

Host Records of *Trissolcus* (Hymenoptera: Platygasteridae: Telenominae) Parasitizing Eggs of Stink Bugs in Korea

Kyoung Young Kim, Deok-Soo Choi¹, Jun-Yeol Choi², Ki-Jeong Hong*

Department of Plant Medicine, Suncheon National University, Suncheon, Jeonnam 57922, Republic of Korea

¹Environment-friendly Agriculture Research Center, Jellanamdo Agricultural Research & Extension Service, Naju, Jeonnam 58213, Republic of Korea

²Research Policy Bureau, Rural Development Administration, Jeonju, Jeonbuk 54875, Republic of Korea

노린재류의 알에 기생하는 *Trissolcus* 속(벌목: 납작먹좀벌과)의 숙주

김경용 · 최덕수¹ · 최준열² · 홍기정*

순천대학교 식물학과, ¹전라남도농업기술원 친환경농업연구소, ²농촌진흥청 연구운영과

ABSTRACT: The Samurai wasp, *Trissolcus japonicus* (Ashmead) (Hymenoptera: Platygasteridae) is recognized as a solitary parasitoid on eggs of the stink bug, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae), an economic pest causing severe damage to fruits, in South Korea. The wasp appears to be a potential biological agent of the pest. In addition, *T. itoi* Ryu and *T. nigripedius* (Nakagawa) were found to parasitize eggs of *Eurydema gebleri* Kolenati and *Dolycoris baccarum* Linnaeus, respectively. Diagnostic characters and photographs are provided for identification, and host records of Korean *Trissolcus* species are also given.

Key words: *Trissolcus*, egg parasitoid, *Halyomorpha halys*, *Eurydema gebleri*, *Dolycoris baccarum*

초 록: 납작먹좀벌과(Platygasteridae)의 큰검정알벌속(*Trissolcus*)에 속하는 *T. japonicus* (Ashmead) (썩덩큰검정알벌, 신칭)이 과수원에서 과일에 심한 피해를 일으키는 해충인 썩덩나무노린재의 알에 기생하는 것으로 확인되었고, 생물적 방제인자로서 가능성이 기대된다. 또한 천마큰검정알벌(*T. itoi* Ryu)이 북쪽비단노린재 알을, 검은다리큰검정알벌(*T. nigripedius* Nakagawa)이 알락수염노린재 알을 숙주로 각각 기생하는 것이 확인되었다. 동정을 위한 진단형질 및 영상자료와 한국에 분포하는 큰검정알벌속(*Trissolcus*)의 종들에 관한 숙주목록을 제공하였다.

검색어: *Trissolcus*, 알기생봉, 썩덩나무노린재, 북쪽비단노린재, 알락수염노린재

Trissolcus is a cosmopolitan genus in Platygasteridae (Hymenoptera) and a relatively large group including 161 described species worldwide (69 species in the Palearctic region) (Johnson, 1992). Most species of the genus are egg parasitoids of economically important pests in Pentatomoidea (Hemiptera). Therefore, they are generally considered as potential agents for biological control, and some of them had been used for biological controls in practice (e.g. Johnson, 1984; Corrêa-Ferreira and Moscardi, 1996).

Trissolcus looks very similar to *Telenomus* but can be readily distinguished by 1) female antennal clava compact and composed of six segments, 2) frons sculptured throughout, and with preocellar pit located below the median ocellus, 3) scutellum with surface sculpture, 4) second metasomatic tergite wider than long, and 5) eyes seeming glabrous under low magnification (Masner, 1980; Johnson, 1991). The two genera have different biological characteristics like that the former almost exclusively parasitizes the eggs of Pentatomoidea, and the latter predominantly the eggs of Lepidoptera (Ryu and Hirashima, 1984).

To date six species of *Trissolcus* and their hosts have been

*Corresponding author: curcul@sunchon.ac.kr

Received October 8 2016; Revised January 8 2017

Accepted February 22 2017

known from Korea (Yasumastu, 1975; Ryu and Hirashima, 1984). In the present paper, we add the Samurai wasp, *T. japonicus* (Ashmead) as an egg parasitoid of *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae) to the Korean insect fauna, and newly confirm that *T. itoi* Ryu and *T. nigripedius* (Nakagawa) parasitize the eggs of *Eurydema gebleri* Kolenati and *Dolycoris baccarum* L., respectively.

