Natural history notes for *Centropogon granulosus* (Campanulaceae)

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1. Flowers

*Centropogon granulosus* is perhaps the most recognizable and observable *Centropogon* species on the eastern slopes of the Andes, and is found in abundance within the wet montane forests of San Pedro, District of Cusco, Peru (~1300 m.a.s.l). This woody vine grows throughout old and new forests alike, producing inflorescences of up to 23 colourful red-orange flowers, typically at forest edges (e.g. trails, river banks, treefall gaps, and roadsides). Most of the plant is unexpectedly fragile; when any tissue is broken a white, irritating latex exudes. However, the inflorescence is reinforced (presumably with lignin) and grows parallel to the ground, holding itself level, as opposed to the drooping nature of the rest of the vine. As the inflorescence grows, new flowers appear at the apex, with old flowers trailing behind, and berries being found at the oldest part (Figure 1). Scars are left on the inflorescence where berries are plucked, presumably by birds (Lagomarsino *et al*. 2014). An inflorescence continues to grow as long as conditions are suitable; by counting scars one can infer how many berries have been produced, I have counted up to 68 (Figure 2). Each berry contains hundreds of seeds.

New flowers grow perpendicular from the inflorescence (i.e. skywards) held upright by the peduncle (Figure 3). It takes on average 2 weeks from the appearance of the first floral tissue from the bud, to anthesis. It takes 1 week from anthesis to produce a berry of 15 mm diameter. Berries can reach up to 25 mm, but are usually eaten before then. I recognize eight stages of floral development, as described in Figure 4.

The flowering phenology of *C. granulosus* is remarkable. The male and female phases are separated temporally: At anthesis, the fused anthers form a rigid scale containing the pollen. Dehisced pollen collects behind the scale so that when the scale is pushed back, most of the pollen is deposited at once. If the scale is triggered even just 1-2 times, most if not all of the pollen will have been released. Following 1-2 days, the pistil grows past the stamens, and only once it has overtaken the anthers does the stigma unfold, thus preventing self-pollination (Figure 5). Because flower growth is staggered along the length of the inflorescence, at any given time 1 to 2 flowers are at anthesis (i.e. male phase) while another 1-2 flowers are at the female phase. Furthermore, those flowers that are close to or at anthesis are the most upright. 1-4 days after the stigma has unfolded, the peduncle is relaxed, allowing the berries to hang (Figure 6).

What constitutes ‘suitable conditions’ for continued growth of the inflorescence remains puzzling. I suspect that besides environmental suitability, successful pollination and maturation of berries dictates whether further flowers will be produced. At the very least, it can be said that the length and number of scars on an inflorescence (indicating past success), is not always a good predictor of continued growth and production of flowers into the future.

2. Animals

Like many plants in these forests, *C. granulosus* is host to a great variety of invertebrates. Of those that I can identify are 3 types of ants, mites (likely *Haulletia*), fruit flies, leaf hoppers, and occasionally spiders. I suspect that all but the spiders are consuming the nectar produced by the flower. Ants guard the nectaries aggressively and will instantly begin searching and communicating with others when a flower is disturbed. Mites are almost always found inside the floral tube and also jolt to action whenever the flower is disturbed, moving towards the apex of the corolla. Presumably these mites are carried on the head of pollinators from flower to flower.

Of the vertebrate visitors to the flowers of *C. granulosus* there are two: a pollinator *Eutoxeres condamini* (Buff-tailed sicklebill) and a nectar robber *Adelomyia melanogenys* (Speckled hummingbird). The bill of *E. condamini* perfectly matches the shape of the corolla tube of *C. granulosus*. Furthermore, the placement and timing of the anthers and stigma on the head of *E. condamini* suggest an efficient outcrossing mechanism. I find no evidence that *E. condamini* uses the lignified inflorescence as a perch, as suggested in Stein (1992). In every documented visit it is shown that *E. condamini* hovers as it drinks from the flower (Figure 7). Mites are frequently found on the bill and within the nares of *E. condamini*. Unlike its close relatives *Phaethornis* spp., *E. condamini* avoids humans and its activities are elusive. *Eutoxeres* spp. are trapliners and have an excellent awareness of the flower phenology of *C. granulosus*. Individuals caught in mist-nets near *C. granulosus* do not seem to be deterred. If caught once, they adjust their future visits to hours before or after the re-opening of the nets.

*A. melongenys* is a short-billed, territorial hummingbird that can be found perched close, and feeding from patches of *Columnea* and *Fuschia* (in San Pedro). In many cases *C. granulosus* will also be nearby. In these patches of *C. granulosus*, evidence of nectar robbing is obvious. A description of nectar robbing behaviour and its ecological implication is discussed in Boehm (2017). What remains unknown is if territorial and traplining species interact, and how this impacts the distribution and fitness of *C. granulosus.*