Project Update: September 2016

In this first update I report my work field activities and present some preliminary results related to the first 3 months of data collection (from June to August 2016).

Activities

So far, work field and data collection (predatory insects, coffee pest, crop management information, landscape mapping and micro-climate variables) were well succeeded and most farmers were very collaborative and interested in our project. During my interaction with farmers, I'm presenting concepts and techniques used to promote biodiversity conservation and ecosystem services in farmland. Additionally, I am showing the species collected in traps to introduce beneficial insects to farmers. In the laboratory, the captured insects are separated by family and sent to the specialists who will identify specimens to species level.

Changes and adjustments

Due to the unusual and constant rain from December 2015 to May 2016 we changed period of data collection that currently is from June 2016 to July 2017. Secondly, I reduced the number of sites from 20 to 16 sites. Four sites were excluded due to the difficult accessibility especially during rain episodes when sites are accessible only on foot. Furthermore, in the four cases the distance is too large to be covered on foot and would result in a prohibitive delay. Anyway, such site reduction does not prevent sampling design neither data analyses.

Finally, I proposed four spatial scales (500, 1000, 1500 and 2000 m) to investigate the effects of landscape variables on local wasp communities, however studies have indicated that most wasp species present a dispersal home range of 300 m in the surroundings of their nests (Santos et al. 2000; Cruz et al. 2006; Ribeiro- Filho et al. 2008). Therefore, we changed the spatial scales and forest cover and habitat diversity were measured at 250, 500, 750 and 1000 m in the surrounding of coffee-forest interfaces.

Preliminary Results

Landscape structure and local crop management

Forest cover and habitat diversity varied considerably among the 16 sites. At 1 km radius, forest cover ranged from 3.7 to 56.2 %, while SDI varied from 1.05 to 1.86. Altitude varied from 720 to 1250 m asl (Table 1). From June to August 2016, 10 sites were submitted to agrochemical applications (fertilizers, herbicides, insecticides and fungicides; Table 1).

Table 1: Location of 16 study sites and description of landscape attributes in a coffee producing region in southeast Brazil. I = number of insecticide applications, H = number of herbicide applications, FU = number of fungicide applications and FE = number of fertilizer applications. SDI means Shannon diversity index which is a metric of habitat diversity at landscape scale. FC means percentage forest cover. Both SDI and FC were calculated at 1 km radius in the surrounding of each of the sampled forest-coffee

interfaces. Al means altitude above sea level.

Sites	I	FU	H	FE	Al	SDI	FC	Coordenate
1	0	0	0	0	755	1.210	3.7	22˚04'49" S; 46˚48'56" W
2	1	0	0	1	770	1.817	5.7	22˚00'55" S; 46˚48'50" W
3	1	1	1	0	840	1.587	7.8	22˚12'53" S; 46˚45'54" W
4	0	0	0	0	875	1.150	11.7	22˚06'48" S; 46˚42'24" W
5	0	0	1	0	850	1.533	14.7	22˚10'01" S; 46˚45'47" W
6	1	1	1	0	800	1.668	17.0	22˚06'51" S; 46˚48'19" W
7	1	1	1	0	890	1.052	21.2	22˚08'44" S; 46˚43'54" W
8	0	1	0	0	900	1.823	22.5	22˚08'06" S; 46˚42'37" W
9	0	1	1	0	1055	1.369	29.5	21˚58'20" S; 46˚42'08" W
10	0	0	0	0	960	1.630	31.0	21˚57'13" S; 46˚42'23" W
11	0	0	0	0	1200	1.755	37.4	21˚51'26" S; 46˚41'18" W
12	0	0	0	0	860	1.593	39.4	22˚10'43" S; 46˚47'00" W
13	0	0	0	0	1020	1.487	44.4	21˚59'33" S; 46˚41'24" W
14	0	0	1	0	1160	1.395	50.8	21˚53'46" S; 46˚43'04" W
15	0	0	1	0	1250	1.247	54.8	21˚47'17" S; 46˚27'59" W
16	0	0	0	0	720	1.861	56.2	22˚09'36" S; 46˚50'05" W

Predatory wasps and pest control services

In June 2016, we collected 547 predatory wasps, recorded 24 species in nine genera (Table 2). The abundance of predatory wasps ranged from 3 to 163 individuals on the 16 sites, and species richness varied from 3 to 21 species per site. Most sites presented higher species richness and abundance of wasps in the centre of coffee crops when compared with crop edges and adjacent forest fragments (Figure 1).

