Review Article / Artículo de Revisión

Eristalinus taeniops (Wiedemann, 1818) (Diptera: Syrphidae), an exotic flower fly rapidly spreading in South America: A review

Eristalinus taeniops (Wiedemann, 1818) (Diptera: Syrphidae), una mosca de las flores exótica que se propaga rápidamente en América del Sur: Una revisión

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Abstract. Information on the world distribution of *E. taeniops* and a distributional map of the species in the New World is presented based on available literature, specimens collected in the present study, and citizen science reports. A morphological diagnosis and background on the biology of the species are provided based on photographs and published literature. We briefly discuss how *E. taeniops* may be spreading in South America via airports and seaports.

Key words: Alien species; *Chenopodium quinoa*; geographical distribution; hoverfly; syrphid fly.

Resumen. Se presenta información sobre la distribución mundial de *E. taeniops* y un mapa distribucional de la especie en el Nuevo Mundo con base en la literatura disponible, especímenes recolectados en el presente estudio y reportes de ciencia ciudadana. Se proporciona un diagnóstico morfológico y antecedentes sobre la biología de la especie con base en fotografías y literatura publicada. Se discute brevemente cómo *E. taeniops* puede estar propagándose en América del Sur a través de aeropuertos y puertos marítimos.

Palabras clave: *Chenopodium quinoa*; distribución geográfica; especie foránea; mosca flotante; mosca sírfida.

Introduction

Amongst the order Diptera, the hoverflies (Diptera: Syrphidae) belong to the most species-rich families, comprising over 6,300 species in more than 200 genera (Skevington *et al*. 2019). Colombia is the second-most species-rich country in hoverfly diversity in the Neotropics after Brazil and has one of the greatest numbers of species per unit area (Montoya *et al*. 2012). In Colombia, 353 species of syrphid flies in 59 genera have been reported, and many more are still yet to be described (Montoya 2016; Montoya and Wolff 2020, 2023; Montoya *et al*. 2012, 2021, 2022; Parada-Marin *et al*. 2021).

The species *Eristalinus taeniops* (Wiedemann, 1818) is endemic to the Old World, known

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from the Ethiopian, Oriental, and Palaearctic regions, but was introduced to the Nearctic and Neotropical regions around the 1980s and 1990s, respectively (Thompson 1999). In the New World, the species was first detected in Dade County, State of Florida, USA, in December 1985 (Thompson *et al*. 1990), later in Chile in the late 1990s (Thompson 1999), and since then, it has been spreading at a high pace throughout the region based on the published literature and citizen science observations (see Tab. 1).

This study aims to shed light on how the exotic band-eyed drone fly, *E. taeniops*, which species was introduced to South America and to provide a diagnosis of the species. In addition, an updated list of the Old-World distribution of *E. taeniops* and a map and country list of the species in the New World are provided based on information gathered from the scientific literature and reports from the iNaturalist citizen science platform (http://www.inaturalist.org).

