

## First Record of *Lachnus chosoni* (Hemiptera: Aphididae: Lachninae) in the Republic of Korea with Description of Sexual Morphs

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**Mariusz Kanturski, Yerim Lee, Jinyeong Choi, and Seunghwan Lee (2018)** This study reports the first record of the oak-feeding aphid species *Lachnus chosoni* Szelegiewicz, 1975 (Hemiptera: Aphididae: Lachninae) in the Republic of Korea. Until now, only apterous viviparous females from the type material and type locality-Myohyangsan Mountain (The Democratic People's Republic of Korea)-were recorded. Apterous viviparous females of *L. chosoni* were collected from *Quercus* sp. in the area of Seoul National University in Seoul for the first time in 2016. The specimens, which were collected in October and November 2017, represent the sexual generation of this species. We describe and figure the hitherto unknown oviparous female and apterous male of *L. chosoni* for the first time in detail. Notes on biology and copulation are also provided.

**Key words:** Aphid, Biodiversity, Lachnini, Morph, *Quercus*, Sexuales.

### BACKGROUND

The genus *Lachnus* Burmeister, 1835, which represents about 23 valid species worldwide (Favret 2018; Kanturski et al. 2017), is regarded as a Holarctic genus. However, most species are native to the Palaearctic, with main centres in Europe, Himalaya and East-Asia (Blackman and Eastop 2018). Almost all of the species that belong to this genus are associated with different *Quercus* species and other related host-plants that belong to Fagaceae (Holman 2009). The *Lachnus* fauna of East-Asia is represented by about six valid *Quercus*-feeding species: *L. chosoni* Szelegiewicz, 1975; *L. shiicola* Sorin, 1980; *L. siniquercus*

Zhang, 1982; *L. sorini* Binazzi and Remaudière, 2006; *L. takahashii* Sorin, 1980 and *L. tropicalis* (van der Goot, 1916). Besides *L. chosoni*, all of the above species are often characterised by a black coloured body for all of the morphs and a similar pigmentation of the wings in alate viviparous females.

Szelegiewicz (1975) described *L. chosoni* from material from three apterous viviparous females that were collected on Myohyangsan Mountain in the central part of the Democratic People's Republic of Korea (DPRK). One of the most characteristic morphological features of this species is that its hind tibiae with inner setae are clearly longer than the outer setae, another is that

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its mesosternal processes are poorly developed (Kanturski et al. 2014). Due to these features, the species was placed in the former subgenus *Schizodryobius* van der Goot with *L. pallipes* (Hartig, 1841). For a long time, *L. chosoni* was one of the least-known species in *Lachnus* and many authors regarded it as a possible synonym of *L. pallipes* (Blackman and Eastop 1994; Remaudière and Remaudière 1997). Kanturski et al. (2014) re-examined the type material of *L. chosoni* and suggested several differences from other species within the so-called “*pallipes*” group. However, all analyses to date were based on the existing type material from the DPRK and, after Szelegiewicz’s description, the species was never collected again.

Although *L. chosoni* was listed in the taxonomic review of the Korean Lachninae (Lee et al. 1994), this record was solely based on Szelegiewicz’s publication (1975) without any direct observations. During research on the aphid fauna of the Republic of Korea, representatives of *L. chosoni* were collected in the Republic of Korea for the first time. The main goal of this paper is to describe and observe the biology of previously unknown sexual representatives of *L. chosoni*—an oviparous female and apterous male.

## MATERIALS AND METHODS

### Specimens examined

Specimens are deposited in the following institutions: College of Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea (CALS SNU) and Department of Zoology, University of Silesia (DZUS), Katowice, Poland. The material was preserved in 70% ethanol and mounted using the Kanturski and Wieczorek (2012) protocol. The specimens were examined using a Nikon Eclipse E600 microscope with differential interference contrast (DIC) and photographed using a DS-Fi2 digital camera.

### Apterous viviparous females

KOREA: 4 apt (DZUS), Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 07.v.2016, *Quercus* sp., Y. Lee leg., Kor05/16/48a, Kor05/16/48b; 2 apt (CALS SNU), Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 07.v.2016, *Quercus* sp., Y. Lee leg., Kor05/16/48c; 4 apt (CALS SNU), Mt. Taehwasan, Dochuck-myeon, Gwangju-si, Gyeonggi-do, 20.vi.2017,

*Quercus* sp., Y. Lee leg., Kor06/17/01, Kor06/17/02 (Fig. 1).

### Oviparous females

KOREA: 2 ♀♀ (DZUS), Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 31.x.2017, *Quercus* sp., J. Choi leg., Kor10/17/4, Kor10/17/5, 1 ♀ (CALS SNU) Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 31.x.2017, *Quercus* sp., J. Choi leg., Kor10/17/6; 6 ♀♀ (DZUS), Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 03.xi.2017, *Quercus* sp., J. Choi leg., Kor10/17/7 DZUS; Kor10/17/8 DZUS; Kor10/17/9 DZUS; Kor10/17/10; Kor10/17/11 DZUS; Kor10/17/12; 1 ♀ (CALS, SNU) Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 31.x.2017, *Quercus* sp., J. Choi leg., Kor10/17/13.

