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First record of the invasive chenopodium aphid,
Hayhurstia atriplicis (Linnaeus, 1761)
(Hemiptera: Aphididae), in Colombia

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First record of the invasive chenopodium aphid,
Hayhurstia atriplicis (Linnaeus, 1761)
(Hemiptera: Aphididae), in Colombia

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Abstract. The chenopodium aphid, *Hayhurstia atriplicis* (Linnaeus, 1761) (Hemiptera: Aphididae), is reported for the first time in Colombia. The aphid was found on the aerial parts of the quinoa plant, *Chenopodium quinoa* Willd. (Amaranthaceae), especially on the leaves, in five municipalities in the department of Cauca, Colombia. Brief information on its natural enemies, distribution and biology is provided. This is the only aphid in Colombia known to cause malformations on the leaves of quinoa plants. In South America, this aphid has been found previously only in Ecuador, where it was reported for the first time in 2023 based on specimens collected from 2019 to 2021. However, we report that *H. atriplicis* was likely introduced to Ecuador in the 2000s or earlier, based on a collection dated 2006 found in the United States National Museum of Natural History.

Key words. *Cheilomenes sexmaculata*, *Cycloneda emarginata*, geographical distribution, *Frankliniella* sp., *Harmonia axiridis*, insect pest, invasive species, leaf-rolling aphid, natural enemies.

Resumen. Se reporta por primera vez en Colombia el pulgón de la quinua *Hayhurstia atriplicis* (Linnaeus, 1761) (Hemiptera: Aphididae). El pulgón se encontró en las partes aéreas de la planta de quinua *Chenopodium quinoa* Willd. (Amaranthaceae), especialmente en las hojas, en cinco localidades del departamento del Cauca, Colombia. Se proporciona brevemente información sobre sus enemigos naturales, distribución y biología. Este es el único pulgón en Colombia que se conoce por causar malformaciones en las hojas de las plantas de quinua. En América del Sur, este pulgón se había encontrado anteriormente solo en Ecuador, donde se informó por primera vez en el 2023 con base en especímenes recolectados entre 2019 y 2021; sin embargo, aquí reportamos que *H. atriplicis* probablemente se introdujo en Ecuador en la década de los 2000s o antes, basado en una colección que data del 2006 encontrada en el Museo Nacional de Historia Natural de Estados Unidos.

Palabras clave. *Cheilomenes sexmaculata*, *Cycloneda emarginata*, distribución geográfica, especie invasora, *Harmonia axiridis*, insecto plaga, *Frankliniella* sp., pulgón enrollador de hojas, enemigos naturales.

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Introduction

During a faunistic survey of the insects associated with quinoa, *Chenopodium quinoa* Willd. (Amaranthaceae), in five municipalities of the department of Cauca, Colombia, conducted by the Corporación Colombiana de Investigación Agropecuaria [Colombian Corporation for Agricultural Research] (Agrosavia) (July 2021–present), an aphid was found to be causing malformations on the leaves (pseudogalls) (Fig. 1C–D). Sometimes this aphid causes significant damage to the quinoa plants.

Quinoa is a pseudocereal native to the Andean regions of South America, mainly grown in Argentina, Bolivia, Chile, Colombia, Ecuador, and Peru, but recently was introduced in Africa, Europe, and North America (Vilcacundo and Hernández-Ledesma 2017). Quinoa seeds are considered of high nutritional value due to their proteins, rich in lysine, iron, and magnesium, and they provide fiber, vitamin E, copper, phosphorus, vitamin B, potassium, and zinc (Abugoch James 2009). In Colombia, quinoa is mainly cultivated at a small scale in the Andean valleys of the departments of Boyacá, Cauca, Cundinamarca, and Nariño (Manjarres-Hernández et al. 2021), where its production has increased in recent years due to its agronomic potential and different benefits derived from production, industrialization, and the marketing of national crops (Morillo-Coronado et al. 2017).

