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Small creatures can lift more than their own bodyweight and a human cannot-an explanation through structural mechanics

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Abstract. Living beings are formed of advanced biological and mechanical systems which exist for millions of years. It is known that various animals and insects right from small ants to huge whales have different weight carrying capacities, which is generally expressed as a ratio of their own bodyweights i.e., Strength to Bodyweight Ratio (SBR). The puzzle is that when a rhinoceros beetle (scientific name: Dynastinae) can carry 850 times its own bodyweight, why a man cannot accomplish the same feat. There are intrinsic biological and mechanical reasons related to their capacities, as per biomechanics. Yet, there are underlining principles of engineering and structural mechanics which tend to solve this puzzle. The paper attempts to give a plausible answer for this puzzle through structural mechanics and experimental modeling techniques. It is based on the fact that smaller an animal or creature, it has larger value of weight lifting by self-weight ratio. The simple example of steel prism model discussed in this paper, show that smaller the physical model size, larger is its SBR value. To normalize this, the basic length of the model need to be considered and when multiplied with SBR, a constant is arrived. Hence, the aim of the research presented is to derive this constant on a pan-living being spectrum through size/scaling effect.

Keywords: animal behavior; strength to bodyweight ratio; load carrying capacity; biomechanics; structural mechanics; size/scaling effect

1. Introduction

Nature is a treasure-house of puzzles which has paved the way for development of science and technology. Humankind has been working on understanding the various phenomenon of nature that has ended up in the evolution of new laws and theories. Yet many amazing questions are to be answered. The metabolic energy consumed by a walking or running animal is related to the magnitude and rate of isometric force development as well as the mechanical work performed by muscles, but it is not yet clear what portion of the energy should be attributed to each of these factors (Kram and Taylor 1990, Alexander 1991). Every human and animal body is a complex structural system, exhibiting a highly coordinated and actively controlled structural form (Balcombe 2009, Broom 2010). The structure of a human body passively standing on two legs is

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