

# Lifecycle, Biology, and Descriptions of Greenhouse Biological Control Agent, *Nesidiocoris tenuis* (Reuter, 1895) (Hemiptera: Miridae)

Kim, Jung Gon

Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University

Lee, Wang Hee

Department of Biosystems Machinery Engineering, College of Agriculture and Life Sciences, Chungnam National University,

Yu, Youg Man

Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University

Yasunaga-Aoki, Chisa

Laboratory of Insect Pathology and Microbial Control, Institute of Biological Control, Faculty of Agriculture, Kyushu University

他

<https://doi.org/10.5109/1685887>

---

出版情報：九州大学大学院農学研究院紀要. 61 (2), pp.313-318, 2016-09-01. Faculty of Agriculture, Kyushu University

バージョン：

権利関係：

## Lifecycle, Biology, and Descriptions of Greenhouse Biological Control Agent, *Nesidiocoris tenuis* (Reuter, 1895) (Hemiptera: Miridae)

Jung Gon KIM<sup>1</sup>, Wang Hee LEE<sup>2</sup>, Yong Man YU<sup>1\*</sup>, Chisa YASUNAGA–AOKI  
and Sung Hoon JUNG<sup>1\*</sup>

Laboratory of Insect Pathology and Microbial Control, Institute of Biological Control,  
Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan  
(Received April 28, 2016 and accepted May 10, 2016)

The plant bug *Nesidiocoris tenuis* (Reuter, 1895) is used as a biological control agent for various crops such as tomato and paprika under greenhouse conditions. In this study, all nymphal stages and male and female genitalia of *N. tenuis* are described and illustrated. Additionally, brief biological information through rearing, including life cycle and feeding habits, is also provided along with photographs.

**Key words:** Biological control agent, Description, Life cycle, Miridae, *Nesidiocoris tenuis*

### INTRODUCTION

*Nesidiocoris tenuis* (Reuter, 1895), belonging to the plant bug family Miridae (Hemiptera: Heteroptera: Miridae: Bryocorinae: Dicyphini), is widely distributed in the Palaearctic and Mediterranean regions (Kerzhner and Josifov, 1999; Sanchez *et al.*, 2008). This polyphagous mirid is commonly found on various plants in a variety of natural ecosystems (Alomar and Albajes, 1996; Perdakis and Lykouressis, 2004; Sanchez *et al.*, 2004), and has a wide range of host plants, including some greenhouse crops (Sanchez *et al.*, 2008). Therefore, previous reports classified this species as an insect pest, as it can damage crops by directly feeding on host plants such as tomato and pepper (Schuh and Slater, 1995; Yasunaga, 2000; Wheeler, 2001; Arnó *et al.*, 2009; Wheeler, 2000a). Conversely, in many countries, this species has recently been used as a biological control agent in agro-ecosystems, in order to control major greenhouses insect pests such as whiteflies [*Bemisia tabaci* (Gennadius, 1889), *Trialeurodes vaporariorum* (Westwood, 1856)], aphids [*Macrosiphum euphorbiae* (Thomas, 1878)], thrips [*Frankliniella occidentalis* (Pergande, 1895)], and moths [*Spodoptera exigua* (Hübner, 1808)], as this species is zoophytophagous, with predatory–preference feeding habits (Wheeler, 2001; Sanchez *et al.*, 2008; Wheeler, 2000b; Bueno and van Lenteren, 2012; Urbaneja *et al.*, 2012; Lins Jr *et al.*, 2014). However, this tiny bug (mainly found in its nymph form) is often difficult to identify, leading to problems with the development and maintenance of an effective quarantine system for use during the import and export of agricultural products and nurseries (Yasunaga, 2000). *N. tenuis* is considered to have been introduced accidentally to multiple regions via agri-

cultural trade (Yasunaga, 2000), because this bug will hide in narrow spaces and oviposits deep in plant tissues. To prevent accidental introduction, it is necessary to identify individuals accurately (including eggs and nymphs) properly, using morphological characters and biological information. Therefore, in this study all nymphal stages are described, and genitalic structures of the male and female adults are illustrated for the first time. Additionally, biological information such as life cycle, oviposition traces, and feeding habits is also provided, along with relevant photographs.

### MATERIALS AND METHODS

To observe morphological characters, photographs and illustrations of examined specimens were taken by a Leica M165C microscope. Measurements were taken using an equipped software program with the same microscope. All measurements are given in millimeters (mm). For observation of the male genitalia, genital segment of each specimen was detached, and then soaked and boiled in 10% KOH solution at 70°C at 10–20 minutes until it became transparent. After being placed distilled water, genitalia and parameres were dissected and examined. Terminology follows mainly those of Yasunaga (1991), Braimah *et al.* (1982) and Yasunaga and Schwartz (2007). To describe morphological characters of each nymphal stage and to observe biological characteristics, nymphs and adults were bred with host plant (*Lycopersicon esculentum*, *Capsicum annuum* var. *angulosum*; Solanaceae) by feeding aphids (*Aphis gossypii* Glover, 1877) as prey in a cage (width: 400 mm; length: 400 mm; height: 550 mm) at 26°C and a photoperiod of 16:8 (L:D) hours in an insect breeding room. Then, photographs of life cycle and biology were taken by a Nikon D300 camera.

