Importance of native vegetation to beneficial insects and its role in reducing insect pest damage in cotton

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ABSTRACT

Conservation biological control is one of the strategies in integrated pest management (IPM). Its aim is to conserve naturally occurring predators within the agricultural landscape. Modifying the landscape to enhance predator efficiency, referred to as habitat management, is one of the methods used in conservation biological control. Habitat management, until recently has largely been ignored within many IPM programs. Area wide management of pests has changed this perception and there is now a realisation that events outside the crop impacts on events within the crop. Many generalist predators have been identified within cotton agro-ecosystems in Australia. To be effective, large populations of generalist predators are required within the cotton agro-ecosystem before pest establishment within the cotton. The surrounding native vegetation, weeds and winter crops provide resources for generalist predators. The management of these resources provides the key in generating and maintaining populations of generalist predators within the cotton agro-ecosystem. The aim of this study (which is in its first year) is to investigate a range of vegetation types and assess their value in supporting populations of generalist predators with the view to enhancing the predator efficiency in cotton agro-ecosystems. The following vegetation types were sampled: open woodland with hummock grassland and other herbaceous plants, sown pasture, dry land lucerne, a windbreak of planted native trees and open riverine forest. The sampling was carried out with a suction sampler and all collected predators identified. Soil samples were also collected to establish over wintering sites of predators. The age and phenology of vegetation was recorded to identify resources, e.g. flowers provided by vegetation types. The presence of juveniles was also noted as this indicates the presence of oviposition sites. The movement of predators from the surrounding vegetation into newly planted cotton fields was investigated with colonization studies. Newly planted fields were sampled at weekly intervals to establish the colonization pattern of the field. The pattern is an indicator of predator mobility, which has implications for the management of resources, and sampling of the cotton. The preliminary results are presented and discussed.

Introduction

Australian cotton production extends from south-western New South Wales to Emerald in central Queensland. Insect pests are a major constraint to cotton production and cause estimated yield losses of between 50-90% (Fitt, 1994). Most control measures are directed at *Helicoverpa armigera* and *Helicoverpa punctigera* (bollworms). Other pests include *Tetranychus urticae* (red spider mite), *Thrips tabaci* (thrips), *Aphis gossyppi* (aphids), *Austroasca viridgrisea* (jassids) and *Bemesia tabaci* (whitefly) (Fitt, 1994). Chemical pesticides play an important role in control. More recently production costs, environmental issues and concerns about resistance have all contributed to reducing the dependence on chemical pesticides. The Australian cotton industry is exploring alternative measures with varying amounts of success. Some examples include the use of new generation pesticides, host plant resistance, beneficial insects, habitat diversity and transgenic Bt cottons directed at *Helicoverpa* control (Fitt, 2000).

Bt cotton has the potential to reduce pesticide use by as much as 50-70% (Fitt, 2000). The adoption of Bt cotton, along with a resistance management program has been gradual and controlled in Australia (Fitt and Wilson, 2000). Whilst there are concerns about the use of transgenic plants, the reduction in pesticide sprays should improve the survival rate of beneficial insects in cotton production areas. Beneficial insects may play a critical role in maintaining populations of pests species not controlled by the Bt cotton. Reports from the USA suggest that pest complexes may change as a result of the use of Bt cotton (Turnipseed and Greene, 1996).

The importance of beneficial insects and the contribution they make towards pest control within IPM programs is recognized by the Australian cotton industry. A review of beneficial insect research in the Australian cotton industry identified 123 predatory species that feed on *Helicoverpa* and red spider mite (Johnson, *et al.*, 2000). The report also highlighted the lack of knowledge surrounding the biology and ecology of these predators. The reductions in pesticide use and selection of "softer" sprays have contributed to conserving beneficial insects. However, this is only the first step and further research is required to understand the ecology of beneficial insects. This will aid in establishing a framework for manipulating the agricultural environment to maximize the effectiveness of beneficial insects (Johnson, *et al*., 2000). The focus of most IPM programs has been within the field and ecological processes outside of fields have largely been ignored. Views of control strategies are changing and with the adoption of area wide pest management there is a realization that the habitat surrounding cropped and fallow fields should also be included when considering pest management strategies (Landis and Marino 1999).