Materials and Methods

Surveys for natural insect enemies of pentatomid pests were conducted mainly in soybean fields and deciduous forests in Jeonnam province, Korea from May to September, 2016. Egg masses of stink bugs laid on the underside of leaves were collected and kept individually in plastic dishes (10 cm in diameter and 4 cm in height). The egg masses were reared in the laboratory at room temperature ($\approx 25^{\circ}\text{C}$) and checked daily until parasitoids emerged from the host eggs. Leica EZ4 HD binocular stereo microscope (Leica Microsystems, Wetzlar, Germany) was used for imaging and identification the parasitoids collected and CombineZM (Free software released from <http://www.hadleyweb.pwp.blueyonder.co.uk/>; UK) for photo-stacking. The voucher specimens are deposited in the insect collection room of Sunchon National University, Suncheon, Korea.

The key to species by Ryu and Hirashima (1984) is referred

for species identification of the parasitoids, and descriptive terminology for morphological characters is taken from Talamas et al. (2015). Acronyms used in the text are as follows: JN, Jeollanam-do (Province); JARES, Jeonnam Agricultural Research & Extension Services; SCNU, Sunchon National University; TL, type locality.

Results

Trissolcus japonicus (Ashmead) 썩덩큰검정알벌(신칭) (Figs. 1-a, b; 2-a, b; 3-a, b; 4-a, b, c)

Dissolcus japonicus Ashmead, 1904: 73 (TL: Japan).

Asolcus plautiae Watanabe, 1954: 18, 22 (TL: Japan).

Trissolcus halyomorphae Yang, in Yang et al., 2009: 40 (TL: China).

Diagnosis. Body length: 1.3-1.4 mm (♀) and 1.2 mm (♂).

♀: Black. Antennae dark brown to black except for scape and pedicel which are yellowish brown. Legs yellowish brown with coxae black and femora infuscated. Antennae 11-segmented; pedicel shorter than 1st funicular segment; 2nd funicular segment distinctly longer than broad. Orbital furrow present. Mesoscutum with notauli sharply defined posteriorly. Scutellum smooth and shining. ♂: Antennae 12-segmented, and brown except for sixth to tenth flagellar segments which are tinged with dark brown. Legs yellowish brown except for

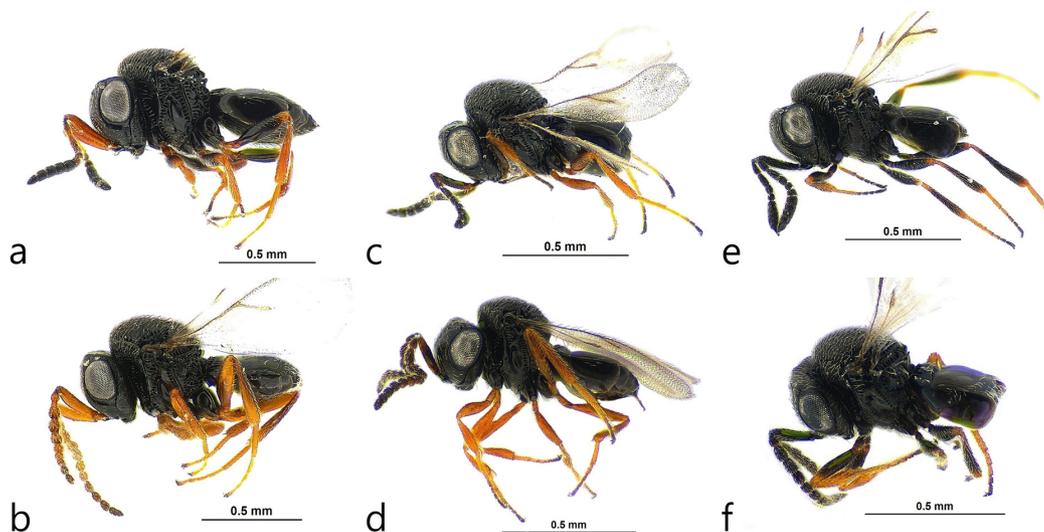


Fig. 1. Lateral habitus of *Trissolcus* species. *T. japonicus* (Ashmead) (a: female, b: male); *T. itoi* Ryu (c: female, d: male); *T. nigripedius* (Nakagawa) (e: female, f: male).

coxae and hind femora which are somewhat infuscated.

