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COMMUNICATION

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COMMUNICATION

Diversity and synanthropy of flies (Diptera: Calyptratae) from Ecuador, with new records for the country

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Abstract: The Calyptratae are one of the most diverse groups of Diptera. Some species have immature states involved in the decomposition of organic matter of animal origin (i.e., they are sarcosaprophagous). In this study, we examined the diversity and synanthropy of sarcosaprophagous calyptrates in several environmental zones of the Ecuadorian Andes. Captures were performed in an urban zone located in the Tocachi community with monocultures (MC) and polycultures (PC), a rural zone with an agroecological farming system (AFS), and a forest zone with a montane forest located in the Parque Arqueológico Cochasquí (PAC) and the Cochasquí montane forest (CMF). A total of 2,925 specimens of Calyptratae were collected, representing 38 morphotypes and 17 species. Four are new reports for Ecuador: *Dolichophaonia trigona* (Shannon & Del Ponte), *Phaonia trispila* (Bigot), *Compsomyiops melloi* Dear, and *Calliphora lopesi* Mello. CMF and PAC presented high abundance and richness, followed by AFS, MC, and PC; PAC showed the highest diversity, in contrast to lowest in MC; the evenness decreased from forest to urban zones. Species that exhibited a preference for human settlements (positive synanthropic index) included *Limnophora marginata* Stein, *Phaonia trispila*, *Lucilia cuprina* (Wiedemann), *Calliphora lopesi*, *Compsomyiops melloi*, and *Calliphora nigribasis* Macquart. Those with a preference for uninhabited areas (negative index) included *Tricharaea* sp1, *Sarconesiopsis magellanica* (Le Guillou), and *Sarconesia chlorogaster* (Wiedemann).

Keywords: Blow flies, Calliphoridae, flesh flies, Muscidae, Sarcophagidae.

Resumen: Calyptratae es uno de los grupos más diverso de Diptera. Algunas larvas están implicados en la descomposición de la materia orgánica de origen animal (es decir, son sarcosaprófagas). En este estudio, examinamos la diversidad y la sinantropía de los caliptratos sarcosaprófagos en varios ambientes de los Andes ecuatorianos. Las capturas se realizaron en una zona urbana ubicada en la comunidad de Tocachi, en áreas de monocultivos (MC) y policultivos (PC), una zona rural con un sistema de agricultura agroecológica (AFS) y una zona forestal con un bosque montano ubicado en el Parque Arqueológico Cochasquí (PA) y el bosque montano de Cochasquí (CMF). Se recolectaron un total de 2.925 especímenes de Calyptratae, que representan 38 morfotipos y 17 especies. Cuatro son nuevos reportes para Ecuador: Dolichophaonia trigona (Shannon y Del Ponte), Phaonia trispila (Bigot), Compsomyiops melloi Dear y Calliphora lopesi Mello. CMF y PAC presentaron alta abundancia y riqueza, seguidos de AFS, MC y PC; PAC mostró la mayor diversidad, en contraste con la más baja en MC; la equidad disminuyó de bosque a zonas urbanas. Las especies que mostraron preferencia por los asentamientos humanos (índice sinantrópico positivo) fueron Limnophora marginata Stein, Phaonia trispila, Lucilia cuprina (Wiedemann), Calliphora lopesi, Compsomyiops melloi y Calliphora nigribasis Macquart. Aquellas con preferencia por áreas deshabitadas (índice negativo) incluyeron Tricharaea sp1, Sarconesiopsis magellanica (Le Guillou) y Sarconesia chlorogaster (Wiedemann).

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Author contribution: KB and ASV conducted the Diptera identification and wrote the first manuscript draft. KB and ASV conducted the specimens collections. ASV and JL wrote the final manuscript. ASV prepared the specimen photographs. All authors elaborated the data analysis.

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INTRODUCTION

The highly diverse Dipteran infraorder Calyptratae has members that widely distributed through most biogeographic regions (Wiegmann et al. 2011; Lambkin et al. 2013). These insects are characterized by a high capacity for decomposing organic matter, where their larvae play an important role in nutrient recycling (Byrd & Castner 2001; Kimberly et al. 2005). Some species are important as disease vectors and feature in medico-legal investigations (Catts & Mullen 2002; Benecke et al. 2004; Magaña et al. 2006). Several Calyptratae are well adapted to human-perturbed habitats, forming an anthropo-biocenosis (Polvoný 1971). This taxon is highly specialized in some feeding habits: Saprophagous, coprophagous, necrophagous, hematophagous and pollen feeders (Hernández & Dzul 2008).

