THE FAMILY BRACONIDAE (HYMENOPTERA) PARASITOIDS: TAXONOMY AND BEHAVIOR

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(Received: 30/01/2015; Revised: 15/05/2015; Accepted: 19/05/2015)

ABSTRACT

Vietnam is a tropical country with high diversity in insect distribution along the country. Rice, vegetables, maize, and beans are grown in all the country and share almost the same pest and parasitoids although the weather range is much different among the country. Long (2011) has listed about 300 species of parasitic braconids in agricultural landscapes in Vietnam and they are playing very important for biological control of insect pests. The short review provides some information on the diversity of parasitic braconids in Vietnam, molecular phylogenetic analysis of the world and the different behavior strategy.

***Keywords**: braconid parasitoid, molecular taxonomy, behavior, insect pest.*

1. Introduction

Recently, sustainable development of farming system has paid attention by using natural enemies to control the pests. Parasitoids of the family Braconidae (Hymenoptera) are one of the most diverse groups with about 300 species revealed in Viet Nam (Long K.D. et al., 2011). Particularly, the subfamily Microgastrinae, which is the most abundant and diverse group in both solitary and gregarious attacking caterpillars, has been known with about 1000 species worldwide and about 34 species discovered in Viet Nam (Salzat A.M., and Whitfiled J.B., 2004; Long K.D., 2011). The Microgastrinae, one of the largest subfamily of the Family Braconidae and the most difficult subfamily in taxonomy, has a wide host range and plays an important role in controlling insect pests (Long K.D., 2011). This group of parasitoids has radiated only order Lepidoptera pests and its anatomical studies have been a monophyletical complex (Dowton and Austin, 1998). Morphological characters have been used to estimate the phylogeny of microgastrines but the results were conversing (Mardulyn and Whitfield, 1999). Study in the phylogeny of Quicke and Achterberg (1990) was different in detail from those of Mason (1983) and Whitfield and Mason (1994). However, molecular data have recently solved such problems. In Viet Nam, urban development and climate change have affected the structure of farming systems and the overuse of chemical pesticides in agriculture caused the harmful impact on parasitic braconids, resulting in changing the diversity distribution of natural enemies. Generally, the information on taxonomy, phylogeny and behavior will play an important role in the diversity of Braconid parasitoids and perspectives of their applications in practice.

2. Studies on taxonomy of Braconid parasitoids

Parasitic Hymenoptera is among the most fascinating and largest orders of insect. The family Braconidae is also one of the largest within Hymenoptera, with nearly 17.532 species in the world and about 300 species in Viet Nam (Long K.D. et al., 2011).

In 2012, Long K.D. et al., has recorded about 20 parasitic braconid of the subfamily Microgastrinae in agricultural and rural-urban areas adjacent to Ha Noi City, with some important parasitoid species such as: *Apanteles cypris*, parasitoid of rice leaf folder *Cnaphalocricis medinalis*, *Apanteles schoenobii* from rice stem borers, *Cotesia vestalis* from cabbage diamondback moth *Plutella xylostella*, *Cotesia glomerata* parasitoid of *Pieris canidia and P. rapae; Meteorus narangae*, parasitoid of *Mythimna* spp., *Microplitis manilae*, etc., revealing some species in risk such as *Cotesia glomerata*, *C. anomidis, and Pseudoshirakia yokohamensis*. In addition, braconid wasp *Microplitis manilae* Ashmead has been recorded its importance in control larvae of *Spodoptera litura* Fabbicius in Mekong Delta River (Huynh Phuoc Man et al., 2012). Two species collected in Gia Lam, Ha Noi, Viet Nam (Nguyen Thi Hong Ha et al., 2007) were also found their parasitization in both larval and pupal of common cutworm *Spodoptera litura*. Moreover, two new species of the genus *Wilkinsonellus* Mason (Long and Achterberg, 2003); three new species of the subfamily Microgastrinae (Hymenoptera: Braconidae) (Khuat Dang Long, 2007); five new species of genus *Apanteles* Foerster, 1862 (Khuat Dang Long (2010), had described and illustrated from Viet Nam indicating the large and diverse species in the subfamily Microgastrinae (Braconidae).