Materials examined. 8 ♀♀, 1 ♂, emerged at 4-5. VIII. 2016, at room temperature from an egg-mass (28 eggs) of *Halyomorpha halys* (Pentatomidae) collected at 26. VII. 2016, Suwol-ri, Gwangui-myeon, Gurye, JN (SCNU); 8 ♀♀, 1 ♂, emerged at 6. VIII. 2016, at room temperature from egg-mass

of *Halyomorpha halys* (Pentatomidae) collected at 2. VIII. 2016, Woesan-ri (Jicho), Sandong-myeon, Gurye, JN (JARES).

Hosts. *Plautia stali* Scott, *P. splendens* Distant, *Elasmucha putoni* Scott, *Halyomorpha halys* Stål.

Distribution. Korea (South), Japan (Kyushu, Honshu, Shikoku), China (Beijing, Shandong, Hebei).

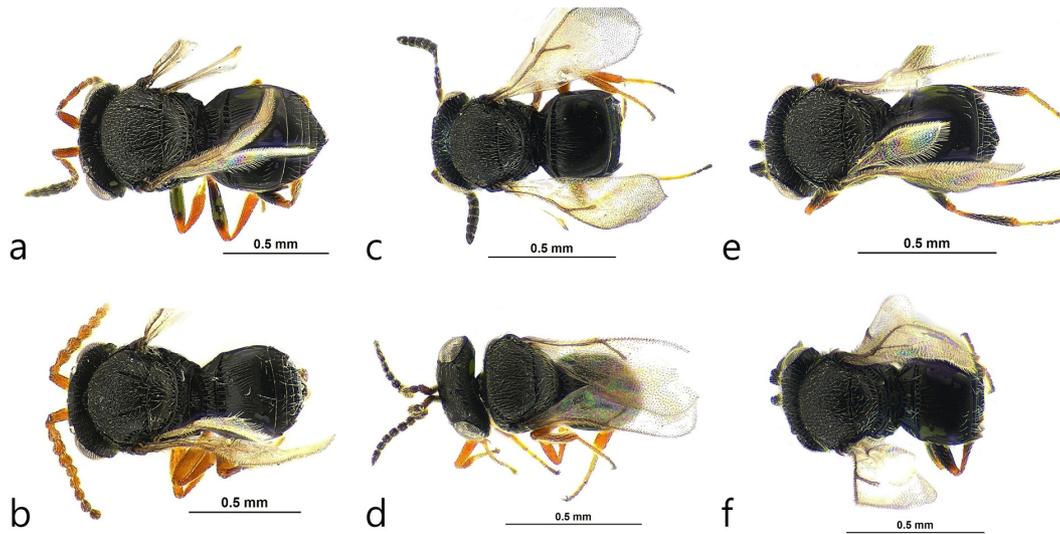


Fig. 2. Dorsal habitus of *Trissolcus* species. *T. japonicus* (Ashmead) (a: female, b: male); *T. itoi* Ryu (c: female, d: male); *T. nigripedius* (Nakagawa) (e: female, f: male).

