Acta Agronómica

UNIVERSIDAD NACIONAL DE COLOMBIA

Presence of *Stigmacoccus asper* Hempel (Hemiptera: Coccomorpha: Stigmacoccidae) associated with oak forests in Boyacá, Colombia

Presencia de *Stigmacoccus asper* Hempel (Hemiptera: Coccomorpha: Stigmacoccidae) asociada a bosques de roble en Boyacá, Colombia

Ingrith Juliette Cortés Ávila [1,3], *Irina Morales* [1,4], *Takumasa Kondo* [2,5].

[1]Universidad Pedagógica y Tecnológica de Colombia. Tunja, Colombia. [2]Corporación Colombiana de Investigación Agropecuaria. Palmira, Colombia.[3] ingrith.cortes@uptc.edu.co; [4] irina.morales@uptc.edu.co [5] tkondo@agrosavia.co

DOI: https://doi.org/10.15446/acag.v73n4.119371

2024 | 73-4 p 353-360 | ISSN 0120-2812 | e-ISSN 2323-0118 | Rec.: 2025-03-16 Acep.: 2025-10-15

Abstract

This study aimed to characterize the occurrence of *Stigmacoccus asper* Hempel, 1900 (Hemiptera: Coccomorpha: Stigmacoccidae) on *Quercus humboldtii* Bonpl., 1805 (Fagaceae) within the Civil Society Botanical Gardens Network of Alto Ricaurte, Boyacá, Colombia. The species was recorded in six of the nine sampled zones across three municipalities (Arcabuco, Gachantivá, and Villa de Leyva) at elevations ranging from 2222 to 2656 m a.s.l. A total of 81 individuals were collected, including 76 immatures and 5 adult females. The population was dominated by immatures (mean = 12.7 individuals) and showed low representation of adults (mean = 0.8 individuals). Adult abundance was negatively correlated with altitude and humidity. The findings highlight the ecological relevance of *S. asper* in Andean oak forest dynamics, emphasizing its trophic role and its potential for sustainable beekeeping and ecosystem conservation.

Keywords: Andean forest, ecosystem services, honeydew, plant-insect interactions, sustainable beekeeping.

Resumen

Este estudio tuvo como objetivo documentar la ocurrencia de *Stigmacoccus asper* Hempel, 1900 (Hemiptera: Coccomorpha: Stigmacoccidae) sobre *Quercus humboldtii* Bonpl., 1805 (Fagaceae) en la Red de Jardines Botánicos de la Sociedad Civil de Alto Ricaurte, Boyacá, Colombia. La especie fue registrada en seis de las nueve zonas muestreadas en tres municipios (Arcabuco, Gachantivá y Villa de Leyva) a elevaciones entre 2222 y 2656 m s. n. m. Se recolectó un total de 81 individuos, incluidos 76 inmaduros (quistes) y 5 hembras adultas. La población mostró predominio de inmaduros (media = 12.7 individuos), así como baja representación de adultos (media = 0.8 individuos). Los adultos tuvieron una correlación negativa con la altitud y la humedad. Los hallazgos evidencian la importancia de *S. asper* en la dinámica andina en bosques de roble, resaltando su rol trófico y su potencial para la apicultura sostenible y la conservación ecosistémica.

Palabras clave: apicultura sostenible, bosque andino, interacciones planta–insecto, mielato, servicios ecosistémicos.

Introduction

The oak forests dominated by *Quercus humboldtii* Bonpl., 1805 (Fagaceae) host, and a diverse assemblage of fauna, including members of the order Hemiptera. Many hemipterans are recognized as major agricultural pests (Moghaddam *et al*., 2021), disease vectors, and valuable indicators of ecosystem health (Schwertner *et al*., 2021). In Colombia, the documented diversity of scale insects (Hemiptera: Coccomorpha) likely represents only a small portion of their actual species richness (Kondo, 2001). These insects, typically less than 5 mm in length, exhibit cryptic habits and disperse naturally through anthropogenic factors such as plant trade and the transport of infested trees (Kondo *et al*., 2008).

Scale insects insert their stylets into the host plant to extract sap used for protein synthesis, expelling sugary compounds through an anal filament (Malumphy, 1997). This surplus of water and sugars—such as raffinose and melezitose—is commonly known as honeydew (*mielato* in Spanish) or honeydew exudates (Kondo *et al*., 2008; Shaaban, 2020). Honeydew serves as an important sugar source for birds and insects, and honeybees collect and process it into honeydew honey (Hodgson *et al*., 2007).

