

1        **Scientific note: Phoretic interaction between *Antherophagus* (Coleoptera) and**  
2        ***Bombus funebris* (Hymenoptera), using *Chuquiraga jussieui* (Asteraceae) as**  
3        **transfer stations in the páramos**

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18       Short title: Phoretic interactions in the páramos

20 **Tropical alpine ecosystems / Beetles / Bumblebees / Flowers / Pollination / Andes**  
21 **Abstract**

22 Beetles of the genus *Antherophagus* are phoretic organisms that inhabit the nests of  
23 *Bombus* species. They migrate and colonize new nests using the same bumblebees as  
24 carriers. Although *Antherophagus* beetles from temperate Europe and North America  
25 are known to use some plant species to move between bumblebees, it is unknown which  
26 plants are used as transfer stations by neotropical *Antherophagus*. Here, we report for  
27 the first time how phoretic *Antherophagus* beetles of an undescribed species use the  
28 inflorescences of *Chuquiraga jussieui* to transfer between individuals of *Bombus*  
29 *funnebris* in the páramos of Central Ecuador. Our observations are the highest records (at  
30 4200 m asl) of a phoretic interaction performed so far.

31 Phoresy is an interaction in which an organism (i.e. the phoront) uses another organism  
32 (i.e. the host) for dispersal (see Borges 2022). Various bumblebee species have been  
33 reported as temporal hosts of phoretic mites and beetles worldwide. However, in the  
34 Alpine ecosystems of Tropical America, only *Bombus funebris* Smith, 1854 has been  
35 reported as a host of both phoretic mites and beetles (Plischuk et al. 2020; Vanegas and  
36 Padrón 2022).

37 *Bombus funebris* is an Andean species distributed from Colombia to northern Chile  
38 (Rasmussen 2003). This bumblebee species is found from 600 up to 4750 m asl  
39 (Rasmussen 2003; Pinilla-Gallego et al. 2016). Nevertheless, *B. funebris* reaches its  
40 peak of abundance between 2800 and 3800 m (Pinilla-Gallego et al. 2016), an elevation  
41 range that overlaps that of the páramos ecosystems in the northern Andes (usually above  
42 3500 m and below the snowline; Sklenář et al. 2014). Although it is a common  
43 bumblebee species in the inter-Andean valleys (Rasmussen 2003), knowledge about its  
44 biology and ecological interactions, such as the flowers they pollinate, is still very  
45 limited. Our preliminary results of a study on plant-pollinator networks in a páramo of  
46 Central Ecuador indicate that *B. funebris* is the main pollinator of many páramos plant  
47 species (Martel unpubl. data) and, therefore, a key pollinator in these ecosystems. This  
48 addresses the importance of this kind of study in the conservation of the neotropical  
49 páramos.

50 The páramos harbour a rich biodiversity of plants and animals and are considered the  
51 world's most diverse high-elevation ecosystems (Sklenář et al. 2014). These ecosystems  
52 are important water sources and contain large soil carbon. Despite its importance, our  
53 knowledge of the ecological interactions of their plants and animals is still poor thus our

54 understanding of the full ecological value of this ecosystem is limited. In the páramos of  
55 Ecuador, one common plant species is *Chuquiraga jussieui* J.F. Gmel. This plant  
56 flowers throughout the year (Ezcurra 1985), including during the wet season, when  
57 other common páramo species do not bloom. Therefore, this species might be an  
58 important source of nectar for pollinating birds and insects, including *B. funebris*.  
59 *Bombus funebris* queens and workers visit the flowers of *C. jussieui* to feed on nectar;  
60 however, during their visits to the *C. jussieui* capitula, some unexpected guests “board”  
61 the bees.

62 During fieldwork carried out in the Yanacocha Reserve in Central Ecuador (0.135669°S,  
63 78.575061°W, 4205 m asl; Fig. 1) between 28<sup>th</sup> and 31<sup>st</sup> October 2023, in a long-term  
64 experimental area of a páramo ecosystem, where we have been observing  
65 plantpollinator interactions, we recorded a small beetle on a capitulum of *C. jussieui*.  
66 This beetle had its mandibles wide open and its head pointed up. One day after, we  
67 recorded a similar beetle attached to the tarsus of a *B. funebris* worker, which was  
68 collected when approaching a *C. jussieui* capitulum. Realizing the beetles could have a  
69 phoretic association with *B. funebris*, and this may involve *C. jussieui*, we inspected the  
70 body of 20 *B. funebris* bumblebees and the capitula of 25 *C. jussieui* plants to record the  
71 occurrence of beetles. As a result, we recorded a *C. jussieui* capitulum hosting one  
72 beetle (Fig. 2) and three *B. funebris* workers bearing a total of five beetles, which were  
73 attached to their antennae and legs (Fig. 3).