The family Aphididae currently comprises 5749 species worldwide (Favret 2024). Aphids can build to high population densities, remove plant nutrients, cause direct damage to plants by removing large amounts of sap, causing withering and death, and often cause indirect damage by transmitting plant viruses (Sorensen 2009). According to Simbaqueba and Serna (2021), there are currently 55 aphid species known in Colombia.

Several aphid species (Hemiptera: Aphididae) have been reported worldwide on quinoa plants, *Chenopodium* spp. In northern Europe, the black bean aphid, *Aphis fabae* Scopoli, 1763 (Aphidinae: Aphidini), has been reported on *Ch. quinoa* (Sigsgaard et al. 2008). In Algeria, *Myzus persicae* (Sulzer, 1776) (Aphidinae: Macrosiphini), *Rhopalosiphum padi* (Linnaeus, 1758) (Aphidinae: Aphidini), *Aphis gossypii* Glover, 1877 (Aphidinae: Aphidini) and *A. fabae* have been reported associated with *Ch. quinoa* (Deghiche-Diab et al. 2021). In Bolivia and Peru, the following aphid species have been reported as pests of quinoa, *Ch. quinoa*: *Macrosiphum euphorbiae* (Thomas, 1878) (Aphidinae: Macrosiphini) (Yábar et al. 2002; Rasmussen et al. 2003; Cruces et al. 2020), *M. persicae* (Yábar et al. 2002; Rasmussen et al. 2003), *Aphis craccivora* C.L. Koch, 1854 (Aphidinae: Aphidini), and *A. gossypii* (Rasmussen et al. 2003). In the USA, the chenopodium aphid, *Hayhurstia atriplicis* (Linnaeus, 1761) (Aphidinae: Macrosiphini), and the sugarbeet root aphid, *Pemphigus betae* Doane, 1900 (Eriosomatinae: Pemphigini) occur on *Chenopodium album* L.; both species compete and *H. atriplicis* will displace *P. betae* in plants susceptible to leaf galling by *H. atriplicis* (Moran and Whitham 1990).

Hayhurstia atriplicis is widespread in Asia and Europe, and found in North and Central Africa, and North and Central America (Blackman and Eastop 2008). It was recently reported for the first time in South America in Ecuador in the organic quinoa cultivation area, based on specimens collected there during May 2019 to August 2020, and from October 2020 to August 2021 (Pruna et al. 2023). In Ecuador, *H. atriplicis* was reported feeding on various structures of quinoa plants; although it is usually found on the leaves, it can be also found on stems and panicles, in all phenological stages of the crop, and it is considered one of the main phytophages of quinoa across its distribution (Pruna et al. 2023). The severity of its damage depends on the phenological stage of the crop, whether plants are under the stress of high temperature and absence of precipitation (Pruna et al. 2023) and the affected cultivar or variety. On *Ch. album*, *H. atriplicis* have been reported to reduce the overall host mass by an average of 54% and seed set by an average of 60% (Moran and Whitham 1990).

The purpose of this study is to report the chenopodium aphid, *H. atriplicis*, for the first time in Colombia, and provide some basic diagnostic information for the species, based on available scientific literature, and photographs of live insects. Furthermore, information on the natural enemies, distribution, and biology of *H. atriplicis* is also provided.

Materials and Methods

Samples were collected in the quinoa-growing region of the department of Cauca, in the municipalities of Bolívar and Totoró, in southwestern Colombia in 2023 (April, August and October). Aphids and their putative natural

