

# Parasitism Rates by Dryinid Wasps of White Backed Planthoppers (*Sogatella Furcifera*) in Paddy Fields, Hualien, Taiwan

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**Abstract**—Dryinid wasp is the one predator or parasitoid of nymphs and adults of white backed planthopper (*Sogatella furcifera*). White backed planthopper usually find in Taiwanese paddy fields and dryinid wasp also have found in Taiwan. Of the seven dryinid adults were found in September 2015. They are *Gonatopus* sp., *Echthrodelpax* sp., and *Haplogonatopus* sp. Of the 233 white backed planthopper were attacked by dryinid wasps. Femal dryinid wasps oviposited their eggs on thorax and abdomen of nymphs and adults. They preferred to oviposit on thorax of nymphs and abdomen of adults. Dryinid wasps attacked both nymphs and adults of white backed planthopper. The rate of parasitism was highest in May (spring season), and September (fall season) which depend on the highest peak densities of white backed planthopper. Superparasitism and multiparasitism of dryinid and strepsipteran parasites were found in paddy fields. Of the six superparasitism by dryinid were attacked by two parasites per host and four superparasitisms by strepsipteran were attacked two parasites per host. Seven cases of multiparasitism included one strepsipteran and one dryinid sacs (five cases), one strepsipteran and two dryinids sacs (one case), and two strepsipterans and one dryinid sacs (one case).

**Keywords**— strepsipteran, seasonal incidence, superparasitism, multiparasitism

## I. INTRODUCTION

White backed planthopper (*Sogatella furcifera*; WBPH) is an important pest in paddy fields [1]. It belongs to family Delphacidae, order Hemiptera. It causes damage by sucking on rice plants and transmitting rice disease viruses [2]. White backed planthopper can destroy rice products as they migrate from one place to another. This is because their populations increase very quickly. Moreover, they are difficult to control because they can spread across a country [3]. Damage from WBPH occurs in Taiwan also [3]. One situation causing them to spread is typhoons. That can move them from China and Vietnam to Taiwan [3].

Actually, a paddy field has many arthropods that can control insect pests as call natural enemies, such as predators and parasitoids [4]. One important natural enemies found in rice

fields are dryinid wasps (Dryinidae: Hymenoptera) [5]. They are also found in Taiwan's paddy fields [6] and they are natural enemy of plant and leaf hoppers [7], [8], including brown planthopper (BPH) and WBPH [7].

Drynid wasp is parasite or predator of hoppers [8]. It expands semi-internally in its hosts and final stage of larva is semi-external [9]. Dryinid wasps consume their hosts either by attacking the prey as a predator [8] and inserting their eggs into the host body [8], [9]. Eventually, the larvae emerge and consume on the hosts body fluids [9]. Dryinid wasps parasitize on nymphs more than adults of leafhopper and planthopper [10] and some dryinids increased fecundity when host increased population [11]. The adult dryinids were often found in Japanese paddy fields, but they are not major parasitoid of planthopper [12], but they are more importance when brown planthoppers were outbreak [5].

More than one dryinid wasp can attack in a same host as superparasitism [13] and can combine to attack host with strepsipteran wasps in a same host as multiparasitism [12], [13]. Strepsipteran wasp is also a parasite of hopper [7], [8]. It feeds on the fluids of the host [8]. In Borneo Island, Sarawak, Malaysia, [15] often found leafhoppers and planthoppers with protruding. Adult of the hoppers were attacked by strepsipteran 65% parasitism rate [14]. Referred to [6] they have recorded dryinid wasps in Taiwan, but there are no studies about superparasitism and multiparasitism occur. Moreover, seasonal abundance and incidence of parasitism of white back planthopper by dryinid also lack of evidence in Taiwan.

Therefore, we investigated species of dryinid wasps in Taiwan paddy fields, compared rates of seasonal abundance and incidence of parasitism, and compared rates of superparasitism and multiparasitism occur.

