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New mosquito species records for Ecuador, from Pululahua volcano (Andes) and Napo province (Amazon)

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Abstract

New records of mosquitoes (Diptera: Culicidae) are reported for Ecuador with the extension of their geographical distribution in South America: *Aedes (Howardina) fulvithorax* (Lutz) in a bromeliad and *Culex (Culex) stenolepis* Dyar & Knab in a ground pool with vegetation, in the province of Napo (Amazon) and the crater of the volcano Pululahua (Province of Pichincha) respectively. Information on collection localities, dates, biogeographical region, climate, number of specimens deposited, collectors, and current distribution is included for each species. With these records, the alpha diversity of the Culicidae of Ecuador is estimated at 242 species.

Keywords: Biodiversity, Culicidae, Ecuador, Mosquitoes, *Culex*, *Aedes*.

1. Introduction

The mosquitoes (Diptera: Culicidae) are considered an important emerging and re-emerging disease vectors. The knowledge of mosquito biodiversity (alpha, beta and gamma diversity) and species distribution is essential to determine areas of potential risk of pathogen transmission and conduct assessments of environmental health in protected and intervened areas, e.g., localities with human interventions as oil and mining exploration, road and highway constructions in forests areas, touristic developments, new urbanizations, etc. Pioneer contributions about Culicidae taxonomy and geographic distribution in Ecuador were made by Levi-Castillo in the 1940s-1950s. Recently, Ecuador's mosquito diversity has been updated, with new distribution records, related to ecological and molecular information in the country [1-9]. After this note, the mosquito fauna of Ecuador will be updated, extending the geographical distribution of two species in South America and also increasing the number of species from the country, which is approximately 242 species recorded [3-7, 10-14]. However, this number must be still underestimated considering that Ecuador is one of the mega diversity countries. The mosquito fauna alpha-diversity should be comparable to that found in Colombia, Peru, and Venezuela [11, 15-16] (more than 300 species) with similar biogeographical regions. The genera *Aedes* and *Culex* are two of the large groups into the family, with also a high diversity of sites for developing immature phase including natural and anthropogenic sites [13]. Here we report two new mosquito species never collected before in Ecuador, in field samplings as part of a project on entomological and zoonotic pathogens surveillance.

2. Materials and Methods

Field collections were conducted in the Andes Mountains and Amazonian Basin at fixed locations in six Provinces of Ecuador (Figure 1). The specimens were collected as immature stages with a 300-ml absorber dropper and dipper between November 17-24th, 2014. Larvae were individually reared to obtain the larval and pupal exuviae associated with the respective adult [17, 18]. Species were identified from larvae, adult males and females, and male genitalia based on the keys *ad hoc* [19-22]. The abbreviations for life stages and other terms used are as follows: male (M), male genitalia (GM), female (F), pupa (P), pupal exuviae (Pe), 4th instar (L4), larval exuviae (Le), the person who determined the species (det.), and the collector (coll.). Information on collection locality, date, biogeographical region, climate, number of specimens examined, deposited individuals, number of specimens deposited, collectors, and current distribution is included for each species.

3. Results

3.1 New mosquito records and general-ecological information

A phytotelmata-inhabiting species was identified, *Aedes (Howardina) fulvithorax* (Lutz), which belongs to a subgenus closely associated with the use of bromeliads as development sites of its immature stages in high Amazonian region [22, 23, 18]. The other species reported here, *Culex (Culex) stenolepis* Dyar & Knab which belongs to a subgenus with wide use of containers and pools (natural and artificial) as development sites of its immature stages, was found in a volcanic ground pool with cold carbonate water (26 °C, pH:8) and the presence of bubbles rising from the bottom to the surface (Figure 2).



Fig 2: Photograph of the ground pool in the crater of the Pululahua volcano, A. General view of pool, B. Collecting larvae with dipper, C. Zoom of bubbles in the surface of pool.

Aedes (Howardina) fulvithorax

This species was found in bromeliads in the backyard of a house in Gonzalo Diaz de Pineda, a small town at 1,475 m in

Napo Province located in the eastern slopes of Andes Mountains toward the Amazonian lowlands (Figure 1). This location belongs to the Napo Biogeographical Province [24]; however it represents a transition zone between Andean mountain foothills and Amazonian lowlands. Secondary forests and farms with cattle production surround the town. The original undisturbed surroundings are characterized by montane evergreen low forest of the northeastern Andes cordillera, rainy and humid forest with several strata (high canopy, shrubs, herbs and abundant epiphytic plants) [25].

