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What is in a label? Rainforest-Alliance certified banana production versus non-certified conventional banana production

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ABSTRACT

Export banana production in Latin America is pesticide intensive, receiving much negative publicity regarding human health problems and environmental degradation. The Rainforest Alliance (RA) certification scheme was established to certify farms that met a number of social, occupation health and environmental standards set by RA and their certifying body, the Sustainable Agriculture Network (SAN). This study was one of the first, independent studies of the environmental impact of some of the principles set by RA and SAN. The study focuses on insect and bird diversity as an indicator of ecosystem health. Five RA certified farms, six non-RA certified farms, and five organic certified farms were sampled. The data was analyzed with RDA multivariate analyses and Monte Carlo permutation tests. The results showed that RA certified farms had less insect diversity compared to non-RA certified farms and that both farm types had less insect diversity than organic farms. There was little difference between RA and non-RA certified farms with regards bird community composition. Thus, organic farming conserves biodiversity, while alternative environmental labels (e.g. a Rainforest alliance seal) may not have any visible positive effect on in-farm biodiversity. This study points to the need for improvements in SAN certification standards to achieve improved environmental conditions.

1. Introduction

As the impact of human activities increasingly degrade environmental quality, the role of conservation of environmental resources becomes increasingly important. Yet, in agricultural areas, this conservation needs to be balanced with the competing economic needs for agricultural production. Agriculture is a significant activity contributing to environmental degradation, and is one sector in which research has focused on practices that may reduce the level of degradation.

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In Latin America, and more specifically in Costa Rica, export banana production is one such agricultural commodity whose production significantly degrades the environment. The high-intensity of pesticide use in Costa Rica for the production of export bananas has been well-documented (Stover and Simmonds, 1987; Hernandez and Witter, 1996; Hernández et al., 2000; Marquardt, 2002; FAO, 2002; Bellamy, 2013). Costa Rica is the world's second largest exporter of bananas. Costa Rica also has one of the highest intensities of pesticide use in the world (per agricultural worker) due in large part to their banana production, which accounts for an estimated one-third of the country's pesticide consumption (Von Düszeln, 1988). It is a similar case with banana production throughout Latin America, where export production is dominated by large farms and largely influenced by the three multinational banana companies, Chiquita, Dole and Del Monte, which export an estimated 80% of the bananas produced (FAO, 2002).

Export banana producers have experienced heavy social pressure, initiated by international environmental and other non-governmental organizations, to produce bananas with less pesticide-intensive methods. As a result of both this pressure and the increasing costs of chemical inputs, research within the export banana sector has looked at how to reduce these costs and at the same time improve environmental quality. One such outcome of this has been the role of the Rainforest Alliance (RA) organization in offering certification to farms that comply with a set of standards chosen in order to achieve improvements in both the environmental and social impacts of banana production.

The largest producer to receive RA certification is Chiquita Brand International; every Chiquita farm in Costa Rica is certified and Chiquita is working with RA to certify all of their farms in Central America. RA certification is awarded to farms that comply with a set of standards that are set by the Sustainable Agriculture Network (SAN). The RA is the secretariat for the SAN. Banana is just one of over 40 crops that the RA use in their certification scheme. RA has certified over 1600 banana farms, resulting in an area of 109,000 ha under certification (RA, 2015). Certification by SAN is based on 10 principles: social and environmental management system; ecosystem conservation; wildlife protection; water conservation; fair treatment and good working conditions for workers; occupational health and safety; community relations; integrated crop management; soil management and conservation; and integrated waste management SAN (2005, 2010). While fieldwork was conducted during 2007, ongoing follow up visits, informal interviews and observations of practices on banana farms confirm that management of banana production remains unchanged. Furthermore, while RA standards are undergone modifications during this time, they have not been to the extent that they have modified management practices in the areas in which this research is concerned SAN (2005, 2010).

While Chiquita began strongly marketing the RA certification seal in Europe in 2005, as an alternative 'green' label that promised reduced environmental impact on the farms receiving its certification (Corporate Social Responsibility, 2005), there is a lack of research to support these claims. In order to convince skeptical consumers and critics, and as a result of their own strong belief that their practices really do make a difference, Chiquita agreed to allow access to their farms for independent research to be conducted that would compare the ecological state of their own farms with those of uncertified competitors. The research presented here is, in part, the result of this open access to Chiquita farms for field work, and aims to fill the void of information regarding the ecological impact of various banana management systems. We test the hypothesis that management practices resulting in RA certification lead to reduced environmental impact on and around these farms compared to non-RA certified farms.