In Ecuador, calyptrate species have been recorded in Muscidae (77 species), Calliphoridae (23 species), Sarcophagidae (18 species), and Fanniidae (4 species) (Löwenberg-Neto & Carvalho 2013; Whitworth 2014; Salazar & Donoso 2015). Ecological investigations in sarcosaprophagous dipterans are scarce. Torres (2016) studied blowfly diversity in different types of human-modified and wild environments, and noted that diversity decreased and species dominance increased in human environments (urban and rural), in contrast to wild habitats.

This study aimed to describe the diversity and synanthropy in Calyptratae from a protected forest in the Archaeological Cochasquí Park, and in human environments in the Tocachi parish, Pedro Moncayo canton. This investigation was authorized with permission Nº 007-2018-RIC-FLO-FAU-DPAP-MA and collection Nº 007-2019-DPAP-MA.

MATERIAL AND METHODS

Study area

The study was undertaken in the Pedro Moncayo canton, north-west of Pichincha province, on the southern slope of Nudo de Mojanda. The total area comprises 339.10km^2 with four life zones in the High Andino zoogeographic level (1,730–2,952 m): lower montane dry forest, montane moist forest, lower montane moist forest, and montane wet forest (Albuja et al. 1980; PDOT 2015). In this area, three types of environment (urban, rural, and forest) were identified: (i) urban zone located in the Tocachi community (-0.0352S & 78.282W), characterized by basic services, with paved streets, a school area, a housing yard consisting of monocultures (MC) and polycultures (PC); (ii) rural zone located 1km away from the community (-0.048S & 78.290W), characterized by a small human population (< 30 permanent inhabitants) without basic services in an agro-ecological farming system (AFS); (iii) forest zone corresponding to low human disturbance, with a lower montane forest located in the Parque Arqueológico Cochasquí (PAC) (-0.059S & 78.304W) and the Cochasquí montane forest (CMF) (-0.058S & 78.304W).

Sampling

Flies were captured with Morón & Terrón (1984) modified necrotraps made of two transparent plastic soup containers, with an internal funnel formed from a foam container. Traps were baited with fish viscera and beef, placed 1m above the ground (Uribe-M et al. 2010; Moreno et al. 2016); 100 traps separated by 30m each following transects in each site (MC, PC, AFS, PAC and CMF) for a period of 48 hours each month from May to November 2017. Trapped specimens were separated into morphotypes, mounted and identified using taxonomic keys (Mc Alpine et al. 1981; Carvalho 2002; Toro 2007; Amat et al. 2008; Carvalho & Mello 2008; Buenaventura et al. 2009; Marshall et al. 2011; Vairo et al. 2011; Patitucci et al. 2013a).

Data analysis

We evaluated the local diversity using Hill numbers (Hill 1973; Moreno 2001) for site diversity estimation ($N_0 = S$, $N_1 = e^{H'}$ and $N_2 = 1 / \lambda$; where S corresponds to species richness, H' Shannon-Wiener index and λ Simpson index); for evenness the $E_{2,1}$ Alatalo index (Heip et al. 1998) was calculated using the formula: $N_1 - 1 / N_2 - 1$. The diversity between sites was evaluated using the Jaccard (quantitative) similarity index. All analyses were made using PAST (Hammer et al. 2001) and EstimateS (Colwell 2019) software.

The synanthropic index (SI) was calculated according to Nuorteva (1963): SI = (2a+b-2c)/2, where "a" corresponds to the percentage of individuals of each species collected in the urban zone, "b" the percentage of the same species collected in the rural zone, and "c" the percentage of the same species collected in the forest zone. The SI fluctuates between +100 to -100, where a value of +100 indicates a strong species preference for densely populated urban areas, -100 indicates a complete avoidance of human settlements and intermediate values indicate differential degrees of synanthropy. For this analysis, only those species with 10 or more individuals were considered.

RESULTS

A total of 2,925 specimens of Calyptratae were collected, representing 38 morphotypes and 17 species; four of these are new reports for Ecuador (Table 1). Muscidae and Sarcophagidae representing 39.6% and 24.7% abundance, respectively. In Muscidae, the most common taxa were *Limnophora marginata* Stein, 1904, followed by *Phaonia trispila* (Bigot, 1885), *Dolichophaonia trigona* (Shannon & Del Ponte, 1926), *Phaonia* sp1, and *Dolichophaonia* sp1. Sarcophagidae was commonly represented by *Tricharea* sp1 and *Peckia* (*Sarcodexia*) sp1. In Calliphoridae, the most abundant species were: *Sarconesiopsis magellanica* (Le Guillou, 1842), *Calliphora nigribasis* Macquart, 1851, and *Lucilia cuprina* (Wiedemann, 1830). Finally, Tachinidae comprises a high number of morphotypes (25) and two species: *Eulasiopalpus* nr. *niveus* Townsend, 1914 and *Eulasiopalpus* nr. *vittatus* Curran, 1947.

