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INSECT PARASITOID COMPOSITION ON SOYBEAN, SOME ECO-BIOLOGICAL CHARACTERISTICS OF THE PARASITOID, *XANTHOPIMPLA PUNCTATA* FABRICIUS ON SOYBEAN LEAFFOLDER *OMIODES INDICATA* (FABRICIUS) IN HANOI, VIETNAM

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ABSTRACT

Soybean is infested by many insect pests, such as stem borer, pod borer, leaffolder, armyworm, bollworm, green stinkbug, but there are also several insect natural enemies. In the summer-autumn of 2009 and spring season 2010, 16 insect parasitoid species of several major insect pests were obtained in soybean production areas of Hanoi. *Microplitis manilae* Ashmead, *Therophilus javanus* (Bhat and Gupta), *Trathala flavoorbitalis* (Cameron) and *Telenomus subitus* Le were the most frequently found. The pupal endoparasitoid, *Xanthopimpla punctata* (Fabricius) which appeared in moderate frequency was further investigated for its biological characteristics. The life cycle of *X. punctata* was about 11.9 ± 0.76 days under conditions of 27.9 ± 2.4ºC and 72.5 ± 4.6% average humidity. Food quality affected adult longevity, as individuals which were fed pure honey lived for an average of 8.5 days compared to those fed with 50% honey solution lived an average of 5.6 days. Those fed pure water lived for only 2.6 days. Female *X. punctata* prefer ovipositing on one-day old host pupae and do not oviposit on 4-day old host pupae.

Key words: Insect pest, natural enemies, biology, diversity, food supplement

INTRODUCTION

Soybean is an important industrial crop because of its nutrition and economic values (Pham, 2000). But, soybean is attacked by many insect pests, such as leaffolder (O*miodes indicata*), armyworm (*Spodoptera litura*), bollworm (*Helicoverpa* spp*.)*, green bug (*Piezodorus hybneri*), among others. To control these insect pests, farmers apply chemical insecticides 8 to10 times per cropping season (Luong et al,1988) which could be detrimental to natural enemies, thus disturbing the biological balance in the field and contaminating the environment. Soybean leaffolder is an important insect pest of soybean (Luong et al., 1988; Dang, 1999) and it has several natural enemies (Dang, 1999; Dang, 2003; Vu et al., 1996). Thus, the use of natural enemies for pest management in soybeans is a very important strategy that needs to be explored.

The Ichneumonidae is one of the most species rich families, with an estimated 60,000 species in the world (Townes, 1969). An estimated 12,100 species of Ichneumonidae occur in the Afrotropical region (Africa south of the Sahara and including Madagascar), of which only 1,927 species have been described (Yu, 1997). Ichneumonids have been used successfully as biocontrol agents and given the largely undocumented fauna, there is a huge potential for their utilization in managed biocontrol programmes (Gupta, 1991). *Xanthopimpla* genus is one of the richest genera of Ichneumonidae. The species of the genus are idiobiont endoparasitoids of Lepidopteran pupae (Gauld, 1991; Upadhyay et al. 2001). Many *Xanthopimpla* species are very abundant in tropical areas and is commonly observed in the vegetation. *X. punctata* Fabricius has an important function in controlling several herbivore species on different plants, such as coconut in Kerala, India, corn in the Mariana Islands, and other places around the world. A survey of the parasitoids of the Asian corn borer, *Ostrinia furnacalis* (Guenée) in the Mariana Islands revealed three species of pupal parasitoids: *X. punctata* (F.), *Brachymeria albotibialis* (Ashmead) and *Tetrastichus inferens* Yoshimoto (Nafus and Schreiner, 1986). The ichneumonid, *X. punctata,* is one of 50 parasitoid species which can be used for biological control of agricultural pests in Vietnam (Khuat, 2002).