2. Methods

In order to measure the impact of production practices on the local ecology, we measured insect diversity and abundance and bird diversity; we complemented this data with a habitat characterization of each sampling site. Arthropods were chosen as the measure of environmental quality for this study because they comprise 90% of the organismal variability of all species; they dominate the structure of ecosystems (Pimentel et al., 1992); and they perform crucial functions to stabilize ecosystems (Wilson, 1987), all of which makes them a good measure for both biodiversity evaluation (Duelli et al., 1999) and ecosystem resilience. Greater ecosystem resilience is in the economic interest of banana producers, because it means that the production system has a greater capacity to respond to extreme events like flooding, drought, and waves of high pest pressure or the introduction of new pests, and enables the system to return to a state of equilibrium.

Surface-dwelling arthropods are often used in biodiversity inventories in agricultural areas because many species are polyphagous predators, they are easily collected in pitfall traps, and catches in pitfall traps provide a large enough number of species to allow for the application of statistical methods (Duelli et al., 1999). In addition to the sampling of surface-dwelling arthropods, sampling Heteroptera and some suborders within the Hymenoptera group (via the use of yellow bowl traps) can be a good indicator of biodiversity (Duelli et al., 1999). Thus, sampling with the use of both pitfall traps and yellow bowl traps can enable the evaluation of environmental quality of a site, with a view towards sustainable management practices within the banana production system.

Insect sampling was thus conducted using these two different methods for trapping insects. Yellow bowl traps and pitfall traps were set out at each sampling site. Sites sampled at the banana farms were placed along a transect running from the forest to the edge, to 30 m in, to the center of the farm. (See Fig. 1.) On some small farms ($n = 2$), the site that was 30 m in also constituted the center of the farm. On other farms there was no adjacent forest ($n = 7$). The specific site for each sampling point was decided in advance after consulting a map of the farm and surrounding land uses. In cases where there was not forest adjacent to the farm, the edge site was placed adjacent to rivers ($n = 3$) or open pasture ($n = 4$).

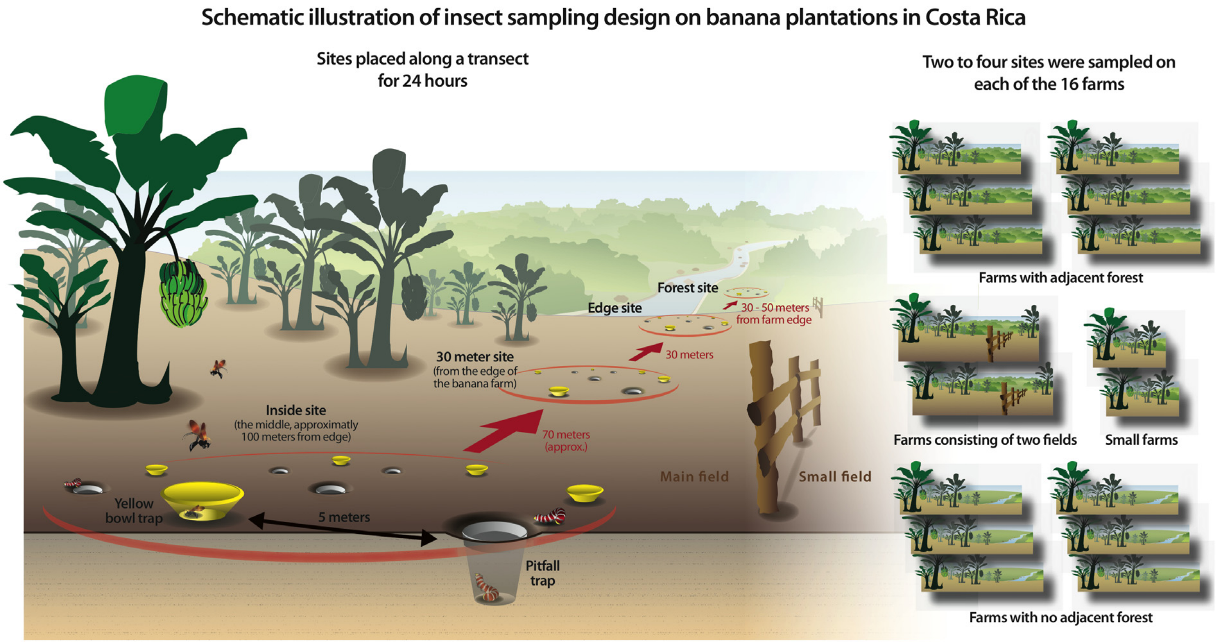

Fig. 1. Schematic illustration of sampling design.

The choice of running a transect from the forest, to the edge, to the interior of the farm was to analyze if farms with adjacent forest areas benefit from the forest as a source of recruitment for insect populations. The 30 m in site was chosen in order to cancel out the possibility of differing edge effects on farms of different sizes; on a large farm, the center point is further from the edge than on a small farm. Thus the sampling point 30 m in is a standardized point of comparison between farms.