### RESULTS

#### Taxonomy

*Nesidiocoris tenuis* (Reuter, 1895)

*Cyrtopeltis tenuis* Reuter, 1895: 139.

*Nesidiocoris tenuis* Kerzhner, 1988: 67.

<sup>1</sup> Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University, Daejeon 305–764, Korea

<sup>2</sup> Department of Biosystems Machinery Engineering, College of Agriculture and Life Sciences, Chungnam National University, Daejeon 305–764, Korea

\* Corresponding authors (E-mail: jung@cnu.ac.kr; ymyu@cnu.ac.kr)

## Morphology

### DESCRIPTION

#### First instar (Fig. 1A)

Body generally oval, length 1.41–1.43. COLORATION: generally greenish brown. **Head:** yellowish green; compound eyes dark brown; tylus slightly brown; antennae generally pale brown, middle part of first antennal segment dark brown, base of second and third antennal segment dark brown; rostrum generally brown, 1/2 apical part of fourth rostral segment dark brown. **Thorax:** almost yellowish green, both sides slightly yellow; legs almost pale brown, third tarsal segment dark brown. **Abdomen:** almost yellowish green. SURFACE AND VESTITURE: glossy, head and pronotum covered with sparse pubescences; tibiae with two rows of erect setae, abdomen covered with dense pubescences. STRUCTURE: **Head:** relatively bigger than pronotum; ocelli absent; vertex width longer than first antennal segment; antennae somewhat long and slender, proportion of first to fourth antennal segments 0.1:0.1:0.2:0.2; rostrum reaching to hindcoxae, proportion of first to fourth rostral segments 0.1:0.1:0.1:0.2. **Thorax:** pronotum almost rectangle with slightly rounded lateral margins; scutellum absent; wing pads not developed; legs generally slender. **Abdomen:** rounded, apical segment of abdomen slightly protuberant.

**MEASUREMENTS:** (n=3): Body length, tylus–apex of abdomen: 1.41–1.43; head length, excluding collar: 0.32–0.33; head width, including compound eyes: 0.28–0.29; vertex width: 0.19–0.20; 1<sup>st</sup> antennal segment length: 0.11–0.12; 2<sup>nd</sup> antennal segment length: 0.16–0.18; 3<sup>rd</sup> antennal segment length: 0.22–0.23; 4<sup>th</sup> antennal segment length: 0.25–0.26; total antennal length: 0.74–0.79; 1<sup>st</sup> rostral segment length: 0.12–0.13; 2<sup>nd</sup> rostral segment length: 0.14–0.15; 3<sup>rd</sup> rostral segment length: 0.14–0.15; 4<sup>th</sup> rostral segment length: 0.20–0.21; total rostral segment length: 0.60–0.64; anterior pronotal margin width (straight): 0.23–0.24; mesal pronotal length: 0.18–0.29; basal pronotal margin width (straight): 0.29–0.30; foreleg (femur: tibia: tarsus): 0.37–0.38: 0.34–0.35: 0.23–0.24; midleg (femur: tibia: tarsus): 0.33–0.34: 0.39–0.40: 0.24–0.25; hindleg (femur: tibia: tarsus): 0.44–0.45: 0.50–0.52: 0.32–0.34.

#### Second instar (Fig. 1B)

Body generally oval, length 1.74–1.76. COLORATION: generally greenish brown. **Head:** yellowish green; compound eyes dark brown; tylus slightly brown; antennae generally pale brown, middle part of first antennal segment dark brown, base and apex of second and third antennal segment dark brown; rostrum generally pale brown, 1/3 apical part of fourth rostral segment dark brown. **Thorax:** almost yellowish green; legs almost pale brown, third tarsal segment dark brown. **Abdomen:** almost yellowish green. SURFACE AND VESTITURE: glossy, head and pronotum covered with sparse pubescences; tibiae with two rows of erect setae, abdomen covered with somewhat dense pubescences. STRUCTURE: **Head:** relatively as big as pronotum; ocelli absent; vertex width longer than first antennal segment; antennae

somewhat long and slender, proportion of first to fourth antennal segments 0.1:0.3:0.3:0.3; rostrum reaching to hindcoxae, proportion of first to fourth rostral segments 0.1:0.1:0.1:0.2. **Thorax:** pronotum almost trapezoid; scutellum absent; forewing pad slightly developed; legs generally slender. **Abdomen:** rounded, apical segment of abdomen slightly protuberant.

