

Abstract

Helicoverpa armigera (Hübner) and *Helicoverpa punctigera* (Wallengren) are significant pests of field crops in Australia. As increasing levels of insecticide resistance are demonstrated by *H. armigera* investigations into biological control have become a priority. This study aimed to determine if the naturally occurring arthropod predators in grain crops are of use for the control of *Helicoverpa* spp. in southeast Queensland. As many as three quarters of grain growers in this region record predator abundance in their crops in some way and the data is used to some extent when making spray decisions. To fully incorporate predators into integrated pest management (IPM) programs we must first understand what predator abundance equates to in terms of pest mortality.

Studies were conducted in unsprayed, irrigated soybean *Glycine max* (L.), and other field crops at the University of Queensland, Gatton campus in the Lockyer Valley over three summer seasons. Exclusion cage studies showed that naturally occurring predators were capable of imposing high levels of mortality on *H. armigera* first instar larvae. Larval survival was greatest in closed cage treatments from which predators were excluded and survival in open cage treatments was intermediate between that of closed cage and no cage treatments. Overall larval survival was very low in unsprayed soybean fields, mean proportion surviving 10% (standard error ± 3), when all mortality factors were combined. Average predator mortality estimates for first instar larvae were similar across seasons; 23-33 percent (2001/02) and 21-30 percent (2002/03). Maximum predator mortality imposed on *H. armigera* eggs attached to cards ranged from 28 to 56 percent. Ground cages (to exclude ground-dwelling predators) and predator inclusion treatments (two predators added per cage) were used to separate the mortality imposed by different predator groups. Estimates of mortality imposed by ground-dwelling predators ranged from zero to nine percent. In experiments using *Dicranolaius bellulus* (Guérin-Méneville) mortality estimates due to added predators was only eight percent. Using *Harmonia octomaculata* (Fabricius) mortality estimates were higher at 50 percent.

One characteristic of “good” biological control agents, at least in theory, is that they can locate and extinguish patches of high prey abundance, termed spatially density-dependent mortality. It is “common knowledge” that within-field abundance and activity of predators is often patchy but field studies investigating spatial patterns in abundance and mortality are

rare. I investigated within-field spatial patterns to determine if predators were aggregated in a soybean field, what the sizes of these aggregations were and if they correlated with pest aggregation, plant damage, or predation rate. An intensive sampling grid (42 sampling sites, 20 metres between sites) was positioned across the interface between a soybean and adjacent lucerne *Medicago sativa* L. field, and sampled at a number of points during the season. Predator activity was assessed using *H. armigera* egg cards placed at each sampling site and exposed for 18 hours. Predators were not evenly distributed in soybean fields but rather exhibited some degree of spatial patterning with regions of high and low abundance and activity. Spatial patterns changed over time within a field during a single season. Ground-dwelling and foliage-dwelling predators were often aggregated in patches of up to 40m across. Lycosidae (captured in pitfall traps) displayed aggregation and were consistently more abundant in lucerne, with decreasing trap catch with distance from the interface. The effect of lucerne fields on predator abundance and movement in an adjacent soybean crop was tested further (see below). Predator aggregation did not consistently correlate with pest aggregation, plant damage, or predation rate. Further studies are required to fully understand the factors that influence spatial patterns in predator abundance.

Lucerne has been suggested as an ideal refuge habitat as part of an IPM program because it harbours high numbers of beneficials. Whether or not cutting of lucerne encourages movement of beneficials into an adjacent target crop of soybean was tested. Vacuum samples of arthropods before and after cutting in lucerne and adjacent soybean were conducted on seven occasions. Cutting of lucerne significantly reduced pest and predator numbers in lucerne but had little effect on pest and predator abundance in adjacent soybean. Cutting of lucerne alone does not guarantee movement of predators into the adjacent target crop. The presence of lucerne fields within a cropping area may have some impact on regional predator populations and be useful for IPM programs but this has yet to be critically tested.

Spiders are among the most abundant predators recorded in grain crops in Australia. They are voracious predators, and may play an important role in the reduction of pest populations. A thorough inventory was made of the spider fauna inhabiting unsprayed soybean fields and a total of 102 morphospecies from 28 families were collected. Water traps were used to investigate spider ballooning in soybean and nearby non-crop areas. Ballooning is a form of aerial movement that may be important for the colonization of annual crops throughout the season. The highest ballooning rate of 14.8 spiders per square metre per day was recorded in a

soybean field. Spider ballooning in soybean increased throughout the season and exhibited a wave pattern. A similar pattern was observed in non-crop areas however the numbers were noticeably lower. Peaks in ballooning activity were synchronised across habitat types and some spider groups. Comparisons were made between the diversity of ballooning (water trap captures) and ground-dwelling spider fauna (pitfall trap captures) in soybean. Composition of ballooning fauna is different to that of the ground-dwelling fauna however some families are present in both trap types. The most abundant families collected in water traps were Linyphiidae, Araneidae and Lycosidae. In pitfall traps Lycosidae, Linyphiidae and Zodariidae were the most abundant.

No-choice feeding tests in the laboratory, using *H. armigera* eggs and larvae as prey, were used to ascertain the predatory potential of non web-building spider groups. Few spider groups consumed eggs in the laboratory with the exception of Clubionidae spiders that ate a mean of 18.4 eggs (± 1.5 , 92% of those available) in 24 hours if starved. All spider groups tested readily consumed first instar larvae in the laboratory. These results may not be indicative of predation rates that occur in the field. However Lycosidae, Clubionidae, Oxyopidae, Salticidae and Thomisidae have the capacity to contribute to control of *Helicoverpa* spp. The impact of spiders on *Helicoverpa* spp. populations in the field must be quantified before they can be fully incorporated into IPM programs. The mortality that they impose on predaceous arthropods is still unknown and may negate some of their potential as biological control agents.

In response to difficulties encountered whilst attempting to quantify predation in the field a molecular technique was developed to detect *Helicoverpa* spp. remains in the guts of Clubionidae spiders (*Cheiracanthium* sp.). Nested primers were used to amplify *H. armigera* DNA (eggs and first instar larvae) from the guts of Clubionidae. The assay was specific within the Heliiothine sub-family but not species specific to *H. armigera* or *H. punctigera*. Molecular methods, such as the protocol investigated here, may be used in the future to quantify predation in the field without confounding effects.

The predator complex in soybean fields consists of a diverse and abundant assemblage of insects and spiders that as a group are capable of substantially reducing pest populations. Whilst there are a number of individual predator species within this complex that are not useful for *Helicoverpa* spp. control, collectively they can impose high levels of mortality on

eggs and first instar larvae. Substantial area-wide reductions in insecticide use, or the use of selective insecticides may be sufficient to encourage naturally occurring predator populations. Greater attention to the components of the cropping landscape (including non-crop areas) provides further promise for increasing predator abundance and activity within-fields. However, this cannot be achieved without a greater understanding of the ecological requirements of predators.