Agathis bishopi, a larval parasitoid of false codling moth *Thaumatotibia leucotreta*: laboratory rearing and effect of adult food on parasitism and longevity

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Agathis bishopi (Nixon) (Hymenoptera: Braconidae) is a koinobiont larval endoparasitoid of false codling moth (FCM), *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), a pest of economic importance on citrus in South Africa. In the field *Agathis bishopi* was found to parasitise up to 34 % of FCM larvae in fruit, reflecting reasonable biocontrol potential. Improving the rearing of *A. bishopi* would therefore complement the existing biocontrol strategies for FCM. In several parasitic wasps, sugar concentration and feeding duration has been shown to influence parasitism and longevity. However, their effect on parasitism and longevity of *A. bishopi* is unknown. In the present study a rearing protocol for *A. bishopi* is described, including evaluation of the effects of honey concentration on parasitoid longevity. On average, 18.2 % of FCM larvae in rearing containers were parasitised under the rearing protocol described. Cotton wool, instead of paper towelling, as honey carrier for feeding parasitoids in rearing containers significantly increased parasitism and yield of offspring. Furthermore, longevity significantly increased with higher concentrations of honey. Maximum lifespan duration for male and female parasitoids was achieved when parasitoids were fed on 36 % (w/v) honey. Results from this study indicate that *A. bishopi* requires a sufficient concentration of sugar, coupled with frequent and prolonged feeding on a cotton wool substrate, in order to achieve maximum parasitism and longevity. Such information provides a basis for optimising mass-rearing and longevity of *A. bishopi* and parasitism of FCM in orchards.

Key words: *Agathis bishopi*, parasitoid longevity, citrus, honey concentration, *Thaumatotibia leucotreta*.

INTRODUCTION

False codling moth (FCM), *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), is a major pest of citrus in South Africa (Moore *et al*. 2004; Malan *et al*. 2011). Damage is mainly caused by larval feeding on fruit resulting in preharvest fruit drop and postharvest decay (Georgala 1969; Newton 1998). With the growing global awareness of the risk of agrochemicals to human health and the environment when misused (Fields & White 2002), stricter regulations on chemical residues have been effected by many citrus markets (Moore & Hattingh 2012). Therefore non-chemical control options are preferred for management of FCM in citrus orchards. Several non-chemical measures have been developed to constitute an effective integrated pest management (IPM) programme for FCM management (Li & Bouwer 2012; Coombes *et al*. 2013; Love *et al*. 2014; Opoku-Debrah *et al*. 2013). Examples of existing non-chemical control options for FCM include orchard sanitation in which FCM-infested fruit is manually removed from orchards (Georgala 1969), granulovirus (CrleGV) (Moore *et al*. 2015), mating disruption (Moore & Hattingh 2012), sterile insect techniques (Barnes *et al*. 2015; Hofmeyr *et al*. 2015) and *Trichogrammatoidea cryptophlebiae* (Nagaraja) (Hymenoptera: Braconidae), an egg parasitoid of FCM (Moore 2002). Therefore, use of *Agathis bishopi* (Nixon) (Hymenoptera: Braconidae) would complement the above-mentioned non-chemical control options.

The ability of parasitoids to regulate populations of herbivorous insects has been harnessed and integrated into biological control strategies for insect pests in various agro-systems (Mattiacci *et al*. 1999; Ghimire & Phillips 2010; Wang *et al*. 2014). Several species of naturally occurring larval parasitoids for FCM, particularly flies and wasps, have been reported in southern Africa (Ullyet 1939; Newton 1998). *Agathis bishopi* is the most effective and is particularly predominant in the

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