
A NEW PHYTOTELM PLANT FOR ECUADOR, *ANANAS COMOSUS* L. MERR. (BROMELIACEAE) AND ITS *WYEOMYIA* SPECIES INHABITANT (DIPTERA, CULICIDAE)

Nueva Phytotelmata para Ecuador, Ananas comosus L. Merr.
(Bromeliaceae) y la especie de *Wyeomyia* asociada (Diptera: Culicidae).

Novo Fitotelmo para o Equador, Ananas comosus L. Merr. (Bromeliaceae) e
a espécie associada *Wyeomyia* (Diptera: Culicidae)

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ABSTRACT

INTRODUCTION. Phytotelmata are a botanical group with water-impounding structures formed by non-aquatic plants, such as leaf axils, perforated internodes, stem holes or depressions, rot-holes in tree trunks or branches (tree-holes), flowers, open fruits, among others. These plants offer suitable conditions for aquatic or semi-aquatic animals, in particular arthropods. Immature mosquitoes (Diptera: Culicidae) are well represented among the inhabitants of phytotelmata. **OBJECTIVE.** Carry out a rapid assessment of the biodiversity of mosquitoes present in different land uses in the population and biological reserve of Limoncocha, to assess the vulnerability and risk of transmission of pathogens that cause emerging diseases. **METHODS.** Immature mosquitoes were collected in different phytotelmata including *Ananas comosus* leaf axils in a deforested area with small crops nearby of the Limoncocha Biological Reserve. **RESULTS.** Fourth instar larvae of *Wyeomyia* (*Wyeomyia*) *medioalbipes* Lutz were found in this plant to confirm their presence in the country and to the cultivated pineapples as phytotelmata in Ecuador. **DISCUSSION AND**

CONCLUSIONS. This is the first report for Ecuador of *Ananas comosus* as phytotelmata and the associated mosquito species. Additionally, the presence of *Wy. medioalpes* in the country is confirmed. This information is added in the epidemiological evaluation of vulnerability and risk for the transmission of pathogens with a biogeographical and ecological vision.

Keywords: Biodiversity, bromeliads, mosquitoes, Pineapple, leaf axils, Sabethini, arbovirus vectors.

RESUMEN

INTRODUCCIÓN. Las fitotelmata son un grupo botánico con estructuras que retienen agua, como axilas de las hojas, internodos perforados, agujeros o depresiones del tallo, agujeros en troncos o ramas de los árboles, flores, frutos abiertos, entre otros. Estas plantas ofrecen condiciones adecuadas para animales acuáticos o semiacuáticos, en particular artrópodos. Los mosquitos inmaduros (Diptera: Culicidae) es un grupo comúnmente asociado a las fitotelmata. **OBJETIVO.** Estudiar la biodiversidad de mosquitos vectores asociados con el cambio de uso de la tierra, el riesgo y la vulnerabilidad de la transmisión potencial de arbovirus en la Amazonía del Ecuador. **MÉTODOS.** Se recolectaron mosquitos inmaduros en diferentes fitotelmatas, entre ellas axilas de *Ananas comosus* en un área deforestada con pequeños cultivos cercanos a la Reserva Biológica Limoncocha. **RESULTADOS.** Se encontraron larvas de cuarto instar de *Wyeomyia (Wyeomyia) medioalbipes* Lutz en esta planta para confirmar la presencia de esta especie en el país y a las piñas cultivadas como fitotelmata en Ecuador. **DISCUSIÓN Y CONCLUSIONES.** Este es el primer reporte para Ecuador de *Ananas comosus* como fitotelmata y la especie de mosquito asociada. Adicionalmente, se confirma la presencia de *Wy. medioalbipes* en el país. Esta información se suma a la evaluación epidemiológica de vulnerabilidad y riesgo para la transmisión de patógenos con una visión biogeográfica y ecológica.