Materials and Methods

During a faunistic survey of the entomofauna associated with quinoa, *Chenopodium quinoa* Willd. (Amaranthaceae), two specimens of syrphid flies with banded eyes were collected resting on the panicles of quinoa plants. The flies were found in the Cauca Province phytogeographical ecoregion as defined by Morrone (2014), which encompasses western Colombia, northern Peru, and Ecuador. The specimens were collected in a quinoa orchard at Las Delicias path, San Fernando farm, 02°37'N, 76°20'W, 2600 masl, municipality of Silvia, department of Cauca, Colombia. The area of the quinoa orchard was about 1 ha, planted in a polyculture scheme, surrounded by other crops including amaranth, *Amaranthus* sp. (Amaranthaceae), broad bean, *Vicia faba* L. (Fabaceae), cabbage, *Brassica oleracea* L., radish, *Raphanus* sp. (Brassicaceae), gooseberry, *Physalis peruviana* L. (Malvaceae), green onion, *Allium fistulosum* L. (Amaryllidaceae), potato, *Solanum tuberosum* L., tree tomato, *Solanum betaceum* Cav. (Solanaceae), and maize, *Zea mays* L. (Poaceae), with abundant weedy mustard flowers, *Brassica* sp. (Brassicaceae). The adult flies were collected with an insect net on the panicle of quinoa plants. The specimens were taken to the Museum of Entomology at the Colombian Corporation for Agricultural Research, Palmira Research Station, where they were pinned, labeled, and identified using taxonomic keys by Thompson (1999) and Smit *et al*. (2017) and diagnostic notes from Miranda *et al*. (2013) and Rossi Rotondi *et al*. (2020). Close-ups of the frontal view of an adult male and female were taken with a Nikon DS-Fi2 digital camera adapted to a Nikon SMZ 1500 stereomicroscope. The distribution map was elaborated with the QGIS program (QGIS.org 2024) using the layers panel tool; coordinates for each point were extracted from iNaturalist (www.inaturalist.org), and distribution data from published literature. 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] and permission granted by the indigenous community of the municipality of Silvia, department of Cauca. Voucher specimens are deposited at the Colección Taxonómica Nacional de Insectos "Luis María Murillo", Corporación Colombiana de Investigación Corpoica, Mosquera, Cundinamarca, Colombia (CTNI).

Results and Discussion

The flies were identified by the first author as the band-eyed drone fly, *Eristalinus taeniops* (Wiedemann, 1818) (Diptera: Syrphidae), an exotic species that has recently been expanding its distribution in South America.

World distribution

Based on a literature review, the world distribution of *E. taeniops* is as follows:

Ethiopian region: Guinea-Bissau, Kenya, Liberia, Mozambique, South Africa, Tanzania, Yemen (Socotra Island), United Arab Emirates, Zimbabwe.

Oriental region: India (Arunachal Pradesh, Assam, Haryana, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Sikkim, Uttarakhand, Uttar Pradesh, West Bengal), Nepal, Pakistan, Vietnam.

Palaearctic region: Afghanistan, Albania, Algeria, Croatia, Cyprus, Egypt, France (mainland, Corsica), Greece (mainland, Crete, Rhodes), Iran, Israel, Italy (mainland, Lampedusa, Sardinia, Sicily), Lebanon, Libya, Malta, Montenegro, Morocco, Oman, Portugal (mainland, Madeira Is), Republic of Georgia, Romania, Saudi Arabia, Serbia, Spain (Balearic Island (Majorca), Canary Island, mainland), Syria, Tunisia, and Turkey (Gomes 1981; Thompson 1988; Whittington 1998; Bańkowska 2000; Dousti and Hayat 2006; Riddiford and Ebejer 2006; Ghahari *et al*. 2008; Speight 2011; Shah *et al*. 2014; Van Steenis 2015; Kapkoti *et al*. 2016; Thangjam *et al*. 2016; Khan 2017; Kumar *et al*. 2017; Sengupta *et al*. 2018; Djellab *et al*. 2019; Monks *et al*. 2019; Dawah *et al*. 2020; Mengual *et al*. 2020; Deidun *et al*. 2021; Vujić *et al*. 2021; Anyieni *et al*. 2023).

Nearctic region: USA: Florida (Thompson *et al*. 1990); California (Miranda *et al*. 2013; Dowell *et al*. 2016).

Neotropical region: Argentina (Rossi Rotondi *et al*. 2020; Torretta *et al*. 2021; Maza *et al*. 2023), Brazil (Morales and Köhler 2006; Martins *et al*. 2013; Ramos *et al*. 2020), Chile (Thompson 1999; Olivares *et al.* 2021; Vieli *et al*. 2021; Barahona-Segovia *et al*. 2021), Colombia (Ángel Villarreal *et al*. 2021; present study), and Paraguay (Goossen-Lebrón *et al*. 2023).

