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Description of *Optioservus gapyeongensis* new species and *Heterlimnius hasegawai* (Nomura) (Coleoptera: Elmidae) new to Korea

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Abstract

A new riffle beetle species *Optioservus gapyeongensis* n. sp. is described from the adult and larval stages. *Heterlimnius hasegawai* (Nomura), previously misidentified in Korea as *Optioservus* (*Cyclolimnius*) *kubotai* Nomura or *Optioservus variabilis* Nomura, is redescribed. The adults and larvae of both species inhabit attached mosses on substrates of clean mountain streams, headwaters or springs. Photographs of dorsal adults and habitats and line drawings of diagnostic characters are provided.

Key words: description, Elmidae, *Heterlimnius hasegawai*, Korea, *Optioservus gapyeongensis* n. sp., riffle beetles.

Introduction

The riffle beetle genera *Optioservus* Sanderson, 1954 and *Heterlimnius* Hinton, 1935 are similar in general morphology, and members of the genera have been historically confused with one another. Both genera are distributed in the Palearctic, Nearctic and Oriental regions (Brown 1981; Kodada & Jäch 2005; Jäch *et al*. 2006; Kamite 2009). At present, 11 species of *Optioservus* occur in the Palearctic region (Jäch *et al*. 2006), and *O. ater* Nomura, 1958 and *O. hasegawai* Nomura, 1958 have been transferred to *Heterlimnius* (Kamite 2009). *Optioservus kubotai kubotai* Nomura, 1958 and *O. kubotai saghaliensis* Nomura, 1958 were synonymized under *H. hasegawai* (Nomura, 1958) (Kamite 2009). *Optioservus hayashii* Nomura, 1960 was synonymized under *H. ater* (Nomura, 1958) (Kamite 2009).

In Korea, two species, *O. kubotai* Nomura and *O. variabilis* Nomura, have been recorded with diagnoses (Yoon 1988; Lee & Lee 1992). As mentioned above, *O. kubotai* Nomura, 1958 was synonymized under *Heterlimnius hasegawai* (Nomura, 1958) by Kamite (2009). Some aspects of the biology of *Optioservus* such as drift patterns (Brusven 1970) and habitats and conservation (Brown 1976; White 1978; Layher 2002) have been studied.

In this paper, we describe a new *Optioservus* species and report *Heterlimnius hasegawai* (Nomura), which has been misidentified in Korea as *Optioservus kubotai* Nomura or *Optioservus variabilis* Nomura.

Materials and methods

Adults and larvae of Korean riffle beetles were collected by a hand net or directly from attached mosses on submerged substrates. They are deposited in the Entomological Museum of Korea University (KU) in Seoul. Russian specimens were loaned from the Entomological Laboratory of Ehime University (EUM) in Matsuyama, Japan and Chinese specimens were loaned from the Naturhistorisches Museum Wien (NMW), Austria. Dorsal adults were photographed with a digital camera (ALTRA 20) on a dissecting microscope (Olympus SZ61) and illustrated using a dissecting microscope with an image analyzer (Carl Zeiss Stemi 2000-C with AxioCam MRc5). Larvae and male and female genitalia were dissected and treated with 10% KOH for a

few days prior to examination. As a result of this study, the holotype of *Optioservus gapyeongensis* n. sp. is deposited at KU; paratypes are deposited at KU, the National Institute of Biological Resources (NIBR) in Incheon, Korea and Yukki Kamite's collection (CKN) in Nagoya, Japan.

Morphological terminology follows Kodada and Jäch (2005). Locality and dimensional abbreviations used in this study are: GG = Gyeonggi-do, GW = Gangwon-do, CN = Chungcheongnam-do, CB = Chungcheongbuk-do, PL = pronotal length along midline in dorsal view, PW = maximum width of pronotum, EL = elytral length along the suture from the scutellar basis to the elytral apices, EW = maximum width of elytra, and TL = total length of PL and EL.