enemies were collected with the aid of a paint brush from the leaves of quinoa plants, *Ch. quinoa*. Samples were preserved in 70% alcohol and taken to the Museum of Entomology at the Colombian Corporation for Agricultural Research, Palmira Research Station, for slide-mounting and identification. Aphids and thrips specimens were slide-mounted following the protocol used for scale insects by Kondo and Watson (2022). The aphids were identified using taxonomic keys to species of aphids of the world's herbaceous plants and shrubs by Blackman and Eastop (2008) and notes from the recent publication by Pruna et al. (2023). The species identification was confirmed by aphid taxonomist, Dr. Gary L. Miller (Systematic Entomology Laboratory, Agricultural Research Service, United States Department of Agriculture). Dermapterans were identified to family level using the keys of Choate (2001), thrips (Thysanoptera) were identified to family level using the keys of Moritz et al. (2007), syrphids and lacewings (both green and brown) were identified to family level using the keys in Triplehorn and Johnson (2005), and the coccinellids were identified to species level using the species diagnoses of González (2016). All insects were identified by the first author. Photographs of close-ups of live specimens (Fig. 1A–B) were taken in the laboratory with a Nikon DS-Fi2 digital camera adapted to a Nikon SMZ 1500 stereomicroscope; and those of the pseudogalls (Fig. 1C–D) were taken *in situ* with an Olympus Tough TG-6 digital camera. Specimens were collected under a permit framework for collecting specimens of wild species of biological diversity for non-commercial scientific research purposes (resolution No. 1466, Autoridad Nacional de Licencias Ambientales – ANLA) [Colombian National Authority Environmental Permits].

Repositories

- CTNI** Colección Taxonómica Nacional de Insectos “Luis María Murillo”, Corporación Colombiana de Investigación Científica, Mosquera, Cundinamarca, Colombia.
- USNM** National Museum of Natural History Entomological Collection, Washington, DC, U.S.A. (National Collection of Aphidomorpha, collection held at USDA, Beltsville, Maryland).

Results

Herein we report the chenopodium aphid, *Hayhurstia atriplicis* (Fig. 1), for the first time in Colombia, based on specimens collected on quinoa in the municipalities of Bolívar and Totoró, Department of Valle del Cauca, Colombia.

Hayhurstia atriplicis (Linnaeus, 1761)

Diagnosis

Insects in life (Fig. 1A–B). Individual of *H. atriplicis* feed on young leaves which become folded along the mid-vein and distorted, forming pseudogalls (Fig. 1C–D), probably due to the injection of toxins in the aphids' saliva. **Females:** Alate with dark head and thorax, abdomen light brown in color; adult apterae dark green, covered with white waxy powder; siphunculi very small, ca. 1.5 to 3.0 mm long, inconspicuous, distinctly shorter than cauda (Blackman and Eastop 2008), oviparous (Hayhurst 1909). **Males:** Apterous or alate (Blackman and Eastop 2008), small, elongated, wingless males yellowish, with blackish appendages (Hayhurst 1909).

Mounted specimens (Not illustrated, but good photographs available in Pruna et al. 2023). *Hayhurstia* Del Guercio, 1917 (Aphidinae: Macrosiphini) is a monotypic genus, with its type species, *H. atriplicis*, defined by the presence of slightly clavate siphunculi with a small flange distinctly shorter than the finger-like cauda (Blackman and Eastop 2008).

Biology. The species is monoecious, holocyclic, ovipositing in October [in temperate regions of the Northern Hemisphere] (Blackman and Eastop 2008). In Colombia, the species is multivoltine and is found throughout the year; only females were observed in the present study. Aphids are commonly found living inside yellowish pod-like pseudogalls which are formed by leaves rolling upwards (Blackman and Eastop 2008). During the present study, inside some of the pseudogalls of *H. atriplicis*, numerous specimens of the thrips, *Frankliniella* sp. (Thysanoptera: Thripidae), were found, probably taking advantage of the protection provided by the pseudogalls (T. Kondo, personal observation). Earwigs and syrphid fly larvae were also found inside the pseudogalls (see below under natural enemies). Quinoa plants of the Blanca de Jerico variety which were heavily infested by *H.*