Most agricultural landscapes are dominated by large fields with straight edges, generally low levels of plant and animal diversity with high levels of disturbance (Landis and Marino, 1999). Australian cotton farms vary in size from 500 to 15000 ha of production. Cotton agro-ecosystems range from virtual monocultures surrounded by grazing pastures to diverse cropping systems with winter and summer crops (Fitt, 1994). This arrangement can result in the fragmentation and isolation of non-crop habitats. Pests seem to behave differently in these simplified ecosystems and have larger populations and higher reproduction rates (Speight, 1993). This, however, does not seem to be the case for beneficial insects as they appear to require certain resources which are lacking in some agricultural systems. A means of mitigating the negative effects of agricultural disturbances is to reintroduce diversity within the agricultural landscape (Speight, 1993).

Through manipulating and conserving the vegetation around agricultural fields, it may be possible to make essential resources available to predators, thus moderating the impact of disturbances on natural predator populations (Altieri and Letourneau, 1982). Resources used by predators include overwintering sites, breeding sites, alternate food sources, pollen and favorable microclimates (Landis *et al.*, 2000). It is, however, important to select vegetation that provides resources required by the generalist predators (Speight 1993) and does not favor pests.

It has been well documented that increasing crop diversity within cotton agro-ecosystems through planting lucerne strips or alternate crops such as sorghum and winter wheat enhances beneficial insect numbers (Walker *et al.,* 1997; Mensah and Kahn, 1997). There is a production cost in planting lucerne strips and it is still viewed as prohibitively high and interferes with management practices on the farm (Fitt, 2000). The use of sorghum as a refuge crop is recommended, however it only has a short growing period. Winter crops, such as wheat, may also provide resources for beneficial insects, particularly in annual cropping systems like cotton (Parajulee and Slosser, 1999). During drought years many farmers refrain from planting winter crops, preferring to preserve their water and like-wise will not cultivate vegetation strips.

Little attention has been given to non-crop vegetation and the role it may play in harboring beneficial insects, particularly in dry years when there are few alternate crops. It has been demonstrated through sampling and pollen studies that beneficial insects utilize non-crop vegetation (Walker *et al*., 1997; Silberbauer, 2001; Yee, 1998). The aim of this study is to investigate the spatial and seasonal fluxes of populations of beneficial insects on several kinds of non-crop vegetation in a cotton growing district. In this paper we present preliminary results from the first year of sampling.

Experimental procedure

A cotton production area was selected along the Mauls Creek road in the Namoi valley in northern New South Wales, Australia. The site had a number of distinct non-crop vegetation types. The vegetation types were all within a 2 km radius of each other and adjoining cotton properties. The following vegetation types were identified; a planted native windbreak (north/south aspect and east/west aspect), riverine trees (two sites), communal grazing lands (two sites), pastures (two sites) and dry land lucerne (two sites). An opportunist weed, turnip weed (*Rapistrum rugosum*) and an irrigated winter wheat crop were also sampled. Irrigated cotton was sampled adjacent to the non-crop vegetation during the cotton growing season.

All the vegetation was sampled with a suction sampler (modified Homelite HB Blower Vac). A 100 m x 200 m rectangle was marked out in the communal grazing lands, dryland lucerne and pastures. The long axis of the rectangle was divided into five equal parts of 20 m. One randomly selected 20 m transect was sampled within each 20 m x 20 m sub-plot on each sampling occasion. Insects from each sample were collected in a gauze net bag, transferred into a plastic bag and frozen on site prior to transport to the University of New England for sorting.

The windbreaks were comprised of 12 native trees species that were randomly planted along the north/south and east/west border of the cotton property. In each windbreak, three tree species were identified and five replicates of each species were sampled with the suction sampler. The sampling unit was an individual tree, sampling the branches at 1.5 m height for a period of two minutes. Trees sampled in north/south aspect were *Acacia* sp., *Eucalyptus* sp. and *Casuarina* sp. Trees sampled in the east/west aspect were *Eucalyptus* sp., *Casuarina* sp. and *Melaleuca* sp.

Lower limbs of riverine trees dominated by the River Red Gum (*Eucalyptus camaldulensis*) were sampled. At each site, 10 lower limbs were sampled from 10 different trees.