In Braconidae, the family shows significant specificity in host relationship at the level of subfamily. The success of the parasitic wasps is reflected in their diversity of lifestyles. They can be ectoparasitic (feed externally), endoparasitic (feed internally and have to overcome the host's immune defenses), idiobiont (prevent host development), koinobiont (allow host development to continue), solitary (one parasitoid per host), and hyperparasitic (parasitic other parasitoids in a host) (Gauld and Bolton, 1996). There is also a complex of braconid subfamilies of the microgastroid including Adeliinae, Cardiochilinae, Miracinae, Microgastrinae, Cheloninae, and Khoikhoiinae which were considered monophyletic (Quicke and van Achterberg, 1990; Whitfiled and Mason, 1994). Some important genera of the subfamily Microgastrinae in Vietnam such as *Apanteles* Foerster, *Cotesia* Cameron, *Microgaster* Latreille, and *Microplitis* Foerster have found (Khuat Dang Long, 2011). The genera of Microgastrinae are the unit group of Lepidopteran hosts which are one of the devastating pests in agricultural production. All Microgastrine are parasitoids and considered in the high diversification rate because of their ecological specialization and particularly insect's diet (Mardulyn P. and Whitfield J.B., 1999). Molecular data have recently been employed to describe generic relationship within subfamilies. It is suggested that using the combination molecular data and morphological characters or other traits will get better for reconstruction the phylogenetic relationship within Braconidae or other groups than molecular data alone (Shi et al., 2005). The study of relationships among the endoparasitic microgastroid complex of braconid wasps by combination of morphological data, sequence data from 16S mitochondrial rDNA and 28S (D2 expansion region) indicated the relationships ((Cardiochilinae + Microgastrinae) + Miracinae) + Cheloninae, with Adeliinae falling inside the Chelininae, and solitary endoparasitsm is ancestral for the microgastroids (Dowton and Austin, 1998). By employing 16S and 28S rDNA gene fragments together, the Aphidiinaae and the Ichineutinase have been recovered as sister groups to the cyclostomes and the microgastroids respectively, which was problems with rooting the braconid tree using of 16S and 28S data alone (Dowton et al., 2002). Using 16S rDNA, 28S rDNA D2 region, and 18S rDNA by both MP (maximum parsimony) method and MRBAYES 3.0B4, Shi, et al., (2005) confirmed a relationship within the microgastroid subfamilies as "Ichneutinae + ((Adeliinae + Cheloninae) + (Miracinae + (Cardiochilinae+Microga strinae)))".

Many parasitoid of Microgastrinae were used as biological agents of agricultural pests worldwide, especially in Viet Nam such as

Apenteles, Cotesia, Protapanteles and Microplitis (Mardulyn P. and Whitfield J.B., 1999; Khuat Dang Long, 2011). Phylogenetic among Genera of Microgastrinae (Hymenoptera: Braconidae) by Mardulyn & Whitfield (1999) in which three genes COI, 16S and nuclear 28S indicated that the rapid diversification of the taxa could be caused by an abundance of host species, and solitary vs gregarious parasitism by genus wasp *Cotesia* was distributed across the phylogeny (Salzat & Whitfiled J.B., 2004) (Fig.1). In addition, the occurrence of the two *Cotesia sesamiae* and *C. flavipes* species in Kenya in different ecological regions was influenced by the geographic (Mailafiya et al., 2010). Indeed, the survey by Long (2011) also indicated *Cotesia vestalis* was found not only during winter in North of Viet Nam, but also in other agricultural areas all year. However, studies by using both molecular and morphological data have not carried out so much in Braconidae, subfamily Microgastrinae (Braconidae) species in Viet Nam in order to understand the diversity of phylogeography relationships among them.

3. Studies on behavior of Braconid parasitoids.

Behavioral processes involved in host finding and the choice of oviposition sites. Oviposition behaviors of parasitoid and defensive responses of hosts are fundamental of host-parasitoid interaction. Parasitic wasps use a variety of cues to assess the quality of hosts for oviposition (Godfray, 1994). When parasitoid females have successfully found the hosts, they will use a variety of cues to assess the quality of their hosts (Godfray, 1994). Chemical cues sensed by the antennae and tarsi are important for recognition of host quality in many parasitoids (Battaglia et al., 2000; Morehead and Feener, 2000; Godfray, 1994). Besides, herbivores host plant volatiles (synomones) have low reliability, but high detectability, and thus often used for the location of host habitat. Volatile infochemicals from the host plant and the herbivores, or the interaction of the two play an important role for parasitoid efficiency to search for host and locate target hosts. For examples, *Aphididus arvi* females use host- induced plants volatiles as host location cues (Powell et al., 1997); the specialist parasitoid *Cotesia vestalis* prefers volatiles from plants attacked by diamondback moth *Plutella xylostella* to the non-host small cabbage white caterpillar *Pieris rapae* (Shiojiri et al., 2000a); or the parasitoid *Cotesia flavipes* is attracted to maize odors and even greater to maize infested with various stem borers, including *Chilo partellus*, *Chilo orichalcociliellus, S. calamistis, and B. fusca* (Nghi-Song et al., 1996).

