Invasion history of *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae) in Ecuador

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Harmonia axyridis is a ladybird extensively used around the world for biological control of agricultural pest. However, it has become invasive in several countries, producing negative ecological and economical impacts. Herein, we review the invasion history of the Harlequin Ladybird *Harmonia axyridis* (Pallas, 1773) in Ecuador. Although first reported in Ecuador in 2012, museum specimens date back to 2001 and it is currently established across the country, especially along the Andean region. Due to its invasive nature, further studies are urgently needed to evaluate possible impacts of *H. axyridis* on the Ecuadorian biodiversity and agroindustry.

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Abstract

Harmonia axyridis is a ladybird extensively used around the world for biological control of agricultural pest. However, it has become invasive in several countries, producing negative ecological and socio-economic impacts. Herein, we review the invasion history of the Harlequin Ladybird *Harmonia axyridis* (Pallas, 1773) in Ecuador. Although first reported in Ecuador in 2012, museum specimens date back to 2001 and it is currently established across the country, especially along the Andean region. Due to its invasive nature, further studies are urgently needed to evaluate possible impacts of *H. axyridis* on the Ecuadorian biodiversity and agroindustry.

Key words: Andes; Coccinellinae; distribution; introduced species; ladybird; new records; range extension.

INTRODUCTION

Numerous species have arrived to regions they would have never reached on their own thanks to human-mediated processes (Boivin et al., 2016, Ricciardi, 2007). Although many non-native species are unable to thrive in new environments, some are successful and become invasive by establishing fast-growing, spreading populations. Invasive species have been described as major drivers of current biodiversity changes due to their contribution to biota homogenization, alteration of biological communities and ecosystem functions, and socio-economic impacts on humans (Chapin III et al., 2000; Daszak et al., 2000; Crooks, 2002; O'Dowd et al., 2003; Clavero & García-Berthou, 2005; Mace et al., 2005; Doody et al., 2009; Pejchar & Mooney, 2009; Ricciardi et al., 2013; Simberloff et al., 2013; Bellard et al., 2016; Doherty et al., 2016; Cisneros-Heredia, 2018).

Harmonia axyridis (Pallas, 1773), commonly referred to as Harlequin Ladybird or Asian Multicolored Ladybeetle, is a member of the family Coccinellidae native to East Asia (Orlova-Bienkowskaja, Ukrainsky & Brown, 2015). It has been deliberately translocated as a biological control in America, Europe and Africa since the beginning of the 20th century, becoming invasive and establishing naturalized and expanding populations in the three continents (Lombaert et al., 2010; Brown et al., 2011). It is a successful invader due to its wide dietary

range, ability to establish and disperse, and robustness and flexibility of its immune system (Roy, Brown & Majerus, 2006; Vilcinskas, Mukherjee & Vogel, 2013). *Harmonia axyridis* is considered as the most invasive ladybird on Earth (Roy, Brown & Majerus, 2006).

Harmonia axyridis is a voracious predator of agricultural pests, consuming soft-bodied Sternorrhyncha hemipterans as essential preys, i.e. aphids, coccids, psyllids, and adelgids (Roy, Brown & Majerus, 2006). However, *H. axyridis* has a wider dietary range and is an interguild and intraguild polyphagous predator, being able to consume immature stages of coccinellids and other coleopterans, lepidopterans, neuropterans, dipterans, tetranychid mites, and plant material such as fruits, pollen, nectar, leaves and seeds (Koch et al., 2004; Roy & Wajnberg, 2008; Koch & Galvan, 2008; Moser, Harwood & Obrycki, 2008; Lucas, 2012; Michaud, 2012). In general, *H. axyridis* is considered one of the top predators in aphidophagous and coccidophagous guilds, largely free from predation pressure, and regulated more by bottom-up than top-down forces (Lucas, 2012). *Harmonia axyridis* seems to dominate confrontations with other coccinellid species, exerting a strong intraguild predation pressure (Lucas, 2012). Due to its polyphagy and guild interactions, non-native populations of *H. axyridis* have adverse effects on native biodiversity and agroindustry by attacking non-target arthropods, modifying the structure and dynamics of invertebrate assemblages, replacing or marginalising native coccinellids by competition and predation, and feeding on commercial fruits or damaging agricultural products (Koch, 2003; Koch et al., 2004; Koch & Galvan, 2008; Honěk, 2012; Lucas, 2012).

In America, *Harmonia axyridis* was deliberately introduced as a biocontrol agent in several countries and has dispersed and established naturalized populations throughout the continent (Brown et al., 2011). It was first recorded in Ecuador in 2012; but geographic and ecological data are scarce and, to the best of our knowledge, only three localities on the southern Pacific lowlands of the country have been published in scientific literature (González & Kondo, 2012; Cornejo & González, 2015). Herein, we discuss about the distribution, natural history, and introduction history of *Harmonia axyridis* in Ecuador, evidencing that it has been present at least since 2004 and is currently widespread across the country.