Interactions between herbivorous insects and their host plants represent fundamental antagonistic associations, specifically herbivory, in which specialized phytophagous insects consume plant tissues (Jones *et al*., 2022). Despite their ecological importance, research on scale insects (*insectos escama* in Spanish) (Hemiptera: Coccomorpha) has primarily focused on species infesting economically important crops, while those associated with wild plant species have received little attention (Kondo, 2001). Records of the entomofauna associated with oak forests are scarce, including in the eastern mountain regions of Colombia. Nevertheless, scale insects have been documented on oak (*Q. humboldtii*), a species currently listed as Least Concern (LC) on the International Union for Conservation of Nature (IUCN) Red List (Gallagher, 2018; Quevedo García and Prato Sarmiento, 2020).

In Colombia, Chamorro *et al*. (2013) analyzed honeydew in oak forests and highlighted the limited information available on the biology and distribution of scale insects associated with *Q. humboldtii*. They emphasized the need for such research to support beekeepers in producing oak honey, a non-timber forest product of both commercial and environmental value (Chamorro *et al*., 2013). Despite the dispersal ability, reproductive capacity, and potential host damage caused by scale insects, baseline information on their presence and diversity on oak ecosystems remains scarce. Therefore, this study aimed to characterize the composition of scale insects associated with reserves within the *Q. humboldtii* forest corridor in Boyacá, contributing to socio-environmental solutions and the conservation of high Andean forests.

Materials and methods

The study area encompassed the oak forest zones located within the Civil Society Botanical Gardens Network of Alto Ricaurte. This network includes eight reserves: Reserva Natural Nido de Águilas, Reserva Natural Jacamaki, Reserva Natural Aguacos, Reserva Natural Veronia, Reserva Natural Khepri, Reserva Natural Madre Monte, Reserva Natural Cochahuaira, and Reserva Natural Rogitama. In addition, the Entre Ríos sector was included. All areas are located within the municipalities of Arcabuco, Gachantivá, and Villa de Leyva, Boyacá (Corpoboyacá, 2023) (Figure 1).

The Alto Ricaurte region, where the Civil Society Botanical Gardens Network operates, underscores the importance of the water resources originating in the Iguaque Flora and Fauna Sanctuary, which supply the municipalities of Villa de Leyva and Chíquiza and support ecosystem services linked to the Moniquirá and Cane–Iguaque River basins (Villarreal *et al*., 2017). Fieldwork conducted between March and May 2023 covered nine sampling zones. In each reserve, forested areas with established *Q. humboldtii* were monitored, recording the presence of scale insects on bark, leaves, and shoots, along with coordinates, altitude, temperature, and humidity.

Using direct sampling, oak trees were examined to confirm the presence of honeydew-producing scale insects. The study employed directed or exhaustive coverage sampling, examining 15-20 accessible trees per reserve, including both juvenile and adult specimens collected on *Quercus humboldtii*. At each site, trunks and branches below 2 m were inspected with a standardized effort of 5 person-hours per reserve. Insect samples were collected with entomological tweezers and preserved in 3 mL of 70 % ethanol. Specimens were transported to the Entomology Laboratory of the Universidad Pedagógica y Tecnológica de Colombia (UPTC), where preparation and mounting followed the protocol for scale insects by Kondo and Watson (2022). Identification was based on documentation and images provided by Hodgson *et al*. (2007). All samples were deposited in the "Luis Gonzalo Andrade" Natural History Museum at UPTC.

A descriptive analysis was performed to estimate basic parameters and the proportions of adults and immatures per reserve. Additionally, a PCA integrated environmental variables (altitude, temperature, humidity) and biological variables (adult and immature abundance) to identify gradients associated with *S. asper* population structure. Data were organized and analyzed using R software (version 4.4.3; R Core Team, 2023). The research was conducted with implicit authorization from AGROSAVIA and UPTC.