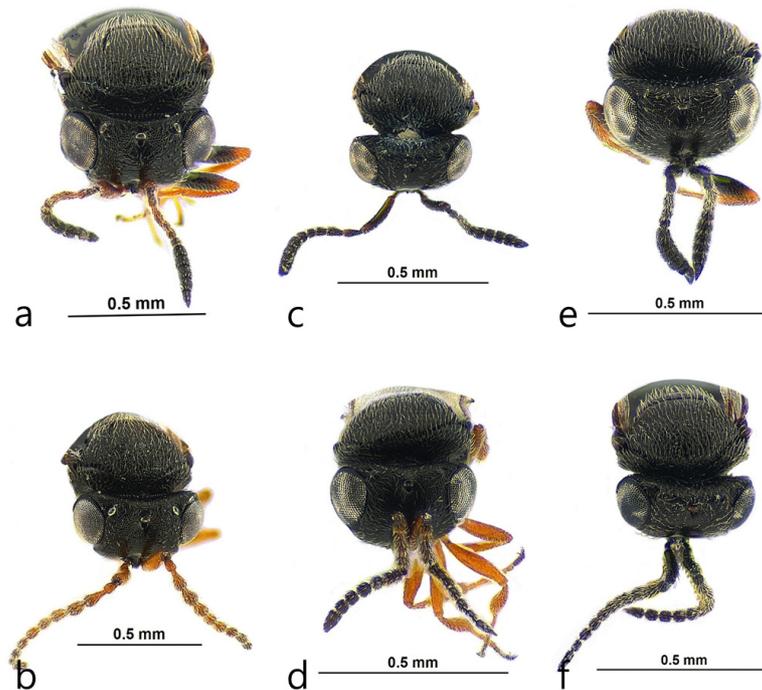


Fig. 3. Dorsal view of the head of *Trissolcus* species. *T. japonicus* (Ashmead) (a: female, b: male); *T. itoi* Ryu (c: female, d: male); *T. nigripedius* (Nakagawa) (e: female, f: male).

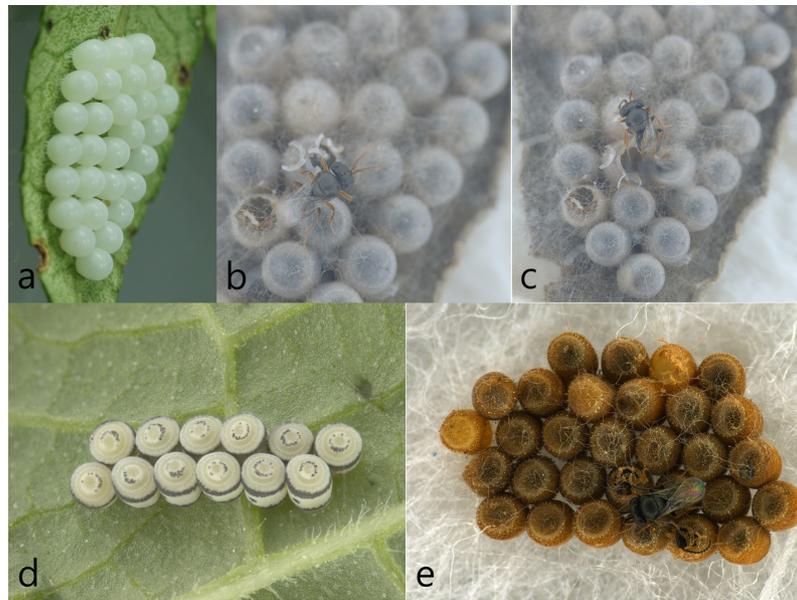


Fig. 4. Host eggs of *Trissolcus* parasitoids. a. egg-mass of *Halyomorpha halys* (Stål); b-c. emergence of a male (b) and a female (c) of *T. japonicus* (Ashmead); d. egg-mass of *Eurydema gebleri* Kolenati, the host of *T. itoi* Ryu; e. egg-mass of *Dolycoris baccarum* L. with an emerged adult of *T. nigripedius* (Nakagawa).

Remarks. Talamas et al. (2015) examined four Korean specimens (3 ♀♀ and 1 ♂) that kept in the Smithsonian National Museum of Natural History, Washington DC, USA. We have given this species a Korean name in this paper.

***Trissolcus itoi* Ryu, 1984 천마큰검정알벌**

(Figs. 1-c, d; 2-c, d; 3-c, d; 4-d)

Trissolcus itoi Ryu in Ryu and Hirashima, 1984: 37, 52 (TL: Japan).

Diagnosis. Body length: 0.9-1.0 mm (♀) and 0.9 mm (♂).

