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FINAL REPORT

Development of *Helicoverpa* population dynamics model

CSE5C

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FINAL REPORT

Project Title: Development of *Helicoverpa* population dynamics model.

Project Code: CSE5C

Field of Research: Crop and environment protection **Field code:** 1.1

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TITLE : Development of *Helicoverpa* population dynamics model

Review of Aims.

To develop, validate and implement a regional model of *Helicoverpa* population dynamics which considers the abundance, movement, oviposition, development and mortality of *H.armigera* and *H.punctigera* on all major hosts within a given region. The purpose is to provide an interactive simulation model which can predict the regional dynamics of *Helicoverpa* populations in response to climatic, biotic, and agronomic conditions.

Four main uses were envisaged:

i) To Make short term predictions of likely egg laying pressures on crops within parts of a region.

ii) To evaluate the effects of various agronomic practices and area-wide management strategies on the regional abundance of *Helicoverpa.*

iii) To evaluate the impact of patterns of pesticide usage on resistance in *H.armigera* populations.

iv) To pinpoint areas for research that are critical for an understanding of *Helicoverpa* dynamics and about which we know little.

Software development.

The model is now complete, and a full scale prototype is being evaluated in the 1991/92 season. However the pesticide resistance module is only partially complete and is not currently functional. Running the full scale prototype has highlighted a number of minor modifications that will be required in the output and user interface routines to improve performance and functionality.

The model has been given the acronym HEAPS (Helicoverpa armigera and punctigera simulation). HEAPS is coded entirely in ANSI standard FORTRAN 77 and runs on both VAX and Macintosh computers. The VAX version of the model only outputs data directly to files and has no screen display. The Macintosh version is identical except for additional routines that drive an interactive screen interface utilizing windows, menus and dialogue boxes. Major emphasis has been placed in maintaining high standards of design, coding and documentation to ensure that the model is robust and easy to use, and that the FORTRAN code is easily maintainable and portable to any scientific computing platform. Parameter values used by the model are read in from files during initialization rather than being hard-wired into the model. Although this incurs a delay when the model is first started, it ensures that the model is as flexible as possible, and means that the user does not have to change values in the code and re-compile the program prior to use.

HEAPS has been designed in a modular fashion. Seven modules have been completed with respect to our current understanding of *Helicoverpa* biology: (i) Spatial representation, (ii) Moth movement, (iii) Oviposition, (iv) Development, (v) Pupal diapause, (vi) Mortality and (vii) Host phenology. Some minor changes to these may be required in the light of results from current studies. A suite of subroutines also exist that handle input, output and the screen interface. The only module not yet complete is the pesticide resistance module. Figure 1 provides a flow chart showing the overall structure of the model.

Validation.

The model as a whole has not been validated. Large scale field trials will be required to provide the model with accurate data, and then to compare the models predictions with actual observations. A new project proposal (Regional validation and implementation of *Heliothis* population dynamics model) is being submitted to CRDC to undertake this.

Some individual modules within HEAPS have been validated, while others are currently under study. The movement and host selection module is still awaiting the derivation of a number of parameters being studied under project CSE24C. The oviposition module has been using a simple algorithm to date but information on fecundity and other reproductive parameters of moths collected in project CSE4C has allowed the development of a new algorithm which considers host effects, moth age and climate conditions. This is now being implemented. The diapause algorithm and parameters have been provided by a separate study (Dr. D. Murray, QDPI Toowoomba). Field studies to evaluate and/or validate model parameters relating to larval development, mortality, and host crop phenology, all with a range of crops, are under way at NARS and on a number of farms throughout the region. A casual assistant (Ms. K. Holland) is currently employed to assist in these studies.

The larval development module has proven to be quite accurate. Given data on the number of eggs and larvae present in a field, and subsequent temperature data, the module can predict the timing of moth emergence six weeks later to within 24 hours. Figure 2 plots the predicted, and the actual observed values, for *Helicoverpa* development and emergence from a chickpea field, and figure 3 illustrates the same scenario in a maize field. The mortality module is not yet so accurate. The differences in figures 2 and 3 between the number of predicted moths emerging and the actual number that did emerge are attributable to variation from predicted mortality. On both the chickpea and maize, on some days more moths emerged, while on other days less moths emerged, than were predicted by the model. Mortality rates are governed by a wide range of factors, including host type and stage, weather conditions, predators, host plant resistance, insecticide resistance and human activities. Validating the mortality parameters has thus proved quite difficult.

populations. Two to three aerial surveys have been undertaken each of the past three seasons to provide data on landuse and host plant distributions over spring and summer. Demographic data for *Helicoverpa* subpopulations in the major crops and on uncultivated host plants are collected by field sampling. A network of wind recorders has been installed to provide wind speed and direction data over the study region, as *Helicoverpa* flight behaviour is strongly influenced by wind conditions. The spring migration of moths into the study area over the previous four years has been monitored with an array of pheromone and light traps distributed over the region.

