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Identification, spatial distribution and report of new records of species of pest and benefical insects in Ecuador from *Samanea saman* trees

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Abstract: Ecuador is a megadiverse country made up of four regions which climate is different. The Coastal Region has seven provinces and Guayas stands out for its biological diversity, with the Guayaquil canton being the most important in the country for its contribution to the economy and biodiversity. Since 2020, there has been an exponential growth of scale insects, which have caused significant damage to trees and ornamentals. The problem is the lack of control and inappropriate use of techniques have caused these pests to proliferate, being responsible for the death of a large number of trees. The objective of this work was to identify and map the distribution of insect pests and beneficial insects associated with the saman tree, *Samanea saman* (Fabaceae). To do so, sampling of infested branches was carried out in different parts of the city, which were placed in plastic containers for later identification. The pests *Crypticerya multicicatrices* (Hemiptera: Monophlebidae), *Ferrisia virgata* and *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae) were identified, and the distributional mapping allowed us to know that currently *F. virgata* is the most widely dispersed mealybug on the trees, followed by *M. hirsutus* and *C. multicicatrices*. These results allow us to deduce that the cause of the death of the trees is caused by a complex of scale insects and not by *C. multicicatrices* as the only pest. Finally, the coccinellid *Cycloneda melanocera* is reported for the first time in Ecuador; as well as other coccinellids, namely, *Hyperaspis bromelicola*, *Cycloneda friiy*, *Tenuisvalvae bromelicola*, *Paraneda pallidula*, *Cycloneda* sp., *Cheilomenes sexmaculata*, *Tenuisvalvae* sp., *Diomus* sp., were found as main natural enemies of mealybugs and *Novius punicus* as the main predator of *C. multicicatrices*.

Keywords: Mealybugs, fluted scales, parasitoids, parasitoids, predators, phylogeography, urban areas.

Introduction

Ecuador is a country rich in biodiversity of species, both plants and animals. It is characterized by being a country with four regions (Coast, Sierra, East, Insular), each of which has different climatic characteristics, thus achieving a megadiverse country. According to Reyes (2019), the Ecuadorian coast is characterized by two defined periods influenced by meteorological factors such as the Intertropical Convergence Zone (Active low pressure belt, which highlights the wet season), the Semi-permanent High of the South Pacific (Determines the climate of the tropical zone) and the High of Bolivia (Incursion mass of air loaded with moisture into the Amazon territory); by geographical factors such as the Andes Mountains (plays a very important role in the generation and displacement of local or regional air masses), oceanographic factors such as Ocean Currents (Cold Humboldt and Warm El Niño) and astronomical factors such as solar incidence (solar radiation that reaches the earth).

These climatic characteristics allow the coastal region to have a diversity of plant species throughout its territory, either destined for agriculture or species that decorate the large cities of Buenos Aires, providing greater enhancement to its urban areas. According to the Municipality of Guayaquil (2020), among the representative flora are the muyuyo (*Cordia lutea*), pechiche (*Vitex gigantea*), mountain muyuyo (*Tecoma castanifolia*), oak (*Tabebuia rosea*), guayacán (*Handroanthus chrysanthus*), jaboncillo (*Sapindus saponaria*), and saman (*Samanea saman*) among others.

Likewise, this flora is home to different ecological niches, such as birds, small rodents and mammals and insects. The latter are characterized by having diverse habits, which can be predators, parasitoids or pests associated with the Buenos Aires trees. According to Delgado (2021), among the main pest insects associated with urban trees is the superfamily Coccoidea, made up of several families, including Monophlebidae.

For Inga (2021), the dry season and the constant use of insecticides implemented by the municipality of Guayaquil to treat the plague of mealybugs and ribbed mealybugs, have caused them to increase in urban green areas, representing a high risk for the main plant species located in the city such as palms, the samans and fruit trees such as mango. Likewise, in Colombia, Kondo et al. (2012) mention legume trees (Fabaceae) as hosts of pests such as *C. multiscars*, in addition to a number of botanical species such as palm species, guava (*Psidium* spp.), *Ficus* spp., among others.

