ABSTRACT

In Queensland citrus, California red scale [*Aonidiella aurantii* (Maskell)] is under good biocontrol by the parasitoid *Aphytis lingnanensis* Compere (Hymenoptera: Aphelinidae). *A. lingnanensis* has been imported and released in other states of Australia, but has failed to establish there. How it entered Queensland is unknown. Ambiguity regarding the origin of *A. lingnanensis* population in Queensland and the common occurrence of cryptic species complexes in the genus *Aphytis* made it crucial to clarify the species status of this population. In addition, another population of *A. lingnanensis* (here called the white louse population, or WLP) had been imported from Thailand and released in Queensland citrus for white louse scale insect [*Unaspis citri* (Comstock)] control.

To clarify the species status of both the Queensland (QP) and WLP populations, morphological investigations (using light microscope and electron microscopy) were carried out. Comparisons were made with *A. lingnanensis* specimens loaned from the University of California (Riverside) Museum. QP specimens are identical to Californian *A. lingnanensis*. But the taxonomic status of WLP was unresolved because some specimens have characters of *A. lingnanensis*, some of *A. coheni* and others of both. No consistent morphological difference was detected in WLP to separate it morphologically from QLP.

Therefore, behavioural studies (including crossing and mate choice experiments) were undertaken. Individuals of QP mated freely with individuals of Philippines and Californian populations (both represent true *lingnanensis*). In choice experiments individuals of both QP and Californian populations mated randomly and produced mixed sex broods, thus indicating that QP may be true *lingnanensis*. Individuals of WLP did not mate with individuals of any of the *lingnanensis* populations, confirming that it is a cryptic species of *A. lingnanensis*. Studies on the host-parasitoid relationships of QP and WLP on California red scale and oleander scale insects were not conclusive, but it seemed that California red scale is not a preferred host of WLP.

Behavioural studies on QP were continued to investigate the long-distance and short-distance attractants that bring mating partners together, to establish whether those used by QP individuals were the same as those used by Californian individuals. There was no indication that males or females use pheromones in locating each other. Males were stimulated by females only after contact. Probably a non-volatile cuticular substance is involved. Studies using an airflow olfactometer revealed neither females nor males were attracted to each other. This aspect requires further investigation.

The main aim of my thesis was to study the activity patterns of *A. lingnanensis* females in relation to their ovarian egg availability and to try and understand how this affected their behaviour in the field. As a first step the fecundity, pre-ovipositional duration and daily patterns of oviposition were investigated in the laboratory. Females laid eggs throughout their life but only during the daylight hours. In the presence of an excess of California red scale insects they deposited eggs in bouts and rested away from hosts between bouts. Most of the eggs were deposited in the first bout of oviposition. This pattern of oviposition was consistent each day. The physiological status of the ovaries of the females at the start and the end of a bout was determined by dissecting the ovaries. Ovipositional activity was governed by the presence of mature eggs in the ovaries and females lay all their available mature eggs in each bout of oviposition.

From the laboratory observations I predicted that in the field females would not oviposit at night, ovipositional activity should begin early in the morning when a full complement of mature eggs is available, females would migrate when they are depleted of mature eggs and migration would occur later in the day because the ovipositional bouts may be longer in the field as suitable hosts are more widely-distributed in the field than in the laboratory. To test these predictions females were trapped at different times of the day and in different situations (in the trees and in flight) to ascertain their ovarian contents.

Results confirmed that females do not oviposit at night and start

ovipositing early in the morning. But contrary to prediction, females in flight always carried mature eggs, and this activity occurred at any time of the day. The number of mature eggs in females in the trees dropped towards the end of the day, when there were many females with no eggs collected from the trees. In contrast, females in flight carried a consistent number of mature eggs throughout the day. *A. lingnanensis* females depleted of mature eggs thus appear to be inhibited from flight whereas the presence of mature eggs in the ovaries did not prevent flight.

The results are discussed in each chapter and in the general discussion chapter I draw the threads of the thesis together by discussing the importance of clarifying the species status of parasitoid populations under consideration for biocontrol and the important implications for prerelease studies in biocontrol. Also, I develop the point that an understanding of the ovarian physiology of a parasitoid species and its consequences for oviposition behaviour can lead to a better appreciation of the complex nature of biocontrol situations. The limited value of ecological generalizations in understanding each biocontrol situation is discussed.