Table 2. Species of Predatory wasps (Family Vespidae, Subfamily Polistinae, Order Hymenoptera) recorded in 16 sites in southeast Brazil. Wasps were identified to species level using the following identification keys: Richards (1978), Carpenter & Marques (2001) and Carpenter & Garcete-Barrett (2003).

Tribe	Genera	Species
Epiponini	*Brachygastra*	*augusti*
Epiponini	*Polybia*	*chrysothorax*

Epiponini	*Polybia*	*dimidiata*
Epiponini	*Protopolybia*	*exigua*
Epiponini	*Polybia*	*fastidiosuscula*
Epiponini	*Polybia*	*ignobilis*
Epiponini	*Polybia*	*jurinei*
Epiponini	*Brachygastra*	*lecheguana*
Epiponini	*Agelaia*	*multipicta*
Epiponini	*Polybia*	*occidentalis*
Epiponini	*Apoica*	*pallens*
Epiponini	*Agelaia*	*pallipes*
Epiponini	*Polybia*	*paulista*
Epiponini	*Polybia*	*sericea*
Epiponini	*Protonectarina*	*sylveirae*
Epiponini	*Pseudopolybia*	*vespiceps*
Epiponini	*Agelaia*	*vicina*
Epiponini	*Polybia*	*vicina*
Mischocyttarin	*Mischocyttarus*	*drewseni*
Mischocyttarin	*Mischocyttarus*	sp
Polistini	*Polistes*	*cinerascens*
Polistini	*Polistes*	*lanio*
Polistini	*Polistes*	*simillimus*
Polistini	*Polistes*	*versicolor*