74 After closer inspection of one collected beetle and the revision of the literature, we  
75 identified the beetle as belonging to the genus *Antherophagus* Dejean, 1821

76 (Coleoptera: Cryptophagidae). This genus is small and includes only 12 species  
77 (Bousquet 1989). In the Americas, five species of *Antherophagus* have been reported,  
78 all of which occur in North America (Evans et al. 2023; Kole and Ivie 2023).  
79 Nevertheless, many species remain undescribed in the Neotropical region since  
80 *Antherophagus* beetles have been recorded from Costa Rica to Brazil (Roubik and  
81 Wheeler 1982; Bousquet 1989; Chavarría 1994a, 1994b; González et al. 2004;  
82 PosadaFlórez and Téllez-Farfán 2021; Vanegas and Padrón 2022). This is the case for  
83 the beetles recorded on *B. funebris*, which belong to a not-yet-described *Antherophagus*  
84 species (Martel unpubl. data).

85 *Antherophagus* beetles inhabit and develop in bumblebee nests, where they feed on  
86 organic detritus acting as scavengers (Wheeler 1919; Frison 1921; Chavarría 1994a), in  
87 a sort of commensalistic relationship. However, since *Antherophagus* beetles have also  
88 been frequently recorded attached to different bumblebee species in Europe and North  
89 America (Wheeler 1919; Frison 1921; von Frisch 1952), they are considered phoretic on  
90 *Bombus* and not to be detrimental to the bumblebee colonies (Frison 1921). However,  
91 some bumblebees might be negatively impacted by the weight of carrying several  
92 beetles, especially those occurring at higher elevations where it is more energetically  
93 costly to fly due to the low air density and low oxygen levels occurring at high altitudes  
94 (Halloy 1989). For instance, we have recorded one *B. funebris* worker carrying three  
95 beetles resting on the grass before taking off (Fig. 3), and Posada-Flórez and  
96 TéllezFarfán (2021) recorded a *B. pauloensis* Friese, 1913 worker on the ground  
97 carrying six beetles in Colombia at 2600 m. The presence of the beetles may also reduce  
98 the capacity of the bumblebee to access nectar and pollen, carry the floral reward to the  
99 nest and ultimately pollinate the plants. Thus, this phoretic *Antherophagus-Bombus*

100 relationship can deviate periodically into a parasitic relationship, which is expected to  
101 evolve over time in phoretic interactions (White et al. 2017). However, whether *Bombus*  
102 species from high elevations are particularly susceptible to being affected by  
103 *Antherophagus* needs to be explored.

104 In the neotropical region, there are four *Bombus* species (*B. ephippiatus* Say, 1837, *B.*  
105 *funnebris*, *B. pauloensis*, *B. pullatus* Franklin, 1913) reported as hosts of phoretic  
106 *Antherophagus* beetles in the cloud forests of Costa Rica and Colombia and páramo  
107 remnants of Ecuador (Roubik and Wheeler 1982; Chavarría 1994a, 1994b;  
108 PosadaFlórez and Téllez-Farfán 2021; Vanegas and Padrón 2022). Although  
109 *Antherophagus* beetles were already reported on *B. funnebris* bumblebees (at 3845 m;  
110 Vanegas and Padrón 2022), our report was made at a higher elevation (4200 m) and in a  
111 wellpreserved páramo, in which we could identify the plant species used by the  
112 *Antherophagus* beetles as transfer stations (i.e. *Chuquiraga jussieui*). It was suggested  
113 that *Antherophagus* beetles occur and use flowers to move between bee hosts in North  
114 America (Parks 2016) and the Neotropics (Roubick 1989), however, knowledge about  
115 which flowers are being used by these beetles in these regions has remained elusive.  
116 Therefore, to our knowledge, *C. jussieui* is the first plant recorded as a bumblebee  
117 transfer station for any New World *Antherophagus* species. The orange colouration of  
118 the capitula of *C. jussieui* and the diameter of the tubular flowers, similar in size to the  
119 beetle height, may help *Antherophagus* beetles to camouflage and stay undetected by an  
120 approaching bumblebee (see Fig. 2). An additional observation of a *Bombus*-  
121 *Antherophagus* interaction in the neotropics can be found on iNaturalist  
122 (<https://www.inaturalist.org/observations/174133066>), in a photo taken at around 2700  
123 m in a cloud forest in northern Ecuador, where a beetle was attached to a bumblebee

124 similar to *B. robustus* Smith, 1854. Thus, in the Andean páramos, there are so far only  
125 two reports of phoretic *Antherophagus* on *Bombus* species, all from the western Andes  
126 of Ecuador (Fig. 1). Further studies would better inform the extent of this interaction  
127 and the ecological implications of this phoretic relationship on neotropical bumblebees.  
128

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145

146 **Competing interests**

147 The authors declare no competing interests.

148

149 **Author contribution**

150 All authors contributed to the study's conception and design. Material preparation and  
151 data collection were performed by Carlos Martel and Laura Cifuentes. Material analysis  
152 was performed by Carlos Martel. The first draft of the manuscript was written by Carlos  
153 Martel, and all authors revised and commented on previous versions of the manuscript.

