

Also in Fernando de Noronha, there was a clear preference of *Z. indianus* for the environments of disturbed forests and urbanized area in relation to the environments of mangrove and adjacent forest, where only 14 individuals were collected. Our results are the first record of *Z. indianus* in an oceanic island in Brazil, 360 km far from the coast. The data reinforce the idea that *Z. indianus* has great dispersion and colonization capacities. The continuous analysis of drosophilids in Fernando de Noronha at this time of the process of colonization may clarify, in the future, the role of this invasive species in the dynamics of other exotic and native species already established on the island for a long time.

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Diversity and geographical distribution of *Drosophila* (Diptera, Drosophilidae) in Ecuador.

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Introduction

Ecuador, with an area of only 256,370 km², is one of the ten most mega-diverse countries in the world (Coloma and Ron, 2001). The latitudinal position, the presence of the Andes Mountains, and the influence of ocean currents of the Ecuadorian coast have produced a wide variety of habitats with a unique flora and fauna.

The first records of the genus *Drosophila* in Ecuador were made by Becker (1919), who reported the results of the entomological collections made by Ribet in the early 18th century in Ecuadorian highlands or Sierra. In 1957, Wheeler recorded species of the *flavopilosa* group around the Cotopaxi Volcano. In 1983, Carson and colleagues made a taxonomic survey of *Drosophila* in the Galápagos Islands. Until then, *Drosophila* records were the result of sporadic collections.

In 1987, studies were initiated to evaluate the Ecuadorian *Drosophila* diversity with the work of G. Arcos (1989), Rafael and Arcos (1988, 1989), Rafael *et al.* (2000a, b), Rafael and Vela (2000, 2003), Vela and Rafael (2001, 2003, 2004a, b, c, 2005a, b), Acurio *et al.* (2002), Rafael (2007), and Acurio (2007). Currently, 16 provinces belonging to 4 geographical regions, Coast, Sierra, Amazon, and the Insular Region, have been sampled (Figure 1).

