CONSTRAINTS ON THE EFFECTIVENESS OF PSYLLAEPHAGUS BLITEUS (HYMENOPTERA: ENCYRTIDAE), A BIOLOGICAL CONTROL AGENT FOR THE RED-GUM LERP PSYLLID (HEMIPTERA: PSYLLOIDEA) IN CALIFORNIA


ABSTRACT

Psyllaephagus bliteus Riek (Hymenoptera: Encyrtidae) was released throughout California in 2000 and 2001 to control the red-gum lerp psyllid, Glycaspis brimblecombei Moore (Hemiptera: Psylloidea). An Eucalyptus feeder native to Australia, G. brimblecombei was first discovered near Los Angeles in 1998 and had spread throughout the state by 2000. The wasp established and quickly became effective in coastal areas but to date has had less impact inland. The experiments discussed herein were designed to address this problem and collect basic biological information that would improve the control program. The specific objectives were to determine adult longevity and fecundity, to determine host-stage preference for oviposition, and to compare parasitism rates in the field at inland and coastal sites. Maximum fecundity occurs at one to three weeks of age. Most eggs are recovered from 3rd instars, but oviposition is attempted into 3rd, 4th, and 5th instars equally. Observations of host-handling behavior suggest that the large lerps of 4th and 5th instars impede oviposition. In 2003, parasitism rates were lower at inland than at coastal sites at the same latitude; cage trials conducted during the summer suggest that the adults do not survive long and lay fewer eggs inland. We hypothesize that high summer temperatures inland limit the effectiveness of this wasp.

INTRODUCTION

Psyllaephagus Ashmead (Hymenoptera: Encyrtidae) is a cosmopolitan genus of parasitic wasps containing over 200 described species and perhaps as many as 1000 in all (Noyes & Hanson, 1996). Australian Psyllaephagus have recently attracted attention in classical biological control programs aimed at psyllid pests of various Eucalyptus species in California, Mexico, and the British Isles (Chauzat, 2002; Dahlsten et al., 1998; Paine et al., 2000). The Australian red-gum lerp psyllid, Glycaspis brimblecombei Moore (Hemiptera: Psylloidea), was first discovered on red-gum trees (Myrtaceae: Eucalyptus camaldulensis Dehn.) in Los Angeles County in 1998 and had spread throughout California by 2000 (Brennan et al., 1999; Paine & Millar, 2002) and Mexico by 2002 (J. Guerra, pers. comm.). The nymphs of G. brimblecombei, like those of other Glycaspis species, construct shelters called lerps from excreted carbohydrates and proteins (Moore, 1961). The accumulation of the sticky lerps on leaves and underneath infested trees creates a nuisance; heavy infestations lead to defoliation, branch dieback, and occasionally the death of trees (Paine et al., 2000). Psyllaephagus bliteus Riek was released throughout California in 2000 and 2001 to control G. brimblecombei after quarantine testing indicated that it would specifically attack this host. The wasp established and quickly became effective in coastal areas but to date has had less impact in the Central Valley (Daane et al., in prep.). The goals of this study were to address this problem and to collect basic biological information that would improve the control program.

MATERIALS AND METHODS

Sources of insects and plants

The psyllids used in these studies were taken from a colony maintained in glasshouse facilities on the U.C. Berkeley campus (20-26°C). The colony originated with psyllids collected on infested red gums in Alameda and Sacramento Counties, California. The psyllids were reared on small potted red-gum trees (0.5-1 m tall). The wasps were reared from infested foliage cut from red gums in the Ardenwood Regional Reserve in Alameda County. This population originated with the releases in 2000 and 2001 of reared wasps from stock collected in southern Australia in 1999.

Host-stage preference for oviposition

For each trial, 3 or 4 psyllid-infested red gums were placed in a cloth-sided cage (96 cm × 32 cm × 45 cm) kept at ambient room temperature (about 25°C) under fluorescent lighting. The trees were selected so that 300-500 psyllids, of all 5 stages, were present in the cage. At the start of a trial, 15-20 female wasps and 4-5 males were released into the cage. After 24 h, the wasps were removed. All of the psyllids were then transferred to 70% ethanol. Five trials were conducted. To determine the ages of the psyllids and whether or not they were parasitized, the psyllids were transferred to a clearing solution of chloralphenol.
In a separate experiment, the behavior of 18 female wasps given cut leaves infested with psyllids was observed under a dissecting microscope. The stages of psyllids used for host-feeding and oviposition were recorded, along with the time spent grooming, resting, and host-feeding or ovipositing into each psyllid attacked. Each wasp was provided with a leaf with 70-100 psyllids in all 5 stages. The leaf was placed in a transparent plastic cylinder (21 cm long × 7 cm diam.) that was ventilated by cloth mesh covering one end and a hole in the side (4 cm diam.). Timing began as soon as a wasp touched the first psyllid and observations continued for 1 h per wasp.