Concerning the abundance and species composition between sites, CMF and PAC presented high abundance and richness, followed by AFS, MC, and PC. The PAC presented the highest N_1 and N_2 Hill diversity index, in contrast to MC which showed the lowest; PC presented intermediate diversity values. On the other hand, evenness $F_{2,1}$ index decreased from forest to urban sites: PAC-CMF > AFS > PC > MC. Figure 1 shows the dendrogram based on Jaccard index similarity; PAC is separated from the other sites, and CMF and AFS form a cluster separated from the crops group (MC and PC).

The synanthropic index was calculated for the most common species (10 individuals or more). In this study, the species and morphotypes that exhibited positive synanthropic index values were (Table 2): *Limnophora marginata* Stein, 1904 (+86.62) showing strong preference for human settlements, *Peckia* (*Sarcodexia*) sp1 (+8.60), *Phaonia trispila* (+6.24), *Lucilia cuprina* (Wiedemann, 1830) (+5.48), *Calliphora lopesi* Mello, 1962 and *Compsomyiops melloi* Dear, 1985 with (+2.98), and *Calliphora nigribasis* (+2.57), all with a preference for human settlements. The values for the other species and morphotypes were negative (showing preference for uninhabited areas): Fannidae sp1 (-40.89), *Tricharaea* sp1 (-14.94), *Sarconesiopsis magellanica* (-5.55), Scatophagidae sp1 (-3.12), *Sarconesia chlorogaster* (Wiedemann, 1831) (-1.75), Sarcophagidae sp1 (-1.36), and *Boettcheria* sp1 (-0.11).

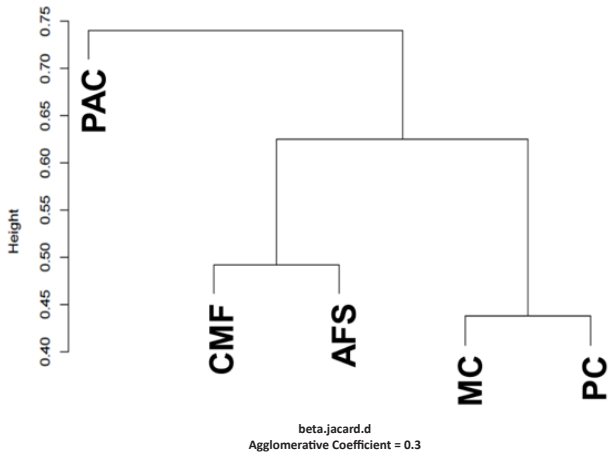

Figure 1. Dendrogram based on the Jaccard coefficient index showing the similarity in the composition of Calyptratae species in the sites sampled. Parque Arqueológico Cochasquí (PAC), Cochasquí montane forest (CMF), agroecologycal farming system (AFS), polyculture (PC), and monoculture (MC).

The list of new records with diagnostic characters and distribution is given below:

Family Calliphoridae

Subfamily Calliphorinae

Calliphora lopesi Mello, 1962 (Image 1A)

This species of *Calliphora* can be distinguished by its bare stem vein, lower calypter setose above, bare suprasquamal ridge, thorax dull grey with whitish microtomentum, and abdomen subshining metallic blue with more or less whitish microtomentum. Other characters include a robust orange palpus with stout black setae; parafacial black to brown, lower half sometimes reddish to orange; parafacial with one or two changeable spots in both sexes, females also with a changeable spot midway on fronto-orbital plate when viewed from above; gena usually brown or black, genal groove black in *C. nigribasis*. Thorax with typical chaetotaxy; normally two postsutural intra-alars. Base of wing infuscated along costa to apex of costal cell, angling back to anterior edge of basal medial and posterior cubital cells, intensity and extent of area with color somewhat variable; and fringe of lower calypter normally brown *C. nigribasis*, rim and fringe are usually white or pale in the remaining four in C. *lopesi*.

Diagnostic characters: Differ from *C. nigribasis* by the reddish genal groove (black in *C. nigribasis*); rim and fringe of lower calypter white (dark reddish-brown in *C. nigribasis*); male frons narrower (related to head width), averaging 0.066 (0.06–0.07/5) (whereas averaging 0.102 (0.09–0.12/5) in *C. nigribasis*); male surstylus and cercus slender (whereas shorter and more stout in *C. nigribasis*); ST5 normal (exceptionally broad in *C. nigribasis*); female T5 without incision (T5 with incision in *C. nigribasis*) (Whitworth & Rognes, 2012).

