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Inventory

Occurrence and characterization of insect galls in two reserves of the Peruvian Amazon

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Abstract: An insect gall inventory was carried out in two reserves of the Peruvian Amazon, Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, both situated in Iquitos, northeastern Peru. Four vegetation types were surveyed between December, 2021 and December, 2022: *terra firme* forest, white-sand wet forest, and white-sand dry forest in Allpahuayo-Mishana National Reserve, and palm swamp forest in Quistococha Regional Reserve. Overall, we found 262 gall morphotypes, distributed across 75 host species representing 66 plant genera and 30 families. Fabaceae was the plant family with the greatest number of gall morphotypes (n = 48), followed by Calophyllaceae (n = 21) and Euphorbiaceae (n = 20). The plant genera that supported the highest diversity of galls were *Caraipa* (n = 17), *Eschweilera* (n = 16), *Tapirira* (n = 16), *Micrandra* (n = 14), and *Iryanthera* (n = 10). The plant species *Tapirira guianensis* (n = 16), *Caraipa utilis* (n = 14), *Micrandra elata* (n = 14), *Eschweilera coriacea* (n = 11), and *Sloanea parvifructa* (n = 10) exhibited the highest richness of galls. Among the host plants, *C. utilis* stands alone as the only species noted as both endemic to the Amazonian region and bearing a Vulnerable (VU) conservation status. The leaves were the most attacked organs (90% of all galls). Most morphotypes are glabrous (89%), green (67%), globoid (53%), and one-chambered (91%). We found galling insects belonging to the orders Diptera, Thysanoptera, Lepidoptera, and Hemiptera. The galling insects of Cecidomyiidae (Diptera) were the most common, inducing 22% of the gall morphotypes. In addition to the gallers, we also observed the presence of successors, cecidophages, and parasitoids. Among the sampled vegetation types, the *terra firme* forest presented the highest richness of gall morphotypes and host plant species. This is the first systematic inventory of insect galls in this part of the Peruvian Amazon.
Keywords: *Cecidomyiidae; Fabaceae; galls; host plant.*

Ocorrência e caracterização de galhas de insetos em duas reservas da Amazônia peruana

Resumo: Um inventário de galhas de insetos foi realizado em duas reservas da Amazônia peruana, Reserva Nacional Allpahuayo-Mishana e Reserva Regional Quistococha, ambas situadas em Iquitos, nordeste do Peru. Quatro tipos de vegetação foram pesquisados entre dezembro de 2021 e dezembro de 2022: floresta de *terra firme*, floresta úmida de areia branca e floresta seca de areia branca na Reserva Nacional Allpahuayo-Mishana, e floresta de pântano de palmeiras na Reserva Regional Quistococha. No total, encontramos 262 morfotipos de galhas, distribuídos em 75 espécies hospedeiras representando 66 gêneros de plantas e 30 famílias. Fabaceae foi a família de plantas com o

maior número de morfotipos de galhas (n = 48), seguida por Calophyllaceae (n = 21) e Euphorbiaceae (n = 20). Os gêneros de plantas que apresentaram a maior diversidade de galhas foram *Caraipa* (n = 17), *Eschweilera* (n = 16), *Tapirira* (n = 16), *Micrandra* (n = 14) e *Iryanthera* (n = 10). As espécies de plantas *Tapirira guianensis* (n = 16), *Caraipa utilis* (n = 14), *Micrandra elata* (n = 14), *Eschweilera coriacea* (n = 11) e *Sloanea parvifructa* (n = 10) apresentaram a maior riqueza de galhas. Dentre as plantas hospedeiras, *C. utilis* destaca-se como a única espécie listada como endêmica da região amazônica e com um status de conservação Vulnerável (VU). As folhas foram os órgãos mais atacados (90% de todas as galhas). A maioria dos morfotipos é glabra (89%), verde (67%), globoide (53%) e possui apenas uma câmara interna (91%). Encontramos insetos galhadores pertencentes às ordens Diptera, Thysanoptera, Lepidoptera e Hemiptera. Os insetos galhadores da família Cecidomyiidae (Diptera) foram os mais comuns, induzindo 22% dos morfotipos de galhas. Além dos galhadores, também observamos a presença de sucessores, cecidófagos e parasitoides. Entre os tipos de vegetação amostrados, a floresta de *terra firme* apresentou a maior riqueza de morfotipos de galhas e espécies de plantas hospedeiras. Este é o primeiro inventário sistemático de galhas de insetos nesta região da Amazônia peruana.
Palavras-chave: *Cecidomyiidae; Fabaceae; galha; planta hospedeira.*

Introduction

Peru is a mega-diverse country in terms of species richness, and comprises a large part of the Amazon forest, which constitutes over 70% of the national territory (Gagliardi-Urrutia et al. 2022). Estimates based on floristic inventories in the Peruvian Amazon suggest that there are approximately 5,000 plant species (Cardoso et al. 2017), almost 756 (13%) of which are endemic (Leon et al. 2006). This high number of plant species represents a great diversity of potential niches for gall-inducing insects (Mendonça 2007). Galling insects are very specialized herbivores and tend to be species-specific with respect to host plants (Stone & Schönrogge 2003, Carneiro et al. 2009). These insects are also very diverse, with some estimates indicating that there could be as many as 132,000 species worldwide (Espírito-Santo & Fernandes 2007), and 3,090 in Peru (Grandez-Rios et al. 2015).

Taxonomic knowledge of gall-inducing insects in the Amazon forest is scarce, largely because of taxonomic uncertainties and difficulty of identification, or else because the species have yet to be described (review in Grandez-Rios et al. 2015). Most inventories of galling insects therefore identify taxa only to the order or family level (Yukawa et al. 2001, Almada & Fernandes 2011), or rarely to genus (Maia 2011). Galling insects recorded in the Amazon forest belong to Diptera, Hemiptera, Coleoptera, Lepidoptera and Hymenoptera, with the Dipteran family Cecidomyiidae particularly well represented (Julião et al. 2014b). Cecidomyiidae comprise more than 6,500 described species worldwide (Gagné & Jaschhof 2021), and achieves its greatest diversity in Amazonia (Grandez-Rios et al. 2015). Insect gall inventories in Amazonia have found that Fabaceae is the most important host plant family (Almada & Fernandes 2011, Maia 2011, Silva et al. 2011, Araújo et al. 2012, Julião et al. 2017). Other host plant families include Burseraceae, Chrysobalanaceae, Sapotaceae and Lecythidaceae (Julião et al. 2014b). Each of these families is notably species-rich in Amazonian forests.

Studies carried out in the Amazonian region have also show that the diversity of gall-inducing insects is highest in *terra firme* forests in comparison with other vegetation types (Julião et al. 2014a). The reason behind this greater diversity of gall-inducing insects in *terra firme* forest lies in the unique characteristics of this habitat (e.g., plant diversity and soil fertility) (Julião et al. 2014b). Furthermore, *terra firme* forest exhibits a remarkable diversity array of plants, providing a wide range availability of ecological niches and an abundant source of resources when compared to the more limited environments, such as white-sand and palm swamp forests (Draper et al. 2018). In this context, the *terra firme* forest is expected to have a higher diversity of gall-inducing insect than other Amazonian vegetation.

Over the last 30 years, several insect gall inventories have been carried out in different phytogeographic domains of the Neotropics, including in the Amazon, although it is one of the least studied (Araújo 2018). In fact, there is a significant bias for studies in Southeast Brazil, where the most important Brazilian research centers regarding galls and galling insects are located, as shown by Araújo (2018). Araújo et al. (2019) compiled data of four inventories performed in the Brazilian Amazon. Despite this small number of published inventories, the galling species richness was greater than in other Brazilian biomes, such as Cerrado. These results show that Amazonian forests host a high galling insect diversity, likely due to the high specialization associated with the remarkable richness of host plants. However, in other parts of the Amazon, such as Peru, insect gall inventories are lacking, and little is known about host plant associations. The objective of the present study was to inventory the galling insects, associated fauna, and their host plants in the Peruvian Amazon.

Materials and Methods

1. Study area

The study was realized southwest of the city of Iquitos, in the province of Loreto in the Peruvian Amazon. The area exhibits a warm and moist climate with an average annual temperature 26 °C and average annual precipitation of 3,087 mm (Marengo 1998). The site is characterized by a long wet season with monthly precipitations > 300 mm in November, March and April, and a weak dry season in June and September. (Marengo 1998). Humidity is 80–90% all year round.

The research was conducted in three vegetation types in the Allpahuayo-Mishana National Reserve (RNAM): *terra firme* forest (S 03° 57.056′, W 073° 26.002′; S 03° 57.051′, W 073° 26.320′; TF), white-sand wet forest (S 03° 57.062′ W 073° 24.586′; WSw) and white-sand dry forest (S 03° 57.253′, W 073° 25.617′; WSd). In addition, one vegetation type was assessed in the Quistococha Regional Reserve (RRQ): palm swamp forest (S 03° 50.037′, W 073° 19.254′; S 03° 50.082′, W 073° 19.019′; PS) (Figure 1). The Allpahuayo-Mishana National Reserve (58,069.90 ha.), exhibits a high degree of both endemism and biodiversity, largely owing to a complex mosaic of habitats—ranging from white sand forest patch growing on nutrient-poor soils, to seasonally-inundated floodplain forests, and *terra firme* forests growing on nutrient-rich clay soils (Salo & Pyhälä 2007). Meanwhile, Quistococha Regional Reserve (369 ha), is characterized by palm swamp forests, with poorly drained soils that are often flooded (Encarnación 1985). These areas are dominated by the palms *Mauritia flexuosa* and *Mauritiella armata* (both Arecaceae), and by the broadleaf tree *Tabebuia insignis* (Bignoniaceae) (Roucoux et al. 2013).

2. *Sampling of galling insects and host plants*

Sampling in the different vegetation types was done bi-monthly between December 2021 and December 2022, with 8 plots of 5 × 20 m each, separated from one another by 20 m, totaling 800 m^2 sampled for each site, in accord with the methodology proposed by Julião et al. (2014a). In each plot, only woody plants with a diameter at breast height (dbh, 1.3 m) equal to or greater than 10 cm were measured and collected, using the standard methods described in the RAINFOR protocol (Phillips et al. 2009). Altogether 32 plots were established, being 24 plots for RNAM (8 plots in *terra firme* forest; 8 plots in white sand wet forest and 8 plots in white sand dry forest) and 8 plots for RRQ (all in palm swamp forest). The woody plant species sampled in the plots were already identified in species as part of a previous floristic project, when each individual received a permanent metal tag, whose related data were downloaded via ForestPlots.net online database (Lopez-Gonzalez et al. 2011, ForestPlots.net et al. 2021). Data on the conservation status and endemism of each host plant species were retrieved from the IUCN Red List of Threatened Species (IUCN 2023) and Leon et al. (2006).