Adult longevity and fecundity

Adult longevity was determined at 5 temperatures (17°C, 21°C, 23°C, 26°C, and 32°C). Males and females were tested separately. The wasps were collected within 24 h of emergence and held in temperature cabinets in 35-mL glass vials (3-10 wasps per vial) streaked with 50% honey water. The honey water was refreshed daily and the vials were changed weekly. For the fecundity trial, 12 female wasps were held with males for ca. 24 h after emergence. They were then transferred individually to clear plastic tubes (4 cm diam. × 8 cm long) covered with fine nylon mesh at one end. The tubes were fixed around leaves on potted red-gum trees in the glasshouse (20-26°C) through a slit in a piece of soft foam. Each leaf was infested with 10-30 psyllids. The leaves were changed every 2 d for the lifetime of the wasps. The psyllids were transferred to 70% alcohol within 3 d of exposure, and later cleared in chloralphenol to determine whether they contained wasp eggs.

Field parasitism, foliage samples

Three pairs (each pair at a similar latitude) of coastal and Central Valley sites were sampled in July 2003: Sonoma and Sacramento, Alameda Co. and Fresno, and San Luis Obispo and Bakersfield. Two 30-cm branch tips were taken from each site. Up to 50 nymphs from each sample were cleared in chloralphenol to check for parasitism.

Field parasitism, cage study

Twenty mesh sleeve cages were fixed to red-gum trees at two sites, Sacramento and Berkeley, in July 2003. Approximately 100 psyllid eggs were placed in each cage. When the psyllids had reached the third instar, a single female wasp was released into each cage. The cages were cut down 1-2 weeks later; all psyllids inside were cleared to check for parasitism.

RESULTS

Host-stage preference for oviposition

Dissection of psyllids exposed to wasps en masse revealed that 3rd instars, and to a lesser degree 4th instars, are the stages into which oviposition most frequently occurs (Fig. 1a). Direct observations of encounters with psyllid nymphs revealed a different pattern (Fig. 1b): 3rd, 4th, and 5th instars were attacked at comparable rates (t-tests). Handling times for oviposition were significantly longer on large (4th and 5th instar) than on small (1st, 2nd, 3rd instar) hosts (232±156s vs. 69±44s, n = 12, p = 0.003, t-test). The nymphs have some free space within the lerp, and the large lerps typical of 4th and 5th instars have a much larger diameter at the leaf surface than those of younger nymphs. The nymphs moved around as the wasp probed with her ovipositor, and could be seen, through the more translucent lerps, to move quickly to the side of the lerp opposite the probing wasp.

Adult longevity and fecundity

Females lived significantly longer than males at all temperatures except for 23°C (Figure 2). Maximum fecundity occurred between one and three weeks of age (Fig. 3).

Field parasitism

Parasitism rates were higher at the coastal site of each pair (Fig. 4a). The cage studies revealed a similar pattern, with parasitism higher at the Berkeley site than at the Sacramento site (Fig. 4b) (t-test, p = 0.003).

DISCUSSION

In 24-h trials with large groups of wasps and psyllids, we found that 3rd instars received significantly more eggs than all other stages. Direct observation of individual wasps, however, showed that 3rd, 4th, and 5th instars were attacked at equal rates. This discrepancy may be explained by the increased handling time involved in attacking larger nymphs, which reflected the difficulties the wasps had in reaching the nymphs inside the lerps. It appears therefore that the large lerps of 4th and 5th instars provide some protection from oviposition by *P. bliteus*: the wasp’s ovipositor is not long enough to consistently reach nymphs within large lerps. Moore (1961), citing the occasionally high rates of parasitism of *Glycaspis* species in Australia, argued that the main function of the lerp was not to protect
the nymphs from natural enemies but to reduce desiccation. Our data are the first indication that the lerps can also play a role in deterring natural enemies.

Our field studies confirmed that parasitism rates are lower at inland than at coastal sites. Lower parasitism rates in the field cages show that the wasps perform poorly at the inland sites, laying fewer eggs. We suspect that the wasps are susceptible to the higher summer temperatures inland. Because under the milder conditions of the glasshouse they lay eggs for several weeks, a decrease in the longevity of adult females would lower their lifetime fecundity and lower parasitism rates accordingly. We intend to further test the hypothesis that temperature responses limit the effectiveness of this parasitoid by conducting field tests of adult longevity and fecundity at inland and coastal sites, and also by comparing the temperature thresholds for development of immature psyllids and parasitoids. It may prove necessary to import additional *Psyllaephagus* in order to obtain species or strains effective in the Central Valley.

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**REFERENCES**


Fig. 1. While most eggs were recovered from 3rd-instar nymphs (A), the wasps attacked 3rd, 4th and 5th instars at equal rates (B), a discrepancy that may be explained by increased handling time on larger nymphs.
Fig. 2. Longevity of adult wasps under laboratory conditions, supplied with honey-water.

![Graph showing longevity of adult wasps under laboratory conditions](image)

Fig. 3. Mean fecundity of wasps (n=12) over their lifetime.

![Graph showing mean fecundity of wasps](image)

Fig. 4. Parasitism rates determined from dissections of nymphs on foliage samples were consistently lower at inland than at coastal sites (A), and parasitism rates by individual wasps released into cages were lower in Sacramento (inland) than in Berkeley (B).

![Graph showing parasitism rates](image)