At each site, we placed 5 yellow bowl traps and 5 pitfall traps. Each trap was placed at least five meters apart (Sutherland, 2006). Traps were left in place for 24 h. Sampling took place during the month of March 2007. While parts of Costa Rica have a defined dry season, rainfall on the Caribbean plains, where banana farms are located, is constant the entire year, with monthly average rainfall varying between 200 and 400 mm. Average monthly maximum and minimum temperature for the region fluctuates by only 1 °C over the year. Owing to both the steady climatic variables and constant vegetation phenology of banana farms, it is expected that there is very little seasonal fluctuation in the insect populations sampled (Lowman, 1982; Wolda, 1988; Agarwala and Bhattacharya, 1994; Young and Wright, 2005; Price et al., 2011).

2.1. Yellow bowl traps

These traps are useful for catching flying insects, especially Diptera (flies), Hymenopteras, Hemipteras, and Homopteras. The traps used in this project were 12-ounce, yellow, Solo brand, plastic bowls (LeBuhn et al., 2006). Water, pre-mixed with blue Dawn detergent soap (3–5 mL soap/L of water; LeBuhn et al., 2003) was poured into the bowl, approximately 3 cm deep. The soil surface was cleared of debris and the bowl placed on the flat ground.

2.2. Pitfall traps

These trap types are useful for catching living, surface-dwelling insects such as Coleopteras (beetles) and Formicidae (ants), and Araneida (spiders). Hard plastic bowls with straight sides, 15 cm deep and a circumference of 44 cm were dug into the ground so that the lip of the bowl was even with ground level. The same water–soap mixture used for the yellow bowl traps was used with the pitfall traps, and was poured into the bowl, approximately 3 cm deep. A plastic lid, propped up approximately 3 cm above the lip of the bowl with the use of 3 popsicle sticks/lid, was put in place to keep rain water and debris from falling into the bowl (Sutherland, 2006).

In the lab, the mixture for both the pitfall traps and the yellow bowl traps were strained, using a 0.5 mm mesh net, rinsed, and then placed in a 70% alcohol solution until identification took place. Identification was conducted with a stereoscope and each insect was identified to family and then morphospecies. Local entomologists who are experts on Central American arthropod fauna were employed to assist us, and we used the most recent versions of the local arthropod fauna identification literature available (Ugalde, 2002; Solís, 2002; Zumbado, 2006). Examples of each morphospecies from each sampling location were deposited with the National Institute of Biodiversity (Instituto Nacional de biodiversidad, INBio) in Costa Rica.

Table 1
A list of the environmentally orientated principles in the Sustainable Agriculture Network certification guidelines. On-farm and off-farm activities refer to actions that can directly impact the environment of the farm and the surrounding areas. The likelihood to impact insect or bird diversity assumes perfect implementation of criterion.
Source: Information presented here is taken from SAN (2005, 2010).

Environmentally orientated principle	On farm activity	Off farm activity	Likelihood to impact insect diversity	Likelihood to impact bird diversity
Ecosystem conservation	Protected riparian zones, hedgerows to prevent drift	Reforestation, forest conservation	Medium	High
Wildlife protection		Conservation of habitat	Low	High
Water conservation	Water quality and analysis program; appropriate treatment of wastewater	Surface water quality and analysis program	Low	Low/Medium
Integrated crop management	Integrated pest management program; rotates use of pesticides; reduces use of pesticide; eliminates use of most toxic pesticides	N/A	High	Medium/High
Soil management and conservation	Soil erosion control program; fertilization program based on soil analysis; organic residue recycled; vegetative ground cover established	Cannot expand production into natural areas	Medium/High	Low/Medium
Integrated waste management	Integrated waste management program		Low	Low

Table 2
Average values for the three farm management types studied: organic, conventional and Earth. *N* is the number of farms in the category. Mean size (ha) is the average size of the farms in hectares. The following three columns refer to the number of herbicide applications, nematicide applications and fungicide applications, respectively, per year. Insecticide-impregnated bags refers to whether or not farms used them (all conventional and Earth farms used them, while none of the organic farms did) to cover the banana bunch during the maturation phase. The final two columns refers to the average number of times manually weeding per year and the average number of other crops cultivated on the farm.

Farm type	*N*	Mean size (ha)	# herbicide applications	# nematicide applications	# fungicide applications	Insecticide-impregnated bags	# times manual weeding	# other crops
Organic	5	13.6	0	0	0	No	3.8	9.2
Conventional non-RA certified	6	172	6.5	3	56	Yes	1.7	0
Conventional RA certified	5	229	7	3	50	Yes	6.5	0

2.3. Bird sampling and habitat characterization

A bird survey was done at the inside, edge and forest site for each farm. Each bird survey consisted of two five-minute point counts with audio recording according to Gibbons and Gregory (2006), with 6 recordings taken for each farm. The audio recordings were later identified by an expert and a list was compiled of each bird species that was present at each site.

