

Feasibility of using domestic, high-definition video cameras to monitor insect predation.

View demonstration on YouTube @:
<http://www.youtube.com/watch?v=jfYkhg1vWus>

Cotton CRC Summer Scholarship Project 2011

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Based @: School of Environmental and Rural Science, University of New England, Armidale.

Report by Melissa Mullee and John Stanley

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Melissa Mullee (Cotton CRC summer scholarship participant) using cameras to film acts of predation and parasitism on *Helicoverpa* larvae in red clover at the UNE.

Background

Monitoring predation using high quality video equipment has a history of requiring very expensive equipment, not only for the cameras, recorders and editing gadgetry but also to protect the equipment from the elements in the field. Over the last ten years, there have been substantial improvements to the miniaturisation and image quality of “off-the-shelf” domestic cameras. This has greatly reduced the price of gaining high definition, 3CCD quality images.

Perhaps the most important development that suggested domestic cameras might be useful for field observations has been the development of high capacity digital storage using solid state memory cards. This removed the vulnerable magnetic tapes or mechanical hard drives that have dominated the domestic market over the last 15 years or so. Both would be likely to fail in the often hot and humid environment of a cotton field. Now we can access large memory (up to 64GB) with fast downloading speeds (30 megabytes per second) domestic cameras could be used to monitor a point in space for a relatively long period of time for rare events in a crop canopy. Here we are thinking of ‘watching’ *Helicoverpa* eggs to see which predators come along to feed on them.

Measuring the contribution of different predatory insects to pest control in cotton has long been elusive. Researchers have tried, direct observation (Dillon et al, 1992), radioactive tracers (Sterling 1989) and serological screening for naturally occurring (Greenstone, 1996) or marker proteins (Whitehouse 2009). As good as these methods are for identifying predators they are not particularly quantitative. We suggest that cameras could record enough predatory events to clearly quantify the contribution by each predatory species? The first step in this approach is to solve whether domestic cameras are up to the job.

Aims and Objectives

This study was not designed to measure predation but to provide the ‘proof of concept’ using only four video cameras. To do this we needed to demonstrate that the cameras can produce images that are clear enough to identify the species of interest, both predators and prey. The depth of field will need to provide sufficient focus throughout a reasonable volume of crop canopy to see what is happening. The project would also need to demonstrate that the cameras can be left in the field at the appropriate time and for sufficient time to record events without running out of video storage capacity, electrical power (for all recording, lighting and protective devices), or breakdown because of overheating, humidity or rainfall.

Costs (Approximate and indicative, this is not a quote for supply):

The cameras can be purchased today for approximately 1200 to 2000 \$AUS and require a few simple modifications to provide; extended battery power, infra red lighting, shelters from the sun, rain, humidity and high operating temperatures (another \$200 each).

Cameras: 3CCD, high definition, SD card memory, external battery input, auto focus.

Editing Software: Movie making software (eg. iMovie®, Final Cut® or Pinnacle Studio® or the like) plus video file conversion software. Most movie-making software can cope with many video formats but AVCHD, the HD video file format, often

requires another program to quickly and easily edit files generated by the camera.

Item	Description	Function	Cost (\$AUS)
Editing Software	Movie Editing Software	Produces clips that can be edited and then made into a movie that can be read by most devices.	~ 1000@
	Video File Conversion Software	Allows unprocessed files to be quickly downloaded for the camera and quickly readed and trimmed to only store the useful moments.	Free to 60@
Cameras	High Definition, 3CCD, SD storage. HD video file type AVCHD.	Record and store video images in digital HD, plus provide recording functions for low light, better contrasts, auto focus, UV recording etc.	1200 to 2000@
Battery power	Sealed 12volt lead acid batteries, 7.2 Ah	Supply electrical power for the camera, IR lighting sources and any environment modification devices cool the cameras, perhaps small fans.	15@
Battery houses	Seal tight freezer boxes	Used to seal the battery and transformer, holes for wires were sealed with silicone.	7@
Transformer (DC)	Domestic voltage converter	12V to 9.4 volts (second voltage must equal the input voltage required by the camera to operate on an external supply.)	15@ plus modification by electrician 15@.
Camera houses	Camera houses plus modifications to provide a base to attach the cameras and heat sinks to the house.	Shelter cameras from rain and humidity.	Materials cost about 35@ for each but parts were made by project staff and represent about a couple of hours work to build.
Sun shield	Reflective shield fitted over the camera house	Reduce heat build-up in camera house.	10@ materials
Camera mounting brackets	Arm with adjustable ball joint	Support camera attached to a post which allows the camera to be set in a certain position.	20@
Star post	Post to support camera in the field		10@
		Total Editing and software	Up to 1000
		Total Camera Unit	Up to 2200@

So the questions come down to:

- 1) How long can we record for: a) memory capacity versus resolution. b) power supply.
- 2) Is the resolution good enough to identify clearly the predator and prey being viewed?
- 3) Do the cameras continue to operate under field conditions without breaking down?
- 4) How well does the camera refocus on the prey as the wind moves things about?