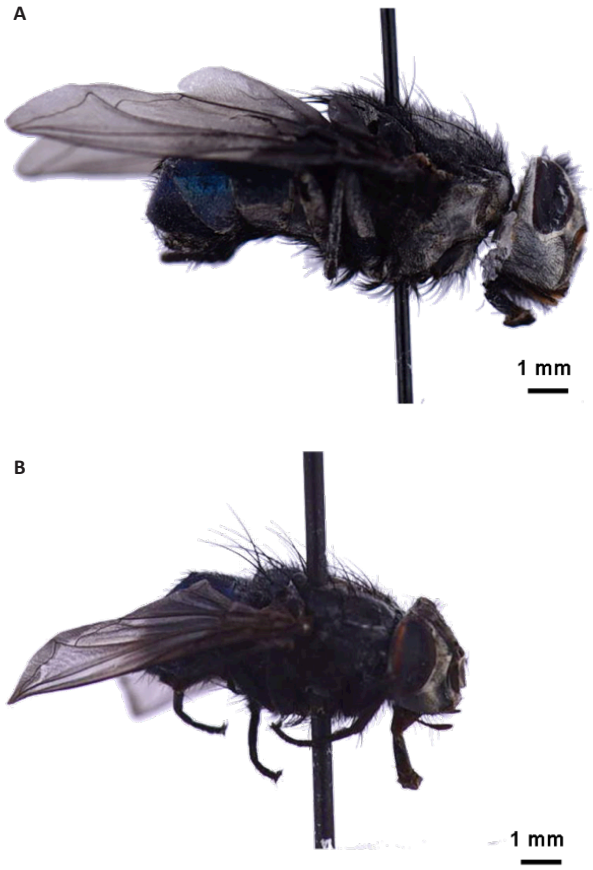

Image 1. Lateral views of Calliphoridae new records species collected at Pedro Moncayo canton in the Pichincha province: A—*Calliphora lopesi* | B—*Compsomyiops melloi*. © Yesenia Tovar & Ana Soto-Vivas

Material examined: MECN-EN-DIP-4862, 17.xi.2017, 1 female, polyculture in urban zone located in the Tocachi community, Pichincha, -0.035S & 78.282W, 2,816m, coll. Blacio & Soto-Vivas.

Distribution (Whitworth & Rognes 2012; Kosmann et al. 2013): Brazil, Uruguay.

Subfamily Chrysomyinae

***Compsomyiops melloi* Dear, 1985 (Image 1B)**

Compsomyiops species can be distinguished by the haired parafacials, pubescent greater ampulla and normal sized palpi (Dear 1985).

Diagnostic characters: Differs from *C. fulvicrura* (Robineau-Desvoidy, 1830) frons 0.40 of the head width; frontal vitta broader than a fronto-orbital plate measured at lunula; parafacial hairs dark and proclinate; genae silvery-yellow dusted anteriorly; frontal vitta orange-brown dusted; calypters pale brown (Dear 1985).

Material examined: MECN-EN-DIP-4861, MECN-EN-DIP-4865, MECN-EN-DIP-4866, MECN-EN-DIP-4867, MECN-EN-DIP-4868, 22.x.2017, 5 females, polyculture in urban zone located in the Tocachi community, Pichincha, -0.035S & 78.282W, 2,816m, coll. Blacio & Soto-Vivas.

Distribution (Dear 1985; Amat 2009; Kosmann et al. 2013): Colombia, Mexico.

Family Muscidae

Subfamily Phaoniinae

***Dolichophaonia trigona* (Shannon & Del Ponte, 1926) (Image 2A)**

Dolichophaonia species are characterized by eye with short cilia, arista plumose, presutural acrostichals often differentiated, dorsocentral setae 2:3-4, prealar present, except in *D. vockerothi* (Carvalho, 1983), shorter than notopleural anterior seta, katepisternals 1:2, meron haired or not; wing veins bare, vein M parallel or very slightly forward-curved apically, calcar present, about twice as long as the basal width of hind tibia; female: clypeus, in lateral view, with a strong, hook-shaped anterior tip, posteriorly with a prominent sclerotization, ovipositor with large tergites and sternites (Carvalho & Couri 2002).

Diagnostic characters: One prepimeral setae development; mid tibia often with 2 median posterior setae; female palpus more dilated than in male; sternite 1 bare; pre-alar present, shorter than noto-pleural anterior seta; two intra-alars post-sutural setae; wing with two conspicuous clouds on cross-veins dm-cu; upper calypter yellowish with dark brown margins; wing with costal margin yellowish; dorso-central setae 2:3-4 (Carvalho & Couri 2002).