Implementation.

A full scale prototype using real data for the Namoi study region is currently in operation. It is anticipated that "real - time" runs to predict *Helicoverpa* distribution and egglaying pressures will be implemented for the 1992/93 cotton season. Up until now smaller scale versions of HEAPS or its modules have been used for a number of purposes. Demonstrations of HEAPS have been given at the 1990 Australian Entomological Conference, the 1990 Australian Cotton conference, and to various research and grower groups visiting NARS. The model has been used to predict the timing of moth emergence and thus assist in the timing of visits by the CSIRO Entomology radar team. Dr. R. Farrow (CSIRO Entomology) has used simulation results from HEAPS as part of his studies into the potential consequences of a warming climate on pest populations in Australia. Finally, although not directly related to HEAPS, the methodology used in implementing the model on Macintosh computers has assisted in allowing the Proxba and *Heliothis* development subroutines from SIRATAC to be incorporated into the entomoLOGIC decision support program.

Publications arising from Project.

Dillon, M.L. & Fitt, G.P. (1990). HEAPS. A regional model of *Heliothis* population dynamics. pp. 337-344 Proc. Australian Cotton Conference 1990, Surfers Paradise

Dillon, M.L. (1991) Simulating the regional population dynamics of *Helicoverpa* spp. Proc. 9th Conference on Modelling and Simulation, Coolangatta, Qld. pp. 405-409.

Fitt, G.P. (1991) Ecological studies of *Heliothis* spp. in cropping areas. pp. 47-62 in *'A review of Heliothis research in Australia'*, P.H. Twine and M.P. Zalucki (eds.). Conference and Workshop Series QC91006, QDPI, Brisbane.

Fitt, G.P. and Dillon, M.L. (1992) Spatial population modelling of *Helicoverpa* spp. : studies of adult behaviour and movement. Proc. 5th Australian Applied Entomology Conference. (in press).

Fitt, G.P., Dillon, M.L., Gregg P.C., Zalucki M.P., Murray, D.A.H. (1992) The dynamics of *Helicoverpa* populations : can we predict ? p. 197-207 in Proc. Australian Cotton Growers Research Conference. Surfers Paradise, 1992

