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A new species of *Ceratosticha* Meyrick, 1935 (Lepidoptera: Psychidae) from Korea

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Abstract

Ceratosticha lineata Roh & Byun, **sp. n.**, is described from Korea. Adults, genitalia, and larvae of the species are described, and DNA barcodes are provided.

Key words: DNA barcode, monotypic genus, Tineoidea

Introduction

The family Psychidae consists of 241 genera with 1,350 described species (van Nieukerken *et al.* 2011). Phylogenetically, Psychidae traditionally have been placed in the superfamily Tineoidea (Davis and Robinson 1998). A recent molecular phylogeny and revised classification of the superfamily (Regier *et al.* 2015) recognized five families, i.e., Dryadaulidae, Eriocottidae, Psychidae, Tineidae, and Meessiidae.

The genus *Ceratosticha* Meyrick, 1935 of the family Psychidae is based on the type species *Ceratosticha leptodeta* Meyrick, 1935. The genus has long been considered monotypic, distributed in Korea, Japan, and Taiwan (Saigusa and Sugimoto 2013; Roh and Byun 2016). The larvae feed on mosses on walls or on tree bark from a mobile case constructed of small sand particles and silk (Saigusa and Sugimoto 2013; Roh and Byun 2016). We recently discovered a new species of *Ceratosticha* in Korea. The purpose of this paper is to describe and illustrate the new species and present collection locations, micro-habitats, and illustrations of adults, genitalia, and larvae. DNA barcodes are also provided.

Material and methods

The material examined in this study is deposited in the Systematic Entomology Laboratory, Hannam University (SEL/HNU), Daejeon, Korea. Genitalia were dissected using standard procedures and slide mounted in 60% euparal. Wing venation was examined under dry conditions. Photographs of adults, larva, and the lateral aspect of the male genitalia were taken using a DFC 495 digital camera (Leica, Wetzlar, Germany) attached to a Leica M205A stereomicroscope (Leica, Wetzlar, Germany). Photographs of the female genitalia and the dorso-ventral aspect of the male genitalia were taken using a Samsung Galaxy S9 cellphone camera (Samsung, Suwon, Korea) attached to a Zeiss Axio Imager A1 (Zeiss, Oberkochen, Germany).

Terminology for morphological characters of the adult, wing venation, and genitalia follow Saigusa and Sugimoto (2005).

Genomic DNA was extracted from the legs of dried specimens of adults and from thoracic parts of larvae preserved in 100% alcohol using a Genomic Cell/Tissue Spin Mini Kit (Qiagen, Inc., Hilden, Germany) according to the manufacturer's protocol. Nine specimens of *Ceratosticha lineata*, **sp. n.**, and five specimens of *C. leptodeta* Meyrick were sequenced; DNA was amplified using the primer pair LepF1 and LepR1 (Hebert *et al.* 2004) and

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MLepF1, MLepR1 (Hajibabaei *et al.* 2006). PCR conditions for amplification followed the manufacturer's protocol (Platinum Taq, Invitrogen, Carlsbad City, CA, USA). Amplicons were purified using the QIAquick® PCR purification kit (QIAGEN, Inc.) and directly sequenced at Genotech Corporation (Yuseong-gu, Daejeon, Korea) and Macrogen (Geumcheon-gu, Seoul, Korea). Contigs were assembled using Geneious 11 (Biomatters, Auckland, New Zealand).

The barcodes were compared to two barcodes of the genus *Ceratosticha* downloaded from Genbank (National Center for Biotechnology Information, USA, http://www.ncbi.nlm.nih.gov/) (Table 1). A neighbor-joining (NJ) was constructed using MEGA X (Kumar *et al.* 2018) based on the K2P model for nucleotide substitutions. Successful sequences were uploaded to BOLD systems (project CNTK) (Table 1).

TABLE 1. Species with DNA barcodes and BOLD systems and Genbank accession numbers used in this study.

Scientific name	Country	Sample ID (BOLD systems)	Accession number (GenBank, BOLD systems)	Number of basepairs
C. lineata **sp. n.**	Korea	CNTK2	**ADQ6602**	658
”	Korea	CNTK4	"	658
”	Korea	CNTK5	"	658
”	Korea	CNTK6	"	658
”	Korea	CNTK8	"	658
”	Korea	CNTK11	"	658
”	Korea	CNTK12	"	658
”	Korea	CNTK13	"	658
”	Korea	CNTK14	**ADP6727**	658
Ceratosticha leptodeta Meyrick, 1935	Korea	CNTK1	"	658
”	Korea	CNTK3	"	658
”	Korea	CNTK7	"	658
”	Korea	CNTK9	"	430
”	Korea	CNTK10	"	430
”	Japan	-	LC094177	565
Ceratosticha sp.	Japan	-	LC094185	665

Results

Ceratosticha Meyrick, 1935

Ceratosticha Meyrick 1935: 580.
Type species. *Ceratosticha leptodeta* Meyrick, 1935: 580.