Methodology

Technical construction:

Camera houses: We used 1.2 litre domestic square freezer boxes. The lids were reinforced with a thick plate of aluminium which provided a solid floor for the cameras to bolt to, a support for the infra red lights and a place to attach the camera mounts. Aluminium was chosen because it would take heat away from the cameras. A heat sink was attached to this plate, immediately below the camera to conduct heat away to the outside (Fig. 1 and 2).

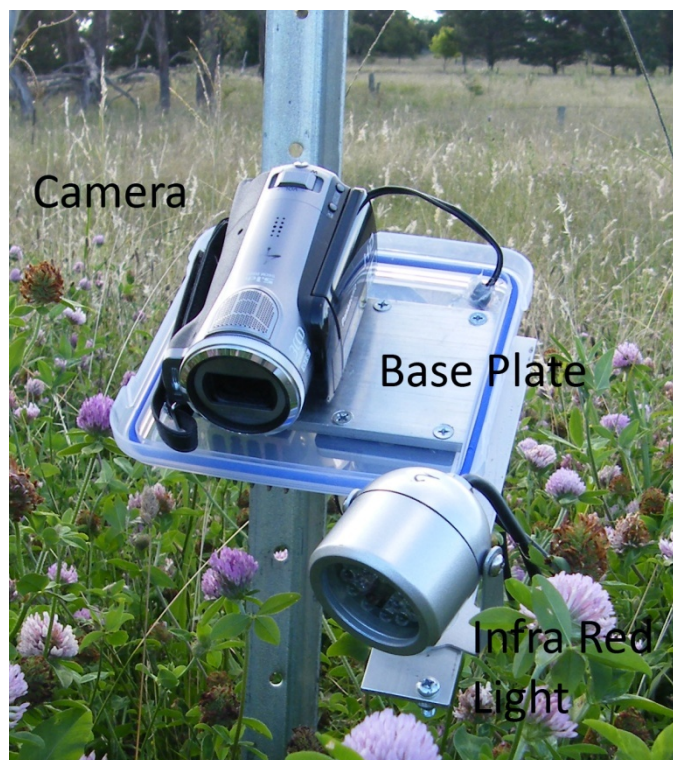


Figure 1: Camera unit humidity cover removed to show how the camera, base plate and infra red light are attached.



Figure 2: Camera unit with humidity cover set up in a pasture of clover. A Perspex window provides a clear section for the camera to record through.

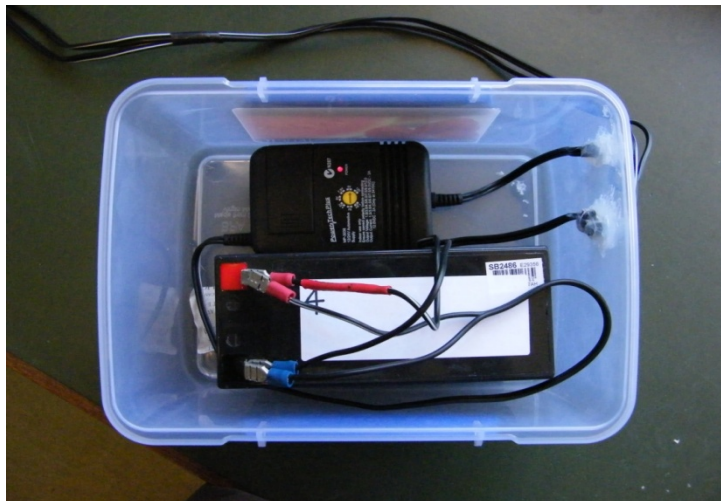


Figure 3: Battery box with lid removed to show the 12 volt, 7.2 Ah battery and voltage regulator to 9.4 volts. Two cables exit the box via sealed holes. One carries 12 volts to power the infra red lighting, the other the 9.4 volts for the camera. Other cables could be added to power fans or heating elements to modify the camera houses in other ways.



