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## Neurotransmitters trigger water vole testes growth as days get longer



A water vole (*Arvicola amphibius*) at La Vezolle, Saint-Julien-Puy-Lavèze, France. Photo credit: Adrien Pinot.

Success is often about timing. Whether departing to migrate or settling down to hibernate, animals are in tune with the seasons to be certain that they don't misjudge when to embark on essential life experiences. And coordinating the arrival of their next litter is equally critical. 'To ensure the survival of mothers and juveniles, many species restrict sexual activity to a limited time window, which leads to synchronization of births when environmental conditions are most favorable', says Matthieu Keller from the CNRS – INRAE Université de Tours, France. And many small creatures effectively put their gonads on ice, to conserve energy until spring, when the days begin growing longer. Knowing that two neurotransmitters – kisspeptin and RF-amide-related peptide 3 (RFRP3), produced in the brain – play a key role in triggering the seasonal growth of many animals' gonads ready for breeding at the right time of year, Keller and his colleagues went in search of male European water voles (*Arvicola amphibius*) to find out whether their testes and scent glands flourish as the days grown longer and whether the regrowth of their gonads is coordinated by the two neurotransmitters.

Although trapping the voles wasn't technically challenging – 'you just have to dig and place the trap', says Kévin Poissenot (INRAE – CNRS Université de Tours) – locating the animals' burrows with Chantal Moussu (INRAE – CNRS Université de Tours) was tricky, and braving the harsh mountain winters where the voles reside, 25 km from Clermont-Ferrand, France, took some courage. Together, over the 17 months from February 2019 to May 2020, the pair visited the voles, collecting males to find out how the size of their testicles varied.

Over the seasons, the water voles' testes increased in size from 0.06% of body mass (February) to almost 0.4% body mass in June – that's a 6-fold increase – before withering again during the late summer and autumn. In addition, the voles' scent glands developed in the late winter and spring before shrivelling in late summer and autumn. The team also checked the pituitary, the region of the brain that produces hormones that might coordinate preparations for the breeding season, and found that it too grew, reaching its largest in April before dwindling to its smallest in November.

In addition, Poissenot analysed the water voles' hypothalamuses, which produce many key hormones, and found that the production of kisspeptin – a key signalling molecule that stimulates reproductive function – fluctuated over the year, peaking in February and November, while cells producing the RFRP3 signalling molecule only appeared in the voles' brains between June and September.

But what was driving the males' dramatic seasonal transformation? After collecting adult males in December 2020, the team transported them back to the lab, providing some animals with 8 h per day of light, to simulate winter, while others were fast-tracked directly to long summer days (16 h per day of light). After 7 weeks, the team checked the testes of the water voles basking in long summer days, and they were almost twice the size (0.44% body mass) of their counterparts that were stuck back in winter (0.26% body mass).

It seems that seasonal changes in day length are the key to driving the physical changes undergone by male water voles in preparation for the breeding season, although the team is a little puzzled by the apparent decline in the kisspeptin neurotransmitter at the time when the voles might need more. However, they suggest that kisspeptin could accumulate in the brain over winter – when it isn't released – ready to spring into action, triggering the regrowth of the males' testes when the sun returns.

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Poissenot, K., Chorfa, A., Moussu, C., Trouillet, A.-C., Brachet, M., Chesneau, D., Chemineau, P., Ramadier, E., Pinot, A., Benoit, E., Lattard, V., Dardente, H., Drevet, J., Saez, F. and Keller, M. (2021). Photoperiod is involved in the regulation of seasonal breeding in male water voles (*Arvicola terrestris*). *J. Exp. Biol.* **224**, jeb242792. doi:10.1242/jeb.242792

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