Taxonomic accounts

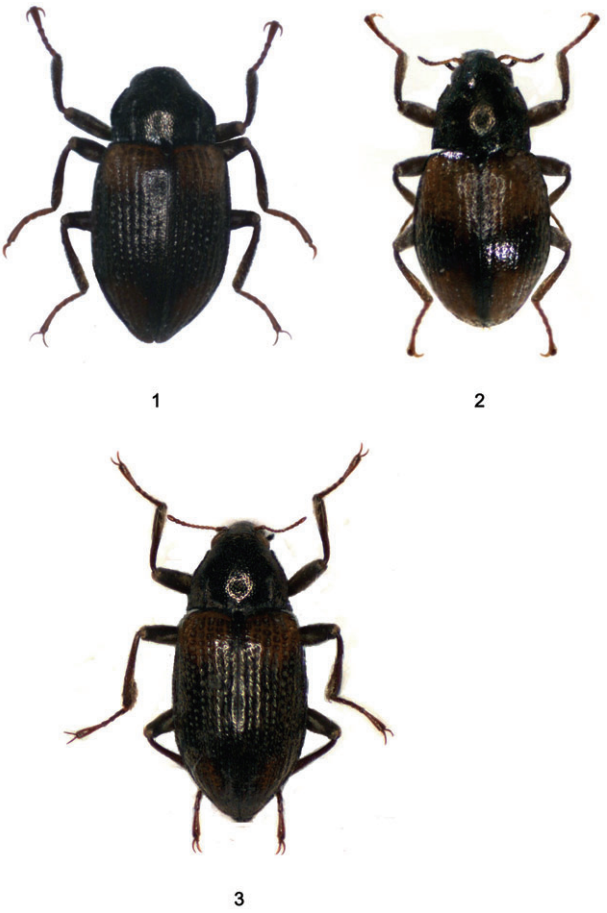
Genus *Optioservus* Sanderson (Korean name: Mu-neui-yeo-ul-beol-re-sok)

Optioservus Sanderson, 1954: p. 8; White 1978: p. 63; Satô 1985a: p. 258; Satô & Yoshitomi 2005: p. 640.
Type species: *Limnius trivittatus* Brown, 1930.
Adult (modified from Kamite 2009). Head granulate or punctuate; antennae 11-segmented. Elytra lateral margins strongly serrate; 4th interval of anterior part wider than or subequal to 3rd interval in width. Hindwings fully developed; radius posterior (RP) long. Apex of intercoxal process of abdominal ventrite 1 pointed; ventrite 5 granulate or rugose. Phallobase squamous or smooth at lateral and ventral surfaces.
Larva. Larvae of *Optioservus* are similar to those of *Heterlimnius*, but they can be easily distinguished by the ventral sclerites of the mesothorax and metathorax, which have three sclerites.

Optioservus gapyeongensis n. sp. (Figs 1, 4–24) (Korean name: Jak-eun-mu-neui-yeo-ul-beol-re)