**MEASUREMENTS:** (n=3): Body length, tylus–apex of abdomen: 1.74–1.76; head length, excluding collar: 0.34–0.35; head width, including compound eyes: 0.35–0.37; vertex width: 0.32–0.34; 1<sup>st</sup> antennal segment length: 0.15–0.16; 2<sup>nd</sup> antennal segment length: 0.30–0.32; 3<sup>rd</sup> antennal segment length: 0.37–0.38; 4<sup>th</sup> antennal segment length: 0.33–0.34; total antennal length: 1.15–1.20; 1<sup>st</sup> rostral segment length: 0.15–0.16; 2<sup>nd</sup> rostral segment length: 0.14–0.16; 3<sup>rd</sup> rostral segment length: 0.12–0.13; 4<sup>th</sup> rostral segment length: 0.18–0.19; total rostral segment length: 0.59–0.64; anterior pronotal margin width (straight): 0.27–0.28; mesal pronotal length: 0.27–0.29; basal pronotal margin width (straight): 0.39–0.40; foreleg (femur: tibia: tarsus): 0.38–0.39: 0.40–0.41: 0.32–0.33; midleg (femur: tibia: tarsus): 0.38–0.39: 0.49–0.51: 0.31–0.32; hindleg (femur: tibia: tarsus): 0.51–0.53: 0.56–0.58: 0.38–0.39.

#### Third instar (Fig. 1C)

Body suboval, length 2.02–2.05. COLORATION: generally greenish brown. **Head:** yellowish green; compound eyes dark brown; tylus slightly brown; antennae generally pale brown, middle part of first antennal segment dark brown, base and apex of second and third antennal segment dark brown; rostrum generally pale brown, 1/3 apical part of fourth rostral segment dark brown. **Thorax:** almost yellowish green, both sides slightly yellowish green; legs almost pale brown, third tarsal segment dark brown. **Abdomen:** almost yellowish green. SURFACE AND VESTITURE: glossy, head and pronotum covered with sparse pubescences; tibiae with two rows of erect setae, abdomen covered with somewhat sparse pubescences. STRUCTURE: **Head:** relatively as big as pronotum; ocelli absent; vertex width longer than first antennal segment; antennae somewhat long and slender, proportion of first to fourth antennal segments 0.1:0.3:0.3:0.3; rostrum reaching to hindcoxae, proportion of first to fourth rostral segments 0.2:0.2:0.2:0.2. **Thorax:** pronotum almost trapezoid; scutellum absent; hindwing pad slightly developed; legs generally slender. **Abdomen:** rounded, apical segment of abdomen slightly protuberant.

**MEASUREMENTS:** (n=3): Body length, tylus–apex of abdomen: 2.02–2.05; head length, excluding collar: 0.37–0.39; head width, including compound eyes: 0.35–0.37; vertex width: 0.22–0.24; 1<sup>st</sup> antennal segment length: 0.15–0.16; 2<sup>nd</sup> antennal segment length: 0.30–0.33; 3<sup>rd</sup> antennal segment length: 0.37–0.39; 4<sup>th</sup> antennal segment length: 0.33–0.34; total antennal length: 1.15–1.22; 1<sup>st</sup> rostral segment length: 0.20–0.21; 2<sup>nd</sup> rostral segment length: 0.21–0.22; 3<sup>rd</sup> rostral segment length: 0.18–0.20; 4<sup>th</sup> rostral segment length: 0.24–0.25; total rostral segment length: 0.83–0.88; anterior pronotal margin width (straight): 0.27–0.29; mesal pronotal length: 0.27–0.29;

basal pronotal margin width (straight): 0.40–0.42; foreleg (femur: tibia: tarsus): 0.39–0.40: 0.51–0.52: 0.33–0.35; midleg (femur: tibia: tarsus): 0.42–0.43: 0.55–0.57: 0.33–0.35; hindleg (femur: tibia: tarsus): 0.52–0.54: 0.79–0.82: 0.40–0.42.

#### Fourth instar (Fig. 1D)

Body elongated oval, length 2.71–2.75. COLORATION: generally greenish brown. **Head:** yellowish green; compound eyes dark brown; sometimes base of tylus slightly brown; antennae generally pale brown, middle part of first antennal segment dark brown, base and apex of second and third antennal segment dark brown; rostrum generally pale brown, 1/3 apical part of fourth rostral segment dark brown. **Thorax:** almost yellowish green, both sides slightly yellowish green; legs almost pale brown, third tarsal segment dark brown. **Abdomen:** almost yellowish green. SURFACE AND VESTITURE: glossy, head and pronotum covered with sparse pubescences; tibiae with two rows of erect setae, abdomen covered with sparse short pubescences. STRUCTURE: **Head:** relatively as big as pronotum; ocelli absent; vertex width longer than first antennal segment; antennae long and slender, proportion of first to fourth antennal segments 0.2:0.4:0.5:0.4; rostrum reaching to hindcoxae, proportion of first to fourth rostral segments 0.3:0.3:0.2:0.2. **Thorax:** pronotum almost trapezoid; scutellum absent; hindwing pad well developed; legs generally slender. **Abdomen:** rounded, apical segment of abdomen slightly protuberant.