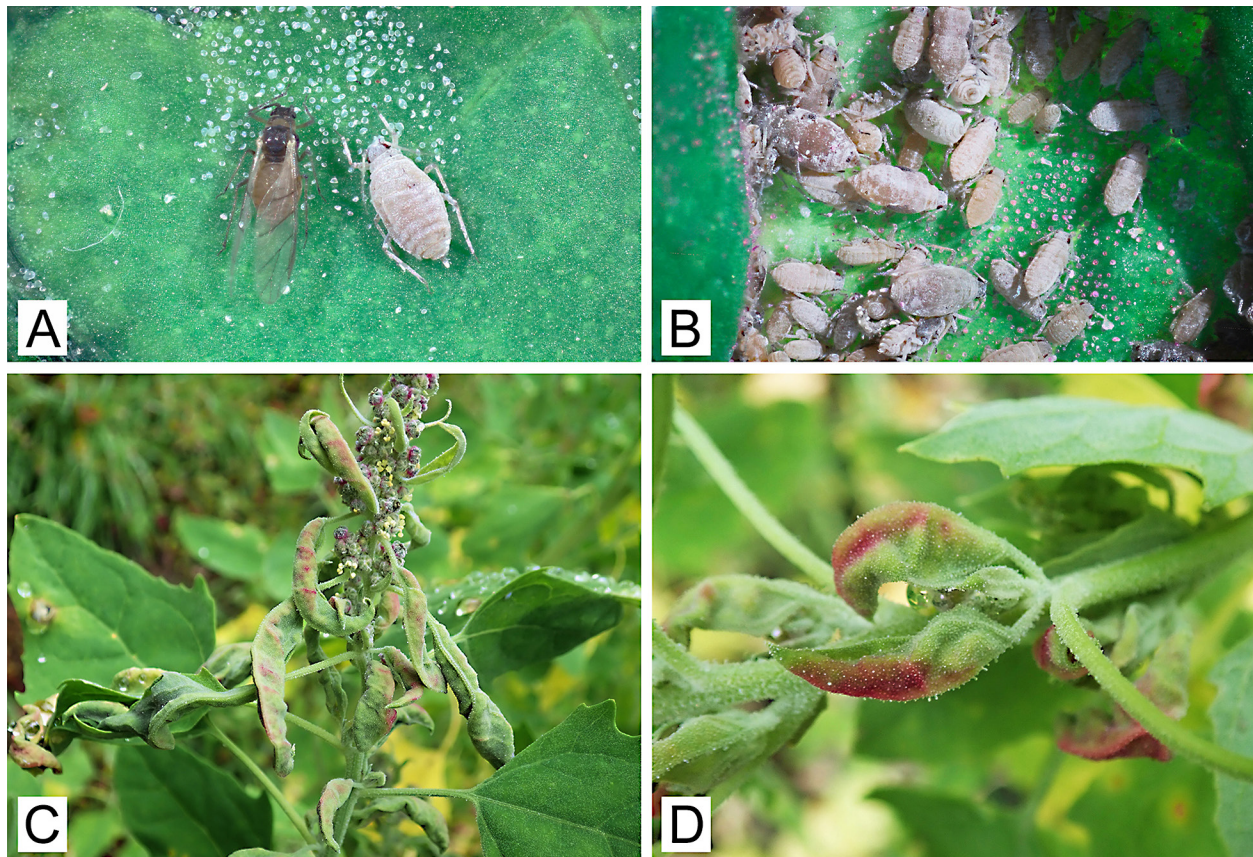


Figure 1. *Hayhurstia atriplicis* (Linnaeus). **A)** Adult alate and apterae. **B)** An aggregation of adults and immature apterae inside a curled infested quinoa leaf. **C)** A quinoa plant with many leaves being infested by the aphid. **D)** Close-up of two pseudogalls on quinoa plant of the Blanca de Jerico variety. Notice the reddish color of the pseudogalls which contrasts with the healthy green leaves. Photos: A and B by Y. Campos Patiño; C and D by T. Kondo.

atriplicis had most of the leaves deformed into pseudogalls, showed stunted growth, and did not develop panicles (T. Kondo, personal observation). During the present study, *H. atriplicis* was found affecting various cultivars, including Blanca de Jericó, Tunkahuan and Aurora, however, the levels of susceptibility and resistance of these varieties to this aphid species remains to be studied.