MATERIALS & METHODS

We conducted surveys at different localities across Ecuador (Table 1, Fig. 1). All specimens were found by searching vegetation to look for adults and larvae. Collected specimens were euthanized by immersion in 70% ethanol or by placing in a killing jar and stored. An Olympus Research Stereomicroscope System SZX16 outfitted with an Olympus DP73 digital colour camera was used to observe specimens. Collected specimens are deposited at the Museo de Zoología, Laboratorio de Zoología Terrestre, Universidad San Francisco de Quito, Ecuador (ZUSFQ). Research permits were issued by Ministerio de Ambiente del Ecuador, 001-16IC-FLO-FAU-DNB/MA, 018-2017-IC-FAU-DNB/MAE, 019-2018-IC-FAU-DNB/MAE, and 006-2015-FAU-DPAP-MA. In addition, we reviewed the entomological collections of Museo de Zoología, Pontificia Universidad Católica del Ecuador, Quito (QCAZ), and Instituto Nacional de Biodiversidad INABIO, Quito (MECN).

Published information on *Harmonia axyridis* in Ecuador was synthesised based on a literature review using the library systems of King's College London and Universidad San Francisco de Quito USFQ, and Google Scholar™ scholarly text search (https://scholar.google.com). Relevant references were gathered using the search terms 'Coccinellidae', 'Harmonia', '*Harmonia axyridis*', 'Mariquita', 'Ladybird', 'Ladybug', and 'Lady beetle', each one combined with 'Ecuador' by the Boolean operator 'AND'. Because *Harmonia axyridis* has a diagnostic colouration pattern that allows its identification in photographs, we assembled data from photographic vouchers using the search engines of Flickr™ (https://www.flickr.com, by Yahoo!) and iNaturalist.org™ (http://www.inaturalist.org, by California Academy of Sciences and the National Geographic Society) through GeoCat (Bachman et al., 2011; http://geocat.kew.org/) using the same search terms used for text searches. All searches were run on 10 February 2019 using on-site search engines and were not limited by study type, study design, or language. All localities, based on literature, museum, or photographic records, were georeferenced manually in Google Earth™ mapping service (7.3.1.5491 release by Google, Inc. on July 2018) based on direct information (coordinates and altitudinal data) when available, and additional data relevant to obtain an accurate and precise positioning, including catalogue and field notes, following recommendations by Wieczorek et al. (2004). All localities were reviewed and validated individually, and coordinates were amended when incorrectly georeferenced in the source (Table 1). We determined the position most closely related with the locality description using

toponymic information based on the Geographic Names Database, containing official standard names approved by the United States Board on Geographic Names and maintained by the National Geospatial-Intelligence Agency (http://geonames.nga.mil/gns/html/), OpenMapStreet data available under the Open Database Licence (http://www.openstreetmap.org), and gazetteers for Ecuador (Brown, 1941; Peters, 1955; Lynch & Duellman, 1997).

Specimens herein reported were identified as *Harmonia axyridis* by its characteristic morphology (Fig. 2), including: upper surfaces of elytra not hairy, distinct transverse fold at rear of elytra, underside of abdomen at least partially orange, brown to orange legs (Koch, 2003; Roy et al. 2016). One phenotypic form was found: f. *succinea*, with ground colour of pronotum white to light brown with M-shaped black marks, ground colour of elytra bright orange, usually with nine black elytral spots (2-3-3-1) and a scutellary spot (Dobzhansky, 1933; Tan & Li, 1934; Koch, 2003; Brown et al., 2008; Roy et al., 2013; Roy et al., 2016).

RESULTS

In total, we collected information for 183 records of *Harmonia axyridis* from 56 localities in Ecuador (Table 1, Fig. 1), including: 144 museum specimens (107 at ZSFQ, 37 at QCAZ, none at MECN), five photographic records from Flickr, 16 records in iNaturalist, four observations, and 14 specimens reported in the literature (González & Kondo, 2012; Cornejo & González, 2015; Guamán Montaño, 2017).

Our study reveals that *Harmonia axyridis* is established in all main biogeographic areas of Ecuador, from sea level to at least 4020 m elevation, across 13 provinces (administrative divisions) (Table 1, Fig. 1). The only regions where we did not found records are the southern Amazonian lowlands and the Galapagos Archipelago. The first specimens found were collected on both geographical extremes of Ecuador: in 2004 at Mindo, northwestern Ecuador, and in 2007 at Loja, in southwestern Ecuador (Table 1). Both localities are separated by about 450 km.

At least 33 localities are mid-size towns and large cities, where *Harmonia axyridis* occupies gardens and urban and suburban green spaces dominated by non-native plants. Other localities correspond to agricultural areas or natural environments, including protected areas. In areas

covered by native vegetation, *H. axyridis* was mainly collected on road borders. At least one record, at Estación Científica Yasuní, may correspond to a hitchhiking individual, since no established population in the Amazonian lowlands has been confirmed.

