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THE BIOLOGICAL CHARACTERISTICS, REPRODUCTIVE CAPACITY AND CONTROL EFFECT OF *DIRHINUS GIFFARDII* WELD (HYM.: CHALCIDIDAE)

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An-Ly Yao (1987) The biological characteristics, reproductive capacity and control effect of *Dirhinus giffardii* Weld (Hym.: Chalcididae). *Bull. Inst. Zool., Academia Sinica* **26**(1): 47-52. The morphology, development and behavior of the solitary pupal parasitoid, *Dirhinus giffardii* Weld, were described. Parasitism was the major factor contributed by *D. giffardii* causing death of the host species. Host-feeding behavior was occasionally observed. *D. giffardii* is more K-selection oriented in terms of host age at times of attack, longevity and reproductive capacity.

Dirhinus giffardii Weld, a solitary pupal parasitoid in the family Chalcididae, was described by Silvestri in 1914 from specimens that emerged from the Mediterranean fruit fly, *Ceratitis capitata* Wied., collected in West Africa, South Africa, Australia, north and south India, Kenya, Nyasaland and Nigeria (Thompson 1954). It is one of three fruit fly parasitoids common to both Africa and Indo-Australasia. The other two are *Spalangia afra* Silv. and *Pachycrepoideus vindemmiae* (Rond.) (Clausen *et al.* 1965). *D. giffardii* has been reared from *Ceretitis capitata* Wied., *Ceratitis* sp., *Dacus cucurbitae* Coq., *D. Oleae* Gmel., *Glossina brevipalpis* Newst., *G. morsitans* Westw., *G. palpalis* R.-D., and *D. dorsalis* Hendel (Thompson 1954). Dresner (1954) briefly described the biology of *D. giffardii*. He determined that duration of the larval stage is 10-12 days. Adult *D. giffardii* parasitizes fruit fly pupae younger than eight days old. According to Silvestri's report, these adults may live for at least five months (Dresner, 1954).

Recently, with successful mass rearing program of this species under laboratory conditions, *D. giffardii* has been considered as a control agent of *Anastrepha suspensa* (Loew) in Florida and of *D. dorsalis* in Taiwan. The attempt of the present study was made to have an understanding of the biological characteristics, reproductive capacity and control effect of this species which are important prior to the introduction of any control agents.

MATERIAL AND METHODS

Insects

All insects conlonies were maintained and experiments were carried out at 25±2°C, 70±10% RH and photoperiod of 12:12 L. D. at Tropical Research and Education Center, Homestead, Florida, U. S. A. *A. suspensa* was reared in a sugarcane bagasse-base medium developed by R. M. Baranowski (unpublished) following the rearing procedures outlined by

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Burditt *et al.* (1975). Two or three day old host pupae confined in a 9 cm diameter petri dish were exposed to *D. giffardii* for five-six days in a 38×34×20 cm cage. Host pupae were removed after exposure and put into moist vermiculate for emergence.

Biological characteristics

One-hundred, 2-3 day old host pupae were exposed to 20 pairs of *D. giffardii* for 2 hours. Dissection of exposed pupae started 24 hours after the exposure period. The duration and morphology of developmental stages were described and recorded.

Reproductive capacity

Ten, 2-3 day old host pupae were exposed to a single mated female *D. giffardii* in a 4 cm diameter petri dish for 24 hours. Samples of host pupae were dissected in 0.8% saline 72 hours after the exposure period. The number of eggs found in the parasitized hosts, number of parasitized hosts, and number of super-parasitized hosts were recorded.

The number of eggs and ovariols were recorded from dissections of 4-5 day old mated females that had never been exposed to hosts. Fifty host pupae parasitized by mature virgin females were held in a 9 cm diameter petri dish until adult emergence in order to determine the sex of the offspring.

Control effect

One hundred, 2-3 day old *A. suspensa* pupae were presented to *D. giffardii* in a 9 cm diameter petri dish. Ten pairs of *D. giffardii* were used for the experiment. *D. giffardii* and petri dish were placed in a 38×34×20 cm cage. Honey, water and sugar were provided. The *A. suspensa* pupae were exposed to *D. giffardii* for 24 hours. Samples for dissection were taken at intervals of 72-144 hours after exposure, and the remaining samples were reared to adult emergence.

As a controlled observation of *A. suspensa*'s natural mortality under the experimental conditions, one petri dish with pupae was set up as described above but was not exposed to parasitoids.

RESULTS AND DISCUSSION

Biological characteristics

The morphology of *D. giffardii* during development is given in Fig. 1. The newly laid eggs were transparent, ellipsoidal in shape, and generally turned white and enlarged during development of the embryo. *D. giffardii*'s eggs were visible through the puparium since they were laid attached to the puparium and outside the true pupa. *D. giffardii* was an external feeding species and the larvae developed outside the true pupa of the host. The first instar of *D. giffardii* is a caudate type. The larval mandible is a simple, pointed structure lacking subsidiary teeth. Hymenopteriform type larvae are found in the second and later instars of this species.