Records of *Eristalinus taeniops* in the New World from the citizen science website iNaturalist.org (http://www.inaturalist.org)

The only records from North America come from the southern USA, mostly from California and Florida, but also a few records from Nevada and New Mexico, and those of Central America are from Costa Rica and Mexico (iNaturalist 2024). There are many records of *E. taeniops* in South America, such as Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, and Uruguay (iNaturalist 2024). The reference source of the distribution record and number of observations reported in iNaturalist can be seen in Tab. 1. The distribution of *E. taeniops* in the New World is concentrated in coastal lines and areas close to ports of entry (Fig. 1).

Table 1. Distribution of *Eristalinus taeniops* in the New World, based on published literature and citizen science reports, including the number of observations. / **Tabla 1.** Distribución de *Eristalinus taeniops* en el Nuevo Mundo, basada en literatura publicada y reportes de ciencia ciudadana, incluido el número de observaciones.

Country	References	Citizen science (No. Observations) (iNaturalist 2024)
North America		
USA	Thompson *et al*. (1990); Miranda *et al*. (2013); Dowell *et al*. (2016)	789 observations
Central America		
Costa Rica		1 observation
Mexico		26 observations

South America		
Argentina	Torretta *et al*. (2007); Rossi Rotondi *et al*. (2020); Torretta *et al*. (2021); Maza *et al*. (2023)	517 observations
Bolivia		17 observations
Brazil	Morales and Köhler (2006); Fragoso (2009); Martins *et al*. (2013); Fragoso and Varanda (2014); Ramos *et al*. (2020)	148 observations
Chile	Thompson (1999); Olivares *et al*. (2021); Vieli *et al*. (2021)	59 observations
Colombia	Ángel Villarreal *et al*. (2021); present study	222 observations
Ecuador		148 observations
Paraguay	Goossen-Lebrón *et al*. (2023)	2 observations
Peru		117 observations
Uruguay		30 observations

Figure 1. Distribution of *Eristalinus taeniops* in the New World. / **Figura 1.** Distribución de *Eristalinus taeniops* en el Nuevo Mundo.

***Eristalinus taeniops* (Wiedemann, 1818)**

Diagnosis. Adult flies 9-14 mm long, eyes striped, with five to six slender bands, and spotted (small brown puncta) (Thompson *et al*. 1999; Smit *et al*. 2017) (Figs. 2A-C). Wings with a characteristic sinuate R4+5 vein (Miranda *et al*. 2013); thorax dull, yellowish gray in color; with four indistinct [longitudinal] black stripes; abdominal segments yellow, with dark [horizontal] bands (Rossi Rotondi *et al*. 2020), dark bands thickening near mid areas of first two visible segments, almost touching; last segment predominantly dark (Fig. 2). The larva of *E. taeniops* is a typical rat tail maggot; for a description of the larva see Pérez-Bañón *et al*. (2003).

Note. Eristaline flies in the New World share a sinuate R 4+5 vein, but *E. taeniops* can be easily separated from congeneric species by the presence of eyes with distinct fasciae and puncta; all other species of *Eristalinus* Rondani, 1845 known from the New World lack fascia (a color pattern with broadband) and maculation on the eyes, except for *E. aeneus* (Scopoli, 1763), which has punctate eyes but lacks the stripes (Thompson *et al*. 1990).

