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Water Requirements on the Journey Through Mordor

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Abstract
This paper considers the water requirements of the two hobbits, Frodo and Sam, on their journey through Mordor to Mount Doom. The number of kcal expended per day are calculated and from this the water requirement in litres is found. The ability of the hobbits to carry their water is investigated and the conclusion is reached that they would not have had the strength to carry all the water necessary for their needs.

Introduction
In *The Lord of the Rings*, a fictional work by JRR Tolkien, two hobbits, Frodo and Sam finish their quest by trekking through the land of Mordor to reach the fiery mountain of Mount Doom [1]. This paper will examine the water requirements of the two hobbits on their journey through Mordor. It will be said that the journey through Mordor proper will begin just after Sam rescues Frodo from the Tower of Cirith Ungol 14th March T.A. 3019 and lasts until they reach Mount Doom on the 25th March T.A. 3019 [1, 2]. Their journey will take them 10 days.

Calorie Expenditure
In order to calculate the water requirements it will be necessary to calculate the number of calories expended on the journey. Here this paper draws substantially on two other papers by Manoharan & Rosetti [3, 4]. The journey from Cirith Ungol to Mount Doom is a journey of 151 miles [2]. So if they travelled on average 15.1 miles per day at a rate of 2.4 mph [6] they would have spent 6.3 hours per day walking. It is imagined that they sleep 8 hours per day and spend the rest of the time (9.7 hours) resting. Using the same method as outlined by [4] this would mean their calorie expenditure would be in total 2402.36 kcal per day. Taking the Basal Metabolic Rate of the hobbits as 76 kcal hr^{-1} and scale factors for resting and heavy duty walking as 1.2 and 1.9 [4] the following table (see table 1) can be produced.

Exercise	Hours spent	Scale factor	Kcal per day
Sleep	8	1	608
Resting	9.7	1.2	884.64
Walking	6.3	1.9	909.72

Table 1 – Summary of the duration and energy expended for each activity type during the journey through Mordor.

This would mean that one hobbit expended 2402.36 kcal day^{-1} or 24023.6 kcal over the entire journey.

Water Requirements
Interestingly there is no agreed upon method to calculate water requirements for adult humans. For example some authors suggest the surface area of the individual be taken as a guide (ml/m^2) [5]. However, for the sake of this paper it will be said that the body needs to consume 1 ml for every kcal expended [5]. This would mean that one hobbit would need to drink 2.4 L day^{-1} or 24 L over the entire journey. It should also be noted that Mordor is a hot and dry environment and so the water requirement calculated here is likely to be even higher as the hobbits would lose water through sweat. For a human the average sweat rate per hour in a hot, dry environment is thought to be 1.2 L [6].

Weight Bearing Capacity
In the book the hobbits only have two opportunities to stop for water when they find two streams along the way. This means that they would have had to set out carrying most of the water needed for the journey. As the weight of 1 L of water is 1 kg this

means that one hobbit would have needed to have started off carrying 24 kg of water. They are in a worse case if it is considered that Frodo is in no condition to carry anything and again even worse if the return journey is considered.

How much can the hobbits carry? According to Adam [7] the strength of any organism depends only upon the cross-sectional area of its muscles. This implies the following two equations:

$$\text{Weight hobbit can lift} = \frac{\text{Weight human can lift}}{\alpha^2}, (1)$$

$$\alpha = \frac{L}{l}, \quad (2)$$

where *L* is the height of human and *l* is the height of hobbit.

The average height of a human male is 1.73m [8]. The average height of a hobbit is 1.07m [3]. According to Adam [7] humans can lift half their weight so if the average weight of a human is 83.6 kg [9] the weight an average human can lift is 41.8 kg. Using equations (1) and (2) this means that the weight a hobbit can lift is:

$$\text{Weight a hobbit can lift} = \frac{41.8}{\left(\frac{1.73}{1.07}\right)^2} = 16.1\ kg$$

Conclusion

It can therefore be concluded that the hobbits would not have had the strength to carry all the water they needed on their journey through Mordor to Mount Doom. As Sam admits 'the water's going to be a bad business.'[1].

References

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