Palabras clave: axilas de plantas, bromelias, biodiversidad, mosquitos, Piña, Sabethini, vectores de arbovirus

RESUMO

INTRODUÇÃO. Os fitotelmos são um grupo botânico com estruturas que armazenam água, como axilas foliares, entrenós perfurados, buracos ou depressões do caule, buracos nos troncos ou galhos das árvores, flores, frutos abertos, entre outros. Estas plantas oferecem condições adequadas para os animais aquáticos ou semi-aquáticos, em particular artrópodes. Os mosquitos imaturos (Diptera: Culicidae) são um grupo comumente associado aos fitotelmos. **OBJETIVO.** Estudar a biodiversidade de mosquitos vetores associados com a mudança do uso do solo, o risco e a vulnerabilidade da transmissão potencial de arbovírus na Amazônia do Equador. **MÉTODO.** Mosquitos imaturos foram coletados em diferentes fitotelmos, incluindo as axilas de *Ananas comosus*, numa área desmatada com pequenas culturas próximas da Reserva Biológica Limoncocha. **RESULTADOS.** Larvas de quarto estágio de *Wyeomyia (Wyeomyia) medioalbipes* Lutz foram encontradas nesta planta para confirmar sua presença no país e aos abacaxis cultivados como fitotelmo no Equador. **DISCUSSÃO E CONCLUSÕES.** Este é o primeiro registro para o Equador de *Ananas*

comosus como fitotelmo e a espécie de mosquito associada. Além disso, a presença de *Wy. medioalbipes* no país é confirmada. Esta informação é adicionada á avaliação epidemiológica da vulnerabilidade e risco para a transmissão de patógenos com uma visão biogeográfica e ecológica.

Palavras-chave: axilas de plantas, bromélias, biodiversidade, mosquitos, abacaxi, Sabethini, vetores de arbovírus.

INTRODUCTION

Phytotelmata is a word was coined by Varga [1] and derived from the Greek words *phyton* (plant) and *telma* (pool), which has been adopted into English [2], [3]. The singular of phytotelmata in English is phytotelma (or phytotelm), while in plural is phytotelmata (or phytotelms). The term has been adopted in Spanish as “fitotelma” or “fitotelmata” [4]. This botanical group are water-impounding structures formed by non-aquatic plants, such as leaf axils (Bromeliaceae and Araceae), perforated internodes (bamboo), stem holes or depressions, rot-holes in tree trunks or branches (tree-holes), modified leaves (*Heliconia*), flowers (Marantaceae), open fruits (cacao pods and coconuts) and fallen leaves (spathes of palms and Musaceae).

Maguire (1971) reviewed the biota and community structure of the phytotelmata taxa and then [3] contributed to a comprehensive book about the subject. The phytotelmata, a non-taxonomic group of taxa, is represented by members of at least 29 plant families [5] mostly monocotyledons, but also some dicotyledons that can form treeholes. Later, an extensive bibliography of the biota inhabiting bromeliad leaf axils [6] was updated. In the Neotropics, the most important phytotelmata are Araceae, Bromeliaceae, Heliconiaceae, Marantaceae, Musaceae, Poaceae Sarraceniaceae, Strelitziaceae and Zingiberaceae, including an uncompiled and probably long list of plant families providing fruits or fallen leaves. There are still no lists of plant families that form tree-holes.

Immature mosquitoes, eggs, larvae and pupae (Diptera: Culicidae) are well represented among the inhabitants of phytotelmata, and they include some vector-borne disease. Some mosquitoes show a species-specific association with phytotelmata species [2], [3], [6], [7], representing an ideal system for ecological, biogeographical [8] and altitudinal range analyses [9].

Bromeliaceae is a family of monocotyledonous plants native to the Neotropics, although a few species can be found in southern USA. They are classified into three subfamilies (Pitcairnioideae, Bromelioideae, and Tillandsioideae), about 60 genera (some of which are *Ananas*, *Aechmea*, *Brocchinia*, *Bromelia*, *Guzmania*, *Puya*, *Tillandsia*, and *Vriesia*) and about 2,900 described species [10].

