Balancing between social and ecological systems to define opportunities for IPM and conservation biological control in subsistence maize agriculture in Central America

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In-field dynamics FAW ~ natural enemies

* Goal: Identify endemic natural enemies and quantify their association with fall armyworm densities and population dynamics in farmers' fields.

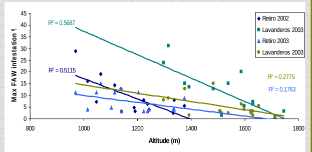
* Approach: Population dynamics of fall armyworm and arthropod predators were measured in 30 maize fields during the 2002 and 2003 cropping season and fall armyworm larvae were collected to screen for parasitism and disease. We assessed the relationships between natural enemy abundance and fall armyworm population dynamics, while correcting for abiotic factors such as altitude.

* Results: We recorded high variability in FAW infestation between fields located within the same community. FAW infestation generally remained below the locally-defined economic threshold of 30-40%. Fall armyworm severity was correlated with altitude, with maize fields at higher altitude characterized by lower pest infestation.

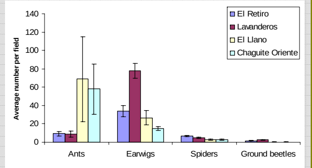
Parasitism rates ranged between 2.7-11.5%, with a total of 13 parasitoid species reared from FAW larvae.

The arthropod predator community was highly abundant and diverse, dominated by Dermaptera (65-70%), Formicidae (15-18%) and Araneae (6%) during both years. The fire ant *Solenopsis geminata* was the most commonly recorded ant (morpho-)species on maize plants (16-46%) and on tuna fish bait (55%).

Between-field variability in FAW infestation was related to abundance (categories) of earwigs, spiders, ground beetles and the ant *S. geminata*. When correcting for the effect of altitude, significant differences in FAW infestation were found for abundance categories of spiders and ground beetles.



Maximum FAW infestation as a function of altitude



Average whorl-stage abundance (± SE) of key natural enemies in the 4 hillside communities

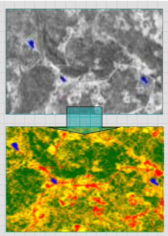
Extra-field contribution ~ FAW predator abundance

* Goal: Relate in-field abundance of predators to the composition and structure of the agricultural landscape that surrounds small-scale maize fields.

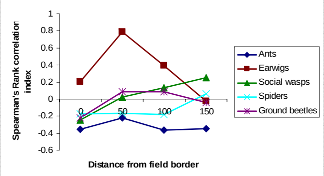
* Approach: We related densities of key predators in fields with the characteristics of the surrounding landscape, through a combination of *in-situ* vegetation classification and spatial analyses. Floristic and vegetational surveys provided an estimate of presence and quality of critical resources within selected extra-field habitats, while spatial analyses allowed us to examine effects of landscape structure.

* Results: In-field abundance of social wasps was related to floral diversity, while earwigs were associated with grass cover in habitats situated beyond the field border. Within-field density of the fire ant, *Solenopsis geminata*, was associated with its presence in the surrounding agro-landscape.

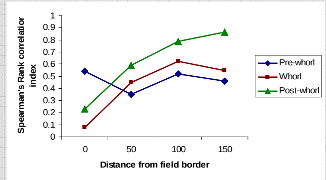
Relationships were explored between predator abundance and spatial cover of habitats that dominate the extra-field environment. Earwigs were associated with grassland patches located in the field surroundings. Abundance of spiders and ground beetles was highest in environments dominated by coffee plantations or mid-successional habitats.



Use of spatial imagery to classify the agricultural landscape in the surroundings of farmers' fields



Correlation between in-field predator abundance and estimates of grass cover at different spatial scales



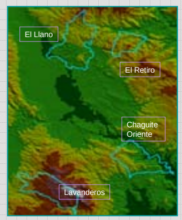
Correlation between in-field *S. geminata* bait occupancy versus its occupancy of bait at different spatial scales

Rationale

To increase agricultural productivity, farmers often rely on chemical inputs that can instigate pest problems, compromise human health, and disrupt the environment. To counteract such effects, integrated pest management (IPM) has been widely promoted in the developing world. Despite these extensive efforts, adoption of crop protection technologies by farmers has varied considerably and factors that limit IPM adoption still await clarification in most crop-pest systems. Experience has shown that, to ensure IPM adoption, the complexities of local agro-production systems, sociological facets of farming communities and context-specific folk knowledge need to be appreciated. Our research then also explores the linkages between social and ecological attributes of subsistence maize agriculture in Honduras.

Research setting & key objectives

Our study was conducted in 4 rural communities located within the Yeguare River valley in SE Honduras. Small-scale agriculture is typical for hillsides environments and is characterized by the cultivation of 2 key staple crops, maize and beans. A major pest of maize production in the region is the Fall Armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Farmers compete with insect pests such as FAW to secure their livelihoods and safeguard their harvest. Subsistence farmers are commonly thought to easily revert to pesticides as option for agricultural pest management and various institutions have then also operated in the region to ease farmers' transition to IPM. Two communities (El Retiro, Lavanderos) are characterized by intense and recent IPM training, while the other 2 have been served to lesser extent.



Positioning of communities in the upper Choluteca watershed along an altitudinal gradient

Key objectives:

Objective 1. Determine FAW pest severity and quantify the contribution of natural control in subsistence maize production.

Objective 2. Assess the contribution of the extra-field environment on the probability of successful IPM implementation.