X. punctata, is commonly found on many crops, such as soybeans (Vu et al., 1996; Dang, 1999), corn (Nafus and Schreiner, 1986, Ueno et al., 1999), vegetable beans (Dang, 2005), rice (Dang, 2006), and coconut (Pillai et al., 1989). It parasitizes rice stem borers and is distributed in all ecological zones (Delucchi, 1976). However, studies on the biological and ecological characteristics of *X. punctata* are still very limited. This paper presents the diversity of insect parasitoids on soybean major insect pests in Hanoi and some biological characteristics of the pupal parasitoid, *X. punctata* on soybean leaffolder, *O. indicata.*

MATERIALS AND METHODS

Soybean DT84 variety, one of the common varieties in Hanoi, was selected by Mai Quang Vinh, a geneticist of the Vietnam National Institute of Agricultural Genetics by using Co^{60} (18Kr) on hybrid train 3-333. Soybean train 3-333 was the first generation (F_1) from a cross of (DT80$_{♀}$ × DT76$_{♂}$, which are old Vietnamese varieties. The DT84 variety was tested in 1990 and accepted as a good variety in 1995 by the Ministry of Agriculture and Rural Development. DT84 has a development period of about 85-90 days with yellow colored seeds and an average yield of 1.3 to 1.8 tons ha^{-1}.

Parasitoid composition

The major insect pests, such as leaffolder *O. indicata*, armyworm *S. litura*, bollworm *H. armigera*, *H. assulta,* soybean pod borer *Maruca vitrata*, *Etiella zinckenella*, semilooper *Plusia eriosoma* and eggs of red shield bug *Piezodorus hybneri* were collected randomly, every week from soybean fields during the summer-autumn of 2009 and the spring season of 2010 in Hanoi. Thirty larvae and pupae of each major pest were collected, while more than twenty egg clusters of egg parasitoids of red shield bug were collected each time (Ogata and Hung, 2003).

Mass rearing of host *Omiodes indicata*

Host pupae and last instar larvae of leaffolder, *O. indicata* (Fabricius) were collected from soybean fields in Tuliem and Gialam districts of Hanoi in the summer-autumn crop of 2009. The pupae and larvae collected were kept separately in plastic cups (10cm, bottom diameter, 12cm (top diameter) x 11cm (height). Larvae were fed soybean leaves every 2 days until these started to pupate. Observations took place every day until adult emergence. After emergence, all adults of both sexes were released into a small net house (5 x 4 x 2m, L x W x H), where host adults were free to oviposit on 1 month-old soybean plants. Larvae fed on the soybean plant and ten 5th instar larvae were introduced into a mica box (20 x 10 x 10 cm, L x W x H) with soybean leaves to produce unparasitized host pupae for the parasitoid *X. punctata* experiments.

Mass rearing of the parasitoid *X. punctata*

Parasitized host pupae, collected from soybean fields in Hanoi in the summer-autumn of 2009 and the spring season of 2010, were kept under laboratory conditions of 25±1°C and 75±2% humidity with 16L:8D photoperiod in the laboratory of the Department of Entomology, HUA until adult emergence. Adults were kept in mica boxes (7 × 9cm, diameter × height) in an incubator with pure honey by placing small drops on the wall of the box using a toothpick. To produce parasitoids, couples of *X. punctata* (at any age) were introduced into mica boxes containing five 1-2 day old pupae, for 24 hours under conditions of 27.9 ± 2.4ºC and 72.5 ± 4.6% humidity at 14L:10D photoperiod. These were transferred to another mica box until adult emergence and replaced with another set of 5 pupae the next day.

Biology and life cycle of *X. punctata*

Thirty batches of parasitized host pupae, as described above, were collected to give a total of 150 test pupae. Ten individuals were taken daily for dissection and observation under binoculars to determine the developmental stages (egg, larva and pupa) until adult emergence.

For adult pre-oviposition stage trials, 15 couples of adult *X. punctata* were introduced into 15 mica boxes, which contained three 1-2 day old *O. indicata* pupae. Adult *X. punctata* were fed with pure honey. Treatments were maintained at 27.9 ± 2.4ºC and 72.5 ± 4.6% humidity at 14L:10D photoperiod. The host pupae were collected every two hours from 6am to 6pm, and replaced with another set of 3 unparasitized pupae. All of the host pupae in this treatment were dissected for *X. punctata* eggs to determine the pre-oviposition stage.

Host Preference Test

To determine the preferred host age *(O. indicata)* for the parasitoid *X. punctata,* pairs of 1-2 day old *X. punctata* were introduced into a mica box (with a mesh lid) which contained 4 pupae of *O. indicata* of different ages (1, 2, 3 and 4 days old) in marked positions for each host pupal age. The parasitoid, *X. punctata* can choose the host pupal age among the different pupae in same box for 24 hours at 14L:10D photoperiod at about 27.9ºC ± 2.4 and 72.5 ± 4.6% average humidity, with 15 replications using a total of 60 host pupae. The number of host pupae parasitized at each age was recorded.