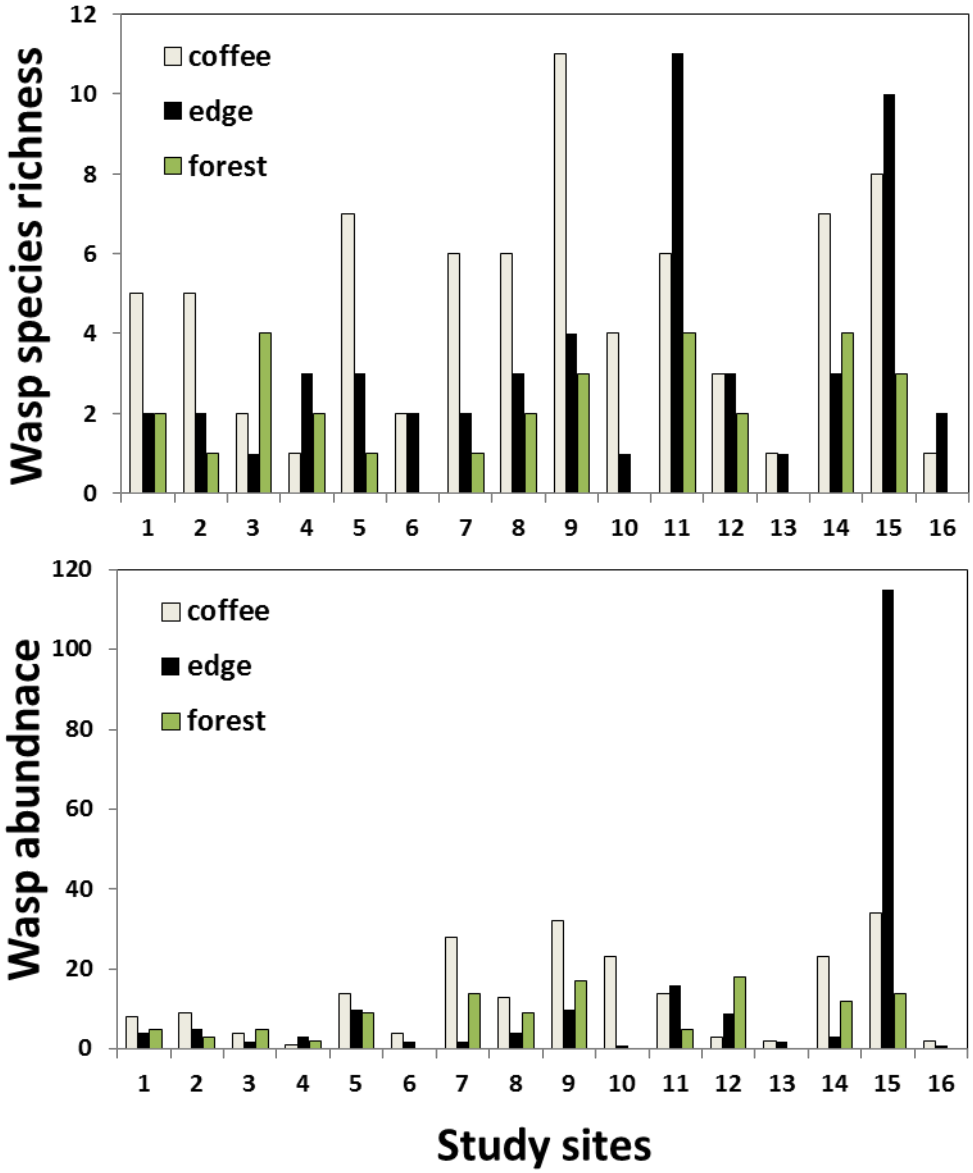

Figure 1. Number of species and specimens collected in the three environments (centre and edge coffee crop and adjacent forest fragment) per site.

To estimate the occurrence of coffee leaf miner *Leucoptera coffeella* (Lyonetiidae: Lepidoptera) and the rates of mine predation per site I visually assessed 200 coffee leaves per site (100 leaves in crop centre and 100 leaves in the edge near forest fragments). The number of mined leaves varied from 37 to 128 and the number of mined leaves with preyed mines ranged from 9 to 51 (Table 3).

Table 3. Number of mined leaves (ML) and number of preyed mines (MLpred) per site.

Sites	ML	MLpred	MLpred (%)	Sites	ML	MLpred	MLpre
1	65	27	41.5	**9**	106	40	37.7
2	104	22	21.1	**10**	115	13	11.3
3	117	30	25.6	**11**	122	42	34.4
4	37	20	54.0	**12**	106	44	41.5
5	79	31	39.2	**13**	49	21	42.8
6	94	9	9.6	**14**	87	37	42.5
7	105	17	16.2	**15**	89	51	57.3
8	96	29	30.2	**16**	128	25	19.5

The rates of mine predation were higher in the edge than in the centre of coffee fields. Indeed, the percentage of mined leaves with preyed mines was higher in the edges than in the centre of coffee crops. This tendency was observed in 12 of the 16 sites (Figure 2).

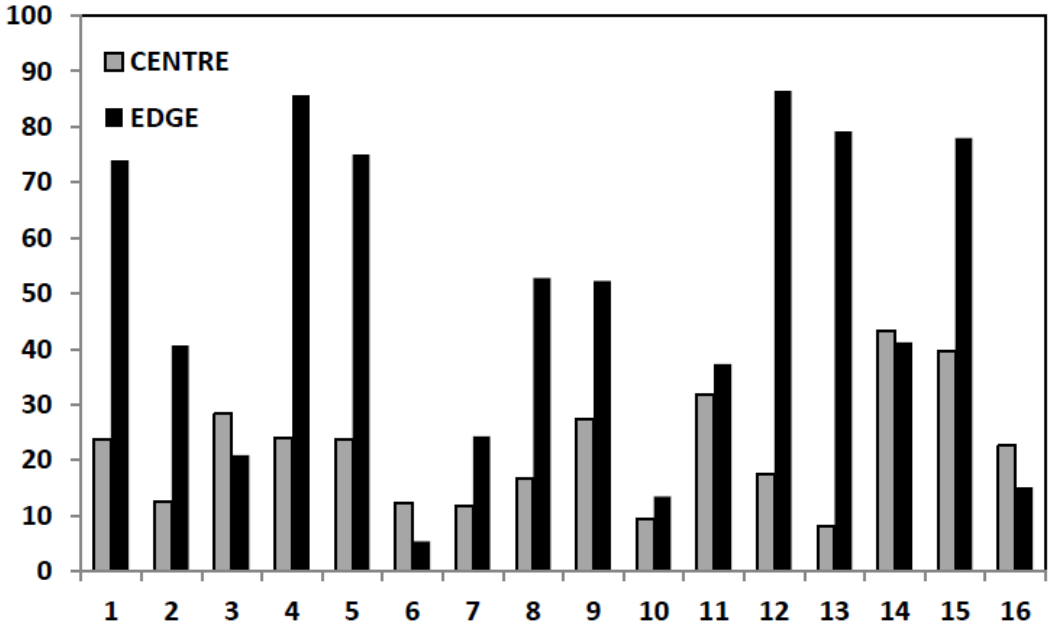

Figure 2. Number of leaves with preyed mines in centre and edge of the 16 sampled coffee crops.