A habitat characterization was done for each site, in order to characterize the complexity of plant structure at each sampling site. This was done by employing 5 × 5 m quadrants, according to Bullock (2006). Three quadrants were used for each sampling site and the inside, edge and forest sites were sampled on each farm. For each quadrant, the number of different plant species measuring over one meter tall were recorded.

2.4. Study area

A total of 16 banana farms of different management regimes were sampled. Five farms were small-scale and had received organic certification for their banana production. These farms were located around Cahuita, on the southeast Caribbean coastline of Costa Rica in the Atlantic zone (see Fig. 2). They varied in size and age, ranging from 2–25 ha and 10–20 years old (see Table 1). They also varied with regards to the diversity of crops grown on the farms.

Six farms were large-scale conventional monocultures of banana production located in three different locations in the Atlantic zone: Matina, Guacimo and Puerto Viejo de Sarapiqui (Fig. 2). The farm sizes ranged from 160–320 ha and 8–17 years of age (Table 1). The final five farms were large-scale conventional monocultures of banana production owned by Chiquita Banana company and had received certification from the Rainforest Alliance program. These farms were located in Matina and Puerto Viejo de Sarapiqui (Fig. 2). They ranged from 120–280 ha (Table 2).

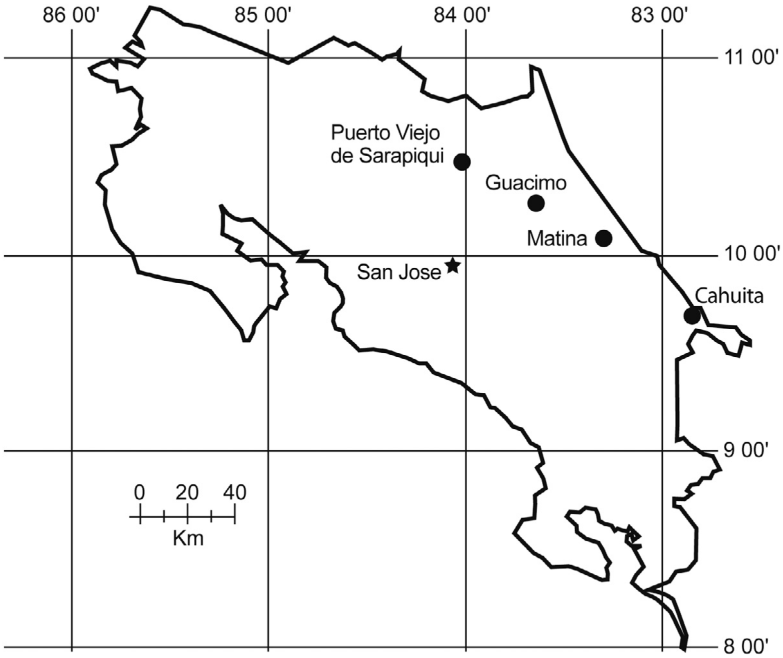

Fig. 2. Map of Costa Rica, with the different sampling areas indicated.

2.5. Data analysis

The effect of management type and sampling location on insect species diversity was studied with multivariate statistics, using two ordination techniques: principle component analysis (PCA) and redundancy analysis (RDA). Multivariate analyses are used frequently nowadays in ecotoxicology to describe differences in community composition among sites and to relate these differences to a chemical treatment (see for instance Van Wijngaarden et al., 1995; Kedwards et al., 1999; van den Brink et al., 2003). We expected that the species measured in this study would have a linear response (as opposed to a unimodal response) to the explanatory variables, so we used PCA, principally RDA, which is the canonical form of PCA. While PCA selects the linear combination of species that gives the smallest total residual sum of squares, RDA also considers the linear combination of explanatory variables in order to analyze how well the explanatory variables explains the species data (Ter Braak, 1995).

PCA and RDA analyses generate ordination diagrams that allow one to compare how closely the different sites are related to each other in terms of species composition and how the species composition varies between treatments, i.e. management types. Sites that lie close together on the diagram share a more similar species composition than those sites that lie further apart (Ter Braak, 1995). In addition to the visual representation of data provided by these ordination techniques, the statistical significance of hypothesized differences was obtained using Monte Carlo permutation testing according to Ter Braak and Šmilauer (2002).

To test our hypothesis, we first performed an RDA analysis using species data from the inside and the 30 m sampling sites on each farm. Nominal variable denoting the management type of the samples were introduced as explanatory variables, while nominal variables denoting whether samples were taken at the inside and 30 m sites were introduced as covariables in the analysis. The latter means that the part of the variance captured by the site location within the farm is excluded from the analysis.