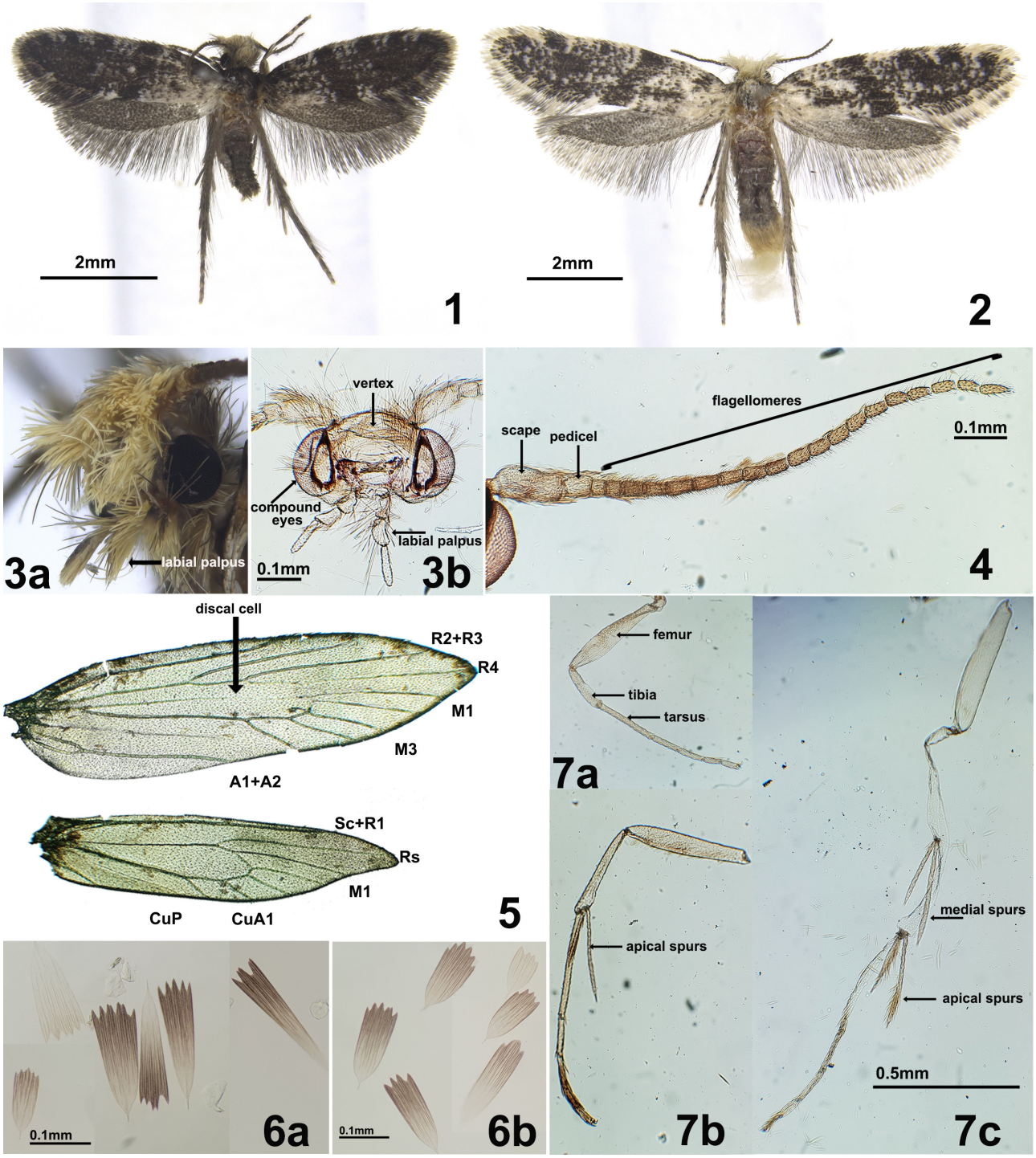
Ceratosticha lineata Roh & Byun, sp. n.

