Inundative Release of *Trichogrammatoidea bactrae* for Biological Control of Pink Bollworm

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Abstract

Replicated, small-plot studies were conducted in 1991 to evaluate control of pink bollworm (PBW), Pectinophora gossypiella, by inundative releases of a newly imported Australian egg parasitoid, Trichogrammatoidea bactrae. Weekly release of parasitoids at equivalent rates of 165,000/HA beginning in mid-June significantly reduced egg and larval populations of PBW in comparison with control plots until mid-August, but provided no control thereafter. Rates of parasitism on artificially-placed PBW egg cards exceeded 90% until mid-July and then declined, becoming somewhat variable over the latter half of the season. Parasitism rates dropped near zero on three dates coinciding with drift from aerial pesticide application at a neighboring cotton field. The seasonal decline in rates of parasitism was not significantly related to increasing plant leaf area, vigor of released parasitoids, or ambient temperature. Parasitism of indigenous PBW eggs on cotton bolls was extremely low and this, along with moth migration from surrounding cotton, may have contributed to the lack of mid- to late-season control in our small plots. Results are encouraging and suggest that larger-scale release studies are warranted.

Introduction

Over the past 80 years the pink bollworm (PBW), *Pectinophora gossypiella*, has been the subject of biological control efforts in many parts of the world where it poses an economic threat to cotton production (Gordh 1992). Biological control efforts in the desert southwest were initiated shortly after the PBW became economically significant in California around 1965 (Bartlett and Gonzales 1970). However, despite fairly extensive efforts in California and Arizona (Orphanides et al. 1971, Bryan et al. 1973, Legner and Medved 1979, Gordh and Medved 1986) biological control has not had a significant role in the development of PBW management programs. Legner and Medved (1979) imported and introduced 14 species of parasitic hymenoptera into California and Arizona between 1969-1978. Several species showed promise as control agents but none became established in subsequent years and problems, including small numbers released, parasite/host asynchrony between seasons, and extensive use of pesticides through the release area, circumvented success. Efforts with fewer species in Arizona (Bryan et al. 1973) met a similar fate.

Mounting concerns with the maintenance of environmental quality, pesticide resistance, and pest resurgence have prompted a re-examination of the utility of biological control as a component of overall programs for PBW management. Renewed interest in biological control has been aided by several factors. First, the best available evidence suggests that the PBW originated in northwestern Australia (Gordh 1992). Thus, the search for new and

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presumably more effective natural enemies has been better directed. Second, the focus of biological control efforts has broadened to include augmentative and inundative strategies in addition to the more classical introduction/establishment approach that has dominated biological control efforts for PBW in the southwest.

The egg parasitoid, *Trichogrammatoidea bactrae*, was imported into California from Queensland, Australia by one of us (GG) during 1985 as a potential biological control agent of PBW. *Trichogrammatoidea* is a moderate sized genus which includes about 25 species. Most species are found in the Oriental, African and Australian regions. Morphologically, *Trichogrammatoidea* resembles the more commonly known genus *Trichogramma*, which contains numerous species of economic importance. Both genera are primarily egg parasitoids of Lepidoptera. In Australia *T. bactrae* attacks eggs of *P. scutigera*, the spotted bollworm, and in California it readily attacks eggs of the PBW. The parasitoid has been recovered at release sites in California and Arizona and aspects of its biology have been studied in the laboratory (Hutchison et al. 1990, Naranjo et al. 1992). Here, we report on a study conducted in 1991 to evaluate the potential of inundative release of *T. bactrae* for biological control of PBW.

Materials and Methods

Release and control plots of DPL-90 were established at the University of Arizona, Maricopa Agricultural Center in 1991. Plots measured 12 rows (1.02-m centers) by 30.5 m and were located in an area with a previous history of high PBW populations. Plots were established on 10 April and maintained according to standard agronomic practices. Plots were kept free of insecticides and were arranged such that release and control areas were separated by ca. 92 m to reduce the likelihood of parasitoid dispersal into control plots. Release and control plots were replicated three times.