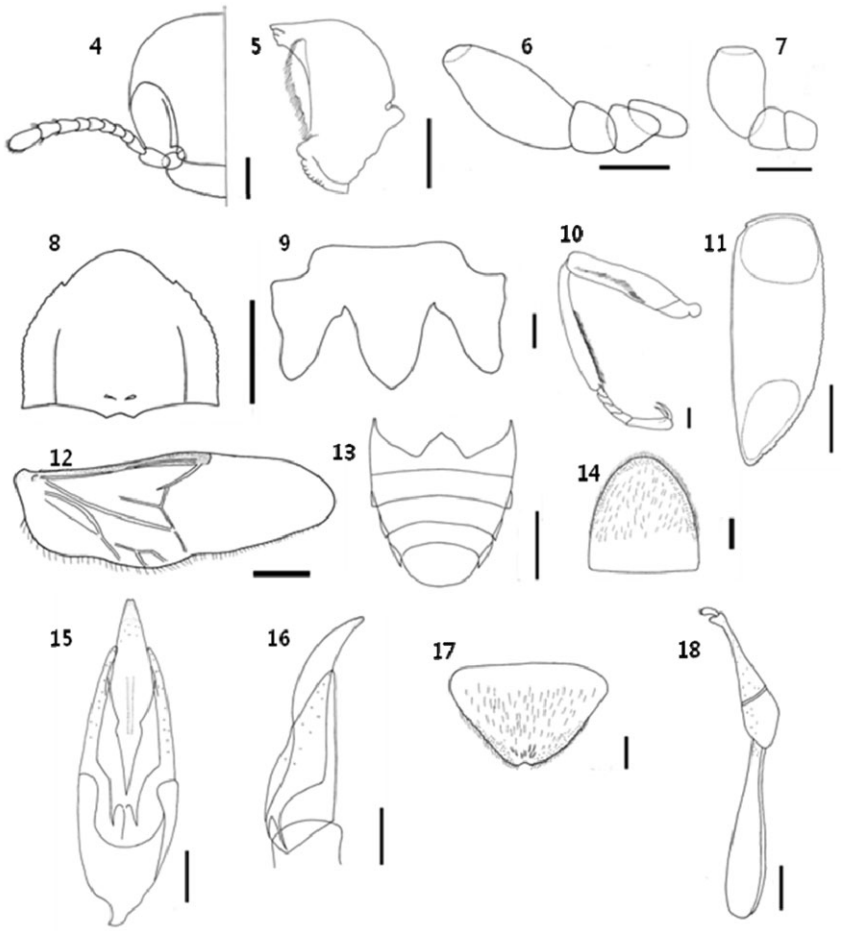
Description. Male adult (holotype). Body elongate, oval; TL/EW 1.99 mm [other specimens (n = 10): 1.97–2.13 mm, mean 2.05 mm]. Head, pronotum, scutellum, prosternum and mesoventrite black. Elytra reddish brown with yellow spots at anterior and posterior parts. Antennae, mouthparts, legs, metaventrite and abdomen reddish brown.

Head (Fig. 4) retractable, hypognathous, granulate on dorsal surface. Frons densely pubescent than labrum; lateral margin of anterior part acute; clypeus wider than labrum, arcuate, rectangular, round in frontal angles, granulate on surface; fronto-clypeal suture slightly serrate. Labrum wider than long, round in frontal angles, slightly concave at middle part, with several long hairs anteriorly at lateral parts. Antennae 11-segmented; antennomere 1 short and stout; antennomere 2 longer than 1 and stout; antennomere 3 long and slender; antennomeres 4–8 shorter than 3; antennomeres 9–11 gradually increasing in length and width, with numerous white setae apically; antennomere 11 oval. Mandibles (Fig. 5) short, with 3 teeth; edge distinctly notched at middle part. Maxillary palp (Fig. 6) 4-segmented; palpomeres 1–3 short; terminal palpomere relatively long. Labial palp (Fig. 7) 3-segmented; palpomeres 1 and 2 short; terminal palpomere large and stout.



Figures 1–3 Elmid adults. **1** *Optioservus gapyeongensis* n. sp., body length 2.57 mm; **2** *Heterlimnius hasegawai* (Nomura), body length 2.20 mm; **3** *Optioservus variabilis* Nomura, body length 2.81 mm.

Pronotum (Fig. 8) strongly convex, wider than long, and widest at posterior 1/3; middle part with small punctures; lateral parts granulate with pubescence; anterior angles more or less protrude; posterior angles rectangular and acute; lateral margins strongly serrate; anterior margin arched; sublateral carinae about 1/2 length of PL (0.36 mm), with two inconspicuous impression in frontal scutellum; PW/PL 1.24 mm [other specimens (n = 10): 1.22–1.39 mm, mean 1.29 mm]. Scutellum subtriangular, longer than wide, round



Figures 4–18 *Optioservus gapyeongensis* n. sp., adult. **4** head; **5** right mandible; **6** right maxillary palp; **7** right labial palp; **8** pronotum; **9** posternal process; **10** right foreleg; **11** right elytron; **12** right hind wing; **13** male abdomen; **14** male tergite 8; **15** aedeagus, dorsal view; **16** aedeagus lateral view; **17** female ventrite 5; **18** ovipositor. Scale bars, 0.05 mm (6, 7), 0.1 mm (4, 5, 9, 10, 14–18), 0.5 mm (8, 11–13).

