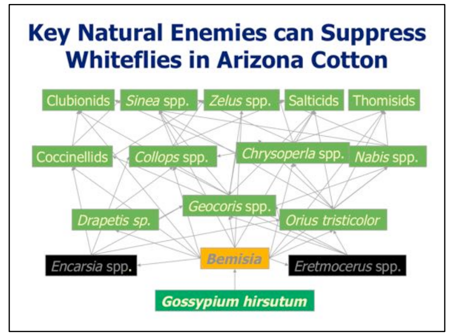
This project is the culmination of two decades of research in cotton to determine the role and activity of natural enemies in the cotton system that are effective in suppressing whitefly populations. This is part of an ongoing collaboration between the University of Arizona and USDA-ARS, ALARC.

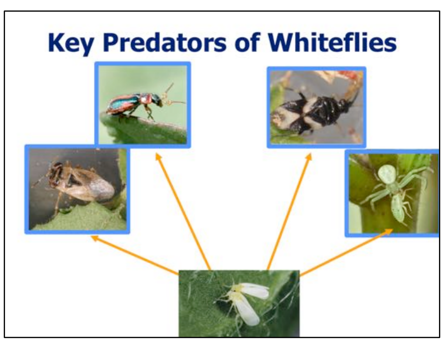
The current project is part of the Ph.D. work and dissertation of Tim Vandervoet. The research is ongoing.

30 min. (0.6 CEUs); 40 people; Maricopa, AZ



In our cotton system we find that there are over 20 natural enemy arthropods (insects and spiders) that prey upon and parasitize whiteflies. My research has been an effort to identify which of these generalist predators is most effective, and to incorporate the measurement of such predators into our whitefly management framework.

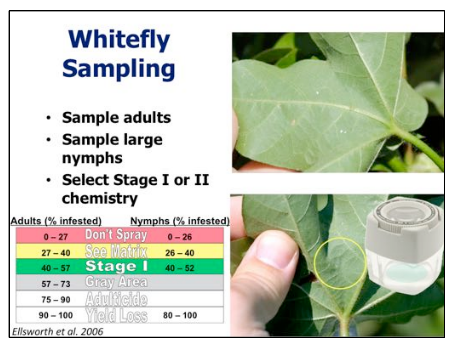
I want to emphasize this point, though. Conservation biological control from natural enemies plays a potentially enormous role in whitefly suppression in our system. This is a very useful service to cotton growers that can limit production costs.



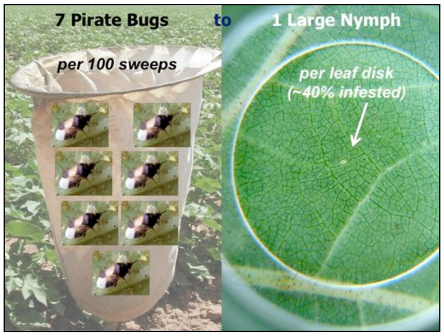
We've identified 4 key generalist predators that are significantly correlated to whitefly suppression – Big Eyed Bugs, Collops beetles, Minute Pirate Bugs, and Crab Spiders. There's been a substantial amount of research previously conducted here at MAC and USDA-ARS that shows these 4 predators consume whiteflies. Our work shows that this predation is linked to the suppression of whitefly populations in the field.

You might notice that in the picture of the crab spider we also see it eating a Lygus nymph – as I mentioned before, these are all generalist predators that likely underlie the biocontrol of other insect pests in cotton.

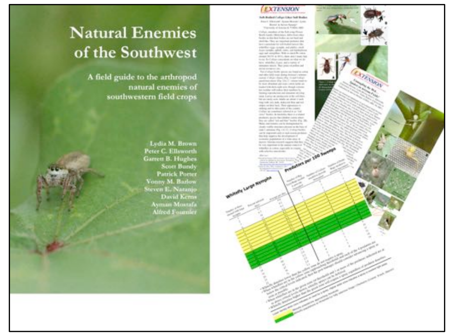
However, beyond just recognizing the key players in this system, we want to measure the effect of these predators in suppressing whitefly populations. So how do we do that? The first thing we do here, which is critical, is to measure whitefly densities.