The effects of explanatory variables on predatory wasps and their pest control services

Species richness and abundance of predatory wasps as well as the rates of mine predation (percentage of mined leaves with preyed mines) increased with increasing forest cover in the surrounding landscape, while pest density (number of mined leaves) decreased with the increment of forest cover (Table 4; Figure 3).

Table 4. Best models to explain the species richness and abundance of predatory wasps, pest density and rates of mine predation in 16 agricultural landscapes in southeast Brazil. AICc = Akaike Information Criterion with the small sample correction; ΔAICc = Delta value of AICc in relation to the best model; and wAICc = weight of evidence of the models. Asterisks indicate the level of significance of the models (model fit). The symbols – and + within parenthesis indicate the direction of correlation between dependent variables and explanatory variables.

Dependent variable	Models	ΔAICc	wAICc
Wasp species richness	~ Forest cover **(+)	0.0	0.50
	~ Habitat diversity	1.1	0.29
	~ Prey density	3.5	0.08
	~ Null	3.5	0.08
	~ Forest connectivity	5.7	0.03
Wasp abundance	~ Forest cover *(+)	0.0	0.40
	~ Habitat diversity	0.9	0.25
	~ Forest connectivity	1.5	0.19
	~ null	2.7	0.10
	~ Prey density	3.8	0.06
Rates of mine predation	~ Predator density **(+)	0.0	0.89
	~ Forest cover	5.2	0.06
	~ Forest connectivity	8.1	0.01
	~ null	8.3	0.01
	~ Habitat diversity	8.6	0.01
Pest density (*L. coffeella*)	~ Forest cover **(-)	0.0	0.95
	~ Habitat diversity	6.7	0.03
	~ Forest connectivity	9.8	0.00
	~ null	11.8	0.00
	~ Predator density	12.4	0.00

* $P< 0.05$; ** $P< 0.01$; *** $P< 0.001$.

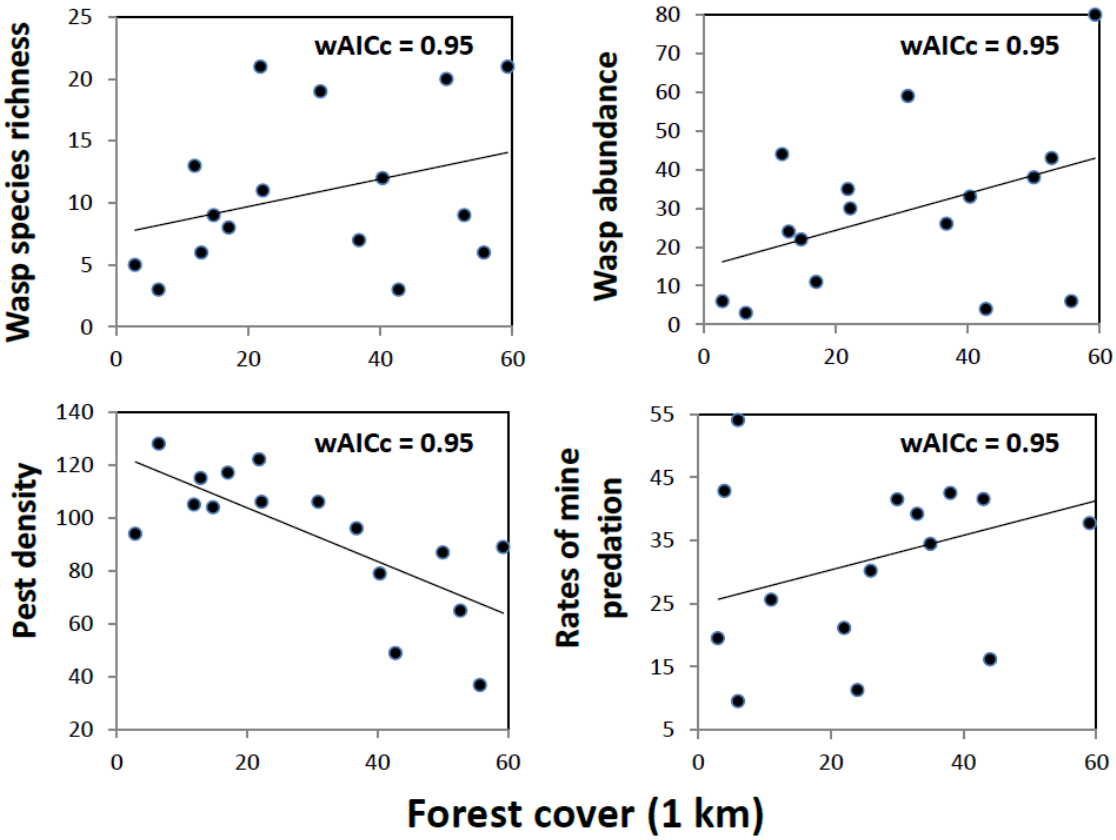

Figure 3. The best supported models of the relationship between predatory wasps, coffee pest and percentage forest cover at 1 km in southeast Brazil. wAICc = weight of evidence of the model. This relationship presented the same tendency at all spatial scales.