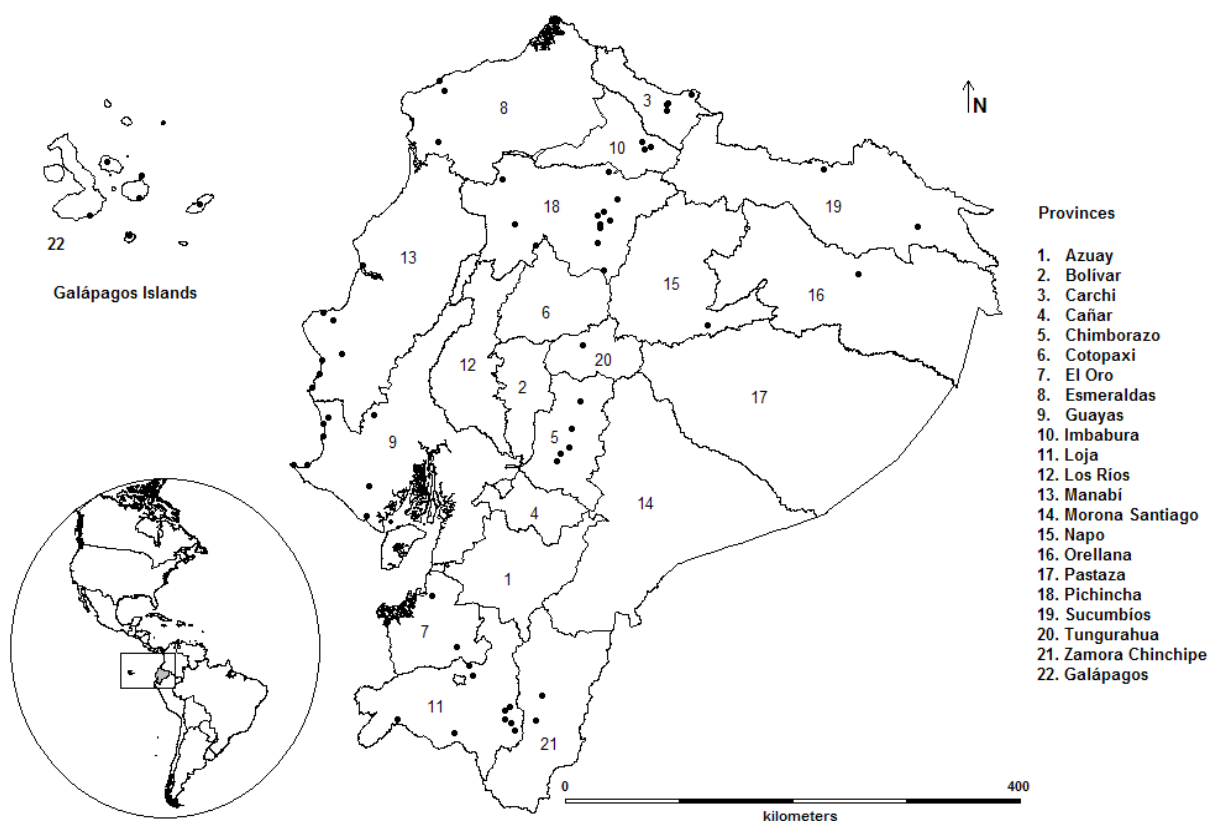


Figure 1. Geographic distribution of *Drosophila* species in Ecuador. The black dots show geographic coordinates of sampling sites.

In this paper, we synthesize what is currently known about the distribution and diversity of the genus *Drosophila* in Ecuador. Distributional data are important to understand population structure, speciation patterns, and community composition over time.

Methods

The data resources consulted were:

1. Literature review of all *Drosophila* records in Ecuador from 1919 to 2008.
2. Face review of the *Drosophila* specimens in Museo Ecuatoriano de Ciencias Naturales (MECN) and Museo de Zoología de la Pontificia Universidad Católica del Ecuador (QCAZ).
3. Taxonomic surveys of *Drosophila* in different localities in Ecuador.
4. Consultation of on-line databases: Taxodros and Species 2000.

Results and Discussion

In Ecuador, 112 *Drosophila* species have been recorded (Table 1). These species are classified in 5 subgenera, *Drosophila*, *Dorsilopha*, *Phloridosa*, *Siphlodora*, *Sophophora*; and species without subgenus designation, *D. dilacerata*, *D. ferruginea*, *D. griseicollis* and *D. xerophila*.

Table 1. *Drosophila* diversity and provincial distribution in Ecuador.