### Apterous males

KOREA: 2 ♂♂ (DZUS) Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 31.x.2017, *Quercus* sp., J. Choi leg., Kor10/17/1 DZUS; Kor10/17/2 DZUS; 1 ♂ (CALS SNU) Seoul National University, Daehak-dong, Gwanak-gu, Seoul, 31.x.2017, *Quercus* sp., J. Choi leg., Kor10/17/3.

### Morphological description

The following abbreviations are used (partly after Blackman and Eastop 1994): BL—body length (from the anterior border of the head to the end of cauda); HW—head width across the compound eyes; ANT—antennae or their length; ANT I–VI—antennal segments I–VI or their lengths (ratios between antennal segments are simply given as e.g. ‘V:III’); LS III—length of the longest seta of ANT III; BD III—basal articular diameter of ANT III; BASE—basal part of the last antennal segment or its length; PT—processus terminalis of the last antennal segment or its length; URS—ultimate segment of the rostrum or its length; III FEMORA—hind femora length; III TIBIAE—hind tibiae length; HT I—first segment of the hind tarsus or its length; HT II—second segment of the hind tarsus or its length; ABD I–VIII—abdominal tergites I–VIII; SIPH—siphunculi apt-apterous viviparous female; ♀—oviparous female; ♂—male. Male genitalia morphology follows Wieczorek et al. (2011).

## RESULTS

*Lachnus chosoni* Szelegiewicz

*Lachnus* (*Schizodryobius*) *chosoni* Szelegiewicz, 1975: 575

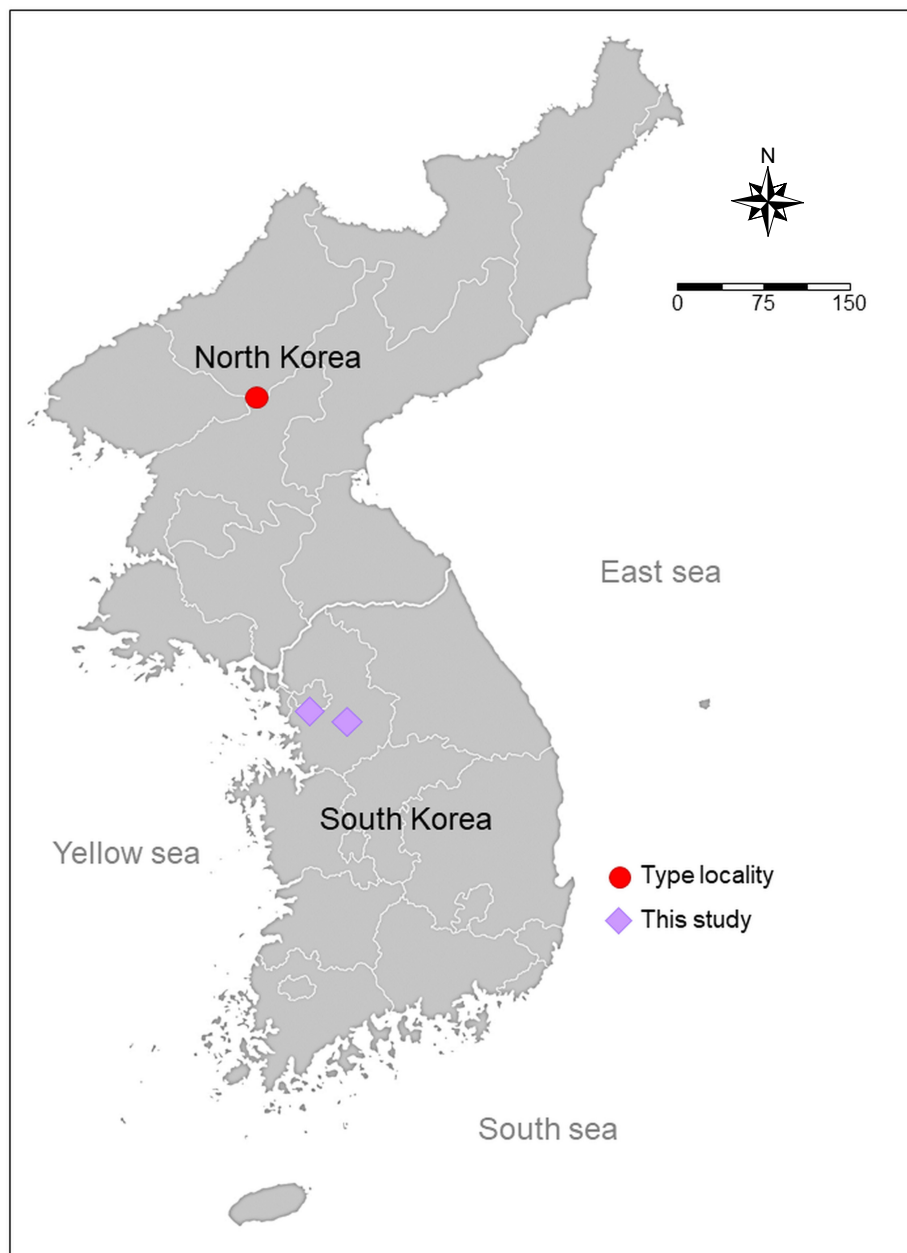
### Remarks on the apterous viviparous females:

