EVIDENCE FOR SPRING MIGRATION OF *HELIOTHIS* SPP. FROM INLAND AUSTRALIA TO COTTON AREAS.

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INTRODUCTION

For many years entomologists have speculated on the origin of spring populations of *Heliothis punctigera* in eastern Australia (Farrow and Daly 1987). Radar studies have shown that this species can migrate over long distances by high altitude night flight (Drake *et al.* 1981, Drake and Farrow 1985). It is even capable of crossing the Tasman Sea to New Zealand (Fox 1978). It is therefore possible that moths appearing in cotton areas in spring have not overwintered there. In fact, overwintering pupae of *H. punctigera* are virtually non-existent under crops in the Namoi-Gwydir (Fitt and Daly in press).

Speculation on the origins of spring populations has been extended to *H. armigera* as the realisation has grown that this species too is capable of extensive migration (see the paper by M. Coombs, these Proceedings). Although *H. armigera* does overwinter in large numbers in cotton areas, the timing of peak pheromone catches in comparison with local emergence suggests that significant numbers of spring moths are not of local origin. Comparisons of the levels of pyrethroid resistance in overwintering pupae and spring moths also suggest that not all of the latter are local (Daly and Fitt in press).

An important question is the area of origin of these spring immigrants. Over the last 3 years, we have been investigating the ecology of *Heliothis* spp. in inland Australia (Gregg *et al.* 1987, 1989). The most recent findings of this work are summarised by G. Fitt *et al.*in these Proceedings. Large populations of *H. punctigera*, and smaller but still significant populations of *H. armigera*, have been found over vast areas. They breed on native annual plants in winter. These plants dry off rapidly in spring, and the *Heliothis* disappear. This paper presents evidence which indicates that in 1989 they emigrated from the inland, and that significant numbers arrived in the cotton areas of northern N.S.W. and southern Queensland (Fig 1.)

METHODS

Demonstrating long distance migration is difficult in any insect. It is necessary to establish the existence of a plausible source area, with populations in a suitable state for migration at the appropriate time. It is then necessary to show appearance in destination areas which is consistent with the time of the presumed migration, but not consistent with local emergence. Finally, it is necessary to demonstrate the existence of transport mechanisms such as upper atmosphere winds. Even then, the evidence is only circumstantial. For full proof we need to find markers which are characteristic of moths originating in source areas but are absent from local moths. For the spring 1989 migration of *Heliothis* spp. all these requirements were met.

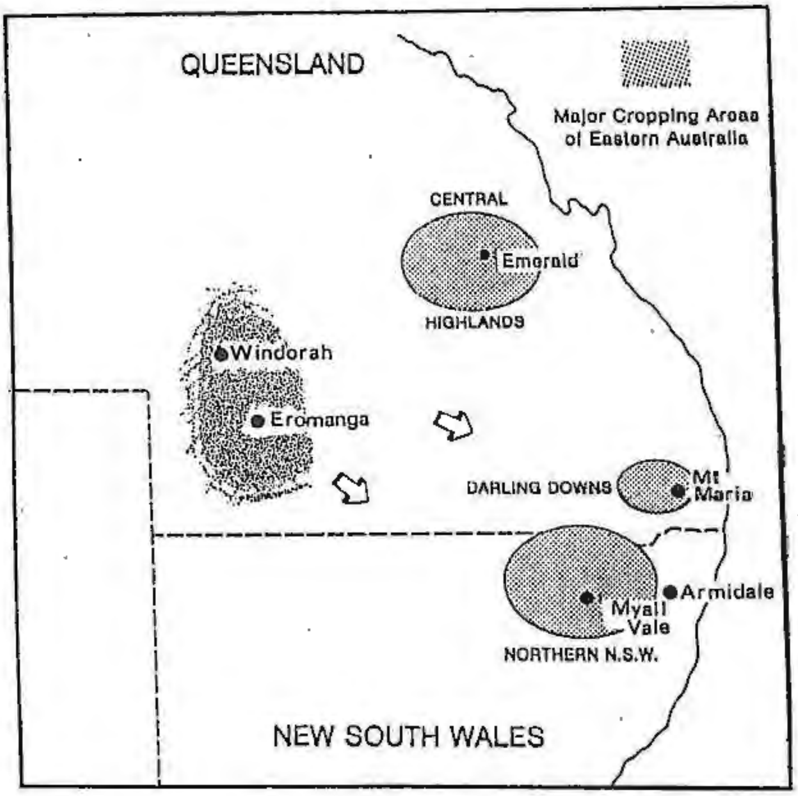

Figure 1. Source areas in western Queensland, and destination areas in the east, for the September 1989 migration of *Heliothis* spp.

RESULTS

The source population

The overwintering population in southwest Queensland was the highest yet recorded from the inland. From surveys conducted in July we estimated a total population of about 2 $x10^{11}$ (200 billion) *Heliothis* larvae in the Windorah-Eromanga region alone. Of these, about 98% were *H. punctigera* and 2% *H. armigera*. These larvae would have pupated in August and emerged in early September. We used the HEAPS model (Hamilton and Fitt 1988, M.Dillon and G.Fitt, these Proceedings) to predict their emergence and compared it with pheromone catches from Myall Vale (Fig. 2). It is clear that peak emergence coincided closely with peak Myall Vale catches. Local emergence would normally peak some time later in October.