Figure 4: Melissa with complete unit set-up in cotton at Carol (nr. Gunnedah) showing sun shield.



Figure 5: Details of camera under the sun shield, note that the humidity cover is not present in this picture. The Perspex window reduces the quality of the picture so when conditions are dry we used the cameras without their humidity covers.

Cables from the battery pack ran to the camera via a drilled and sealed hole (Fig. 3). Larger batteries up to 5.4 Ah are available from Panasonic for the cameras but we chose to adapt cheap readily available 12 volt lead acid batteries to give a much greater capacity to run the cameras and lights. These can be recharged easily and could be topped up by solar panels if necessary. A 12 volt infra red light source was also attached to the camera housing for monitoring at night (Fig. 1 and 2). Each camera requires a 9.4 volt DC power supply so the UNE physics workshop modified readily available voltage regulators to provide exactly what was needed (incidentally the voltage needed was not the voltage indicated on the unit by the manufacturer). The battery and transformer were also sealed in a plastic box along with silica gel sachets to maintain very low humidity (but not measured). See the series of figures from 1 to 5 to see the full setup of components for the remote camera system used in this project.

In the Laboratory

On laboratory benches, four cameras were mounted on wooden retort stands and each focused onto a single leaf of potted cotton plants. *Helicoverpa punctigera* (prey) and assassin bugs (*Pristhesancus plagipennis*) (predator) were placed onto the leaf and recorded for two hours. This provided lots of practice with the cameras for Melissa Mullee; the summer scholarship participant and for Ryan Ross and Simon Porter; two PICSE students gaining industry placement experience in agricultural science at UNE (PICSE is the Primary Industries Centre for Science Education). In the absence of field extremes of heat, light, wind and humidity the cameras performed very well. The *Helicoverpa* larvae and assassin bug nymphs were in perfect focus and the approaches by the predators to the prey were clearly visible (See clips names assassin bugs on flash-drive supplied with this report). The depth of field was also excellent for seeing the approach of the predators and allow the full leaf to be viewed. Only the centre of the view was followed by the auto-focusing mechanism of the camera. This was clearly sufficient to capture the action and identify the prey and predatory species. A stationary egg that could be set in the centre of the view finder would make an ideal target for study in this way because it can't move away. Despite the *Helicoverpa* larvae moving around, they were easily identifiable within approximately 10cm radius of the centre of the view. Although inside, there was enough breeze to move the cotton leaves about. It was encouraging to see that the auto-focus recaptured the insects in focus as the leaves moved back and forth.

The laboratory studies allowed us to test the downloading protocol. Initial downloads from the cameras using the typical movie making software like iMovie® (Apple-Macintosh) and linked to the camera took nearly as long as the filming period to get the files from the cameras into a viewable form for editing. Note that this is not movie editing, simply collecting the files so they can be viewed quickly for selecting useful clips. i.e. a six hour film required almost six hours to get to the point of trimming. The solution was a small program called Wondershare converter (Mac) which allows the camera footage to be viewed after a much shorter time. Approximately 20 minutes for a six hour film. Note that the cameras can play back the film directly from its original file format but the idea is not to view the whole film in real time. It is much better to scan the film by dragging the 'play-point' across the time bar to locate a point of interest, say when an egg disappears. Note that a six hour clip can be scanned in this way in a few seconds. Then the film can be trimmed back to the 2 to 5 minute clip containing the predatory event, before downloading to a movie editor. This step has been accomplished and appears to work well. See footage of prey (clip of 'EggOnStemGreenSoldier' to see how clear an egg shows up and captures the green soldier beetles moving about). An act of predation or parasitism would be very clear and this was demonstrated in the clip called 'HeliParasite' captured on the accompanying video files. A card reader was also very helpful to allow the cameras to resume surveillance while the video files were being downloaded.

We suggest the parasitism clip be used to enthuse growers and students about biological control in cotton by posting it on the UNE-Cotton CRC and PICSE web sites. 'HeliParasite' has been provided in a web-ready form for this purpose. Perhaps the viewers could be set the task of trying to see what happens playing the clip at normal speed before the second clip is played which shows the details in slow-motion. The parasitism event is very quick.

In the Field

Several attempts were made to use the cameras in the field, including i) setting the cameras up in a vegetable gardens for initial trials, ii) setting up the cameras in commercial cotton fields at Carol "Longacreas" from 9-30 am to 13-30 pm and iii) finally testing in the early morning on thick clover pasture near the UNE farm 'Laureldale'.

