# NATURAL MORTALITY OF *HELICOVERPA* EGGS ON COTTON.

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A great proportion of the *Helicoverpa* eggs laid onto cotton never hatch. They are either eaten by predators, dislodged from the plant by wind and rain, killed by climatic extremes, or are infertile. If we could accurately predict the level of natural mortality of eggs, growers would be better placed to make control decisions. Utilising the natural mortality of these pests would allow growers the option of sometimes reducing or avoiding insecticidal controls when natural mortality rates are high. A reduction in pesticide application holds many benefits, especially early in the season, when sprays can disrupt the establishment of beneficial insects which are important for the integrated control of both *Helicoverpa* and mites in cotton. Over the past three seasons, research has been carried out to determine the levels of natural mortality in *Helicoverpa* eggs, the primary factors causing this mortality and changes in rates of mortality throughout the season. In addition to this, preliminary studies on the establishment and behaviour of newly hatched *Helicoverpa* larvae on cotton have also been conducted.

## Levels of egg mortality

All studies to date have been carried out in unsprayed cotton so that levels of natural mortality can be observed without the complicating effect of mortality due to insecticides. The position of white eggs on cotton plants in the field were marked and their condition and stage of development were checked daily. If eggs hatched, the presence or absence of larvae was noted. As a result of these observations, the fate of each egg was determined as belonging to one of five categories:

• Disappearance: no trace of egg remaining. This could be attributable to several factors such as dislodgment due to wind or rain, egg loss due to shedding of plant parts and predation in which eggs are entirely removed, such as may be exhibited by some species of beetles, spiders or ants.

• Predation: this includes only predation in which recognisable egg remains were left, such as that caused by the feeding of some bugs and mirids. These sucking insects leave characteristically puckered empty eggs which are easy to identify.

• Infertile/dead eggs: those which were still present on the plant but were either undeveloped, still white or cream in colour, or eggs in which development had stopped.

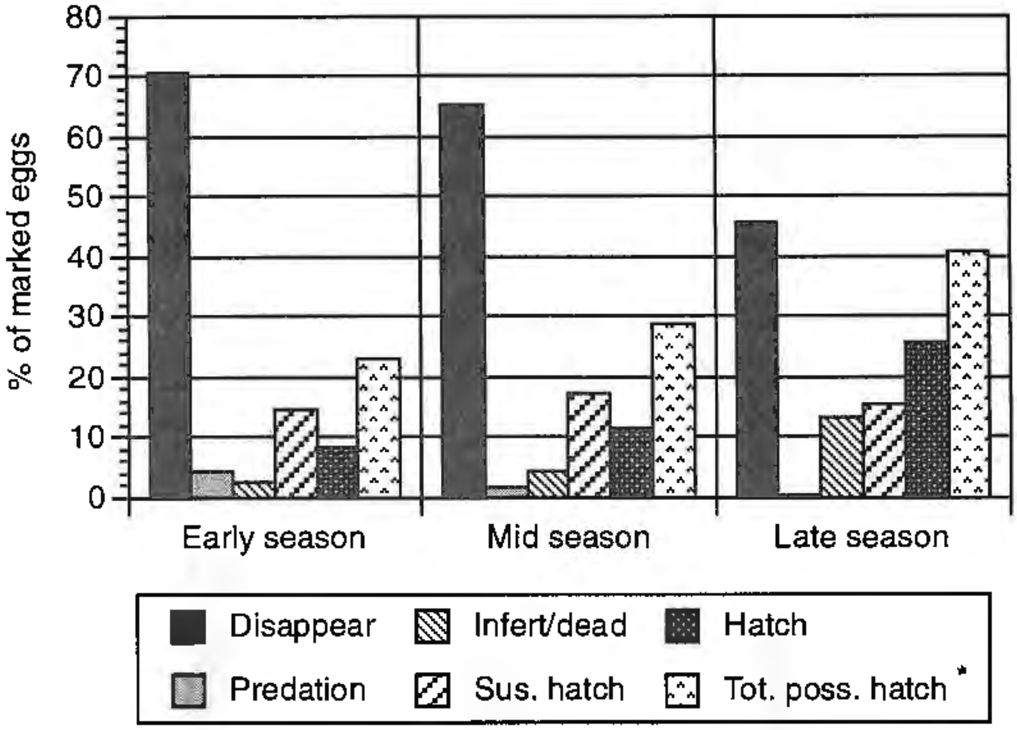
• Suspected hatched: this category was applied when egg remains indicating a successful hatching were found but the newly hatched larvae was no longer present. When a larvae hatches from an egg it usually consumes the egg shell leaving only a small remnant at the site of attachment to the leaf.