Since 2015, we surveyed periodically the population of *Harmonia axyridis* at Cumbayá, a suburban parish of Quito, capital city of Ecuador. *Harmonia axyridis* is well established in Cumbayá, with several subpopulations detected in gardens and small urban and suburban green areas. They are usually associated with the following plants (local names in parentheses): *Hibiscus rosa-sinensis* (Cucarda), *Senna multiglandulosa* (Chinchín), *Citrus* x *limon* (Limonero), *Prunus setorina* (Capulí), *Prunus persica* (Peach), *Lantana camara* (Tupirrosa or Supirrosa), and *Ficus benjamina* (Ficus). We found five coccinellid species in sympatry in gardens, urban/suburban green areas and agricultural lands of Cumbayá: *Harmonia axyridis*, *Hippodamia convergens*, *Mulsantina mexicana*, *Cheilomenes sexmaculata* and *Rodolia cardinalis*. *Harmonia axyridis* was the most common species in gardens and urban/suburban green areas, but it was not found in agricultural areas, where *H. convergens* was dominant. Only *R. cardilanis* was found in syntopy with *H. axyridis*. By 2017, *H. convergens* is almost absent in most gardens and urban/surburban areas, remaining common only in agricultural areas. *C. sexmaculata*, an apparently recent arrival—first recorded in the area on 2017, is nowadays becoming the second most common coccinellid in urban/suburban green areas of Cumbayá, although still with a patchy distribution.

The following coccinellids have been found in sympatry with *Harmonia axyridis* at different localities: *Brachiacantha* sp. cf. *anita* (Mindo), *Cheilomenes sexmaculata* (Quito, Cumbayá), *Cycloneda ecuadorica* (Guajalito, San Vicente), *C. emarginata* (Guajalito, Loja), *C. sanguinea* (San Vicente), *Epilachna monovittata* (Guajalito), *E. flavofasciata* (Guajalito), *E. paenulata* (Quito, Mindo), *Hippodamia convergens* (Quito, Lumbisí, Cumbayá, Yaruquí, Guajalito, San Vicente, Mindo, Loja), *Mulsantina mexicana* (Cumbayá, Yaruquí, Guajalito), *Neda norrisi* (San Antonio de Pichincha), and *Rodolia cardinalis* (San Antonio de Pichincha, Cumbayá).

DISCUSSION

171 In America, the first translocation of *Harmonia axyridis* was to the USA in 1916, and recurrent
172 introductions to that country occurred between 1964 and 1982 (Gordon, 1985). The first
173 established feral populations were recorded in 1988 in eastern USA (Chapin & Brou, 1991), in
174 1991 in western USA (LaMana & Miller, 1996), and in 1994 in Canada (Coderre et al., 1995).
175 The two USA populations originated from independent introductions from the species' native
176 range (Lombaert et al., 2010), and the Canadian population apparently spread from eastern USA
177 (McCorquodale, 1998). All subsequent successful introductions of *H. axyridis* across America
178 have seemingly sourced from eastern USA (Lombaert et al., 2010). Mexican populations
179 descend from eastern USA stocks deliberately released in northern Mexico (ca. 1997) and
180 southeastern Mexico (1999–early 2000s) (Quiñones Pando & Tarango Rivero, 2005; Barrera &
181 López-Arroyo, 2007). First translocations to Argentina (1986) and Chile (1998) used parental
182 stocks from France but were unsuccessful in establishing populations (García, Becerra &
183 Reising, 1999; Saini, 2004; Grez et al., 2010). Naturalised populations reported in Argentina in
184 2001, southern Brazil in 2002, and Chile in 2003 descend from at least two different eastern
185 USA stocks (Almeida & Silva, 2002; Saini, 2004; Grez et al., 2010; Lombaert et al., 2010). The
186 oldest known naturalised populations in South America were established in Colombia, where *H.*
187 *axyridis* was first collected in 1989 (Kondo & González, 2013). Since *Harmonia axyridis* was
188 extensively raised and shipped in the USA in the 1980s and 1990s (Tedders & Schaefer, 1994),
189 and based on available dates, Colombian populations may also descend from eastern USA stock.
190 It is probable that unrecorded international shipments were sent to Colombia, Argentina, and
191 Chile—possibly to private farmers, thus the absence of public records. Subsequent South
192 American records come from Ecuador (2004, this study), Paraguay (2006, Silvie et al., 2007),
193 Uruguay (2009, Nedvěd & Krejčík, 2011), Peru (ca. 2010, Grez et al., 2010), and Venezuela (ca.
194 2014, Solano & Arcaya, 2014). It has not been formally recorded in Central America, Guyana,
195 Suriname and Bolivia (Camacho-Cervantes, Ortega-Iturriaga & del-Val, 2017). However,
196 established populations may occur at least in southern Mexico (Saenz Garcia, 2015; Ramírez
197 Marcial, 2016), Guatemala (Amador da Silva, 2017), and Costa Rica (Cralingworld, 2009;
198 Spring,2011; Mclaren, 2015).
199
200 All published records of *Harmonia axyridis* in Ecuador were reported from southern Ecuador.
201 González & Kondo (2012) presented the first reports of *H. axyridis* in the country, based on 11