Species group	Species, authority (first record in Ecuador) and provincial distribution
<i>Drosophila</i> subgenus: 92 species	
<i>annulimana</i> 3 species	<i>aracataca</i> Vilela & Val, 1983 (■ R&Ve) in Loja; <i>araicas</i> Pavan & Nacur, 1950 (A) in Orellana; <i>yana</i> Vela & Rafael, 2005 in Pichincha.
<i>bromeliae</i> 1 species	<i>bromelioides</i> Pavan & Cunha, 1947 (R&As) in Cotopaxi.
<i>cardini</i> 4 species	<i>cardini</i> Sturtevant, 1916 (R&As) in Cotopaxi, Guayas, Imbabura, Loja, Manabí, Orellana and Pichincha; <i>cardinoides</i> Dobzhansky & Pavan, 1943 (Ca) in Cotopaxi, Galápagos, Orellana; <i>neocardini</i> Streisinger, 1946 (■ R&Ve) in Loja; <i>polymorpha</i> Dobzhansky & Pavan, 1943 (H) in Esmeraldas, Guayas, Manabí and Pichincha;
<i>canalina</i> 1 species	<i>canalina</i> Patterson & Mainland, 1944 (W) in Pichincha.
<i>flavopilosa</i> 5 species	<i>korefae</i> Vela & Rafael, 2004 (†V&R) in Pichincha; <i>sisa</i> Vela & Rafael, 2005 (‡Ve&R) in Pichincha and Zamora; <i>suní</i> Vela & Rafael, 2005 (‡Ve&R) in Pichincha; <i>taxohuaycu</i> Vela & Rafael, 2005 (‡Ve&R) in Pichincha
<i>guaraní</i> 7 species	<i>cuscungu</i> Vela & Rafael, 2005 (‡Ve&R) in Pichincha; <i>ecuatoriana</i> Vela & Rafael, 2004 (‡Ve&R) in Pichincha; <i>griseolineata</i> Duda, 1927 (Mo) in Pichincha; <i>ornatifrons</i> Duda, 1927 (R&Ve) in Pichincha; <i>pichinchana</i> Vela & Rafael, 2004 (‡Ve&R) in Pichincha; <i>quitensis</i> Vela & Rafael, 2004 (‡Ve&R) in Pichincha; <i>urubamba</i> Vilela & Pereira, 1993 (Mo) in Imbabura and Pichincha.
<i>immigrans</i> 1 species	<i>immigrans</i> Sturtevant, 1921(Ca) in Chimborazo, Galapagos, Guayas, Imbabura, Loja, Pichincha.
<i>mesophragmatica</i> 7 species	<i>amaguana</i> Vela & Rafael, 2004(♦Ve&R) in Pichincha; <i>gasici</i> Brncic, 1957(R&As) in Pichincha; <i>gaucha</i> Jaeger & Salzano, 1953(R&Ve) in Pichincha, <i>mesophragmatica</i> Duda, 1927(R&Ve) in Chimborazo, Cotopaxi, Loja, Pichincha and Tungurahua; <i>pavani</i> Brncic, 1957(R&Ve) in Pichincha; <i>ruminahui</i> Vela & Rafael, 2004(♦Ve&R) in Pichincha; <i>shyri</i> Vela & Rafael, 2004(♦Ve&R) in Pichincha.
<i>morelia</i> 1 species	<i>ogradi</i> Vela & Rafael, 2004(†Ve&R) in Pichincha.
<i>onychophora</i> 2 species	<i>asiri</i> Vela & Rafael, 2005 (■Ve&R) in Pichincha; <i>margarita</i> (NR) Hunter, 1979 in Pichincha.
<i>pallidipennis</i> 1 species	<i>pallidipennis</i> Dobzhansky & Pavan, 1943(Mo) in Pichincha.
<i>repleta</i> 26 species	<i>aldrichi</i> Freire-Maia & Pavan, 1950 (R&Ve) in Esmeraldas, El Oro, Loja, Manabí, Guayas, Imbabura and Pichincha; <i>ellisoni</i> Vilela, 1983(Vi) in Cotopaxi and Pichincha; <i>guayllabambae</i> Rafael & Arcos, 1988 (R&As) in Chimborazo, El Oro, Imbabura, Loja, Pichincha and Tungurahua; <i>huancavilcae</i> Rafael & Arcos, 1989 (♦R&As) in Guayas and Manabí; <i>huayla</i> Suyo, Pilares & Vasquez (NR) in Manabí; <i>hydei</i> Sturtevant, 1921 (Ca) in Galápagos, Guayas, Imbabura, Loja, Pichincha and Tungurahua; <i>inca</i> Dobzhansky & Pavan, 1943(♦R&As) in Chimborazo, Loja, Pichincha in Tungurahua; <i>longicornis</i> Patterson & Wheeler, 1942(R&As) in Chimborazo, Imbabura and Pichincha; <i>mayaguana</i> Vilela, 1983(W&W) in Manabí; <i>mercatorum</i> Patterson & Wheeler, 1942 (R&Co) in Cotopaxi, Orellana, Pichincha and Tungurahua; <i>meridiana</i> Patterson and Wheeler, 1942 (NR) in Manabí and Imbabura; <i>meridionalis</i> Wasserman, 1962 (*R&Co) in Guayas and Manabí; <i>neohydei</i> Wasserman, 1962 (R&Ve) in Pichincha and Tungurahua; <i>neorepleta</i> Patterson & Wheeler, 1942 (A&Co) in Pichincha; <i>nigricruria</i> Patterson & Mainland, 1943 (R&Ve) in Pichincha and Tungurahua; <i>nigrohydei</i> Patterson & Wheeler, 1942 (R&As) in Imbabura, Loja and Pichincha; <i>nigrospiracula</i> Patterson & Wheeler, 1942(R&As) in Pichincha; <i>paranaensis</i> Barros, 1950(R&Ve) in El Oro, Esmeraldas, Guayas, Loja, Manabí and Orellana; <i>parisiana</i> Heed & Grimaldi, 1991(W&W) in Manabí; <i>peninsularis</i> Patterson & Wheeler, 1942 (A) in Orellana; <i>pseudorepleta</i> Vilela & Bächli, 1990 (A&Co) in Orellana and Pichincha; <i>repleta</i> Wollaston, 1858(Ca) in Galapagos, Pichincha and Tungurahua; <i>shuyu</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>straubae</i> Heed & Grimaldi, 1991(W&W) in Manabí; <i>vicentinae</i> Vilela, 1983(■R&Ve) in Loja and Orellana; <i>yangana</i> Rafael & Vela, 2003(■R&Ve) in Loja.
<i>tripunctata</i> 19 species	<i>arcosae</i> Vela & Rafael, 2001(£Ve&R) in Pichincha; <i>bandeirantorum</i> Dobzhansky & Pavan, 1943(Mo) in Imbabura, Loja and Pichincha; <i>carlosvilelai</i> Vela & Rafael, 2001(R&Ve) in Pichincha; <i>fontdevilai</i> Vela & Rafael, 2001(R&Ve) in Pichincha; <i>ichubamba</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>machachensis</i> Vela & Rafael, 2001(R&Ve) in Pichincha; <i>mesostigma</i> Frota-Pessoa, 1954(R&Ve) in Pichincha; <i>metzii</i> Sturtevant, 1921(Ca) in Galapagos; <i>ninarumi</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>paraguayensis</i> Duda, 1927(R&Ve) in Pichincha; <i>pasochoensis</i> Vela & Rafael, 2001(R&Ve) in Pichincha; <i>patacorona</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>pilaresae</i> Vela