• Hatched: Eggs were deemed to have hatched if egg remains were present and a newly hatched larvae was found close to the egg site.

The study has shown a consistently high level of natural mortality of *Helicoverpa* eggs (Figure 1). This level was highest early in the season (Oct/Nov) when only 23% of all marked eggs survived to hatch. The level of mortality showed a decline throughout the season with a corresponding increase in the number of eggs hatching, with a total hatching rate of almost 41% late in the cotton growing season (Feb/March). This increase in survival as the season progresses suggest that the increasing density of the plant canopy offers more favonrable conditions for egg survival.

**Identifying causes of mortality**

The majority of eggs lost were found to have disappeared, with only a small proportion of egg loss directly attributable to predation, egg death or infertility. In an attempt to further partition the mortality factors a series of protection treatments were used. This involved enclosing plants within fine mesh cages in the field, moths were placed in these cages and allowed to lay eggs for one night. These eggs were then marked and one of three protection treatments applied. One third of eggs were left entirely unprotected, another third were enclosed within "open" cages with four walls and no lid so that predators still had access to the eggs. The remaining eggs were on plants that were fully enclosed within closed cages. These closed cages had also been treated with a knockdown pyrethrum insecticide prior to the eggs being laid so that they were in a predator free environment.

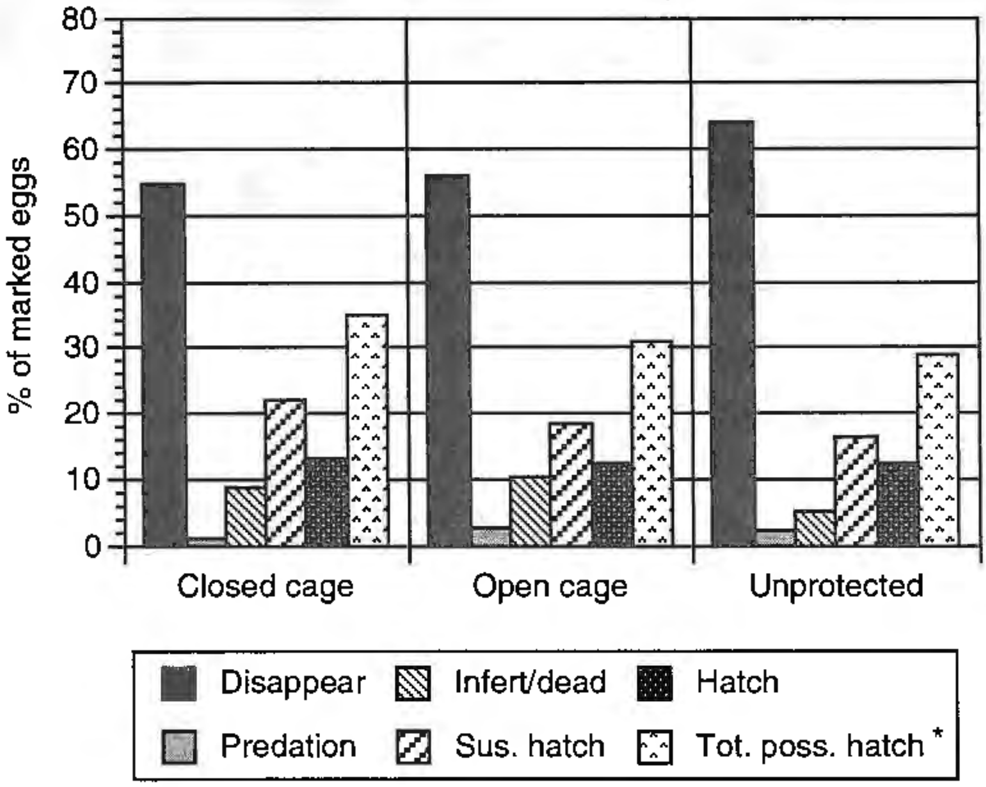



* N.B. Total possible hatch = suspected hatch + hatch

Figure 1. Fate of marked *Helicoverpa* eggs, showing changes in mortality and survival rates throughout the cotton season.