specimens collected in 2012 in deciduous forests on La Ceiba and Laipuna natural reserves (762 and 828 m elevation, respectively), province of Loja, extreme southwestern lowlands of Ecuador. Cornejo & González (2015) reported the species from mangroves on Santay island (at sea level), province of Guayas, southwestern Ecuador. González (2015) reported *H. axyridis* from the provinces of Azuay, Guayas and Loja, but without referencing any voucher specimen from Azuay. Guamán Montaño (2017) presented photographs of *H. axyridis* from El Pangui (830 m elevation), province of Zamora-Chinchipe, providing the first reports on the south-eastern slopes of the Andes of Ecuador.

Extensive and intensive entomological studies conducted in northern Ecuador up to 2001 did not recorded *Harmonia axyridis* (e.g., Cardona et al., 2005; Carvajal et al., 2005). Thus, the first naturalised populations of *H. axyridis* in Ecuador probably got established between 2001 and 2004. Intentional introduction of *H. axyridis* in Ecuador seems probable. Introduction of ladybirds in Ecuador has a long history in Ecuador, for example, in 1978, official national authorities released 24 million individuals of *Hippodamia convergens* in the city of Quito and surroundings as an attempt to control *Icerya purchasi* (Molineros Andrade, 1984). However, it is also likely that Ecuadorian populations spread from southern Colombia, since the oldest Colombian populations occurred very close to the Ecuadorian border (Kondo & González, 2013). The presence of earliest Ecuadorian localities on opposite sides of the country (Mindo and Loja) and the absence of geographically intermediate records could suggest that Ecuadorian populations have two independent origins. However, museum records are biased due to limited collection efforts in the central provinces of Ecuador. Furthermore, spread rate of *H. axyridis* may be extremely fast and compensate for the distance between the localities (100 km/year in the UK, 200 km/year in Slovakia, Roy et al. 2016; 185 km/year in Chile, Grez et al., 2016; 442 km/year in USA-Canada, McCorquodale, 1998; 500 km/year in South Africa, Stals, 2010). If southern Ecuadorian population would be demonstrated to have an independent origin, they may have given origin to the northern Peru populations—which remained unrecorded during extensive surveys in 2006 (Miró-Agurto & Castillo-Carrillo, 2010) and became established around 2010 (Grez et al., 2010).

Populations of *Harmonia axyridis* in Ecuador are established at elevations between sea level and 4020 m, the highest record worldwide, 500 m higher than the upper elevational ranges reported by Grez et al. (2017) and González et al. (2018). Lowland records mainly come from the Pacific lowlands and western Andean slopes, but also from the Amazonian lowlands. The Andean region was predicted as suitable for the expansion of *H. axyridis* by distribution models analysed by Koch et al. (2006) and Poutsma et al. (2007), which although predicted the expansion of *H. axyridis* across different habitat of America, their models did not predict lowland forest. Interestingly, Ecuadorian records come from a variety of habitats, including cloud montane forest and dry montane and lowland forest, and across the urban-suburban matrix. However, the most extensive and dense populations were found in urban and suburban areas.

It is likely that *Harmonia axyridis* will spread across most of Ecuador, especially in urban and agricultural environments. Establishment of *H. axyridis* may significantly impact predatory arthropods guilds (Lucas et al. 2002, Koch 2003, Ducatti et al. 2017, Koch & Galvan 2008); having varied impacts on the diverse South American fauna of coccinellids due to competition, exclusion, and intraguild predation. Changes in the predatory arthropod guilds may interfere with invertebrate population dynamics, potentially impacting agricultural pests (Lucas et al. 2002, Pervez & Omkar 2006). In addition, since it feeds opportunistically on damaged fruit when prey is scarce (Koch et al. 2004), *H. axyridis* may impact fruit production. Unfortunately, information on the coccinellids of Ecuador is fragmentary. It is important to increase research on the diversity and population ecology of coccinellids of Ecuador, including ecological relationships between native and non-native arthropod species across urban-agricultural-natural matrices, in order to evaluate the impacts of *H. axyridis* and other non-native species in the country.

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Figure 1(on next page)

Distribution of Harlequin Ladybird *Harmonia axyridis* in Ecuador.

Map showing known localities of *Harmonia axyridis* in Ecuador organised by year and elevation.