Material examined: MECN-EN-DIP-4859, MECN-EN-DIP-4869, MECN-EN-DIP-4870, 22.ix.2017, 3 females, Cochasquí

montane forest, Pichincha, -0.058969S & 78.304351W, 3052m, coll. Blacio & Soto-Vivas. MECN-EN-DIP-4871, MECN-EN-DIP-4872, 22.ix.2017, 2 females, monoculture in urban zone located in the Tocachi community, Pichincha, -0.035S & 78.282W, 2,816m, coll. Blacio & Soto-Vivas.

Distribution (Löwenberg-Neto & Carvalho 2013): Argentina, Brazil, Uruguay.

***Phaonia trispila* (Bigot, 1885) (Image 2B)**

Phaonia species are characterized by: eyes ciliated, arista plumose, dorsocentral setae 1–2:3–4, notopleuron with covering setulae and with two setae, the posterior one weaker; pre-alar seta present (absent in *P. lentiginosa* Snyder), lower calypter glossiform, *Phaonia* type, Rs node bare or ciliated, vein M usually curved forward apically, hind tibia on postero-dorsal surface with the calcar about as long as the width of the tibia at calcar

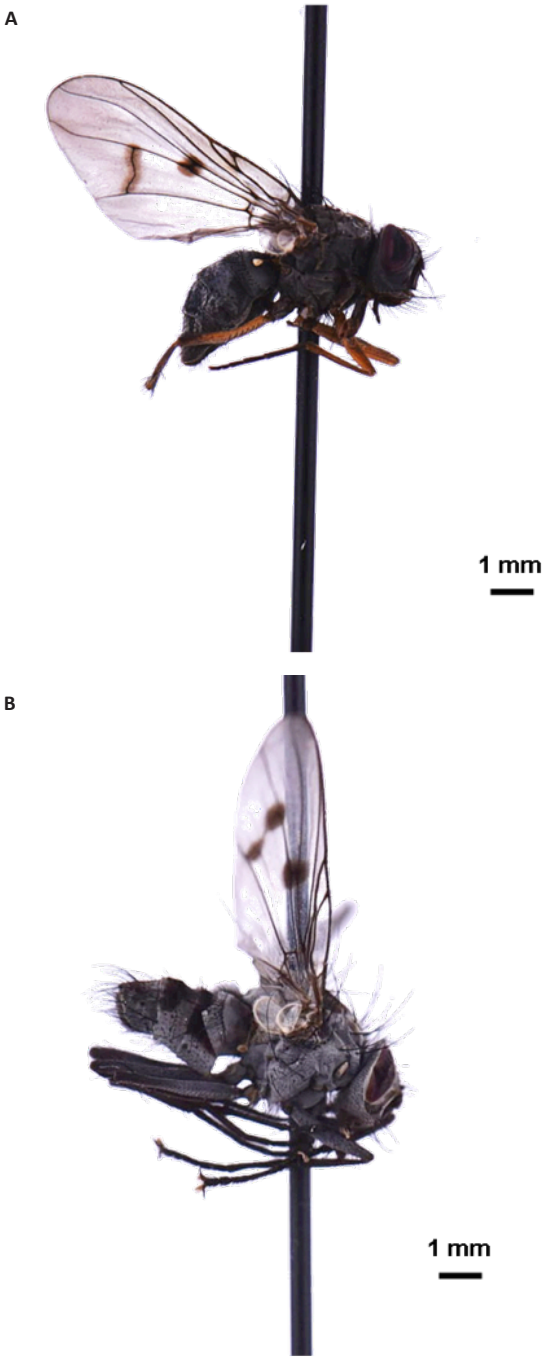

Image 2. Lateral views of Muscidae new records species collected at Pedro Moncayo canton in the Pichincha province: A—*Dolichophaonia trigona* | B—*Phaonia trispila*. © Yesenia Tovar & Ana Soto-Vivas

insertion; female: ovipositor elongated, tubular, tergites narrow; stemite 8 reduced to two sclerites, microtrichia usually well-developed only on the membrane, cerci free (Carvalho & Couri 2002).

Diagnostic characters: General coloration black; scutellum with a yellowish-brown apex; wing with dark brown macules in the anterior and posterior transverse veins and a slight spot at the end of the Sc vein; posterior spiracle on the PV margin without setae. Male: Paramere without concavity on the ventral surface; gonopod with the anterior region not exceeding the paramere width; ventral face curved. Female: proboscis in lateral view, with the clypeus, in the anterior region, with a strong tip; dorsal and basal haustellum sclerites with many setae (Coelho 2000).