All the plots were established in the understory vegetation and then visually projected onto the canopy, delimiting the sampling area to collect the tree crown above each individual. Ten terminal units of the plant were randomly collected by climbing, and with a 10 m telescoping aluminum pole pruner. In the field, all gall morphotypes were characterized with respect to external morphology, and by shape, color, presence of trichomes, number of chambers, and the host plant organ attacked, as proposed by Isaias et al. (2014).

Galled branches were photographed, collected and transported to the Natural Products Chemistry Laboratory of the Peruvian Amazon Research Institute (IIAP) in closed and labeled transparent plastic bags. Some specimens of each gall morphotype were dissected using a stylet under a Leica Wild M3C stereoscopic microscope, to observe the number of internal chambers and obtain the immature insects (larvae and pupae). These immatures were initially preserved in 70% alcohol in labeled microtubes. The remainder of the sample was used

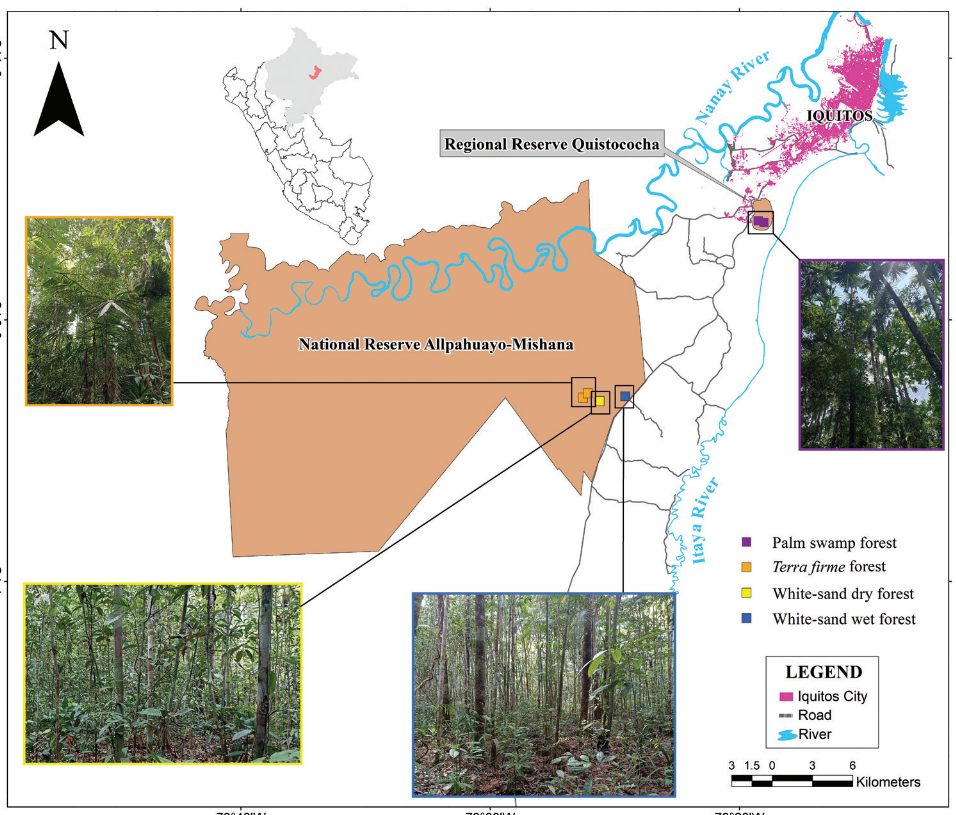

Figure 1. Map of the distribution of sampling areas in four different types of vegetation in the National Reserve Allpahuayo-Mishana and Regional Reserve Quistococha, Iquitos, Peru.

for rearing galling insects and associated fauna (successor, inquilines, cecidophages, and parasitoids). To distinguish these guilds in this study, we used the interaction parameters proposed by Luz & Mendonça Júnior (2019). Successors are organisms that utilize the gall after the inducer departs (Mani 1964), and they use gall tissues for both food and shelter. Inquilines and cecidophages utilize galls alongside the gall inducer. Both feed on plant tissues and consume gall tissues, but only the inquilines stimulate the growth of new tissues (Luz & Mendonça Júnior 2019). Parasitoids are organisms that closely associate with the host, exploiting the host's resources, eventually leading to the host's demise upon the completion of the parasitoid development (Maia 2022). Furthermore, each gall morphotype was placed in a closed transparent plastic pot, labeled and with moistened paper at the bottom. All pots were checked daily for adult emergence.

All insects were preserved in 70% alcohol. The gall midges (Diptera: Cecidomyiidae) were later mounted on slides for microscope, following the methodology outlined in Gagné (1994). Cecidomyiidae genera were determined based on the keys of Gagné available for the Neotropical region (1994). Micro-Hymenoptera were identified to the family and genus levels using Gibson's key (Gibson et al. 1997). Hymenoptera obtained only in the larval or pupal stage remained identified only to order. All the specimens were deposited in the Diptera collection of Museu Nacional (MNNRJ)/ Universidade Federal do Rio de Janeiro, and at the Peruvian Amazon Research Institute (IIAP). The other insects were sent to specialists for identification.

Results

We found 262 gall morphotypes, distributed across 30 botanical families and comprising 66 genera and 75 species (Table 1, Figures 2–12). The average number of gall morphotypes per host plant species was 3.5. The plant families that showed the greatest richness of insect galls were Fabaceae with 48 morphotypes, Calophyllaceae with 21, Euphorbiaceae with 20, Lecythidaceae with 18, Lauraceae with 17, Anacardiaceae with 16, Sapotaceae with 14, Malvaceae and Myristicaceae with 12, Phyllanthaceae with 11, and Elaeocarpaceae with 10 morphotypes. The remaining families had less than 10 insect gall morphotypes each. The plant genera *Caraipa* Aubl. (Calophyllaceae), *Eschweilera* Mart. ex DC. (Lecythidaceae), *Tapirira* Aubl. (Anacardiaceae), *Micrandra* Benth. (Euphorbiaceae) and *Iryanthera* (A. DC.) Warb. (Myristicaceae) hosted the highest numbers of insect gall morphotypes (17, 16, 16, 14 and 10, respectively). The most important host plant species were *T. guianensis* Aubl., *C. utilis* Vásquez, *M. elata* (Didr.) Müll. Arg., *E. coriacea* (DC.) S.A. Mori, and *Sloanea parvifructa* Steyerm., hosting 16, 14, 14, 11 and 10 insect gall morphotypes, respectively (Table 2). On the other hand, among all host plant species, only *C. utilis* is mentioned as endemic to the Amazonian region with a Vulnerable (VU) conservation status, while *T. insignis* (Miq.) Sandwith was categorized as Near Threatened (NT). The rest of the plant species were categorized as Least Concern (LC), with some not being classified within the IUCN list (Table 2).

Galls were found in leaves (n = 235), stems (n = 21), buds (n = 3) and fruits (n = 2), with 90% of all galls occurring on leaves. All morphotypes occurred in just one plant organ, except one morphotype that was found in both leaves and petioles of *E. coriacea.*

Table 1. Number of host plant species and insect gall morphotypes per host plant family in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru.

Host family	Number of plant genera	Number of plant species	Number of gall morphotypes
Anacardiaceae	1	1	16
Annonaceae	3	4	7
Apocynaceae	2	2	5
Araliaceae	1	1	3
Bignoniaceae	1	1	5
Burseraceae	1	1	1
Calophyllaceae	2	3	21
Chrysobalanaceae	1	1	3
Elaeocarpaceae	1	1	10
Euphorbiaceae	4	4	20
Fabaceae	11	12	48
Humiriaceae	1	1	2
Lauraceae	5	5	17
Lecythidaceae	3	4	18
Lepidobotryaceae	1	1	1
Malpighiaceae	1	1	2
Malvaceae	3	3	12
Melastomataceae	1	1	2
Meliaceae	1	1	3
Metteniusaceae	1	1	2
Moraceae	3	3	3
Myristicaceae	2	4	12
Myrtaceae	3	3	6
Nyctaginaceae	1	2	5
Olacaceae	1	1	2
Phyllanthaceae	3	3	11
Salicaceae	1	1	3
Sapindaceae	2	3	5
Sapotaceae	3	4	14
Urticaceae	2	2	3
Total	66	75	262

Ten distinct gall shapes were found: globoid, lenticular, fusiform, marginal roll, conical, clavate, amorphous, cup, pocket, and rosette. The globoid, lenticular and fusiform shapes were the most frequent ones, with 130, 58 and 39 morphoytpes, respectively, followed by marginal roll (n = 15), conical (n = 14), clavate (n = 2), and others (n = 1). The gall morphotypes included green, brown, black, and yellow coloration with green color predominant (67%), followed by brown (32%). The majority of galls were glabrous, with 232 morphotypes (89%); the remainder were hairy, with 30 morphotypes (11%). About 91% (238 morphotypes) of galls were one-chambered, often occupied by a single larva; just 9% (24 morphotypes) were multi-chambered.

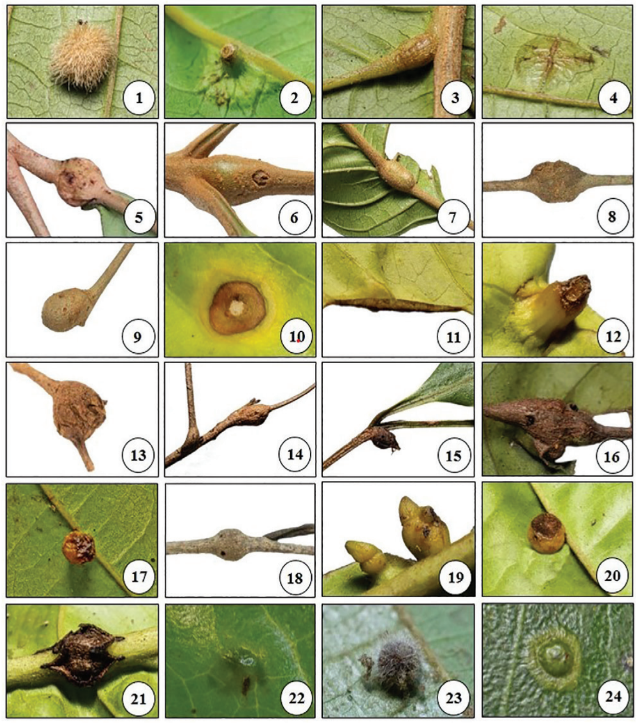

Figure 2. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 1–16; *Tapirira guianensis* (1. globoid-leaf, 2. conical-leaf, 3. fusiform-leaf, 4. lenticular-leaf, 5. globoid-leaf, 6. globoid-leaf (rachis), 7. fusiform-leaf, 8. globoid-leaf (petiole), 9. globoid-leaf, 10. lenticular-leaf, 11. marginal roll-leaf, 12. conical-leaf, 13. globoid-stem, 14. globoid-leaf (rachis), 15. conical-leaf (rachis), 16. fusiform-leaf), 17–18; *Diclinanona tessmannii* (17. globoid-leaf, 18. globoid-stem), 19–21; *Guatteria megalophylla* (19. conical-leaf, 20. globoid-leaf, 21. globoid-leaf), 22; *Porcelia nitidifolia* (22. globoid-leaf), 23; *Unonopsis spectabilis* (23. globoid-leaf), 24; *Aspidosperma excelsum* (24. lenticular-leaf).