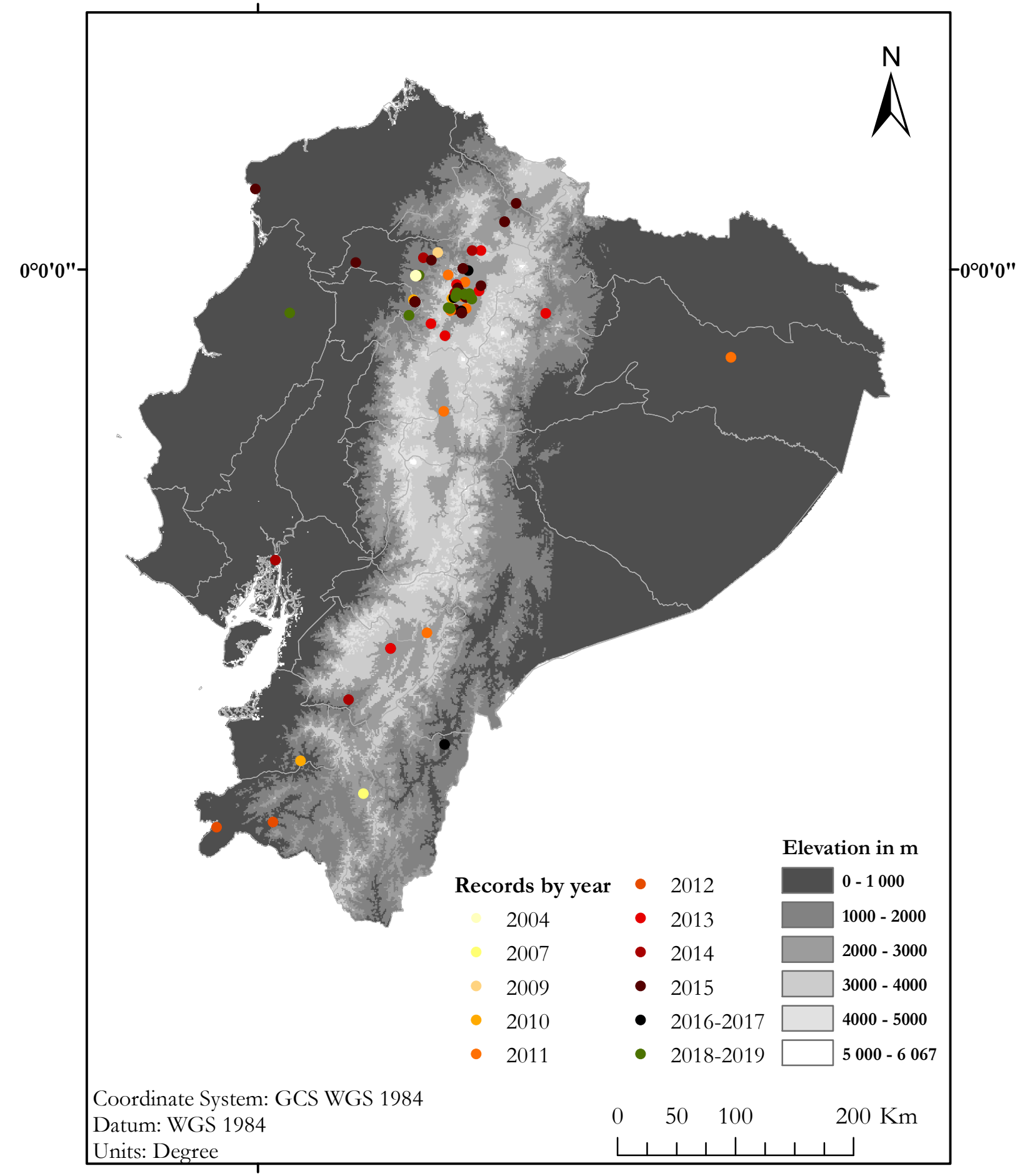
80°0'0"W
0°0'0"
0°0'0"
N
Records by year
2004
2007
2009
2010
2011
2012
2013
2014
2015
2016-2017
2018-2019
Elevation in m
0 - 1 000
1000 - 2000
2000 - 3000
3000 - 4000
4000 - 5000
5 000 - 6 067
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
0 50 100 200 Km
80°0'0"W

Figure 2

Harmonia axyridis from Ecuador

Photo of specimen of Harlequin Ladybird *Harmonia axyridis* (ZSFQ-I058) from Cumbayá (USFQ campus), province of Pichincha, Ecuador, showing the typical habitus of Ecuadorian populations.

Table 1(on next page)

Localities of the Harlequin Ladybird *Harmonia axyridis* (Pallas, 1773) in Ecuador.

All known localities of *Harmonia axyridis* based on museum specimens (ZSFQ: Museo de Zoología, Universidad San Francisco de Quito, QCAZ: Museo de Zoología, Pontificia Universidad Católica del Ecuador), photographic records from Flickr, citizen-science records from iNaturalist, and literature records.