The city of Guayaquil in the last four years has been experiencing a serious problem in the green areas of the city, due to the high populations of mealybugs and ribbed mealybugs, which have colonized several sectors and in the most serious cases, has caused the death of the trees, for which, in 2021 for the first time a very high infestation was recorded, and as a result of this situation, the municipality of Guayaquil declared the trees in emergency.(Herrera, Rizzo, Arias, Rodríguez, & Molina, 2021)

Knowing the distribution of pests is a fundamental study to observe how they disperse in time/space, in addition to studying the interaction present between individuals. For Wald (1945) and Binns and Nyrop (1992), Knowledge of the spatial arrangement of insects is one of the stages in building a sampling plan. The sequential probability ratio test follows one of the most widely used models for insect counting and decision-making, following the principles of Integrated Pest Management (IPM). Once different distributions result in the way in which the mathematical expressions of the sequential plane are elaborated. For Morláns (2004), the spatial dispersion of a population in an agroecosystem basically responds to three models: aggregate (or contagious), random (or random) or uniform (or regular). Various mathematical models are used to evaluate the spatial distribution of insects. The probabilistic models (Poisson, Negative Binomial and Positive Binomial) stand out for the wide acceptance reported in various published works and for their mathematical simplicity (Young & Young, 1998)(Fernandes et al., 2003; Fonseca et al., 2013; Souza et al., 2013).

For Moral (2004), the use of geographic information systems (GIS), with the support of geostatistics, is an instrument that allows explaining the ecological processes of species in a very simple way, since they are computerized tools that help the study of the fluctuation and distribution of pests in crops.

This research work is justified due to the alarming situation that the trees in the city of Guayaquil are experiencing, since the majestic trees that previously provided shade now look defoliated and in many cases, the death of the tree has been imminent, being a panorama that is repeated more and more, becoming critical the state of the green areas of the city.

Therefore, the objective of this study was to identify pest and beneficial insects by sampling samán trees for the modeling of their spatial distribution in the Guayaquil Canton.

Materials and methods

This research work was carried out in the urban area of Guayaquil, where samples of material infested with mealybugs (Hemiptera: Pseudococcidae) and ribbed mealybugs (Hemiptera: Monophlebidae) were taken at various points in the northern area of the city. In addition, the vegetative material that contained these insects and their natural enemies was taken during the dry season, when these pests predominate in the city.

Sampling of pest and beneficial insects

Samples were taken in different parts of the city of Guayaquil presented in Table 1, in samán trees that were infested with mealybugs and ribbed mealybugs. Infested branches were cut with pruning shears and then stored in large sleeves to preserve the specimens collected.

Once in the laboratory, the samples were side-cut, cutting-type and placed in small moistened containers under each twig to preserve the sample for as long as possible. These were then placed in a larger jar to preserve each sample in its entirety. This procedure was performed in the case of samples containing monoglycebids. The samples that had the presence of pseudococcids were placed in small containers, whose interior contained a beet previously disinfected with 5% hypochlorite, and the branches containing the pseudococcids were placed near the alternate host so that they migrate to it. This procedure was carried out in order to be able to feed the natural enemies present and obtain the adult specimens.

Table 1. Samples collected and their respective coordinates in the study area in Guayaquil, Eduador.

Samp le No.	Zone	Location	Species Vegetative	Georeferencing		
				Coord. X	Coord. And	Altitud e m.a.s.l.
1	North	Samanes Park	Saman	622120	9767595	17m
2	North	Sector Villa Bonita	Saman	612752	9772879	19m
3	North	My Lot Sector	Saman	615066	9771802	34m
4	North	Gustavo Noboa Benjamin (via Daule)	Saman	616910	9771649	27m
5	North	Via Daule roundabout	Saman	617910	9769590	33m
6	North	Narcisa de Jesús Highway in front of Romeria Plaza	Saman	621685	9771599	8m
7	North	Narcisa de Jesús Highway against Mucholote	Saman	622643	9770636	12m
8	North	Narcisa Jesús and Av Paseo del Parque	Saman	623102	9768323	19m
9	North	Av Paseo del Parque	Saman	622694	9767863	14m
10	North	Narcisa de Jesús Highway	Saman	623967	9766472	16m
11	North	Los Geranios- Highway	Saman	622720	9769353	16m
12	North	Mucholote 2 – Paraiso del Rio Av Costanera	Saman	624060	9772409	11m
13	North	Av. The Americas and John Tanca Marengo	Saman	623250	9760766	5m
14	North	Isidro Ayora Avenue	Saman	623638	9763109	9m
15	North	Agustin Freire Garden Park of Infants	Saman	622687	9762755	11m
16	North	Watercolor of the Park River	Saman	623718	9764195	20m
17	North	Brisas del Rio Main Park	Saman	623878	9764325	8m
18	North	Av. Las Americas on TC TV	Saman	623668	9761480	7m
19	North	La Garzota Park, Av la Salle	Saman	623431	9763083	8m
20	North	Atarazana, Parque Jardín de Infants	Saman	624349	9759858	12m
21	North	Sauces 3 – in front of the market Sauces 9	Saman	623261	9764626	6m

Identification of pest and beneficial insects

The insects found in the different samples were taken to the Agency for Phytosanitary and Zoosanitary Regulation and Control (AGROCALIDAD), Entomology Laboratory for their respective assembly and identification at the genus and species level.