Longevity

The effect of food on longevity of *X. punctata*, was evaluated using 3 treatments: (1) pure honey, (2) honey solution, 50% and (3) pure water. Each treatment included at least 10 pairs of male and female wasps at one day after emergence into separate glasses which contained 3 pupae of the one day old host (according to the results of the treatment of host age preferred by the parasitoid adults). Treatments were maintained at an average temperature of 27.9ºC ± 2.4 and 72.5 ± 4.6% humidity at 14L:10D photoperiod. Unparasitized one day old host pupae were replaced every day until females of the parasitoid died. Observations were made daily until all adults of *X. punctata* died. The life span of each individual *X. punctata* adult was recorded.

The identification of *X. punctata* was done by Assoc. Prof. Dr. Khuat Dang Long, a taxonomist of Hymenoptera (Braconidae) at the National Institute of Ecology and Biological Resources, Vietnam, using Townes and Chiu (1970). The 16 parasitoid species were identified by Assoc. Prof. Dr. Khuat Dang Long, who used Achterberg *et al.* (2010) for larval and pupal parasitoid identification, while Assoc. Prof. Dr. Le Xuan Hue of the National Institute of Ecology and Biological Resources, Hanoi, Vietnam identified the egg parasitoids.

RESULTS AND DISCUSSION

Insect parasitoid composition of soybean key pests

The insect and their natural enemies composition on any plant varies in time and space and is dependent on many factors, such as weather, crop variety, and use of chemical insecticides. Thus, there were 16 insect parasitoid species obtained from soybean fields during summer-autumn of 2009 and 14 species during spring crop in 2010 in Hanoi (Table 1). All of these were hymenopterans: 8 braconids, 4 ichneumonids, 2 celionids and 2 chalcidids. Four species collected with high frequency in summer-autumn of 2009 were *Microplitis manilae* Ashmead (Braconidae), about 32.8% individual were parasitized (117 per 357 individuals); *Therophilus javanus* (Bhat and Gupta) (Braconidae) 27.6% parasitized (45/163); *Trathala flavoorbitalis* (Cameron) (Ichneumonidae), about 29.8% parasitized (74/248) and *Telenomus subitus* Le (Scelionidae) about 45.3% parasitized (786/1736). These high parasitism rates, together with other parasitoids (microorganisms, nematodes and predators), can control the key pests such as, armyworm, leaffolder, pod borer and red shield green stinkbug.

In the spring season of 2010, the frequency of parasitoids obtained were lower than in the summer-autumn of 2009 and may be due to fewer host individuals after the winter season and parasitoids could be over wintering and develop in the spring season (Bale et al., 2009). Therefore in the spring season, the percentage of host parasitized was lower than in summer-autumn season (Table 1). In the summer-autumn season, the weather conditions were better for both hosts and parasitoids than in the spring season. Furthermore, the number of parasitoid individuals could have accumulated from generation to generation, from spring season to summer season, resulting in higher frequency of parasitoids in the summer-autumn season than in the spring season.

Most host larvae collected from soybean field during the summer-autumn of 2009 and spring season of 2010 were parasitized at young instars (2nd to 4th), exclusive of *Microplitis prodeniae* which preferred to parasitize on 1st to 4th instar host *S. litura* and the ichneumonid wasp, *Charops bicolor* which tends to parasitize 4th to 5th instars of its host, *S. litura* (Table 1).

There was a bias for female parasitoid individuals compared to males, especially for species which had low percent parasitism (under 5%) except for *T. sereus* which had 8.8% parasitism. For example, percent parasitism for *A. hanoii* on *E. zinckenella* was 3.8% (7/184) while the female population was 71.4% in the spring of 2010. Similar results were observed for *C. munatakae* on *O. indicata* in the summer-autumn of 2009 and *M. pallidipes* on *S. litura* in the spring season of 2010, where percentage of females was the same with *A. hanoii*. For *X. flavolineata* on *O. indicata,* females were 71.4% in the summer-autumn of 2009 and 75.0% in the spring of 2010. For *Brachymeria secundata* on *O. indicata* in the spring of 2010, females were 75% and *Brachymeria* sp. on *O. indicata* on both seasons was 66.7%. These parasitoid species have high potential for controlling soybean key pests.