♀: Black. Antennae dark brown to black; basal and apical parts of scape tinged with yellowish brown and club somewhat darker. Legs brown with coxae black, femora remarkably infuscated. Antennae 11-segmented; pedicel about as long as 1st funicular segment. Mesoscutum without notauli. Scutellum strongly sculptured with irregular wrinkles as in posterior part of mesoscutum. ♂: Antennae 12-segmented, and brownish to dark brown. Legs brownish except for femora which are infuscated; hind femora darker than other femora.

Materials examined. 6 ♀♀, 1 ♂, emerged at 2. VIII. 2016, at room temperature from an egg-mass of *Dolycoris baccarum* (Pentatomidae) collected at 28. VII. 2016, Sindae-ri, Haeryong-myeon, Suncheon, JN (SCNU); 5 ♀♀, 1 ♂, emerged at 15.

VIII. 2016, at room temperature from an egg-mass of *Dolycoris baccarum* (Pentatomidae) collected at 6. VIII. 2016, ditto (SCNU).

Hosts. *Homalogonia obtusa* (Walker), *Elasmucha putoni* Scott, *Eurydema gebleri* Kolenati.

Distribution. Korea (Central, South), Japan (Honshu, Shikoku).

***Trissolcus nigripedius* (Nakagawa, 1900) 검은다리큰검정알벌**

(Figs. 1-e, f; 2-e, f; 3-e, f; 4-e)

Asolcus nigripedius Nakagawa, 1900: 17 (TL: Japan).

Diagnosis. Body length: 1.1-1.2 mm (♀) and 1.0 mm (♂).

♀: Black. Antennae dark except for junction of scape and apex of pedicel which is somewhat yellowish brown. Legs yellowish brown except for coxae which are black; femora sometimes infuscated. Antennae 11-segmented; pedicel as long as 1st funicular segment. Mesoscutum without notauli. Scutellum weakly tessellate, much less strongly sculptured than in posterior part of mesoscutum. Mediotergite I with distinct longitudinal striae. ♂: Antennae 12-segmented, and brownish black; sixth to tenth flagellar segments somewhat darker than other segments.

Materials examined. 22 ♀♀, 3 ♂♂, emerged at 24. VIII.

2016, at room temperature from an egg-mass of *Nezara antennata* (Pentatomidae) collected at 17. VIII. 2016, Namsan-dong, Gwangsan-gu, Gwangju, JN (SCNU); 21 ♀♀, 2♂♂, emerged at 5. VIII. 2016, at room temperature from an egg-mass of *Nezara antennata* (Pentatomidae) collected at 2. VIII. 2016, Jigok-ri, Bonggang-myeon, Gwangyang, JN (SCNU).

Host. *Dolycoris baccarum* L.

Distribution. Korea (South), Japan (Kyushu, Honshu, Hokkaido, Shikoku).

Discussion

The most common stink bug are serious agricultural pests that has been readily causing damage to crops. To obtain their food, stink bugs use their stylets to pierce the plant tissue in

order to extract the plant fluids. The most common signs of stink bug damage are pitting and scarring of the fruit, leaf destruction, and a mealy texture to the harvested fruits and vegetables. In most cases the signs of stink bug damage makes the plant unsuitable for sale in the market as the insides are usually rotten. They are a threat to soybeans, ornamental trees, shrubs, vines, weeds, and many cultivated crops. In Korea, several stink bugs such as *Halyomorpha halys* (Stal) and *Plautia stali* Scott have recently become serious pests of fruits such as persimmons and citrus (Kim et al., 2014; Park et al., 2015).

Many species of *Trissolcus* are egg parasitoids of economically important pests in the superfamily Pentatomoidea (Hemiptera) in Korea and neighboring countries (Table 1). Three species of the genus found in the present work are confirmed

Table 1. Species of *Trissolcus* and their hosts known from Korea, Japan and China