Power supply: The 7.2 volt batteries supplied sufficient power for all trials. The longest trial was from 8pm to 8am the following morning where the camera and lights were operated for 12 hours within a single charge. Therefore the power supply was adequate for this but no attempt was made to run the batteries until they expired. If an application required more power, larger sized batteries could be bought and would require no change to this equipment until they exceeded the size of the battery box. Solar panels are also available to charge lead-acid, 12 volt batteries, so powering the cameras without resorting to the expensive tailor-made versions from the camera manufacturer are possible.

Trials to explore the capacity of the cameras to cope with the heat and humidity were done tentatively because testing the cameras to the point of destruction was not economically acceptable. Although not measured, humidity was never seen on the cameras lens or in the camera houses or battery boxes, despite being left outside overnight. The freezer boxes appeared to seal sufficiently well to allow the silica gel sachets (two in each box) to cope with any residual moisture. This does not prove that conditions could not exceed dew points and lead to moisture that might damage the quality of the picture or operation of the cameras but many useful periods were filmed and problems did not occur.

The temperature of the environment inside the camera houses was recorded while the cameras were set up in cotton, on a slightly hazy but dry day in Carol in early February (Fig. 6). The temperature reached 46°C for one camera which exceeds the 40°C upper limit stated by the manufacturer (Panasonic). The cameras continued to record throughout this period so it was encouraging to see this margin for error but we have no way of knowing whether this was about to go horribly wrong. The cameras were retrieved at 13-00 pm so they had not reached the hottest period of the day, probably 15-00 to 18-00 pm (note EST - daylight saving time). This casts considerable doubt that the cameras could be left in full sunlight (even under the sun shield) at the height of summer in cotton fields. If surveillance throughout the hottest period was needed then further modifications that actively cool the cameras or houses would be needed. However, we noted that the activity of the insects was very low during the hottest periods of the day, so perhaps predation and parasitism can be represented very well by dawn and dusk observations alone. Cameras could be retrieved during the middle of the day or perhaps a timer could be installed to turn off the cameras during this period. A temperature-operated cut out switch might also be possible but does not remove the heat input from the sun. We were not prepared to risk the cameras beyond this temperature.