To make good whitefly management decisions, we take regular whitefly counts. We recommend 30 leaf turn and leaf disk samples / management area, looking at both whitefly adult and live, large nymph on the 5th mainstem cotton leaf and specific leaf disk location. If we find 3 or more adults on that leaf, the leaf is infested. If we find 1 or more large nymphs (3rd or 4th instar) then that disk is infested. The number of leaves and leaf disks infested out of the 30 leaf sample gives us our percent infestation for each life stage. We then make management decisions (to spray or not to spray, and which chemistry to apply) based on the % infestation of both of those life stages. For example 40% adults and 40% large nymphs infestations is generally good timing for the use of Stage I selective chemistries, like Courier, Knack or Oberon.



This whitefly sampling measures are the foundation of predator : prey ratios that measure predator effects on whiteflies. We then used 100 sweeps / field to measure the density of 4 key predators, the same 100 sweeps a PCA might take to sample Lygus pests. In this case, we're looking for 7 pirate bugs relative to an average of one large nymph per leaf disk. This ratio, 7:1, indicates that the biocontrol potential within the field is high enough to continue suppressing whiteflies. Ratios lower than this (6 : 1, or 10 : 2, or 3 : 0.5) indicate that biocontrol is not functioning well. Ratios serve as indicators of the entire natural enemy community's effect on whiteflies. Thus we only need to find 1 of the 4 key predators at specific densities to know biocontrol is functioning. Furthermore, if enough are counted in fewer than 100 sweeps (e.g., first 50 sweeps), the pest manager can stop counting predators. It's critical that whiteflies be sampled prior to sampling predators – that makes the task of measuring biocontrol and making management decisions simpler for the pest manager.

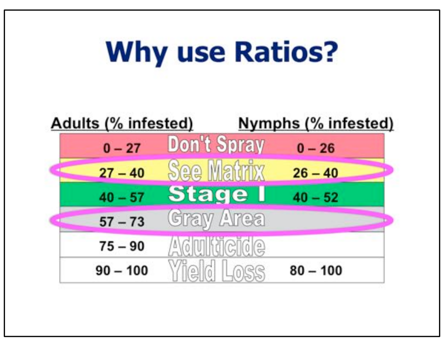


To support this work, we've produced a number tools to help incorporate biocontrol into whitefly management decisions. The Natural Enemies of the Southwest guide is a great tool for predator identification. We've also produced a number of IPM Shorts - 1 page documents for growers and PCAs that explain the biology and impact of various natural enemies, and how to sample whiteflies and/or natural enemies.

The ratio for Collops is 2:1 whitefly large nymph,

Crab spiders are 2:1 whitefly adult

Big Eyed Bug are 1:1 whitefly adult

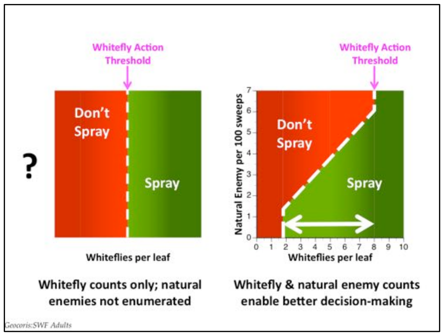


There are a lot of reasons why PCAs and growers might benefit from using predator : prey ratios. But I think the core of it comes down to 2 points.

The first point being by measuring biological control you can make more informed whitefly control decisions – spray earlier when biocontrol is lacking, or spray later when biocontrol is functioning – both of these scenarios lead to better control that can have impacts on whiteflies season-long. In essence, these ratios allow us to 'flex' the whitefly action threshold

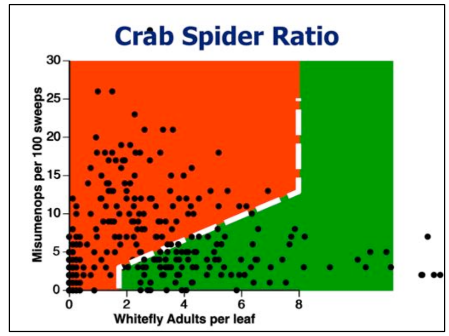
The second key point: ratios can help reduce uncertainty in whitefly decision-making. We recognize that there are whitefly densities, especially around the action threshold, that are difficult to confidently assess.