Figs. 1–13
urn:lsid:zoobank.org:pub:2A86F40D-4308-4116-8F42-118362FADD3B

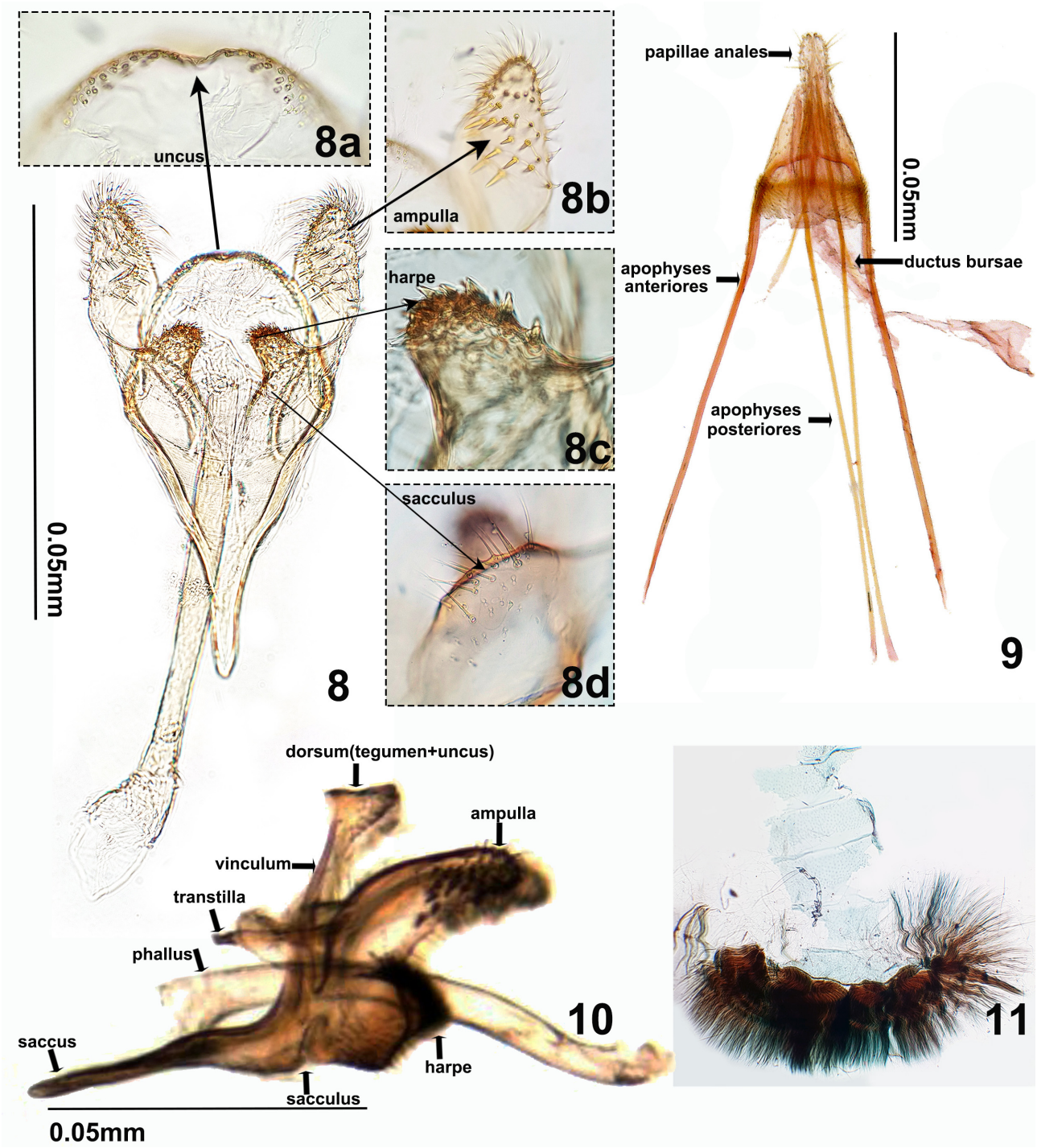
Type material. Holotype: ♂, KOREA: Ulsan, Ulju-gun, 19.iv.2018, 35.61522778, 129.172925, 536 m, leg. D.S. Kim, emerged 18.vi.2018, genitalia slide no. KNAESJ52, BOLD systems DNA Specimen ID: CNTK12 (SEL/HNU).

Paratypes: 1♂, 5♀, same locality as holotype, emerged 18.vi–6.vii.2018. 1♂, 4♀, Sileuksa, Yeoju-si, Gyeonggi-do, 24.iv.2018, 37.29758611, 127.6616861, 57 m, leg. J.W. Jo, emerged 12.vi–2.vii.2018, BOLD

systems DNA Specimen ID: CNTK11, CNTK13, CNTK14. 11♂, 10♀, Naeryeong-ri, Namwon-si, Jeollabuk-do, 4.vi.2015, leg. B.K. Byun, S.J. Roh, B.S. Jeon, emerged 5–15.vi.2015, 35.39920833, 127.601575, 423 m, genitalia no. KNAESJ47, KNAESJ50, KNAESJ56 (in 80% glycerol), wing venation no. KNAEVSJ22, KNAEVSJ25, KNAEVSJ26, scales of wing no. KNAESSJ14, BOLD systems DNA Specimen ID: CNTK4, CNTK5, CNTK6. 29♂, 72♀, Haemi-castle, Seosan-si, Chungcheongnam-do, 1.v.2015, 36.71184722, 126.5470167, 36 m, S.J. Roh, B.S. Jeon, D.S. Kim, emerged 6–22.vi.2015, genitalia no. KNAESJ44, KNAESJ49, KNAESJ54, KNAESJ55 (in 80% glycerol), wing venation no. KNAEVSJ21, KNAEVSJ23, KNAEVSJ24, scales of wing no. KNAESSJ13, KNAESSJ15, Specimen ID: CNTK2 (SEL/HNU).