## II. METHODS

The experiment was conducted in the paddy fields of Shoufeng, Ji'an, Guangfu, and Hualien townships, Hualien County, Taiwan. There are two sites in each township. We sampled arthropods 20 sweep samples at eight different sites and the arthropods were sampled using a standard sweep net. We catch four times per site in a season from April to June (spring season) and August to October 2015 (fall season), for a total of 1,280 sweeps. The samples were collected during the morning hours (0800 to 1200 h) and about one hour was spent in each sampling site. The insects were sampled at random towards from the edge of paddy bund to the end of each plot. Sweep net

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transects were walked slowly and one sweep was taken with two sweep net transects. The insect samples were collected in plastic bags and put into containers with 95% ethanol. Specimens of insect were examined under a stereo microscope and counted the numbers of each species. Adults of dryinid wasp were identified into genus, using the keys of [15]. Insects that were attacked by dryinid wasps were classified and counted the numbers and compared with normal insects. Statistical comparisons of percentage of parasitism in insect hosts were calculated by mean of the Wilcoxon Rank Sum test [16].

### III. RESULTS AND DISCUSSIONS

#### A. Adults of Dryinid Wasps

We found seven adults of dryinid wasps, all of them found in September 2015. The species of dryinid wasps belong to the three genera, namely, *Gonatopus*, *Echthrodelphax*, and *Haplogonatopus* (Table 1). Referred to [15] they have recorded four genera ten species of dryinid were found in paddy fields of tropical Asia and the four genera have been found in Taiwan also [17]. This result seems that *Echthrodelphax* sp. and *Haplogonatopus* sp. are dominant species in Hualien, Taiwan, but we found a few adult samples. Perhaps, our method was not suitable for catch other species. *Gonatopus* sp. is a female. According to [18] assumed that probably *Gonatopus* is a bisexual and parthenogenesis as in *G. sepsoides*. In case of parthenogenesis, the off spring will be cloning their mother, thus they are usually female [18].

TABLE I

ADULTS OF DRYINID WASP IN PADDY FIELDS, HUALIEN, TAIWAN IN 2015

Sites of Occurrence	Parasite	Numbers and Sex of Dryinid wasp
Shoufeng 1	<i>Gonatopus</i> sp.	1 female
	<i>Echthrodelphax</i> sp.	1 male
	<i>Haplogonatopus</i> sp.	3 females
Guangfu 1	<i>Echthrodelphax</i> sp.	1 male
Guangfu 2	<i>Echthrodelphax</i> sp.	1 male

#### B. Position of Dryinid Sac on Host

After adult of dryinid wasp insert its eggs into the host body, the larvae emerge and grow. Eventually, the body host would appear a black to grayish sac that protrude from the abdomen of their hosts [8]. Our results showed in the same way that the position of dryinid sac protruded from the abdomen of WBPH and we also found the dryinid sac protruded from the thorax of WBPH (Fig. 1). Percent parasitism of WBPH nymphs by dryinid wasps that protruded from the thorax was 53.01% and from the abdomen was 46.99%. We assumed that female dryinids prefer to oviposit around the thorax of WBPH nymphs more than abdomen. In the other hand, female dryinids prefer to oviposit around the abdomen of WBPH adults. We found percent parasitism of WBPH adults by dryinid wasps that protruded from the thorax was only 1.28% and from the abdomen was 98.72%. However, [19] mentioned that dryinid wasps fluctuated in the position of the larva sac on the host. They referred the dryinid sac of some species in subfamily Aphelopinae and Anteoninae protruded from the abdomen or thorax of host, but the dryinid sac of subfamily Gonatopodinae

only protruded from the abdomen of host. Some of the dryinid wasps that live in paddy fields, they belong to Gonatopodinae also [19]. This contrasted to our results that dryinid wasps that found in paddy fields varied in the position of the larva sac on the host, because we found the dryinid sac protruded from both of the abdomen and thorax.

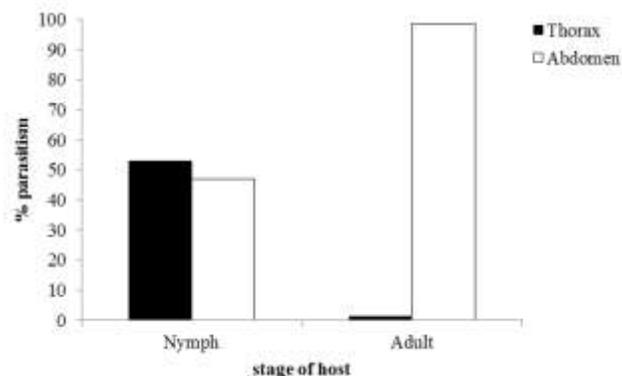


Fig. 1 Position of dryinid larva sac on white backed planthopper at Hualien paddy fields in 2015