Ananas comosus L. Merr. (**Fig.1**) is a tropical plant with edible multiple fruits consisting of coalesced berries, also called pineapples, and the most economically significant plant in the family Bromeliaceae, native of South America. The word "pineapple" in English was first recorded to describe the reproductive organs of conifer trees. Its original name was “anana”, a word derived from the Tupi-Guarani word “nanas” in South America, which literally

means excellent fruit [11]. However, “piña” is its common name in Spanish. In Ecuador, the pineapple has extensive lands for its cultivation in Los Rios, Santo Domingo de los Tsachilas, and in coastal Pacific Provinces covering 5,750 Ha, as well as being usual in small plantations (“chacras”) and backyard culture in many places in the Amazonian.

The bromeliads vary considerably in architecture. Many impound water within their inner leaf axils provide a habitat for terrestrial arthropods with aquatic larvae, while their outer axils provide terraria for an assemblage of fully terrestrial arthropods [6]. Many bromeliads are epiphytic, but the pineapple is terrestrial.

Mosquitoes (Family Culicidae) is one of the more important aquatic insects associated to bromeliads and many species develop its immature stages within them in a complex ecological network [3], [6], [12]. To date, there have been reported close to 1,000 mosquito species from the Americas [13], [14]. The “Collection records of the project ‘Mosquitoes of Middle America’” [15] published 14 works during eight years that systematically sampled immature stages of mosquitoes from southern USA to Argentina, with many documented habitats including mosquitoes in bromeliads reported in a comprehensive review [16]. Analysis of literature shows that immature stages of more than 200 mosquito species had been reported from bromeliad, representing around 20% of the Culicidae diversity. The usual mosquito genera strongly associated with bromeliads are *Culex* (*Microculex*), *Aedes* (*Howardina*), *Wyeomyia* and *Anopheles* (*Kerteszia*) [7].

***Ananas comosus* L. as phytotelmata**

Ananas comosus has been reported as host plant for mosquitoes in Africa such as *Aedes simpsoni* Theobald, a yellow fever vector [17]; in Indonesia as host plant for dengue fever vectors, *Aedes albopictus* (Skuse) and *Ae. chrysolineatus* (Theobald) [18]; and other mosquito genera in India [19]. In the Americas, immature *Aedes albopictus* have been found developing in pineapple plantations in Panamá [20] and Costa Rica, while collected mosquito adults have been found infected by dengue virus [21]. Also in Panamá, the new species *Wyeomyia* (*Hystatomyia*) *intoca* Porter & Wolff has been collected in pineapple axils [22]. In Iquitos, Peru, *Wyeomyia* sp. and Ceratopogonidae larvae have found an optimal breeding site in this plant due to changes in land use such as patches of deforested areas substituted by pineapple plantation [23].





Figure 1. Photographs of a patch of *Ananas comosus* plants, flower and a close-up of its axil filled with water, providing a phytotelm at the bottom right corner.

METHODS

In a project searching for mosquito biodiversity vectors associated to land use change, risk and vulnerability of potential arboviruses transmission in an Amazon of Ecuador, we collected on phytotelmata species in the Limoncocha Biological Reserve and in different land uses (primary, secondary and flooded forests, urbanized location and ecotone, plantations) around the Limoncocha village, an indigenous Kichwa locality 250 km from Quito, at Sucumbios Province at SW 21⁰ 18.2, W 76 38 29.1 (Santiago Lanza Farm) and SW 17⁰ 12.3, W 76 38 29.1 (Angel Velasco Farm) and 200m average (**Fig. 2**). This village is located in the north-central part of the Ecuadorian Amazon, eastern of the Andes cordillera. The average annual temperature is 25.6°C (13-32 °C), 86% RH, and 14 rainy days/month [24] in a couple of cacao-coffee plantation with forest relicts.

The larvae and pupae were collected in more than 20 pineapple plants (March 2018), a scant 3-10 ml of clean rainfall water in the axils, stored, transported and reared in the field station and the laboratory following standard methods [7], [15].