Scientific name	Distribution	Host and references
<i>T. cultratus</i> (Mayr)	Korea (Talamas et al., 2015), China (Talamas et al., 2015), Japan (Talamas et al., 2015)	[Pentatomidae] <i>Carpocoris pudicus</i> (Poda) (Talamas et al., 2015) [Pentatomidae] <i>Raphigaster nebulosa</i> (Poda) (Talamas et al., 2015) [Scutelleridae] <i>Eurygaster</i> sp. (Talamas et al., 2015)
<i>T. delucchii</i> Kozlov	Japan (Ryu & Hirashima, 1984)	Unknown
<i>T. flavipes</i> (Thomson)	Korea (Ryu & Hirashima, 1984), Japan (Ryu & Hirashima, 1984)	Unknown
<i>T. japonicus</i> (Ashmead)	Korea (Talamas et al., 2015), China (Yang et al., 2009), Japan (Ashmead, 1904)	[Pentatomidae] <i>Plautia stali</i> Scott (Watanabe, 1954) [Pentatomidae] <i>Plautia splendens</i> Distans (Watanabe, 1954) [Acanthosomatidae] <i>Elasmucha putoni</i> Scott (Ryu & Hirashima, 1984) [Pentatomidae] <i>Halyomorpha halys</i> Stål (Talamas et al., 2015; herein)
<i>T. mitsukurii</i> (Ashmead)	Japan (Watanabe, 1951), China (He, 2004)	[Pentatomidae] <i>Dolycoris baccarum</i> L. (Watanabe, 1951) [Pentatomidae] <i>Nezara antennata</i> Scott (Watanabe, 1951) [Pentatomidae] <i>Nezara viridula</i> L. (Ryu & Hirashima, 1984) [Pentatomidae] <i>Lagynotomus assimulans</i> Distan (Watanabe, 1951) [Pentatomidae] <i>Piezodorus rubrofasciatus</i> Fab. (Watanabe, 1951) [Phyllocephalidae] <i>Gonopsis affinis</i> Uhler (Ryu & Hirashima, 1984)
<i>T. tumidus</i> (Mayr)	Japan (Ryu & Hirashima, 1984)	Unknown
<i>T. elasmuchae</i> (Watanabe)	Japan (Watanabe, 1954)	[Pentatomidae] <i>Elasmucha putoni</i> Scott (Watanabe, 1954)
<i>T. gonopsidis</i> (Watanabe)	Korea (Ryu & Hirashima, 1984), Japan (Watanabe, 1951)	[Phyllocephalidae] <i>Gonopsis affinis</i> Uhler (Watanabe, 1951)
<i>T. itoi</i> Ryu	Korea (Ryu & Hirashima, 1984), Japan (Ryu & Hirashima, 1984)	[Pentatomidae] <i>Homalogonia obtusa</i> (Walker) (Ryu & Hirashima, 1984) [Pentatomidae] <i>Elasmucha putoni</i> Scott (Ryu & Hirashima, 1984) [Pentatomidae] <i>Eurydema gebleri</i> Kolenati (herein)
<i>T. nigripedius</i> (Nakagawa)	Korea (Ryu & Hirashima, 1984), Japan (Nakagawa, 1900), China (He, 2004)	[Pentatomidae] <i>Dolycoris baccarum</i> L. (Watanabe, 1951)
<i>T. yamagishii</i> Ryu	Korea (Ryu & Hirashima, 1984)	Unknown

as egg parasitoids of *Halyomorpha halys* (Stål), *Eurydema gebleri* Kolenati and *Dolycoris baccarum* L. that are severe pests to many cultivated crops. It is expected that these solitary endoparasitoids in the many pentatomid eggs are developed as excellent biological control agents through the investigation of biological characters including sex ratio, developmental time, parasitism rate, mass rearing, and so on.

Especially, the brown marmorated stink bug (BMSB), *Halyomorpha halys* Stål (Hemiptera: Pentatomidae), was accidentally introduced into the United States from native area to China, Japan, Korea or Taiwan. The first documented specimen was collected in Allentown, Pennsylvania, in September 1998. A decade after its introduction into the United States, the BMSB has been detected in 39 US states as well as Canada, Switzerland, Germany, France, and Italy, and has been intercepted in New Zealand (Xu et al., 2014). Due to the potential non-target effects of controlling the BMSB with pesticides, USDA conducted foreign exploration in Asia for natural enemies of BMSB in South Korea and China (Xu et al., 2014). As the result, two parasitoid, *Trissolcus japonicus* (Ashmead) and *Trissolcus cultratus* (Mayr) are considered with potential as classical biological control agents, and are presently studying the host preferences of these parasitoids and the ability of these parasitoids to successfully develop in BMSB eggs (Talamas et al., 2015).