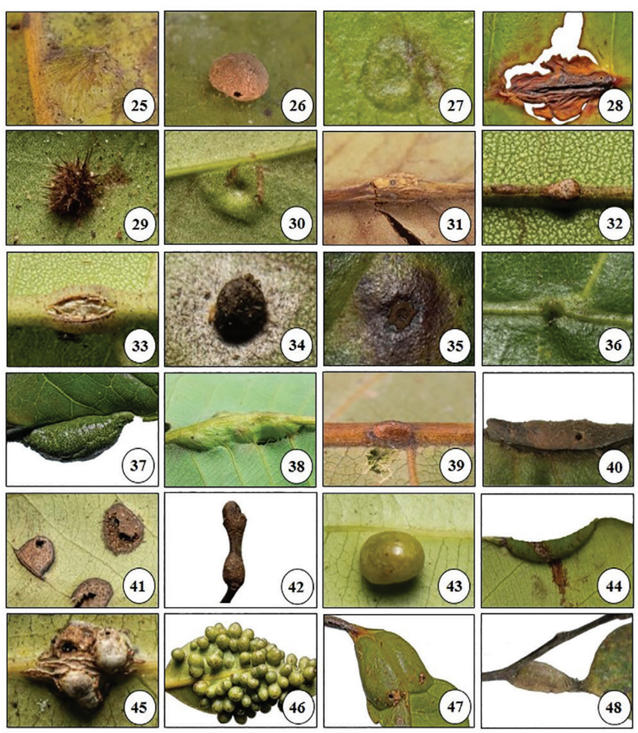

Figure 3. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 25–26; *Aspidosperma excelsum* (25. lenticular-leaf, 26. globoid-leaf), 27–28; *Parahancornia peruviana* (27. lenticular-leaf, 28. fusiform-leaf), 29–31; *Dendropanax umbellatus* (29. globoid-leaf, 30. lenticular-leaf, 31. fusiform-leaf), 32–36; *Tabebuia insignis* (32. globoid-leaf, 33. fusiform-leaf, 34. globoid-leaf, 35. lenticular-leaf, 36. globoid-leaf), 37; *Protium crassipetalum* (37. marginal roll-leaf), 38–40; *Caraipa tereticaulis* (38. fusiform-leaf, 39. Globoid-leaf, 40. marginal roll-leaf), 41–48; *Caraipa utilis* (41. lenticular-leaf, 42. globoid-stem, 43. globoid-leaf, 44. marginal roll-leaf, 45. globoid-leaf, 46. globoid-leaf, 47. globoid-leaf, 48. globoid-leaf (petiole)).

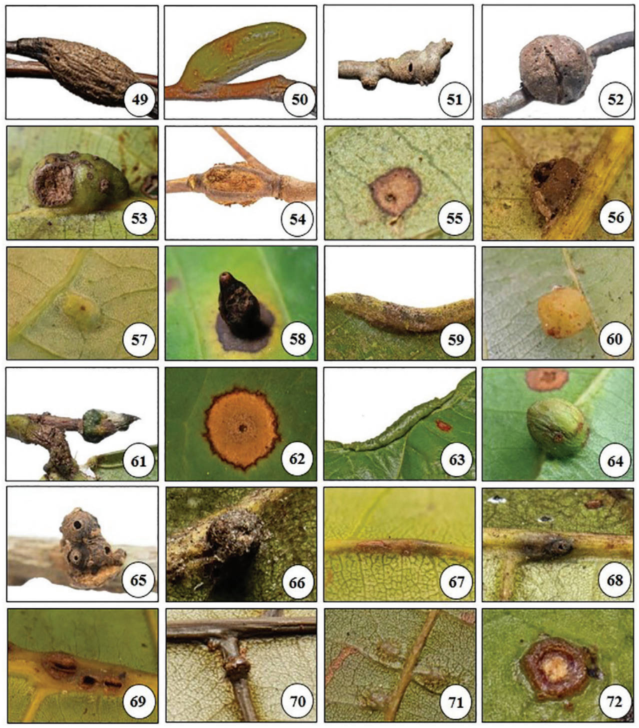

Figure 4. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 49–54; *Caraipa utilis* (49. globoid-leaf (petiole), 50. globoid-leaf, 51. globoid-stem, 52. globoid-stem, 53. globoid-leaf, 54. globoid-stem), 55–58; *Haploclathra cordata* (55. lenticular-leaf, 56. globoid-leaf, 57. globoid-leaf, 58. conical-leaf), 59–61; *Couepia williamsii* (59. marginal roll-leaf, 60. globoid-leaf, 61. globoid-bud), 62–71; *Sloanea parvifructa* (62. lenticular-leaf, 63. marginal roll-leaf, 64. globoid-leaf, 65. globoid-stem, 66. globoid-leaf, 67. fusiform-leaf, 68. fusiform-leaf, 69. globoid-leaf, 70. globoid-leaf, 71. lenticular-leaf), 72; *Alchorneopsis floribunda* (72. lenticular-leaf).

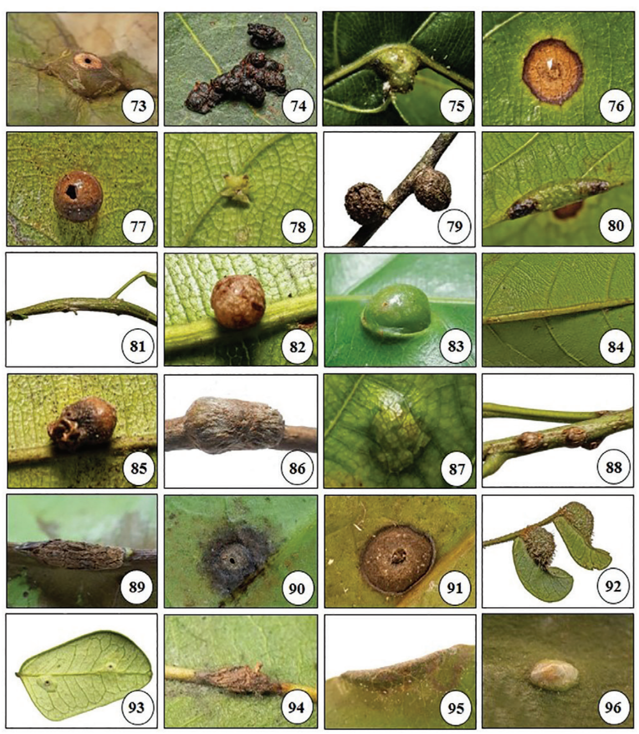

Figure 5. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 73; *Alchorneopsis floribunda* (73. globoid-leaf), 74; *Hevea guianensis* (74. globoid-leaf), 75–88; *Micrandra elata* (75. globoid-leaf, 76. lenticular-leaf, 77. globoid-leaf, 78. amorphous-leaf, 79. globoid-stem, 80. marginal roll-leaf, 81. fusiform-stem, 82. globoid-leaf, 83. globoid-leaf, 84. fusiform-leaf, 85. globoid-leaf, 86. globoid-stem, 87. globoid-leaf, 88. globoid-stem), 89–91; *Nealchornea yapurensis* (89. fusiform-leaf, 90. lenticular-leaf, 91. lenticular-leaf), 92–93; *Abarema auriculata* (92. globoid-leaf, 93. lenticular-leaf), 94–96; *Cynometra bauhiniifolia* (94. fusiform-leaf, 95. marginal roll-leafl, 96. globoid-leaf).

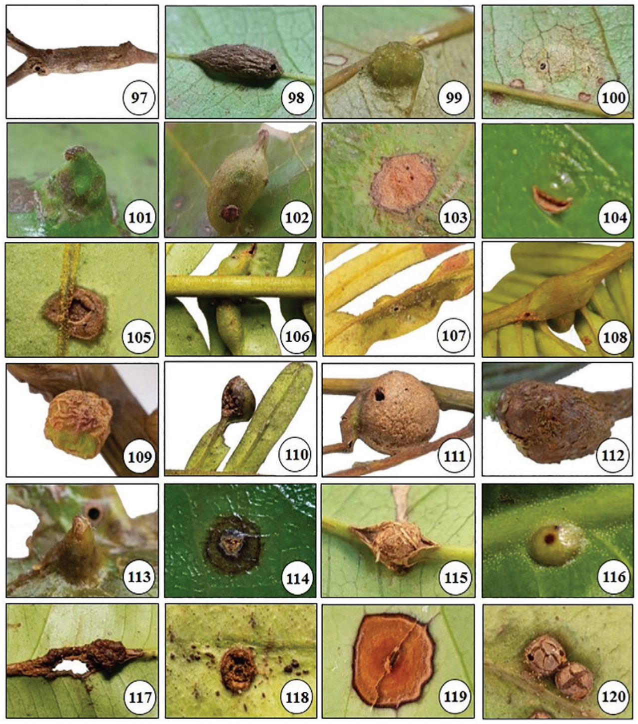

Figure 6. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 97; *Cynometra bauhiniifolia* (97. fusiform-stem), 98–101; *Dialium guianense* (98. fusiform-leaf, 99. globoid-leaf, 100. lenticular-leaf, 101. conical-leaf), 102–103; *Dicymbe uaiparuensis* (102. conical-leaf, 103. lenticular-leaf), 104–111; *Dimorphandra macrostachya* (104. globoid-leaf, 105. lenticular-leaf, 106. globoid-leaf, 107. pocket-leaf, 108. globoid-leaf, 109. globoid-leaf, 110. globoid-leaf, 111. globoid-leaf (rachis)), 112–114; *Hymenaea courbaril* (112. globoid-stem, 113. conical-leaf, 114. lenticular-leaf), 115; *Inga nobilis* (115. globoid-leaf), 116–119; *Macrolobium limbatum* (116. globoid-leaf, 117. fusiform-leaf, 118. lenticular-fruit, 119. lenticular-leaf), 120; *Macrolobium microcalyx* (120. globoid-leaf).