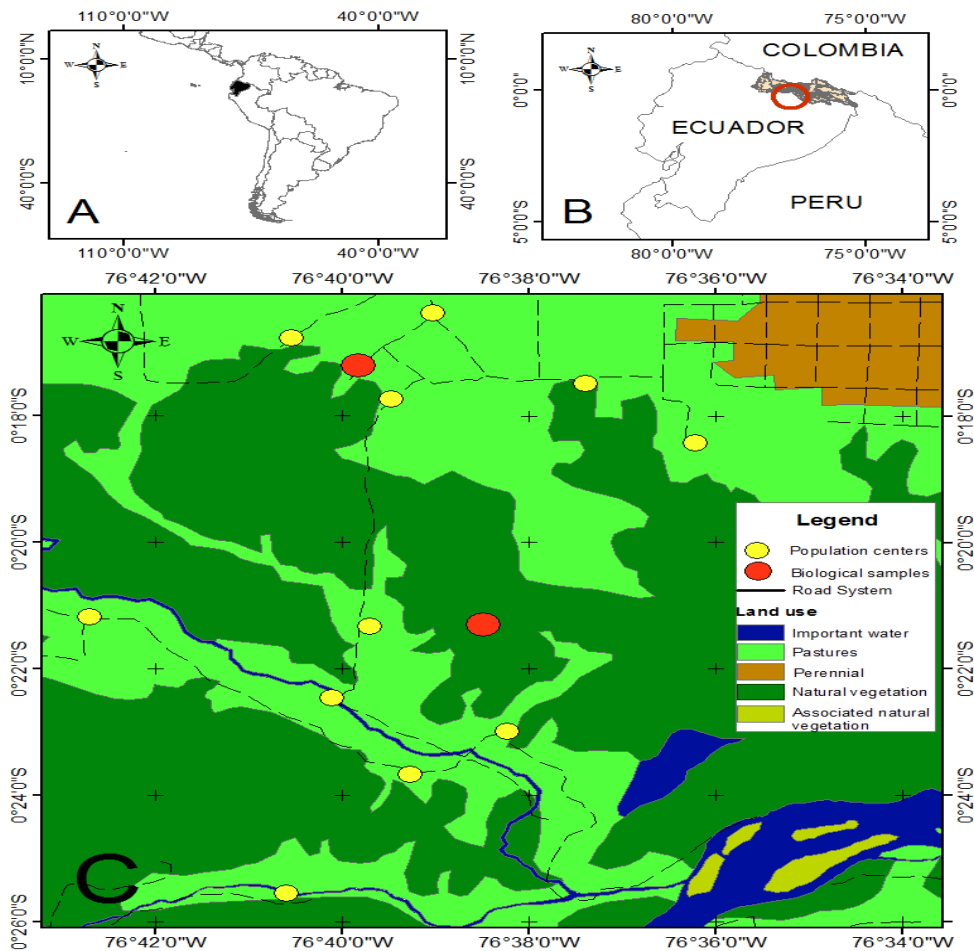


Figure 2. Map of locations in the Amazon. A. Ecuador location in South America. B. Sucumbios Province in Ecuador. C. In red circles, the sites where plants and mosquitoes species were sampled around Limoncocha village.

RESULTS

The mosquito species was identified in 4th instar and adult females and males as *Wyeomyia (Wyeomyia) medioalbipes* Lutz using *ad hoc* keys [25]. The material voucher has been deposited in two institutional collection centers. The ID codes for voucher material are UISEK-L-13 to UISEK-L-73 and UISEK-S-304 to UISEK-S-346 in wet and dry collections (including immatures and adults mounted with immature skins associated) at UISEK Biodiversity Collection. Specimen of this material was also deposited in CoNRAZ-CIZ-UCE.

First report of pineapple as phytotelmata and its mosquito inhabitant. We found mosquito specimens associated with the following phytotelmata in a deforested area with small crops: fallen leaves of “platanillo” (*Musa velutina* H. Wendl. et Drude [Musaceae]), cocoa husks (*Theobroma cacao*), *Calathea* spp. flowers and the pineapple *Ananas comosus* L. Merr (**Fig. 2**). In the last one, immature stages of *Wy. medioalbipes*, was collected in several leaf axils.