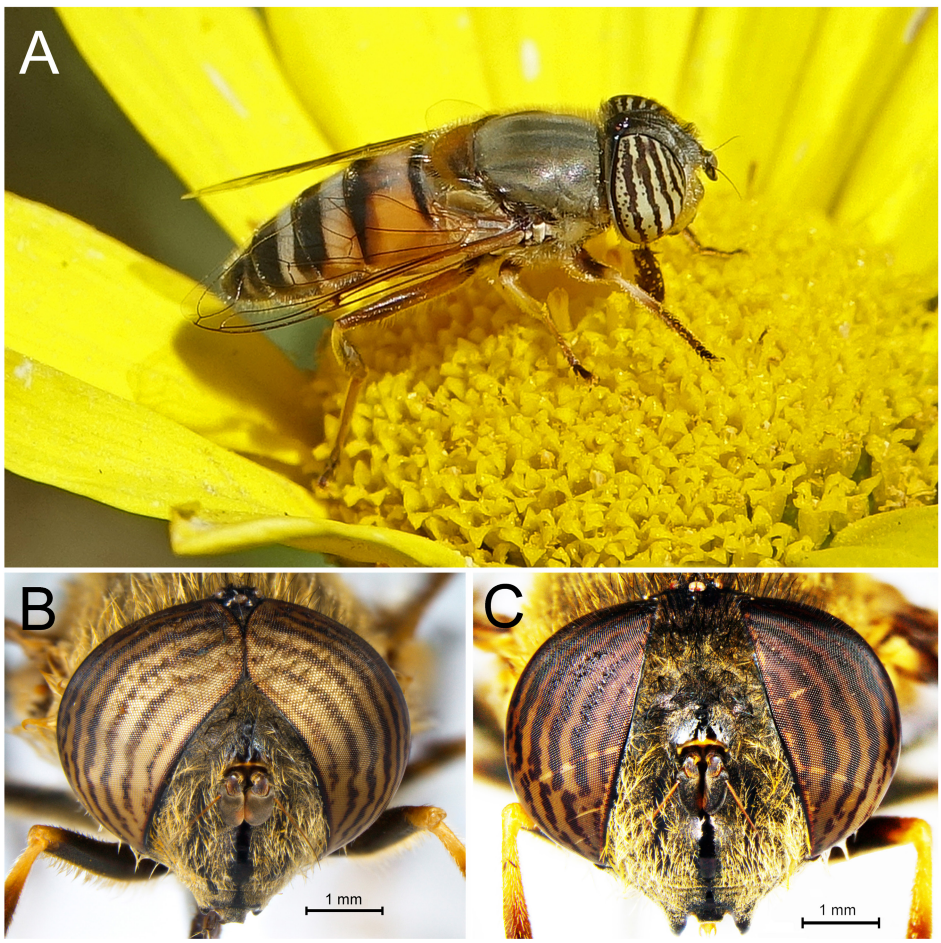

Figure 2. *Eristalinus taeniops* (Wiedemann). **A.** Adult male fly resting on flower. **B.** Frontal view of a male specimen. **C.** Frontal view of a female specimen. / **Figura 2.** *Eristalinus taeniops* (Wiedemann). **A.** Mosca adulta macho descansando sobre una flor. **B.** Vista frontal de un ejemplar macho. **C.** Vista frontal de un ejemplar hembra. Photos: A. Ramon Evans (California, USA). B and C. Robert Rosero (Cauca, Colombia).

Material examined. *Eristalinus taeniops* (Wiedemann). **Colombia:** Cauca, Silvia, Las Delicias, San Fernando, 02°37'N, 76°20'W, 2600 masl, 10.VII.2023, coll. Takumasa Kondo, *ex* panoja de quinua, *Chenopodium quinoa* (grano pastoso), 1 specimen, catalogue No. 10049 [CTNI]; same data except: 13.IX.2023, coll. Robert Rosero, *ex* panoja de quinua, *Chenopodium quinoa* (grano lechoso), 1 specimen, catalogue No. 10049 [CTNI].