Spatial distribution mapping

For the spatial analysis, the Sadieshell and Surfer software were used, which allows us to know the degree of association of the variables studied. This program was conceived to perform analyses in the field of entomology and in its current development SADIE allows the analysis of the spatial pattern of individual variables and pairs of variables taken in the same coordinates, which can well reflect the analysis of the same variable over time using a series of distance indices. and relying heavily on graphical representations, SADIE allows characterizing the spatial pattern of a given variable within the study area (Maestre et al., 2008). Using a series of distance indices, SADIE makes it possible to characterize the spatial pattern of a given variable within the study area (fundamentally distinguishing three types of spatial pattern: aggregate, regular or random) and to estimate the contribution of each sampling point to the overall spatial pattern. SADIE also allows the statistical evaluation of the spatial association/dissociation patterns of two variables in the study area, provided that the data for both have been taken at the same coordinates, and the generation of local association/dissociation indices for each sampling point that can be represented graphically by means of maps (Maestre et al., 2008).

Results and discussion

Pest and beneficial insects found in the city of Guayaquil

The pest insects that predominated in the samplings were the superfamily Coccoidea, *Crypticerya multicicatrices* Kondo and Unruh, 2009 belonging to the family Monophlebidae, followed by the family Pseudococcidae, with the species *Ferrisia virgata* Cockerell, 1893 and *Maconellicoccus hirsutus* Green.

Other insects belonging to the order Hemiptera were found in lower density, such as *Brachyplatys subaeneus* Westwood, 1837 (Hemiptera: Plataspidae) and *Spilostethus* sp. (Hemiptera: Lygaeidae).

In the research carried out by Herrera et al. (2021), the presence of *C. multiscars* was confirmed in several parts of the city of Guayaquil, such as in the Entre Ríos citadel and the Guayaquil Botanical Garden, which has reported high infestations during this time since July 2021. These authors state that the most susceptible species recorded in the evaluation carried out in the cantons of Guayaquil, Samborondón, Daule and Durán, are mostly of the Fabaceae family such as: *S. saman* (saman), *Delonix regia* (red locust), *Cassia reticulata* (drone), and *Tamarindus indica* (tamarind).

According to the scale insect database, ScaleNet (García Morales et al., 2016), *S. saman* is a host of *F. virgata*, but in Ecuador this is the first report of this species as a potential pest in the urban area of the city.

The presence of M. hirsutus *as a potential pest in* S. saman *is reported for the first time*. Authors such as González (2009) confirm the pink mealybug of the hibiscus *M. hirsutus* as a plague of the saman. Likewise, Hernández et al. (2020) mention *M. hirsutus* as a polyphagous pest that represents a global threat, affecting the diversity of crops such as cocoa plantations that are in bloom, at the same time that they fall on the shoots, leaves and fruits (chilillos), cause yellowing symptoms in the leaves and intervene in the photosynthesis process.

As far as beneficial insects are concerned, predators were found mealybugs (Hemiptera: Pseudococcidae) several species of ladybugs (Coleoptera: Coccinellidae), such as *Cheilomenes sexmaculata* Fabricius, 1781, *Diomus* sp., *Cycloneda friiy* Crotch, 1874, *Cycloneda melanocera* Mulsant, 1850, *Cycloneda* sp., *Hyperaspis bromelicola* Sicard, 1925, *Tenuisvalvae bromelicola* Sicard 1925, *Paraneda pallidula* Mulsant 1850, and *Tenuisvalvae* sp., , and the species *Novius punicus* Gordon, 1972, as predator of the ribbed mealybug, *C. multiscars*. A species of killer bug, *Zelus* sp. (Hemiptera: Reduviidae), and a low percentage of lacewing, *Chrysoperla carnea* (Neuroptera: Chrysopidae).

