POSITIVE CORRELATION OF MALE AND FEMALE *BACTROCERA TRYONI* (FROGGATT) (DIPTERA: TEPHRITIDAE) CATCHES IN ORANGE-AMMONIA TRAPS

A.R. Clarke[1,2] and B.C. Dominiak[3,4]

[1] Discipline of Biogeoscience, Faculty of Science and Technology, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia
[2] Cooperative Research Centre for National Plant Biosecurity, LPO Box 5012, Bruce ACT 2617, Australia
[3] Industry & Investment NSW, Locked Bag 21, Orange NSW 2800, Australia
[4]The Department of Brain, Behaviour & Evolution, Macquarie University, NSW 2109, Australia
Email: bernie.dominiak@industry.nsw.gov.au

Summary

Populations of the Queensland fruit fly, *Bactrocera tryoni*, are routinely monitored using the male attractant cue-lure. This monitoring provides no information about female numbers. Using a data set of 1148 weekly clearances of orange-ammonia baited traps, which catch both males and females, the correlation between male and female numbers was tested for 48 weeks of the year (four weeks each month) and for the combined data set. Weekly male and female trap catches were significantly correlated for 47 of the 48 weeks, regardless of mean population size or time of year. For the whole 48 weeks, the correlation between male and female numbers was $r = 0.722$, significant at $p<0.001$. Results suggest that changes in the numbers of male *B. tryoni*, as detected through cue-lure sampling, also reflects changes in number of females.

Keywords: sex-ratio, field sampling, monitoring, cue-lure

INTRODUCTION

Males of approximately 70% of fruit flies of the genus *Bactrocera* (Diptera: Tephritidae) respond strongly and positively to either one of two chemicals, cue-lure (4-(4-acetoxyphenyl)-2-butanone) or methyl eugenol (4-allyl-1,2-dimethoxybenzene) (Fletcher 1987). The Queensland fruit fly, *Bactrocera tryoni* (Froggatt), is cue-lure responsive and cue-lure baited traps are used extensively for research (e.g. Dominiak *et al*. 2003a), operational field monitoring (e.g Dominiak *et al*. 2003b) and male annihilation (e.g. Lloyd *et al*. 2010).

The lures have one major and obvious weakness; they trap only male flies, leaving us ignorant about the activity of females. In the use of cue-lure for research or management, the females are either completely ignored, or assumed to be present in equal proportion with males (Balagawi 2007, Dominiak *et al.* 2008). There are, however, reasons why the numbers of male flies in the environment may not be the same as the number of females, for example if the sexes have differential dispersal (Bateman and Sonleitner1967, Fletcher 1974) or, as in the case of *B. minax* (Enderlein), differential mortality (Dorji *et al.* 2006).

Orange-ammonia is a fruit based, liquid lure used in McPhail traps (Caldwell and May 1943). The lure is weakly attractive (compared to cue-lure) and operationally difficult to use as traps need to be cleared quickly as captured flies tend to rot, particularly in hot weather. The benefit of orange-ammonia traps, however, is that they capture both males and females (with a female bias) (Caldwell and May 1943, May 1961). Because they simultaneously catch both males and females, data from orange-ammonia baited traps offer a source by which to investigate if *B. tryoni* male populations are correlated with *B. tryoni* female populations.

May (1961) produced a very large population data-set for *B. tryoni*, based on orange-ammonia trapping. Never formally analysed, May's data offers an opportunity to explicitly investigate correlations between male and female *B. tryoni* populations during the year. Because orange-ammonia trap catches are female biased, this data-set cannot be used to explicitly investigate field sex ratios. On the assumption that the ratio of females to males caught by a trap remains relatively constant, so long as the ratio of females and males in the environment is constant, then we should expect to see strong correlations between the total numbers of females and males in the traps. If, however, the ratio of males to females in the environment is not constant, then we would not expect to see significant female to male correlations in the trap catches. Knowing if male populations are correlated or not with female populations is critical when making interpretations from male attracting cue-lure traps.

In this paper, using trapping data from May (1961), we test if male and female numbers in weekly trap catches, or combined across the year, are correlated. Further, we tested if these correlations (or lack thereof) were associated with population size or time of year. The population phenology aspects of May's data are developed elsewhere (Muthuthantri *et al*. in press).

MATERIALS AND METHODS

Trapping data

May (1961) used McPhail traps baited with orange-

ammonia to sample *B. tryoni* and other *Bactrocera* species at multiple sites throughout Queensland (i.e. tropical and subtropical parts of *B. tryoni*'s endemic range), for multiple years during the 1940s and 1950s. The lure solution was made using pulped orange (283 g), ammonium carbonate (14.2 g) and rain water (570 mL) held for 24 hours in a closed container. This solution was then diluted with water at 1:30. There was a minimum of three years weekly trapping data for each site, with some sites (e.g. Lockyer Valley) sampled weekly for up to eight years. Up to a dozen individual traps were placed within a local area (for example an orchard or research farm) for each site, but the catches from each trap are combined in May's presentation to give a single, weekly site value. Fuller details of sites and collecting methodology are given in May (1961) and Muthuthantri *et al.* (in press).

