SPATIAL RELATIONSHIPS OF COTTON PESTS IN THE SOUTH TEXAS LANDSCAPE

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Abstract

The cotton fleahopper and the verde plant bug (Hemiptera: Miridae) have become more problematic in recent years in the cotton growing region of South Texas. They feed on reproductive tissue: squares (cotton fleahopper) and young bolls (verde plant bug). Feeding during these stages can cause severe damage to the final cotton yield as well as introduce cotton boll rot. A pest management issue is that outbreaks vary from year to year and their densities vary from field to field. Edges and ecotones are often used in landscape ecology to aid in interpreting the functional heterogeneity of an organism; in the case of these cotton insects, how the surrounding landscape effects their population occurrence and movement from squaring through flowering. The goal of this study was to investigate the spatial relationships with these pest populations to get a better understanding of why some of these pests are present in some areas and not present in others. Our study found an edge effect for both verde plant bugs and cotton fleahoppers (more bugs were found nearer to the field edge) and ecotone modifies the strength of the edge effect. Edge effect was more predominant in the cotton/natural habitat ecotone than the others. This information can prove to be useful in pest management as it may help managers focus on fields or areas of fields that may be of higher risk to colonization by these pests.

Introduction

The use of broad spectrum insecticides in cotton, *Gossypium hirsutum* L. (Malvaceae), has been greatly reduced after the success of transgenic Bt (*Bacillus thuringiensis*) cotton and area-wide eradication of the boll weevil, *Anthonomous grandis grandis* Boheman (Coleoptera: Curculionidae) (Allen 2008). This success has often been attributed to the release of the sucking bug complex, consisting of plant bugs and stink bugs, from indirect insecticide control in not only the United States but also in Australia and China (Lu et al. 2010; Armstrong et al. 2010; McColl et al. 2011). The proposed research will be focused on the plant bug species of this 'sucking bug' complex; the cotton fleahopper *Pseudatomoscelis seriatus* (Reuter) (Hemiptera: Miridae) and the verde plant bug *Creontiades signatus* Distant (Hemiptera: Miridae) in the cotton growing regions of South Texas.
The cotton fleahopper is a key pest of cotton in Texas, Oklahoma and other mid-south states. Cotton fleahoppers feed on squares and are prevalent on early blooming stages of cotton growth. They tend to cause square abscission and in high numbers, can cause significant damage and reduction of yield. Damage in individual fields varies spatially and in population density from none, to extremely high square loss when and where high populations are found. This variability is partly associated with cultivar differences and other host plant factors such as timing of cotton fleahopper movement from non-cultivated weed hosts to cotton and the stage of the cotton when the migration occurs (Parajulee et al 2006). Many of these non-cultivated weed hosts such as woolly croton (*Croton capitatus* Michx: Euphorbiaceae) and horsemint (*Monarda punctata* L: Lamiaceae) can be found throughout the growing regions of South Texas (Barman et. al 2011) often adjacent to agricultural fields.

In contrast, the verde plant bug is native to the cotton growing regions of South Texas and Mexico. They are a polyphagous insect species feeding on many plants such as coastal sapweeds *Saueda spp*. pigweed and even sorghum (personal observation on sorghum). Unlike cotton fleahopper, infestations in cotton occur later in the growing season, after first bloom (Brewer et al 2013). They tend to feed on young bolls, where they damage developing lint and seeds which can cause boll abscission. In addition to physical damage, feeding and probing sites provide invasive pathways for pathogens that cause boll rot which is associated with the verde plant bug and reduces the overall quality and yield of the crop (Brewer et al 2012). Much like cotton fleahopper, damage to individual fields varies both spatially and in population density. For example, one field may have a large population of verde plant bugs and another field adjacent to it may have none. The reasoning behind this phenomenon is not relatively understood and we aim to investigate this spatially or at the landscape scale due to this variability at the field by field level.

In landscape ecology, edge is defined as the distinct border between two different land cover types. These edges can be soft or hard and natural or anthropogenic. In our case, since this is an agricultural setting, our edges are hard anthropogenic edges between one crop type and another or one crop type and natural un-cultivated habitat. An edge effect refers to the high population density and diversity of a species or species in the outer portion or edge of a patch of habitat. Ecotones are defined as the area occurring at the interface of two or more distinct landscape elements. In this study ecotones, would be the transition between different crops (i.e interface between cotton and sorghum) and natural habitat. We aim to investigate the role edges and ecotones have on the populations of these pests with two approaches, transect and random point sampling.

Materials and Methods

We constructed two parallel transects 100 meters apart from field edge inward to 300 meters into the field. The transects were sampled at 0, 15, 25, 50, 100, 200 and 300 meters from field edge. Each transect was sampled two to three times throughout the growing season depending on field conditions and for both verde plant bugs and cotton flea hoppers. For our random point sampling, field edges were divided into three sections where the middle portion of the field was selected. This was done to avoid complications where points may be closer to a different edge. A random point generator was used to select 8 points within our predetermined portion of the field. Points varied in distance from the edge between 0 and 200 meters. We are mainly focused on three ecotones: cotton adjacent to cotton (CC), cotton adjacent to sorghum (CS), and cotton adjacent to natural habitat (CN). For all sampling, transects and random points, the beat bucket was used to sample 40 plants within a 3m radius of our predetermined site.