Material examined: MECN-EN-DIP-4864, MECN-EN-DIP-4860, 22.ix.2017, 2 females, Cochasquí montane forest, Pichincha, -0.058S & 78.304W, 3,052m, coll. Blacio & Soto-Vivas. MECN-EN-DIP-4857, 22.ix.2017, 1 female, monoculture in urban zone located in the Tocachi community, Pichincha, -0.035S & 78.282W, 2,816m, coll. Blacio & Soto-Vivas. MECN-EN-DIP-4858, 17.xi.2017, 1 female, polyculture in urban zone located in the Tocachi community, Pichincha, -0.035S & 78.282W, 2,816m, coll. Blacio & Soto-Vivas. MECN-EN-DIP-4863, 22.x.2017, 1 female, agroecological farming system 1km away from the Tocachi community, Pichincha, -0.048S & 78.290W, 3,000m, coll. Blacio & Soto-Vivas.

Distribution (Löwenberg-Neto & Carvalho 2013): Argentina, Brazil, Venezuela, Uruguay.

DISCUSSION

The most abundant and diverse Calyptratae community was observed in the wild environment (Cochasquí Archaeological Park). This suggests that the species share the available resources, from pollen to organic matter in animal and plant decay (Baumgartner & Greenberg 1985; Carson & Schnitzer 2008). In contrast to the urban area (mono- and polycultures) where the richness was lower, possibly due to anthropogenic modifications such as garbage and drains which support flies adapted to these environments (Carvalho et al. 1984; Souza et al. 2014). On the other hand, the dipteran community similarity found between urban areas and the montane forest and agro-ecological farming system could be associated with the fact that Tocachi rural and urban environments are partially preserved, due to the agricultural practices that are carried out in some areas.

Muscidae were the most abundant taxa in this study; adults can be predatory, hematophagous, saprophagous or necrophagous, living in varied habitats, such as dung, decomposing organic vegetable or animal matter, wood, fungi, nests, and dens, among others (Couri & Carvalho 2005). These flies are relatively common at high altitude regions, where they are important as pollinators and

Table 1. Absolute frequency of Calyptratae in five sites in Pedro Moncayo canton, Ecuador from May to November 2017. * New report from Ecuador.

Family	Species / morphotype	PAC	CMF	AFS	PC	MC	Total
Calliphoridae	*Calliphora lopesi* Mello, 1962*	0	0	0	10	0	10
	Calliphora nigribasis Macquart, 1851	9	1	10	10	2	32
	Chlorobrachycoma splendida Townsend, 1918	2	0	0	2	0	4
	Chrysomya albiceps (Wiedemann, 1819)	1	0	0	0	1	2
	Cochliomyia hominivorax (Coquerel, 1858)	7	0	0	0	0	7
	Cochliomyia macellaria (Fabricius, 1775)	1	0	0	0	0	1
	Compsomyiops melloi Dear, 1985*	0	0	0	10	0	10
	Lucilia cuprina (Wiedemann, 1830)	1	0	0	19	0	20
	Lucilia eximia (Wiedemann, 1819)	0	0	0	3	0	3
	Lucilia sericata (Meigen, 1826)	0	0	0	0	5	5
	Sarconesia chlorogaster (Wiedemann, 1831)	10	0	0	0	0	10
	Sarconesiopsis magellanica (Le Guillou, 1842)	87	67	28	17	35	234
	Roraimomusca roraima Townsend, 1935	2	0	0	0	0	2
	Rhiniinae sp1	0	0	0	2	0	2
Sarcophagidae	*Blaesoxipha* sp1	0	0	1	0	0	1
	Boettcheria sp1	11	7	8	2	5	33
	Peckia sp1	0	0	0	1	0	1
	Peckia (Sarcodexia) sp1	61	59	97	25	40	282
	Tricharaea sp1	189	44	82	38	20	373
	Sarcophagidae sp1	16	1	10	0	3	30
	Sarcophagidae sp2	0	0	0	0	1	1
Muscidae	*Dolichophaonia* sp1	0	1	0	0	3	4
	Dolichophaonia trigona (Shannon & Del Ponte, 1926)*	0	4	0	0	4	8
	Phaonia trispila (Bigot, 1885)*	1	13	15	16	7	52
	Phaonia sp1	0	0	7	0	1	8
	Limnophora marginata Stein, 1904	43	333	336	158	210	1080
Fanniidae	Fanniidae sp1	64	413	60	14	17	568
Scatophagidae	Scatophagidae sp1	51	10	24	8	10	103
Tachinidae	*Eulasiopalpus* nr. *niveus* Townsend, 1914	0	1	0	0	0	1
	Eulasiopalpus nr. *vittatus* Curran, 1947	0	0	1	0	0	1
	Adejeania sp1	0	0	4	0	0	4
	Tachinidae sp1	1	0	0	0	0	1
	Tachinidae sp2	1	0	0	0	0	1
	Tachinidae sp3	1	0	0	0	0	1
	Tachinidae sp4	1	0	0	0	0	1
	Tachinidae sp5	1	0	0	0	0	1
	Tachinidae sp6	1	0	0	0	0	1
	Tachinidae sp7	4	0	0	0	0	4
	Tachinidae sp8	5	0	0	0	0	5
	Tachinidae sp9	0	1	0	0	0	1
	Tachinidae sp10	0	1	0	0	0	1
	Tachinidae sp11	0	1	0	0	0	1
	Tachinidae sp13	0	1	0	0	0	1