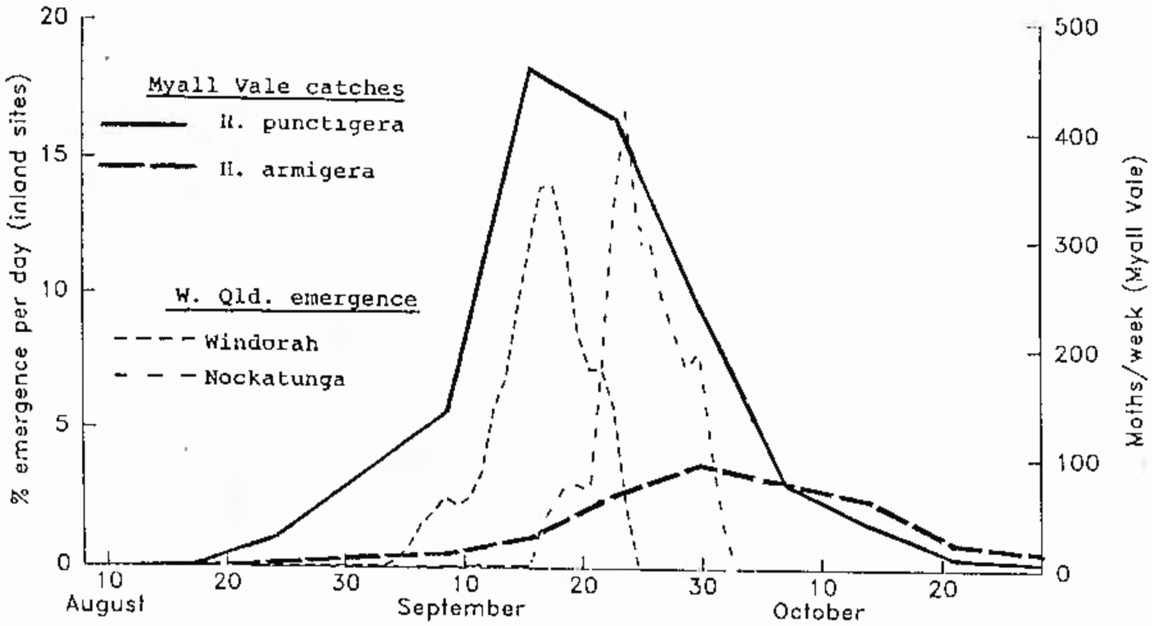

Figure 2. Pheromone trap catches at Myall Vale for August-October 1989 compared to emergence from two sites in the source area (Windorah and Nockatunga) as predicted using the HEAPS model.

The transport mechanism

Heliothis spp. migrate at altitudes of 300-1500m, where night winds are frequently strong even though surface conditions may be relatively calm. Wind velocity at these altitudes greatly exceeds flight speed so the movement of a moth is approximately equivalent to the movement of the parcel of air which contains it. The latter can be calculated by the technique of synoptic backtracking, which uses simple mathematical calculations based on upper level winds recorded on working charts prepared by the Bureau of Meteorology (Drake and Farrow 1985).

In spring strong winds blowing from the west or northwest result from the passage of cold fronts. These systems are known to be associated with the migration of Australian Plague Locusts and various moths (Farrow and McDonald 1988).

We identified five such systems in August-September 1989 (4-5 August, 19-20 August, 31 August-1 September, 10-13 September, and 24-26th September). All these might have brought moths in the general direction of the cotton areas, but the strongest and most persistent system was 10-13 September. Backtracks for this system are shown in Fig. 3. It is obvious that moths flying from western Queensland and