Sampling commenced in July 2002 and continued to January 2003. For beneficial insects to be effective in cotton they need to be present early in the cotton growing season and so we focused the sampling effort on late winter and early spring, before and shortly after cotton planting. Adult predators from all samples were recorded and the presence of larvae and nymphs noted. As the larvae of most generalist insect predators are less mobile than the adults, the presence of larvae indicated that beneficial insects were using the vegetation as potential oviposition sites.

Results

Beneficial insects were present in all the vegetation types sampled. The following beneficial species were selected as a target group: Neuroptera: *Mallada signata* (green lacewings), *Micromus tasmaniae* (brown lacewing); Coleoptera: *Dicranoliaus bellulus* (red and blue beetles), *Coccinella transversalis* (transverse ladybirds), *Hippodamia varigata* (varigated ladybirds), *Diomus notescens* (minute two spot ladybirds); and Hemiptera: *Nabis kinbergii* (nabids or damsel bugs), *Pristhescancu plagipennis* (assassin bugs).

Windbreak

Green and brown lacewings were present in the windbreak from mid-winter (July) to early spring (October). Lacewing larvae were present in mid-winter (July) to spring (October). Red and blue beetles were also present from mid-winter (July) through to summer (January). Nabids were present only in early spring (September) and summer (December). Transverse and minute two spot ladybird adults and ladybird larvae were also collected in spring (October) (Figure 3). For the red and blue beetles there appeared to be differences in tree species preference and they were more abundant on the *Melaleuca* sp. (Figure 1). The green lacewings also were more abundant on trees from the north/south aspect, possibly due to improved microclimate conditions (Figure 2).

Riverine trees

The riverine trees supported low populations of generalist predators. Brown and green lacewings were present only in mid winter and early spring. Red and blue beetles were also present in early spring and nabids were present in summer (Figure 4).

Communal grazing land

Nabids were present in late winter, early spring and summer. Nymphs were collected in the summer samples. Small numbers of red and blue beetles and minute two spotted ladybird were present in early summer. No lacewings were present in any of the samples (Figure 5).

Pastures

Small numbers of brown lacewings and red and blue beetles were present during late winter. No beneficial insects were present during the spring and early summer. Red and blue beetles, variegated ladybirds, ladybird larvae and nabids were present in summer (Figure 6).

Dryland lucerne

Small numbers of red and blue beetles and brown lacewings were present in early spring. Ladybirds, nabids and assassin bugs were collected in late spring and summer (Figure 7).

Turnipweed (R. rugosum)

The turnipweed was only present during October and November when it flowered, after which it senesced and died. Brown lacewings, reds and blues and variegated ladybirds were present in the turnipweeds. The abundance of brown lacewings increased quite rapidly from October to November (Figure 8).

Irrigated wheat

During early spring, whilst the wheat was still green, brown lacewings, green lacewings, red and blue beetles, variegated ladybirds and nabids were present. Once the wheat had matured in the summer, only nabids were present (Figure 9).

Cotton

Red and blue beetles were collected in summer with small numbers of green lacewings present (Figure 10). No other beneficials were collected during the sampling period.

Discussion

Beneficial insects are present in the surrounding non-crop vegetation. The low numbers are consistent with other studies in the region (Walker *et al.*, 1997). Nonetheless, these preliminary findings contribute to a greater understanding of beneficial insect ecology, which is lacking in some cases (Johnson, Pierce *et al.,* 2000). Some species-specific distribution patterns are becoming apparent. For example, nabids were more abundant in the communal grazing lands and pastures that were dominated by native grasses. Green lacewings were more abundant in the windbreaks and riverine trees. This sort of information is useful as it provides a key for managing population numbers of individual beneficial insect species through manipulation of vegetation types.

Rapid colonization is an important trait in ephemeral cropping systems like cotton and therefore it is important that beneficial insects demonstrate this ability. The red and blue beetles, the brown lacewings and variegated ladybirds were all present in transitory vegetation types, namely the turnip weed and winter wheat. This would suggest such as that they are able to rapidly colonies suitable vegetation types.

Some of the proponents of habitat management suggest that improving diversity offers suitable resources overwintering sites, breeding sites, alternate food sources, pollen and favorable micro climates for beneficial insects (Landis *et al*., 2000). The presence of larvae in some of the samples suggests that non-crop vegetation is being used as oviposition sites. If this vegetation were not present it could potentially mean that oviposition sites would be reduced and, ultimately, populations of beneficial insects would be reduced. Improved microclimate is an example of another resource utilized by beneficial insects. Within the windbreaks it appears that green lacewings favor the north/south aspect against the east/west aspect. This could be due to microclimatic effects but further research is needed to confirm this.