In the samples collected, the parasitoid was found *Homalotylus* sp. endoparasitoid of larvae and pupae of Coccinellidae. 40 species have been described in the world, of which 13 are found in America and are known to be endoparasitoids of coccinellid larvae and pupae. Several authors point out that the populations of this group of encircleds can affect the natural regulation of pests since they can reach up to 100% parasitism, affecting the natural regulation of several pests of the families Aphididae, Coccidae and Pseudococcidae (Trjapitzin & Ruíz, 1997)(Bayoumy, 2011)(Yinon, 1969)(González et al., 1999).

The genus *Cycloneda* has been reported by González et al. (2022) with several species that exert their predatory activity on several pests. In the present study, a new record is reported for Ecuador of the coccinellid *C. melanocera*¸ which has not been previously reported in Ecuador, but is widely distributed in Colombia.

Spatial distribution of the insects found

With regard to the spatial distribution of insects, it can be observed that *F. virgata* It is the pest that has a greater spatial distribution compared to *C. multiscars*, despite being the predominant species in saman trees, its dispersion is less (Figures 1A and 2A). This behavior is due to the fact that the nymphs of both families have different morphological characteristics, the nymphs of *Ferrisia* They are very active and can travel long distances through the wind. In addition, pseudococcids in the first nymphal stage measure approximately 0.20 mm and have three evolutionary periods known as "torpedo" which begins when the nymphs move in search of food, "activity" and "growth". In addition, the biological cycle of mealybugs is approximately 40 days. Authors such as (Jacas & Urbaneja, 2006)(Panis, 1969)(Jacas & Urbaneja, 2006)Sotelo and Kondo (2016) they mention that *C. multiscars* It is characterized by a long life cycle that extends over five months. These same authors state that nymph I has high mobility and can migrate to the top of a host plant, and once they settle they double their size and length, in addition, in this nymphal state there is a high mortality between (45%-52%).

These biological parameters explain the rate of dispersion of both families of scale insects present in the city's trees. Since their morphological characteristics provide advantages in the speed of host colonization.

Maconellicoccus hirsultus , although it is true that it is the least predominant, it can be observed that it occupies a second place in dispersion. For Niebla et al. (2010), *M. hirsutus* represents a potential danger to Cuba due to its ecological plasticity, colonization capacity, and the harmful nature it has had as a pest.

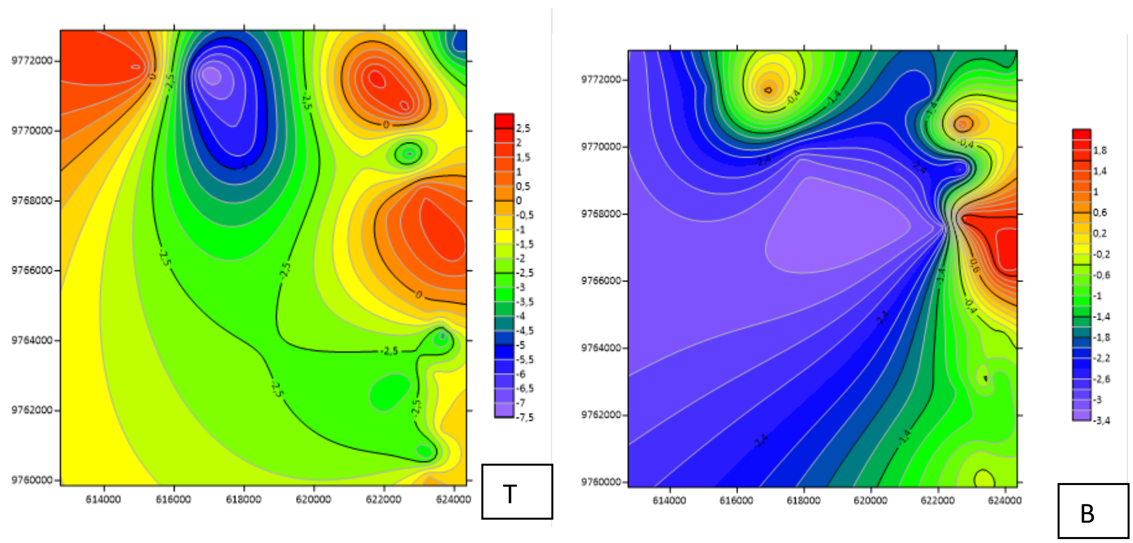

Figure 1. Spatial distribution of A) *Ferrisia virgata* and B) *Maconellicoccus hirsutus.*

