sweet tooth

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Unlike most birds, a wide range of passerines, including specialist nectarivores like this Malachite Sunbird, can taste sweet flavours.

For years birders have marvelled at birds' impressive sensory abilities. We talk about having the eyes of a hawk, and indeed we know that raptors can resolve much finer visual signals than humans, but all birds have good eyesight to make split-second decisions in flight. Sound is also a major modality for most birds. Acoustic acuity reaches its peak in the barn owls, which use their asymmetrical ears to locate prey in absolute darkness. Birds' use of smell is less well known, but it is extremely well developed in groups such as the petrels, which use scent to locate food at sea and their burrows when they return to their colonies at night. And when it comes to touch, few organisms can match the exquisite touch-sensitive bill-tip organs of birds such as shorebirds and ibises that feed by probing. But what about birds' sense of taste?

Humans, like most mammals, recognise five primary tastes: sweet, sour, salt, bitter and umami, the rich savoury taste associated with certain amino acids. We use these tastes to decide whether something is good to eat or not. Sweet and umami are generally 'good' tastes, whereas sour and bitter tastes typically are 'bad.' Salt can be good or bad, depending on the context and on the physiological state of the animal.

We have known for some time that the responses to different tastes are genetically coded, not learnt. And we now know that the ability to detect these five basic tastes is mediated by different families of genes, which code for the proteins used to detect taste-specific markers in potential food items. By scanning the genomes of birds we can thus infer how different bird species taste their food.

For example, penguins have a rather unsophisticated palate, having lost the ability to detect sweet, umami and bitter flavours (Zhao et al. 2015, *Current Biology* 25: R141–142). This is assumed to be linked to their extreme marine lifestyle. The ancestors of seals and cetaceans also lost the ability to taste sweet and umami flavours as they evolved into marine predators. Various hypotheses have been suggested to explain this pattern, including the masking effect of the high concentrations of salt in seawater and the need to swallow prey whole underwater. However, the penguin's close relatives, the albatrosses and petrels, still have the genes to detect umami and bitter flavours and so we cannot blame their lack of taste ability for their predilection for consuming non-food items such as pumice and plastic.

However, it appears that birds lost their sweet tooth during their early radiation. Sweet flavours are detected by two proteins, T1R2 and T1R3, that work together to detect sugars in potential food items. The genes coding for these proteins are found in most vertebrates, from mammals to fish, but the gene for T1R2 was lost by the ancestor of all modern birds. However, the umami taste receptor is very similar to the sweet receptor, comprising proteins T1R1 and T1R3. We know that the ancestral hummingbird evolved the ability to detect sweet flavours through changes to its T1R1 umami receptor that allows it to mimic the function of the T1R2 protein (Baldwin et al. 2014, *Science* 345: 929–933). This adaptation triggered the extraordinary radiation of hummingbirds from their swift-like ancestor.

Now a new study has shown that a similar (but not the same) adaptation of the umami T1R1 receptor occurred early in the radiation of passerines (Toda et al. 2021, *Science* 373: 226–231). It occurred after the divergence of the suboscine and oscine passerines, because the modified T1R1 gene is absent from lyrebirds and only a weak sweet response is found in the Australasian treecreepers. The authors surmise that the abundance of sugar-rich secretions from plant-sucking insects and *Eucalyptus* trees favoured the evolution of a sweet tooth in the early Australian passerines that are the ancestors of most modern songbirds. Whether this adaptation contributed to their extraordinary diversification is debatable, but it explains why so many songbirds are partial to nectar and other sugar-rich foods such as fruits.

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