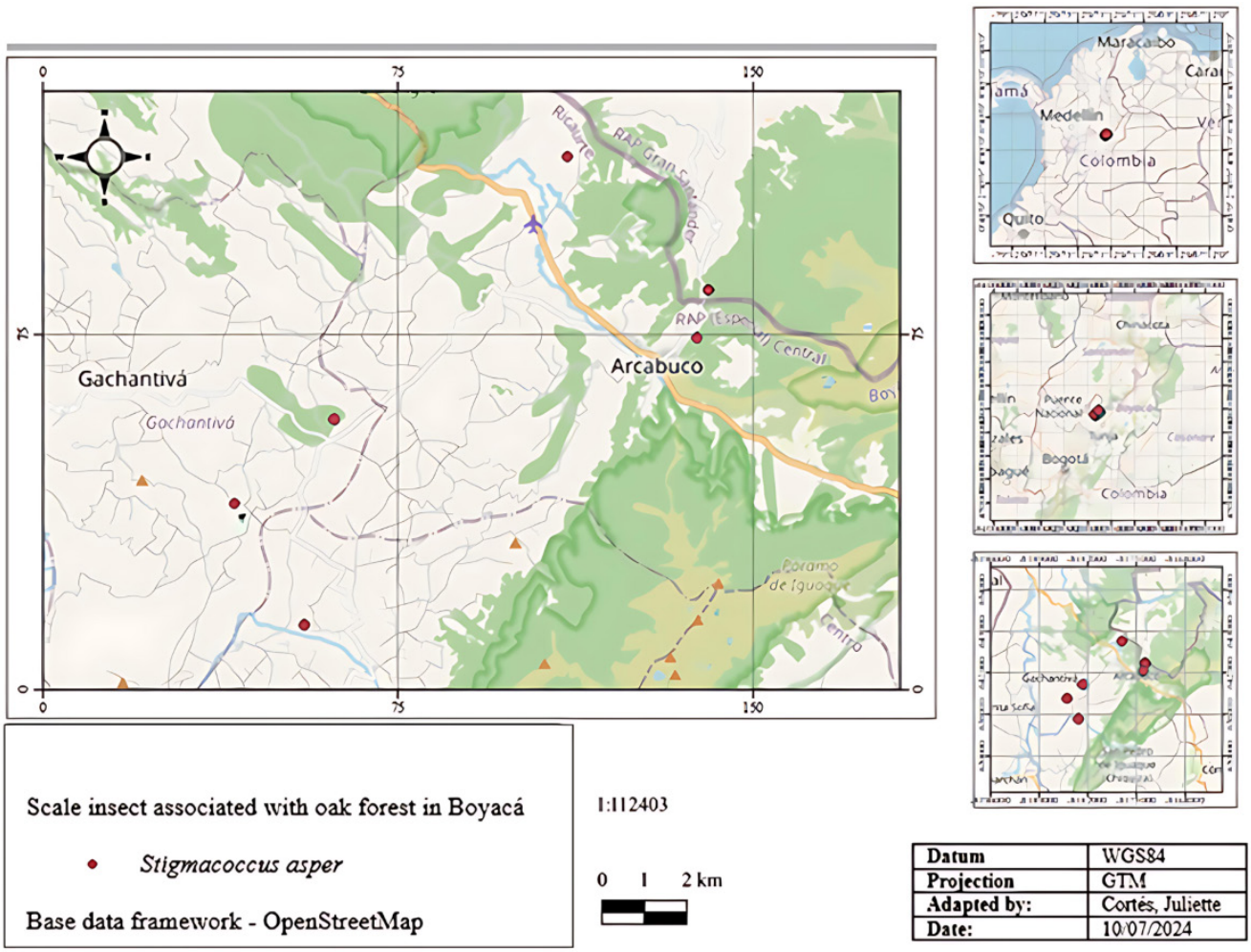

Figure 1. Map of the study area showing the collection points of scale insects within the Civil Society Botanical Gardens Network of Alto Ricaurte, Boyacá, Colombia.

Results and discussion

Stigmacoccus asper Hempel, 1900 (Hemiptera: Coccomorpha: Stigmacoccidae) was recorded in six of the nine sampled zones. A total of 76 cyst-stage individuals (Figure 3) and 5 adult females (Figure 2) were collected (Table 1). The insects were found exclusively on oak trees (*Q. humboldtii*), in areas located within the municipalities of Arcabuco, Gachantivá, and Villa de Leyva (Figure 1).

Stigmacoccus asper was recorded between 2222 m a. s. l. in Vereda Capilla, Entre Ríos Sector (Villa de Leyva), and 2656 m a. s. l. in Vereda La Palma, Veronia Natural Reserve. A mean temperature of 17.4 °C and 62 % humidity was recorded in Vereda La Palma, Madre Monte Natural Reserve (Arcabuco), while the highest values—20.4 °C and 80 % humidity—were registered in Vereda Saavedra de Roncancios, Jacamaki Natural Reserve (Gachantivá).

Material examined for *Stigmacoccus asper* Hempel in Boyacá, Colombia

Arcabuco

- Vereda La Palma, Madre Monte Natural Reserve – Flora and Honey Sanctuary, 05°46'13" N, 73°25'32" W, 2621 m a. s. l., host: *Quercus humboldtii*; 17 cysts, 1 adult female, coll. I. J. Cortés, 01.III.2023 (UPTC-In-32465–32469).

- Vereda La Palma, Veronia Private Natural Reserve, 05°45'37" N, 73°25'41" W, 2656 m a. s. l., host: *Q. humboldtii*; 9 cysts, 2 adult females, coll. I. J. Cortés, 19.V.2023 (UPTC-In-32474–32475).