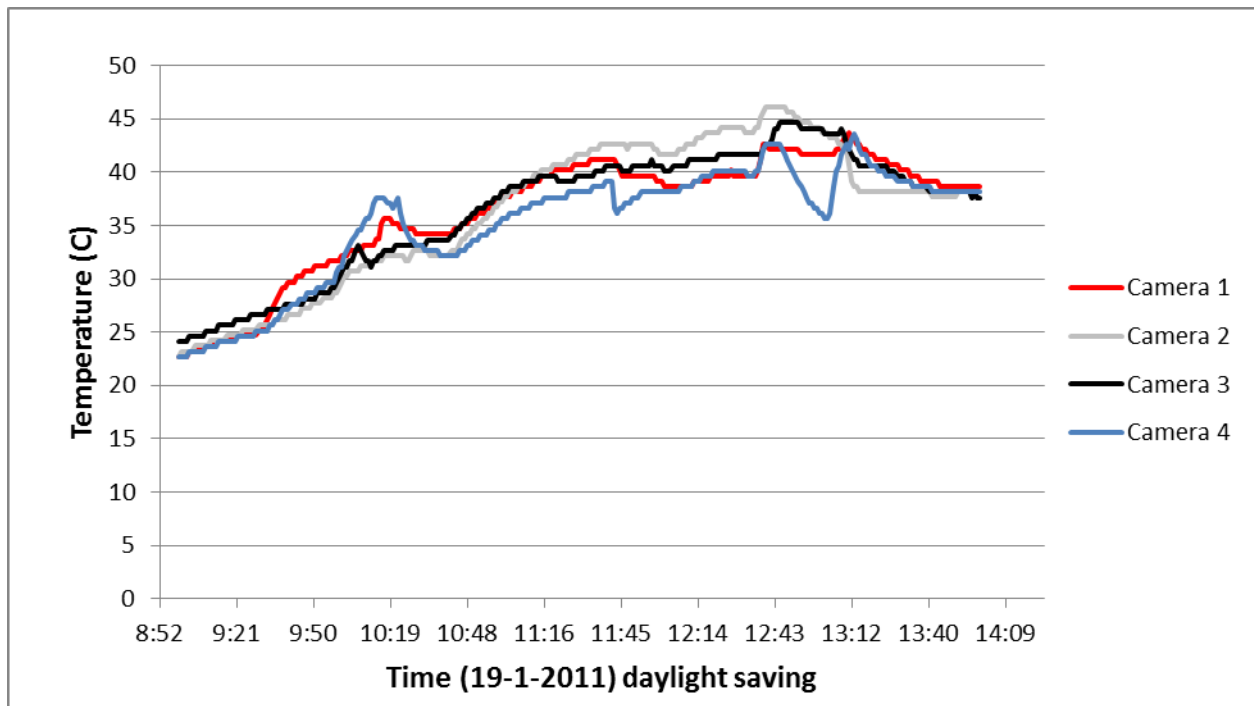


Figure 6: Temperature inside the camera houses for the four cameras set up in cotton at Carol. The cameras were in the field from 9-30 to 13-00. The large fluctuations at 9-00 occurred when the cameras were sitting by the field prior to setting up in the crop. The sudden drops in temperature show when the camera houses were opened to readjust the aim of the cameras.

Video Clips

Several video clips are provided on the accompanying flash-drive. These include:

- 1) Laboratory footage of a cultured *Helicoverpa* larvae and wild Assassin Bugs.
- 2) Field footage of wild *Helicoverpa* egg on cotton at Carol to demonstrate that the level of detail would be sufficient to identify the predation in the field.
- 3) Amazing footage of parasitism by a wild *Heteropelma scaposum* (parasitoid) of a wild *Helicoverpa* larvae (5th to 6th instar) in clover pasture.

Conclusion

Domestic cameras are a viable option for recording predation in the field. Relatively cheap cameras with simple modifications can survive long periods in the field and produce very high quality images, capable of identifying predatory events and the predators and prey species involved easily down to the size of a *Helicoverpa* egg.

If the cameras are to be used throughout the hottest period of the year in cotton crops, further modifications would be needed than were tested here. The cameras reached 6°C above the manufacturer's limit of 40°C in mid January at Carol (near Gunnedah NSW) but were not left beyond 13-00 to test the hottest time of day. Conditions could easily exceed these in cotton fields. We recommend that improvements be made to the cooling capacity of the camera system if very hot conditions are expected.

The film clips generated during this project should serve to demonstrate the proof of concept of using HD cameras for insect surveillance.

Highlights

Capturing parasitism on film (Clip 'HeliParasite' on flash drive).

Working with the PICSE students as we attempted to coax assassin bugs to be assassins.

Setting up the cameras up in a commercial cotton field at Carol for the first time, wondering what we might capture on film.

Presentations and public relations

PICSE Science camp lecture 10th January 2011. The cameras were used to demonstrate biological control and agricultural science in a 1.5 hour presentation to 30 PICSE students during their science camp. A story on the PICSE activities including footage from this presentation was aired on PRIME NEWS at 6-00pm, 10th January 2011.

Ryan Ross and Simon Porter (PICSE) were PICSE students on industry placement with Dr. John Stanley from the 17th to the 21st of January 2011. They presented a seminar to parents and other PICSE students on the 17th Jan at the University of New England.

Collaborating with the Physics workshop at UNE to provide power supplies and various components for the camera houses.

Collaboration with Andrew Ceeney (Private consultant for 'Longacreas') who organised the commercial cotton field for us to use. Andrew also talked to Melissa, Ryan and Simon about his job as a cotton consultant and discussed many of the things we could see at the cotton field.

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Executive Summary

Domestic, high definition video cameras are capable of recording predatory events in cotton crops in considerable detail. Modifications to the power supply and shielding to protect the cameras from the elements can be made easily and cheaply.

The cost per camera and associated hardware is approximately AUS\$2,200. Software to support a set of cameras would cost another \$1000 dollars although this would depend on the quality of the images needed, the size of the files to be stored and the time available to download events. We assume portable computers and various large capacity hard drives are available. Both are relatively cheap these days.

The cameras are likely to get too hot if used in full sun positions (even with a sun shield) during the hottest parts of the day for some regions (ca. 12-00 to 15:00 pm in mid-summer), however for many months and over periods when insects are most active (dawn and dusk) temperatures would be acceptable. The camera houses used in this project would be sufficient for many studies.

This project has captured parasitism of a late instar *Helicoverpa* larvae by a large Ichneumonid wasp. This was captured by leaving the cameras for 3 hours unattended from 6-00 am to 9-00 am in a clover pasture at UNE. This event is an excellent example of the performance of the camera system tested in this project. Demonstration now available on YouTube:

<http://www.youtube.com/watch?v=jfYkhg1vWus>

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