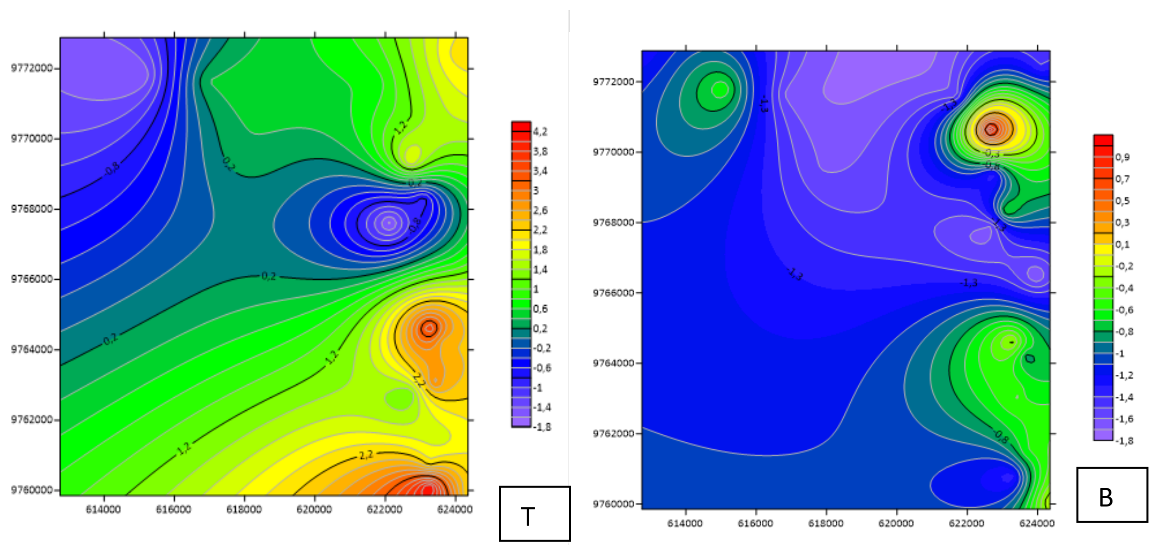

Figure 2. Spatial distribution of A) *Crypticerya multiscars*.B) *Spilostethus* sp. where?

The insects *Spilostethus* sp. and *Brachyplatys subaeneus* were found in a smaller proportion in the samples collected (Figures 2B and 3A).

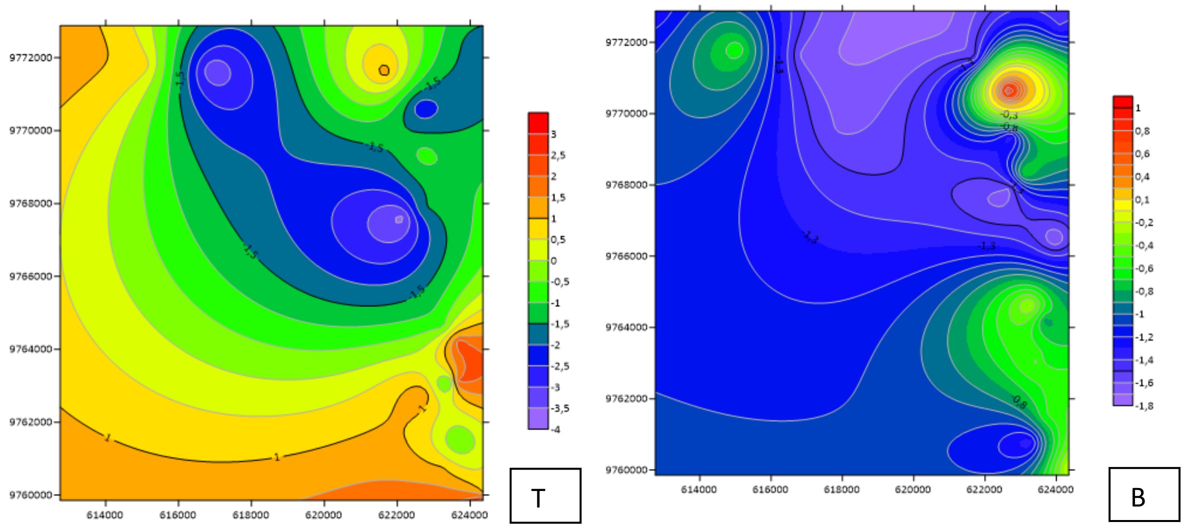

Figure 3. Spatial distribution. A) *Brachyplatys subaeneus* and B) family Coccinellidae.

With regard to beneficial insects, a much wider distribution of coccinellids can be observed compared *to Chrysoperla carnea* and *Zelus* sp. (Figures 3B and 4).