These morphs were re-described by Kanturski et al. (2014) when the status of *L. chosoni* was revised, but the colour of live specimens was unknown (Blackman and Eastop 2018).

In life: Head, thorax and abdomen very shiny

dark brown to black. ANT brown with dark apical part of ANT V and dark ANT VI. Femora of legs dark brown with brown distal part and knee area (III FEMORA brown from half of their length). Tibiae with brown proximal part, slightly lighter central part and dark to black distal part, tarsi dark. Nymphs shiny black (Fig. 2a, b).

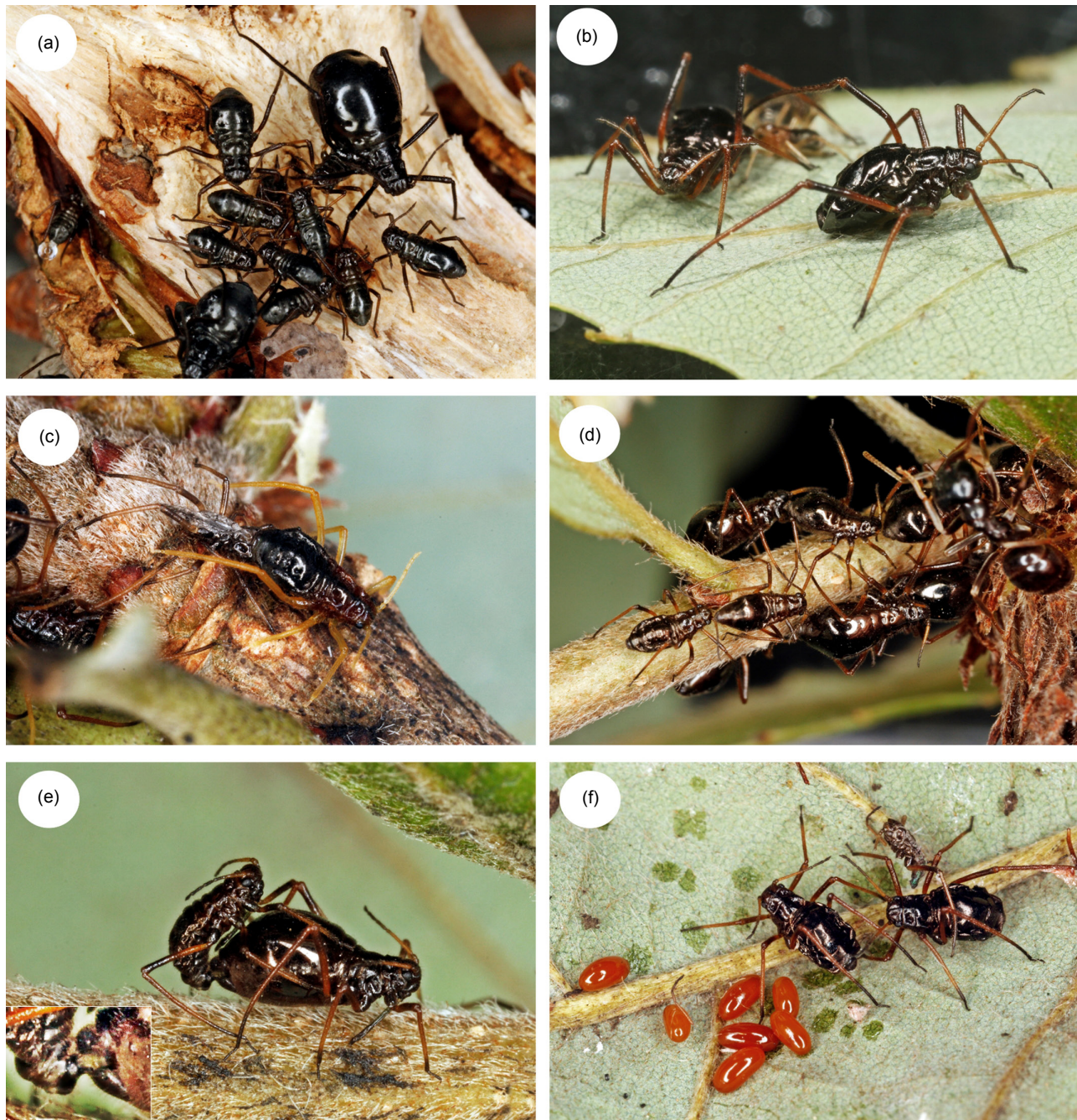
**Description of sexual morphs:** The sexual generation shares most features with the vivipara. Head with well-visible median suture, big compound eyes with poorly visible ocular tubercles



