Researchers discover 'law of urination' for animal pee times

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Credit: puppy-training-solutions

(Phys.org) —Researchers at the Georgia Institute of Technology have discovered that mammals above a certain size appear to conform to what they have dubbed, the "law of urination"—that is, mammals of all sizes, they report, take approximately 21 seconds to void their bladder. Not content to use existing data, the research team undertook field work—visiting zoos and other places where animals reside—where they filmed the animals urinating (or medically speaking—engaging in micturition). They have written a paper describing their adventures and

results and have posted it on the preprint server, *arXiv*, for those that wish to review their work.

The study, led by Professor David Hu, began as a fluid mechanics puzzle: how long should it take animals of various sizes to pee?—an apparently valid question considering the differences in size of not just the animals, but the body parts they use when relieving their bladder. The team notes that there are two main parts involved: the bladder and the urethra—the straw-like tube that carries urine from the bladder to the outside world. They note that gravity is an issue with urination mechanics—large animals, such as elephants (which can drain up to 42 gallons in one release) tend to allow gravity to do all the work. Smaller animals, such as dogs or goats use muscles to help the process along.

Hu left it to his team (of undergrads) to collect field data, recording animals at various sites as they relieved themselves, hopefully, without attracting the notice of others worried they might have less than scientific notions in mind, to learn more. In studying the videos, along with others found on YouTube, the team discovered that regardless of size, all of their subjects appeared to take approximately the same amount of time to finish the job. What's more, they discovered that the body parts used by the animals to urinate tended to have the same proportions, size-wise.

Hu and his team don't speculate as to why animals larger than bats and rats (they take just a second to urinate) take roughly the same amount of time to pee, but do note that nature seems to have made sure it wouldn't take too long. With elephants for example, the urethra is so long that the urine speeds up as it falls, bursting out of the animal like a fire-hose. They also note that they didn't test human beings, though they do suggest it's likely people conform to the law of urination as well, so long as they go when their bladders are full, rather than when it's simply convenient.

More information: Law of Urination: all mammals empty their bladders over the same duration, arXiv:1310.3737 [physics.flu-dyn] arxiv.org/abs/1310.3737

Abstract

The urinary system evolved to eject fluids from the body quickly and efficiently. Despite a long history of successful urology treatments in humans and animals, the physics of urination has received comparatively little attention. In this combined experimental and theoretical investigation, we elucidate the hydrodynamics of urination across five orders of magnitude in animal mass, from mice to elephants. Using high-speed fluid dynamics videos and flow-rate measurement at Zoo Atlanta, we discover the "Law of Urination", which states animals empty their bladders over nearly constant duration of average 21 seconds (standard deviation 13 seconds), despite a difference in bladder volume from 100 mL to 100 L. This feat is made possible by the increasing urethra length of large animals which amplifies gravitational force and flow rate. We also demonstrate the challenges faced by the urinary system for rodents and other small mammals for which urine flow is limited to single drops. Our findings reveal the urethra evolved as a flow-enhancing device, enabling the urinary system to be scaled up without compromising its function. This study may help in the diagnosis of urinary problems in animals and in inspiring the design of scalable hydrodynamic systems based on those in nature.