Biology. Hurtado-Asencio (2013) studied the biology of *E. taeniops*; the adults of this species are found in both wooded and open areas but are especially frequent in the vicinity of aquatic environments, such as seasonal ponds, rivers, lagoons, coastal swamps, among others. Under laboratory conditions, the complete life cycle of *E. taeniops* typically ranges from 60 to 110 days, depending on factors such as temperature, humidity, and the type of food provided (Hurtado-Asencio 2013). This cycle includes both the pre-imaginal stages (egg, larva, and pupa) and the adult stage; the pre-imaginal period usually lasts between 36 and 54 days (larval stage: 23-39 days; pupal stage: 12-15 days) when reared on a medium such as oats, whereas individuals reared on pig slurry exhibit a pre-imaginal period extended to 65 days (Hurtado-Asencio 2013). Adult flies typically live between 4 and 8 weeks (under laboratory conditions) and feed on nectar and pollen to complete their development and reproduction; once the adult emerges, it takes about 27 days to reach sexual maturity, and the female adult lays 112 eggs in average in their first oviposition (Hurtado-Asencio 2013). The complete generation in the congeneric species, *E. arvorum* (Fabricius, 1787), reared in captivity under a temperature of 25 °C, lasts about 30 days; adults feed on nectar and pollen to complete their development and reproduction and live for about 1 to 2 months; once the adult emerges, it takes about nine days to reach sexual maturity; and the female adult lays 100-150 eggs at a time (Cao *et al*. 2022). The filter-feeding larvae are known as rat-tailed maggots and inhabit small temporary water bodies with decaying plant material and in sewage from farms and factories (Rossi Rotondi *et al*. 2020) and are also known to develop on decomposing animal corpses (Pérez-Bañón *et al*. 2003). Carpaneto and Vigna Taglianti (1995) reported a case of accidental myiasis that was likely caused by the ingestion of eggs or small larvae present in contaminated agricultural water and the use of manure by the affected person. Species of the genus *Eristalinus* can be considered beneficial insects since they are known to be good pollinators (Sonet *et al*. 2019). Numerous reports have indicated *E. taeniops* as a good pollinator (*e.g*., Morales and Köhler 2006; Tshilingalinga *et al*. 2023). Studies have been carried out on the mass rearing of the closely related species, *Eristalis tenax* (Linnaeus, 1758) (Upchurch *et al*. 2023), indicating the importance of eristaline hover flies as pollinators, and decomposers of biofactory residues.

The expansion of exotic insect species, or their introduction and spread beyond their native ranges, is influenced by a variety of factors, including the following:

1) **Global trade and transportation.** Increased global trade and transportation facilitate the movement of insects across borders, either inadvertently through cargo or intentionally for agricultural purposes (Hulme 2021). The global movement of commodities, including plants, soil, and wood products, can inadvertently introduce exotic insect species to new areas (Fenn-Moltu *et al*. 2023).
2) **Climate change.** Altered temperature and precipitation patterns can create favorable conditions for exotic species to establish and spread in new regions (Bellard *et al*. 2012).
3) **Habitat disturbance and urbanization.** Human activities that disturb natural habitats, such as deforestation and urban development, can create environments that are more hospitable to exotic species (McKinney 2002).
4) **Agricultural practices.** The introduction of new crops and agricultural practices can attract or support exotic insect species, which may become pests (Liebhold and Tobin 2008).

5) **Escape from natural enemies.** The enemy escape or escape-from-enemy hypothesis (Elton 1958; Jeffries and Lawton 1984) or Enemy Release Hypothesis (ERH) predicts that an alien species that is introduced to a new region will increase in distribution and abundance due to the reduced impacts from natural enemies (Roy *et al*. 2011).

These factors interact in complex ways, often making challenging the management and mitigation of exotic insect species. According to the distribution records of *E. taeniops* in the New World, the introduction of this exotic syrphid fly into the New World likely occurred through global trade via airports and seaports, *e.g*., in Florida and in California, there are the Miami and Los Angeles international airports and numerous seaports, respectively. The same pattern is seen in South America, where most records of *E. taeniops* are clustered around capital cities with international airports and near the coastline, *e.g*., Río de la Plata in Argentina, Porto Alegre and Rio de Janeiro in Brazil. In Colombia, records of its distribution are concentrated in the Andean region, including Bogota, where an international airport may have been the point of entrance of this exotic syrphid fly. However, this hypothesis needs to be tested since records of iNaturalist may tend to be higher near larger cities. Further studies are needed to study aspects of its biology and its interactions (*e.g*., interspecific competition) with native syrphid flies.

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Author Contributions

TK: Conceptualization, investigation, methodology, writing - original draft preparation, resources, reviewing and editing, supervision, visualization. **RR:** Data curation, investigation, writing- original draft preparation, visualization. **JG:** Investigation, project administration, funding acquisition, original draft preparation, resources, writing- original draft preparation.

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