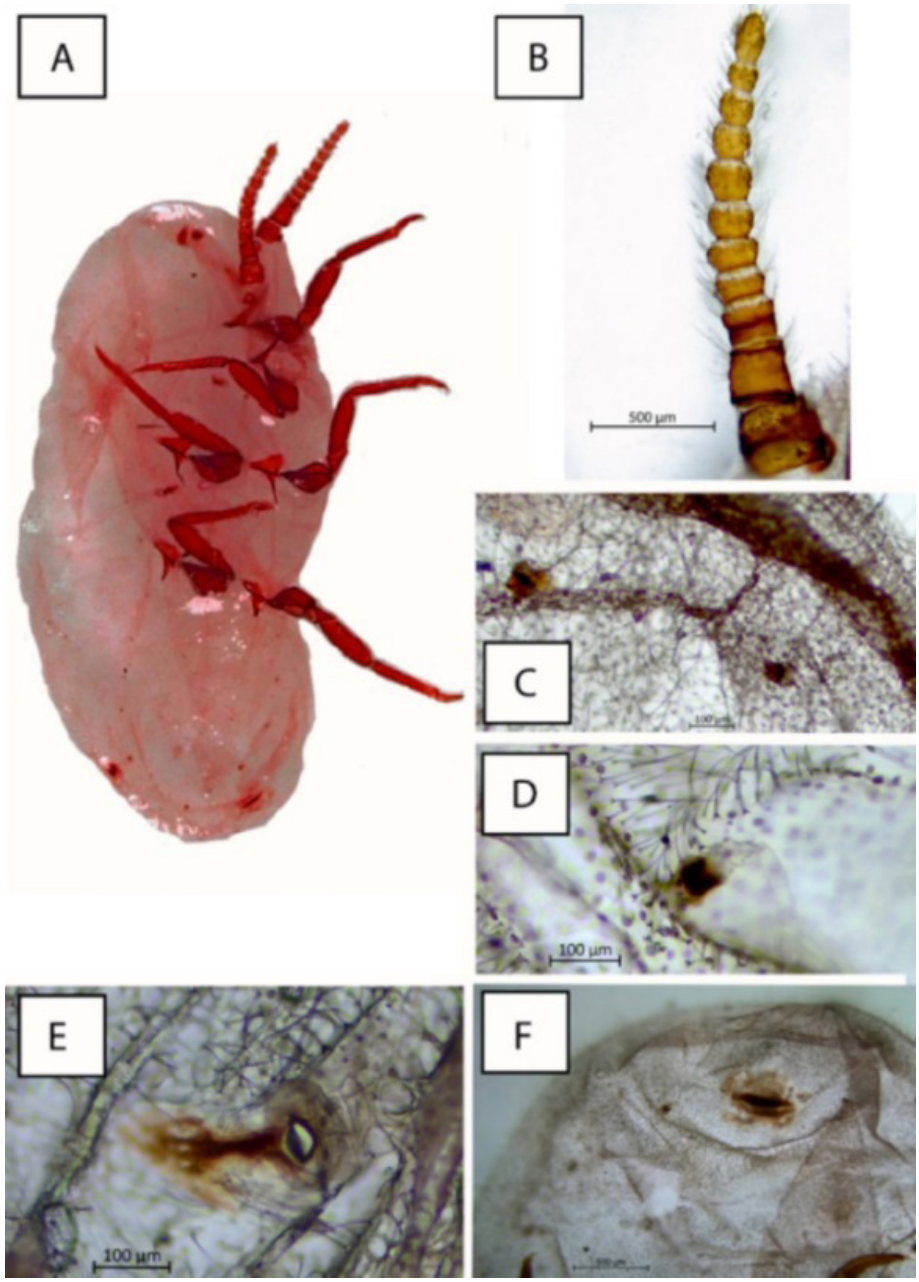

Figure 2. *Stigmacoccus asper*, adult female, Veronia Natural Reserve. **A.** Ventro-lateral view of the adult female, **B.** Antenna, **C.** Structures associated with the abdominal spiracles, **D.** Abdominal spiracle, **E.** Thoracic spiracle, **F.** Abdominal area.

- Vereda Peñas Blancas, Rogitama Biodiversity Civil Society Natural Reserve, 05°47'55" N, 73°27'20" W, 2569 m a. s. l., host: *Q. humboldtii*; 5 cysts, coll. I. J. Cortés, 19.V.2023 (UPTC-In-32476).

Gachantivá

- Los Aguacos Civil Society Natural Reserve, 05°44'34" N, 73°30'20" W, 2419 m a.s.l., host: *Q. humboldtii*; 14 cysts, coll. I. J. Cortés, 02.III.2023 (UPTC-In-32472).