	& Rafael, 2001(∥R&Ve) in Pichincha; <i>quillu</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>roehrae</i> Pipkin & Heed, 1964 (NR) in Cotopaxi and Pichincha; <i>surucucho</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>tomasi</i> Vela & Rafael, 2001(∥R&Ve) in Pichincha; <i>urcu</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>valenciai</i> Vela & Rafael, 2001(∥R&Ve) in Pichincha.
<i>virilis</i> 1 species	<i>virilis</i> Sturtevant, 1916(R) in Esmeraldas and Manabí.
<i>willistoni</i> 7 species	<i>bocainensis</i> Pavan & Cunha, 1947(Mo) in Pichincha; <i>equinoxialis</i> Dobzhansky, 1946(A) in Orellana; <i>nebulosa</i> Sturtevant, 1916(Ca) in El Oro, Esmeraldas, Galápagos, Guayas, Manabí, Napo, Orellana; <i>paulistorum</i> Dobzhansky & Pavan, 1949(D&S) in Orellana and Pichincha; <i>sucinea</i> Patterson & Mainland, 1944(∥R&Ve) in Loja, Orellana and Pichincha; <i>tropicalis</i> Burla & da Cunha, 1949(S) in Pichincha; <i>willistoni</i> Sturtevant, 1916(C) in El Oro, Esmeraldas, Galápagos Guayas, Loja, Manabí, Orellana, Pichincha and Sucumbios.
Not grouped 7 species	<i>apag</i> Vela & Rafael, 2005(■Ve&R) in Pichincha; <i>condormachay</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>mellea</i> Becker, 1919(B) in Carchi; <i>neochracea</i> Wheeler, 1959(NR) in Pichincha; <i>pugyu</i> Vela & Rafael, 2005(‡Ve&R) in Pichincha; <i>rumipamba</i> Vela & Rafael, 2005(■Ve&R) in Pichincha; <i>runduloma</i> Vela & Rafael, 2005(■Ve&R) in Pichincha.
<i>Dorsilopha</i> Subgenus : 1 species	
<i>busckii</i> 1 species	<i>busckii</i> Coquillett, 1901(Mo) in Imbabura, Loja, Orellana and Pichincha.
<i>Phloridosa</i> Subgenus : 1 species	
Not grouped 1 species	<i>lutzii</i> Sturtevant, 1916(Mo) in Pichincha;
<i>Siphlodora</i> Subgenus : 1 specie	
Not grouped 1 species	<i>flexa</i> Loew, 1866(Vi&B) in Chimborazo and Pichincha.
<i>Sophophora</i> Subgenus : 13 species	
<i>melanogaster</i> 5 species	<i>ananassae</i> Doleschall, 1858(Ca) in Cotopaxi, El Oro, Esmeraldas, Galápagos, Guayas, Loja, Manabí, Orellana; <i>kikkawai</i> Burla, 1954(A) in Orellana and Pichincha; <i>malerkotliana</i> Parshad & Paika, 1964(R&Co) in El Oro, Esmeraldas, Guayas, Loja, Manabí, Orellana, Pichincha and Sucumbios; <i>melanogaster</i> Meigen, 1830(Ca) in Chimborazo, Esmeraldas, Galápagos, Guayas, Imbabura, Loja, Manabí, Orellana, Pichincha and Sucumbios; <i>simulans</i> Sturtevant, 1919(Ca) in Chimborazo, El Oro, Galápagos, Guayas, Loja, Manabí, Orellana, Pichincha and Sucumbios;
<i>obscura</i> 1 species	<i>tolteca</i> Patterson & Mainland, 1944(NR) in Cotopaxi and Pichincha.
<i>saltans</i> 7 species	<i>emarginata</i> Sturtevant, 1942(Ma) in El Oro, Guayas, Loja, Manabí, Orellana and Pichincha; <i>neocordata</i> Magalhaes, 1956(A) in Orellana; <i>parasaltans</i> Magalhaes, 1956(∥R&Ve) in Orellana and Pichincha; <i>prosaltans</i> Duda, 1927(R&Co) in Loja and Orellana; <i>saltans</i> Sturtevant, 1916(R&Co) in El Oro, Guayas, Loja, Napo; <i>sturtevantii</i> Duda, 1927(∥R&Ve) in El Oro, Esmeraldas, Loja, Manabí, Orellana, Pichincha and Sucumbios; <i>subsaltans</i> Magalhaes, 1956(A) in Orellana.
Without subgenus: 4 species	
	<i>dilacerata</i> Becker, 1919(B) in Carchi; <i>ferruginea</i> Becker, 1919(B) in Chimborazo and <i>griseicollis</i> Becker, 1919(B) in Carchi; <i>xerophila</i> Val, 1983(Ca) in Galapagos.