Identification of *Wy. medioalbipes*. The females present the 4th vein with lateral anterior scales ligulate, sternopleurals below margin of meron; postnotum without a spot of silvery scales; proboscis long as femur, mid lobe of scutellum dark, abdomen with colors separated laterally in a straight line, pronotal lobe in dark, with metallic sheen and white scales on top, the mid tarsi marked with white from the distal third of II to the base of segment V. Larvae L4: Siphon four times its greatest width; the setae long and double, dorsal tuft of anal segment with two setae, pecten of segment VIII with free scales and false pecten absent. (**Fig. 3**)



Figure 3. *Wyeomyia (Wyo) medioalbipes* Lutz. Left: Female adult; Right: ventral view of 4th instar larvae.

DISCUSSION AND CONCLUSIONS

Wy. medioalbipes has been reported in Belize, Brazil (type locality, Bahia), Colombia, Cuba, Dominica, Dominican Republic, Guyana, Haiti, Jamaica, Nicaragua, Paraguay, Suriname, Trinidad and Tobago, United States, and Venezuela. A previous uncertain report as “*Wy. near medioalbipes*” had been done in the Amazonia of Ecuador in the Tiputini National Park [27], which can be confirmed here due to the proximity with our locality.

Recently, a new phytotelmata from the Americas (*Crinum moorei*, Amaryllidaceae, introduced from South Africa) was reported in Ecuador [4]. However, to date the pineapple had not been recorded as phytotelmata in any mosquitoes related work since the pioneering studies of Levi-Castillo [28]–[30] to the recent and most extensive ones dedicated to the biodiversity of mosquitoes and phytotelmata in the country [4], [27], [31]–[36].

The results suggest that the pineapple that is an important economic plant and its extended distribution in open and deforested areas can serve as reservoir of mosquitoes through the Provinces with extensive or subsistence crops which should be evaluated next. Additionally, previous works point out the high specificity of mosquito species for different bromeliads subfamilies [8], [16]. This relationship can also be evaluated in a biogeographical context for this plant as well for the other phytotelmata species using new data along with data accumulated in recent years.



Wyeomyia genus is the largest in the Sabethini Tribe, including sylvatic species and phytotelmatic immatures stages, and comprises more than 100 species and 15 subgenera. *Wyeomyia* genus is a poorly studied mosquito taxa with taxonomic boundaries confused due to the unclear or absence of reliable characters [13], [37]–[39].

The *Wyeomyia* subgenus, the largest in the genus, remain unclear due to the use of inconsistent morphological characters [37]. However, most of them use the bromeliads as main breeding sites.

The finding of *Wy. medioalbipes* confirms the specificity of the genus in the family Bromeliaceae, but also shows that there is still work to in order to know the different mosquito-plant relationships in the country and that the diversity of mosquitoes is still underestimated despite the efforts in recent years. There are around 252 species of mosquitoes recorded to date in Ecuador [35], [40], however, this must be close to or greater than the diversity reported in other Andean and mega-diverse countries such as Colombia and Peru, and close to countries such as Venezuela and Brazil with also other biogeographical areas and ecosystems not present in Ecuador (e.g. llanos and Atlantic coast). A conservative estimate could be a little over 300 species, work that we intend to achieve in the coming years. In parallel, this information will allow us to obtain an estimation of risks and vulnerabilities of the transmission of pathogens with a biogeographic and ecological vision.

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DISCLOSURE OF INTEREST

The authors declare that they have no conflicts of interest concerning this article.

CONTRIBUTION OF THE ARTICLE IN THE RESEARCH LINE

The finding of *Wyeomyia medioalbipes* confirms the specificity of the genus to the family Bromeliaceae and also to report new phytotelmata in Ecuador, but also to contribute to the knowledge of disease vectors biodiversity in the country which is to date around 252 species of mosquitoes recorded. Also, this information will allow us to obtain an estimation of risks and vulnerabilities of the transmission of pathogens with a biogeographic and ecological vision.

AUTHORS CONTRIBUTIONS

JCN and SE coordinate the project and get the funds. PD, JL, FV, JS, SE and JCN performed the field work, FV and PD, reared and mounting the specimens in lab, JCN studied the specimens, JCN and PD wrote the paper, PD and JS elaborated the map.

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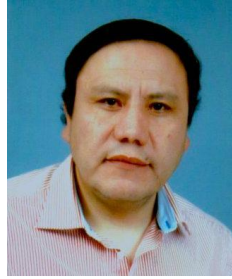
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