#### C. Stage and Sex Ratio of Dryinid Parasites on WBPH

Drynid wasps fluctuated in the stage of WBPH as their host attacked and they also oviposit in the WBPH adult that difference between forms of wings (Table 2). Of the total 233 parasitized WBPH, nymphs were more parasitized than adults. Moreover, female adults of WBPH were more parasitized than male adults and adults in macropterous form were more parasitized than adults in brachypterous form. The results seem female adult of dryinid wasps prefer to oviposit on WBPH nymphs more than WBPH adults, however when we compared the numbers of WBPH nymphs and adults we found the numbers of nymphs more than adults 3.27 times. Probably parasitism ratio of WBPH by dryinid wasps varies in the densities of host. Hence, we compared percent parasitism of WBPH, we found the percent parasitism of nymphs and adults by dryinid wasps were 2.50 and 3.73, respectively. This result in contrast with [10], it showed dryinid wasps parasitized on nymphs more than adults of leafhopper and planthopper.

The results remained dryinid wasps varied in the stage of host. They attacked both of nymphs and adults. Similar with [19] also showed the hosts of dryinid in Anteoninae and Gonatopodinae were attacked on both nymph and adult stages.

TABLE II

STAGE AND SEX RATIO OF DRYINID PARASITES ON WHITE BACKED PLANTHOPPER AT HUALIEN PADDY FIELDS, TAIWAN IN 2015

Stage of White Backed Planthopper	Numbers of Parasites
nymph	160
male-macropterous form	28
male-brachypterous form	2
female-macropterous form	31
female-brachypterous form	12

#### D. Seasonal Incidence of WBPH and Parasitism by Dryinids

We found the number of white backed planthopper and percent parasitism of dryinid wasp (Table 3). The percent of dryinid parasitism were 1.79 - 4.32 in different sites. The ratio

was very low, however when compared with [13] results they found *Prokelisia* spp. (delphacid planthoppers) were parasitized by *Pseudogonatopus* sp. (dryinid wasps) only 0 – 1% in each month. Moreover, dryinid wasps are predator also. They consume 2 – 4 prey a day [8]. Therefore, we assumed that dryinid wasp is the one important natural enemy in paddy fields at Hualien, Taiwan, especially in Shoufeng and Hualien townships.

TABLE III  
NUMBERS OF WHITE BACKED PLANTHOPPER AND PERCENT PARASITISM OF WHITE BAKED PALNTHOPPER BY DRYINID WASP IN PADDY FIELDS, HUALIEN, TAIWAN IN 2015

Sites of Occurrence	Number of White backed Planthopper	Percent Parasitism of Dryinid wasp
Shoufeng 1	1366	2.49
Shoufeng 2	385	4.16
Jian 1	1,638	2.56
Jian 2	2,176	2.99
Hualien 1	967	2.17
Huenlien 2	602	4.32
Guangfu 1	824	2.67
Guangfu 2	392	1.79

Seasonal incidence of WBPH and parasitism by dryinid wasps showed in Fig. 2. The rate of parasitism in spring season was highest in May (6.78%), and in fall season was highest in September (6.47%). Similar with numbers of WBPH, the rate of WBPH in spring season was highest in May and in fall season was highest in September. Therefore, we indicated that the numbers of dryinid parasitism varied in host densities. We found that numbers of WBPH that were attacked by dryinid wasp correlated to WPBH desities ( $r=0.56^{**}$ ). As the results in C., we found the numbers of WBPH nymphs more than adults 3.27 times. Therefore, female adult of dryinid wasps oviposited on WBPH nymphs as host more than adults. Referred to [20] showed the long distance migration of dryinid wasps in monsoon Asia varied in activity of host. That means when their host migrate, dryinid wasps probably migrate also. Therefore, the host affected the distribution of dryinid wasps.