Temporal patterns of beneficial insect populations are also emerging. For example, brown lacewings are recorded in non-crop vegetation in late winter and early spring, but not in summer. Nabids seem to occur in late spring and early summer, whilst red and blue beetles appear to be present throughout the sampling period. Some vegetation types also appear to have maintained beneficial populations through out the sampling period whilst others only had beneficial insects for a short period of time. This is probably related to rainfall conditions during the sampling period. The inconsistent nature of populations of beneficials in some vegetation types has been noted (Walker *et al*.,1997; Stanley, 1997). During the 2002/03 cotton growing season, most of New South Wales was in drought. Many plants died and the acreage of winter and summer annual crops was greatly reduced compared with usual plantings. It is possible that the drought-affected vegetation may have impacted on beneficial insect populations. It is interesting to note that in these dry conditions, the windbreaks and dryland lucerne had populations of beneficial insects throughout the sampling period, unlike the pastures, communal grazing land and riverine forest.

These preliminary findings seem to indicate that there are temporal and spatial patterns in how beneficial insects utilize non-crop vegetation. Beneficial insects may benefit from improved microclimate and oviposition sites within the non-crop vegetation. These observations should contribute to a greater understanding of the ecology of beneficial insects and assist with managing beneficial insect populations within agroecosystems. The factors influencing the movement of beneficial insects from vegetation types are still not clear. Until these triggers are understood it will be difficult to manage beneficial insect populations. Further research is needed to confirm the temporal and spatial patterns in an effort to understanding the triggers for movement.

Acknowledgements

Jack Warnock, Darren Ether, CRDC, Australian Cotton CRC, Dave Britton, Bronwyn Haller, Sam Lowor and Martin Dillon.

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Figure 1. Mean number of red and blue beetles with SE bars on wind-break trees.

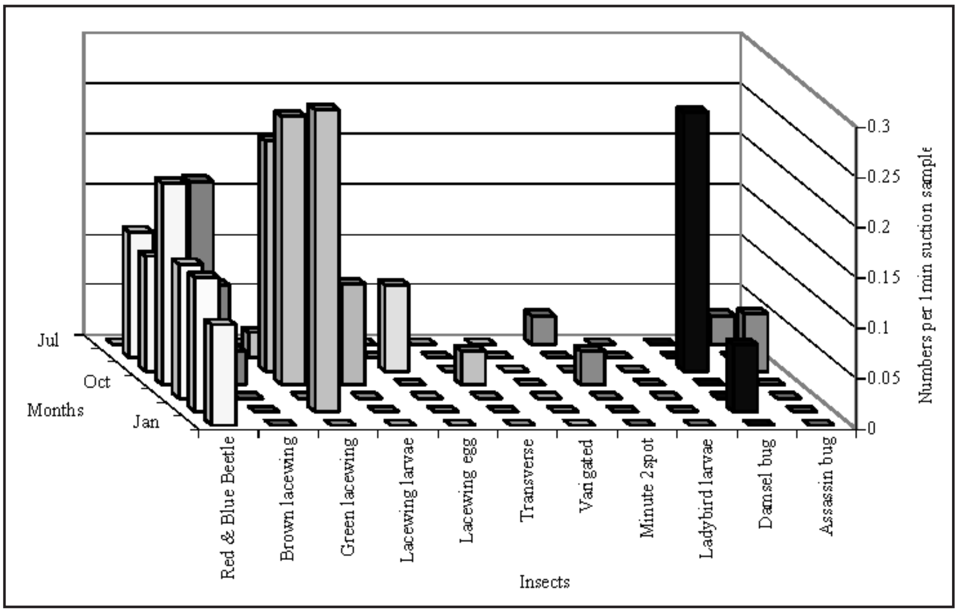

Figure 2. Mean number of green lacewing adults with SE bars within the windbreak.