The majority of the 42 insect parasitoid species in soybean fields in Northern Vietnam during 1995-1996 were hymenopterans (39/42) (Vu et al., 1996). Among these, 13 species were parasitoids of soybean leaffolder *(O. indicata)*: *Apanteles hanoii* Tobias et Long, *Chelonus pectinophorae* Cushman, *C. munakatae* Munakata, *Chelonus* sp., *Brachymeria secundaria* (Ruschka), *Elasmus* sp., *Xanthopimpla flavolineata* Cameron, *X. punctata* Fabricius, *Trathala flavoorbitalis* (Cameron) and *Phaeogenes* sp. Two parasitoid species *(Microplitis prodeniae* Rao & Kurian and *M. manilae* Ashmead) were found in army worm *(Spodoptera litura)*, two parasitoid species, *Cotesia ruficrus* (Haliday), *Apanteles salutifer* (Wilkinson) in bollworm (*Helicoverpa* spp.) and 3 parasitoid species (*Telenomus subitus* Le, *T. rudus* Le and *T. libioceris* Kozlov et Le) in red shield green bug eggs.

Table 1. Composition of important parasitoids reared from key pests infesting soybeans in the summer-autumn of 2009 and the spring of 2010 in Hanoi, Vietnam.

Parasitoids	Hosts	Stage of parasitized host	Frequency * Sex ratio (Male: Female)	
			Summer-Autumn, 2009	Spring, 2010
Braconidae				
1. *Apanteles hanoii* Tobias and Long	*Omiodes indicata*	L2-L3	15/248 (1: 1.5)	5/225 (1: 0.7)
	Etiella zinckenella,	L2-L4	5/168 (1: 1.5)	7/184 (1: 2.5)
2. *Chelonus munatakae* Matsumura	*Omiodes indicata*	L2-L4	7/248 (1: 2.5)	0/225
	Helicoverpa assulta,	L3-L4	48/314 (1: 1.0)	21/265 (1: 1.3)
3. *Cotesia ruficrus* (Haliday)	*Helicoverpa armigera*	L3-L4	39/328 (1: 1.2)	34/276 (1: 0.9)
	Plusia eriosoma	L3-L4	19/114 (1: 1.4)	8/92 (1: 1.7)
4. *Microplitis manilae* Ashmead	*Spodoptera litura*	L2-L4	117/357 (1: 1.2)	65/344 (1: 1.4)
5. *Microplitis pallidipes* Szépligeti	*Spodoptera litura*	L2-L4	11/357 (1: 1.8)	7/344 (1: 2.5)
6. *Microplitis prodeniae* Rao & Kurian	*Spodoptera litura*	L1-L4	31/357 (1: 1.3)	31/344 (1: 1.8)
7. *Therophilus javanus* (Bhat & Gupta)	*Maruca vitrata*	L2-L3	45/163 (1: 1.5)	26/107 (1: 1.4)
8. *Therophilus marucae* van Achterberg & Long	*Maruca vitrata*	L2-L3	6/163 (1: 1)	0 (107)
Ichneumonidae				
9. *Charops bicolor* (Szépligeti)	*Spodoptera litura*	L4-L5	14/357 (1: 1.3)	9/344 (1: 1.2)
10. *Trathala flavoorbitalis* (Cameron)	*Maruca vitrata*	L2-L4	13/163 (1: 0.9)	7/107 (1: 1.3)
	Omiodes indicata	L2-L4	74/248 (1: 1.3)	38/225 (1: 1.2)
	Etiella zinckenella,	L2-L4	11/168 (1: 2.7)	12/184 (1: 1.4)
11. *Xanthopimpla flavolineata* Cameron	*Omiodes indicata*	Pupae	7/97 (1: 2.5)	4/89 (1: 3.0)
12. *Xanthopimpla punctata* (Fabricius)	*Omiodes indicata*	Pupae	17/97 (1: 1.4)	17/89 (1: 1.8)
Scelionidae				
13. *Telenomus cereus* Le	*Piezodorus hybneri*	Egg	131/1736 (1: 1.2)	77/784 (1: 2.2)
14. *Telenomus subitus* Le	*Piezodous hybneri*	Egg	786/1736 (1: 0.9)	152/784 (1: 1.3)
Chalcididae				
15. *Brachymeria secundata* Fabricius	*Omiodes indicata*	Pupae	5/97 (1: 1.5)	4/89 (1: 3.0)
16. *Brachymeria* sp.	*Omiodes indicata*	Pupae	3/97 (1: 2.0)	3/89 (1: 2.0)
Sum of species			**16**	**14**