Locality	Province	Latitude	Longitude	Altitude (in m)	Collection Date	Collection Year	Catalogue number / Reference	Numbe Individ
Mindo	Pichincha	-0,0500	-78,8000	1600	28/12/04	2004	QCAZ	1
Loja	Loja	-3,9958	-79,1994	2064	17/12/07	2007	QCAZ	2
Maquipucuna	Pichincha	0,1251	-78,6315	1309	1/5/09	2009	QCAZ	1
San Roque	El Oro	-3,7458	-79,6752	1050	31/10/10	2010	Serrano, 2010	1
Monjas	Pichincha	-0,1894	-78,4939	2800	24/4/10	2010	QCAZ	1
Quito	Pichincha	-0,2243	-78,5242	2854	15/3/10	2010	QCAZ	1
Guajalito	Santo Domingo	-0,2333	-78,8167	1800	16/4/10	2010	QCAZ	1
Guanchapala	Azuay	-2,7693	-78,7144	2200	1/1/11	2011	QCAZ	1
Pataín	Cotopaxi	-1,0840	-78,5847	2675	25/2/11	2011	QCAZ	1
Estación Científica Yasuní PUCE	Orellana	-0,6713	-76,4005	450	20/4/11	2011	QCAZ	2
Alangasi	Pichincha	-0,3000	-78,4167	2597	11/4/11	2011	QCAZ	2
Calderón	Pichincha	-0,1001	-78,4246	2663	5/4/11	2011	QCAZ	1
Cumbayá	Pichincha	-0,2107	-78,4400	2400	13/2/11	2011	Galárraga, 2011	1
Guayllabamba	Pichincha	-0,0446	-78,5529	2204	3/11/11	2011	QCAZ	1
Nayón	Pichincha	-0,1836	-78,4494	2643	30/4/11	2011	QCAZ	1
Valle de los Chillos	Pichincha	-0,3167	-78,5333	2980	7/2/11	2011	QCAZ	1
Valle de los Chillos	Pichincha	-0,3167	-78,5333	2980	18/3/11	2011	QCAZ	1
El Chical	Carchi	-0,6713	-76,4005	1200	11/2/12	2012	QCAZ	1
Reserva Natural Laipuna, Loja, Cangonamo	Loja	-4,2105	-79,8868	828	13/4/12	2012	Gonzalez & Kondo, 2012	10
Reserva Natural La Ceiba, Loja, Zapotillo	Loja	-4,2500	-80,3150	762	12/4/12	2012	Gonzalez & Kondo, 2012	1
Cuenca	Azuay	-2,8900	-78,9900	2500	4/9/13	2013	Phillipsen, 2013	1
Mojanda	Imbabura	0,1394	-78,3017	4020	10/2/13	2013	QCAZ	1
El Chaco	Napo	-0,3376	-77,8096	1536	13/4/13	2013	QCAZ	1
El Cedral	Pichincha	-0,4181	-78,6836	2610	2/3/13	2013	QCAZ	1

Machachi	Pichincha	-0,5069	-78,5777	2900	21/4/13	2013	QCAZ	1
Quito	Pichincha	-0,1167	-78,4869	2768	30/3/13	2013	QCAZ	1
Yaruquí	Pichincha	-0,1675	-78,3186	2552	17/2/13	2013	QCAZ	1
Yunguilla	Azuay	-3,2800	-79,3100	1500	26/7/14	2014	Maldonado, 2014	1
Área de Recreación Nacional Isla Santay y Gallo, Isla Santay's mangrove, ca. 200 m from Duran's bridge.	Guayas	-2,2169	-79,8666	1	30/12/14	2014	Cornejo & Gonzalez, 2015	2
San José de Minas	Imbabura	0,1397	-78,3700	1900	12/4/14	2014	QCAZ	1
Gualea	Pichincha	0,0847	-78,7408	1563	15/2/14	2014	QCAZ	1
Rumipamba	Pichincha	-0,1833	-78,5000	2723	12/4/14	2014	QCAZ	4
Cuenca	Azuay	-2,8900	-78,9900	2500	2015	2015	Observed but not preserved sample	1
Muisne	Esmeraldas	0,6100	-80,0200	5	12/6/15	2015	Tovar, 2015	1
Ibarra	Imbabura	0,3604	-78,1237	2200	2015	2015	Observed but not preserved sample	1
Ibarra	Imbabura	0,3604	-78,1237	2200	9/5/15	2015	QCAZ	3
San Vicente	Imbabura	0,5000	-78,0333	1700	2015	2015	Observed but not preserved sample	1
Conocoto	Pichincha	-0,3069	-78,5000	2700	20/10/15	2015	ZSFQ-I107	1
Cumbayá, Ruta Ecológica El Chaquiñan	Pichincha	-0,2003	-78,4235	2326	15/11/15	2015	ZSFQ-I084	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	4/12/15	2015	ZSFQ-I010	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	4/12/15	2015	ZSFQ-I011	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	12/11/15	2015	ZSFQ-I012	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	12/11/15	2015	ZSFQ-I013	1

Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	12/11/15	2015	ZSFQ-I014	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	12/11/15	2015	ZSFQ-I015	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	12/11/15	2015	ZSFQ-I016	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	7/11/15	2015	ZSFQ-I017	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	18/11/15	2015	ZSFQ-I018	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	15/10/15	2015	ZSFQ-I053	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/11/15	2015	ZSFQ-I054	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/11/15	2015	ZSFQ-I055	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/11/15	2015	ZSFQ-I056	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/11/15	2015	ZSFQ-I057	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/11/15	2015	ZSFQ-I058	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/11/15	2015	ZSFQ-I059	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	15/12/15	2015	ZSFQ-I085	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	15/12/15	2015	ZSFQ-I086	1

Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	15/12/15	2015	ZSFQ-I087	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	15/12/15	2015	ZSFQ-I088	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	12/12/15	2015	ZSFQ-I089	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	16/12/15	2015	ZSFQ-I090	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	15/12/15	2015	ZSFQ-I091	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	14/12/15	2015	ZSFQ-I110	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	10/10/15	2015	ZSFQ-I001	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	10/10/15	2015	ZSFQ-I002	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	10/10/15	2015	ZSFQ-I003	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	10/10/15	2015	ZSFQ-I004	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	10/10/15	2015	ZSFQ-I005	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	11/11/15	2015	ZSFQ-I006	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	11/11/15	2015	ZSFQ-I007	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	11/11/15	2015	ZSFQ-I008	1

Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	11/11/15	2015	ZSFQ-I009	1
Lumbisí	Pichincha	-0,2167	-78,4167	2300	18/11/15	2015	ZSFQ-I040	1
Lumbisí	Pichincha	-0,2167	-78,4167	2300	18/11/15	2015	ZSFQ-I041	1
Lumbisí	Pichincha	-0,2167	-78,4167	2300	18/11/15	2015	ZSFQ-I042	1
Lumbisí	Pichincha	-0,2167	-78,4167	2300	18/11/15	2015	ZSFQ-I043	1
Mindo	Pichincha	-0,0500	-78,7781	1250	21/3/15	2015	QCAZ	1
Mindo	Pichincha	-0,0480	-78,7751	1300	2015	2015	QCAZ	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/11/15	2015	ZSFQ- I104	1
Nanegalito	Pichincha	0,0667	-78,6806	1550	11/4/15	2015	QCAZ	1
Quito, Parque Metropolitano Güanguiltagua	Pichincha	-0,1763	-78,4600	2800	18/10/15	2015	ZSFQ-I036	1
Quito, Parque Metropolitano Güanguiltagua	Pichincha	-0,1763	-78,4600	2800	18/10/15	2015	ZSFQ-I037	1
Quito, Parque Metropolitano Güanguiltagua	Pichincha	-0,1763	-78,4600	2800	18/10/15	2015	ZSFQ-I038	1
Quito, Parque Metropolitano Güanguiltagua	Pichincha	-0,1763	-78,4600	2800	18/10/15	2015	ZSFQ-I039	1
Quito	Pichincha	-0,1462	-78,4799	2809	28/12/15	2015	ZSFQ-I095	1
Quito	Pichincha	-0,1462	-78,4799	2809	28/12/15	2015	ZSFQ-I096	1
Quito	Pichincha	-0,1462	-78,4799	2809	28/11/15	2015	ZSFQ-I097	1
Quito	Pichincha	-0,1700	-78,4800	2800	29/9/15	2015	ZSFQ-I105	1
Quito	Pichincha	-0,1462	-78,4799	2809	15/11/15	2015	ZSFQ-I106	1
Río San Vicente, near La Abundancia town	Pichincha	0,0493	-79,2559	310	15/11/15	2015	ZSFQ-I109	1
San Antonio de Pichincha	Pichincha	0,0040	-78,4400	2400	7/11/15	2015	ZSFQ-I061	1
San Antonio de Pichincha	Pichincha	0,0040	-78,4400	2400	7/11/15	2015	ZSFQ-I062	1
San Antonio de Pichincha	Pichincha	0,0040	-78,4400	2400	7/11/15	2015	ZSFQ-I063	1
Sangolquí	Pichincha	-0,3344	-78,4475	2500	15/12/15	2015	ZSFQ-I092	1

Sangolquí	Pichincha	-0,3344	-78,4475	2500	12/12/15	2015	ZSFQ-I093	1
Sangolquí	Pichincha	-0,3344	-78,4475	2500	12/12/15	2015	ZSFQ-I094	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I044	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I045	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I046	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I047	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I048	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I049	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I050	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I051	1
Tumbaco	Pichincha	-0,2106	-78,3950	2300	20/10/15	2015	ZSFQ-I052	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	20/11/15	2015	ZSFQ-I033	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	20/11/15	2015	ZSFQ-I034	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	20/11/15	2015	ZSFQ-I035	1
Yaruquí	Pichincha	-0,1272	-78,3039	2580	15/12/15	2015	ZSFQ-I108	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I064	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I065	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I066	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I067	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I068	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I069	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I070	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I071	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I072	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/10/15	2015	ZSFQ-I073	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/11/15	2015	ZSFQ-I074	1

Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/11/15	2015	ZSFQ-I075	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/11/15	2015	ZSFQ-I076	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	2/11/15	2015	ZSFQ-I077	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	3/11/15	2015	ZSFQ-I060	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I078	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I079	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I080	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I081	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I082	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I083	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I078	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/11/15	2015	ZSFQ-I098	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/9/15	2015	ZSFQ-I099	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/9/15	2015	ZSFQ-I100	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/9/15	2015	ZSFQ-I101	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/9/15	2015	ZSFQ-I102	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	28/9/15	2015	ZSFQ-I103	1
Bosque Protector Río Guajalito	Santo Domingo	-0,2493	-78,8036	1890	26/9/15	2015	ZSFQ-I111	1
Cumbayá, Casa del Quinde, barrio Pacaypamba	Pichincha	-0,1968	-78,4554	2450	1/9/16	2016	ZSFQ-I112	1
El Pangui	Zamora-Chinchipe	-3,6200	-78,5800	830	8/7/05	2016	Guamán-Montaño, 2017	1
Cumbayá, Universidad San Francisco de Quito campus	Pichincha	-0,1973	-78,4353	2400	2017	2017	ZSFQ-I116	1
Bosque Protector Jerusalem	Pichincha	-0,0100	-78,4008	1820	24/11/17	2017	ZSFQ-I115	1
Sangolquí, San Rafael	Pichincha	-0,3183	-78,4517	2475	1/12/17	2017	ZSFQ-I113	1
Quito	Pichincha	-0,2185	-78,5100	2816	26/11/17	2017	ZSFQ-I114	1
Cumbayá, Parque del Reservorio de Cumbayá	Pichincha	-0,1898	-78,4261	2360	2018	2018	Observed but not preserved sample	1
Quito, Parque La Carolina	Pichincha	-0,1824	-78,4839	2770	10/1/18	2018	Vivar Ayora, 2018	1

Quito, Parque de la Vida, Casa de la Cultura	Pichincha	-0,2091	-78,4955	2802	25/10/18	2018	Rojas, 2018	1
Quito, Parque de la Vida, Casa de la Cultura	Pichincha	-0,2099	-78,4952	2805	25/10/18	2018	Cadena, 2018	1
Tumbaco, Centro Académico Docente Experimental La Tola CADET UCE	Pichincha	-0,2284	-78,3716	2481	5/11/18	2018	Celorio, 2018	1
Quito, San Pedro de Guajaló, Unidad Educativa Autogestionaria Solidaridad	Pichincha	-0,2994	-78,5379	2901	9/11/18	2018	Campoverde, 2018	1
Quito, San Pedro de Guajaló, Unidad Educativa Autogestionaria Solidaridad	Pichincha	-0,2990	-78,5374	2900	9/11/18	2018	Sierra Herrera, 2018	1
Quito, San Pedro de Guajaló, Unidad Educativa Autogestionaria Solidaridad	Pichincha	-0,2997	-78,5378	2902	9/11/18	2018	Mora, 2018	1
Tumbaco, Centro Académico Docente Experimental La Tola CADET UCE	Pichincha	-0,2286	-78,3716	2481	14/11/18	2018	andrew-av97, 2018	1
Quito, Quitumbe, Rucullacta, Quebrada Ortega	Pichincha	-0,2948	-78,5535	2906	17/11/18	2018	Realpe, 2018	1
Quito, Parque La Carolina	Pichincha	-0,1861	-78,4853	2784	28/11/18	2018	Inclan, 2018	1
Cumbayá, Parque del Reservorio de Cumbayá	Pichincha	-0,1933	-78,4281	2368	8/12/18	2018	Aldana, 2018	1
Cumbayá, Parque del Reservorio de Cumbayá	Pichincha	-0,1906	-78,4269	2364	10/12/18	2018	Aldana, 2018	1
Quito, Parque La Carolina	Pichincha	-0,1854	-78,4858	2787	3/12/18	2018	Del Hierro Calvachi, 2018	1
La Crespa, along the road between El Carmen and Flavio	Santo Domingo	-0,3352	-79,7588	449	26/12/18	2018	La Crespa, 2018	1

Alfaro								
La Hesperia	Santo Domingo	-0,3522	-78,8497	1350	1/11/18	2018	ZSFQ-I1279	1
La Hesperia	Santo Domingo	-0,3522	-78,8497	1350	1/11/18	2018	ZSFQ-I1280	1
Cumbayá, Ruta Ecológica El Chaquiñan	Pichincha	-0,1884	-78,3908	2343	3/12/18	2018	ZSFQ-I1281	1
Cumbayá, Ruta Ecológica El Chaquiñan	Pichincha	-0,1884	-78,3908	2343	3/12/18	2018	ZSFQ-I1282	1
Quito, Parque La Carolina	Pichincha	-0,1859	-78,4854	2785	2/1/19	2019	Del Hierro Calvachi, 2019	1
Mindo	Pichincha	-0,0487	-78,7752	1281	6/1/19	2019	Gelis, 2019	1

1