Two years ago I met with a variety of PCAs working in Arizona, as well as California & Mexicali. We asked, 'to what degree of certainty did you feel you had when making whitefly spray decisions'. Fewer than 20% of PCAs felt they had 100% certainty. The rest of us know that there is always a time when we have less than 100% certainty, and that making a whitefly control decision is tricky and making predictions about whitefly population growth can be difficult to do. Measuring biocontrol can help. It provides critical information when it is most relevant, around the whitefly action threshold. We recognize this uncertainty in the whitefly action threshold. A pest manager should take regular samples (of both adult & large nymphs), decide to spray or not to spray, and then choose from a variety of different insecticides (and different modes of action). On top of this, there are growers' desires to consider (spray early or late), other pests to manage, and other general plant health to consider. We think that the measurement of 4 key predators can help to make decision-making clearer, and increase certainty.

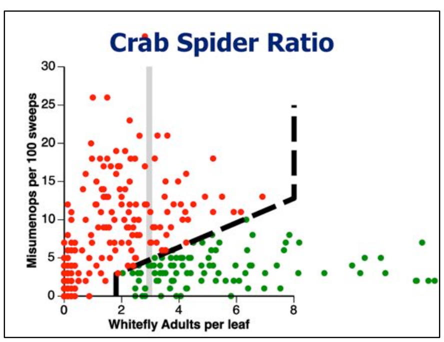


This is how we can picture our current whitefly threshold – more or less static (left) (even though it covers a range of densities for both adults and large nymphs, we haven't counted natural enemy levels explicitly). But as I mentioned previously, with ratios we can flex this threshold. Counting natural enemies allows us to do this.

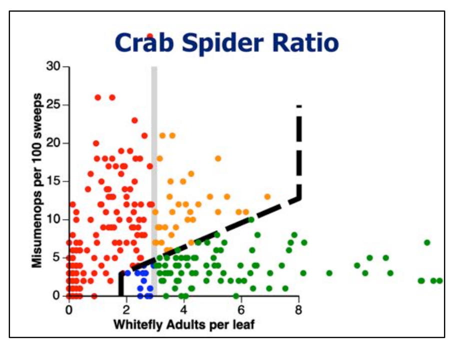
This flexing creates changes in spray decisions as a result of greater information regarding biocontrol potential. Previously we might have made spray decisions based on whitefly densities alone. By adding natural enemy counts we see the distribution of spray decisions change. Spray decisions that use predator : prey ratios can be advanced or delayed



So what does this look like with real data? Here I've charted out data from a 2013 trial – each data point represents a predator and whitefly count on different sampling dates, in what might be equivalent to a field plot. I've superimposed the spray/don't spray zones from the previous slide as well as the ratio indicating whitefly suppression, in this case for crab spiders in relation to whitefly adults.

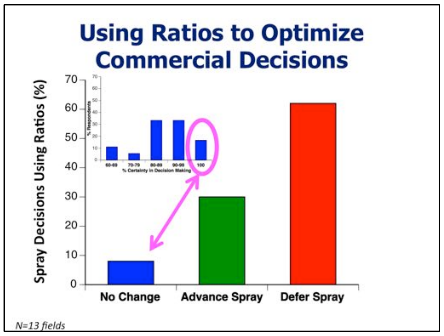


Here, the vertical grey line represents our conventional whitefly threshold – this is generally the earliest adult level of the standard threshold. To the right of it you see a lot of red points – these are situations where we would have normally sprayed under the standard system but would now delay because of high crab spider counts. To the left of it you see a few green points – these are all sprays where we would have normally not sprayed, but now recommend advancing sprays sooner based on low crab spider counts.