* L: Larvae; Rating scale: very low (<5%), low (5-10%), moderate (>10 -20%), high (>20% parasitized)
* No. of host parasitized per total no. of host observed

In 2006-2007, the number of parasitoids collected from key pests in soybean fields in Gialam, Hanoi was high. The number of parasitoids obtained from leaffolder (*O. indicata*), *S. litura* and red shield green bug eggs (*P. hybneri*) were 13, 8 and 5 species, respectively (Nguyen et al., 2008). Ten parasitoid species of soybean leaffolder (*O. indicata*) were collected during summer-autumn crop 2003 at Gialam, Hanoi, where *T. flavoorbitalis* was the most common species, followed by *X. puntata*. (Dang, 2003). There are 492 hymenopterous parasitoids known in Vietnam as of 2000. Twenty seven of these have been studied for ecological and biological characteristics, where 7 species belong to Braconidae and 8 species belong to Ichneumonidae (Khuat, 2002). A survey of the hymenopteran parasitoids of crop pests in Aralaganwila, Sri Lanka showed that leaffolder (*O. indicata*), army worm (*S. litura*), bean pod borer (*M. vitrata)*, and eggs of red shield green bug (*P. hybneri*) were parasitized by 6, 4, 3 and 3 species, respectively (Ketipearachchi, 2002). A survey in Taiwan revealed the natural enemies composition of *M. vitrata* which feed on leaves of a green manure legume (*Sesbania cannabina*) during the summer seasons of 1996 and 1997. There were 7 species of hymenopterous parasitoids (*Apanteles taragamae, Bassus asper, Dolichogenidea* sp., *Trichomma* sp., *Triclistus* sp., *Plectochorus* sp., and two unidentified tachinids). Among them, *A. taragamae* was the most common (Huang et al., 2003).

The diversity of insect parasitoids is relative rich in Vietnam not only in soybean fields, but also on vegetables. There were 13 species of hymenopterous parasitoids reared from the leafminer that infested vegetables in three regions of central Vietnam (Tran, 2009). Another survey of the parasitoid complex on vegetables in central and southern Vietnam obtained 18 species (Tran et al., 2005).

Developmental period of *X. punctata* feeding on pupae of soybean leaffolder *O. indicata*

The developmental period of insects, in general and of parasitoids, in particular, is one important biocharacter, because this increases the number of generations. If this period is short, it can increase the number of generations, and of course, it depends on temperature conditions. On the other hand, it can represent the suitable time between host and parasitoid.

The pre-adult period of *X. punctata* in host *O. indicata* is an average of 11.7 ± 0.15 days (varied from 9 to 15days) at 27.9 ± 2.4ºC and 72.5 ± 4.6 % RH. The adult pre-oviposition period ranged from 2 to 6 hours while the life cycle averaged about 11.9 ± 0.76 days (Table 2).

Table 2. Developmental period of *X. punctata* on pupae of soybean leaffolder, *O. indicata*

Development stage	No. of individuals tested	Development time (days)		
		Min.	Max.	Mean ± SD
Pre-adult (in host)	50	9	15	11.7 ± 0.15
Adult pre-oviposition	15	0.08 (2h)	0.25 (6h)	0.17 ± 0.004
Life cycle	15	9.08	15.25	11.9 ± 0.76