**MEASUREMENTS:** (n=3): Body length, tylus–apex of abdomen: 2.71–2.75; head length, excluding collar: 0.40–0.42; head width, including compound eyes: 0.45–0.47; vertex width: 0.26–0.28; 1<sup>st</sup> antennal segment length: 0.20–0.21; 2<sup>nd</sup> antennal segment length: 0.46–0.49; 3<sup>rd</sup> antennal segment length: 0.53–0.55; 4<sup>th</sup> antennal segment length: 0.41–0.43; total antennal length: 1.60–0.68; 1<sup>st</sup> rostral segment length: 0.30–0.32; 2<sup>nd</sup> rostral segment length: 0.24–0.25; 3<sup>rd</sup> rostral segment length: 0.22–0.23; 4<sup>th</sup> rostral segment length: 0.27–0.28; total rostral segment length: 1.03–1.08; anterior pronotal margin width (straight): 0.35–0.37; mesal pronotal length: 0.36–0.38; basal pronotal margin width (straight): 0.57–0.59; foreleg (femur: tibia: tarsus): 0.54–0.56: 0.55–0.58: 0.34–0.35; midleg (femur: tibia: tarsus): 0.54–0.56: 0.62–0.64: 0.38–0.40; hindleg (femur: tibia: tarsus): 0.77–0.79: 1.18–1.24: 0.49–0.53.

#### Fifth instar (Fig. 1E)

Body elongated oval, length approximately 2.99–3.02. COLORATION: generally greenish brown. **Head:** yellowish green; compound eyes dark brown; sometimes base of tylus slightly brown; antennae generally pale brown, middle part of first antennal segment dark brown, base and apex of second and third antennal segment dark brown; rostrum generally pale brown, 1/3 apical part of fourth rostral segment dark brown. **Thorax:** almost yellowish green; legs almost pale brown, third tarsal segment dark brown. **Abdomen:** almost yellowish green. SURFACE AND VESTITURE: glossy, head and pronotum covered with sparse pubescences; tibiae with two rows

of erect setae, posterior part of abdomen covered with sparse short pubescences. STRUCTURE: **Head:** relatively as big as pronotum; ocelli absent; vertex width longer than first antennal segment; antennae long and slender, proportion of first to fourth antennal segments 0.2:0.4:0.5:0.4; rostrum reaching to hindcoxae, proportion of first to fourth rostral segments 0.3:0.3:0.2:0.2. **Thorax:** pronotum almost trapezoid; scutellum absent; wing pads elongated and thick; legs generally slender. **Abdomen:** rounded, apical segment of abdomen slightly protuberant.

**MEASUREMENTS:** (n=3): Body length, tylus–apex of abdomen: 2.99–3.02; head length, excluding collar: 0.44–0.46; head width, including compound eyes: 0.44–0.46; vertex width: 0.21–0.23; 1<sup>st</sup> antennal segment length: 0.20–0.21; 2<sup>nd</sup> antennal segment length: 0.46–0.48; 3<sup>rd</sup> antennal segment length: 0.55–0.57; 4<sup>th</sup> antennal segment length: 0.41–0.42; total antennal length: 1.62–1.68; 1<sup>st</sup> rostral segment length: 0.30–0.31; 2<sup>nd</sup> rostral segment length: 0.29–0.30; 3<sup>rd</sup> rostral segment length: 0.20–0.21; 4<sup>th</sup> rostral segment length: 0.26–0.27; total rostral segment length: 1.05–1.09; anterior pronotal margin width (straight): 0.34–0.36; mesal pronotal length: 0.38–0.41; basal pronotal margin width (straight): 0.56–0.57; foreleg (femur: tibia: tarsus): 0.68–0.70: 0.76–0.78: 0.41–0.43; midleg (femur: tibia: tarsus): 0.72–0.74: 0.78–0.81: 0.39–0.41; hindleg (femur: tibia: tarsus): 0.97–1.03: 1.24–1.31: 0.49–0.53.