Figure 2 outlines the different survival rates of *Helicoverpa* eggs under the various protection treatments. By identifying which mortality factors have been removed in each protection treatment we can gain an idea of their relative importance with regard to egg mortality. The open cage offers plants some protection from the effect of wind buffeting and plant entanglement but would still allow predators access to the eggs. This protection has reduced the rate of disappearance by 8%. The protection of a closed cage has only produced a further 1% reduction in the disappearance rate. This protection treatment would remove the presence of predation and reduce the exposure of eggs to direct impact from rain. But even in these fully enclosed cages, averaged across the whole season, only 35% of the eggs survived to hatch.

The importance of abiotic factors, such as the effect of wind and rain, in the disappearance of eggs is further highlighted by the results of an experiment in which eggs were marked on potted plants kept in a controlled environment with no rain and minimal air movement. With the elimination of these environmental factors, the disappearance rate of marked eggs fell dramatically to 4%. Thus rain and air movement obviously play an important role in *Helicoverpa* egg mortality in the field.




* N.B. Total hatch = suspected hatch + hatch

Figure 2. Fate of *Helicoverpa* eggs in 3 different protection treatments. The results incorporate data from three full seasons.

**Predicting egg mortality**

During the last three seasons, detailed records of localised weather conditions have been kept, including wind speed, rainfall, plant canopy temperatures and relative humidity. These localised records have been used in conjunction with the relevant *Helicoverpa* egg survival data to develop a predictive model of egg mortality. Through the use of multiple regression, two factors, rainfall over the preceding 24 hours and a measure of wind speed, have emerged as explaining most of the variation in egg disappearance. Several other factors were tested and proved to be non-significant. These included plant height, days since sowing, mean number of predators per metre of cotton and daily maximum temperatures. Further work on the validation of this predictive model is needed before it can be used in the prediction of *Helicoverpa* egg mortality. But the capacity is there to allow growers to utilise natural mortality of *Helicoverpa* eggs as part of their pest management system and data on rates of egg mortality have already been incorporated into developing the "stop/go" charts for use with the Lepton test kit.

**Behaviour of newly hatched larvae**

Another interesting aspect of this project has been the observation of the behaviour of neonate *Helicoverpa* larvae. Many insecticide sprays target newly hatched larvae, so a better understanding of their feeding behaviour and movement around the cotton plant could provide insight into more effective control techniques. Observations showed that new larvae, like eggs, have a very high mortality rate, however the nature of much of this loss is still to be ascertained. One point of interest was the time taken for new larvae to establish within protected feeding sites on the cotton plant, such as in folded growing tips or inside squares. The amount of time spent prior to reaching these feeding sites represents the time that larvae are exposed and vulnerable to both insecticide applications and potentially unfavourable environmental conditions. Throughout the study the time taken for larvae to establish within these sites ranged greatly from a minimum of 15 minutes to a maximum of over 5 hours. The greatest number of observed larvae took between

30 and 45 minutes to become established within a feeding site, but many took significantly longer.

## Future work

The study to date has produced interesting and important data on levels of *Helicoverpa* egg and neonate larvae mortality. Future work will now concentrate on validation of the predictive model for egg mortality in relation to environmental factors, and observations of further aspects of neonate larval behaviour. In the coming cotton season it is planned to work within sprayed cotton crops to compare results with those gathered in unsprayed cotton. It is hoped that in conjunction with other researchers it will be possible to further refine our knowledge of the mortality factors involved in the as yet unexplained "disappearance" of both eggs and neonate larvae.

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