Results and Discussion

Does Edge Matter?

Upon a simple linear regression analysis, there is a significant negative relationship between distance from the edge and pest density for both cotton fleahoppers ($\beta = -.0007$, $p<.001$) and verde plant bug ($\beta = -.0006$, $p<.001$). Both insects appear to be “edge” species, in which there are more insects on average toward the edge of the field than the interior of the field. However, upon further analysis there appeared to be another factor in play. When ecotone was added to the model, we saw significant effects of not only edge but also an ecotone effect for fleahoppers (Edge: F=45 effect) and verde plant bugs (Edge: F=46.65, $p<.0001$, Ecotone: F=3.14 $p<.05$). This analysis suggests that not only are there significantly more insects at the edge of the field, there are also differences in pest density across ecotones. In the case of fleahoppers however, there is a significant interaction effect between ecotone and edge (Ecotone*Edge: F=15.76 $p<.001$) (Fig. 1). This suggests that although there is a significant edge effect for fleahoppers, certain areas of the field (ecotones) have different edge effects than others. This is seen in the CN ecotone in which there are more fleahoppers at the edge of the field than the CC of CS ecotones and sharply decreases as you proceed into the field compared to a steady trend in the CC and CS ecotones. Individual slopes for ecotones are as follows: CC: $\beta = -.0004$, CS: $\beta = -.0005$, CN: $\beta = -.0013$.

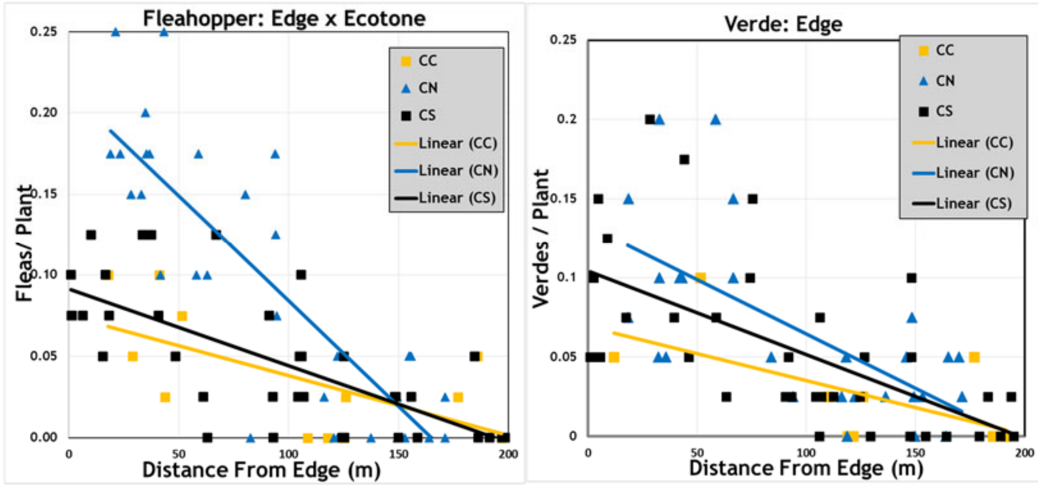

Figure 1: Fleahopper density decreases from field edge inward and this effect is different for certain ecotones than others (Left). Verde plant bug desnsity decreases from field edge inward and this effect shares a common edge effect across ecotones. These figures were derived from 2016 data.

We then looked at green boll damage for the verde plant bugs and there was a similar trend in the amount of boll damage and distance from the edge which is what we would have expected from the results of our density numbers (Fig. 2). A linear regression analysis with ecotone and edge in the model showed a significant effect of edge and ecotone on boll damage percentage (Edge: F=65.8 p<.0001, Ecotone: F=5.3 p<.0001). Much like density data, there is more damage near the edge of the field and decreases as you move to the field interior, there is also a difference in the damage across the ecotones. The interaction effect is slightly significant (Ecotone*Edge: F=2.9 p=.05) for green boll damage however when compared with the interaction effect of the verde density data (Ecotone*Edge: F=2.9 p=.49) there is a considerable difference. This may be representative from the biology of the insect; the verde plant bug is a highly mobile insect whereas green bolls do not move. Green bolls may be a better proxy to fully understand the verde plant bug response to edge and ecotone as damage is static.

Results from transect data showed similar results to the random point sampling data. For the cotton flea hopper, there was a significant interaction effect (Ecoton*Edge: F=8.1 p<.0001) as well as an edge and ecotone effect (Ecotone: F= 63.43, p<.001, Edge: F=28.77 p<.001). We also see similar results in data from 2015 with a completely different set of fields to work with. As for the verde plant bug, much like the cotton flea hopper, results were very similar to our random point sampling. We see significant edge and ecotone effects in both 2015 (Edge: F=14.8, p<.001, Ecotone: F=14.02 p<.01) and 2016 (Ecotone: F=3.2, p<.01, Edge: 7.78 p<.0001) transect data. There was no interaction effect for verde plant bugs in 2016 (Ecotone*Edge: F=1.1 p=.1) however, the 2015 transects did show a significant interaction effect (Ecotone*Edge: F=8.2 p<.05). This again may be influenced by the highly mobile nature of the verde plant bug and we may not be collecting true population numbers. Verde plant bugs often aggregate and rest on the leaves of the cotton plants and flee as you approach the plant to sample. Damage data needs to be re-analyzed to determine if we see the same pattern in the damage data as we saw in the random point analysis. We would expect to see a similar pattern in which boll damage is higher in the edge of a field that slowly or sharply decreases as you enter the field.