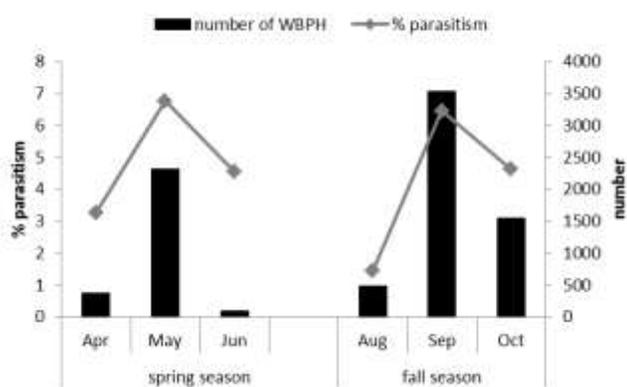


Fig. 2 Seasonal incidence of white backed planthopper and parasitism by dryinids at Hualien paddy fields in 2015

### E. Superparasitism and Multiparasitism

We found more than one dryinid or strepsipteran larva sac appeared on the same WBPH body as called superparasitism and we also found dryinid and strepsipteran larva sac in the same host as called multiparasitism (Table 4). Referred to [21] mentioned that in the case of superparasitism, probably more than one of dryinid female were coincidence when they oviposited on the same host. We found two dryinid wasps oviposited on three nymphs, two male adults (macropterous form), and one female adult (macropterous form). Moreover, we found four strepsipteran wasps oviposited on four male adults (macropterous form). Our result indicated that female dryinids prefer to oviposit on nymphs and adults, especially male of WBPH, but female strepsipterans prefer to oviposit on male adults. This result we unable to confirm that sex of host related to dryinid parasite ratio, because we found a few samples. However, [22] showed the results about host sex related to parasitoids. They studied host chemical footprints in some bugs as hosts induce the ability to distinguish host sex in *Trissolcus* egg parasitoids. Thus, that egg parasitoids be able to distinguish female from male. Probably, white backed planthoppers have some chemical or pheromone to induce dryinid or strepsipteran wasps.

Referred to [23] mentioned that when two parasites appeared on the same host, the parasite sac protruded on host body wherever there is space, but almost sacs would protrude on the opposite sides of host. We also found the same pattern that almost of dryinid and strepsipteran sac protruded from the opposite sides of WBPH abdomen and only one of WBPH was attacked by two strepsipteran protruded on the same side of WBPH abdomen.

We found seven cases of multiparasitism (Table 4). One strepsipteran and one dryinid sacs were found on the same host. They parasitized on one nymph and four adults (macropterous form) of WBPH. We also found male adult of WBPH (macropterous form) was parasitized by one strepsipteran and two dryinids and another male adult of WBPH (macropterous form) was parasitized by two strepsipterans and one dryinid. We found seven multiparasitized individuals in 8,350 WBPH. The rate of multiparasitism is 0.08% within six months. Multiparasitism by strepsipterans and dryinids on homopteran group is not common [13], because [24] found only one sample within many years and similar with [25] found multiparasitism 1.3% or 207 samples of all delphacid planthoppers that she found during in 1958 – 1964.

TABLE IV NUMBERS OF SUPERPARASITISM AND MULTIPARASITISM OF DRYINID AND STREPSIPTERAN WASPS ON WHITE BACKED PLANTHOPPER AT HUALIEN PADDY FIELDS IN 2015

Numbers of Parasites	Numbers of Dryinid Wasps on Each Stage of WBPH		
	Nymph	Male Adult	Female Adult
<i>Superparasitism</i>			
2 dryinids	3	2	1
2 strepsipterans	0	4	0
<i>Multiparasitism</i>			
1 strepsipteran and 1 dryinid	1	2	2
1 strepsipteran and 2 dryinids	0	1	0
2 strepsipterans and 1 dryinid	0	1	0

## IV. CONCLUSION

Dryinid wasp is one important natural enemy in paddy fields at Hualien, Taiwan, especially in Shoufeng and Hualien townships. We found the percentage of dryinid parasitism were 1.79 - 4.32 in different sites. Even though the ratio is very low, adults of dryinid wasp can directly consume their prey also [8]. The numbers of dryinid parasitism varied in host densities. As the result, numbers of dryinid parasitism on white backed planthopper correlated to WBPH densities in paddy fields ( $r=0.56^{**}$ ). They are not major parasitoid of planthopper [12], however, they are more importance when planthoppers were outbreak [5].

Female of dryinid wasps oviposited on both of nymphs and adults of WBPH. Moreover, two or more than of dryinid individuals able to attacked in the same host and they able to oviposit in the same host with strepsipterans. Even though it is not common to find multiparasitism in paddy fields, we found seven cases of them in Haulien, Taiwan. Therefore, dryinid wasp is very interesting to study in many perspectives, especially biological control in paddy field.

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