Aedes fulvithorax have been reported from Brazil (Type loc.), and other six South American and Caribbean countries including Venezuela, Peru and Bolivia [22, 12]. Thus, Ecuador represents a logical geographical continuation of the Trans-Andean and Amazonian distribution and expands the distribution to eastern Amazonian basin *sensu* map of the distribution by Berlin²² (1969:134). *Aedes fulvithorax* become the seventh species of subgenus *Howardina* in Ecuador along with *Ae. sexlineatus* (Theobald), *Ae. quadrivittatus* (Coquillett), *Ae. albonotatus* (Coquillett), *Ae. pseudodominici* Komp and the two species originally described from Ecuador (type loc): *Ae. brevittatus* Berlin and *Ae. ecuadoriensis* Berlin. The *Howardina* species in Ecuador are reported mainly from the Andean highlands on both sides of the Andes Cordillera. *Howardina* species have been collected in various phytotelmata. *Aedes fulvithorax* is reported for tree holes [22], however there is little knowledge of the development sites, so finding this species in bromeliads is to be expected. Ecological studies are needed to determine the range of aquatic habitats and oviposition preferences.

Experimental studies about *Ae. fulvithorax* showed that while it could be infected with and maintain the yellow fever virus (YFV), it was not able to transmit by bite [26, 27], however, Berlin²² suggest that *Howardina* species may transmit the YFV if the incubation period is prolonged at favorable temperatures.

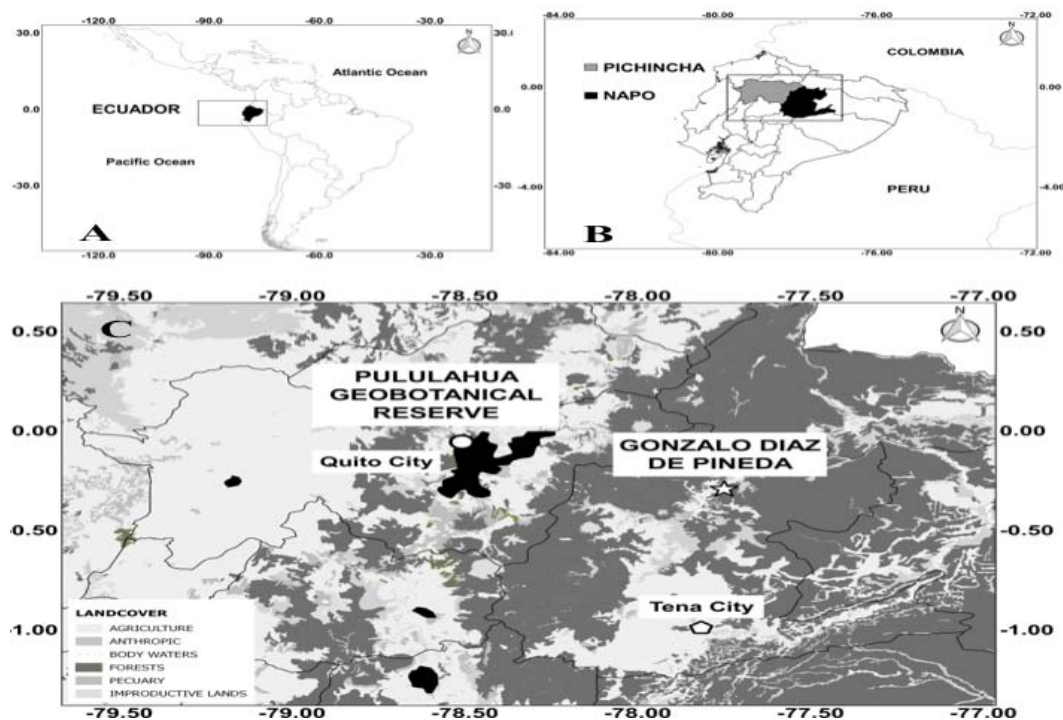


Fig 1: Political map with the locations of species collection, A. Ecuador location in South America, B. Pichincha and Napo Provinces location in Ecuador, C. Pululahua Geobotanical Reserve, Pululahua Volcano, the Andean locality (Pichincha) and Gonzalo Diaz de Pineda town, the Amazon locality (Napo).