The general biological characteristics of *D. giffardii* is given in Table 1. The developmental duration of the immature stages of *D. giffardii* is more or less synchronized

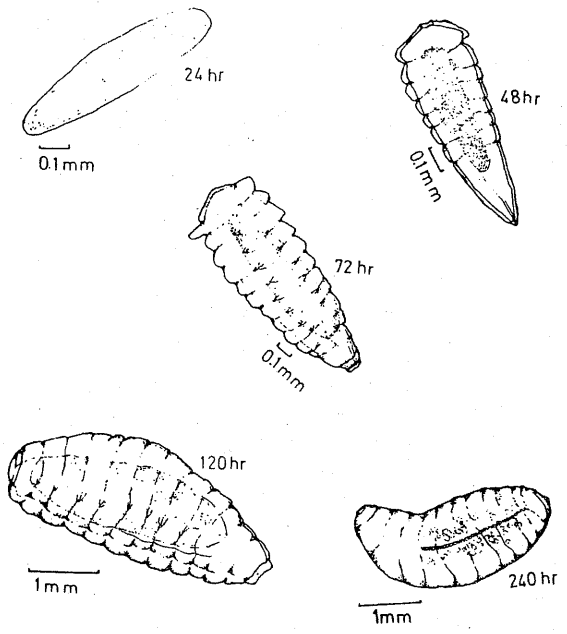

Fig. 1. Morphological characteristics of immature stages of *Dirhinus giffardii*.

with that of the host *A. suspensa*, 18-24 days (Lawrence 1975) and of *D. dorsalis*, 20-24 days (Lee 1978). However, as a resident of subtropic and tropic areas, *A. suspensa* as well as *D. dorsalis* have many generations each year and the synchronization of parasitoid and host is not so important as long as the number of available hosts is sufficient.

The longevity of the female is important because the longer the adult life, the greater than number of hosts that can be expected to be encountered. Short-lived species may compensate for the disadvantage through high reproductive or competitive abilities. Less reproductive species may compensate through an extended life span. In the present study, the longevity of *D. giffardii* was relatively long (30-37 days) (Table 1).

D. giffardii had a tendency to lay eggs in the caudal area of the purparium (Yao 1985). Because of the selective phenomenon, it is logical to conclude that the choice of oviposition site may be assumed a morphological correlation with its short ovipositor. *D. giffardii* has a relatively short ovipositor 0.25 ± 0.03 cm (Table 1). The cephalic and caudal ends have the shortest distances between puparium and true pupa. *D. giffardii* probably chooses the caudal end instead of the cephalic end because the former is closer to the hemocole. The location of larvae found inside the hosts was not always associated with the oviposition position. The first instar of *D. giffardii* usually moved to the central portion of the ventral junction of the thorax and abdomen before the first molt.

Host feeding behavior was observed occasionally in *D. giffardii* females, usually shortly after the females deposited an egg. The female turned or circled around the oviposition site several times then started feeding from the wound. Feeding lasted no more than 10 seconds. Host-feeding by *D. giffardii* always occured only after oviposition but was not consistantly observed, thus it was difficult to quantitatively measure the the host destruction done by host-feeding.

Parasitoid rearing programs are designed to produce a maximum number of mated females for release, therefore, a population with female-dominant sex ratio is favored. The ratio of males to females of the adult parasitoid study was 1:2.3 of *D. giffardii*. But the ratio might have been altered due to different degrees of intraspecific and/or interspecific competition (Yao 1985).

Reproductive capacity

The reproductive characteristics of *D. giffardii* is given in Table 2. Females of this species continue to produce mature eggs throughout their lives (synovigenisis). A meroistic-polytrophic type of ovariole, in which nutritive cells are located in ovarioles,

TABLE 1
Biological characteristics of *Dirhinus giffardii*

Characteristics	*D. giffardii*
Length of ovipositor (cm)	0.25±0.03
Female longevity (day)	30-37
Duration of immature (day)	17-20
Duration of egg stage (hr)	36-48
Duration of 1st instar (hr)	24-48
Superparasitism	rarely
Other possible lethal factors	host-feeding
Sex ratio ♂ : ♀	1 : 2.3

TABLE 2
Reproductive characteristics of *Dirhinus giffardii*

Characteristics	*D. giffardii*
Type of ovarioles	meroistic-polytrophic
No. ovarioles/ovary	3
No. mature eggs/ovariole	1-2
No. eggs/ovary	3.06±0.1
$\bar{X}$±S. E.	(n=17)
Eggs/♀/day	4.9±0.4
$\bar{X}$±S. E.	(3-7)
Solitary	yes
Arrhenotoky	yes

were found in *D. giffardii*. In most chalcid families, ovarioles are rather long and slender and indicate a linear series of immature oocytes at their distal portion (Iwata 1962). The three pairs of ovarioles found in *D. giffardii* females each produce one mature egg—and on rare occasions, two eggs—a day. Similar findings were observed in the chalcid pupal parasitoid, *Brachymeria intermedia* (Nees), of the gypsy moth by Barbosa and Frongillo (1979). A maximum number of six parasitoid progeny were produced by *B. intermedia* females in a 24-hour period.