#### Adult (Fig. 1F)

*Male:* Body elongated oval, length 3.01–3.08. COLORATION: generally greenish brown with dark spots. **Head:** greenish brown; compound eyes dark brown; tylus entirely dark brown; antennae generally pale brown, middle part of first antennal segment dark brown, base and apex of second antennal segment dark brown, base of third antennal segment dark brown; rostrum generally pale brown, 1/2 apical part of fourth rostral segment dark brown. **Thorax:** almost yellowish green; carina dark brown; collar greenish pale brown; posterior part of pronotum generally brown with dark spots; mesoscutum greenish brown, scutellum pale brown, apex of scutellum dark brown; hemelytra generally greenish brown; commissure dark brown; corium tinged with dark brown, posterior part of corium with dark brown spots; membrane grayish brown with dark brown spots, vein dark brown; legs almost pale brown, base of tibiae dark brown; third tarsal segment dark brown. **Abdomen:** almost yellowish green. SURFACE AND VESTITURE: glossy, hemelytra covered with sparse pubescences; tibiae with two rows of erect setae. STRUCTURE: **Head:** relatively smaller than pronotum; ocelli absent; vertex width longer than first antennal segment; antennae somewhat long and slender, proportion of first to fourth antennal segments 0.2:0.6: 0.7:0.4; rostrum reaching to hindcoxae, proportion of first to fourth rostral segments 0.3:0.3:0.2:0.3. **Thorax:** pronotum almost trapezoid; scutellum equilateral; lateral margin of hemelytra straight; cuneal fracture developed; legs generally slender. **Abdomen:** rounded, almost reaching to base of membrane. GENITALIA: gonopore relatively short and rounded, with curved par-



ameres (Fig. 2A–B); left paramere with slender hypophysis with setae and sensory lobe (Fig. 2A); right paramere with slender hypophysis and sensory lobe (Fig. 2B); endosoma membranous, densely with small protuberances (Fig. 2C).

**Female:** Body elongated oval, length 3.22–3.26. COLORATION: as in male. SURFACE AND VESTITURE: as in male. STRUCTURE: somewhat more rounded oval and larger size in overall shape than male. GENITALIA: Ovipositor with small toothes (Figs. 2D, E); posterior wall with lined membrane (Fig. 2F (arrow)); genital chamber with sclerotized rings (Fig. 2G) and median process projecting into genital chamber (Fig. 2H (arrow)) with membrane connecting to median process.

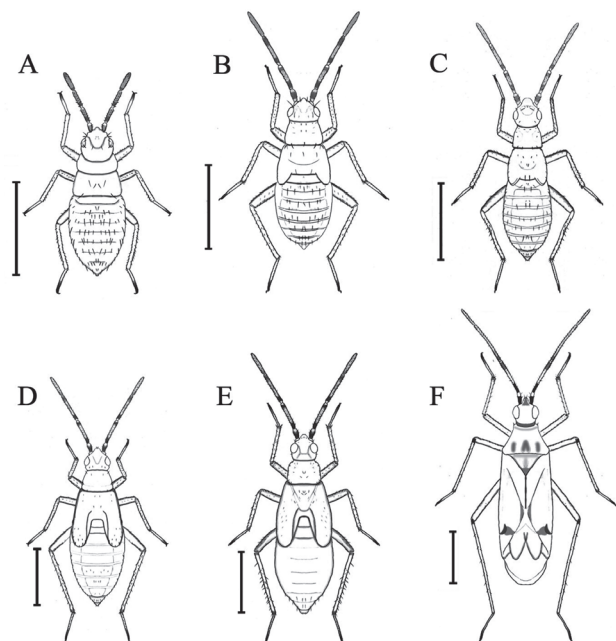
**MEASUREMENTS:** Male (n=3)/female (n=3): Body length, tylus–apex of membrane: 3.01–3.08/3.22–3.26; head length, excluding collar: 0.39–0.45/0.40–0.41; head width, including compound eyes: 0.46–0.47/0.46–0.49; vertex width: 0.16–0.19/0.19–0.20; 1<sup>st</sup> antennal segment length: 0.27–0.29/0.24–0.25; 2<sup>nd</sup> antennal segment length: 0.56–0.57/0.50–0.54; 3<sup>rd</sup> antennal segment length: 0.61–0.70/0.56–0.61; 4<sup>th</sup> antennal segment length: 0.34–0.35/0.32–0.40; total antennal length: 1.55–1.91/1.62–1.80; 1<sup>st</sup> rostral segment length: 0.25–0.34/0.30–0.33; 2<sup>nd</sup> rostral segment length: 0.31–0.34/0.30–0.32; 3<sup>rd</sup> rostral segment length: 0.23–0.25/0.24–0.26; 4<sup>th</sup> rostral segment length: 0.30–0.31/0.29–0.30; total rostral length: 1.09–1.24/1.13–1.21; anterior pronotal margin width: 0.33–0.38/0.32–0.33; mesal pronotal length: 0.41–0.43/0.37–0.39; basal pronotal width: 0.73–0.74/0.72–0.73; outer embolial margin length: 1.45–1.55/1.51–1.54; outer cuneal margin length: 0.43–0.52/0.46–0.49; maximum width across hemelytron: 0.42–0.44/0.42–0.45; foreleg (femur:

tibia: tarsus): 0.85–0.91: 0.82–0.90: 0.39–0.40/0.78–0.80: 0.82–0.87: 0.37–0.41; midleg (femur: tibia: tarsus): 0.88–0.89: 0.96–1.03: 0.37–0.38/0.78–0.83: 0.91–0.97: 0.39–0.40; hindleg (femur: tibia: tarsus): 1.12–1.23: 1.44–1.61: 0.44–0.50/1.09–1.10: 1.52–1.55: 0.45–0.48.