To further test our hypothesis, we looked at the effect of forest conservation on insect community composition. We performed a RDA analysis again using species data from the inside and the 30 m sampling sites on each farm, which were introduced as covariables in the analysis. In both analyses, Monte Carlo permutation tests were run to evaluate the differences in species composition between each management type separately in the first case and between sample locations for farms with and without forests in the second case.

3. Results

In all of the traps combined, we captured 38 091 individual insects, representing 239 families and 19 orders; 67% of the insects were caught in pitfall traps and 33% in yellow bowl traps. A summary of the collected insect data is presented in Table 3. On average, the most insects were caught on non-RA farms, 12% more than on organic farms and 36% more than on RA farms. However, on average, more morphospecies were found per farm on organic farms, followed by non-RA farms

Table 3
Summary of insect data. All data is presented as the average number of individuals caught per site for both yellow bowl and pitfall traps combined. The second column is the average value of insects caught per site for all farm management types (e.g. for the 16 farms sampled, on average 2795 individual insects were trapped), whereas the last three columns present the average values per farm management type.

Average # of insects per:	Overall	RA	Non RA	Organic
Farm	2795	2144	3335	2946
Inside	676	348	901	826
30 m	714	374	861	878
Edge	867	702	981	897
Forest	557	720	592	346
# morphospecies/farm	208	188	210	234

and then RA farms. Lower insect abundances were found in the forest sites compared to other sampling sites on organic and non-RA farms, but the opposite dynamic was true for the forest site on RA farms.

We began testing our hypothesis that RA farms' management practices would lead to reduced environmental impact by running a RDA on the insect samples taken from organic, non-RA and RA banana farms. Fig. 3 shows the results of this analysis, which is that organic, non-RA and RA farms are all different from each other, evident by their location far from the origin of the axis and in three different quadrants and confirmed by Monte Carlo permutation tests, in which all differences tested were significant ($p \leq 0.001$). Fig. 3 also shows an increasing difference in the diversity of community composition across management treatments: organic farms have the highest diversity of insect families, whereas non-RA farms have fewer insect families compared to organic farms, and RA farms have only one insect family with which it is positively associated.

We continued to explore the difference in environmental impact of RA farms and non-RA farms by running an RDA with only these farms present, in order to see where individual farm sites lay with respect to species in the biplot. Fig. 4 shows that all of the RA farms, regardless of whether or not they have forest conserved at their borders, lie on one side of the *x*-axis, whereas all of the non-RA farms and the species lie on the opposite side of the *x*-axis.

Lastly, we ran an RDA on the bird species data that was collected in order to determine if management changes on RA-certified farms made an impact on the diversity of bird species present. Fig. 5 shows that the largest diversity of birds is associated with the organic farms; the forest, edge and inside sites are all different from each other, and each associated with a few bird species; the inside sites are not as strongly associated with any particular bird species, evidenced by its placement close to the origin; there is a small difference between RA certified farms and non-certified farms with regards the diversity of the bird species surveyed; and plant diversity is positively associated with forest, organic farms and a larger proportion of the bird species.

4. Discussion

We find the opposite from what we would expect with regards to insect community composition on RA certified and non-RA certified farms; that is RA certified farms have less diversity in community composition compared to non-RA certified farms. However, when looking at Table 1, one can see that there is very little difference in the number of pesticide applications. The number of fungicide, herbicide and nematicide applications are all equal or similar and both types of farms use insecticide-line bags to cover banana bunches. When looking at Table 2, one can see that the inside and 30 m sites on non-RA certified farms have more insects compared to RA certified farms, and the non-RA certified farms also have more morphospecies per farm, indicating not only a increased insect abundance (which could simply be the result of high insect dominance in a few families), but also increased insect diversity in community composition. This is further supported by Fig. 3, which shows only one insect family positively associated with RA farms, whereas there are 11 families positively associated with non-RA farms. Thus, one can conclude that management practices other than the number of pesticide applications must have an effect on the insect community composition that we see here. Our findings are also quite clear that while alternative environmental labels (e.g. a Rainforest alliance seal) may not have any visible positive effect on in-farm biodiversity compared to their non-certified counterpart, organic farming systems do conserve in-farm biodiversity.