Figure 1. HEAPS FLOW CHART

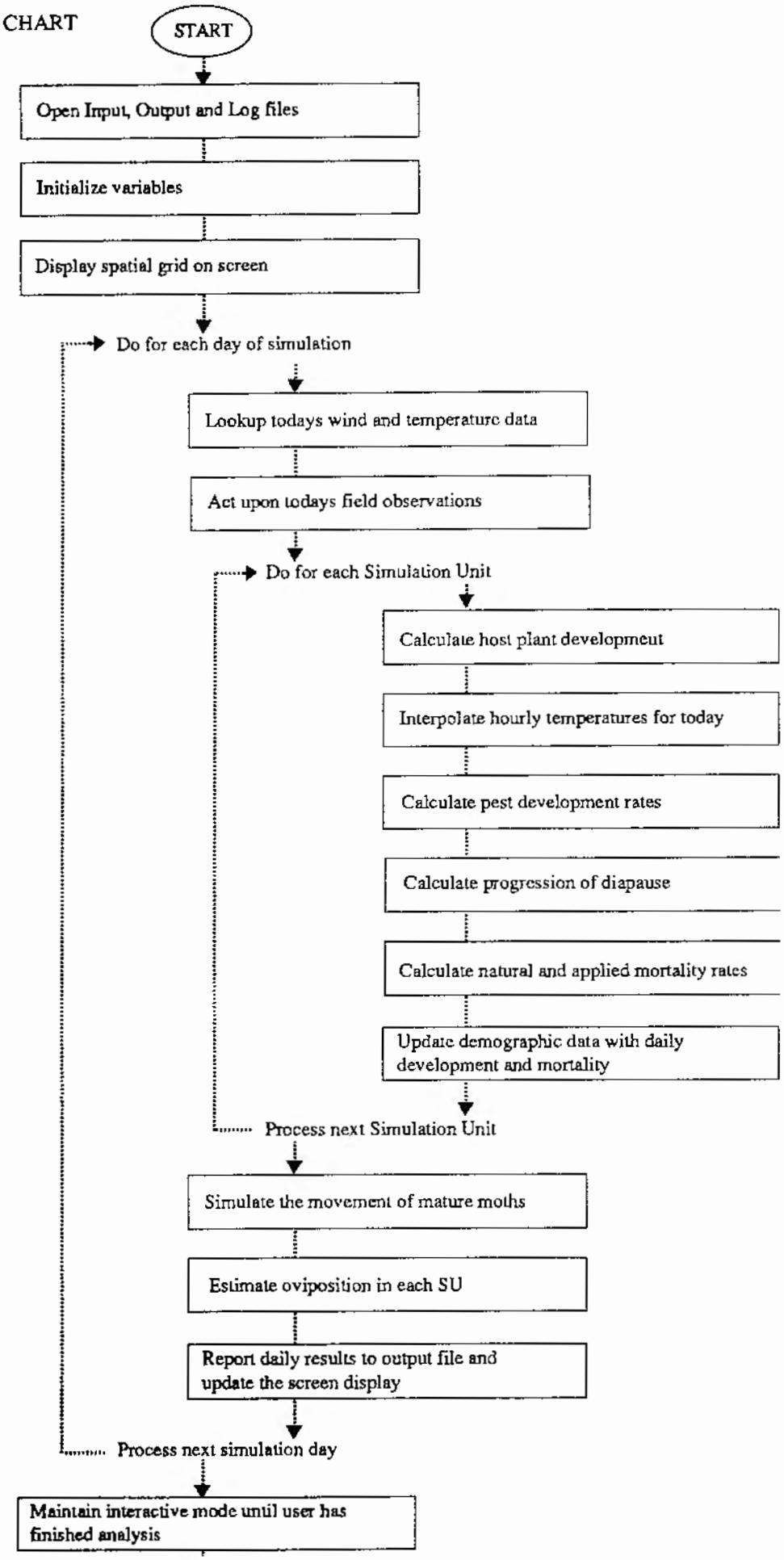

Figure 2. Numbers of eggs laid and moths emerged from chickpea crop. For moths the figure shows actual emergence and the predicted emergence from the HEAPS *Heliothis* model (simulating from Oct. 26, Jday 299 indicated by arrow). (note different axes for eggs and moths)

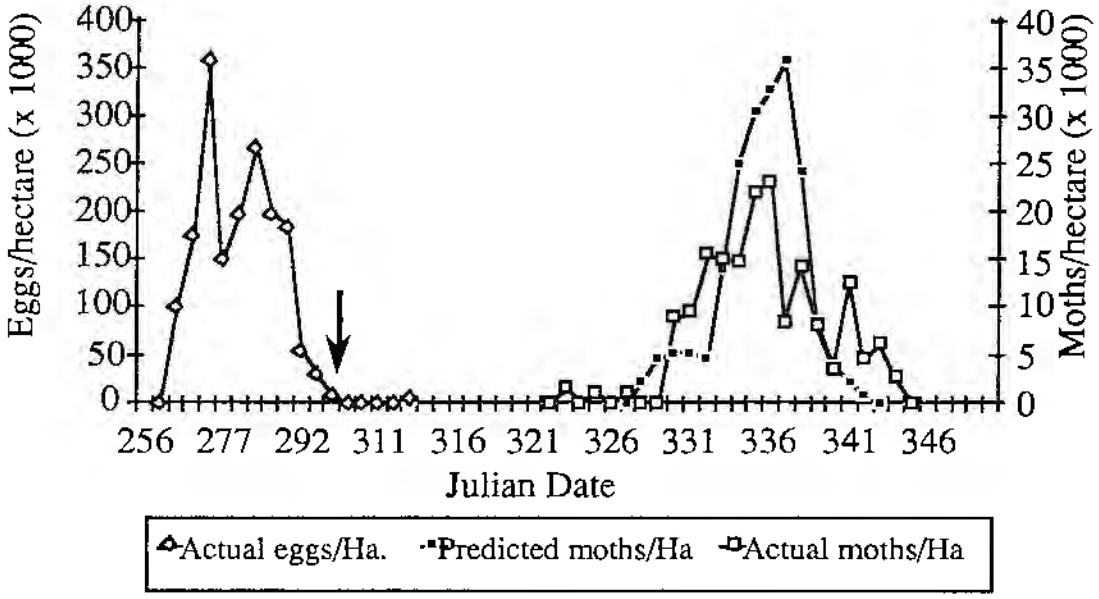

Figure 3. Numbers of eggs laid and moths emerged from maize crop. For moths the figure shows actual emergence and the predicted emergence from the HEAPS *Heliothis* model (simulating from Dec. 18, Jday 352 indicated by arrow). Note different axes for eggs and moths.