Note: Average temperature: 27.9 ± 2.4ºC; average humidity: 72.5 ± 4.6 %

Comparing the life cycle of *X. punctata* with *Trathala flavoorbitalis* (Ichneumonidae) on *O. indicata* (19.31 ± 0.34 days at 26.3^{o}C and 86.3% RH (Dang, 1999), *X. punctata* is better because its life cycle is shorter. But in comparison with others, the developmental period of *X. punctata* was similar, because it was highly dependent on temperature, like *Diadromus collaris* in diamondback moth. At 15^{o}C, the developmental period of *D. collaris* was 30.6 days, at 32.5^{o}C it was 10.2 days (Wang, 1998) while at 25-27^{o}C it was 18 days (Chua *et al.,* 1986). Similarly, another study showed the developmental period of *D. collaris* in *P. xylostella* was 34.29, 19.75, 13.63 and 11.57 days at 15, 20, 25 and 30^{o}C, respectively (Ho, 2002a). The developmental period of the braconid *Microplitis prodeniae* (Rao & Kurian) reared on armyworm was 12.68 days under conditions of average temperature and humidity of 27.9^{o}C and 82.6% (Dang and Ha, 1999). Another braconid (*Microplitis plutellae* (Muesebeck), which parasitizes *P. xylostella,* had a total developmental time in diamondback moth of 16-18 days at 25-30°C (Gharuka et al., 2004) while *Cotesia plutellae* in *P. xylostella* had a developmental time of 13.89 ± 1.41 days at 25°C and 60-80% RH (Ho, 2002b).

Effect of supplemental food on adult longevity

The longevity of the parasitoid adult is one important character because of the increased ability for host searching or waiting for the suitable stage of the host. The longevity of the parasitoid adult in nature, depends mainly on food that can be found in nature. In nature, there are different types of food that wasps can find and feed for their life and existence such as aphid's honey dew (residue from digestion), honey from flowers, rain-water or dew-water. These sources contain different concentrations of honey, some of them contain a high honey concentration, and can be considered as pure honey. Others contain less honey, and can be considered 50% honey solution. In the treatments, based on it is supposed that wasps have found the supplemental food which contain different concentration of honey: (1) high concentration of honey (considered as pure honey); (2) diluted honey (similar to 50% honey solution); and (3) only rain-water or dew-water (considered as pure water).

The adult ichneumonoid wasp, *X. punctata* which were fed with pure honey, lived longer than those that were fed 50% honey solution, 8.5 and 5.6 days for females while 14.3 and 6.3 days for males, respectively. Those fed pure water lived for a very short time, 2.6 days for females and 2.9 days for males (Table 3). Data analysis showed that the effect of supplemental nutrition on wasp longevity was statistically significant at $P \leq 0.05$. In addition, males lived longer than females.

Table 3. The effect of food on longevity of the wasp, *X. punctata*

Food	No. of adults tested	Longevity of adult *X. punctata* (days)					
		Female			Male		
		Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
Pure honey	28	3	27	8.5 ± 2.8 a	2	27	14.3 ± 1.9 a
Honey solution, 50%	22	2	9	5.6 ± 1.6 b	2	11	6.3 ± 3.1 b
Pure water	20	1	4	2.6 ± 0.4 c	1	5	2.9 ± 0.6 c

Note: Average temp: 27.9ºC ± 2.4; average humidity: 72.5±4.6 %;
Mean values followed by the same letter within a column do not differ significantly at $P < 0.05$ by DMRT.

Food (quality and quantity) has a strong effect on insect health, longevity and productivity. The longevity of wasp parasitoids not only depends on food supplement and temperature, but also on species. *X. punctata* which were fed similar food, lived longer than the braconid, *Microplitis prodeniae.* The parasitoid *M. prodeniae* fed with pure honeybee and 50% sugar solution lived 3.5 and 4.0 days, respectively, longer than those fed with 50% honey (2.75 days) and water (1.5 days) with statistically significant at $\alpha \leq 0.05$ by DMRT (Dang and Vu, 1999).

Diadromus subtilicornis that parasitizes diamondback moth, under the same conditions of temperature (25°C) and photoperiod (16L:8D), as those fed honey solution, lived an average of 56 days, compared with those fed with water or nothing and survived for only 3-4 days. ANOVA showed that, a food provision effect was significant at P<0.0001 (Tan et al., 2000a). The longevity of the adult parasitoid *Diadromus collaris* was longest (25.28 days) when fed with pure honey, followed by those fed with 50% honey solution (21.27 days) while those fed with water lived the shortest (4.6 days) at Fisher's PLSD test P<0.05 (Ho, 2002b). When provided with honey solution, the female wasp *Diadromus collaris* lived an average of 8.3, 11.5 and 7.0 days at 20, 25 and 30°C, respectively (Liu et al., 2001).