Reduced pesticide use can help to improve the overall biodiversity of beneficial insects and other organisms on banana farms (Bellamy et al. in prep). Greater insect biodiversity is, in turn, in the economic interest of banana producers, because beneficial insects provide a number of ecosystem services important for farm productivity (Daily, 1997). Some insects act as pests and feed on different parts of the banana plant; in the case of bananas produced in Costa Rica, the principle pests are Black Sigatoka, an air-borne fungus and the burrowing nematode *Radopholus similis*, but there are other pests, like the virus disease bunchy top (vectored by the banana aphid *Pentalonia nigronervosa*), and *Cosmopolites sordidus* and *Cheatanaphothrips* spp, which are both insects that affect farms sporadically (Ortiz Vega et al., 1999). These different pest species are the target of the heavy pesticide applications used by conventional banana farms. However, as shown in this research, there are on average over 200 other species found on the farm, that are also adversely affected by the application of pesticides. These non-target organisms play many other functional roles that are beneficial to the production system. Among these functional roles are predation (by both predators and parasitoids), organic matter decomposition and nutrient recycling, regulation of soil

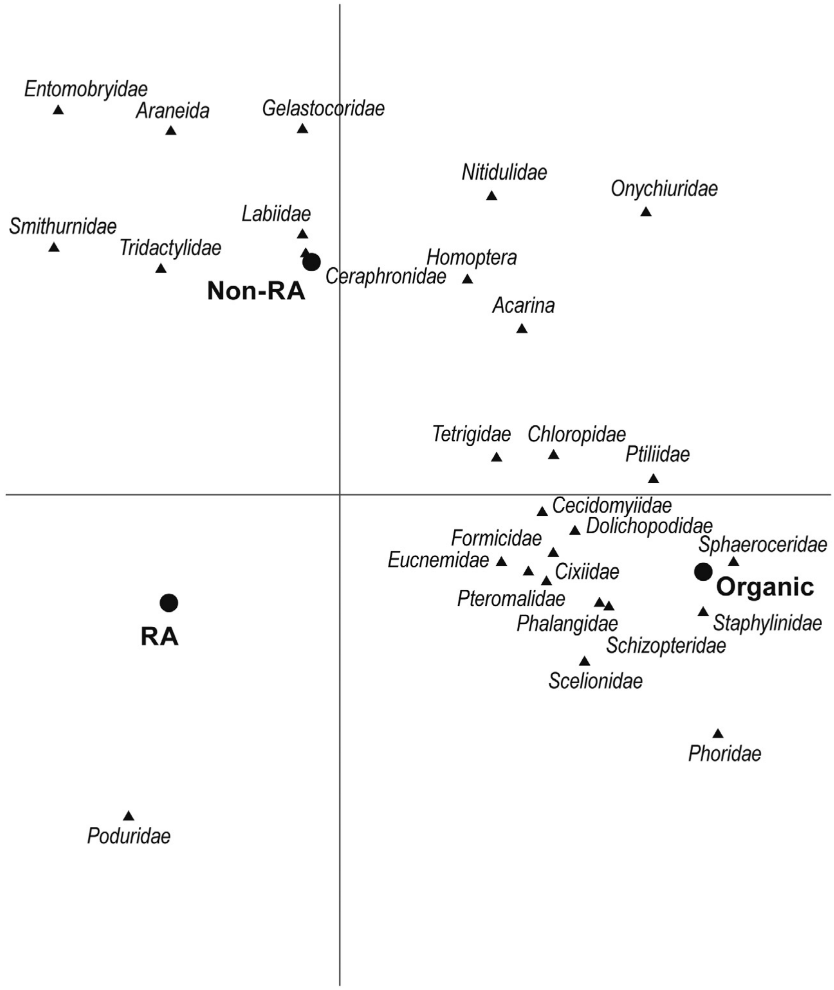

Fig. 3. RDA biplot using pitfall trap data and management as explanatory variables and sample position (inside and 30 m) as covariables. Permutation tests showed that all management styles differed significantly ($p < 0.001$) in species composition. Sample position explained 1% of the total variation in species composition, while management styles explained 11%. Of the latter 68% is displayed on the horizontal axis and the remaining 32% on the vertical axis.

microorganisms, and soil conditioning (soil channeling and moving material to different soil layers). At a broader, landscape-scale, insects also provide pollination services and are an important source of food for birds and mammals. Consequently, the overwhelming majority of insects play a beneficial role, while there are only a few insect species that act as pests, causing economic damage to banana production.

Different species respond differently to stressors, so redundancy within functional roles can act as an insurance and increase the likelihood that net community function will be maintained after a disturbance or extreme event (Loreau et al., 2000; MEA, 2005; Yachi and Loreau, 1999). It has been shown that a large pool of species is especially important in intensive agricultural landscapes to maintain ecosystem functioning (Loreau et al., 2001; Tscharntke, 2005). Enhanced ecosystem resilience is an important benefit provided by biodiversity. Loss of biodiversity undermines the resilience of the system, making it more susceptible to sudden environmental changes or management mistakes, and can translate into lower yields for producers, or even system collapse (Daily, 1997; Russell, 1989).

