BRIEF COMMUNICATIONS

Nectar bat stows huge tongue in its rib cage

The extreme length of this bat's tongue might have coevolved with the long flowers it pollinates.

Bats of the subfamily Glossophaginae (family Phyllostomidae) are arguably the most specialized of mammalian nectarivores, and hundreds of neotropical plants rely on them for pollination[1,2]. But flowers pollinated by bats are not known to specialize for bat subgroups (unlike flowers that have adapted to the length and curvature of hummingbird bills, for example), possibly because the mouthparts of bats do not vary much compared with the bills of birds or the probosces of insects[3,4]. Here I report a spectacular exception: a recently-described nectar bat that can extend its tongue twice as far as those of related bats and is the sole pollinator of a plant with corolla tubes of matching length.

The nectar bat *Anoura fistulata* was discovered in the cloud forests of the Andes of Ecuador, where it lives with two other glossophagines, *A. caudifer* and *A. geoffroyi* [5]. I measured the tongues of these bats by placing them in separate flight cages and training them to drink sugared water from a modified straw (6 mm in diameter; see supplementary information). The *A. caudifer* drank to a maximum depth of 36.7 mm (± 2.28 s.d., $n = 6$) and the *A. geoffroyi* to 39.3 mm (± 2.21 s.d., $n = 5$). The tongue of the *A. fistulata*, however, reached 84.9 mm (± 3.51 s.d., $n = 4$), which is 150% of its body length (Fig. 1a). This relative tongue protrusion is greater than that seen in any other mammal, and is second only to the chameleon[6] among the vertebrates.

Across the glossophagine nectar bats, maximum tongue extension is tightly correlated with the length of their rostral components, such as the palate and mandible[7]. Although the correlation holds for *A. caudifer* and *A. geoffroyi*, *A. fistulata* falls far outside the 95% confidence interval (Fig. 1b). Close examination of tongue morphology reveals the basis for this pattern. In other nectar bats, the base of the tongue coincides with the base of the oral cavity[8] (the typical condition for mammals), but in *A. fistulata* the tongue passes back through the neck and into the thoracic cavity. This portion is surrounded by a sleeve of tissue, or glossal tube, which follows the ventral surface of the trachea back and positions the base of the tongue between the heart and the sternum (Fig. 1c).

Darwin famously (and correctly) predicted that the long-spurred Malagasy star orchid (*Angraecum sesquipedale*) would be pollinated by a hawkmoth with an extremely long proboscis[9]. Likewise, a nectar bat that has such extreme tongue extension points to the existence of a flower that has a corolla of comparable length.

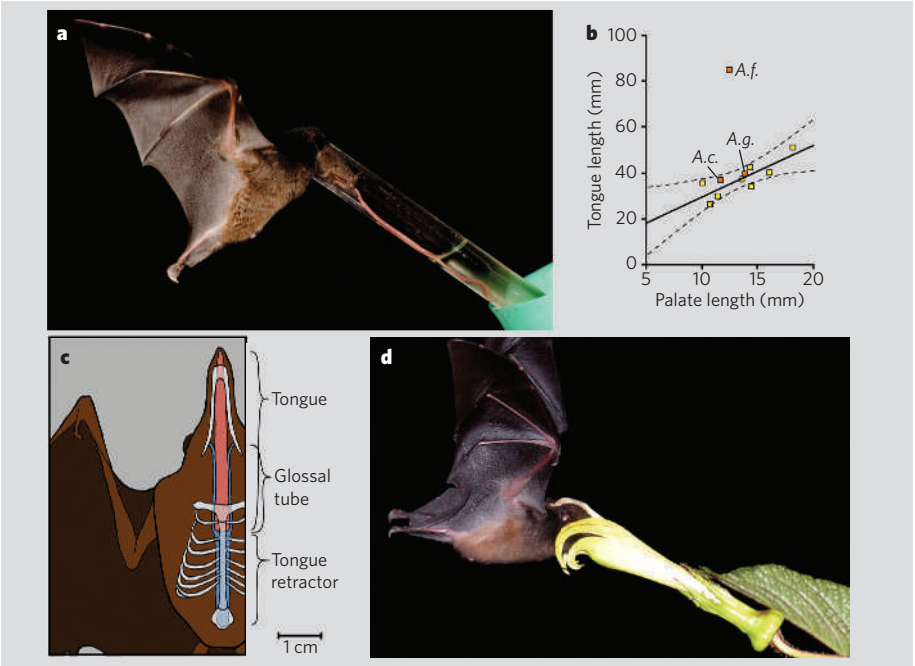

Figure 1 | Protrusible tongue of the nectar bat *Anoura fistulata*. **a,** *Anoura fistulata* feeding from a test tube filled with sugared water; its tongue (pink) can extend to 150% of body length. **b,** Relation between maximum tongue extension and palate length for 11 species of glossophagine nectar bat. *Anoura fistulata (A. f.)* is an outlier; solid line, regression for ten other bats ($y=2.25x + 6.78$, $r^2=0.68$); dashed lines, 95% confidence intervals. Orange squares, *A. fistulata*, *A. geoffroyi* and *A. caudifer*; yellow squares, data for species from ref. 7 (from left, *Lichonycteris obscura, Glossophaga comissarisi, G. soricina, Hylonycteris underwoodi, A. cultrata, Lonchophylla robusta, Leptonycteris curosoae, Choeronycteris mexicana*). **c,** Ventral view of *A. fistulata*, showing tongue (pink), glossal tube and tongue retractor muscle (blue), and skeletal elements (white). **d,** *Anoura fistulata* pollinating the specialized flower of *Centropogon nigricans*; because of the long corolla, only *A. fistulata* can reach its nectar. (Fig. 1a, M. Cooper; Fig. 1d, N. M.)

Dietary studies of *Anoura* in four reserves on the eastern and western slopes of the Andes confirm this prediction. During 129 nights of mist-netting in 2003–05, I captured 46 *A. geoffroyi,* 38 *A. caudifer,* and 21 *A. fistulata*, and identified the pollen on their fur and in their faeces. Pollen from *Centropogon nigricans*, which has corollas 8–9 cm long, was carried only by *A. fistulata* (Fig. 1d), as might be expected, given that other *Anoura* could not reach this flower's nectar. During 55 hours of nocturnal and diurnal videotaping of 12 flowers of *C. nigricans*, ten bats were the only visitors. This observation, combined with the finding that *A. fistulata* was the only bat visitor, supports the conclusion that *A. fistulata* is the only pollinator of this plant.

Specialization on one species of pollinator is exceedingly rare in angiosperms[10], and *C. nigricans* is the only example known in flowers pollinated by bats. After the initial evolution of a glossal tube, the extreme tongue length of *A. fistulata* probably coevolved with long flowers such as those of *C. nigricans*. In an example of convergent evolution, pangolins (scaly anteaters) also have a glossal tube[11]; despite their different diets, ant-eating and nectar-feeding animals face similar evolutionary pressures for highly protrusible tongues, and pangolins and *A. fistulata* have independently converged on a similar solution.

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1. von Helversen, O. & Winter, Y. in *Bat Ecology* (eds Kunz, T. H. & Fenton, M. B.) 346–397 (University of Chicago Press, Chicago, 2003).
2. Dobat, K. & Peikert-Holle, T. *Bluten und Fledermause* (Waldemar Kramer, Frankfurt am Main, 1985).
3. Stiles, F. G. *Am. Zool.* **18**, 715–727 (1978).
4. Fleming, T. H., Muchhala, N. & Ornelas, J. F. in *Contribuciones Mastozoológicos en Homenaje a Bernardo*