D. giffardii was found to be absolutely solitary and arrhenotokous, since no more than one parasitoid emerged from any singly isolated pupa and only males emerged from virgin female parasitoid hosts. These results differ from Dresner's (1954) findings on *D. giffardii*. He suggested a somewhat gregarious habit of *D. giffardii* in which more than one parasitoid emerged from a single host puparium.

In a comparison of ovariole numbers among parasitoid families, Price (1975) found that families (e. g., Ichneumonidae and Tachinidae) that attacked the host in its later stages had fewer ovarioles per ovary. Since the mortality of the parasitoids declined with increased host age, the later the stage attacked the less the need for high fecundity (Price 1975). Those species with high fecundity that attack early host stages may be regarded as *r* strategists, and those with relatively low fecundity that attack later stages may be considered as *K* strategists (Price 1973 a, b, 1975; Force 1975). In the present study, *D. giffardii* had relatively low fecundity. This disadvantage, however, was compensated for by *D. giffardii*'s greater longevity. Thus, *D. giffardii* is more *K*-selection oriented in terms of host age at times of attack, longevity, and reproductive capacity.

Control effect

The analysis of mortality factors contributed by *D. giffardii* upon dissection and comparisons with reared samples is given in Table 3. The assumed natural mortality of *A. suspensa* under experimental condition

TABLE 3
Analysis of mortality factors of *A. suspensa* after exposure to *D. giffardii*

	Mortality category	Mortality factors	$\bar{X}\% \pm$ S. D.
Dissected Samples (DS) n=379	Mortality of host due to parasitoid	Parasitism (I)	33.12±4.59
		Multi-probing scars, no progeny, host content rotten	1.62±0.78
		Total	34.74±5.41
	Estimated total mortality due to *D. giffardii*		34.74±5.41
			$\bar{X}\% \pm$ S. D.
Reared Samples (RS) n=4201	Total mortality (TM)		42.70±5.61
	Natural mortality		21.45±6.50
	Mortality due to parasitoid (TM-21.45) (II)		21.25±6.71*
	% Parasitoid emergence (no. emerged parasitoid/RS) (III)		19.92±3.67*
	Mortality due to parasitoid besides parasitism (II-III)		1.33±1.40
	Difference of parasitism between DS and RS (I-III)		13.20±5.12

* No significant difference between values with the same marks by t-test, p=0.05.

was 21.45±6.50%.

There is no parasitoid mortality factor was found in *D. giffardii*. Therefore, the difference between dissected samples and reared samples is due to unknown factors. Some pathogenic factor which might have been introduced during female oviposition, or through the wounds due to probing could be suspected. The fatal effect of this pathogen on the progeny could not have been detected during the dissection period.

Host feeding is also a possible factor contributing to the mortality of the host which occurred in *D. giffardii* with or without parasitoid progeny. In the present study no attempt was made to quantify the damage done by host feeding.

From the reared samples (Table 3), the difference between the host mortality due to the parasitoids (II) and the percent of F_1 parasitoid emergence (III) was not significant in *D. giffardii*, This indicated that parasitism was the major factor causing death of the host species. Repeated attack by *D. giffardii*, as evidenced by multiple scars on the host, by lack of parasitoid progeny, and by decayed host contents were also minor causes of host death.

The dissected samples revealed that the percent parasitism was relatively low in *D. giffardii*. This was due to the low number of ovarioles/ovary (n=3) which restricted the number of eggs formed per day (n=6-7) (Table 2). Additionally, occasional superparasitism was observed which would have restricted the number of host pupae *D. giffardii* could have parasitized on a daily basis.

D. giffardii would be expected to complement the control efforts of some larval parasitoids already established in the field. In Taiwan, an attempt has been made to utilize *D. giffardii*, the more *K*-oriented parasitoid, to complement control effect of the native larval parasitoid, Biosteres oophilus (Fullaway), which has been the major natural parasitic parasitic enemy of *D. dorsalis* in the field.

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Dirhinus giffardii Weld (膜翅目：粗脚小蜂科) 的生物特徵、繁殖潛能及防治能力研究

姚 安 莉

本文除研究果實蠅蛹寄生蜂 *Dirhinus giffardii* 的幼蟲期形態、生活史及行爲外，並研究其繁殖潛能及治蟲能力以考慮大量釋放田間的可能性。*D. giffardii* 導致寄主死亡的主因爲其寄生習性。雖然在此種昆蟲上也發現吸食寄主體液的行爲，但此現象是不規則發生，無法估計其危害程度。由於 *D. giffardii* 爲寄主發育後期（蛹期）之寄生蜂，成蟲壽命長及偏低的繁殖潛能顯示其爲一趨於 K —選擇性的天敵。