Based on the results of Fig. 4, we can conclude that the presence of forest conserved at the boundaries of the farm has an impact on insect community composition as shown by the permutation tests. It is concluded that forests in areas adjacent to the farm can serve as a source of beneficial insects providing important on-farm ecosystem services, such as those listed above. However, since both RA- and non-RA certified farms conserve forests in adjacent areas, it does not help to differentiate RA certified farms from non-RA certified farms.

According to Table 1, we would have expected some of the changes in management practices on RA certified farms to have a positive effect on insect and bird communities. Yet this is not the case according to our results. This could be for two different reasons; the first is that changes in management practices on RA certified farms are not qualitatively different from those implemented on non-RA certified farms. The second reason could be that sampling did not capture the full range

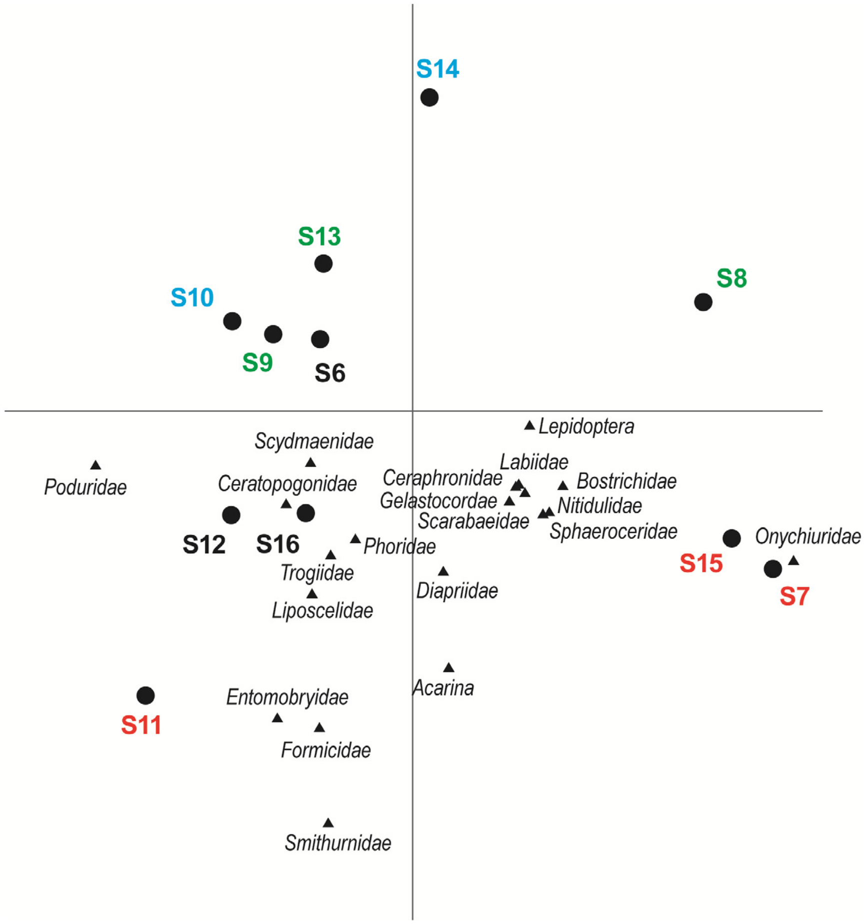

Fig. 4. RDA biplot using sites as explanatory variables and sample position (inside and 30 m) as covariables. Only the RA and non-RA sites are included in the analyses. Sites highlighted in green are RA sites with forest, sites highlighted in blue are RA sites without forest, and sites highlighted in red are non-RA sites with forests. Permutation tests showed that sites with forest differed significantly ($p < 0.001$) in species composition from sites without forest. Sample position explained 1% of the total variation in species composition, while sites explained 37%. Of the latter 48% is displayed on the horizontal axis and 28% on the vertical axis. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of dynamics in insect and bird communities on RA certified farms. Results presented here are less likely to stem from the latter, as sampling was conducted on five different days over the course of a month on farms at different locations, each with a different farm manager and schedule of production practices (i.e. application schedule for herbicides, nematicides, fertilizers, etc.), and yet the results for each farm are remarkably similar. This leads to the conclusion that the dynamics seen here are the result of the collective management activities over a longer time frame than days or weeks.

Thus we come back to the former reason, that of qualitative differences in management practices. The principles of the SAN and RA are to be applauded, as are the indicator activities (see Table 1 for a list of some of these), but many of the activities suggested as indicators are similar to those being implemented on non-RA certified farms, as suggested by interview data presented elsewhere (Bellamy, 2013). Understandably, the SAN standards that have been met best are those that are either profitable or pose no to little risk for productivity. This may be one of the reasons that we see these same actions implemented on non-certified farms.

