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Could a super mutant behemoth really exist?

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Abstract

The post-apocalyptic world of the *Fallout* series is home to an array of mutated creatures, including 'super mutants', humans that have been mutated to be much larger and stronger. The biggest of these is the super mutant behemoth, which can grow to gargantuan sizes, run very fast and perform acts of incredible strength. This paper investigates the viability of such a creature existing, using dimensional analysis to determine what would happen if an ordinary super mutant were scaled up to the size of a behemoth. First the relative strength of the behemoth was estimated, then the effects of gravity on such a creature were discussed. It was found that the behemoth represented in-game would find it very difficult to survive in reality.

Introduction

Fallout is a role-playing game series that takes place in a post-apocalyptic world, ravaged by nuclear war in the year 2077; all games in the series take place in what was once America.

The game features 'super mutants', which are the result of humans having been exposed to Forced Evolutionary Virus (FEV). They are physiologically very different from ordinary humans, but the most immediately noticeable effects are their immense size and strength, with a standard super mutant standing at approximately 10.4 feet tall (7.8 feet when hunching) and weighing around 800 pounds [1]. Two variants of super mutants, the ones created in the underground 'vault 87' and those created by the Institute (a scientific group that began operating in the year 2110), grow much larger as they age [2]. The super mutant behemoths are the result of extreme growth, and stand at roughly 20 feet tall, though some sources report specimens up to 30 feet in height [2-4].

This paper will assume that the body layout of a behemoth is geometrically identical to that of a standard super mutant (SSM), and that it is 30 feet tall.

Theory, Calculations and Discussion

As behemoths hunch over in the same manner as SSMs, the ratio of upright height (U) to hunched height (H) are the same. Given the aforementioned values:

$$\frac{U_{Behemoth}}{H_{Behemoth}} = \frac{U_{SSM}}{H_{SSM}}$$

$$U_{Behemoth} = \left(\frac{U_{SSM}}{H_{SSM}}\right) H_{Behemoth}$$

$$U_{Behemoth} = \left(\frac{10.4}{7.8}\right) 30 = 40\ feet.$$

This makes a behemoth taller than a standard super mutant by a factor of roughly 3.85. To assess the strength of a behemoth, the strength of an SSM must first be estimated. In *Fallout 2*, the main character is able to beat a super mutant (Francis) in an arm wrestle. However, to have a realistic chance of winning the player must have a strength and endurance rating of at least 9/10 [5]. While this is immensely strong, it suggests that the strength of an SSM falls within the realms of a human. However dialogue from *Fallout 3*, most notably the dialogue of the scientist scribe Bowditch, states that SSMs are capable of crushing a human's skull and even tearing people in half with their bare hands, acts requiring strength far beyond that of a normal human. Animals such as gorillas are capable of extreme acts of

strength, but that is because their nervous system is balanced to do so; their incredible strength comes at a loss of fine motor control [6]. Super mutants do appear to exhibit some loss of fine motor control in their movements and in the weapons they will make use of, but in general are capable of actions such as writing. However, super mutants are also much larger than gorillas, and muscle makes up around 75 % of their body mass [7].

This paper will make the assumption that super mutants are roughly as strong as gorillas. While the strength of a gorilla is hard to assess as any of the events humans use to do so require an element of skill, it has been estimated that, with training, a male gorilla could lift about 816 kg [8]. If an SSM is about this strong, it will be able to lift more than twice its own 800 lb (362.87 kg) mass:

$$strength\ to\ mass\ ratio = \frac{816}{362.87} = 2.25.$$

The strength to mass ratio of a behemoth will be considerably different. The mass of a creature scales with its volumetric size. A behemoth is 3.85 times larger than an SSM in all three dimensions, giving a mass of:

$$m_{Behemoth} = (3.85)^3 \times (362.87) = 20.7\ tonnes.$$

Its strength will instead scale roughly with the cross sectional area of its bones and muscle fibres: a two dimensional increase:

$$Behemoth\ strength = (3.85)^2 \times (816)$$
$$= 12.1\ tonnes.$$

So the strength to mass ratio will be:

$$strength\ to\ mass\ ratio = \frac{12.1}{20.7} = 0.585.$$

So the behemoth is far weaker relative to its mass than the SSM. This brings into question their ability to carry several tonnes of equipment around with ease as they can be seen doing in the games, as 12.1 tonnes is the maximum weight that they can carry.

The punishing effect of gravity on the behemoth is also an important factor. Very large land animals such as elephants are almost always quadrupedal, distributing their weight between all legs. For adequate support the larger an animal becomes, the greater the percentage of its total mass must be made up of bone. The bone mass of mammals follows the power law [9]:

$$m = 0.061M^{1.09},$$

where m is the mass of bone and M is the mass of the mammal. Putting the data in for a behemoth yields:

$$m = (0.061) \times (20700)^{1.09} = 3090\ kg.$$

This is almost 15 % of the behemoth's total mass. However, only about 10 % of an SSM's mass is bone [7]. There is also reason to believe that necessary mass increases faster at the upper end of the spectrum. Elephants' bones make up 27 % of their mass, so it's possible the behemoth would need even more, as an elephant weighs at maximum roughly 6000 kg, less than a third as much [9, 10]. Standing bipedal, the behemoth also does not have its weight distributed among as many limbs. The weaker supporting parts of its biology would be at particular risk, such as the cartilage in the knees. It is unlikely that it would be able to run fast as it does in-game, as this would put immense pressure on its unequipped skeleton; it is also likely that it may have other issues, such as spinal problems. All in all, it would find it very hard to survive.

Conclusion
Using dimensional analysis, it has been shown that it is very unlikely that a behemoth could exist as it appears in the Fallout games. It would be far weaker, and would suffer ill effects due to the enormous gravitational forces, which it is not prepared to deal with. This would almost certainly render it incapable of the fast movement seen in-game, and would likely have some more serious effects on its biology, limiting its survival.

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