These preliminary results supported the hypothesis that higher forest cover at landscape scale benefits predatory insects and increases biological control in agroecosystems. High forest cover in the surrounding of coffee crops provides refuges for biodiversity including crop associated species. This is particularly true in episodes of agrochemical usage or when floral and prey availability is low in crops. In the case of predatory wasps, forest fragments provide nesting micro-habitats, alternative preys and constant supply of flower resources (pollen and nectar). Wasps probably alternate between forest fragments and coffee crops and concentration or dilution of population in these two environments is probably moderated by both anthropogenic disturbances in crops and the amount and spatial arrangement of crop and non-crop habitats at landscape level.

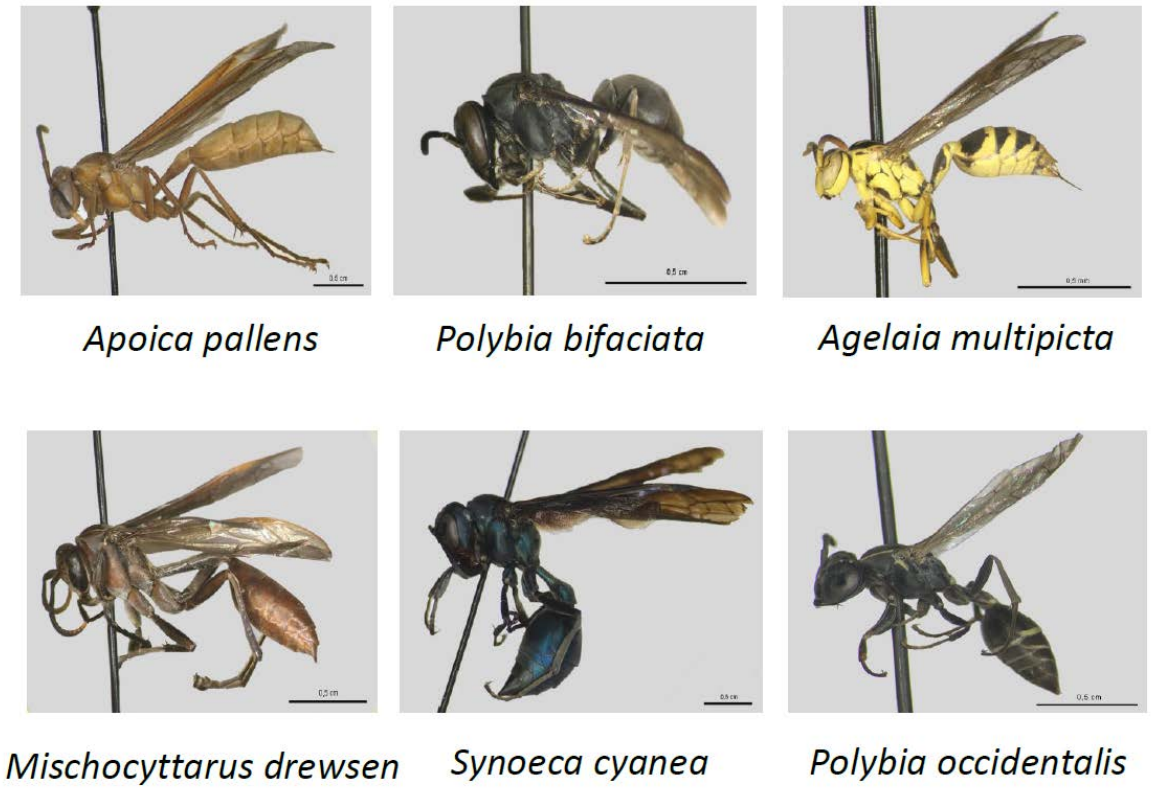

Figure 4. Some predatory wasp's species captured in the study sites. Author: Yuri Campanholo Grandinete. Wasps were identified to species level using the following identification keys: Richards (1978), Carpenter & Marques (2001) and Carpenter & Garcete-Barrett (2003).

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