Culex (Culex) stenolepis

This species was found in the ground pool that occurs within and downslopes from the crater of the Pululahua Volcano at 2,101 m, 80 km from the capital Quito, in the North Andean Paramo biogeographical Province [24] (Figure 1). Its climate is moderately cold in the highlands, and the northwest is temperate and subtropical, with temperatures ranging from 13-15 °C. Summer extends from June to December and winter from December to June. The annual rainfall ranges from 500 to 3000 mm. Pululahua is an extinct inhabited volcano, the third largest at 12 km in diameter. This location has evergreen shrubs and small trees, opened canopy, and humid, successional vegetation from the northern Andes [25]. *Culex stenolepis* is so far as we know the first species reported in a volcanic crater in the Americas.

This species has been reported from Mexico to Costa Rica [12, 13] and reported in bromeliads and terrestrial aroids [28, 29], however and interestingly Heinemann & Belkin²⁸: (page 242, locality record 62) reports this species with a question mark in the subgenus (?). Our experience in phytotelmata mosquito fauna, addresses this report as a casual/eventual collection or with doubts in the identification in Costa Rica. An extensive study in Venezuela [30-32, 17] and so on the reviews of mosquito fauna for Phytotelmata and bromeliads [23] has been found the subgenus *Microculex* associated with Bromeliads and aroids, so rarely found the subgenus *Culex*.

The new record in Ecuador, Pichincha Province in the Andes Mountains represents a possible continuous Cis-Andean distribution. We suggest that this species can be strongly associated with volcano areas in the continent from Mexico to Cañar Cross in Ecuador at 2° 30' S that separate the Ecuadorian Andes in two geological provinces, the north with quaternary volcanoes and south with absence of these volcanoes [33]. Further south of Cañar Cross a gap occurs without chain of volcanoes to the south of Peru at 15° S and then, the presence of volcanoes continues to 28° S in Chile. Probably, *Cx stenolepis*, due to this interruption of the volcanic chain, occurs from Mexico to Ecuador including Colombia and Panama, and it would be absent in Peru, Bolivia, Argentina and Chile.

This species has a strong morphological similarity and geographical distribution similarity with *Cx. pinarocampa* Dyar & Knab with diagnostic characters based mainly on male genitalia mainly. Both species were described by the same authors in the same reference [34]. A detailed characterization and re-descriptions would be necessary in order to discard a synonymy.

It was abundant at sampling location and showed a marked anthropophily (females were captured landing on collectors (YC, JCN) between 10:00 – 15:00 hours, outside and in a small forest). There is no published information about its developmental sites and medical importance

3.2 The specimens and collection data***Aedes (Howardina) fulvithorax* (Lutz, 1904)**

Label #: ECU-N-V18-03-100 (P_e,F); 6P (ECU-N-V18-03-101, 10,11,12,13,16); 5L₄ (EC-N-V18-03-14, 15,17,18,19). Date of Collection: 25, 26, 27/XI/2014.

ID Characters: In the female, the “mesonotum usually entirely golden-scaled from anterior promontory to wing root,

rarely a few darker scales along dorsocentral lines posteriorly; no conspicuous dark bronzy scales on fossa” (Berlin 1969:14²², female diagnostic characters, and Berlin 1969:140²² to see mesonotum pattern). (Figure 3).



Fig 3: Photograph of thorax, dorsal view, of *Aedes fulvithorax*. Show the pattern with golden scales in the anterior part of mesonotum.

Distribution in Neotropic: Brazil (Ponte Ipé Arcado, Goiás, Type loc.), Trinidad, Suriname, French Guiana, Venezuela, Peru, and Bolivia. (Berlin 1969²², Guimarães 1997¹²). Now also in Ecuador.

Locality in ECU, data: Napo Province, Gonzalo Díaz de Pineda town, El Chaco County (Municipio). Altitude: 1,475 m, Coordinates: 00° 17'42.6'' S; 77° 44'58.9'' W.