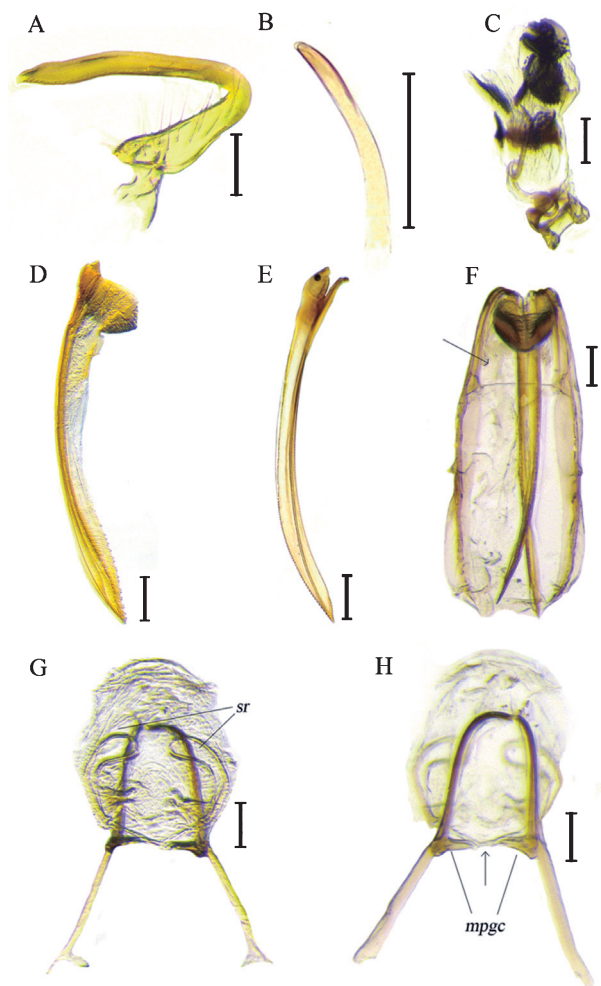
**DISTRIBUTIONS:** Asia, Australia, Europe, North Africa, North America, Pacific Islands, tropical Africa, West Indies (Kerzhner and Josifov, 1999).

**HOSTS:** Capparidaceae (Lindberg, 1958), Euphorbiaceae (Lindberg, 1958), Solanaceae (Carvalho, 1956; Alayo, 1974), Asteraceae (Linnavuori, 1986), Pedeliaceae (Alayo, 1974).

**MATERIALS EXAMINED:** 5♂♂, 5♀♀, Gukdong-ri, Dong-myun, Hwasoon-gun, Jeollanam-do, Korea, 35°01'48"N; 127°02'19"W, 16.vi.2014, on *Capsicum annuum* var. *angulosum* (Solanaceae), Junggon Kim; 1♂, 1♀, Gyora-ri, Jocheon-eub, Jeju-si, Korea, 33°25'42"N; 126°39'56"W, 17.vi.2014, on *Capsicum annuum* var. *angulosum* (Solanaceae), Junggon Kim; 1♂, Gung-dong, Yuseong-gu, Daejeon-si, Korea,



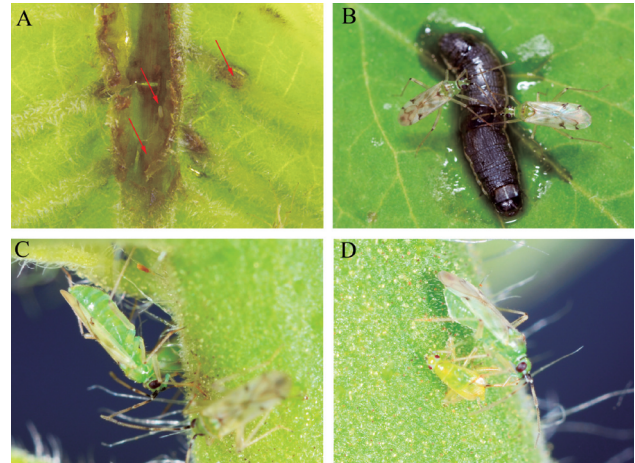
**Fig. 1.** Descriptions of nymphal stages and adult of *N. tenuis*. A: first instar; B: second instar; C: third instar; D: fourth instar; E: fifth instar; F: adult. Scale bar: 1 mm.