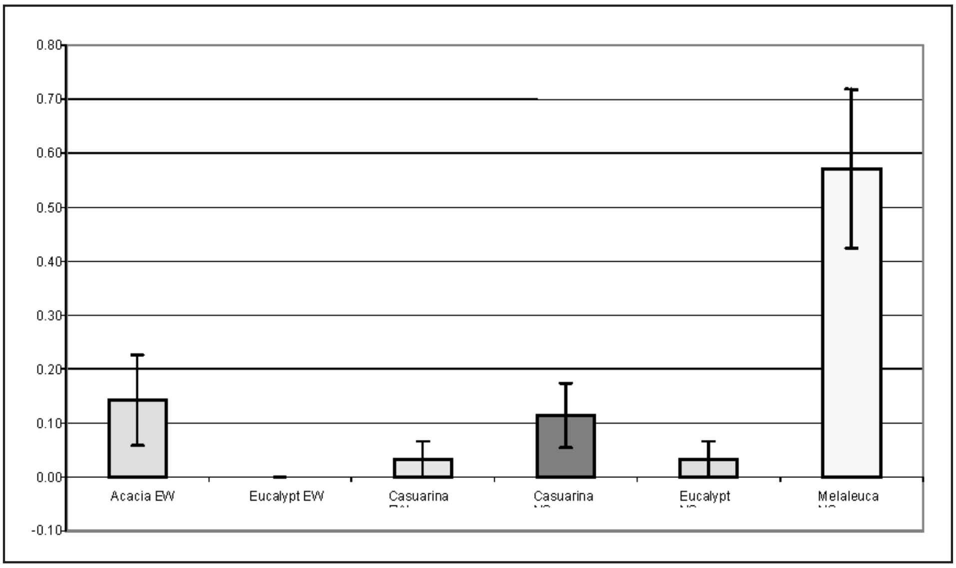

Figure 3. Temporal movement of insects in the windbreak.

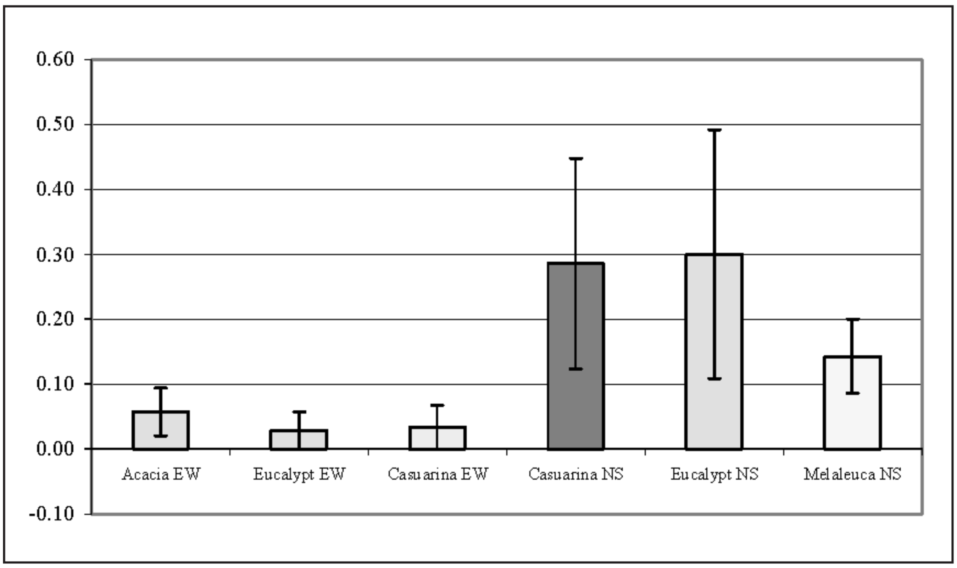

Figure 4. Temporal movement of insects in River Reds.