The authors Roig et al. (2020) They mention that coccinellids act effectively as biological controllers of important pests of agriculture, the most common prey being species of the order Hemiptera suborder Sternorrhyncha such as "aphids" (Aphidoidea), "scales" (Coccoidea), "whiteflies" (Aleyrodoidea), "psyllids" (Psyllidae) and "cottony mealybugs" (Monophlebidae). In predatory coccinellids, capture is based on a search where the insect travels the leaves following specific patterns until it contacts the prey. In Argentina Heit et al. (2013) They studied the species *Cycloneda sanguine* Linnaeus, 1763, the effect of odoriferous signals emitted by prey on prey search patterns. In addition, biological aspects such as laying, which range between 300 and 500 eggs, and in many cases more than a thousand during their life, an amount related to availability and type of feeding. (Hurst & Jiggins, 2000)In In the Southern Cone of America, larvae are most abundant in the months of November and December, declining towards March Roig et al. (2020). Based on the experience of the aforementioned studies, this would explain the wide dispersal of coccinellids in the city's woodlands, since mealybugs are widely distributed in saman trees.

The neuroptera *C. carnea* is also associated with populations of *M. hirsutus* (Chong et al., 2015). In addition, Watson (2016) mentions *C. carnea* as a predator of *F. virgata*.

Finally, despite the fact that *Zelus* sp. is a generalist predator and has been reported preying on mealybugs, this behavior could not be observed on the pests found.

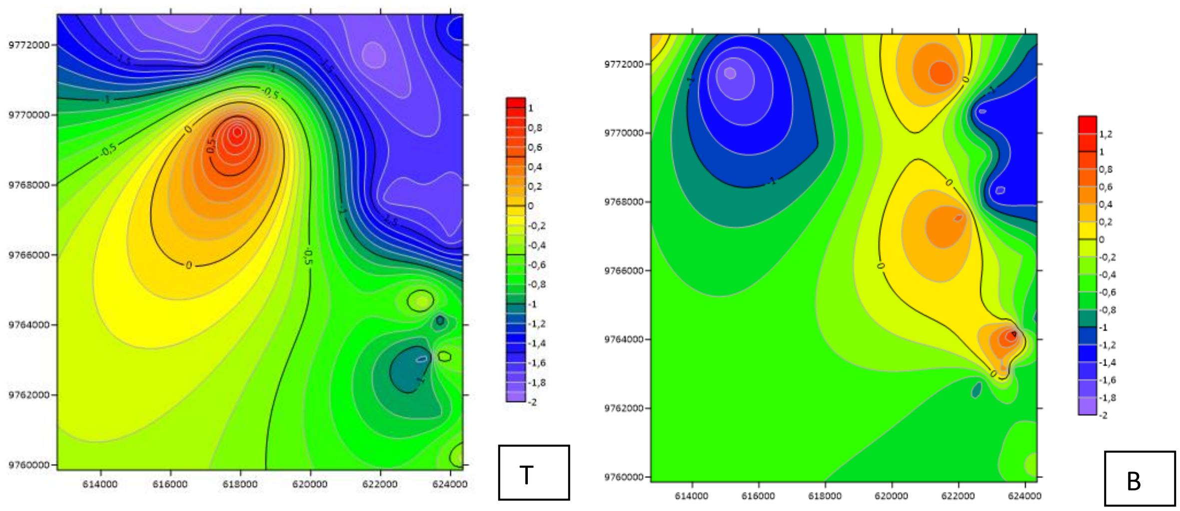

Figure 4. Spatial distribution A) *Chrysoperla carnea and* B) *Zelus sp*.

Conclusions

The pest insects that cause the death of samán trees correspond to a complex of scale insects belonging to the superfamily Coccoidea, identified *C. multiscars* (Hemiptera: Monophlebidae), *F. virgata* and *M. hirsutus* (Hemiptera: Pseudococcidae). In addition, *F. virgata* and *M. hirsutus* are reported in Ecuador as potential pests in saman, since they showed a greater dispersion despite *the fact that C. multicatrices* is the predominant species in all samplings, which suggests urgent actions to address this problem since the complex of mealybugs and ribbed mealybugs causing the death of Buenos Aires trees is advancing.

Coccinellids are the biological controllers that predominate in this study, therefore, the study on the biology of the coccinellid parasitoid *Homalotylus* sp. is of special interest since it may be the cause of the inefficiency of the biological control of this pest by this important family of predators.

The coccinellid *C. melanocera* (Coleoptera: Coccinellidae) is first reported for Ecuador.

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