A= Acurio (2007); A & Co = Acurio, *et al.* (2002); B = Becker (1919); Ca= Carson, *et al.* (1983); C = da Cunha, *et al.*, (1959); D & S = Dobzhansky & Spassky (1959); H= Heed (1963); MA = Magalhaes (1962); (Mo)= Morán *et al.*, (1999); R & As = Rafael & Arcos (1988); ♦ R & As = Rafael & Arcos (1989); R & Co = Rafael *et al.*, (2000a); *R & Co = Rafael *et al.*, (2000b); ∥ R & VE = Rafael & Vela (2000); ■ R & VE = Rafael & Vela (2003); R = Rafael (2007); S = Spassky, *et al.* (1971); £ Ve & R = Vela & Rafael (2001); ♦ Ve & R= Vela & Rafael (2004a); † VE & R = Vela & Rafael (2004b); ‡ VE & R= Vela & Rafael (2004c); ■ VE & R= Vela & Rafael (2005a); ‡ VE & R = Vela & Rafael (2005b); (Vi) Vi = Vilela (1983); Vi & B = Vilela & Bachli (2000); W & W = Wasserman & Wasserman (1992); W = Wheeler (1957); (NR) new records to Ecuador.

The *Drosophila* subgenus is represented by 15 species: *annulimana*, *bromeliae*, *cardini*, *canalina*, *flavopilosa*, *guarani*, *immigrans*, *mesophragmatica*, *morelia*, *onychophora*, *pallidipennis*, *repleta*, *tripunctata*, *virilis*, *willistoni* and 7 species not grouped. The dominant species groups are *repleta* and *tripunctata* with 26 and 19 species, respectively.