For the current paper, trapping data from six sites across Queensland was combined (Table 1). For a given site, for a given month, there was between one and eight years of data available. Each month provides four weeks of trapping data (partial weeks in a month were excluded for ease of analysis). The number of years of available data for a given month varied within and between sites due to duration of sampling at the site, when sampling commenced and finished, and missing data. Months in which no flies were caught were also excluded from analysis. For each of the 48 weeks of the year (four weeks in each month), between 21 and 28 trap collections were available (Table 1), for a total data set of 1148 weekly trap catches.

Analysis

The purpose of the analysis was to determine if fluctuations in the number of trapped male flies were correlated with the numbers of trapped female flies. The sex ratio *per se* was not considered important as orange-ammonia traps are known to be female biased (Caldwell and May 1943). For each of the 48 weeks of trap data, a Pearson correlation analysis (Zar 1996) was carried out on the number of female versus male flies in the catch. A correlation was also done on the entire combined data set. The weekly correlation scores (i.e. r values) were subsequently themselves correlated against total weekly trap catch to see if the correlation between male and females differed with population size (e.g. correlations between males and females may have been significant for small fly populations, but non-significant for large populations). The r values for each week were also plotted against time, to see if there were any temporal patterns in weak or strong correlations between male and female flies.

RESULTS

During the trial period 77466 female and 24509 male *B. tryoni* were trapped (female to male ratio 3.1:1) and female trappings exceeded male trappings in all 48 periods. Male and female *B. tryoni* trap catch was strongly positively correlated for the entire combined data set ($n = 1148$, $r = 0.72$, $p<0.001$) and for most individual weeks through the year. For each of the 48 weeks, only in one week was the correlation between males and females non-significant. Of the remaining 47 weeks, the correlation was significant at $p=0.05$ for two

Table 1. **Location and number of years of orange-ammonia based McPhail trapping data used in the current study. For each month, four weeks of trapping data was available (i.e. January week 1, January week 2, etc). Thus, for example, for the month of January at Brisbane, three years of data was available, with four weeks of data each year, providing 12 individual collection records. All data was analysed at the weekly, not monthly, level.**

Collection site	Years of data											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Stanthorpe	4	4	4	3	3	2	1	1	1	4	3	3
Toowoomba	4	2	4	4	4	4	5	5	5	5	4	3
Brisbane	3	2	2	3	3	3	3	3	4	4	2	1
Lockyer	7	7	7	6	6	7	7	6	7	8	8	8
Atherton	5	4	3	5	4	4	4	3	3	3	5	5
Ayr	4	2	2	4	3	4	4	4	2	4	3	3
Total	**27**	**21**	**22**	**25**	**23**	**24**	**24**	**22**	**22**	**28**	**25**	**23**