**Fig. 1.** Known distribution of *Lachnus chosoni* in the Korean Peninsula: the type locality in North Korea (red circle), first records in South Korea (violet rhombus).

and triommatidia. Head and thorax covered by long, fine and pointed setae. Head, pronotum and metanotum sclerotised. ANT 6-segmented. ANT V with one rounded primary rhinarium at the apex with well-developed sclerotic rosette. ANT VI with short PT, one rounded primary rhinarium with well-developed sclerotic rosette, and with six

accessory rhinaria. ANT VI PT with 4 subapical, and 3 apical setae. ANT setae numerous, long, very fine and pointed, always longer than the diameter of the antennal segments. URS long and narrow, segments 4 and 5 fused. First segments of tarsi without dorsal setae. Abdominal dorsum membranous, with numerous intersegmental



**Fig. 2.** Representatives of *Lachnus chosoni* in life: (a) spring colony of apterous viviparous females and nymphs feeding on scars of a branch, (b) apterous viviparous females on leaves, (c) freshly moulted male with uniformly light brown legs, (d) autumnal colony of oviparous females and males visited by ants, (e) oviparous female and male in copula (in the bottom left corner magnification of the male genitalia and female perianal area), (f) oviparous females with freshly laid eggs.

muscle attachment plates and numerous long, fine and pointed setae. SIPH low, on small, rounded or slightly oval, setose siphuncular sclerites. Cauda broadly rounded with many long, fine and pointed setae.

#### Oviparous female - description based on 10 specimens

(Figs. 2-4; Table 1)

*In life:* Body size as in apterous viviparous female. *Colour:* Head shiny dark brown. Thorax and abdomen shiny dark brown to black. ANT I and II dark brown, ANT III brown with darker distal end, ANT IV-VI dark brown. Femora of legs brown with dark brown distal half. Femora brown with dark to black distal parts. Tarsi dark to black (Fig. 2d-f).

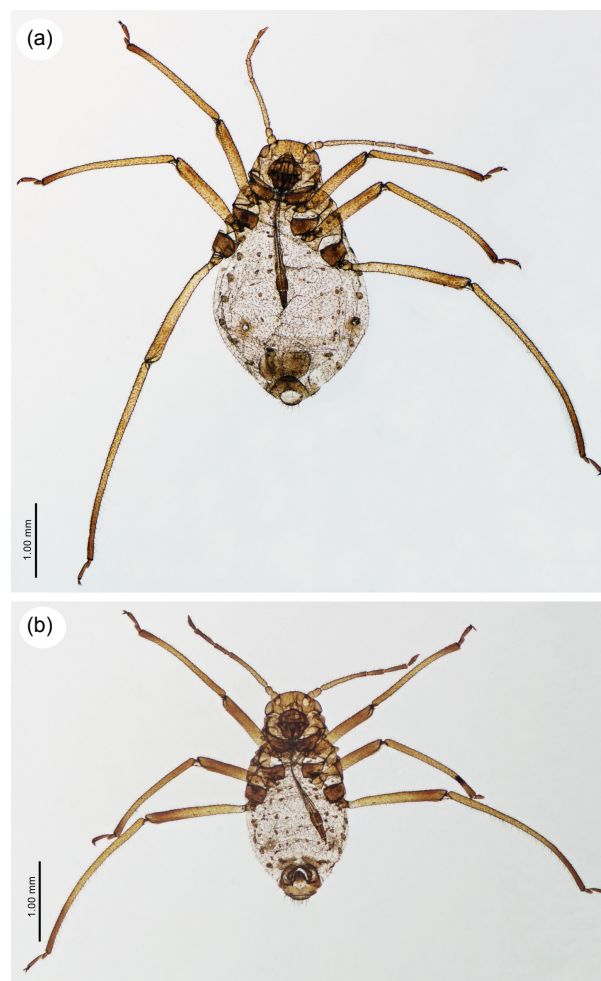
*Slide-mounted:* *Colour:* Head and thorax sclerotised, light brown. ANT light brown with darker distal end of ANT V and ANT VI. Legs brown and light brown with darker distal parts of femora, distal parts of tibiae and tarsi. Abdomen membranous with brown intersegmental muscle attachment plates. Siphuncular sclerites light brown. Genital plate, ABD VIII and cauda sclerotised, brown (Figs. 3a, 4d). Other morphological characters: HW 0.44-0.47 × ANT. Head setae, 0.065-0.090 mm long. ANT 0.46-0.49 × BL. ANT III shorter than ANT IV + V + VI, with 1-4 small, rounded and slightly protuberant secondary rhinaria situated on the distal half of the segment. ANT IV shorter than ANT V, with rounded or oval 2-4 secondary rhinaria of different size. ANT V longer than ANT VI. PT:BASE 0.35-0.40. Other antennal ratios: VI:III 0.28-0.30, V:III 0.41-0.42, IV:III 0.37-0.40. LS III 1.55-1.87 × BD III. Mesosternal tubercles poorly visible and low (Fig. 4b). Rostrum reaching abdominal sternite IV. URS 0.29-0.31 × ANT III, 1.02-1.09 × ANT VI and 0.81-0.88 × HT II, with 18-20 accessory setae. III FEMORA setae 0.055-0.075 mm long, III TIBIAE setae 0.050-0.090 mm long on the outer side and 0.09-0.13 mm long on the inner side. Hind tibiae with very small and not well visible 37-145 pseudosensoria which are single and rounded, double oval and 8-shaped (Fig. 4a, c). HT II 0.34-0.36 × ANT III, 1.02-1.09 × ANT VI. Dorsal setae on ABD I-VII 0.070-0.080 mm long. ABD VIII with numerous setae, 0.070-0.085 mm long. Genital plate large, ellipsoid, covered by numerous, in all specimens with a clear suture, forming two symmetric sclerites (Fig. 4e). Eggs ellipsoidal with membranous and smooth surface (Fig. 4f).