Three *Drosophila* subgenera are represented by 1 species each: the subgenus *Dorsilopha* with *D. busckii*, subgenus *Phloridosa* with *D. lutzii*, and the subgenus *Siphlodora* with *D. flexa*. The *Sophophora* subgenus is represented by three species groups: *melanogaster*, *obscura*, and *saltans*.

In this work we record five new country records: *D. margarita*, *D. huayla*, *D. meridiana*, *D. roehrae*, and *D. neochracea*. These species were collected in different surveyed localities using banana baited traps and were identified using their terminalia and morphological characters. Male and female specimens were pinned, labeled, and deposited as voucher at the Invertebrate Section of QCAZ.

Drosophila latifasciaeformis that was previously classified in the subgenus *Scaptodrosophila* and *Drosophila pictiventris*, previously classified in the subgenus *Hirtodrosophila*, were promoted to the genus level by Grimaldi (1990). Therefore, these species have not been included in Table 1.

Although distributional records were gleaned from disparate sources, the results show that due to both historical and ecological factors the *Drosophila* fauna is not evenly distributed within Ecuador. Despite the small geographical area, Ecuador has a large *Drosophila* species richness demonstrated by a high proportion of endemic *Drosophila* species. There are 41 species only recorded in Ecuador, more than 36% of the total of 112 species.

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Olfactory response of *Drosophila* flies for different fruits.

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The fruit fly, *Drosophila*, is equipped with a sophisticated olfactory sense system that permits it to recognize and discriminate hundreds of discrete odorants. The olfactory response of these odorants is essential for the animal to identify relevant good sources and suitable sites for egg laying. *Drosophila* and related genera occupy a wide variety of habitats including rotting fruit and plant parts in deserts and tropical forests, slime fluxes, fungi, flowers, ferns, and crabs. A major problem in rearing such species is inducing females to oviposit. Different species may show different distribution patterns and seasonal frequencies ranging from a tight nuclear distribution at a food source to a uniform low-density distribution (Carson *et al.*, 1970; Dobzhansky and Pavan, 1950). A variety of behavioral factors are involved in habitat choice, and it is clear that different species rely on different sensory modalities to varying degrees in deciding their direction of movement. The present study was made to study the preference of adults to different fruits.

For the present investigation *D. melanogaster*, *D. simulans*, *D. ananassae*, *D. malerkotliana*, *D. yakuba*, and *D. mauritiana* were collected from University of Mysore, Mysore. These flies were used to study the olfactory response of flies in different fruits, such as banana, sapota, apple, and papaya. The sliced fruits were placed inside the four culture bottles. They were kept in each corner of the experimental transparent glass box (35 × 25 cm). 300 flies are released to the box and closed, and then the boxes were kept without any disturbance. The flies were observed, and the numbers of flies attracted towards specific fruits were recorded carefully for an interval of one hour. Three replicates were carried out at ambient temperature of 25 ± 2°C. The data were analyzed by Chi-Square test.

Table 1 shows the percentage of *Drosophila* flies attracted to various fruits. Sapota was found to be a good attractant in all the species. All the species were attracted at maximum to sapota (observation I-III), except banana, which attracted more *D. simulans* flies at the end of the third observation, whereas the minimum attraction of different species of flies varies in the remaining three fruits. *D. melanogaster* and *D. bipectinata* were attracted minimum to papaya in all the observations, except the third observation of *D. simulans* (papaya). *D. yakuba* and *D. malerkotliana* were attracted least to banana and apple, respectively. The Chi-Square test reveals that the differences of attraction of flies between different fruits are found to be highly significant at all the three observations (χ^2 - 233.75, χ^2 - 209.93, and χ^2 - 239.75, df = 20).

In the present study, the percentage of olfactory responses of various species of *Drosophila* varies in all the fruits analyzed. It is evident that all the species prefer maximum sapota, whereas *D. melanogaster*, *D. simulans* and *D. bipectinata* prefer minimum for papaya (10.1%, 5.8%, and 5.6%,