Adult collected in: by rearing; immature collected in terrestrial *Aechmea* sp. (Bromeliaceae: Bromelioideae).

Coll.: S. Enríquez, Y. Campaña, P. Duque, V. Romero; Det.: J.C. Navarro.

Associated fauna in the development site: *Wyeomyia (Pho.) lassalli* (Bonne-Webster and Bonne), *Wyeomyia scotinomus* (Dyar & Knab).

Material deposited at: National Collection of Arthropoda of Zoonotic Importance (Ticks, Mosquitoes, Sandflies, and others) in the Centro Internacional de Zoonosis (CIZ) at Universidad Central del Ecuador Museum.

***Culex (Culex) stenolepis* Dyar & Knab, 1908**

Label #: ECU-Pul-01-13 (L_e, P_e, M, GM), ECU-Pul-01-14 (L_e, P_e, M, GM), ECU-Pul-01-101 (P_e, F); associate series ECU-Pul-01-(10,13,15,16,18,19,27) (L_e, P_e, M); ECU-Pul-01-100 (P_e, M); 9 L₄ (ECU-Pul-01-12,17,20,21,22,23,24,25,26).

Date of Collection: 17/XI/2014.

ID Characters: “Basistyle conical, about twice as long as the basal width; clothed with fine setae in addition to the normal, long setal pattern. Apical lobe of the basistyle somewhat flattened, undivided, and also clothed with fine setae. Appendices of the apical lobe as follows: basal rod strong, straight, and pointed; median rod broader and longer than the basal rod and terminating in a gentle hook; apical rod longer than, but not as broad as the median rod, also terminating in a gentle hook; leaf moderate in size, obovate, with several prominent, longitudinal, centripetal

striations; one long, pointed, gently curved accessory seta present. Dististyle normal. The external process gradually tapering to a point, reaching about the ventral cornu in length. Ventral cornu large, rounded, and rugulose. Median process with about seven sharply pointed subequal teeth. Basal process short, straight, broad, and bluntly rounded.” (sensu Bram 1967:104²¹ based on Dyar & Knab 1908:60³⁴). (Figure 4).

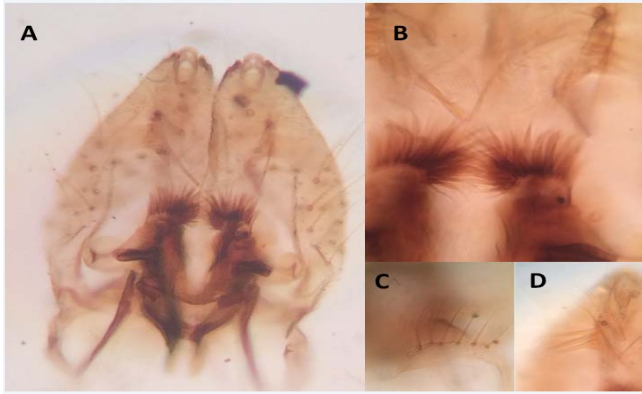


Fig 4: Photograph of male genitalia of *Culex stenolepis*, A. Dorsal aspect of complete genitalia. B View of paraproct and paraproct crown (subgenus *Culex*). C. Right lobe of IX tergite, D. Setae and leaf of subapical lobe.

Distribution in Neotropic: Mexico to Costa Rica. With this record, the distribution include Ecuador now.

Locality in ECU, data: Pichincha Province, Quito D.M., Pululahua Geobotanical Reserve, Pululahua Volcano. Altitude: 2,101 m; Coordinates 00° 03' 28.9" N; 78° 30' 29.1" W. Coll.: P. Duque, Y. Campaña, J. Vieira, V. Romero; Det.: J.C. Navarro.

Associated fauna in the area: *Culex (Microculex) pleuristriatus* Theobald, *Aedes (Howardina) sexlineatus* collected in bromeliads and landing on authors.

Adult collected in landing on authors, immature collected on a border of the volcanic ground pool.

Material deposited at: National Collection of Arthropoda of Zoonotic Importance (Ticks, Mosquitoes, Sandflies, and others) in the Centro Internacional de Zoonosis (CIZ) at Universidad Central del Ecuador Museum.

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enfermedades re-emergentes zoonóticas en la Amazonía Ecuatoriana” to WBO and SE.

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