LIGHT MANAGEMENT AND EGG PRODUCTION OF QUEENSLAND FRUIT FLY, *BACTROCERA TRYONI* (FROGGATT), IN A MASS REARING FACILITY

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Summary

Lighting conditions in a mass rearing facility were changed in the adult rooms after one year of operation. Neon tubes were replaced with tri-phosphate tubes and skylights were added. An increase in the light intensity and a natural dusk resulted in an average increase of 43% in egg production for the three weeks after the change compared with the three weeks before the change or an average increase of 30% using all observation data.

INTRODUCTION

The Queensland fruit fly (Qfly), *Bactrocera tryoni* (Froggatt), is the most significant Australian fruit fly pest. It is responsible for most of the damage caused by fruit flies in horticultural industries (Anon. 1991; Horwood and Keenan 1994). The sterile insect technique (SIT) is a cost effective and environmentally acceptable strategy for eradicating fruit fly outbreaks or suppressing the population of fruit flies (James 1992). The success of this procedure is dependent on the mass production of large numbers of insects for sterilisation and release (Fisher 1992).

One important component for mass rearing fruit flies is the maintenance of a fertile egg-producing adult colony. Under favourable conditions, flies will mate and lay large quantities of eggs for use in the production facility. For this to occur, adult rearing rooms should be adequately lighted to ensure high fertility and egg production (Monro and Osborn 1967). Mating in *B. tryoni* is stimulated by exposure either to natural or artificial dusk (Myers 1952; Barton-Browne 1956, Tychsen and Fletcher 1971). Under the artificial conditions of mass rearing, it is necessary to simulate dusk by providing a period of low light intensity during the day to maintain activity and fecundity (Myers 1952; Barton-Browne 1956). Bateman (1972) identified that light plays an important role in fecundity of fruit flies by affecting two main areas. Firstly, increasing light resulted in increasing general activity of adult females, especially feeding and oviposition activity, and secondly, dawn/dusk played an important role in synchronisation of mating behaviour.

Despite this knowledge, light is managed differently in mass rearing facilities in different countries. Fay (1989) reviewed a number of species and noted that the *Anastrepha* and *Ceratitis* facilities used constant lighting while *Bactrocera* facilities tended to use light-dusk-dark because of their dusk mating. Fisher (1992) reported using fluorescent ceiling lights at a constant 1000 lux for uninterrupted periods of up to 48 hours. Constant light resulted in poor egg lay of Qfly; a higher production of eggs was obtained by resting the colony every third day. Spencer and Fujita (1997) used a photoperiod of 12:12 (L:D) from ceiling lights, with no lateral lighting, to rear *B. cucurbitae* (Coquillet), *B. dorsalis* (Hendel) and *Bactrocera latifrons* (Hendel). Tzanakakis (1989) noted that natural diurnal light was not necessary in a rearing practice with some *Dacus oleae* (Gmelin) facilities using light intensities from 5,000 to 400 lux. Mexico uses a constant 3000 lux in their Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) facility (Schwarz *et al.* 1985), lighting cages from the sides.

Following a review of egg production at the TriState Fruit Fly Production Facility at Camden, New South Wales, it was perceived that lighting for the adult colony was inadequate.

While much has been reported about daily rhythm of Qfly in natural and laboratory light, the details of egg laying response over the life of a Qfly in factory lighting have never been reported. This paper reports on a change in light management in the Qfly mass production facility and the resultant changes in egg production over the 12 day egg laying life of adult Qflies.

METHODS

The TriState Fruit Fly Production Facility at Camden, NSW, became operational in November 1996 (Terras *et al.* 1997). The adult colony was housed in two rooms with the temperature and humidity in both rooms being regulated at 26 ±1°C and 60 ±5% relative humidity. There were 20 oviposition cages and each cage was seeded with approximately 200,000 pupae, and flies were allowed to emerge. Each batch consisted of five cages. The flies were provided with sugar, yeast hydrolysate and water. A batch was kept for 3 weeks and then replaced with a new group of flies. Eggs were collected every 2–3 days from females of 8–21 days old. Harvested eggs

were washed into measuring cylinders and allowed to settle before being measured.

All lighting was wall mounted with two lighting tubes being vertically mounted to maximise light entry into each cage; this design provided diffuse light and minimised flies crowding towards narrow bands of light (Tzanakakis 1989). The original lighting was controlled so that fluorescent tubes were on for 12 hours during the day then automatically turned off and the incandescent globes automatically turned on simultaneously for one hour to simulate dawn and dusk. Light intensity was monitored initially in November 1996 and eventually, following a further assessment, it was decided that the existing light regime was inadequate. To provide more and natural lighting, tri-phosphate tubes and sky-lights were installed in December 1997, creating an increase in light intensity during the day and a natural dusk in the afternoon. The volume of eggs collected before altering the lighting was compared to the volume collected afterward (Table 1).

Light intensity readings were taken using a Hobo Data Logger. The logger was placed on the front of a cage facing the light tubes; the front cage wall was about 10 cm away from the lights. The logger was also hung at the back of the cage on the outside and facing the light source, about 55 cm from the lights. The reading at the back of the cage measures light intensity after it had passed through the front mesh and back mesh. An additional logger was placed on the top of the cage facing upwards to measure the light reflected from the ceiling, and entering from the skylights.

Statistical analysis

All batches presented in Table 1 were included in the analysis. Data of collections 1 and 2 (Day 8 and Day 10) were pooled because the first collection data came from 2 cages only. Data were log-transformed to minimise the variance heterogeneity between collections and found to be timely un-correlated with the correlation between collections ranges from –0.199 to 0.116. Therefore, a factorial analysis of variance was used to compare yields before and after the change overall and within collection time. The analysis was run on an S-Plus module written by Azzalini and Chiogna (1996).