at apex. Prosternum produced anteriorly, round in anterior angle; prosternal process (Fig. 9) longer than wide, subtriangular, pointed at apex, dorsally curved with pubescence. Mesoventrite deeply grooved for reception of prosternal process. Metaventrite smooth, shiny and convex at middle part; median longitudinal sulcus with deep impression; lateral and posterior parts with large punctures; posterior part with transverse suture. Legs (Fig. 10) long and slender; procoxae and mesocoxae globular; metacoxae transverse; femurs clavate, with golden setae; tibiae slender, with spine at apex, with tomentum on inner surface; tarsi 5-segmented, light brown; tarsomeres 1–4 short; tarsomere 5 longest, as long as 1–4 tarsomeres combined; claws two, slender, sharp, and shiny.

Elytra (Fig. 11) elongate oval, convex dorsally, widest near middle part, densely pubescent laterally, with yellow (live specimen) or brown (in alcohol) spots in anterior 1/4 and posterior 1/4 areas as in Figure 1; each side subparallel; anterior margin smooth; lateral margin crenulate, more or less emarginate near apex. Each elytron with 10 punctate striae; strial punctures moderately large and deep in anterior 1/2, becoming gradually finer and obscure posteriorly; 1st strial punctures relatively large and closely located each other in anterior part; 2nd and 3rd striae combined with 4th at posterior 1/4 and 1/3 parts, respectively; striae 6–8 finer and obscure at anterior 1/5 part; 9th stria combined with 10th at posterior 1/3 part; 10th stria starting at anterior 1/3 part; intervals 6–8 convex near base; epipleura moderately wide, gradually narrowing posteriorly; EL/EW 1.41 mm [other specimens (n = 10): 1.40–1.54 mm, mean 1.47 mm]; EL/PL 2.42 mm [other specimens (n = 10): 2.40–2.65 mm, mean 2.54 mm]; EW/PW 1.38 mm [other specimens (n = 10): 1.29–1.39 mm, mean 1.34 mm]. Hindwings (Fig. 12) fully developed; radial cell incomplete; radius anterior (RA_{3+4}) short; radius posterior (RP) long; media posterior (MP_{1+2}) distinct and long; medial spur long, nearly reaching margins;

cubito–anal cell elongate; media posterior 3 and 4 (MP_3, MP_4) vestigial; cubitus anterior (CuA_{1+2}) short; CuA_{3+4} fused with anal anterior (AA_{1+2}).

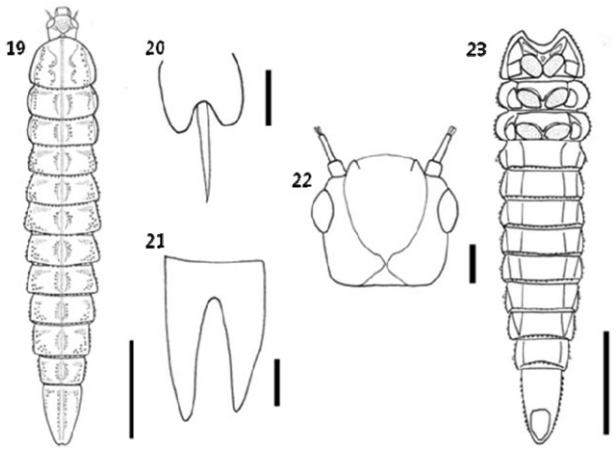
Abdomen (Fig. 13) with five ventrites, longer than wide, with pubescence (except 1–2 ventrites at middle); ventrite 1 with large shallow punctures laterally; ventrite 2 sparsely and shallowly punctuate, with small lateral processes; ventrite 3 not punctuate, with small lateral processes; ventrite 4 not punctuate, with relatively long lateral processes; ventrite 5 granulate, with posterior margin feebly crenulate. Tergite 8 as in Figure 14.

Aedeagus as in Figures 15 and 16; penis longer than parameres, slightly emarginate apically, ventrally curved in lateral view; penis basolateral apophyse long and sharp; parameres subtriangular, widest posteriorly, strongly narrowed anteriorly, twice as long as phallobase; phallobase shorter and wider.