Parasitoids were reared under controlled conditions (27°C, 75% RH) at the Western Cotton Research Laboratory, Phoenix using PBW eggs. Releases were made on a weekly basis for 15 weeks beginning 13 June. On the day prior to adult parasitoid emergence parasitized eggs were placed in release vials (8.5 x 5 cm dia.) and held under rearing conditions. The following day five vials were evenly distributed in each release plot. Each release vial was strapped to a cotton plant at mid-canopy level and the newly-emerged parasitoids were allowed to escape. All releases were made at 0800-0900 h at average rates of 165,000 adult parasitoids per Ha (ca. 5600/plot). Pink bollworm egg cards (50-100 eggs) were stapled to the underside of leaves around mid-canopy height to evaluate parasitoid activity in both release and control plots. Ten cards were evenly distributed in each plot. Twenty-four hours after release, PBW egg cards were returned to the laboratory and held for parasitoid emergence. Release vials were also collected to measure parasitoid emergence and more accurately estimate release densities.

Fifty bolls were collected from each plot on a weekly to bi-weekly basis to determine parasitism of indigenous PBW eggs on bolls and to estimate PBW egg and larval infestations. Any eggs found on bolls were held in the laboratory for eclosion or parasitoid emergence. End-of-season lint yield and seed damage estimates were made in release and control plots. These data are still being processed and will not be presented here.

Ambient temperature was monitored continuously through the season with a data-logger in a standard weather shelter. Ten cotton plants were randomly collected at the study site each week and returned to the laboratory for measurements of leaf area.

Results and Discussion

Mean levels of parasitoid activity, measured by parasitism of PBW egg cards, varied considerably throughout the season (Fig. 1). Rates of parasitism exceeded 90% during late June through early July, declined to around 50-70% during July and August, and were somewhat variable from late August through September (20-90%). On three dates of release, 13 June, 2 August, and 22 August, rates of parasitism were very low or zero. On all three of these dates (marked by arrows in Fig. 1) aerial pesticide applications were made at a neighboring cotton field ca. 50 m to the south. Drift was noticeable within our plots on two of these dates and was the most likely cause of the poor levels of parasitism in our release plots. No parasitism was detected on PBW egg cards placed in any of the control plots throughout the season.

We observed similar variation in parasitism levels during preliminary studies in 1990 at release sites in close proximity to those used in 1991. Many factors change throughout the season, including environmental conditions, plant size, and abundance of alternate hosts. We examined several of these factors in an attempt to determine if they correlated with observed changes in parasitoid activity (see Fig. 2, A-D). Plant leaf area changes dramatically over the season and has been shown to affect rates of parasitism by other Trichogrammatides (e.g. Need and Burbutis 1979). At our study site cotton plant leaf area varied from ca. 1000 cm^2 per plant in mid-June to over 5400 cm^2 by late September (measurement of one side of the leaf surface only). Also, our parasitoid release densities varied somewhat around the mean of 5600/plot. To examine the influence of changes in leaf area we used leaf area and release densities to calculate numbers of parasitoids per cm^2 of leaf area each week and then regressed percent parasitism of egg cards against this measure. There was a slight trend for parasitism to increase as parasitoids per cm^2 of leaf area increased but the slope of the regression was not significantly different from zero ($P > 0.05$) (Fig. 2A). Regressions of percent parasitism on the mean and maximum temperatures during the 24 h following parasitoid release also proved insignificant ($P > 0.05$), as did the relationship between percent emergence of released parasitoids (a measure of parasitoid vigor) and percent parasitism (Fig. 2, B-D). Recent studies (Naranjo and Martin, in prep.) indicate that *T. bactrae* are well adapted to the high temperatures of the desert environment. Given this, and the fact that cotton leaf temperatures are from 6-8°C cooler than ambient temperatures during the hottest part of the day (Naranjo, unpubl.), it was not surprising that temperature played no significant role in parasitoid performance. The influence of alternate hosts has not been examined but may play an important role and deserves study. *T. bactrae* will readily attack the eggs of other lepidopteran species commonly found in cotton (Hutchison, unpubl.) and appear to prefer larger host size when presented with a choice in the laboratory (Naranjo et al. 1992). This is significant because PBW eggs are relatively small in comparison to those of the noctuid moths inhabiting cotton.

We began to detect PBW oviposition on green bolls on 10 July; however, levels of infestation remained very low (0-4%) in both release and control plots until late August (Fig. 3A). Parasitism of indigenous PBW eggs on bolls was found on only two dates in late August and early September and never exceeded 7%. This result is consistent with studies in 1990 in Arizona and California (Naranjo, Gordh, unpubl.) where parasitism rates never exceeded 15% using similar release densities. The extremely low percentage of bolls with PBW eggs during July and most of August made accurate estimation of parasitism rates difficult. Sample size could be increased, but there is a limit to the number of bolls that can be examined for eggs in a reasonable period of time. Additionally, laboratory studies (Hutchison et al. 1990) indicate that female parasitoids prefer young eggs (1-2 d old). Thus, even if eggs were present on bolls their age-distribution probably influenced susceptibility to parasitoid attack. If only those bolls with young PBW eggs were considered sample sizes were reduced even more.