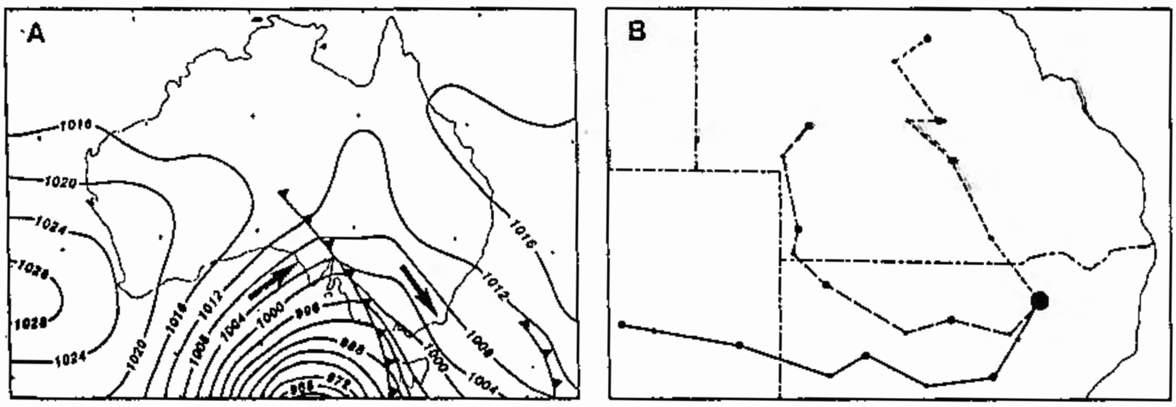

Figure 3. A. Synoptic weather map for 10th September 1989, showing approachimng cold front and the direction of associated winds. B. Backtracks originating from Narrabri for moths arriving on 11th September (– – – –), 12th September (—— ——) and 13th September (————). Each leg of the path represents movement over a 5 hour period. Dots represent pauses during daylight.

other inland areas at this time could have reached northern NSW and the Darling Downs after 2-3 nights flight. The backtracking procedure we used was a conservative one which made no allowance for downwind flight, flight during daylight or the existence of low level jet streams, all of which might have shortened the required flight time. There is little doubt that both *Heliothis* species have the capacity to make flights of the necessary duration.

Markers

Artificial markers are often used in the study of bird and mammal migration, but have little application to insects because of their high mortality, short life cycles and large numbers. It is better to find a natural marker which characterises most if not all of the migrants.

One such marker is pollen. It is extremely durable and morphologically distinctive. The plant family, and sometimes the species, from which it is derived can be identified. If it is known that a plant grows only in the source area, or flowers only there at the time of migration, its pollen can be a useful marker (Hendrix *et al.* 1987). Variations of this method have been used in disciplines ranging from archaeology to forensic science to place a "suspect" at the "scene of the crime". We decided to try it for *Heliothis* arriving at 3 eastern sites (Myall Vale, Armidale and Mt. Maria) in September.

Pollen is collected on the proboscis of a moth when it visits flowers to feed on nectar. *Heliothis* adults visit a variety of flowers. Included are those of plants which do not support larvae, such as eucalypts.

The probosces of moths caught in pheromone traps at the eastern sites were examined under a scanning electron microscope, and pollen present was compared with a reference collection of about 50 samples from flowering plants common in the source area (Eromanga and Windorah) and in the east. Up to 6 different types of pollen were found on each moth. Mostly, the abundance of pollen reflected the abundance of local flowers (Table 1). For example, wild turnip (*Brassica* spp.) was common at Myall Vale, and all moths trapped there carried it. There were some important exceptions to this. Pollen from *Velleia* and *Ptilotus* spp. and from daisies of the subfamily Tubuliflorae was found on moths at all three eastern sites. These plants do not exist there, or do not flower there in September. On the other hand, they were flowering in abundance in the inland. About 1/3 of the moths trapped at eastern sites carried pollen from such plants. As it is highly unlikely that they could have acquired it anywhere else than the inland, these moths were almost certainly migrants. The proportion of migrants could be higher than 1/3, because moths feed after migration and lose pollen in the process.

Other characteristics which might prove useful as markers of origin include elemental profiles (Fitt 1986) and, for *H. armigera*, resistance to pyrethroids. We have begun work on the elemental composition of moths from inland and eastern sites at different times of the year, but it is too early to draw any conclusions. Similarly, we have initiated studies in cooperation with J. Daly and

Pollen type	Windorah Hp	Eromanga Hp	Myall Vale Hp	Myall Vale Ha	Armidale Hp	Armidale Ha	Mt.Maria Hp	Mt.Maria Ha
Amaranthaceae								
Ptilotus macrocephalus	1	4	0	1	0	0	0	0
Ptilotus polystachyus	7	1	0	1	0	0	0	0
Asteracea - Tubuliflorae	9	7	4	5	2	1	1	1
Goodeniaceae								
Velleia spp.	1	7	0	1	1	0	2	0
Brassicaceae	8	0	10	10	1	1	8	4
Fabaceae								
Swainsona microphylla	5	0	0	0	0	0	0	0
Trifolium repens	0	0	0	0	2	0	0	0
Myrtaceae								
Eucalyptus spp.	0	2	2	5	8	7	4	8
Thymelaeaceae								
Pimelea sp.	0	2	0	0	0	0	0	0
Unknowns								
Boraginaceae	0	0	0	0	0	0	3	4
Proteaceae	0	0	1	2	5	3	6	3
Other families	1	4	1	2	2	2	2	1

Table 1. Numbers of moths carrying pollen of different types from areas in western Queensland and eastern Australia. *Hp*= *Heliothis punctigera*, *Ha*= *H. armigera*. Plants in the top part of the table are considered migration indicators. Number of moths examined was 10 for all groups except *Hp* from Mt. Maria, where it was 8.

J. Fisk on the frequency of resistance in *H. armigera* in the inland. It is reasonable to think that resistance might be uncommon, and initial results seem to confirm this. If so, migration will be of considerable interest for management of resistance, and resistance will provide a good marker of migration.

ACKNOWLEDGMENTS

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