- Vereda Saavedra de Roncancios, Jacamaki Natural Reserve, 05°43'30" N, 73°31'36" W, 2419 m a. s. l., host: *Q. humboldtii*; 14 cysts, coll. I. J. Cortés, 02.III.2023 (UPTC-In-32473).

Villa de Leyva

- Vereda Capilla I, Sector Entre Ríos, 05°41'57" N, 73°30'43" W, 2222 m a. s. l., host: *Q. humboldtii*; 9 cysts, 2 adult females, coll. I. J. Cortés, 01.III.2023 (UPTC-In-32470–32471).

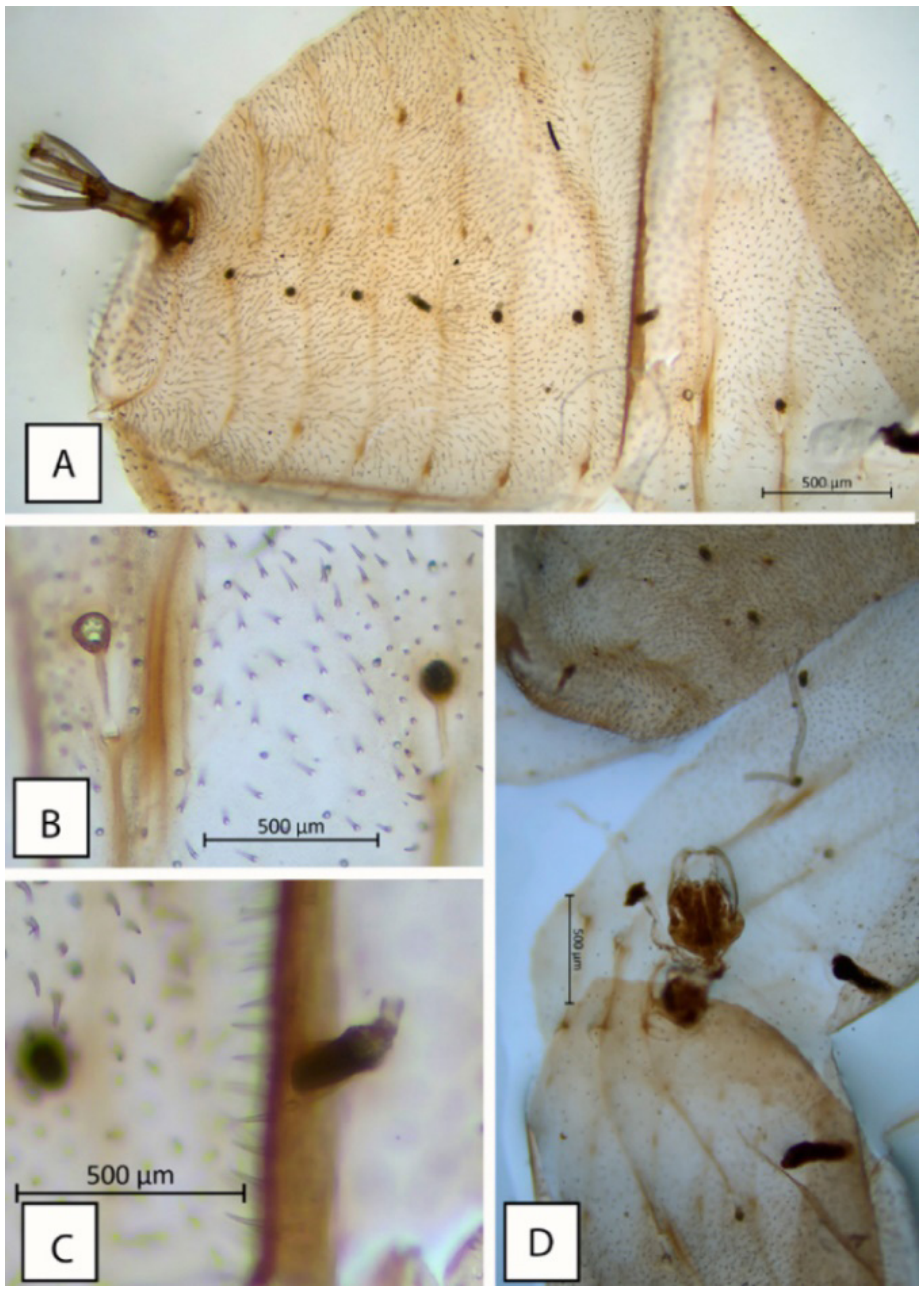

Figure 3. Cyst of *Stigmacoccus asper*, Madre Monte Natural Reserve. **A.** General view of the cyst, **B.** Thoracic spiracle, **C.** Abdominal spiracle, **D.** Mouthparts.