Similarly, for the microgastrine parasitoid, *M. manilae*, pure honey was the best food, followed by 50% honey solution and lastly, pure water, accounting for 4.29, 3.08 and 1.67 days adult longevity, respectively at $P<0.05$ by DMRT analysis (Nguyen et al*.,* 2007).

Host age preference

For parasitioids, the developmental period in the host is very important for them to exist. If the time in host is short, they can not complete their development. Bradleigh (1976) said that, parasitoid wasps must choose the host stage appropiate for development of parasitoid larvae and the effect of host age on parasitoid vigour. The wasp, *X. punctata* preferred the 1day old host pupae most frequently (60%) than 2 days old (46.7%) and 3 days old (13.3%). The 4 day old host pupae were not preferred (Table 4).

Table 4. Host pupal age preference *(Omiodes indicata)* of the parasitoid, *X. punctata.*

Host pupal age	Number of hosts tested	Number of hosts parasitized	Percent parasitized (%)
1 day old	15	9	60.0
2 days old	15	7	46.7
3 days old	15	2	13.3
4 days old	15	0	0

Note: One couple per 4 hosts of different age, 15 replicates, duration of host-parasitoid: 24h

The pupal parasitoid, *Diadromus collaris,* in diamondback moth preferred host pupae that were in the first half of their pupal development. In addition, survival from larva to adult, size and parasitizing capacity of the resultant female adults of *D. collaris* decreased dramatically as host pupal age increased (Wang et al., 2001). The host pupae of *Galleria mellonella* (L.) at 8-11 days old were less suitable for larval development of the parasitoid, *Itoplectis naranyae* (Ashmead) than prepupae and 0-7 day old pupae. Thus, *I. naranyae* females preferentially oviposit on hosts suitable for larval development (prepupae and pupae 0-7 day old). In addition, the sex ratio of the offspring that emerged from host pupae 8-11 d old were more male-biased than those from prepupae and pupae 0-7 days old (Ueno, 1997).

Females of *Diadromus subtilicornis* (Gravenhorst) oviposited on host diamondback moth prepupae, 1-day old and 2-day old pupae, 66-75% of the time. However, females oviposited in only 43% of 1-day old pupae, 31% of 3-day old pupae and none in 4-day old pupae, while the pupal parasitoid, *Diadromus collaris,* prefered host pupae of 1 and 2 day old than 3 days old. Host pupae of 4 days old were the least preferred for oviposition by *D. collaris* (2.4, 2.0, 0.8 and 0.2 host pupa parasitized per female per day of each pupal age). Data analysis by DMRT was significant at $P \leq 0.05$ (Tan et al*.,* 2000b).

The braconid *Cotesia plutellae* has been demonstrated to parasitize diamondback moth, preferring to oviposit on 2nd and 3rd instar host larvae than 1st and 4th larvae. The number of host *P. xylostella* parasitized by one female of *C. plutellae* at each instar (from 1st to 4th) is: 2.6 ± 1.35, 5.35 ± 2.83, 5.55 ± 2.58 and 1.10 ± 1.17 individuals per female, respectively. These data were significantly different at $P \leq 0.05$ (Ho, 2002b). For the braconid, *M. prodeniae*, the 2nd and 3rd instar of host armyworm larvae were most preferred for parasitic oviposition (82% at both instars) (Dang and Vu, 1999).

CONCLUSION

The insect parasitoids of soybean major pests in the summer-autumn crop of 2009 and spring season of 2010 in Hanoi were rich in diversity. Four of the 16 species were (*Microplitis manilae* Ashmead, *Therophilus javanus* (Bhat and Gupta), *Trathala flavoorbitalis* (Cameron) and *Telenomus subitus* Le appeared with high frequency, these can control soybean key pests in combination with other natural enemies like microbial parasites, nematode parasites and insect predators. Under conditions of high temperature (summer autumn season), mass rearing of the parasitoid, *X. punctata* to control soybean leaffolder, *O. indicata,* pure honey should be a food additive. The wasp, *X. punctata* can wait for the suitable stage of the host in the field, for about 2.6 to 8.5 days, depending on honey quality or rain-water that the wasp can find. The big leaffolder larvae, *O. indicata,* should be maintained at low temperatures for suitable host source as 1-2 day old pupae.

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