Measurements (holotype). TL 2.57 mm; PL 0.75 mm; PW 0.93 mm; EL 1.82 mm; EW 1.29 mm. [Other specimens (n = 10): TL 2.41–2.86 (2.64) mm; PL 0.66–0.81 (0.75) mm; PW 0.92–1.03 (0.96) mm; EL 1.75–2.05 (1.89) mm; EW 1.21–1.41 (1.29) mm].

Female adult. Externally similar to male, larger than male. Abdominal ventrite 5 (Fig. 17) concave at apex; ovipositor (Fig. 18) long and slender; stylus moderately long, slender, slightly curved; coxite long and slender, lateral angle dilated outer at apex; distal sclerite longer than proximal sclerite. Valvifer longer than coxite and distal sclerite combined.

Larva. Body length 4.24 mm (excluding head, n = 1), greatest width 0.78 mm (n = 1). Body (Fig. 19) elongate, triangular in cross section; tubercles dense and setigerous (Fig. 20); marginal tubercles elongate (Fig. 21); dorsal surface brown or blackish brown; ventral surface lighter in color than dorsal surface.



Figures 19–23 *Optioservus gapyeongensis* n. sp., larva. **19** dorsal body; **20** setigerous tubercle; **21** marginal tubercle; **22** head; **23** ventral body. Scale bars, 0.01 mm (20, 21), 0.1 mm (22), 1 mm (19, 23).

Head (Fig. 22) subquadrate, visible from above, slightly longer than wide; short teeth on anterior margin between antenna and frontoclypeal suture. Antennae slender, 3-segmented; antennomere 1 short and wide; antennomere 2 longest, almost twice of antennomere 1, with sensorial appendage; antennomere 3 almost as long as antennomere 1, with one seta at apex. Labrum transverse, round in front angle, with 4 simple setae, and with 12 tufted scales on anterior half. Mandibles well developed, with 3 obtuse teeth; incisor area with long articulated setose process; prostheca well developed; mola absent; penicillus well developed. Maxillae slender; cardo small, transverse; galea as long as lacinia; maxillary palp 4-segmented, longer than galea; palpomeres 1 and 2 short; palpomere 3 slightly longer than 2, almost as long as palpomere 4; palpomere 4 slender. Labium slender; prementum transverse; labial palp 2-segmented, very short; palpomere 2 globular, longer than palpomere 1.

Thorax wider than long. Prothorax with 7 ventral sclerites (2 anterior sclerites, 2 anterolateral sclerites, 2 posterolateral sclerites, and 1 sclerite between coxae); prosternal region without posterior sclerite. Mesothorax and metathorax with 3 ventral sclerites (1 anteromedial sclerite and 2 lateral sclerites). Legs light brown, 5-segmented, short and stout; coxae large; trochanters smallest; femora and tibiae transverse, equally long; femora with plumose scales mostly on inner side; tibiae with long seta on anterior 2/3 part; claws about 1/2 length of tibiae, moderately curved, with short seta (1/2 length of claw) on inner side.

Abdomen (Fig. 23) long, 9-segmented; segments 1–8 with lateral prominent tubercles; segments 1–7 with pleural sclerites (1st–6th sclerites rectangular; 7th sclerite subtriangular; 8th sclerite with suture); terminal segment moderately long, slightly emarginate at apex.

Type material. Holotype: ♂, Korea, GG, Gapyeong-gun, Buk-myeon, Jeokmok-ri, Garim Spring (37°58′24.8″ N, 127°26′43.7″ E, 320 m a.s.l.) beside Gapyeong Stream, 10.v.2009, YJ Bae & SW Jung (KU).

Paratypes (34 adults): [Korea] 2 ♂, 6 ♀, 5 exs., same locality and data as holotype (KU & NIBR); 1 ♀, ditto but 17.iii.2009, YJ Bae & SW Jung (KU); 1 ♂, 3 ♀, ditto but 16.ix.2010, YJ Bae & SW Jung (KU); 2 exs., GG, Gapyeong-gun, Buk-myeon, Jeokmok-ri, Gapyeong Stream at Nonnam, 3.viii.2005, HG Lee and DG Kim (KU); 2 ♂, ditto but 29.ii.2004, HG Lee and DG Kim (KU); 2 ♂, 1 ex., ditto but 5.vi.2004, HG Lee and DG Kim (KU & CKN); 1 ex., ditto but 30.x.2004, HG Lee and DG Kim (CKN); 1 ex., ditto but 3.xii.2005, SW Jung and DG Kim (CKN).