#### Apterous male - description based on three specimens

(Figs. 2, 3, 5; Table 1)

*In life:* Body smaller than the oviparous females. *Colour:* Head, thorax yellow and abdomen shiny black. ANT dark brown to black with slightly lighter ANT I, II and basal part of ANT III. Femora of legs dark brown with brown distal part and knee area (III FEMORA brown from half of their length). Tibiae with brown proximal part, slightly lighter central part and dark to black distal part, tarsi dark. Freshly moulted specimens shiny black with light brown appendages (Fig. 2c, d, e).

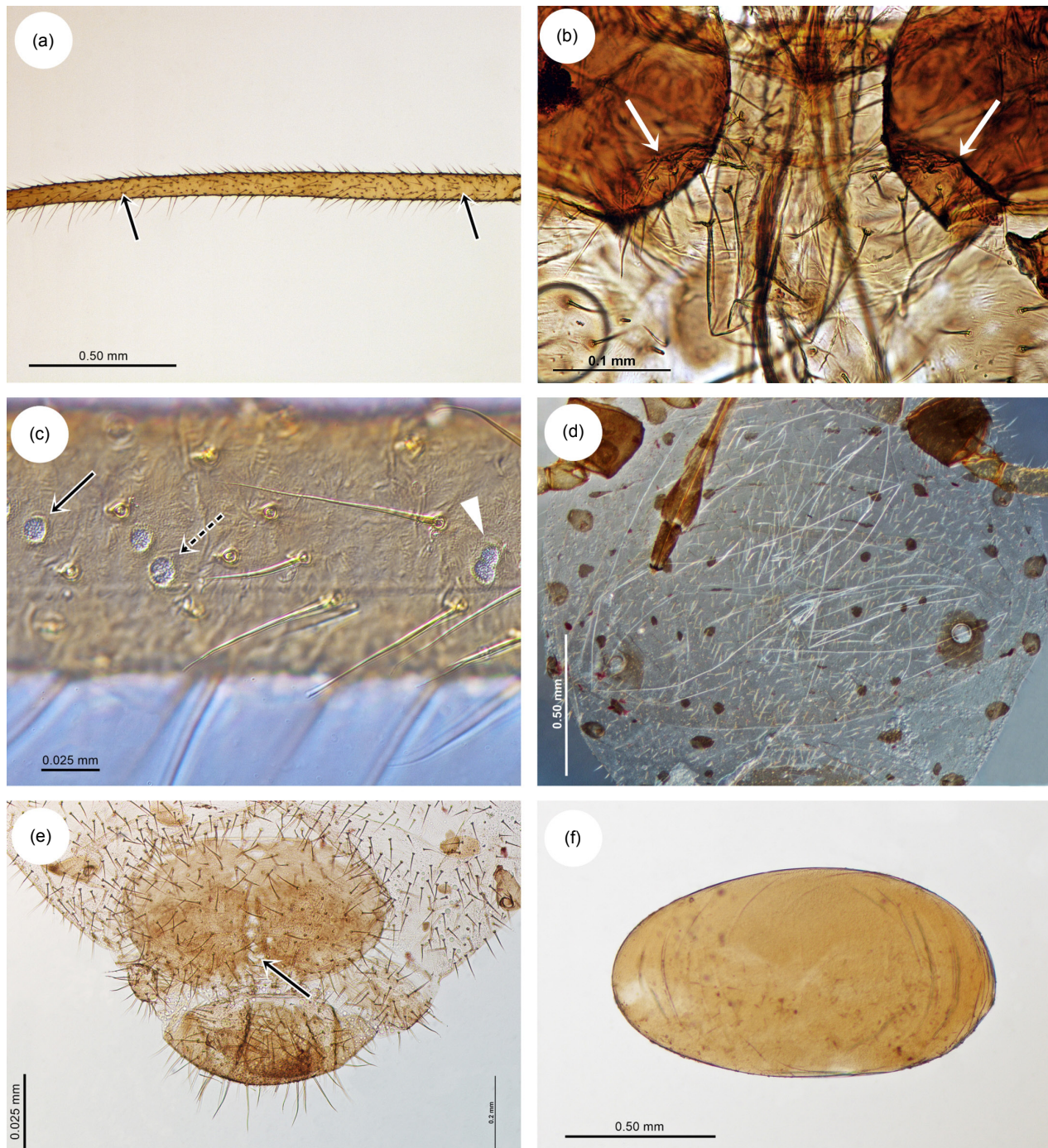
*Slide-mounted:* *Colour:* Head, pronotum and mesonotum sclerotised, brown. ANT brown, with paler ANT I, II and about 1/3 of length of ANT III. Femora of legs brown with lighter proximal part and darker distal part. Tibiae brown with darker distal parts and tarsi. SIPH light brown. Abdominal