Host plants. *Hayhurstia atriplicis* is found on host plants of the family Amaranthaceae (as Chenopodiaceae), usually on *Atriplex* spp. [hence its specific epithet “*atriplicis*”] and *Chenopodium* spp. [hence its common name “Chenopodium aphid”] (Blackman and Eastop 2008). Ellis (2024) reported *H. atriplicis* as oligophagous on Amaranthaceae and provided a detailed list of plant hosts as follows: *Atriplex calotheca* (Rafn) Fr., *A. glabriuscula* Edmondston, *A. halimus* L., *A. hortensis* L., *A. laciniata* L., *A. littoralis* L., *A. patula* L., *A. prostrata* Boucher ex DC., *A. sagittata* Borkh.; *Bassia scoparia* (L.) A.J. Scott; *Chenopodiastrum hybridum* (L.) S. Fuentes-B., Uotila & Borsch, *Chenopodiastrum murale* (L.) S. Fuentes-B., Uotila & Borsch; *Chenopodium album* L., *Ch. bonus-henricus* L., *Ch. ficifolium* Sm., *Ch. foliosum* (Moench) Asch., *Ch. glaucum* L., *Ch. opulifolium* Schrad. ex W.D.J. Koch & Ziz, *Ch. quinoa*, *Ch. rubrum* L., *Ch. strictum* Roth, *Ch. urbicum* L., *Ch. vulvaria* L.; *Dysphania ambrosioides* (L.) Mosyakin & Clemants, *D. botrys* (L.) Mosyakin & Clemants; *Einadia nutans* (R. Br.) A.J. Scott; *Halimione pedunculata* (L.) Aellen, *H. portulacoides* Aellen; *Haloxylon tamariscifolium* (L.) Pau (as “*Hammada tamariscifolia*”); and *Lipandra polysperma* (L.) S. Fuentes-B., Uotila & Borsch. Additionally, it is rarely found on *Beta vulgaris* L. and *Spinacia oleracea* L. (Ellis 2024).

Natural enemies. A study conducted in the Czech Republic reported that *H. atriplicis* is commonly parasitized by two braconid parasitoids, namely, *Diaeretiella rapae* (McIntosh, 1855) and *Ephedrus nacheri* Quilis,

1934 (Hymenoptera: Braconidae) (Starý and González 1991). Furthermore, the Universal Chalcidoidea Database (UCD Community 2023), lists five wasp parasitoids of *H. atriplicis*, namely *Aphelinus atriplicis* Kurdjumov, 1913 (Hymenoptera: Aphelinidae), *Asaphes rufipes* Brues, 1909, *A. suspensus* (Nees, 1834), *A. vulgaris* Walker, 1834 and *Pachyneuron siphonophorae* (Ashmead, 1886) (Hymenoptera: Pteromalidae). During the present study, numerous natural enemies were found inside the pseudogalls of *H. atriplicis*, including an undetermined species of parasitoid wasp (Hymenoptera) (based on the presence of mummies of both alate and apterous aphid individuals), an unidentified earwig (Dermaptera: Forficulidae), and the larvae of at least two unidentified species of syrphid flies (Diptera: Syrphidae). Other generalist predators were found on infested plants (outside the pseudogalls), including the invasive ladybird beetles, *Harmonia axyridis* (Pallas, 1773) and *Cheilomenes sexmaculata* (Fabricius, 1781), and New World species, *Coleomegilla maculata* (DeGeer, 1775), *Cycloneda emarginata* (Mulsant, 1850), and *Neda* sp. (Coleoptera: Coccinellidae), as well as an undescribed species of green lacewing (Neuroptera: Chrysopidae) and a brown lacewing (Neuroptera: Hemerobiidae); all of the latter are possible predators of *H. atriplicis*, however, further studies are needed to confirm their role as predators of this aphid species. Specimens of the natural enemies are deposited in CTNI.