Other material: [Korea] 2 ♂, GG, Gapyeong-gun, Seorak-myeon, Mukan-ri, Johanggyo (Br.), 14.vi.2008, YC Jeon (NIBR); 4 ♂, 2 ♀, ditto but 29.iv.2008, YC Jeon (NIBR); 2 ♀, 1 ex., GG, Icheon-si, Sindun-myeon, Doam-ri, 14.vi.2005, YC Jeon (NIBR); 2 ♂, GG, Namyangju-si, Onam-eup, Palhyeon-ri, 22.viii.2005, YC Jeon (NIBR);

a

b

Figure 24 Habitat of *Optioservus gapyeongensis* n. sp. in Garim Spring (holotype locality) beside Gapyeong Stream, Gapyeong, Korea. (a) Spring with water mosses *Chiloscyphus polyanthos*; (b) outlet headwater.

1 ex., CB, Boeun-gun, Songnisan-myeon, Sangpan-ri, 25.ix.2004, YC Jeon (KU); 1 ♀, 3 L, CN, Gongju-si, Janggi-myeon, Eunnyoung-ri, 22.iv.2009, SW Jung (KU); 1 ♀, GW, Wonju-si, Munmak-eup, Bongcheon-ri, 29.viii.2008, IK Shin (KU); 2 ♀, GW, Wonju-si, Munmak-eup, Gunghye-on-ri, 22.v.2009, IK Shin (KU); 1 ♀, GG, Gwangju-si Toechon-myeon Doma-ri, 3.iv.2000, YJ Bae (KU). [Russia] 23 exs., Mt. Tumannaya, Primorskij, 20–22.viii.1991, M Satô leg. (EUM); 2 exs., Shamora R, Viadivostok, 18.viii.1991, M Satô leg. (EUM); 1 ex., Staraya, Kamenka, 21.viii.1992, M Satô leg. (EUM); 1 ex., 1 L, Primorskij Kral Ussuriskij Reserve, 18.vii.1983, Vshivkova (EUM); 2 exs., ditto but 21.ix.1984, Vshivkova (EUM); 2 exs., ditto but 8.vii.1972, Toistikova (EUM); 1 ex., ditto but 9.x.1972, Levaniciova (EUM); 1 ex., Primorskij Kral Novaya Moskva, 8.viii.1978, GS Lafer (EUM); 2 exs., Primorskij Kral Kedrovaya Pady, 10.i.1975, Vshivkova (EUM); 1 ex., Vshivkova Primorskij Kral Kedrovaya Pady, 11.viii.1973, GS Lafer (EUM). [China] 70 exs., Liaoning, 50 km SE Benxi, 26.ix.1994, 300 m a.s.l., Ji and Wang leg. (61) (NMW); 15 exs., Liaoning (164), 50 km NE Kuandian, 300 m a.s.l., Qingshangou For. Park, 1.ix.1996, Ji and Wang leg. (NMW); 1 ex., Liaoning (167), 50 km NE Kuandian, 300 m a.s.l., Qingshangou For. Park, 1.ix.1996, Ji and Wang leg. (NMW).

Distribution. Korea, China, Far East Russia.

Etymology. The species is named after the holotype locality, Gapyeong Stream, where the species occurs abundantly.

Habitat. We collected most of the Korean specimens from water mosses of Bryophytes *Chiloscyphus polyanthos* in headwater streams or springs (Fig. 24). Streams are about 30–50 cm wide, 5–15 cm deep, with boulders, gravel and sand, and are partially shaded with riparian trees. *Chiloscyphus polyanthos* could almost be considered an aquatic moss and is found mainly on submersed or partially submersed stones or wet ground.