**Fig. 3.** Sexual morphs of *Lachnus chosoni* in mounted specimens: (a) oviparous female, (b) apterous male.

sclerotisation brown. Genitalia sclerotised, brown (Fig. 3b). Other morphological characters: HW  $0.44\text{--}0.47 \times \text{ANT}$ . Head setae,  $0.055\text{--}0.09 \text{ mm}$  long. ANT (Fig. 5a)  $0.53\text{--}0.60 \times \text{BL}$ . ANT III slightly shorter than ANT IV + V + VI, with 70–92 very

small, rounded and clearly protuberant secondary rhinaria situated on the whole length of the segment (Fig. 5b). ANT IV (Fig. 5c) shorter than ANT V, with rounded or oval 5–6 secondary rhinaria of different size. ANT V with 3–7 secondary rhinaria



**Fig. 4.** Oviparous females of *Lachnus chosoni* characters: (a) hind tibiae with different length of inner (longer) and outer (shorter) setae and pseudosensoria area (arrows); (b) poorly visible, low mesosternal processes (arrows); (c) different types of pseudosensoria on hind tibiae—single, rounded (arrow), 8-shaped (dotted arrow) and double, oval (arrowhead); (d) egg capsules inside the abdomen; (e) genital plate with a median suture; (f) egg.

(Fig. 5d). PT:BASE 0.42-0.56. Other antennal ratios: VI:III 0.29-0.33, V:III 0.45-0.49, IV:III 0.31-0.35. LS III 1.44-1.87 × BD III. Rostrum reaching abdominal sternite V. URS 0.31-0.36 × ANT III, 1.05-1.12 × ANT VI and 0.80-0.90 × HT II, with 15-16 accessory setae (Fig. 5e). III FEMORA setae 0.05-0.08 mm long, III TIBIAE setae (Fig. 5f) 0.05-0.0940 mm long on the outer side and 0.09-0.12 mm long on the inner side. HT II 0.39-0.43 × ANT III, 1.25-1.33 × ANT VI. Dorsal setae on ABD I-VII 0.075-0.085 mm long. ABD VIII with 18-25 setae, 0.06-0.095 mm long. The genital area strongly sclerotised and easily visible. Parameres clearly visible, short, almost semi-circular with separate apices with numerous long, fine and pointed setae, 0.08-0.09 mm long. Basally the parameres are fused, forming strongly sclerotised, wide rounded ring with very short setae. Basal part of phallus separate, robust, long, finger like with 17-24 sensilla (Fig. 5g).