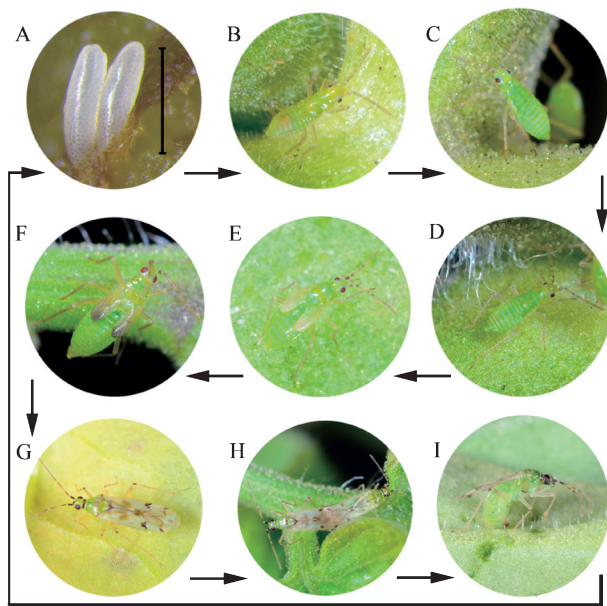
**Fig. 2.** Parameres and genitalia of male and female of *N. tenuis*. A: left paramere; B: right paramere; C: endosoma; D–E: ovipositor in lateral view; F: posterior wall; G–H: genital chamber; sr: sclerotized rings; mpgc: median process projecting into genital chamber; arrow: membrane. Scale bar: 0.1 mm.

36°22'06"N; 127°21'10"W, 11.viii.2014, on *Humulus japonicus* Siebold & Zucc. (Cannabaceae), Junggon Kim; 1♂, Gyejok-san (Mt), Jang-dong, Daeduk-gu, Daejeon-si, Korea, 36°23'07"N; 127°26'22"W, 22.viii.2014, Light trap, Junggon Kim; 1♀, Gung-dong, Yuseong-gu, Daejeon-si, Korea, 36°22'06"N; 127°21'10"W, 12.viii.2014, Light trap, Junggon Kim; Compared with Japanese specimens: 1♂, Awa, Tokushima, Japan, 34°06'10"N; 134°17'49"W, 29.vii.2014, on *Sesamum indicum* (Pedaliaceae), K. Matsuo.

**REMARKS:** Length of each antennal segment and each rostral segment of fourth instar are approximately equal to those of fifth instar. It is thought that length of body and legs increases mainly after fourth instar.



**Fig. 4.** Egg and traces of oviposition and prey types of *N. tenuis*. A: egg and traces of oviposition on underside of tomato leaf (red arrows); B: *N. tenuis* feeding on moth larva; C: adult feeding on its host plant (tomato); D: adult feeding on its nymph (cannibalism).



**Fig. 3.** Life cycle of *N. tenuis*. A: eggs (Scale bar: 0.5 mm); B: first instar; C: second instar; D: third instar; E: fourth instar; F: fifth instar; G: adult; H: mating of adult; I: oviposition of female.

### DISCUSSION

In the two host plants we used in this study, immature stages of *N. tenuis* developed into adult successfully, which was subsequently confirmed to mate and oviposit (Fig. 3). Traces of oviposition were found on the underside of young leaves (Fig. 4A). Nymphs and adult fed on their prey wandering host plants from the stem to flowers. *N. tenuis* fed on not only tiny prey such as aphids and whitefly but also somewhat large prey such as moth larvae (Fig. 4B). In the case of lack of prey, *N. tenuis* gained nutrients from host plants for survival, which indicates that they are zoophytophagous as (Fig. 4C). In addition, cannibalism was also observed in adults that had fed on fourth instar immature (Fig. 4D) as an opportunist (Wheeler, 2001). Therefore, this mirid bug is assumed to be predominantly predaceous, but it becomes injurious to plants if its prey population density is low.

### ACKNOWLEDGEMENTS

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2014R1A1A1005338), and was supported by a fund (22-14-6-0712-01) by Research of Animal and Plant Quarantine Agency, South Korea.

### REFERENCES

Alayo, D. P. 1974 Los Hemipteros de Cuba. Parte XIII. Familia Miridae. *Torreia.*, **32**: 1-41

Alomar, O. and R. Albajes 1996 Greenhouse whitefly (Homoptera: Aleyrodidae) predation and tomato fruit injury by the zoophytophagous predator *Dicyphus tamaninii* (Heteroptera: Miridae). In "Zoophytophagous Heteroptera: Implications for Life History and Integrated Pest Management", ed. by O. Alomar and R. N. Wiedenmann, Entomological Society of America, Lanham, MD, pp. 154-177

Arnó, J., C. Castañé, J. Riudavets and R. Gabarra 2009 Risk of damage to tomato crops by the generalist zoophytophagous predator *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae). *Bull. Entomol. Res.*, **100**(1): 105-115