154 All authors read and approved the final manuscript.

155

156 **Ethics approval**

157 Not applicable.

158

159 **Consent to participate**

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161

162 **Consent to publish**

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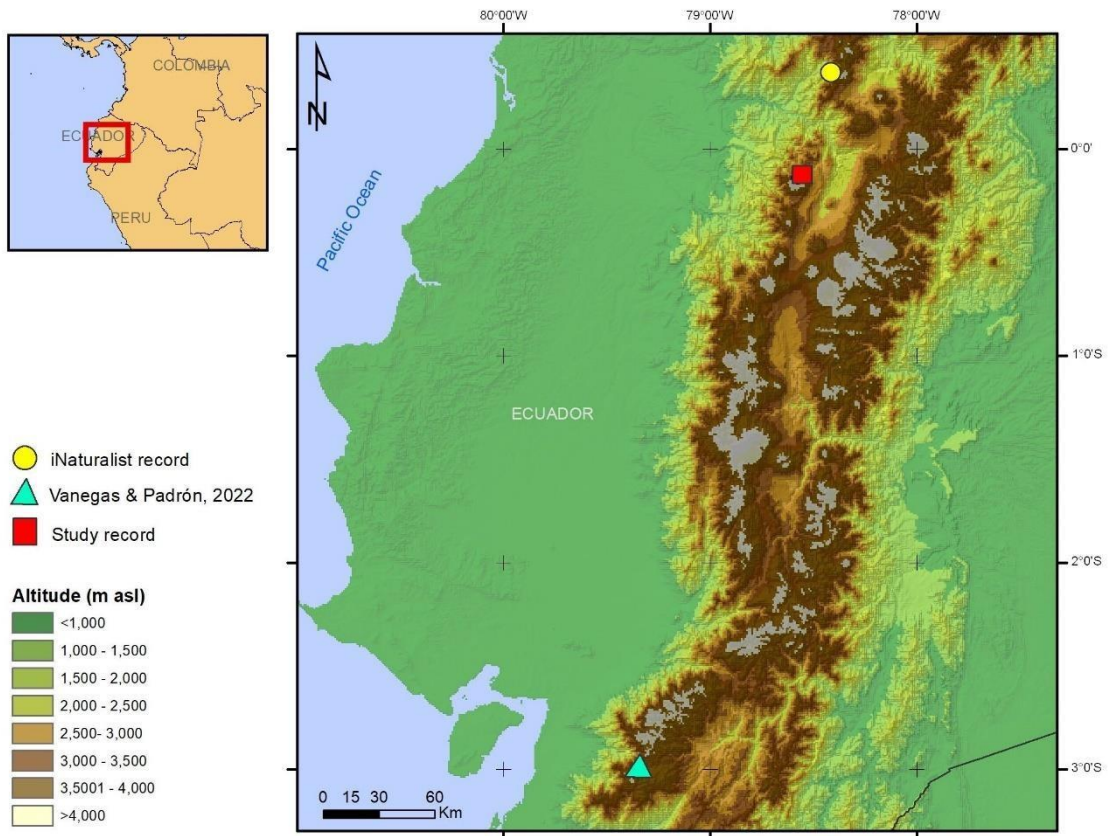
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- 220  
221 **Figure 1.** Map showing the current known locations where phoretic *Antherophagus* spp.  
222 beetles have been recorded on *Bombus* species in Ecuador. Square and triangle symbols  
223 are records involving *B. funebris*.
- 224

225 **Figure 2.** *Chuquiraga jussieui* capitulum and *Antherophagus* sp. beetle: **(a)** An  
226 *Antherophagus* beetle among the flowers of *C. jussieui* (arrow) and **(b)** a close-up of the  
227 beetle on the bracts of the same capitulum.

228

229 **Figure 3.** *Bombus funebris*, *Chuquiraga jussieui* and *Antherophagus* sp.: **(a)** One  
230 bumblebee worker collecting nectar from *C. jussieui* and bearing three *Antherophagus*  
231 beetles on its tarsus (arrow) and antenna (arrow). **(b)** The same bumblebee resting on  
232 the grass before taking off and flying.

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