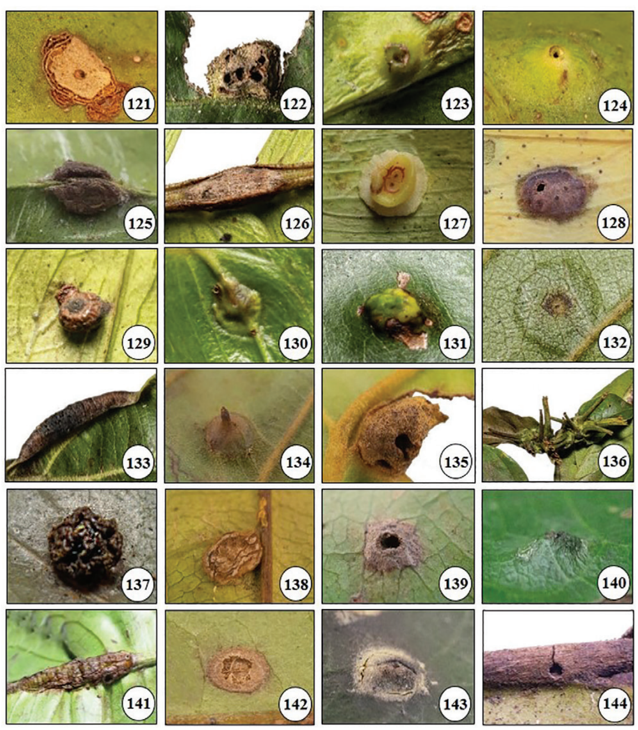

Figure 7. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 121–125; *Macrolobium microcalyx* (121. lenticular-leaf, 122. globoid-leaf, 123. conical-leaf, 124. globoid-leaf, 125. fusiform-leaf), 126–130; *Parkia igneiflora* (126. fusiform-leaf, 127. cup-leaf, 128. lenticular-leaf, 129. globoid-leaf, 130. globoid-leaf), 131–136; *Tachigali loretensis* (131. globoid-leaf, 132. lenticular-leaf, 133. marginal roll-leaf, 134. globoid-leaf, 135. globoid-leaf, 136. rosette-leaf), 137–139; *Vatairea erythrocarpa* (137. globoid-leaf, 138. globoid-leaf, 139. lenticular-leaf), 140–141; *Vantanea parviflora* (140. globoid-leaf, 141. fusiform-leaf), 142–144; *Aniba taubertiana* (142. lenticular-leaf, 143. globoid-leaf, 144. fusiform-leaf).

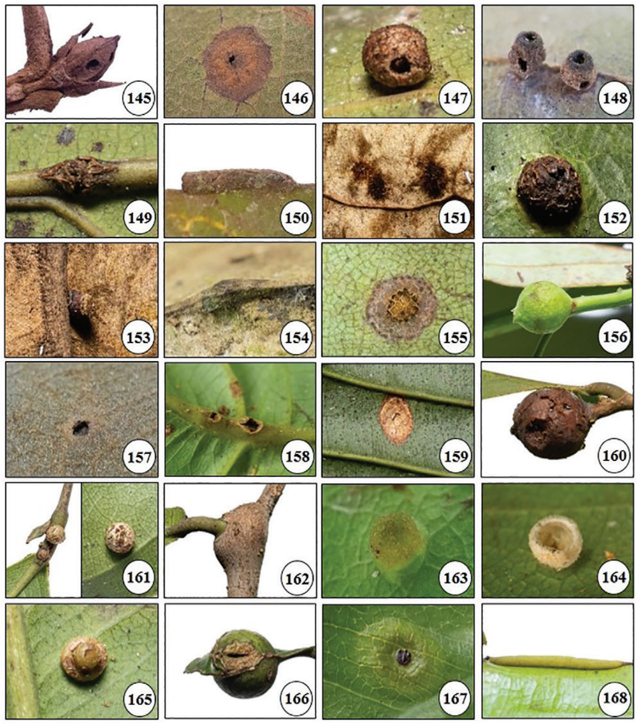

Figure 8. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 145; *Aniba taubertiana* (145. globoid-bud), 146–150; *Nectandra longifolia* (146. lenticular-leaf, 147, globoid-leaf, 148. globoid-leaf, 149. fusiform-leaf, 150. marginal roll-leaf), 151–154; *Ocotea argyrophylla* (151. globoid-leaf, 152. globoid-leaf, 153. conical-leaf, 154. fusiform-leaf), 155–156; *Persea boliviensis* (155. lenticular-leaf, 156. globoid-bud), 157–158; *Pleurothyrium cuneifolium* (157. lenticular-stem, 158. fusiform-leaf), 159; *Allantoma pluriflora* (159. lenticular-leaf), 160–168; *Eschweilera coriacea* (160. globoid-leaf, 161. globoid-petiole/leaf, 162. globoid-stem, 163. globoid-leaf, 164. globoid-leaf, 165. globoid-leaf, 166. globoid-leaf, 167. lenticular-leaf, 168. marginal roll-leaf).

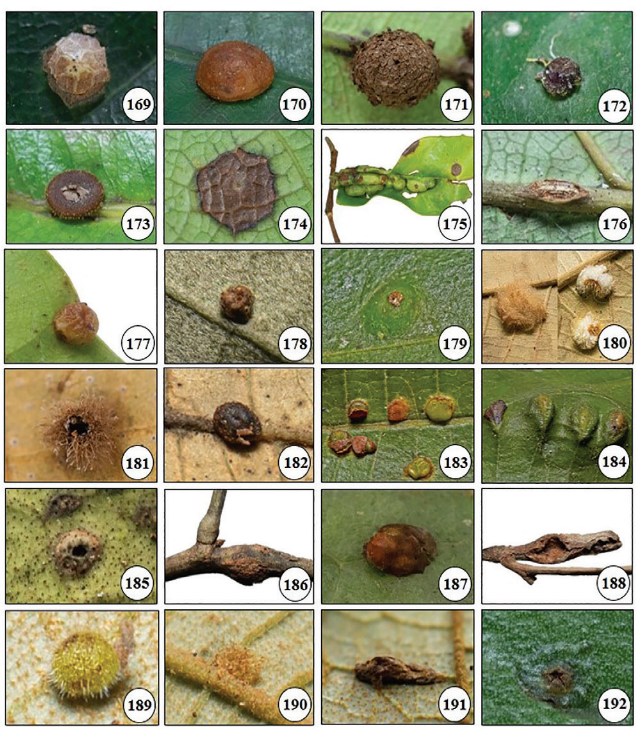

Figure 9. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 169–170; *Eschweilera coriacea* (169. globoid-leaf, 170. globoid-leaf), 171–175; *Eschweilera rufifolia* (171. globoid-leaf, 172, globoid-leaf, 173. lenticular-leaf, 174. lenticular-leaf, 175. globoid-leaf), 176; *Gustavia longifolia* (176. fusiform-leaf), 177; *Ruptiliocarpon caracolito* (177. globoid-leaf), 178–179; *Bunchosia argentea* (178. globoid-leaf, 179. globoid-leaf), 180–184; *Luheopsis hoehnei* (180. globoid-leaf, 181. globoid-leaf, 182. 183. globoid-leaf, 184. fusiform-leaf), 185–188; *Pachira brevipes* (185. lenticular-leaf, 186. globoid-stem, 187. globoid-leaf, 188. fusiform-stem), 189–191; *Theobroma subincanum* (189. globoid-leaf, 190. globoid-leaf, 191. fusiform-leaf), 192; *Mouriri vernicosa* (192. lenticular-leaf).

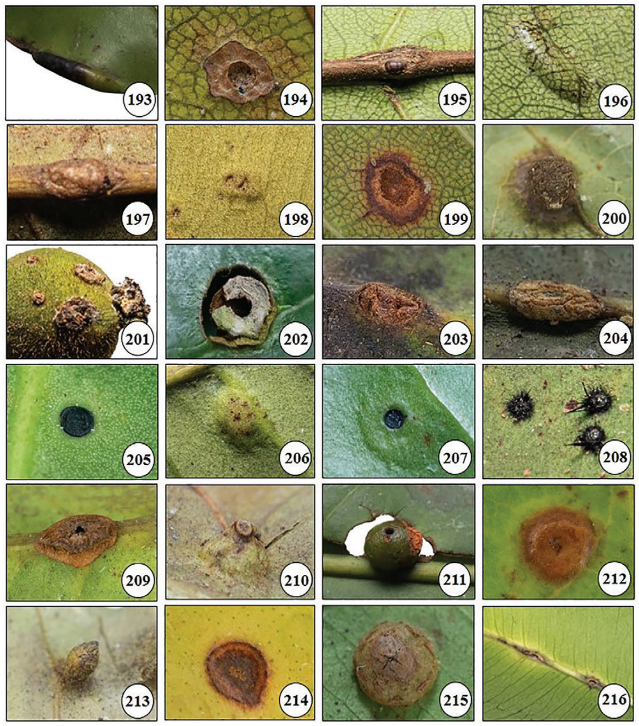

Figure 10. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 193; *Mouriri vernicosa* (193. Marginal roll-leaf), 194–196; *Carapa procera* (194. lenticular-leaf, 195, fusiform-leaf, 196. globoid-leaf), 197–198; *Emmotum floribundum* (197. fusiform-leaf, 198. lenticular-leaf), 199; *Brosimum utile* (199. lenticular-leaf), 200; *Perebea xanthochyma* (200. globoid-leaf), 201; *Trymatococcus amazonicus* (201. lenticular-fruit), 202–203; *Iryanthera juruensis* (202. lenticular-leaf, 203. fusiform-leaf), 204–205; *Iryanthera laevis* (204. fusiform-leaf, 205. lenticular-leaf), 206–211; *Iryanthera lancifolia* (206. lenticular-leaf, 207. lenticular-leaf, 208. lenticular-leaf, 209. fusiform-leaf, 210. conical-leaf, 211. globoid-leaf), 212–213; *Virola pavonis* (212. lenticular-leaf, 213. Conical-leaf), 214; *Blepharocalyx eggersii* (214. lenticular-leaf); 215–216; *Eugenia riparia* (215. globoid-leaf, 216. fusiform-leaf).