As this is one of the first studies to be conducted by independent researchers comparing the ecological impact of implemented management practices, there is also little knowledge about how different practices, and changes in these practices, may affect environmental quality. Chiquita's willingness to open up access to their farm for a comparison of environmental parameters is an indication of their desire to make meaningful change, further indicated by ongoing discussions with RA. We suggest that in addition to discussions about proposed changes to certification standards, systematic approaches to testing environmental impacts of proposed changes on a selection of farms be introduced. Results from these evaluations can better inform the process of decision-making and earn credibility from both producers contemplating certification and from consumers purchasing RA-certified products.

It is important to note that this study is not a comprehensive study of all of the impacts of the RA certification-induced changes in management practices; it did not examine the effect of principles and indicators addressing social,

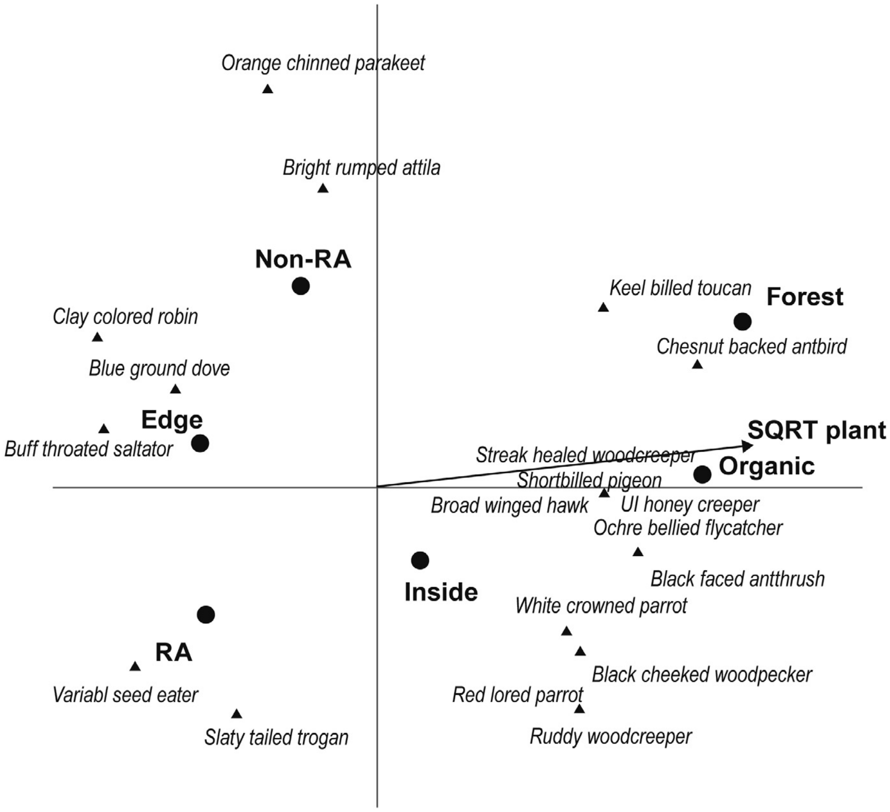

Fig. 5. RDA biplot of bird species, using management, sample position and number of plants (square root transformed) as explanatory variables. The explanatory variables explained 22% ($p = 0.004$) of the total variation in species composition, of which 41% is displayed on the horizontal axis and 20% on the vertical axis.

employment, occupational health or community relations aspects. Additionally, this study did not investigate the effects of water conservation and integrated waste management on adjacent surface waters (although another study conducted by the authors indicate promising results on a method that can be used to investigate impacts to surface waters; Svensson et al. unpublished data). Instead, this study focused on the parameters of certification that influence productivity on the farm, namely integrated crop management, soil management and conservation, and ecosystem conservation (of which there is some overlap with wildlife conservation).

5. Conclusion

Among the different environmental principles of the SAN standards investigated in this study, the results indicate that there is not a difference between RA certified farms and non-RA certified farms. There are, however, a number a efforts made by RA certified farms, such as ditches dug in the canals and planting trees or other broad leaf plants in the canals to intercept pesticide drift and prevent pesticides from moving into the surface waters via the canal drainage system, that have yet to be studied. Furthermore, this study does not investigate the impact of the large areas of forest conservation and reforestation that have been undertaken by RA certified farms in areas adjacent to banana farms and elsewhere.

Based on data presented here, the RA seal cannot compete with organic farming when it comes to biodiversity conservation of arthropods and birds. The risk with the current RA label is that environmentally concerned consumers make choices they would not normally do when buying fruits and other products branded with this label. However, this study is a modest start of a necessary process if RA certified farms are sincere in their efforts to improve the environmental impact of their production practices. It is also a process beneficial to the SAN standards as a means of scientifically informing what changes can lead to meaningful differences in the environmental impact of banana production.

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