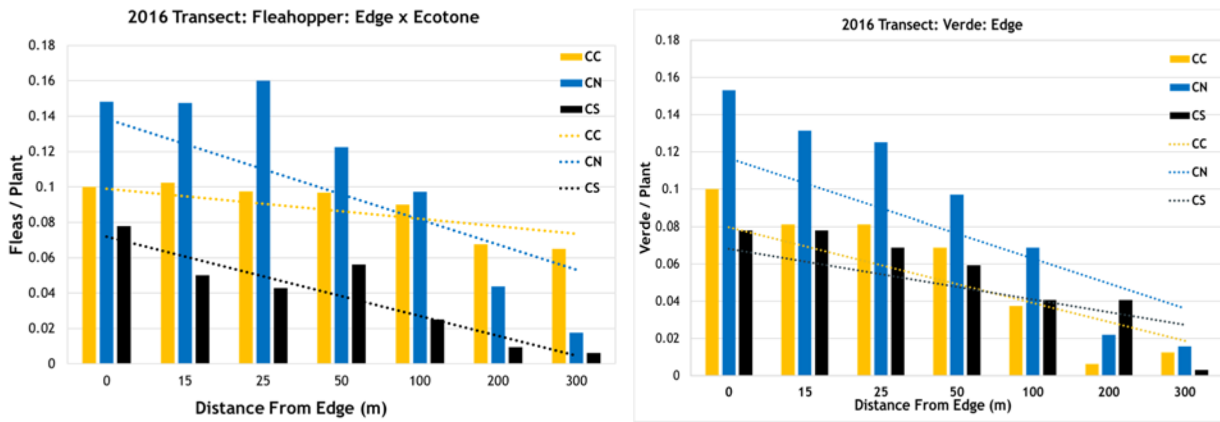

Figure 2: Transects showing similar edge effect for both fleahoppers (Left) and verde plant bug (Right). For fleahoppers, edge effect is different across the ecotones while as the edge effect for verde plant bug are indistinguishable across the ecotones.

Summary

Overall, we saw a significant negative relationship between insect density and distance from the edge for both cotton fleahoppers and verde plant bugs. This relationship is stronger when broken down by ecotone and appears to be influenced by natural habitat that borders some of our research fields. We also see significant ecotones effects for both insects and a strong interaction between ecotone and edge consistency seen in flea hoppers. This would suggest that even though there is an overall edge effect in flea hoppers the strength of this effect is dependent upon the ecotone. In 2015, we did see an interaction between ecotone and edge but did not see one in 2016. Again, this is thought to be influenced by the mobile nature of the verde plant bug, we may have captured a true population estimate in 2015 compared to 2016. Interestingly enough, green boll damage ratings for 2016 did show a significant interaction effect which could be representative of verde plant bug pressure. Our findings suggest that the spatial relationship (field juxtaposition) of fields should be considered when monitoring and controlling cotton flea hopper and verde plant bug. For example, in cotton fleahopper, our fields were only above threshold in sampling sites under 100 meters from the edge of the field and mainly in the cotton/natural habitat ecotone. Perhaps a zone-management approach to pest control or variable rate of spray by ecotone could be taken into account for these two pests (Fig 3).

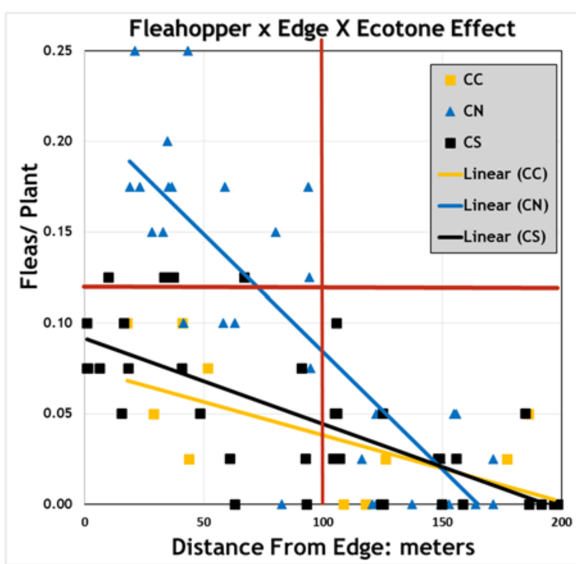

Figure 3: Random sampling for cotton fleahopppers with fleahopper threshold added (.12 fleas/plant). Only above threshold at sites less than 100 meters and mainly in the CN ecotone.

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