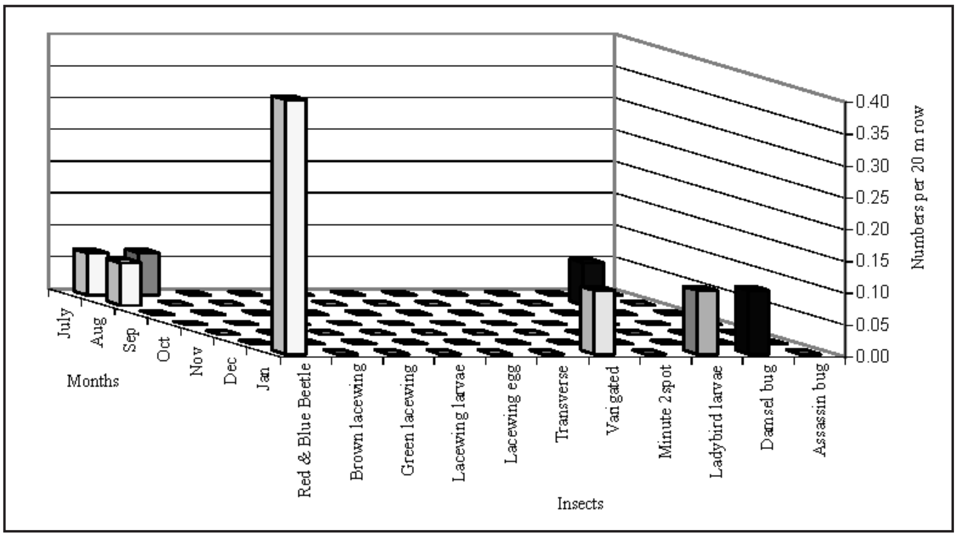

Figure 5. Temporal movement of insects in, traveling stocks route.

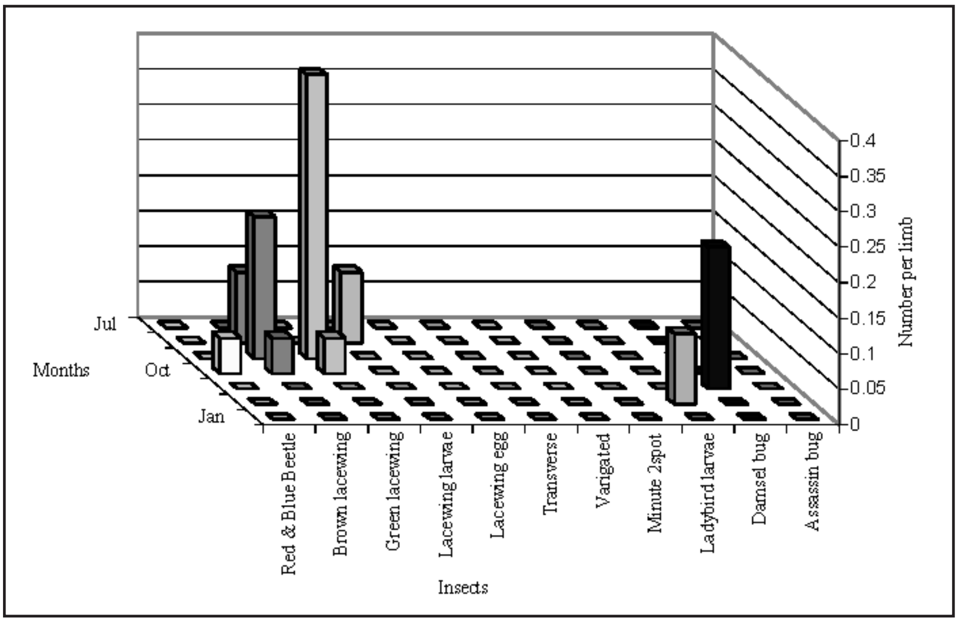

Figure 6. Temporal movements of insects in pasture.

