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Developmental Biology of *Trichospilus pupivorus* Ferrière (Hymenoptera: Eulophidae), a Pupal Parasitoid of the Coconut Black-headed Caterpillar, *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae)

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ABSTRACT

Background: The coconut black-headed caterpillar, *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae) has been a serious defoliator of coconut plants in many coconut producing countries including Vietnam. *Trichospilus pupivorus* Ferrière (Hymenoptera: Eulophidae) is pupal endo-parasitoid of *O. arenosella* with high percent parasitism and abundance in the coconut fields and appears to be a good biological control agent against the coconut black-headed caterpillar in Vietnam. The objective of this study was to investigate the developmental biology of *T. pupivorus* on *O. arenosella*.

Methods: The experiment was carried out at the Faculty of Agronomy, Nong Lam University, Viet Nam during 2020 and 2021. The developmental biology of *T. pupivorus* on *O. arenosella* was studied in the laboratory at a constant temperature of 28°C and a photoperiod of 12L: 8D.

Result: Total developmental time from egg to adult emergence was 14.0 days. The females laid a mean of 124.2 eggs during an average lifespan of 9.4 days. The number of progenies emergence from a single pupa of *O. arenosella* was 103.8. The offspring sex ratio was female-biased (8.0%). The results would contribute to the knowledge of the biology of this parasitoid to optimize a mass rearing system for a biological control program against *O. arenosella*.

Key words: Coconut, Mass-rearing, *Opisina arenosella*, Parasitoid, *Trichospilus pupi*.

INTRODUCTION

The coconut black-headed caterpillar, *Opisina arenosella* Walker (Lepidoptera: Xyloryctidae), an indigenous pest and outbreak insect pest of coconut in Sri Lanka and India (Perera *et al*., 2010; Chalapathi *et al*., 2016), has been one of the most serious defoliator of coconut plants in many coconut producing countries. Its serious damage has been reported in some Southeast Asian countries including Thailand (Kumara *et al*., 2015), Malaysia (Nor Ahya and Tajul Ariffin, 2018), Vietnam (Le *et al*., 2020). Recently, outbreak of the defoliator has been found in coconut across Vietnam and it controlled by a wide range of conventional insecticides, which was ineffective (Le *et al*., 2020). It is necessary to consider a biological control program based on the use of parasitoids against this pest.

Trichospilus pupivorus Ferrière (Hymenoptera: Eulophidae) is a gregarious pupal endoparasitoid of many insect pests (Kumar *et al*., 1995; Tavares *et al*., 2011; Tavares *et al*., 2013; Silva *et al*., 2016) including *O. arenosella* (Winotai, 2014; Nor Ahya *et al*., 2019; Abhisheck and Dwivedi, 2021). *Trichospilus pupivorus* wasan efficient pupal parasitoid of *O. arenosella* with high percent parasitism and abundance in the coconut fields in Mekong Delta, Vietnam (Le *et al*., 2020). While attempting to manage *O. arenosella* are mostly by inundative releases of parasitoids (Vidyasagar and Bhatt, 1991; Winotai, 2014; Abhisheck and Dwivedi, 2021), *T. pupivorus* appears to be a good biological control agent against the coconut black-headed caterpillar in Vietnam.

Information on basic biology of a parasitoid species (e.g. developmental time, longevity, fecundity, sex ratio) is fundamentally necessary to evaluate its effectiveness as a biological control agent. However, biological studies of *T. pupivorus* developing on *O. arenosella* has been limited. The objectives of the present studies are to determine development time for immature developmental stages and longevity, fecundity

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of *T. pupivorus* reared on *O. arenosella*. The results would contribute to the knowledge of the biology of this parasitoid to optimize biological control program against *O. arenosella*.

MATERIALS AND METHODS

The experiment was carried out at the Laboratoty of Entomology, Faculty of Agronomy, Nong Lam University, Viet Nam during 2020 and 2021.The coconut black-headed caterpillar, *O. arenosella* andthe wasp parasitoid, *T. pupivorus* used for the present study were collected from infested coconut plants at Tan Thanh Binh commune, Mo Cay Bac district, Ben Tre province, Southern Vietnam (10°16′76″N 106°35′72″E). *Opisina arenosella* was reared on coconut leaves inside 30 × 30 × 25 cm cages. The colony of *O. arenosella* was maintained on coconut leaves for two to three generations prior to use in experiments. The parasitoids were offered with three- days-old pupae of *O. arenosella* in plastic bottles (500 ml). Parasitoid adults were provided with a honey solution (30%) immediately after emergence. The colonies were maintained under the condition of 28±1°C, 60-70% humidity and 12L: 12D photoperiod.

Sixty 3-days-old pupae of *O. arenosella* and a piece of tissue paper (2 cm × 2 cm) saturated with a honey solution (10%) were placed in a plastic bottle (160 ml) covered with a fine nylon mesh. About 20 couples of *T. pupivorus* were introduced into the box. After the exposure for 24 h,parasitized pupae were transferred into other plastic boxes. The boxes with parasitized pupae were maintained in the environmental chambers set at 28±1°C, 60-70% humidity and 12L: 12D photoperiod until emergence of the parasitoids. Every day, 2 parasitized pupae were dissected using a stereo microscope (Olympus SZX10, Japan) to determine the developmental times of parasitoid eggs, larvae and pupae.