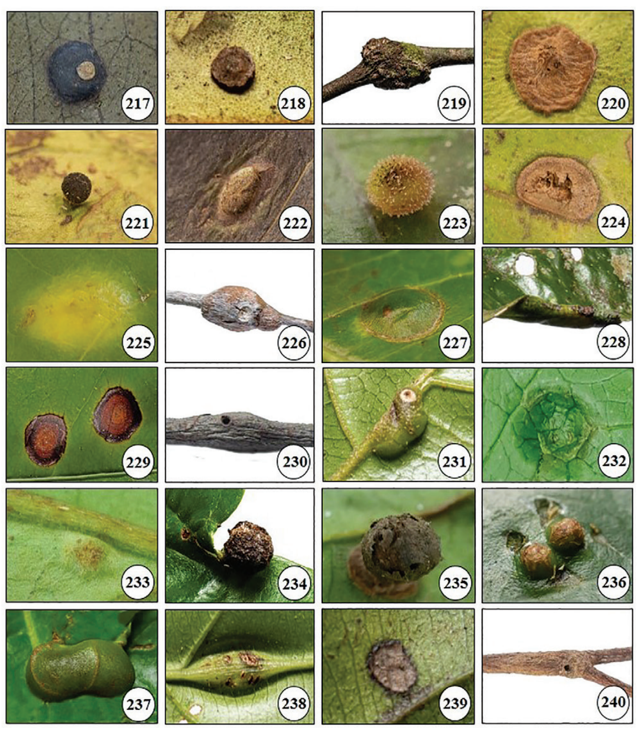

Figure 11. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 217; *Eugenia riparia* (217. globoid-leaf), 218–219; *Myrcia cebra* (218. lenticular-leaf, 219, globoid-stem), 220–222; *Neea spruceana* (220. lenticular-leaf, 221. globoid-leaf, 222. lenticular-leaf), 223–224; *Neea verticillata* (223. globoid-leaf, 224. lenticular-leaf), 225–226; *Cathedra acuminata* (225. lenticular-leaf, 226. globoid-stem), 227–230; *Amanoa guianensis* (227. lenticular-leaf, 228. marginal roll-leaf, 229. lenticular-leaf, 230. globoid-stem), 231–232; *Hieronyma oblonga* (231. globoid-leaf, 232. globoid-leaf), 233–237; *Richeria grandis* (233. globoid-leaf, 234. globoid-leaf, 235. globoid-leaf, 236. globoid-leaf, 237. globoid-leaf), 238–240; *Casearia arborea* (238. fusiform-leaf, 239. lenticular-leaf, 240. fusiform-stem).

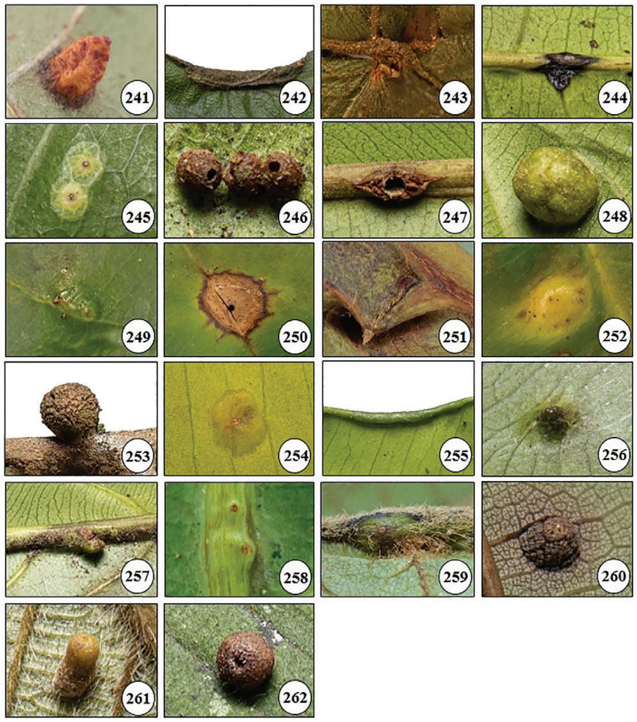

Figure 12. Galls found in four vegetation types in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. 241; *Cupania diphylla* (241. conical-leaf), 242–243; *Cupania latifolia* (242. Marginal roll-leaf, 243, fusiform-leaf), 244–245; *Talisia firma* (244. fusiform-leaf, 245. lenticular-leaf), 246–251; *Chrysophyllum sanguinolentum* (246. globoid-leaf, 247. fusiform-leaf, 248. globoid-leaf, 249. globoid-leaf, 250. lenticular-leaf, 251. Fusiform-leaf), 252–255; *Manilkara bidentata* (252. globoid-leaf, 253. globoid-stem, 254. lenticular-leaf, 255. Marginal roll-leaf), 256–258; *Pouteria subrotata* (256. conical-leaf, 257. clavate-leaf, 258. globoid-leaf), 259; *Pouteria torta* (259. fusiform-leaf), 260; *Cecropia distachya* (260. globoid-leaf), 261–262; *Pouroma bicolor* (261. clavate-leaf, 262. globoid-leaf).

The galling insects were distributed across four orders: Diptera (n = 58), Thysanoptera (n = 2), Lepidoptera (n = 2), and Hemiptera (n = 1) (Table 3). The Cecidomyiidae (Diptera) was responsible for 22% of all morphotypes. In 199 (76%) of the gall morphotypes we did not find the gall-inducing insect, either because the galls were empty, contained parasitoids, or were occupied by multiple potentially gall-inducing taxa. Eigtheen species of gall midges were identified, in two genera: *Contarinia* Rondani, 1860 with five morphospecies and *Bruggmanniella* Tavares, 1909 with one morphospecies. The tribes: Asphondyliini and Lasiopteridi both contained two morphospecies, while Clinodiplosini and Lopesiini had three and five morphospecies, respectively. This is due to scarcity of material, either because one or both sexes were absent, or because no immature specimens were observed. Additionally, the inducer of two gall morphotypes was identified as *Plagiothrips* sp. 2 (Thysanoptera).

The associated fauna comprised successors, cecidophages and parasitoids. Successors, represented by Thysanoptera (*Adraneothrips* sp., *Holothrips* sp. 1, and *Plagiothrips* sp. 1), Hymenoptera (Formicidae and Apidae), Collembola and Acari, were found in 8, 8, 5 and 3 morphotypes, respectively. Cecidophages, Curculionidae (Coleoptera) and Sciaridae (Diptera) were found in only one morphotype. The parasitoids obtained from 55 morphotypes (21% of the total) represented 11 families and 23 genera of Hymenoptera: Aphelinidae (*Coccobius* sp.), Braconidae (*Allorhogas* sp. 1, 2), Encyrtidae (*Metaphycus* sp.), Eulophidae (*Aranobroter* sp.; *Baryscapus* sp.; *Chrysonotomyia* sp.; *Euderus* sp.; *Euderomphale* sp.; *Galeopsomyia* sp.; *Horismenus* sp.; *Neopomphale* sp. 1, 2), Eupelmidae (*Lambdobregma* sp.), Eurytomidae (*Calorileya* sp.; *Phylloxeroxenus* sp.; *Platyrileya* sp. 1; *Prodecatoma* sp.; *Tenuipetiolus* sp.), Mymaridae (*Polynema* sp.), Torymidae (*Torymus* sp. 1, 2), Platygastridae (*Magellanium* sp. 1, 2), Pteromalidae (*Cerocephala* sp.; *Euteloidea* sp.), and Scelionidae (*Baryconus* sp.).

In the Allpahuayo-Mishana National Reserve, a total of 240 gall morphotypes were found across 68 plant species, representing 29 botanical families and 59 genera. Meanwhile, in the Quistococha Regional Reserve, 22 gall morphotypes were found, distributed among 8 families, 8 genera, and 8 species. These data were also analyzed based on the type of vegetation present in each reserve.

The *terra firme* forest showed the greatest diversity of galls and host plants, with 111 different morphotypes found on 39 host plant species, followed by white-sand wet forest, white-sand dry forest and palm swamp forest, which had 73, 56 and 22 morphotypes, among 16, 16 and 8 host plant species respectively (Table 2). In *terra firme* forest, leaves (n = 104) were the most commonly galled plant organ; the most common gall morphologies included the globoid shape (n = 51), green color (n = 70), glabrous surface (n = 94) and single internal chamber (n = 104). In white-sand wet forest, leaves are most commonly attacked (n = 65), and morphologies are mostly globoid (n = 41), green (n = 52), glabrous (n = 67) and with a single inner chamber (n = 66). In white-sand dry forest: leaves (n = 45), globoid (n = 29), green (n = 35), glabrous (n = 52), and a single inner chamber (n = 48). For palm swamp forest: leaves (n = 21), globoid (n = 9), green (n = 18), glabrous (n = 19), and a single inner chamber (n = 20) (Table 2).

The *terra firme* forest also showed the richest gall-inducing insect fauna, represented by Diptera (n = 18), Thysanoptera (n = 2),

Table 2. Characterization of insect galls in four vegetation type in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru. Legends: P = Parasitoid, S = Successor, C = Cecidophages; TF = Terra firme forest, WSd = White-sand dry forest, WSw= White-sand wet forest, and PS = Palm swamp forest.

Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
Anacardiaceae	*Tapirira guianensis* Aubl.	Leaf	Globoid	Brown	Yes	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 1
		Leaf	Conical	Green	Yes	One-chambered	TF	Unidentified	Hymenoptera (P)		Fig. 2
		Leaf	Fusiform	Brown	Yes	One-chambered	TF	Unidentified			Fig. 3
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 4
		Leaf	Globoid	Brown	Yes	One-chambered	TF	Unidentified			Fig. 5
		Leaf	Globoid	Brown	Yes	One-chambered	TF	Unidentified			Fig. 6
		Leaf	Fusiform	Brown	No	One-chambered	TF	Thysanoptera (*Plagiothrips* sp. 2)	Hymenoptera (P)		Fig. 7
		Leaf	Globoid	Brown	No	One-chambered	TF	Thysanoptera (*Plagiothrips* sp. 2)			Fig. 8
		Leaf	Globoid	Brown	No	One-chambered	TF	Cecidomyiidae	Hymenoptera (P)		Fig. 9
		Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified			Fig. 10
		Leaf	Marginal roll	Green	No	One-chambered	WSd	Unidentified			Fig. 11
		Leaf	Conical	Green	No	One-chambered	WSd	Unidentified			Fig. 12
		Stem	Globoid	Brown	No	One-chambered	WSd	Cecidomyiidae			Fig. 13
		Leaf	Globoid	Brown	No	One-chambered	WSd	Cecidomyiidae	*Allohorgas* sp. 2 (P) (Hymenoptera)		Fig. 14
		Leaf	Conical	Brown	No	One-chambered	WSd	Unidentified			Fig. 15
		Leaf	Fusiform	Brown	No	Multilocular	WSd	Cecidomyiidae	Hymenoptera (P)		Fig. 16
Annonaceae	*Diclinanona tessmannii* Diels	Leaf	Globoid	Brown	No	One-chambered	WSd	Unidentified		Least Concern (LC)	Fig. 17
		Stem	Globoid	Brown	No	One-chambered	WSd	Unidentified			Fig. 18
	Guatteria megalophylla Diels	Leaf	Conical	Green	No	One-chambered	WSd	Unidentified		Least Concern (LC)	Fig. 19
		Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified	Formicidae (S)		Fig. 20
		Leaf	Globoid	Brown	No	One-chambered	WSd	Unidentified			Fig. 21
	Porcelia nitidifolia Ruiz & Pav.	Leaf	Globoid	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 22
	Unonopsis spectabilis Diels	Leaf	Globoid	Green	Yes	One-chambered	TF	Cecidomyiidae		Least Concern (LC)	Fig. 23