Diagnosis

Cyst stage. The cyst stage of *S. asper* is circular to slightly oval (Figure 3A), with its margins defined by the abdominal spiracles (Figure 3C), anus, and mouthparts (Figure 3D). The derm is slightly sclerotized and bears spines, setae, and pores (Figure 3A). The anal tube terminates in eight cylindrical extensions (Figure 3A). Thoracic spiracles are ventral in position (Figure 3B), and there are eight pairs of abdominal spiracles, all similar in size (Figure 3C).

Adult female. Adult females are wingless and sedentary (Figure 2A). The body is oval, with the head, thorax, and abdomen fused; dorsal sclerotized areas bear setae (Figure 2C). The setose antennae consist of 11 segments (Figure 2B), and the legs are well developed (Figure 2A). Two pairs of thoracic spiracles are present, each sclerotized and accompanied by adjacent spines and pores near them (Figure 2E). The abdomen bears eight pairs of marginal spiracles and a basal vulvar area equipped with pores and setae (Figure 2F).

Table 1. *Stigmacoccus asper* individuals recorded in Alto Ricaurte, Boyacá

No.	Reserve	Geographic coordinates	Conditions		Number of individuals		
			Temperature	Humidity	Adults	Immatures (cyst stage)	Subtotal
1	Aguacos Natural Reserve	05°44'33.96'' N 073°30'19.53'' W	17.9 °C	64 %	-	22	22
2	Entre Ríos Sector	05°41'56.93'' N 073°30'42.52'' W	20.3 °C	50 %	2	9	11
3	Jacamaki Natural Reserve	05°43'29.76'' N 073°31'35.747" W	20.4 °C	80 %	-	14	14
4	Madre Monte Natural Reserve – Flora and Honey Sanctuary	05°46'12.943'' N 073°25'31.879'' W	17.4 °C	62 %	1	17	18
5	Rogitama Biodiversity Civil Society Natural Reserve	05°47'55.03'' N 073°27'20.175'' W	18.9 °C	78 %	-	5	5
6	Veronia Private Natural Reserve	05°45'36.73'' N 073°25'40.76'' W	19.5 °C	76 %	2	9	11
				Total	5	76	81

Conclusions

Species of the genus *Stigmacoccus* Hempel, 1900 (Hemiptera: Stigmacoccidae) are primarily distributed in the Neotropics—in Panama, Colombia, Venezuela, and Brazil—and their main hosts include trees from genera such as *Inga* Mill., and *Cassia* L. (Fabaceae), *Schizolobium* Vogel (Fabaceae), and oaks (*Quercus* L., Fagaceae) (Hodgson *et al.*, 2007; Martins-Mansani *et al.*, 2021). In the Colombian Andes, *S. asper* is exclusively associated with *Q. humboldtii*, a species that plays a key role in honeydew-based trophic interactions; however, it remains poorly studied. The morphology of its cysts and adult females matches the descriptions provided by Hodgson *et al.* (2007). Stigmacoccids insert their stylets into the tree trunk to suck the sap to obtain amino acids for protein synthesis, eliminating sugary compounds through an anal filament (Malumphy, 1997; Shaaban, 2020). This excess water and sugars—such as raffinose and melezitose—constitutes what is commonly known as honeydew (Shaaban, 2020), an important sugar source for bees (Hymenoptera: Apidae), which collect, transport, and process it in the hive, contributing to the production of honeydew honey (Chamorro *et al.*, 2013; Hodgson *et al.*, 2007).

In Boyacá, this product corresponds to "oak honeydew honey," a non-timber forest resource with recognized potential for economic diversification and sustainable forest conservation (Chamorro *et al.*, 2013). Currently, honeydew honey is exploited by communities worldwide. For example, in Greece, more than 65 % of honey production comes from the giant pine scale *Marchalina hellenica* (Gennadius, 1883) on *Pinus* spp. (Pinaceae) (Kondo and Gullan, 2022). In California and Oregon, USA, honeybees produce "white cedar honey" from the honeydew of *Xylococculus macrocarpae* (Coleman, 1908) (Hemiptera: Xylococcidae) on *Calocedrus decurrens* (Cupressaceae) (Kondo *et al.*, 2008).

The genus *Stigmacoccus* has been studied primarily for its interactions with forest species and its ability to produce honeydew. In Brazil, Bogo *et al.* (1999) described the relationship between *S. asper* and *Schizolobium excelsum* Vogel (Fabaceae). In Colombia, Chamorro *et al.* (2013) analyzed honeydew honey in oak forests, highlighting a critical knowledge gap regarding scale insects in Boyacá, where understanding of their biology and ecology remains limited.