## DISCUSSION

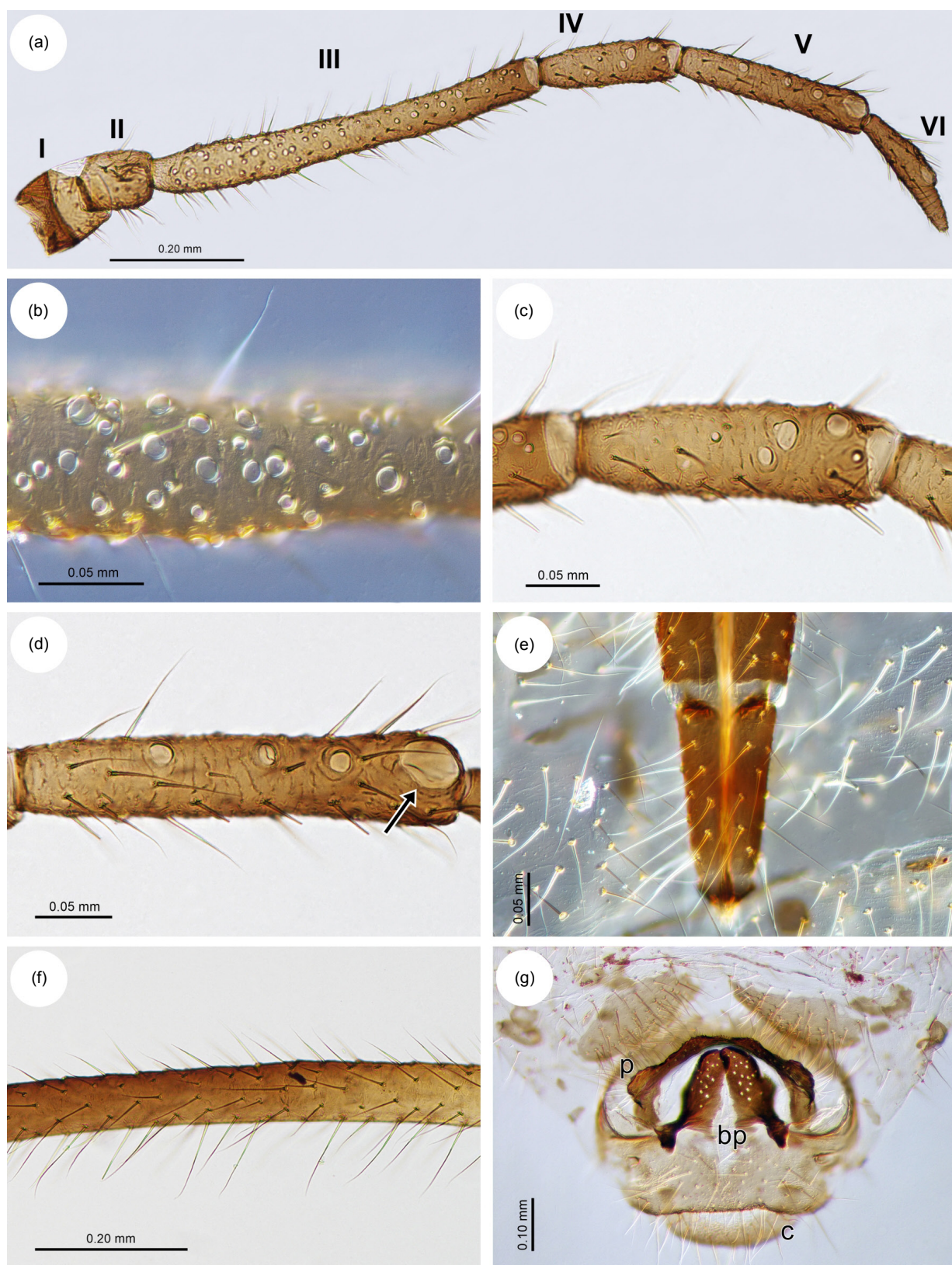
### Biology and copulation

To date, sexual morphs of East-Asiatic *Lachnus* are very poorly known. Oviparous

females and males have only been described in *L. tropicalis* (males alate) and *L. sorini* (only ovipara) (Shinji 1927; Binazzi and Remaudière 2006). Oviparous females and apterous males are the second and best known *L. chosoni* morphs and provide more information about the species' systematic position and biology. Representatives of this species feed on twigs and in the cracks of bark (Fig. 2a) and are often ant-attended, like other lachnid species (Fig. 2d). Although colonies are not numerous and no alate viviparous females have been collected yet, they can be easily distinguished from representatives of *L. tropicalis* due to the pigmentation of their legs and very shiny body. *L. chosoni* is a holocyclic species with viviparous generations in spring and summer and a sexual phase in autumn (the end of October and beginning of November in South Korea). Males are rare in the colony and are visibly smaller than the oviparous females, but are similarly pigmented (Fig. 2c, d). The male copulates with the oviparous female in a normal manner (dorso-ventral). The abdomen is slightly curved, the hind legs support the body while the fore and middle legs embrace the female's abdomen on the dorsal (fore legs) and lateral (middle legs) sides (Fig. 2e). The aedeagus is completely inserted into the female's genital pore while the parameres (or their numerous long

**Table 1.** Measurements of oviparous females ( $N = 10$ ) and apterous males ( $N = 3$ ) of *Lachnus chosoni*

Character	Oviparous female $N = 10$	Male $N = 3$
BL	3.50-4.00	2.60-2.77
HW	0.81-0.84	0.70-0.74
ANT	1.74-1.85	1.48-1.58
ANT III	0.72-0.75	0.59-0.66
ANT IV	0.27-0.30	0.20-0.22
ANT V	0.30-0.32	0.29-0.30
ANT VI	0.21-0.22	0.19-0.20
BASE	0.15-0.16	0.12-0.14
PT	0.05-0.06	0.06-0.07
URS	0.22-0.23	0.21-0.22
III FEMORA	1.67-1.75	1.27-1.35
III TIBIAE	2.85-3.12	2.10-2.27
HT I	0.14	0.14-0.15
HT II	0.26-0.27	0.25-0.26
SIPH sclerite	0.30-0.34	0.13-0.16
Genital plate length	0.40-0.43	-
Genital plate width	0.70-0.78	-
Egg length	1.50-1.60	-
Egg width	0.85-0.90	-
Genital capsule length	-	0.24-0.26
Genital capsule width	-	0.48-0.49
Basal part of phallus length	-	0.15-0.16