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
Apocynaceae	*Aspidosperma excelsum* Benth.	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 24
		Leaf	Lenticular	Green	No	One-chambered	TF / WSd	Cecidomyiidae	Hymenoptera (P)		Fig. 25
		Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified			Fig. 26
	Parahancornia peruviana Monach.	Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified		-	Fig. 27
		Leaf	Fusiform	Green	No	One-chambered	PS	Unidentified			Fig. 28
Araliaceae	*Dendropanax umbellatus* (Ruiz & Pav.) J.F. Macbr.	Leaf	Globoid	Brown	Yes	One-chambered	WSw	Unidentified		-	Fig. 29
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 30
		Leaf	Fusiform	Green	No	One-chambered	WSw	Cecidomyiidae	Hymenoptera (P)		Fig. 31
Bignoniaceae	*Tabebuia insignis* (Miq.) Sandwith	Leaf	Globoid	Brown	No	One-chambered	PS	Unidentified		Near Threatened (NT)	Fig. 32
		Leaf	Fusiform	Green	No	One-chambered	PS	Unidentified	Polynema sp. (P) (Hymenoptera)		Fig. 33
		Leaf	Globoid	Green	No	One-chambered	PS	Unidentified			Fig. 34
		Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified	*Adraneothrips* sp. (S) (Thysanoptera)		Fig. 35
		Leaf	Globoid	Green	No	One-chambered	PS	Unidentified			Fig. 36
Burseraceae	*Protium crassipetalum* Cuatrec.	Leaf	Marginal roll	Green	No	One-chambered	TF	Cecidomyiidae	Hymenoptera (P) *Holothrips* sp. 1 (S) (Thysanoptera) Formicidae (S)	-	Fig. 37
Calophyllaceae	*Caraipa tereticaulis* Tul.	Leaf	Fusiform	Green	No	Multilocular	WSw	Cecidomyiidae	Hymenoptera (P)	Least Concern (LC)	Fig. 38
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 39
		Leaf	Marginal roll	Green	No	One-chambered	WSw	Cecidomyiidae	Hymenoptera (P)		Fig. 40
	Caraipa utilis Vásquez	Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified		Vulnerable (VU)	Fig. 41
		Stem	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 42

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Leaf	Globoid	Green	No	Multilocular	WSw	Cecidomyiidae	*Magellanium* sp. 2 (P) (Hymenoptera) *Holothrips* sp. 1 (S) (Thysanoptera)		Fig. 43
		Leaf	Marginal roll	Green	No	One-chambered	WSw	Cecidomyiidae	*Holothrips* sp. 1 (S) (Thysanoptera) Collembola (S)		Fig. 44
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 45
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 46
		Leaf	Globoid	Green	No	One-chambered	WSw	Cecidomyiidae	Collembola (S) Formicidae (S) Eupelmidae (P) Braconidae (P) (Hymenoptera)		Fig. 47
		Leaf	Globoid	Brown	No	One-chambered	WSw	Cecidomyiidae	*Tenuipetiolus* sp. (P) (Hymenoptera)		Fig. 48
		Leaf	Globoid	Brown	No	One-chambered	WSw	Unidentified	*Phylloxeroxenus* sp. (P) (Hymenoptera)		Fig. 49
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 50
		Stem	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 51
		Stem	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 52
		Leaf	Globoid	Green	No	Multilocular	WSw	Unidentified			Fig. 53
		Stem	Globoid	Brown	No	One-chambered	WSw	Cecidomyiidae	Curculionidae (C) (Coleoptera)		Fig. 54
	Haploclathra cordata Vásquez	Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified		-	Fig. 55
		Leaf	Globoid	Green	No	Multilocular	WSw	Unidentified	Hymenoptera (P)		Fig. 56
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 57
		Leaf	Conical	Green	No	One-chambered	WSw	Unidentified			Fig. 58
Chrysobalan-aceae	*Couepia williamsii* J.F. Macbr.	Leaf	Marginal roll	Green	No	One-chambered	WSd	Lopesiini		-	Fig. 59
		Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified	Hymenoptera (P)		Fig. 60

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Bud	Globoid	Green	No	One-chambered	WSd	*Contarinia* sp.			Fig. 61
Elaeocarpaceae	*Sloanea parvifructa* Steyerm.	Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified		-	Fig. 62
		Leaf	Marginal roll	Green	No	One-chambered	WSw	Cecidomyiidae	*Horismenus* sp. (P) (Hymenoptera)		Fig. 63
		Leaf	Globoid	Green	No	Multilocular	WSw	Lopesiini	Hymenoptera (P)		Fig. 64
		Stem	Globoid	Green	No	Multilocular	WSw	Asphondyliini	Collembola (S) *Prodecatoma* sp. (P) Platyrileya sp. 1 (P) *Torymus* sp. 1, 2 (P) *Cerocephala* sp. (P) *Lambdobregma* sp. (P) *Allorhogas* sp. 1 (P) (Hymenoptera)		Fig. 65
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 66
		Leaf	Fusiform	Green	No	One-chambered	WSw	Unidentified			Fig. 67
		Leaf	Fusiform	Brown	No	One-chambered	WSw	Unidentified			Fig. 68
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified	Apidae (S) (Hymenoptera)		Fig. 69
		Leaf	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 70
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 71
Euphorbiaceae	*Alchorneopsis floribunda (Benth.)* Müll. Arg.	Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified		Least Concern (LC)	Fig. 72
		Leaf	Globoid	Green	Yes	Multilocular	PS	Unidentified	Hymenoptera (P)		Fig. 73
	Hevea guianensis Aubl.	Leaf	Globoid	Brown	No	One-chambered	WSw	Unidentified		Least Concern (LC)	Fig. 74
	Micrandra elata (Didr.) Müll. Arg.	Leaf	Globoid	Green	No	Multilocular	WSd	Unidentified	Eulophidae (P) (Hymenoptera)	Least Concern (LC)	Fig. 75
		Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified			Fig. 76
		Leaf	Globoid	Green	No	Multilocular	WSd	Lasiopteridi	*Neopomphale* sp. 2 (P) *Calorileya* sp. (P)		Fig. 77

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Leaf	Amorphous	Green	No	One-chambered	WSd	Cecidomyiidae	*Coccobius* sp. (P) (Hymenoptera) *Neopomphale* sp. 2 (P) (Hymenoptera)		Fig. 78
		Stem	Globoid	Brown	No	One-chambered	WSd	Cecidomyiidae	Hymenoptera (P)		Fig. 79
		Leaf	Marginal roll	Green	No	One-chambered	WSd	Lopesiini	Hymenoptera (P)		Fig. 80
		Stem	Fusiform	Green	No	One-chambered	WSd	Cecidomyiidae	*Plagiothrips* sp.1 (S) (Thysanoptera) Collembola (S) Formicidae (S)		Fig. 81
		Leaf	Globoid	Green	No	One-chambered	WSd	Cecidomyiidae	*Magellanium* sp.1 (P) (Hymenoptera) Hymenoptera (P) Collembola (S)		Fig. 82
		Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified			Fig. 83
		Leaf	Fusiform	Green	No	One-chambered	WSd	Unidentified			Fig. 84
		Leaf	Globoid	Brown	No	One-chambered	WSd	Unidentified			Fig. 85
		Stem	Globoid	Brown	No	One-chambered	WSd	Cecidomyiidae	Hymenoptera (P)		Fig. 86
		Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified			Fig. 87
		Stem	Globoid	Brown	No	One-chambered	WSd	Unidentified			Fig. 88
	Nealchornea yapurensis Huber	Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 89
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 90
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 91
Fabaceae	*Abarema auriculata* (Benth.) Barneby & J.W. Grimes	Leaf	Globoid	Green	Yes	One-chambered	WSw	Lopesiini	Hymenoptera (P)	Least Concern (LC)	Fig. 92
		Leaf	Lenticular	Green	No	One-chambered	WSw	Cecidomyiidae			Fig. 93
	Cynometra bauhiniifolia Benth.	Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 94
		Leaf	Marginal roll	Green	No	One-chambered	TF	Unidentified			Fig. 95

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Leaf	Globoid	Green	No	One-chambered	TF	Lasiopteridi	Acari (S)		Fig. 96
		Stem	Fusiform	Brown	No	One-chambered	TF	Unidentified			Fig. 97
	Dialium guianense (Aubl.) Sandwith	Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 98
		Leaf	Globoid	Green	No	One-chambered	TF	Clinodiplosini	Hymenoptera (P)		Fig. 99
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 100
		Leaf	Conical	Green	Yes	One-chambered	TF	Cecidomyiidae			Fig. 101
	Dicymbe uaiparuensis R.S. Cowan	Leaf	Conical	Green	Yes	One-chambered	WSw	Cecidomyiidae	*Baryscapus* sp. (P) (Hymenoptera)	-	Fig. 102
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 103
	Dimorphandra macrostachya Benth.	Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified		Least Concern (LC)	Fig. 104
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 105
		Leaf	Globoid	Green	Yes	One-chambered	WSw	Cecidomyiidae	Hymenoptera (P)		Fig. 106
		Leaf	Pocket	Green	No	One-chambered	WSw	Cecidomyiidae	*Galeopsomyia* sp. (P) (Hymenoptera)		Fig. 107
		Leaf	Globoid	Green	No	One-chambered	WSw	Clinodiplosini	Hymenoptera (P)		Fig. 108
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 109
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified	Sciaridae (C) (Diptera)		Fig. 110
		Leaf	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 111
	Hymenaea courbaril L.	Stem	Globoid	Brown	No	Multilocular	TF	Asphondyliini	*Euteloidea* sp. (P) (Hymenoptera)	Least Concern (LC)	Fig. 112
		Leaf	Conical	Green	No	Multilocular	TF	*Bruggmanniella* sp.			Fig. 113
		Leaf	Lenticular	Brown	No	One-chambered	TF	Unidentified			Fig. 114
	Inga nobilis Willd.	Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 115
	Macrolobium limbatum Spruce ex Benth.	Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified		Least Concern (LC)	Fig. 116
		Leaf	Fusiform	Brown	No	One-chambered	WSd	Unidentified			Fig. 117