Many foragers use visual cues to locate and to evaluate resources (Bell, 1991). Despite of the importance of chemical cues, the motion of hosts also plays a key factor for dipteran parasitoids to recognize their hosts for oviposition (Walker, 1993; Morehead and Feener, 2000; Weinbrenner and Volkl, 2002). For example, a study in the tachinid fly *Exorista japonica* has shown that the length, diameter, and velocity of dummy hosts affect the ovipositional behavior (Yamawaki and Kainoh, 2005). The combination of visual and chemical cues was important in the dipteran parasitoid *Apocephalus paraponerae* (Phoridae), where visual cues help to recognize the body size of ants and species-specific cuticular hydrocarbons for oviposition (Morehead and Feener, 2000). However, visual cues from host movements in the oviposition behavior of parasitoid attacking lepidopteran larvae have not been studied intensively, except for *Campoletis sonorensis* (Hymenoptera: Icheneumonidae) (Wilson et al., 1974) and *Euplectrus separatae* (Hymenoptera: Eulophidae). Godfray (1994) mentioned that although parasitoid females use many different sources for host location, the host movement should be considered more, especially in the final step of host location. Previous studies indicated that visual cues from host movement were required for successful oviposition in *Meteorus pulchricornis*, a solitary endoparasitoid (Hymenoptera: Braconidae) (Chau and Maeto, 2009). Study by Roux et al. (2005) also indicated that antennal contact is the key stimulus inducing oviposition behavior of *C. vestalis (=C. plutellae).* More investigations on the role of visual factors on the oviposition behavior of hymenopteran parasitoids are also required for implementation of biocontrol by parasitoids. Geography structure may effect on the interaction between parasitoids and their insect hosts, resulting differed in time allocated to the host, searching behavior and ovipositor length in the genus *Agathis* (Althoff &Thompson, 2001). In addition, for parasitoids, the ability of females to locate hosts and overcome the host defenses is critical to their fitness (Godfray, 1994).

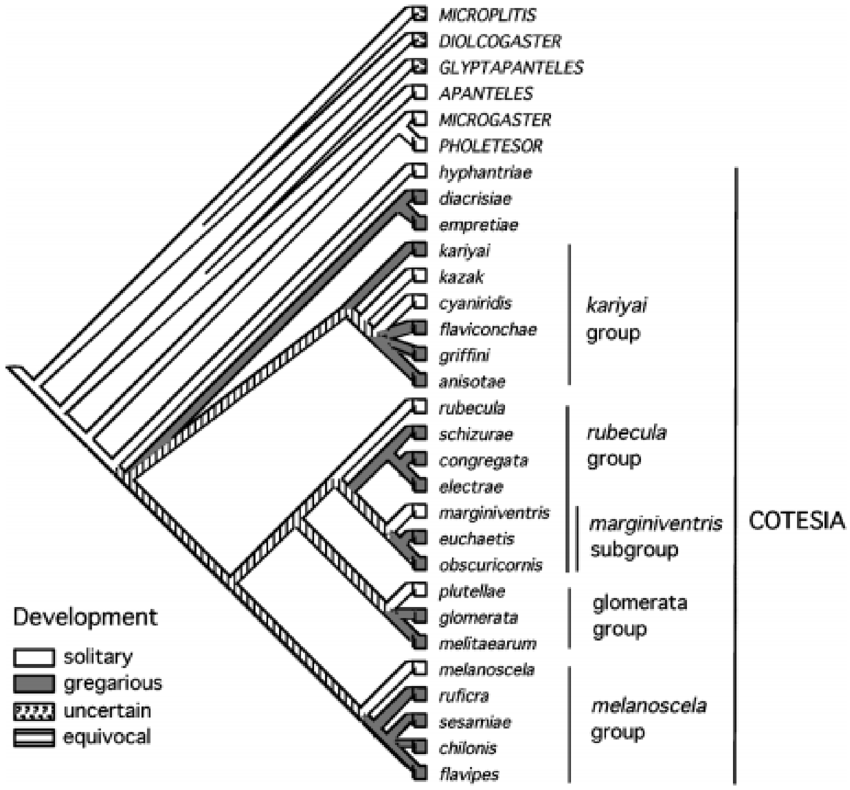

Fig. 1: Possible relationship of *Coteisa* taxa (Salzat and Whitfiled, 2005)

3. Conclusion:

The review has indicated the importance of combination between taxonomy and molecular analysis for understanding Braconid parasitoid phylogenic systems. Besides, study the behavior of parasitoid help to understand host-parasitoid interaction and evolution. Because of their diversity of parasitic lifestyles, the braconids have much potential for furthering study in these areas. It may shed a new light to study the combination between taxonomy and molecular data for Braconidae parasitoids, especially subfamily Microgastrine in Viet Nam. The evolutionary relationships with subfamily of Microgastrinae (Braconidae) and oviposition behavior of parasitoid in Viet Nam will provide useful information for parasitoid database and related research. A study on the oviposition behavior of parasitoid will also provide the necessary information before applying for biocontrol programs. Understanding species in different geographic locations to the host will be a potential for mass rearing and application to sustainable agriculture in Viet Nam.

Acknowledgments

This review was supported by a grant from Ho Chi Minh City Open University (Grant D2014.2)

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