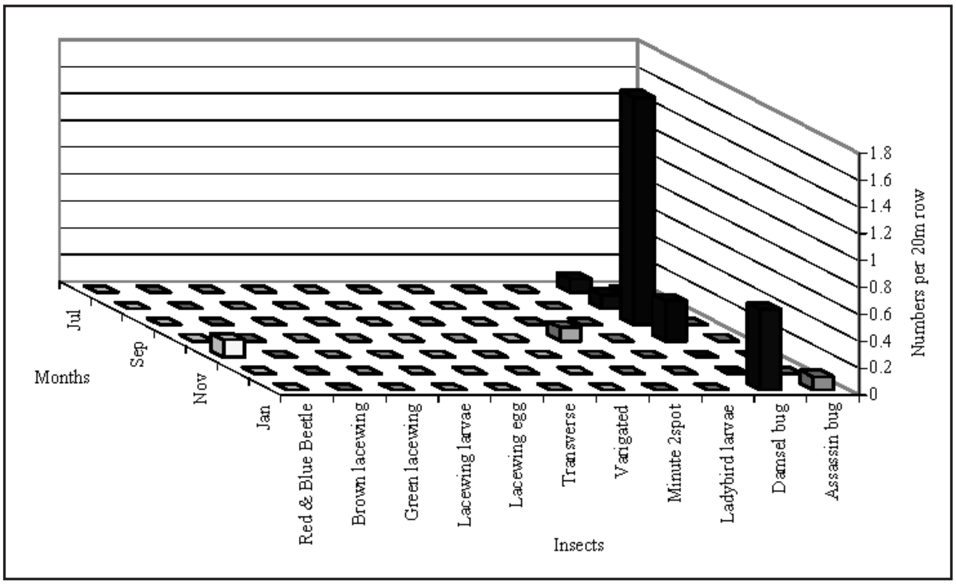

Figure 7. *Temporal movements of insects in lucerne.*

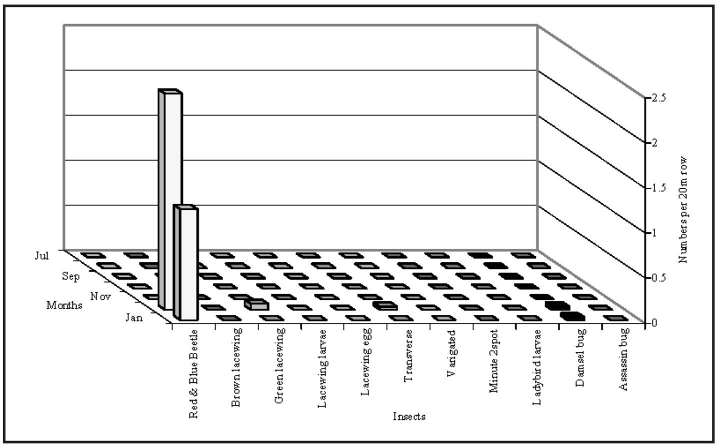

Figure 8. *Temporal movement of insects in turnipweed.*

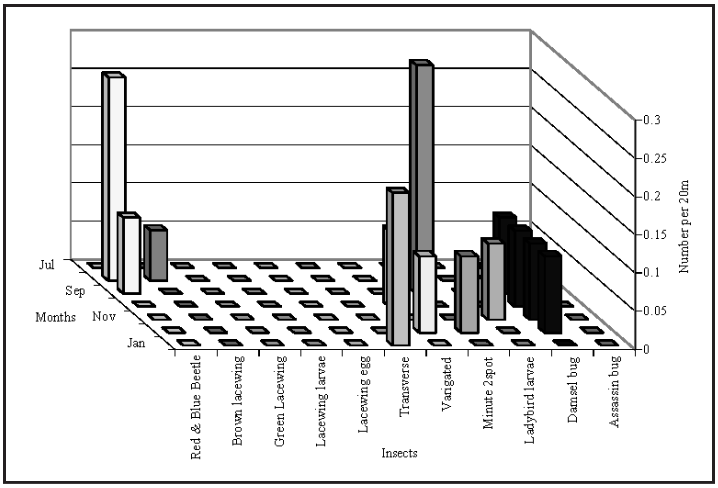

Figure 9. *Temporal movement of insects in irrigated wheat.*

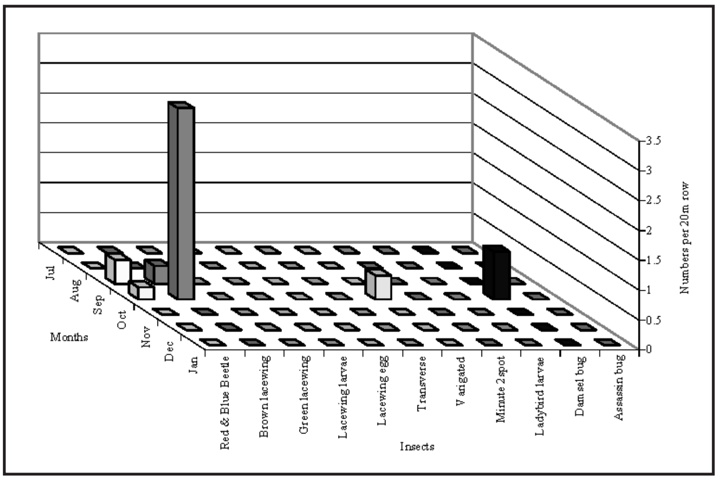

Figure 10. *Temporal movement of insects in cotton.*