To show it a little more clearly – orange points are delayed sprays and blue points are advanced sprays. These are changed spray recommendations relative to what the standard, static, whitefly threshold calls for. Green and red data points are spray recommendations that the standard whitefly action threshold and new ratios-based system agree upon – situations that we would always hold off on spraying (red points), and situations we would always spray (green points).

Now these are all just data points of predator and whitefly densities, but how does this affect decisions? And more importantly, how does this effect decisions in commercial settings?



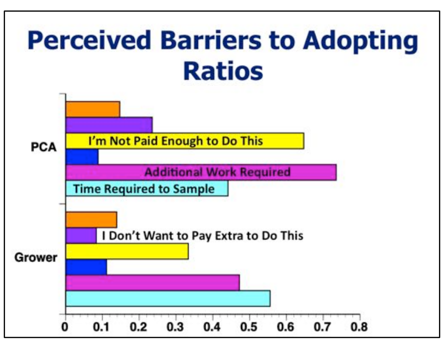
To understand better how this plays out in commercial fields, in 2014 we tracked whitefly and the 4 key predator densities in Arizona commercial fields, as well as the spray decisions PCAs made. Using that data we identified how spray decisions would change relative to the PCAs' decisions had they been based on predator : prey ratios. Around 10% of decisions wouldn't change – 30% would be advanced and around 60% would be delayed.

While these are slightly different metrics, you'll remember that in a previous slide I showed PCAs' confidence in whitefly decision making – around 15% felt they had 100% certainty. I think these statistics are hitting on the same point – there are situations where it is very easy to make a whitefly control decision (densities are very high, or very low and 'spray' or 'don't spray' are the obvious answers. However, there are many situations where the correct response is not so clear (80% of the time in the previous slide, and 90% of the time in this one). Understanding what natural enemies are doing helps reduced this uncertainty.

What the chart doesn't capture are all of the other valid reasons a PCA might have to advance or delay a spray that has nothing to do with predator : prey ratios.

In a commercial setting, there are many economically important reasons to advance or delay a whitefly spray. Irrigations or workers in the field can dictate spray timing, so can other pest management needs (Lygus, etc.), and plant health (herbicide and plant growth regulator applications).

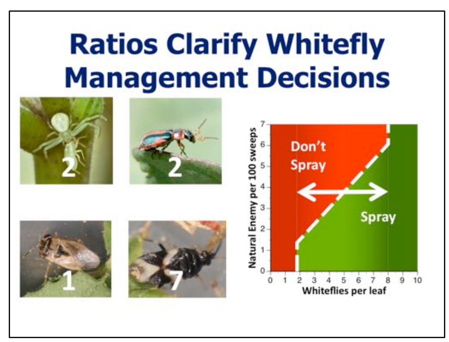
Surely, PCAs and growers will need to continue to consider these factors, "external" to the central whitefly density / whitefly control question. However, this new biocontrol, ratios-based system will give growers and PCAs another way to consider whether these other factors should override whitefly control decisions or not.



We know that there are barriers to adopting predator : prey ratios – both real and perceived. We asked PCAs and growers to identify them, here are some responses. Sampling 4 predators requires additional time/work in any way that you look at it – for time-limited PCAs that can be difficult to add-on to the normal work-load. PCAs also indicated that they aren't paid enough to use ratios for whitefly management.

We asked growers the same question and they identified similar concerns (about time and work required) – but you'll notice that very few of them (fewer than 10%) indicated that they didn't want to pay for this work (purple bar).

I would encourage any PCA who is interested in using predator : prey ratios to have a conversation with their grower – this is a tool that can be very helpful in whitefly management (and potentially reduce costs).



The predator : prey ratios we've developed are a simple tool that PCAs can use to measure biocontrol and clarify whitefly management decision-making. The 4 key predators are easy to identify and the ratios are easy to measure if whiteflies are being regularly sampled. Using these ratios can help to flex the standard whitefly action threshold by spraying earlier when biocontrol potential is low, and spraying later when biocontrol potential is high. The impact from this can be better season-long management of whiteflies and more confident decision-making.

This project has been supported by many institutions and grants shown here.