Three 3-days-old pupae of *O. arenosella* were placed in a 5 ml glass vials covered with a fine nylon mesh. One pair of newly emerged wasps was released into the vial. Honey solution (30%) was streaked on a piece of Sealon film (Fuji Photo Film Co., Ltd.). The streaked honey film was attached to the top of the vial and replaced daily to provide wasps with fresh food. These vials were kept in the environmental chambers set at 28±1°C, 60-70% humidity and 12L : 12D photoperiod. After the exposure for 24 h, the pupae were removed and were then dissected under a microscope to check for paralyzed eggs. Pupae of *O. arenosella* were exchanged daily until the females died. The number of parasitoid eggs was recorded as fecundity capacity and longevity of females was determined. A total of 10 females were used for test.

Ten parasitized pupae were individually placed in 5 *ml* glass vials maintained at the same experimental condition until wasp emergence. All offspring wasps were sexed. The sex ratio is expressed as the proportion of males among the offspring (Godfray, 1994).

RESULTS AND DISCUSSION

Developmental time for immature stages of *T. pupivorus* is summarized in Table 1. Total developmental time from egg to adult emergence was 14.0 days. The duration of egg and larva periods were 1.3 and 6.7 days, respectively. The pupal development lasted an average of 6.0 days. Although *T. pupivorus*is a potential biological control agent to control *O. arenosella* (Nor Ahya *et al*., 2019, Le *at al*., 2020), limited data on the developmental biology of *T. pupivorus* on *O. arenosella* are available. The present study indicated that total developmental time from egg to adult emergence of *T. pupivorus* was ranged from 13-15 days. Our results are in agreement with the results of Gosh and Abburahiman (1985) who reported that developmental times for immature stages of *T. pupivorus* on *O. arenosella* was 13-15 days.

The females produced a mean of 124.2 eggs during an average lifespan of 9.4 days (Table 2). Longevity of the female (9.4 days) was longer than that of the male (2.8 days). While the pre-oviposition period lasted for 2.5 days after emergence, the females stopped laying eggs (post-oviposition) about an average of 4.1 day before death. The fecundity of *T. pupivorus* on *O. arenosella* was higher than the results of Nor Ahya *et al*. (2020) who reported that fecundity of *T. pupivorus* rearedon *O. arenosella* with 30% honey at 30°C was 105.4 progenies. However, female longevity (9.4 days) was longer than that was recorded by Gosh and Abburahiman (1985) (5.0 days) and Nor Ahya *et al*. (2020) (6.0 days).

The number of progenies emergence from a single pupa of *O. arenosella* was 103.8 in average with a range of 28-161 (Table 3). Gosh and Abburahiman (1985) also reported that the number of eggs laid on a single *O. arenosella* was 22-162 days. The offspring sex ratio (8.0%) was female-biased (Table 3). There was no other information on the offspring sex ratio of *T. pupivorus* to be a comparison. However female-biased sex ratio of *T. pupivorus* is similar with other eulophid parasitoids (Tran and Takagi, 2006).

Table 1: Developmental time (days) of *Trichospilus pupivorus* at 28°C.

Stage	Mean±SD	Range
Egg	1.3±0.52	1-2
Larva	6.7±0.55	6-7
Pupa	6.0±0.01	6-6
Egg-adult	14.0±0.6	13-15

Table 2: Longevity and fecundity parameter of *T. purivorus* at 28°C.

Parameters	Mean±SD	Range
Pre-oviposition (days)	2.5±0.71	2-4
Oviposition (days)	2.7±0.67	2-4
Post-oviposition (days)	4.1±2.81	1-8
Fecundity (eggs)	124.2±27.80	87-167
Female longevity (days)	9.4±2.59	5-12
Male longevity (days)	2.8±1.03	1-4

Table 3: Progenies emergence and offspring sex ratio of *T. purivorus* at 28°C.

Parameters	Mean±SD	Range
No. of emerged progenies from one parasitized pupa	103.8±36.1	28-161
Sex ratio	8.0±2.85	3.5-12.5

Because laboratory rearing *O. arenosella* on coconut leaves is laborious, a maintain of *O. arenosella* on large scale on natural host (*e.g.* coconut leaves) is not possible to supply insect hosts to a mass-rearing of the parasitoid *T. pupivorus*. Murthy *et al*. (2002) indicated that an artificial diet reared *O. arenosella* can be used for mass rearingthe parasitoid*B. nephantidis* without depending on the natural host, plant host and factitious hosts. Moreover, previous studies reported that *Galleria mellonella* L. (Lepidoptera: Galleridae) was a potential alternative host for the rearing of *Goniozus nephantidis* Muesebeck (Hymenoptera: Bethylidae), a larval parasitoid of *O. arenosella* (Mohan and Shameer, 2003; Venkatesan *et al*., 2007) Therefore, those alternative rearing systems can be used for a mass rearing of *T. pupivorus*. While previous studies have indicated that biology of an insect parasitoid depends on abiotic and biotic factors including temperature, relative humidity and host available (Tran *et al*., 2007; Tran *et al*., 2012), suitability of *T. pupivorus* reared with artificial diet and alternative hosts as well as temperature dependent development of *T. pupivorus* are needed further studies.

CONCLUSION

It is concluded that *T. pupivorus* could completely develop on the pupae of *O. arenosella*. The total developmental time from egg to adult emergence of *T. pupivorus*was 14.0 days. The females produced a mean of 124.2 eggs during an average lifespan of 9.4 days. The number of progenies emergence from a single pupa of *O. arenosella* was 103.8. The offspring sex ratio was female-biased (8.0%). The results would contribute to the knowledge of the biology of *T. pupivorus*to optimize the mass-rearing system for a biological program against *O. arenosella*.

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Conflict of interest: None.

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