Remarks. This new species resembles *O. variabilis* Nomura (Fig. 3), but can be distinguished by the following morphological characters: body smaller (mean 2.64 mm) and oval-shaped; each side of pronotum flat and wide; elytra more convex at middle of anterior part; femora more reddish. Type specimen (male adult) of *O. variabilis* Nomura from Japan was measured as follows: TL 2.81 mm, PL 0.76 mm, PW 1.05 mm, EL 2.05 mm, EW 1.32 mm, TL/EW 2.13 mm, PW/PL 1.38 mm, and EL/EW 1.55 mm.

Genus *Heterlimnius* Hinton (Korean name: No-ran-mu-nui-yeo-ul-beol-re-sok)

Heterlimnius Hinton, 1935: p. 178 (for full description see Kamite 2009: p. 200).

Type species: *Elmis koebelei* Martin, 1927.

Heterlimnius hasegawai (Nomura) (Fig. 2) (Korean name: No-ran-mu-nui-yeo-ul-beol-re)

Optioservus (s. str.) *hasegawai* Nomura, 1958: p. 8; Jäch *et al*. 2006: p. 436.

Optioservus (*Cyclolimnius*) *kubotai* Nomura, 1958: p. 10; Satô 1977: p. 4; Satô 1982: p. 391; Satô 1985b: p. 438; Lee & Lee 1992: p. 63; Kim *et al*. 1994: p. 154; Jäch & Kodada 1995: p. 290; Jäch *et al*. 2006: p. 436.

Optioservus (*Cyclolimnius*) *kubotai saghaliensis* Nomura, 1958: p. 11; Jäch *et al*. 2006: p. 436.

Optioservus variabilis Nomura: Yoon 1988: p. 648 (misidentification); Lee 1995: p. 16 (misidentification).

Heterlimnius hasegawai (Nomura): Kamite 2009: p. 208.
Redescription. Female adult. Body length 2.20–2.25 mm; width 1.18–1.20 mm (Fig. 2). Body elongate, oval, and convex dorsally. Head black, with punctures, retracted into prothorax. Antennae 10-segmented; antennomeres 1 and 2 short and stout; antennomere 5 shortest; antennomeres 8–10 reddish brown, gradually increasing in length; antennomere 11 oval. Pronotum 0.72 mm (n = 1) long, 0.85 mm (n = 1) wide, wider than long, widest posteriorly, with sublateral carinae; anterior margin broadly round, sparsely pubescent, with punctures; lateral and posterior margins not serrate; anterior angles more or less protrude; posterior angles subacute. Scutellum black, subtriangular, longer than wide. Prosternal process longer than wide, narrowing behind and round at apex. Legs long and slender; tibiae with tomenta along inner surface; tarsi 5-segmented, light brown; tarsomeres 1–4 short; tarsomere 5 longest, as long as 1–4 segments combined; two claws slender, sharp, shiny. Elytra convex dorsally, widest at middle, sparsely pubescent, with large yellow spots at anterior and posterior parts as in Figure 2; lateral margins not serrate. Abdomen longer than wide, with pubescence; ventrite 5 truncate or slightly round.
Material examined. 1 ♀, Korea, GW, Pyeongchang-gun, Jinbu-myeon, Ganpyeong-ri, Odaesan (Mt.) National Park, 8.viii.2008, YC Jeon (KU); 1 ex., ditto (CKN).
Distribution. Korea, China, Far East Russia, Japan.
Remarks. Previously known records of *O. kubotai* in Korea (Lee & Lee 1992; Kim *et al*. 1994) belong to this species as this species was synonymized under *H. hasegawai* (Nomura) by Kamite (2009). We corrected misidentified records of *O. variabilis* (Yoon 1988; Lee 1995) using available material and description.

This species can be distinguished from other *Optioservus* species by the following characters: lateral margins of elytra and pronotum not serrate; elytra more oval-shaped and widest at middle part, with larger yellowish brown spots.

The larva of *H. hasegawai* (Nomura) was described by Kamite (2009). Antennal segmentation of *Heterlimnius* adult is not a diagnostic character for species because both 10- and 11-segmented antennal types sometimes occur in a population. Moreover, Shepard (1993) observed that single individual of *H. corpulentus* adult possesses both 10- and 11-segmented antennae.

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