits to ungulate carry weight. Research has been carried out on pack-animals such as horses, mules and goats, while not on other herd-animals that are not typically used for this purpose, such as sheep. Nevertheless, this information may be used to get a reasonable idea as to the weight the ram could withstand. Equine veterinary scientists have shown that a horse carrying more than 20% of its weight is likely to cause damage to muscle and joints [5]. Some sources, however, quote the remarkable strength of mules carrying comfortably over 30% of their body weight [6]. The smaller pack-goat, more similar to our ram, is said to also be able to carry a third of its weight [7]. The Golden Fleece is calculated to weigh around 80% of the mass of the average Sarakatsaniko ram [4]. It

therefore needs the strength of a ram over double its size in order to carry its own fleece. A larger sheep will have a relatedly increased fleece weight, and an even heavier task.

### Conclusion

Research separately carried out by this group suggests that the golden wool would be up to 1000 times more thermally conductive than ordinary wool. The sheep would require a much thicker fleece to survive in the Caucasus, where temperatures in lowland regions remain negative throughout winter [8]. This, along with the proportionality issue mentioned above, suggests that the 50 kg fleece is likely to be a severe underestimate. This indicates the extremely low likelihood that such a creature could survive to maturity, as being in perpetual pain and exhaustion would make it unable to flock and evade predation successfully.

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