This study documents *Stigmacoccus asper* in six of the nine sampled zones within the Civil Society Botanical Gardens Network of Alto Ricaurte, Boyacá, Colombia. The species was found exclusively on *Quercus humboldtii* at elevations between 2222 m and 2656 m. A total of 81 individuals were collected, including 76 immatures (cysts) and 5 adult females. *S. asper* exhibits a broad altitudinal distribution and has previously been recorded at lower elevations in Colombia.

The population was dominated by immatures (mean = 12.7 individuals; range = 5-22) and contained few adults (mean = 0.8; maximum = 2), which were absent in half of the reserves and represented only 5 % – 18 % of individuals in the others. This pattern reflects high juvenile mortality and low adult survival (Pinto *et al.*, 2022). Possible explanations include a mismatch between the sampling season and female emergence, as well as environmental effects on stage

synchronization (Chamorro *et al.*, 2013). Additionally, visual inspection tends to favour detection of sedentary cysts and may underestimate adult females, highlighting the need for complementary collection methods (Schwertner *et al.*, 2021).

The PCA showed that PC1 (52.7 % of the variance) was associated with altitude and humidity and negatively related to adult abundance, whereas PC2 (25.7 %) was related to temperature and the occurrence of immatures, together explaining 78.4 % of the total variance. Adults were found mainly in warmer, drier areas, while immatures tolerated a broader range of environmental conditions. Similar edge-abundance patterns have been reported by Chamorro *et al.* (2013) and Pinto *et al.* (2022).

From an ecological perspective, *S. asper* maintains mutualistic interactions with Hymenoptera, as its honeydew attracts ants (*Azteca*, *Pheidole*) (Schifani *et al.*, 2024) and birds (Capelão and Piratelli, 2025), which help regulate honeydew accumulation and limit the development of sooty mold, thereby reducing potential impacts on *Q. humboldtii* (Kakoti *et al.*, 2023). From a socioeconomic standpoint, beekeeping incorporates honeydew into sustainable value chains with potential for organic certification and reduced logging pressure (Kondo and Gullan, 2022). *Q. humboldtii* forests provide essential ecosystem services (Villarreal *et al.*, 2017), underscoring their ecological and cultural importance.

Overall, our findings highlight the need for seasonal monitoring of *S. asper*, its inclusion in forest management plans, and the promotion of non-invasive beekeeping practices supported through community participation and institutional alliances.

Acknowledgements

We thank the Young Researchers Program (call VIE 14 - 2022) and the SGI Project 3443 "*Natural history and distribution of Stigmacoccidae (Hemiptera) associated with oak forests (Quercus humboldtii) of the Alto Ricaurte Botanical Gardens Network, Boyacá-Colombia*", founded by the Universidad Pedagógica y Tecnológica de Colombiain Tunja, Boyacá. The third author thanks the Corporación Colombiana de Investigación Agropecuaria (AGROSAVIA) for the partial funding of this study.

References

Bogo, A.; Watson, G. W.; Mantle, P. G. and Mottana, G. M. (1999). Honeydew sugars eliminated by *Stigmacoccus* sp. nr. *asper* Hempel (Hemiptera: Margarodidae) feeding on leguminous trees in Brazil. *Entomologica*, 33, 275-278. https://doi.org/10.15162/0425-1016/846

Capelão, R. S. and Piratelli, A. J. (2025). Avian use of honeydew (Hemiptera: Coccoidea) in the Atlantic Forest of Southeastern Brazil. *Journal of Tropical Ecology*, 41, e27. https://doi.org/10.1017/S0266467425100308

Chamorro, F. J.; Nates-Parra, G. and Kondo, T. (2013). Honeydew of *Stigmacoccus asper* (Hemiptera: Stigmacoccidae): a bee-honey resource in oak forests of Colombia. *Revista Colombiana de Entomología*, 39(1), 61-70. https://www.scielo.org.co/scielo.php?pid=S0120-04882013000100012&script=sci_arttext

Corpoboyacá. (2023). Áreas protegidas civiles. Sistema Regional de Áreas Protegidas (SIRAP). Corporación Autónoma Regional de Boyacá (Corpoboyacá). https://www.corpoboyaca.gov.co/sirap/

Gallagher, G. (2018). *Quercus humboldtii*. The IUCN Red List of Threatened Species. e.T194139A2302449. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T194139A2302449.en

Hodgson, C.; Gamper, H.; Bogo, A. and Watson, G. (2007). A taxonomic review of the Margarodoid genus *Stigmacoccus* Hempel (Hemiptera: Sternorrhyncha: Coccoidea: Stigmacoccidae), with some details on their biology. *Zootaxa*, 1507, 1-55. https://doi.org/10.5281/zenodo.177176

