

## Universal law of urination found in mammals

18:17 17 October 2013 by [Jacob Aron](#)Video: [Math reveals secrets of mammal urination](#)

You'll never look at Dumbo in the same way again. Elephants, cows, goats and dogs all take roughly 21 seconds to empty their bladders. A "law of urination" now explains the physics behind what happens when you just gotta go.

Patricia Yang and colleagues at the Georgia Institute of Technology in Atlanta use high-speed video to study how fluids and animals interact; they have previously investigated [how dogs shake themselves dry](#).

While filming at a local zoo, they noticed that animals of various sizes, both male and female, took a similar time to empty their bladders.

The team filmed rats, dogs, goats, cows and elephants urinating and gathered footage from YouTube of others relieving themselves. Combining this with data on mass, bladder pressure and urethra size, they were able to create a mathematical model of urinary systems to show why mammals take the same time to empty their bladder, despite the difference in bladder size.

Previous models have only considered the effects of bladder pressure, but the length of the urethra turns out to be important as well.

### Elephant pee

"Most of the research is on humans or animals smaller than humans," says Yang. In these species, the effect of gravity can be ignored. That's not true of elephants, whose urethral dimensions are comparable to a household pipe: a diameter of around 10 centimetres and a length of about 1 metre.

In this case size matters, as it means urine feels the pull of gravity stronger at the bottom of the elephant's urethra. This means that as it travels down the pipe, the urine accelerates and its flow rate rises, resulting in an elephant's large bladder being emptied in a similar time to those of smaller animals.

Medium-sized animals like dogs and goats have shorter urethras, so get less of a gravitational boost: their flow is slower. In addition, they have smaller bladders. The result of both effects is that they empty their bladders in roughly the same time as elephants.

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Pees like an elephant? (Image: Francis Dean/REX)

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According to the team's model, an animal's size does make a difference to urination time – but only very slightly. Their law of urination says that the time a mammal takes to empty a full bladder is proportional to the animal's mass raised to the power of a sixth, meaning even very large changes in mass have little effect on the time.

There are limits to this scaling. Gravity only plays a small role in the urination of very small mammals like rats and bats, which urinate in under a second. Instead, viscosity and surface tension dominate, which explains why their urine is released as a stream of individual drops rather than the continuous jet seen in larger mammals.

The team will present the results at the [American Physical Society Division of Fluid Dynamics meeting](#) in Pittsburgh, Pennsylvania, next month. Yang hopes the law of urination might help diagnose urinary problems in elephants and other large mammals. It might even inspire new designs for water towers, which also pump water using the force of gravity, she says.

Journal reference: [arxiv.org/abs/1310.3737](http://arxiv.org/abs/1310.3737)



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