Objective 3. Evaluate the adoption of IPM practices by small-scale maize farmers in Honduras.

Objective 4. Determine the role of social connectedness in IPM diffusion.

Lessons learned & implications for IPM extension

* Lessons learned:

1. Natural enemies are important in preventing FAW pest outbreaks; the natural enemy complex includes spiders, earwigs, carabid beetles, ants and social wasps
2. Characteristics of the natural enemy community are set by patchiness of the agro-landscape, which is mainly shaped through shifting cultivation
3. Complex of natural enemies in different agro-landscapes is sufficient to moderate FAW dynamics to prevent outbreaks in farmers' fields across communities
4. Farmers have a good appreciation of abundant, conspicuous predatory species, and their knowledge reflects ecological features of their respective fields
5. Farmers evaluate pest severity well and make pest management decisions accordingly, with IPM training boosting farmer technical and agro-ecological knowledge
6. Information on natural enemies and pesticide alternatives diffuses through the social system

* Implications for IPM extension:

1. A solid understanding of ecological facets of subsistence maize production is crucial to formulate appropriate, locality-specific IPM recommendations
2. Visualizing results from field surveys in a GIS environment could shed light on regional patterns of pest severity and availability of 'ecological tools' for pest management
3. Extra-field contribution to pest management accentuates the importance of filling gaps in farmer knowledge on habitat manipulation, evt. through adaptive co-management and active involvement of farmers and IPM / NRM professionals
4. Availability of a range of pest management options in folk knowledge may be necessary for livelihood strategies to remain adaptive over time
5. Patterns in natural enemy diversity within and between communities stress the need for participatory IPM extension that embraces differences as well as similarities
6. The sharing of pest management information through interpersonal channels creates opportunities for IPM extension modules such as 'Going public'

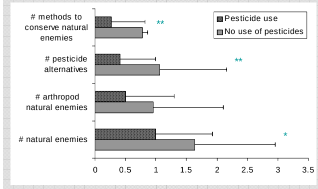
Local agro-ecological knowledge ~ pest management

* Goal: Determine farmers' knowledge of major pests and associated natural enemies in maize production systems. Compare agro-ecological knowledge of trained vs. untrained farmers and link farmer knowledge to understanding and adoption of IPM, including conservation biological control.

* Approach: A total of 30 farmers per community were surveyed on their perception of FAW pest severity and related management decision making. We also assessed farmers' agro-ecological understanding and their knowledge of biological control. Lastly, we recorded farmer attendance of IPM training sessions and related this to their knowledge and behavior.

* Results: Although 92% of farmers mentioned FAW as an herbivore in their fields, crop losses from this pest were considered negligible. Many farmers ascribed low FAW infestation to weather anomalies (47%), while the role of biological control (2.5%) was poorly recognized.

Most farmers (66.7%) did not actively manage FAW in their fields, mainly because they felt no need for intervention. Of the farmers that adopted pest management practices, 55% relied on chemical insecticides. Farmers cited various alternatives to pesticide use, with curative practices (e.g., manual control) better known than preventative ones (e.g., alteration of planting date, soil management).



Differences in agro-ecological and technical knowledge (e.g., conservation biological control) for farmers who used insecticides and those who didn't

Farmers were aware of several natural enemies operating in their fields, with local knowledge largely restricted to easily observable predatory species. On a community level, farmers' appreciation of natural enemies was associated with their in-field abundance.

The number of insect natural enemies known was correlated with the number of recognized pesticide alternatives and conservation methods. Farmers who used insecticides knew little about biological control and pesticide alternatives. Trained farmers mentioned more natural enemies and were familiar with a broader range of pesticide alternatives than untrained ones.

Role of social connectedness & information sources in IPM diffusion

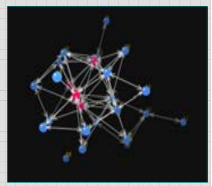
* Goal: Assess the composition of farmers' social networks and their importance in IPM diffusion. Determine the role of opinion leadership and the influence of pest management information sources in affecting the spread of IPM-related information.

* Approach: We asked 120 farmers to describe the information sources they relied upon for making pest management decisions, used sociometrics to obtain a measure of opinion leadership and plotted social networks in each community based upon farmers' social connectedness.

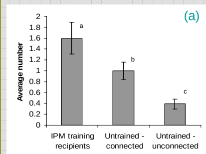
* Results: Farmers reported friends and relatives (41%), outreach agencies (26%) and pesticide sellers (19%) as sources of pest management information. FAW pesticide alternatives were mainly learned through interpersonal communication channels.

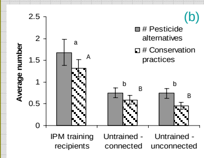
Opinion leaders farmed more land, were socially better connected than farmers who were not sought for advice, and were involved with significantly more local institutions. About half of the IPM training recipients were considered opinion leaders within their respective communities.

Untrained farmers socially connected to IPM training recipients knew significantly more insect natural enemies than unconnected ones. However, untrained, connected farmers did not know more pesticide alternatives or conservation practices than their unconnected peers.



Visualization of the social network in El Llano. Red 'dots' represent trained farmers and 'lines' show social relationships between farmers.





Comparison of knowledge of insect natural enemies (Fig. a), pesticide alternatives and natural enemy conservation methods (Fig. b) amongst different farmer categories. Figures represent average numbers (± SE), compared between subsequent categories using ANOVA.