Although PBW population were generally low during July and August, average infestations of PBW eggs were significantly lower in release plots in comparison to control plots on 10 July, and 6 and 15 August ($P < 0.05$) and marginally significant on 25 July ($P < 0.10$) (Fig. 3A). After mid-August average egg infestation levels were not significantly different ($P > 0.05$) between release and control plots. The same general pattern was found for PBW larval infestations (Fig. 3B). Larval infestations were significantly lower in release plots on 25 June and 15 August ($P < 0.05$), but no differences were found after mid-August.

Overall, results suggest that parasitoid activity was generally high and some control of PBW was achieved in the early part of the season. This level of control, however, was insufficient to prevent the late season explosion of PBW populations. In part, the loss of control can be attributed to dispersal of PBW adults between non-release and release areas. Our release plots were small and surrounded by infested cotton. Better evaluation of control potential might have been afforded by controlling PBW in areas immediately surrounding release sites or making releases within field cages. However, the best method for evaluating parasitoid effectiveness would be to release over much larger areas to mitigate the effects of moth migration. It is impossible to determine if any control would have been realized in a more typical year where larval infestations could easily exceed 25-30% by early-August in unsprayed cotton. However, the fact that any control was achieved in our small plots is encouraging and suggests that larger-scale tests are warranted. In any circumstance, our results suggest that *T. bactrae* would be best utilized during the earlier part of the growing season. Parasitoid activity declines later in the season and parasitism of eggs on bolls is too low to impact the PBW population to any significant degree. Early-season release would permit parasitoids to attack PBW eggs on the cotton plant surface and may reduce the need for disruptive pesticides in the first half of the season. Further research will be needed to determine if higher release rates may ameliorate the short-comings of this biological control agent for mid- to late-season control.

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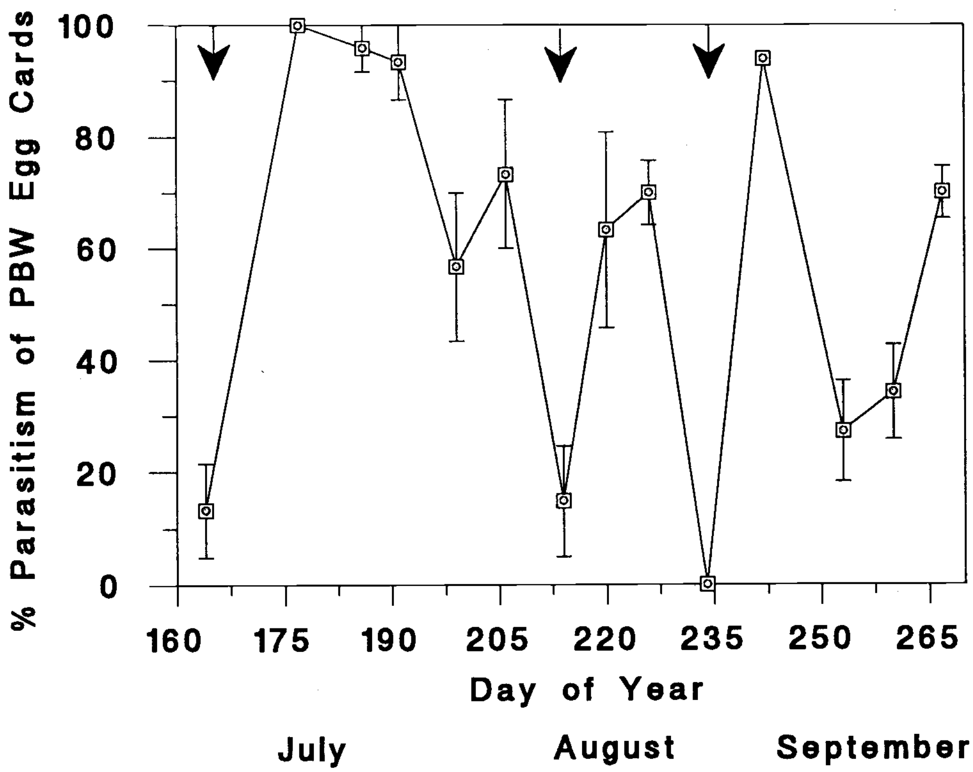

Figure 1. Percent parasitism of artificially-placed PBW egg cards in cotton plots receiving weekly releases of *Trichogrammatoidea bactrae* over the season at the Maricopa Agricultural Center, 1991. Arrows along the top indicate release dates when aerial pesticide applications were made at a neighboring cotton field. Error bars are S.E.