Family	Species / morphotype	PAC	CMF	AFS	PC	MC	Total
	Tachinidae sp14	0	1	0	0	0	1
	Tachinidae sp15	0	1	0	0	0	1
	Tachinidae sp16	0	1	0	0	0	1
	Tachinidae sp17	0	1	0	0	0	1
	Tachinidae sp18	0	1	0	0	0	1
	Tachinidae sp19	0	1	0	0	0	1
	Tachinidae sp20	0	0	0	0	1	1
	Tachinidae sp21	0	0	0	0	1	1
	Tachinidae sp22	0	0	0	0	1	1
	Tachinidae sp23	0	0	3	0	0	3
	Tachinidae sp26	0	0	1	0	0	1
	Tachinidae sp27	0	0	0	1	0	1
	Hill N_0 (=S)	**25**	**23**	**16**	**17**	**19**	
	N_1 ($e^{H'}$)	**8.51**	**4.44**	**5.63**	**7.07**	**5.10**	
	N_2 (1/λ)	**5.80**	**3.19**	**3.51**	**3.96**	**2.81**	
	Alatalo $E_{2,1}$ (N_1-1/N_2-1)	**0.64**	**0.64**	**0.54**	**0.49**	**0.44**	

PAC—Parque Arqueológico Cochasquí | CMF—Cochasquí montane forest | AFS—Agroecologycal farming system | PC—Polyculture | MC—Monoculture.

floral visitors and account for a high proportion of fauna (Proctor et al. 1996; Carvalho et al. 2005; Pérez & Wolff 2011). The most common species were *L. marginata*, *D. trigona* and *P. trispila*, the last two species have not been collected previously in Ecuador; *D. trigona* is reported in Argentina, Brazil, and Uruguay, and *P. trispila* has been registered in Argentina, Brazil, Venezuela and Uruguay (Löwenberg-Neto & Carvalho 2013). In this study, *L. marginata* showed a highly positive synanthropic index, suggesting strong preference for human settlements, in contrast to *P. trispila* that showed a low positive synanthropic index, indicating a mild preference for human settlements. Patitucci et al. (2013b) studied the ecological assemblages of saprophagous muscids in three sites with different urbanization levels. Particularly, *P. trispila* showed high abundance in rural areas, and a negative synanthropic index associated with complete avoidance of human settlements. Sarcophagidae was mainly represented by *Tricharaea* sp1, *Peckia* (*Sarcodexia*) sp1 and *Boettcheria* sp1; this family have a wide variety of habits, some species being scavengers, coprophages, hosts of ant and termite nests, some cause myiasis to amphibians and mammals, others are predators on arachnid eggs, butterfly larvae and bee pupae (Pape et al. 2004). Yepes-Guarisas et al. (2013) investigated the ecology and synanthropy of Sarcophagidae from Antioquia-Colombia. These authors found that *Tricharaea* spp. and *Pekia* (*Sarcodexia*) *lambens* (Wiedemann, 1830), showed a positive synanthropic index. Pinilla et al. (2012) studied the synanthropy of Calliphoridae and Sarcophagidae in three zones in Bogotá-Colombia. They reported a *Boettcheria* morphotype associated mainly in the forest but also represented in rural areas.

With Calliphoridae, most species are sarcosaprophagous, but there are also predators and parasitoids. Souza et al. (2014) point out that this family is associated with regenerating forest, due to certain species colonizing at some stages. Also, studies with different degrees of urbanization showed that calliphorids prefer baits of animal origin (D'Almeida & Almeida 1998). This taxon is one of the most important families representative of synanthropic species (Souza & Zuben 2012). In the present study, the Calliphoridae species had a greater relationship in wild and rural environments, however, they are also present in the urban environment; this could be due to small vegetation patches and the association with domestic or farm animals. *S. magellanica* was the most abundant species and demonstrated a preference for uninhabited areas; Figueroa & Linhares (2002) and Pinilla et al. (2012) stated that this species was abundant in rural and wild areas. In concordance with our results, *S. chlorogaster* was reported by Schnack et al. (1989) in Argentina and Vianna et al. (1998) in Brazil, as a species with independence from human settlements. *L. cuprina* was found to be widely distributed in rural and urban areas on Pedro Moncayo canton, in particular, densely

Table 2. Synanthropic index of Calyptratae in five sites in Pedro Moncayo canton, Ecuador from May to November 2017 from those species with a number equal or higher to 10 individuals.