**Fig. 5.** Male of *Lachnus chosoni* characters: (a) antenna; (b) small, rounded, protuberant secondary rhinaria on ANT III; (c) secondary rhinaria on ANT IV; (d) ANT V with primary rhinarium (arrow) and secondary rhinaria; (e) ultimate rostral segments; (f) hind tibiae chaetotaxy; (g) genitalia-bp-basal part of phallus, p-parameres, c-cauda.

setae) appear to touch the anal plate and the basal part of the phallus touches the genital plate (sensilla on this part of the genitalia are very short) (Figs. 2e, 5g). The oviparous females are very similar to apterous viviparous females and lay ellipsoid orange-brown eggs (Fig. 2f) that turn black over time.

### Sexual morphs characters

*L. chosoni* was once treated as a synonym of *L. pallipes* due to the characteristic features of its hind tibiae (the inner setae clearly longer than the outer setae) (Blackman and Eastop 1994). After revising its status, Kanturski et al. (2014) placed it in the “*pallipes*” species group. However, species belonging to this morphologically similar species group (*L. pallipes*, *L. crassicornis* Hille Ris Lambers, 1948 and *L. pseudonodus* Kanturski and Wieczorek, 2014) are characterised by a complete lack of mesosternal processes and only some of its inner setae are longer than the others on the distal end. Based on this background, *L. chosoni* (with a small but present mesosternal processes and different tibiae chaetotaxy) may not be a true member of this group.

The first record of *L. chosoni* confirmed not only the presence of this species on the Korean Peninsula but also revealed a hitherto unknown oviparous female and male, which may be compared with the sexuales of *L. pallipes* (sexuales of *L. crassicornis* and *L. pseudonodus* are unknown). Oviparous females of are similar to apterous viviparous females in *L. chosoni* (except for a larger genital plate and pseudosensoria on hind tibiae) and, because of this character, they manifest similarities with *L. pallipes* (body length, small SIPH sclerites, body setae, pseudosensoria). The bisexual *L. chosoni* females have longer inner setae on the hind tibiae than the outer ones, but in *L. pallipes* only some of the distal inner setae are longer. The oviparae of *L. chosoni* also have small but visible mesosternal processes, which are lacking in both the viviparous and oviparous females of *L. pallipes* (and viviparae of *L. crassicornis* and *L. pseudonodus*). The described oviparous females are characterised by one quite unique feature—a genital plate with a clear median suture, which divides the plate into two smaller plates. This kind of genital plate has only been known in some species of the *Stomaphis* Walker subgenus *Parastomaphis* Pašek (Depa et al. 2015). The males in both species are apterous and, although they superficially similar, many of

their characters are different. The males in *L. chosoni* are characterised by a large number of secondary rhinaria on ANT III (70–92) while in *L. pallipes*, this segment carries only 0–17, which is more similar to the number in *L. roboris* (84–97) (Mróz et al. 2015). The genitalia of *L. chosoni* are characterised by the basal part of the phallus with short sclerotised arms (long in *L. pallipes*) and a ring, which is formed by the bases of parameres, which are absent in *L. pallipes* (the bases of the parameres are separated). Genitalia with those characters are also closer to the features of genitals of *L. roboris* (Mróz et al. 2015; Wieczorek et al. 2012).

The above-mentioned characters of both the viviparous and sexual morphs of *L. chosoni* indicate that this species is morphologically similar to representatives of the “*pallipes*” group. However, they most probably have their own place and status within the genus *Lachnus*, which should be confirmed in a molecular study.

### CONCLUSIONS

The present study confirms that *Lachnus chosoni*’s range expands to the area of the Korean Peninsula and, most probably, East Asia (Russian Far East and China). The presence of sexual morphs, which are described in this paper for the first time, confirms that the species is characterized by a holocycle. Characters of the oviparous female and male clearly confirm that descriptions of unknown morphs and life stages are crucial to better understand the evolution and phylogenetic relationships of many insect taxa, especially in the subfamily Lachninae.

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**Authors’ contributions:** MK - conceptualization, data analysis, manuscript draft writing; YL - material collection, manuscript draft revising; JC -

material collection, manuscript draft revising; SL - data analysis, manuscript draft revising. All authors read and approved the final manuscript.

**Competing interests:** The authors declare they have not competing interests.

**Availability of data and materials:** The materials in this study are available for anybody's research in the future. Specimens used here are deposited in public collections (DZUS, CALS SNU).

**Ethics approval consent to participate:** Not applicable.

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