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Fruit	Lenticular	Brown	No	One-chambered	WSd	Lepidoptera			Fig. 118
		Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified			Fig. 119
	Macrolobium microcalyx Ducke	Leaf	Globoid	Green	No	Multilocular	WSd	Unidentified		Least Concern (LC)	Fig. 120
		Leaf	Lenticular	Green	No	One-chambered	WSd / WSw	Unidentified			Fig. 121
		Leaf	Globoid	Green	No	Multilocular	WSw	Unidentified			Fig. 122
		Leaf	Conical	Green	No	One-chambered	WSw	Unidentified			Fig. 123
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 124
		Leaf	Fusiform	Brown	No	One-chambered	WSw	Unidentified			Fig. 125
	Parkia igneiflora Ducke	Leaf	Fusiform	Green	No	One-chambered	WSw	Unidentified		Least Concern (LC)	Fig. 126
		Leaf	Cup	Yellow	Yes	One-chambered	WSw	Cecidomyiidae	Braconidae (P) (Hymenoptera)		Fig. 127
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 128
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 129
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified	Hymenoptera (P)		Fig. 130
	Tachigali loretensis van der Werff	Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified		-	Fig. 131
		Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified			Fig. 132
		Leaf	Marginal roll	Green	Yes	One-chambered	WSd	Unidentified	Formicidae (S) *Holothrips* sp. 1 (S) (Thysanoptera)		Fig. 133
		Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified			Fig. 134
		Leaf	Globoid	Green	Yes	Multilocular	WSd	Unidentified			Fig. 135
		Leaf	Rosette	Green	Yes	Multilocular	WSd	Cecidomyiidae	Hymenoptera (P)		Fig. 136
	Vatairea erythrocarpa (Ducke) Ducke	Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 137
		Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified			Fig. 138
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 139
Humiriaceae	*Vantanea parviflora* Lam.	Leaf	Globoid	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 140
		Leaf	Fusiform	Green	No	One-chambered	TF	Lepidoptera			Fig. 141

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
Lauraceae	*Aniba taubertiana* Mez	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 142
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 143
		Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified			Fig. 144
		Bud	Globoid	Brown	Yes	One-chambered	TF	Unidentified			Fig. 145
	Nectandra longifolia (Ruiz & Pav.) Nees	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		-	Fig. 146
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 147
		Leaf	Globoid	Green	No	One-chambered	TF	Cecidomyiidae			Fig. 148
		Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified			Fig. 149
		Leaf	Marginal roll	Green	No	One-chambered	TF	Unidentified			Fig. 150
	Ocotea argyrophylla Ducke	Leaf	Globoid	Brown	Yes	One-chambered	WSd	Unidentified		Least Concern (LC)	Fig. 151
		Leaf	Globoid	Brown	No	One-chambered	WSd	Unidentified	Hymenoptera (P)		Fig. 152
		Leaf	Conical	Brown	No	Multilocular	WSd	Unidentified			Fig. 153
		Leaf	Fusiform	Brown	No	One-chambered	WSd	Unidentified			Fig. 154
	Persea boliviensis Mez & Rusby ex Rusby	Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified		-	Fig. 155
		Bud	Globoid	Green	No	One-chambered	WSd	Cecidomyiidae			Fig. 156
	Pleurothyrium cuneifolium Nees	Leaf	Lenticular	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 157
		Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified			Fig. 158
Lecythidaceae	*Allantoma pluriflora* S.A. Mori, Y.Y. Huang & Prance	Leaf	Lenticular	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 159
	Eschweilera coriacea (DC.) S.A. Mori	Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 160
		Leaf-Petiole	Globoid	Brown	No	One-chambered	TF	Cecidomyiidae	*Holothrips* sp. 1 (S) (Thysanoptera)		Fig. 161

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Stem	Globoid	Brown	No	One-chambered	TF	Cecidomyiidae			Fig. 162
		Leaf	Globoid	Green	No	One-chambered	TF	*Contarinia* sp.	Formicidae (S) Baryconus sp. (P) (Hymenoptera)		Fig. 163
		Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified			Fig. 164
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 165
		Leaf	Globoid	Green	No	Multilocular	TF	Cecidomyiidae			Fig. 166
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 167
		Leaf	Marginal roll	Green	No	One-chambered	TF	Unidentified			Fig. 168
		Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified			Fig. 169
		Leaf	Globoid	Brown	No	One-chambered	TF	*Contarinia* sp.			Fig. 170
	Eschweilera rufifolia S.A. Mori	Leaf	Globoid	Brown	No	Multilocular	TF	Unidentified	Formicidae (S) *Plagiothrips* sp.1 (S) (Thysanoptera) Braconidae (P) (Hymenoptera)	-	Fig. 171
		Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified	Hymenoptera (P)		Fig. 172
		Leaf	Lenticular	Brown	Yes	One-chambered	TF	Unidentified			Fig. 173
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 174
		Leaf	Globoid	Green	No	Multilocular	TF	Unidentified			Fig. 175
	Gustavia longifolia Poepp. ex O. Berg	Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified		-	Fig. 176
Lepidobotryaceae	*Ruptiliocarpon caracolito* Hammel & N. Zamora	Leaf	Globoid	Green	No	Multilocular	TF	Unidentified	Eupelmidae (P) (Hymenoptera)	Least Concern (LC)	Fig. 177
Malpighiaceae	*Bunchosia argentea (Jacq.)* DC.	Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 178
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 179
Malvaceae	*Lueheopsis hoehnei* Burret	Leaf	Globoid	Brown	Yes	One-chambered	PS	Unidentified		-	Fig. 180

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
		Leaf	Globoid	Green	Yes	One-chambered	PS	Lopesiini	*Euderus* sp. (P) (Hymenoptera)		Fig. 181
		Leaf	Globoid	Brown	No	One-chambered	PS	Unidentified			Fig. 182
		Leaf	Globoid	Green	No	Multilocular	PS	Unidentified	Chrysonotomyia sp. (P) *Euderomphale* sp. (P) *Metaphycus* sp. (P) (Hymenoptera)		Fig. 183
		Leaf	Fusiform	Green	No	One-chambered	PS	Cecidomyiidae	Hymenoptera (P)		Fig. 184
	Pachira brevipes (A. Robyns) W.S. Alverson		Lenticular	Green	No	One-chambered	WSw	Unidentified		Least Concern (LC)	Fig. 185
		Leaf									
		Stem	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 186
		Leaf	Globoid	Brown	No	One-chambered	WSw	Unidentified			Fig. 187
		Stem	Fusiform	Brown	No	One-chambered	WSw	Unidentified			Fig. 188
	Theobroma subincanum Mart.	Leaf	Globoid	Green	Yes	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 189
		Leaf	Globoid	Brown	Yes	One-chambered	TF	Unidentified			Fig. 190
		Leaf	Fusiform	Brown	Yes	One-chambered	TF	Unidentified			Fig. 191
Melastomataceae	*Mouriri vernicosa* Naudin	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 192
		Leaf	Marginal roll	Green	No	One-chambered	TF	Unidentified	Hymenoptera (P)		Fig. 193
Meliaceae	*Carapa procera* DC.	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 194
		Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified			Fig. 195
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 196
Metteniusaceae	*Emmotum floribundum* R.A. Howard	Leaf	Fusiform	Brown	No	One-chambered	WSw	Unidentified		-	Fig. 197
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 198
Moraceae	*Brosimum utile* (Kunth) Oken	Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified		Least Concern (LC)	Fig. 199

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
	Perebea xanthochyma H. Karst.	Leaf	Globoid	Green	Yes	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 200
	Trymatococcus amazonicus Poepp. & Endl.	Fruit	Lenticular	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 201
Myristicaceae	*Iryanthera juruensis* Warb.	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 202
		Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified			Fig. 203
	Iryanthera laevis Markgr.	Leaf	Fusiform	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 204
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 205
	Iryanthera lancifolia Ducke	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 206
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 207
		Leaf	Lenticular	Black	Yes	One-chambered	TF	Unidentified			Fig. 208
		Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified			Fig. 209
		Leaf	Conical	Green	Yes	One-chambered	TF	Unidentified			Fig. 210
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 211
	Virola pavonis (A. DC.) A.C. Sm.	Leaf	Lenticular	Brown	No	One-chambered	PS / WSd	*Contarinia* sp.	Hymenoptera (P)	Least Concern (LC)	Fig. 212
		Leaf	Conical	Green	No	One-chambered	PS	Cecidomyiidae			Fig. 213
Myrtaceae	*Blepharocalyx eggersii* (Kiaersk.) Landrum	Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified		Least Concern (LC)	Fig. 214
	Eugenia riparia DC.	Leaf	Globoid	Green	No	One-chambered	TF	Unidentified	*Neopomphale* sp. 1 (P) (Hymenoptera)	-	Fig. 215
		Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified			Fig. 216
		Leaf	Globoid	Green	Yes	One-chambered	TF	Unidentified			Fig. 217
	Myrcia crebra (McVaugh) A.R. Lourenço & E. Lucas	Leaf	Lenticular	Brown	No	One-chambered	WSd	Cecidomyiidae		Least Concern (LC)	Fig. 218
		Stem	Globoid	Brown	No	One-chambered	WSd	Unidentified			Fig. 219

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
Nyctaginaceae	*Neea spruceana* Heimerl	Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 220
		Leaf	Globoid	Green	No	One-chambered	TF	Cecidomyiidae			Fig. 221
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 222
	Neea verticillata Ruiz & Pav.	Leaf	Globoid	Green	No	One-chambered	WSd	Unidentified	Hymenoptera (P)	-	Fig. 223
		Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified			Fig. 224
Olacaceae	*Cathedra acuminata* (Benth.) Miers	Leaf	Lenticular	Green	No	One-chambered	WSd	Unidentified	Hymenoptera (P)	Least Concern (LC)	Fig. 225
		Stem	Globoid	Brown	No	Multilocular	WSd	Unidentified			Fig. 226
Phyllanthaceae	*Amanoa guianensis* Aubl.	Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified		Least Concern (LC)	Fig. 227
		Leaf	Marginal roll	Green	No	One-chambered	PS	Cecidomyiidae			Fig. 228
		Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified			Fig. 229
		Stem	Globoid	Brown	No	One-chambered	PS	Unidentified			Fig. 230
	Hieronyma oblonga (Tul.) Müll. Arg.	Leaf	Globoid	Green	No	One-chambered	TF	*Contarinia* sp.	Hymenoptera (P)	Least Concern (LC)	Fig. 231
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified	Acari (S)		Fig. 232
	Richeria grandis Vahl	Leaf	Globoid	Green	No	One-chambered	TF	Unidentified		-	Fig. 233
		Leaf	Globoid	Green	No	Multilocular	TF	Unidentified			Fig. 234
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified	Acari (S)		Fig. 235
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 236
		Leaf	Globoid	Green	No	One-chambered	TF	Hemiptera (Psyllidae)	*Aranobroter* sp. (P) (Hymenoptera)		Fig. 237
Salicaceae	*Casearia arborea* (Rich.) Urb.	Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 238
		Leaf	Lenticular	Green	No	One-chambered	TF	Unidentified			Fig. 239
		Stem	Fusiform	Brown	No	One-chambered	TF	Unidentified			Fig. 240
Sapindaceae	*Cupania diphylla* Vahl	Leaf	Conical	Brown	Yes	One-chambered	WSw	Unidentified		Least Concern (LC)	Fig. 241