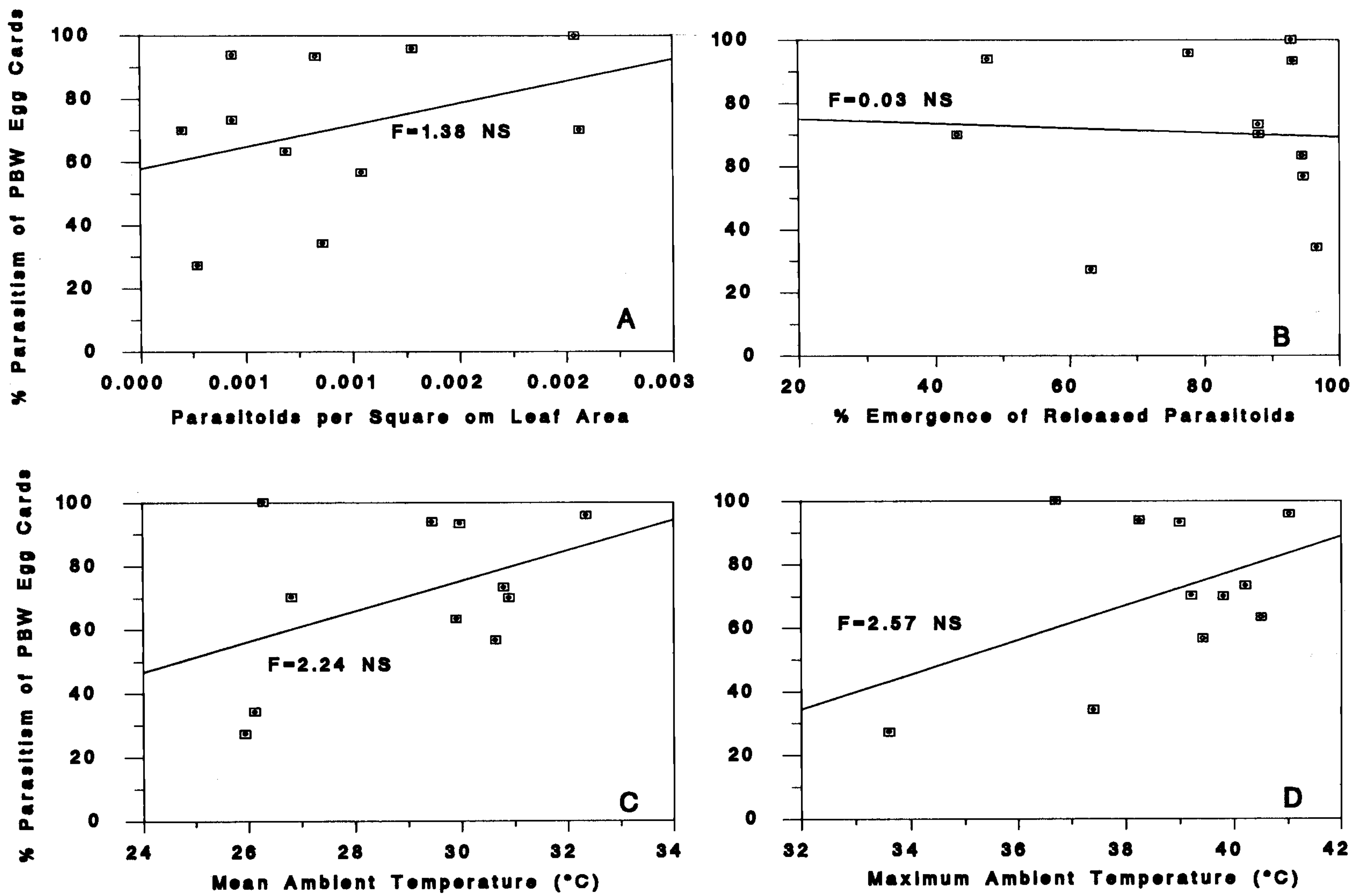

Figure 2. Relationship between levels of parasitism by *T. bactrae* in release plots and A) plant size, measured as parasitoid density per cm^2 leaf area, B) parasitoid vigor, measured as percent emergence of released parasitoids, C) mean ambient and D) maximum ambient temperature during the 24 h following release. *F*-statistics given for regressions; NS = not significant. Data from pesticide drift dates not included in analyses.