Species / morphotype	PAC	%	CMF	%	AFS	%	PC	%	MC	%	Total	SI
Sarconesiopsis magellanica (Le Guillou, 1842)	87	15.24	67	6.95	28	4.08	17	5.06	35	9.54	234	-5,55
Sarconesia chlorogaster (Wiedemann, 1831)	10	1.75	0		0		0		0		10	-1,75
Calliphora nigribasis Macquart, 1851	9	1.58	1	0.10	10	1.46	10	2.98	2	0.54	32	2,57
Calliphora lopesi Mello, 1962	0		0		0		10	2.98	0		10	2,98
Compsomyops melloi (Wiedemann, 1819)	0		0		0		10	2.98	0		10	2,98
Lucilia cuprina (Wiedemann, 1830)	1	0.18	0		0		19	5.65	0		20	5,48
Tricharaea sp1	189	33.10	44	4.56	82	11.94	38	11.31	20	5.45	373	-14,94
Peckia (Sarcodexia) sp1	61	10.68	59	6.12	97	14.12	25	7.44	40	10.90	282	8,60
Boettcheria sp1	11	1.93	7	0.73	8	1.16	2	0.60	5	1.36	33	-0,11
Sarcophagidae sp1	16	2.80	1	0.10	10	1.46	0		3	0.82	30	-1,36
Phaonia trispila (Bigot, 1885)	1	0.18	13	1.35	15	2.18	16	4.76	7	1.91	52	6,24
Limnophora marginata Stein, 1904	43	7.53	333	34.54	336	48.91	158	47.02	210	57.22	1080	86,62
Fannidae sp1	64	11.21	413	42.84	60	8.73	14	4.17	17	4.63	568	-40,89
Scatophagidae sp1	51	8.93	10	1.04	24	3.49	8	2.38	10	2.72	103	-3,12

PAC—Parque Arqueológico Cochasquí | CMF—Cochasquí montane forest | AFS—Agroecologycal farming system | PC—Polyculture | MC—Monoculture | SI—Synanthropic Index.

inhabited areas. Several authors associate *L. cuprina* with densely populated areas and due to this, this species is considered to be a medical-veterinary important species because it is associated with the transmission of pathogenic micro-organisms and primary myiasis in sheep and humans (Vianna et al. 1998; Souza & Zuben 2012). *C. melloi* and *C. lopesi* were collected for the first time in Ecuador in this study. Dear (1985), Amat (2009) and Kosmann et al. (2013) recorded *C. melloi* in Mexico and Colombia, and Whitworth & Rognes (2012), and Kosmann et al. (2013) reported *C. lopesi* in Brazil and Uruguay. Finally, *C. lopesi* and *C. nigribasis* showed independence from human settlements; similar findings to those reported by Vianna et al. (1998) and Pinilla et al. (2012), in Brazil and Colombia, respectively.

Finally, Tachinidae presented a high number of morphotypes and two species *Eulasiopalpus* nr. *niveus* and *Eulasiopalpus* nr. *vittatus*. This family is extremely diverse in the Neotropics, a common taxon at middle elevations (1,000–2,000 m) along the mountain chains of tropical Central and South America (Stireman et al. 2006; Stireman 2007). Only a fraction of Neotropical Tachinidae have been described, and for most of those that have been described, the life history host associations, or behavior are poorly known (Guimarães 1977; Toma 2012). The tachinid species provide various ecosystem services in the Andean forests, their value as pest controllers and pollinators, favors the variability of the forest flora as well as maintaining the balance of the ecosystem by regulating populations (Ssymank et al. 2008; Quintero et al. 2017).

Urbanization processes cause an ecosystem negative impact by decreasing the proportion of native species, while introduced species usually occupy urbanized environments due to pre-adaptation processes (McKinney 2002; 2008). Several authors affirm that the introduced species proportion increases as it approaches large heavily urbanized sectors; in contrast to those native species that are more abundant in less modified sectors. In sarco-saprophagous dipterans, the environmental colonization success depends on their morphology, flexibility in the use of different resources, as well as on life history (Vianna et al. 1998; Uribe-M et al. 2010; Mulieri et al. 2011; Pinilla et al. 2012).

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