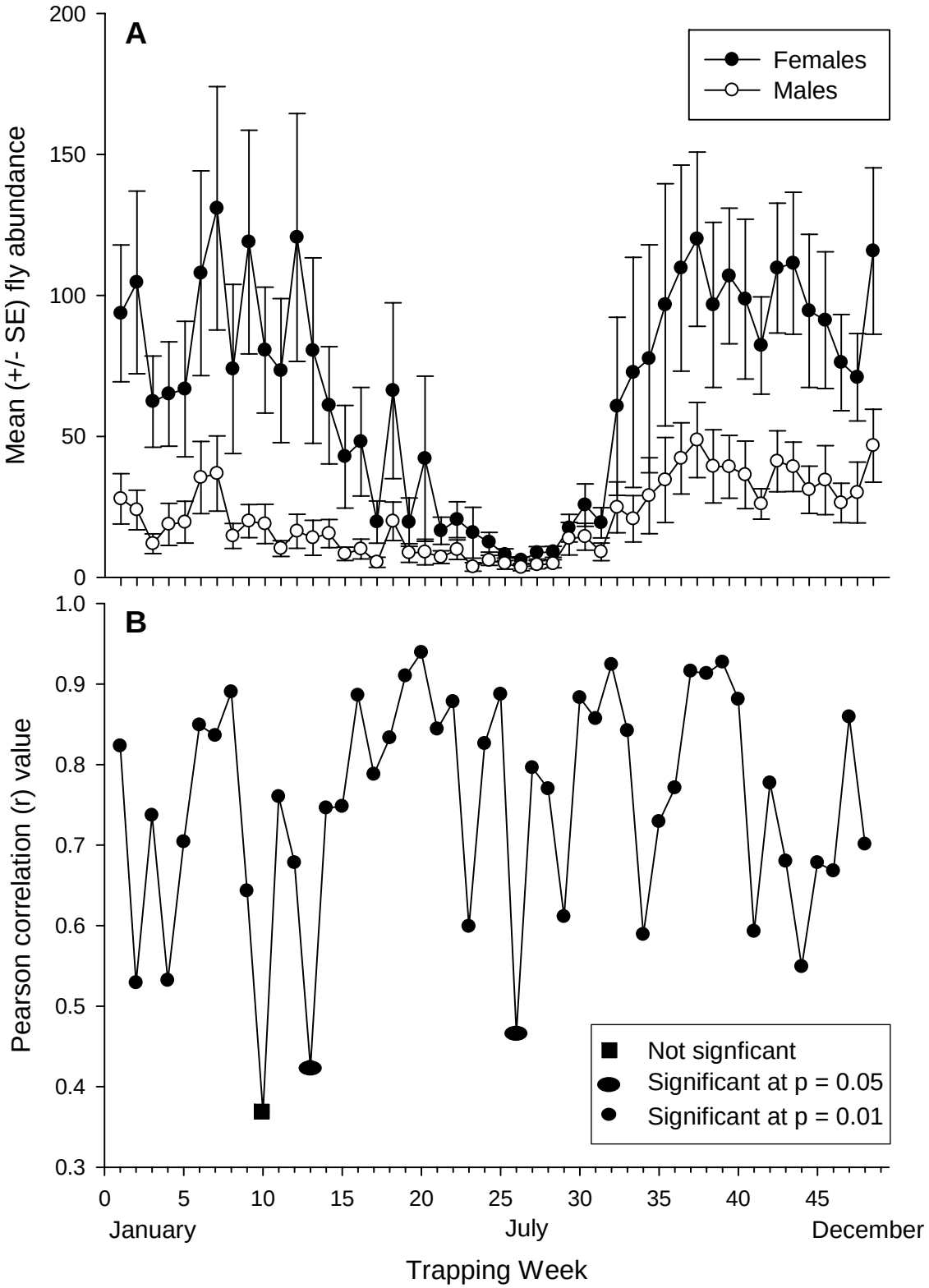

Figure 1. (A) Mean weekly abundance of female and male *Bactrocera tryoni* caught in orange-ammonia baited McPhail traps. (B) Weekly correlation between the numbers of female and male *B. tryoni* caught in those same traps. For each week, the number of individual trap catch events ranges between 21 and 28. There are 48 weeks of data (four weeks per month).

weeks and significant at p=0.01 for 45 weeks (Figure 1). There was no significant correlation between weekly r-value and mean weekly trap catch (n =48, r = -0.06, p = 0.68). The weekly r-value also fluctuated in an apparently random fashion with respect to time of year (Figure 1).

DISCUSSION

Cue-lure trap catches tell us nothing about female *B. tryoni* numbers. When using cue-lure, females thus need to be ignored from analyses, or the assumption made that their numbers fluctuate equally with male numbers. The results of the extensive orange-ammonia trapping presented here support the assumption that changes in male *B. tryoni* numbers are positively correlated with changes in female numbers. Based on a data set of over 1100 weekly trap catches, male and female catches were closely correlated for nearly the entire year, regardless of mean population size or temporal point on the annual phenology cycle. The only week where the male:female correlation was not significant (the second week of March) was not part of a larger pattern (Figure 1) and is assumed to be a random result (the data set shows a number of trap clearances for that week with very large female numbers but very low male numbers).

With respect to regulatory aspects of fruit fly monitoring, this paper supports an assumption that low numbers of male flies in cue-lure traps also equates to low numbers of females flies in the local population. The female bias in orange-ammonia baited traps, however, does not help us understand the dispersion of the sexes within the local environment. In our study, orange-ammonia traps caught more females than males, and this may have occurred for two reasons. Firstly, there may be equal numbers of males and females at the trap site, but females may more readily respond to a trap and so dominate the trap catch. Females may be attracted to the orange component of the lure for egg laying, while males are unlikely to respond to oviposition stimuli. Alternatively, females and males may enter the traps equally readily, but females may be numerically dominant at the trap site (if an orchard or fruiting tree), with the majority of males elsewhere in the local environment. If the latter is the case, then detecting males in cue-lure traps does not guarantee that there are female flies in the immediate vicinity of the trap, though we could be certain that females are present in the local environment.

The Queensland Fruit Fly Code of Practice (Anon. 1996) allows for an orange-ammonium lure (280 g of pulped orange or pure orange juice with 25 g of ammonium carbonate and 1 g of potassium sorbate, the stock solution to stand for 24 hours and then diluted with one part stock and ten parts water) similar to that used by May. Orange-ammonia-baited McPhail traps can be used as an alternative to protein-baited McPhail traps for supplementary monitoring of a suspected fruit fly outbreak. The similarity of the lure used by May (1961) and that provided by the Code means that the results of May's paper will almost certainly be applicable to current orange-ammonia trap results.

In comparison to dry lure Lynfield traps, wet food lure in McPhail traps is rarely used operationally because the lures need to be prepared before each inspection, the traps take considerably longer to service individually and flies may start to degrade making identification more difficult. Commercial monitoring of *B. tryoni* is likely to remain dependent on Lynfield traps baited with cue-lure (Dominiak *et al.* 2003a, Gillespie 2003, Smith 2000). Our paper provides confidence that the monitoring of a population based on the male lure alone is an accurate indicator of females in the environment.

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