Jones, L. C.; Rafter, M. A. and Walter, G. H. (2022). Host interaction mechanisms in herbivorous insects – life cycles, host specialization and speciation. *Biological Journal of the Linnean Society*, 137(1), 1-14. https://doi.org/10.1093/biolinnean/blac070

Kakoti, B.; Deka, B.; Roy, S. and Babu, A. (2023). The scale insects: Its status, biology, ecology and management in tea plantations. *Frontiers in Insect Science*, 2, 1048299. https://doi.org/10.3389/finsc.2022.1048299

Kondo, T. (2001). The scale insects of Colombia (Hemiptera: Coccoidea). *Biota Colombiana*, 2(1), 31-48. https://revistas.humboldt.org.co/index.php/biota/article/view/88

Kondo, T. and Gullan, P. J. (2022). Giant pine scale *Marchalina hellenica* (Gennadius, 1883) (Hemiptera: Coccomorpha: Marchalinidae). In Kondo, T. and Watson, G. W. (Eds.), *Encyclopedia of Scale Insect Pests* (pp. 83-85). CABI. https://doi.org/10.1079/9781789249381.0000

Kondo, T.; Gullan, P. J. and Williams, D. J. (2008). Coccidology: The study of scale insects (Hemiptera: Sternorrhyncha: Coccoidea). *Revista Corpoica – Ciencia y Tecnología Agropecuaria*, 9(2), 55-61. https://doi.org/10.21930/rcta.vol9_num2_art:118

Kondo, T. and Watson, G. W. (2022). Collection, preservation, slide mounting, labelling and vouchering of scale insects. In Kondo, T. and Watson, G. W. (Eds.), *Encyclopedia of Scale Insect Pests* (pp. 548-558). CABI. https://doi.org/10.1079/9781789249381.0548

Martins-Mansani, M.; Faita, M. R.; Orth, A. I. and Nodari, R. O. (2021). Production of honeydew by scale insects associated with bracatinga (*Mimosa scabrella* Benth) in Serra Catarinense, Southern Brazil. *Revista Brasileira de Entomologia*, 65(1), e20200072. https://doi.org/10.1590/1806-9665-RBENT-2020-0072

Malumphy, C. P. (1997). Morphology and anatomy of honeydew eliminating organs. In Ben-Dov, Y. and Hodgson, C. (Eds.), *Soft scale insects, their biology, natural enemies and control* (vol. 7A) (pp. 269-274). Elsevier Academic Press.

Moghaddam, M.; Abdollahipour, M. and Fathipour, Y. (2021). Scale insects. In Omkar (Eds.), *Polyphagous Pests of Crops* (pp. 273-310). Springer. https://doi.org/10.1007/978-981-15-8075-8_6

Pinto, J. R., Fernandes, O. A., Higley, L. G., and Peterson, R. K. (2022). Do patterns of insect mortality in temperate and tropical zones have broader implications for insect ecology and pest management?. *PeerJ*, 10, e13340. https://doi.org/10.7717/peerj.13340

Quevedo García, E. and Prato Sarmiento, A. I. (2020). Germination of Quercus humboldtii Bonpl. (Fagaceae) seeds: vulnerable species of the high Andean forest. *Revista Mexicana de Ciencias Forestales*, *11*(62), 157-164. https://doi.org/10.29298/rmcf.v11i62.792

R Core Team. (2023). R: *A language and environment for statistical computing* (Version 4.4.3). R Foundation for Statistical Computing. https://www.R-project.org/

Schifani, E., Giannetti, D., and Grasso, D. A. (2024). Toward sustainable management of ant-hemipteran mutualism in agricultural settings: a comparison of different approaches. *Crop protection*, *175*, 106468. https://doi.org/10.1016/j.cropro.2023.106468

Schwertner, C. F.; Carrenho, R.; Moreira, F. F. F. and Cassis, G. (2021). Hemiptera sampling methods. In: Santos, J. C. and Fernandes, G. W. (Eds.), *Measuring Arthropod Biodiversity* (pp. 289-313). Springer, Cham. https://doi.org/10.1007/978-3-030-53226-0_12

Shaaban, B. (2020). *The identification of botanical and zoological origins of different honeydew honeys*. [Doctoral dissertation]. OPUS Universität Wuppertal. https://doi.org/10.25926/mesk-c384

Villarreal, H.; Núñez, M.; Zorro, W. and Pacheco, C. (2017). *Plan de manejo del Santuario de Fauna y Flora Iguaque*. Parques Nacionales Naturales de Colombia.https://www.parquesnacionales.gov.co/wp-content/uploads/2020/10/plan-de-manejo-sff-iguaque.pdf