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Family	Species	Organ	Shape	Color	Pubescence	Chambers	Vegetation type	Gall-inducers	Associated fauna	Conservation status (IUCN 2023)	Figure number
	Cupania latifolia Kunth	Leaf	Marginal roll	Green	Yes	One-chambered	TF	Clinodiplosini		Least Concern (LC)	Fig. 242
		Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified			Fig. 243
	Talisia firma Radlk.	Leaf	Fusiform	Green	No	One-chambered	PS	Unidentified		Least Concern (LC)	Fig. 244
		Leaf	Lenticular	Green	No	One-chambered	PS	Unidentified			Fig. 245
Sapotaceae	*Chrysophyllum sanguinolentum* (Pierre) Baehni	Leaf	Globoid	Brown	No	One-chambered	WSw	Unidentified		Least Concern (LC)	Fig. 246
		Leaf	Fusiform	Brown	No	One-chambered	WSw	Unidentified			Fig. 247
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 248
		Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified			Fig. 249
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 250
		Leaf	Fusiform	Green	No	One-chambered	WSw	Unidentified			Fig. 251
	Manilkara bidentata (A. DC.) A. Chev.	Leaf	Globoid	Green	No	One-chambered	WSw	Unidentified	Hymenoptera (P)	Least Concern (LC)	Fig. 252
		Stem	Globoid	Brown	No	One-chambered	WSw	Cecidomyiidae			Fig. 253
		Leaf	Lenticular	Green	No	One-chambered	WSw	Unidentified			Fig. 254
		Leaf	Marginal roll	Green	No	One-chambered	WSw	Unidentified			Fig. 255
	Pouteria subrotata Cronquist	Leaf	Conical	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 256
		Leaf	Clavate	Green	No	One-chambered	TF	Unidentified			Fig. 257
		Leaf	Globoid	Green	No	One-chambered	TF	Unidentified			Fig. 258
	Pouteria torta (Mart.) Radlk.	Leaf	Fusiform	Green	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 259
Urticaceae	*Cecropia distachya* Huber	Leaf	Globoid	Green	No	One-chambered	TF	Cecidomyiidae		Least Concern (LC)	Fig. 260
	Pourouma bicolor Mart.	Leaf	Clavate	Brown	No	One-chambered	TF	Unidentified		Least Concern (LC)	Fig. 261
		Leaf	Globoid	Brown	No	One-chambered	TF	Unidentified			Fig. 262

Table 3. Number and percentage of gall morphotypes in the different taxa of galling insects recorded in the Allpahuayo-Mishana National Reserve and Quistococha Regional Reserve, Iquitos, Peru.

Gall-inducing taxa	Gall morphotypes	
	N	%
Diptera (Cecidomyiidae)	58	22.14
Thysanoptera	2	0.76
Lepidoptera	2	0.76
Hemiptera (Psyllidae)	1	0.38
Unidentified	199	75.95
Total	262	100

Hemiptera (n = 1), and Lepidoptera (n = 1) (Table 2); white-sand dry forest was next, with Diptera (n = 15) and Lepidoptera (n = 1) as gall-inducing taxa. White-sand wet forest and palm swamp forest had only Diptera (n = 19 and n = 4, respectively). Additionally, two gall-inducing insects (Diptera) were found in two types of vegetation, one in palm swamp and white-sand dry forests on *Virola pavonis* (A. DC.) A.C. Sm. (Myristicaceae), and other in *terra firme* and white-sand dry forests on *Aspidosperma excelsum* Benth. (Apocynaceae).

The associated fauna was found in 66 gall morphotypes, with the highest frequency of occurrence observed in the white-sand wet forest (n = 23 morphotypes), followed by *terrra firme* forest (n = 18), white-sand dry forest (n = 17), and palm swamp forest (n = 6).

Discussion

We recorded 262 gall morphotypes across our sites in the Peruvian Amazon, a relatively high number compared to other areas with similar vegetation. For example, Almada & Fernandes (2011) reported the highest insect gall diversity (n = 309 insect gall morphogypes) in an Amazonian forest site, FLONA-Saracá Taquera, Brazil. Other studies in the Brazilian Amazon recorded from 27 to 236 morphotypes (Almada & Fernandes 2011, Maia 2011, Silva et al. 2011, Araújo et al. 2012, Julião et al. 2017, Carvalho & Mota 2018). Thus, our study presents the second highest diversity of galling insects recorded in Amazonian forest. We also found that the average number of gall morphotypes per plant species was 3.5, which was high when compared to other locations in the Amazon—with average values of 1.2, 2.0, 1.7, 1.4 (Almada & Fernandes 2011, Maia 2011, Araújo et al. 2012, Julião et al. 2017). Variations in the insect gall richness and number of gall morphotypes per plant species can be explained by differences in sampling method, collecting effort and host plants sampled (Bergamini et al. 2017).

Among the sampled vegetation types, the *terra firme* forest exhibited the greatest richness of gall morphotypes and host species. This can be attributed to the exceptionally diverse and heterogeneous flora found in this forest type, which characterized by nutrient-rich soils and a wide array of niches and ecological resources (Pitman et al. 2001). This finding is consistent with results reported by Julião et al. (2014b), which demonstrated that *terra firme* forests have a greater number of galling insect morphospecies per sampled area than other vegetation types, such as *várzea* forest.

Many inventories of gall diversity in the Amazon forest indicate that Fabaceae is the most important host plant family (Almada & Fernandes 2011, Maia 2011, Araújo et al. 2012, Julião et al. 2017, Carvalho & Mota 2018), a result also observed in the present study. Araújo et al. (2012) suggested that the main explanation for the high insect gall richness hosted by Fabaceae in the Amazon is the large number of species in that family. According to Julião et al. (2014b), Fabaceae stands out as the family with the greatest richness of Cecidomyiidae galls in the Amazon. It is expected that the number of taxa in a host plant family will be reflected in the number of galling associates, with more species-rich families hosting a richer fauna (Gonçalves-Alvim & Fernandes 2001). Consistent with previous work, we showed that the host genus *Eschweilera* (Lecythidaceae) was one of the richest in insect gall morphotypes. Julião et al. (2014b) found that 77% of galling insect morphospecies sampled from Lecythidaceae are associated with this single genus. With respect to the high gall diversity on *T. guianesis*, *C. utilis*, *M. elata*, *E. coriacea* and *S. parvifructa*—the most important host species in the present study—there are no reports in the literature. Among all host plants, only *C. utilis* is endemic to the Amazonian region. This plant hosts 14 gall-inducing species. Since galls result from species-specific interactions, the plant endemism also applies to the inducers. So, these 14 cecidogenous species are endemic too.

Leaves were the most frequently galled plant organ in our study. This pattern was observed in previous studies, including inventories carried out in the Amazon forest (Mani 1964, Almada & Fernandes 2011, Maia 2011, Silva et al. 2011, Araújo et al. 2012, Julião et al. 2017, Carvalho & Mota 2018), and in other biomes (Rodrigues et al. 2014, Bergamini et al. 2017, Marinho et al. 2023). According to Proença & Maia (2023), 81% of galls occurred on leaves in the Amazon forest. This is probably because leaves represent an abundant and renewable resource available to gall inducers (Maia 2011). The globoid shape also was the most common one, together with the green color, glabrous surface and one-chambered galls. These predominant characteristics are also consistent with previous studies in the Amazon (Almada & Fernandes 2011, Maia 2011, Silva et al. 2011, Araújo et al. 2012, Julião et al. 2017, Carvalho & Mota 2018).

Galling insects of the family Cecidomyiidae were the most important in the fauna studied. This result corroborates previous studies that pointed to the dominance of Cecidomyiidae in the Amazon forest (Proença & Maia, 2023). For example, Julião et al. (2014b), showed that Cecidomyiidae was responsible for 72% of gall morphospecies in the Amazon forest. This points to Cecidomyiidae as the family with the greatest diversity of galling insects in the Neotropical region (Gagné 1994).

Regarding the associated fauna, Thysanoptera, Hymenoptera, Acari, and Collembola were found as successors. Additionally, Curculionidae (Coleoptera) and Sciaridae (Diptera) were identified as cecidophages, which is the first documented record of this in Amazonian forest. Hymenoptera was the only insect order represented as a parasitoid. Among the Hymenoptera families, Eulophidae was the most frequent in our study. This pattern aligns with previous findings in the Brazilian Amazon, where Eulophidae has been reported as the predominant parasitoid group (Carvalho & Mota 2018). In restinga areas of the state of Rio de Janeiro (Atlantic forest), Eulophidae were also the most frequent and best represented parasitoids (Maia & Azevedo 2009), as well as in Cerrado (Maia & Silva 2021), showing that this pattern can be widespread in South America.

The taxonomic resolution of gall-inducing insects in our study was low, which was also observed in previous studies in the Amazon. Julião et al. (2014b) recorded 1,549 gall morphotypes in the Brazilian

Amazon, and inducers of only 386 morphotypes were identified to order or family level. In that study, gall-inducing insects were found to belong to the orders Diptera (Cecidomyiidae), Hemiptera, Coleoptera, Lepidoptera, and Hymenoptera, while 24% of the inducers could not be identified to any possible level.

Conclusions

This is the first systematic survey of insect galls undertaken in the Peruvian Amazon. With this study, 262 gall morphotypes and 75 host plant species have been recorded. Fabaceae was the family with the highest number of galled species. *T. guianesis*, *C. utilis*, *M. elata*, *E. coriacea* and *S. parvifructa* were identified as the host plant species with the highest richness of gall-inducing insects. The leaf was the most galled plant organ, and globoid shape was the most common morphology. Among the galler orders, Diptera was the most representative, with Cecidomyiidae being the standout family in terms of species richness. Hymenoptera was identified as the only order of parasitoids, while successors were represented by four orders. Cecidophages were represented by both Coleoptera and Diptera orders. Finally, *terra firme* forest presented the largest richness of gall morphotypes and host plant species.

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Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available at: https://doi.org/10.48331/scielodata.025WUA.

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