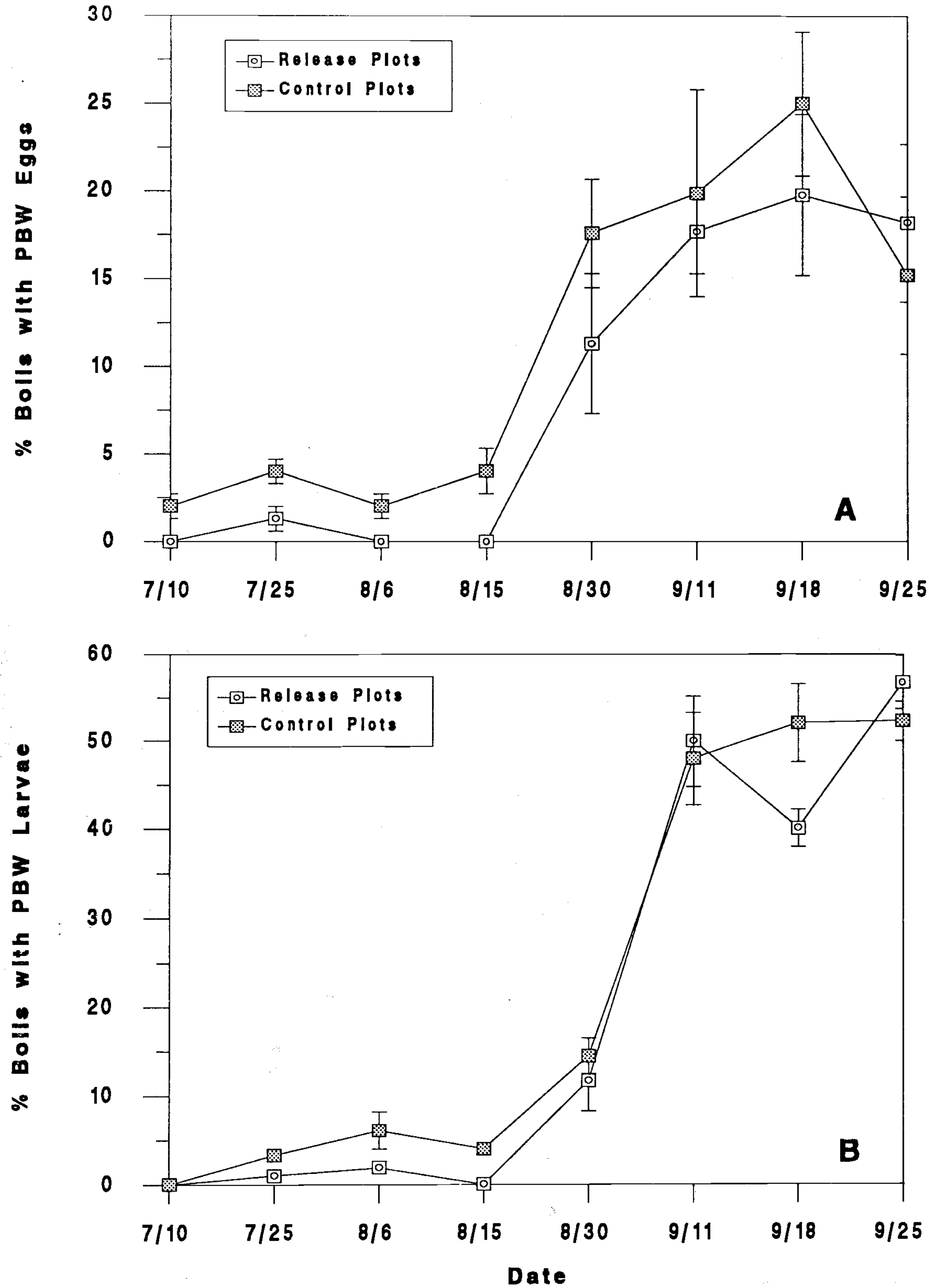

Figure 3. Seasonal PBW infestations in parasitoid release and control plots at the Maricopa Agricultural Center, 1991. A) Percent of bolls with eggs and B) percent of bolls with larvae. Fifty bolls were examined per plot; error bars are S.E.