Material examined. *Hayhurstia atriplicis* (Linnaeus, 1761). Colombia: Cauca, Bolívar, Vereda La Zanja, 01°46'28"N, 76°53'38"W, 1,777 m.s.n.m., ex *Chenopodium quinoa*, 5.x.2023, coll. Takumasa Kondo, 5 slides, 5 specimens (CTNI); same data except, 28.viii.2023, coll. Robert Rosero, 5 slides, 5 specimens (CTNI); Cauca, Totoró, vereda La Palma, Finca La Palma, 02°33'45"N, 76°26'14"W, 2,600 m.s.n.m., 11.iv.2023, coll. Robert Rosero, 5 slides, 5 specimens (CTNI). Ecuador: *Hayhurstia atriplicis* / (Linnaeus) / ECUADOR / ex *Chenopodium* sp. / April 20, 2006 / K. Ahuja / Elizabeth 210904 / 0608240 / Balsam, 1 slide, 2 specimens (USNM).

Other material studied. *Frankliniella* sp. (Thysanoptera: Thripidae). Colombia: Cauca, Totoró, vereda La Palma, Finca La Palma, 02°33'45"N, 76°26'14"W, 2,600 m a.s.l., 11.iv.2023, coll. Robert Rosero, 4 slides, 4 specimens (CTNI). *Cycloneda emarginata* (Mulsant) (Coleoptera: Coccinellidae), Colombia: Cauca, Bolívar, La Zanja, Finca La Zanja, 01°46'27.9"N, 76°53'37.5"W, 1777 m a.s.l., ex panicle of quinoa *Chenopodium quinoa*, 28.iii.2023, coll. Jackeline Gaviria, 1 specimen (CTNI); same data, except *Neda* sp., 1 specimen (CTNI); *Cheilomenes sexmaculata* Fabricius (Coleoptera: Coccinellidae), Colombia: Cauca, Totoró, La Palma, Finca La Palma, 02°33'45"N, 76°26'14"W, 2,600 m a.s.l., 11.ix.2023, coll. Robert Rosero, 1 specimen (CTNI); same data, except *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae); same data except 10.vii.2023, *Coleomegilla maculata* De Geer (Coleoptera: Coccinellidae), 1 specimen (CTNI).

Discussion

In Ecuador, *H. atriplicis* has been found in the organic quinoa cultivation area of the province of Chimborazo in an altitudinal range from 3,130 to 3,520 m a.s.l. (Pruna et al. 2023). Specimens collected in Colombia in the present study were collected in an altitudinal range from 1,777 to 2,600 m a.s.l., and also observed at an altitude of 2,800 m a.s.l. Although *H. atriplicis* is currently only known from Colombia and Ecuador in South America, it is expected to spread to other quinoa producing countries in the region, such as Argentina, Bolivia, Chile, and Peru in the future.

The earliest samples of *H. atriplicis* from South America were collected in May 2019 (Pruna et al. 2023). In the present study, a slide deposited at the USNM was found containing two specimens of *H. atriplicis* (identification confirmed by G.L. Miller) from an unknown locality in Ecuador, collected from *Chenopodium* sp. and dated April 20, 2006. The latter indicates that this aphid species was introduced to Ecuador and South America much earlier than 2019, at least before 2006.

The present report of *H. atriplicis* in Colombia is based on specimens collected in 2023, but the authors had already observed and photographed the aphid on August 6, 2021, at Ledesma pass (01°59'N, 76°48'W, 2,800 m a.s.l.), municipality of Almaguer, Cauca, during a preliminary survey. The aphid is also common in the municipalities of La Vega and Silvia, however, due to collecting restrictions in these municipalities which includes indigenous reservations, we were not able to collect specimens in those areas. Based on the common presence of *H. atriplicis* in five municipalities of the department of Cauca, it is likely that the aphid was introduced in

Colombia much earlier than our earliest observation from 2021, probably around the same time it was introduced to Ecuador or soon after.

Hayhurstia atriplicis has many natural enemies that keep its population under control, however, damage symptoms are frequent in crops in which pesticides are used, probably because of the susceptibility of the natural enemies to chemical control. The chenopodium aphids are not affected by contact pesticides because they are found inside the pseudogalls where pesticides cannot reach. Further studies should be carried out to confirm the predation of coccinellids, green lacewings and brown lacewings on *H. atriplicis*, and determine to species, genus or family level the natural enemies and associated insects which were only identified to genus, family or order level.

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