Braimah, S. A., L. A. Kelton and R. K. Stewart 1982 The predaceous and phytophagous plant bugs (Heteroptera: Miridae) found on apple trees in Quebec. *Nat. Can.*, **109**(2): 153-180

Bueno, V. H. P. and J. C. van Lenteren 2012 Predatory bugs (Heteroptera). In "Insect bioecology and nutrition for integrated pest management", ed. by A. R. Panizzi and J. R. P. Parra, CRC Press, Boca Raton, USA, pp. 539-569

Carvalho, J. C. M. 1956 *Insects of Micronesia: Miridae*. Bishop Museum, Honolulu, 7, pp. 1-100

Kerzhner, I. M. 1988 *Novye i maloizvestnye poluzhestkiokrylye nasekomye (Heteroptera) Dal'nego Vostoka SSSR [New and little known heteropteran insects (Heteroptera) from the Far East of the USSR]*. Akademija Nauk USSR, Vladivostok 1987, pp. 1-84

Kerzhner, I. M. and M. Josifov 1999 *Cimicomorpha II. Miridae. Catalogue of the Heteroptera of the Palaearctic region. Vol. 3*. Netherlands Entomological Society, Amsterdam, pp. 1-577

Lindberg, H. 1958 Hemiptera Insularum Caboverdensium. *Soc. Scient. Fenn., Comm. Biologicae*, **19**(1): 1-246

Linnavuori, R. E. 1986 *Insects of Saudi Arabia. Heteroptera*.

- Fauna Saudi Arabia*, **8**: 31–197
- Lins, Jr J. C., J. J. A. Loon, V. H. P. Bueno, D. Barbosa, M. Dicke and J. C. Lenteren 2014 Response of the zoophytophagous predators *Macrolophus pygmaeus* and *Nesidiocoris tenuis* to volatiles of uninfested plants and to plants infested by prey or conspecifics. *Biocontrol*, **59**(6): 707–718
- Perdikis, D. C. and D. P. Lykouressis 2004 *Macrolophus pygmaeus* (Hemiptera: Miridae) population parameters and biological characteristics when feeding on eggplant and tomato without prey. *J. Econ. Entomol.*, **97**: 1291–1298
- Reuter, O. M. 1895 Ad cognitionem Capsidarum. III. Capsidae ex Africa boreali. *Revue d'Entomologie*. Caen, **14**: 131–142
- Sanchez, J. A. D. Gillespie and R. McGregor 2004 Plant preference in relation to life history traits in the zoophytophagous predator *Dicyphus hesperus*. *Entomol. Exp. Appl.*, **112**: 7–19
- Sanchez, J. A., A. Lacasa, J. Arnó, C. Castañé and O. Alomar 2008 Life history parameters for *Nesidiocoris tenuis* (Reuter) (Het., Miridae) under different temperature regimes. *J. Appl. Entomol.*, **133**(2): 125–132
- Schuh, R. T., and J. A. Slater 1995 *True bugs of the world (Hemiptera: Heteroptera): Classification and Natural History*. Cornell University Press, Ithaca and London, pp. 1–336
- Urbaneja, A., J. G. Cabrera, J. Arnó and R. Gabarra 2012 Prospects for the biological control of *Tuta absoluta* in tomatoes of the Mediterranean basin. *Pest Manag. Sci.*, **68**(9): 1215–1222
- Wheeler, A. G. Jr. 2000a Plant bugs (Miridae) as plant pests. In “Heteroptera of Economic importance”, ed. by C. W. Schaefer and A. R. Panizzi, CRC Press, Boca Raton, Florida, pp. 37–83
- Wheeler, A. G. Jr. 2000b Predacious plant bugs (Miridae). In “Heteroptera of Economic importance”, ed. by C. W. Schaefer and A. R. Panizzi, CRC Press, Orlando, Florida, pp. 657–693
- Wheeler, A. G. Jr. 2001 *Biology of the Plant Bugs (Hemiptera: Miridae): pests, predators, opportunists*. Cornell University Press, Ithaca, New York, pp. 1–507
- Yasunaga, T. 1991 A revision of the plant bug, genus *Lygocoris* Reuter from Japan, part I (Heteroptera, Miridae, *Lygus*-complex). *Jpn. J. Entomol.*, **59**(2): 435–448
- Yasunaga, T. 2000 An annotated list and descriptions of new taxa of the plant bug subfamily Bryocorinae in Japan (Heteroptera: Miridae). *Biogeography*, **2**: 93–102
- Yasunaga, T. and M. D. Schwartz 2007 Revision of the mirine plant bug genus *Philostephanus* Distant and allies (Heteroptera: Miridae: Mirinae: Mirini). *Tijdschr. Entomol.*, **150**: 101–180