RESULTS

There was strong evidence that the change of the room light regime had a significant effect on the egg yield ($F_{1,241}$=20.60; P<0.001) with 'after treatment' yielding an average of 109.1 mL per collection day and 'before treatment' yielding an average of 85.7 mL. The yields at the first 2 collections were generally the highest and decreased as the collection time was longer ($F_{3,241}$ =269.15; P<0.001).

The natural lighting conditions and an increase in light intensity resulted in a substantial increase in egg production (Table 1). Percentage increase calculated using the data of three weeks before and after the lighting change (Increase[1] in Table 1) was 43%. The fourth week after the change was the Christmas week with significant staff disruption occurring and hence batch D28 was out of character with all other batches. When this batch was included along with other data in the analysis, there was still an increase of 30% (Increase[2] in Table 1).

Table 1. Average volume (mL) of eggs collected from each batch of *B. tryoni* 8–20 days after emergence. Figures in bold indicate average volume collected after the change in lighting.

Batch	Total volume (mL)	Average collection Day 8 [3]	Average collection Day 10	Average collection Day 14	Average collection Day 16	Average collection Day 20
D18	1865	105	89	144	58	50
D19	1865	123	101	98	101	46
D20	1710	113	70	97	47	38
D21	1615	125	111	85	42	35
D22	1650	125	118	86	43	33
D23	1440	50	90	92	45	41
D24	1775	68	**106**	**122**	**62**	**38**
D25	**2170**	**173**	**163**	**104**	**53**	**45**
D26	**2290**	**147**	**138**	**135**	**69**	**28**
D27	**2400**	**183**	**157**	**124**	**56**	**33**
D28	**1740**	***15**	**92**	**131**	**68**	**48**
D29	**2485**	**138**	**149**	**146**	**69**	**50**
D30	**2205**	**110**	**142**	**146**	**87**	**64**
Increase[1]	**143%**	**206%**	**127%**	**137%**	**121%**	**117%**
Increase[2]	**130%**	**126%**	**140%**	**129%**	**109%**	**107%**

* Batch was egged too early due to Christmas Holiday schedule.

[1] Increase is calculated by dividing the average collection for three weeks after the change by the average collection for three weeks before the change in lighting.

[2] Increase is calculated by dividing the average collection for all weeks in the table after the change by the average collection for all weeks in the table before the change in lighting.

[3] This column contain means based on 2 or 3 cages, depending on when cages started to produce.

Table 2. Recordings of the average light intensity (lux) before and after the change in light regime in December 1997.

Location	November 1997	January 1998	July 1998
Front of cage—full light	62	160	180
Front of cage—dawn/ dusk	3		40
Back of cage—full light	1	6	3
Back of cage—dawn/ dusk	<1	<1	1.5
Top of cage—full light		6–14	3–16
Top of cage—dawn/dusk		<1	2

The greatest increase (106%) occurred in the first collection and generally the level of egg production decreased with each subsequent collection from the same batch (range 17%–37%).

The changes in average light intensity (lux) is given in Table 2 with readings being recorded when the lights were on.

DISCUSSION

The introduction of mass-rearing insects, using the sterile insect technique, is mainly aimed to produce males that can be competitive in the field. However, the artificial conditions of rearing may change the behaviour or reduce longevity and so make the sterile males less fit (Monro and Osborn 1967). Implementation of the SIT for Queensland fruit fly requires reliable production of competitive sterile fruit flies.

The daily availability of eggs for the production cycle can be a limiting factor, therefore adult colony vitality needs to be optimised to ensure maximum egg production. For this to occur, adults require exposure to either natural or artificial dusk to stimulate mating (Monro and Osborn 1967). The usual lighting regime are a period of simulating dark, dawn, day and dusk. In the factory, dawn and dusk were originally simulated by incandescent lights and day light was produced by neon lights with electronically switching on and off. Following the change, the dawn/dusk lighting was provided by incandescent and natural lighting and the day light was produced by triphosphate fluorescent lights.

The restriction of mating to dusk serves to synchronise female responsiveness with the time when males are sexually active and releasing pheromone (Fletcher and Giannakakis 1973). An optimal light intensity of 10 lux is required for mating (Smith 1991). Also, there seemed to be value in the steady decline in light intensity rather than the critical values themselves. Smith (1991) noted that Qfly activity increased as light intensity fell below 850 lux and male fly activity became more competitive as light intensity approached 10 lux and declined rapidly after that. Monro and Osborn (1967) state that adult flies need a period of low light intensity near the end of the photoperiod to stimulate mating and that light from the sky during natural dusk was more effective than an artificial dusk.

Bateman (1972) noted that falling illuminance at dusk acts as a stimulus for the initiation of sexual activity. With the introduction of sky lights and the increased lighting, it may be concluded that sky lights resulted in better sexual activity, compared with the artificial dusk created by incandescent lights.

Changes in fecundity of *B. tryoni* are related to both illuminance and photoperiod which are directly correlated to feeding activity and rate of ovarian maturation (Bateman 1972). The largest percentage increase occurring in the first collection suggests that females matured sooner after the lighting change compared with those females before the change.

We conclude that change in lighting regime, including natural lighting and increased lighting, has resulted in the adult colony flies in the mass rearing facility laying more eggs. We are not able to separate the effects of increased day lighting and the effects of the skylights because the two changes occurred together; this may be the subject of future research. The ramping of light intensity appears to result in more egg production presumably from better or more matings, rather than the 'on-off' approach of a critical light intensity. Future research might examine the daylight light intensity; currently the Camden facility has 160 to 180 lux as the artificial daylight; Smith (1991) suggested that 10,000 lux was the natural light intensity. However the egg production under the new light regime is adequate for current production needs.

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