Acknowledgment

This work was supported by a grant from the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries (IPET) of Republic of Korea (Project No. 115091-2).

Literature Cited

- Ashmead, W.H., 1904. Descriptions of new Hymenoptera from Japan. *J. New York ent. Soc.* 12(2), 86-99.
- Corrêa-Ferreira B.S., Moscardi, F., 1996. Biological control of soybean stink bugs by inoculative releases of *Trissolcus basalıs*. *Entomol. Exp. Appl.* 79, 1-7.
- He, J.-H. [ed.], 2004. Hymenopteran insect fauna of Zhejiang. Science Press, Beijing, China.
- Johnson, N.F., 1984. Revision of the Nearctic species of the *favıpes* group (Hymenoptera: Scelionidae). *Proc. Entomol. Soc. Wash.* 86, 797-807.
- Johnson, N.F., 1991. Revision of Australasian *Trissolcus* species (Hymenoptera: Scelionidae). *Invertebr. Taxon.* 5, 211-239.
- Johnson, N.F., 1992. Catalog of world species of Proctotrupeoidea, exclude Platygasteridae (Hymenoptera), pp. 1-825. *Memories of American Entomological Institute* No. 51.
- Kim, S., Kwon, S., Chang, Y., Yang, Y., Hyun, S., Song, J., Kim, D., 2014. Damage and Control Strategy of *Halyomorpha halys* Stål in Citrus Orchard. *Scientific Abstract of Spring Congress of the Korean Society of Applied Entomology*, p. 269.
- Masner, L., 1980. Key to genera of Scelionidae of the Holarctic Region, with descriptions of new genera and species (Hymenoptera: Proctotrupeoidea), pp. 1-54. *Mem. Entomol. Soc. Can.* No. 113.
- Nakagawa, H., 1900. Illustration of some Japanese Hymenoptera parasitic on insect eggs. I. *Spec. Rep. Agric. Exp. Stat.*, 6, 1-26.
- Park, C.G., Kwon, J.H., Lee, D.W., 2015. An Illustrated Color Guide Book to Insect Pests and Diseases of Persimmon in Korea. Animal and Plant Quarantine Agency. 147 pp.
- Ryu, J., Hirashima, Y., 1984. Taxonomic studies on the genus *Trissolcus* Ashmead of Japan and Korea (Hymenoptera, Scelionidae). *Journal of the Faculty of Agriculture, Kyushu University*, 29, 35-58.
- Talamas, E.J., Johnson, N.F., Buffington, M., 2015. Key to Nearctic species of *Trissolcus* Ashmead (Hymenoptera, Scelionidae), natural enemies of native and invasive stink bugs (Hemiptera, Pentatomidae). *Journal of Hymenoptera Research* 43, 45-110.
- Watanabe, C., 1951. On five Scelionid egg-parasites of some Pentatomid and Coreid bugs from Shikoku, Japan (Hymenoptera: Proctotrupeoidea). *Trans. Shikoku Ext. Sot.* 2(2), 17-26.
- Watanabe, C., 1954. Discovery of four new species of Telenominae, egg parasites of pentatomid and plataspid bugs, in Shikoku, Japan. *Transactions of the Shikoku Entomological Society* 4, 17-22.
- Xu, J., Foneseca, D.M., Hamilton, G.C., Hoelmer, K.A., Nielsen, A.L., 2014. Tracing the origin of US brown marmorated stink bugs, *Halyomorpha halys*. *Biological Invasions* 16, 153-166.
- Yang, Z.Q., Yao, X.Y., Qiu, L.F., Li, Z.X., 2009. A new species of *Trissolcus* (Hymenoptera: Scelionidae) parasitizing eggs of *Halyomorpha halys* (Heteroptera: Pentatomidae) in China with comments on its biology. *Annals of the Entomological Society of America* 102, 39-47.
- Yasumastu, K., 1975. Preliminary studies on the taxonomy of natural enemies of agricultural pests for the development of integrated control programmes. *FAO, UN.* 32 pp.