FIGURES 1–7. Morphological features of adults. 1, Male, paratype; 2, Female, paratype; 3, Head, paratype (a, lateral view of male head; b, anterior view of female); 4, Antenna of female, paratype; 5, Wing venation, paratype (slide no. KNAEVSJ22); 6, Wing scales (a, forewing scales; b, hindwing scales, slide no. KNAESSJ13); 7, Legs (a, foreleg; b, midleg; c, hindleg).

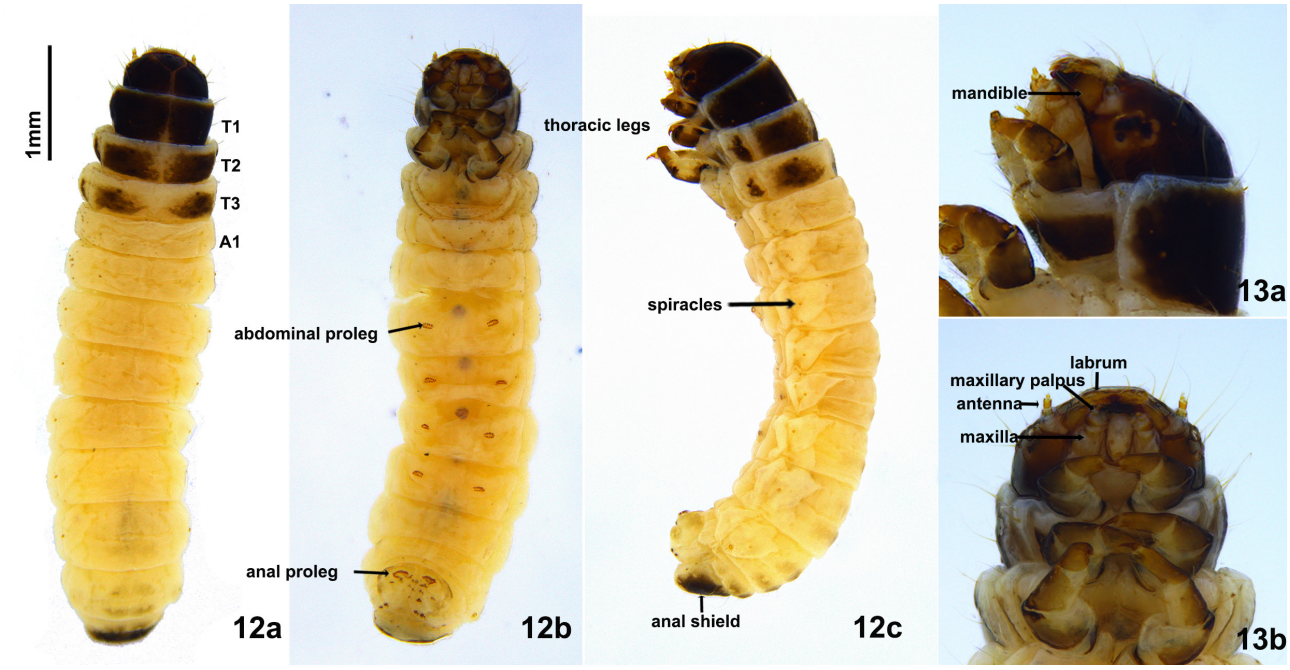


FIGURES 8–11. Genitalia. 8, Male, holotype (a, uncus; b, ampulla of valva; c, harpe; d, sacculus, slide no. KNAESJ52); 9, Female, paratype (slide no. HNU5200); 10, Male, lateral aspect, paratype; 11, Abdominal segment seven with dense long hairs (corethrogyne, slide no. KNAESJ 44).

Other material. 1 larva (in 90% ethanol): Haemi-castle, Seosan-si, Chungcheongnam-do, 1.v.2015, 36.71184722, 126.5470167, 36 m, leg. S.J. Roh, D.S. Kim, B.S. Jeon, T.H. Yoo, BOLD systems DNA Specimen ID: CNTK8. 1 larva (in 90% ethanol): Sileuksa, Yeoju-si, Gyeonggi-do, 24.iv.2018, 37.29758611, 127.6616861, 57 m, leg. J.W. Jo (SEL/HNU).

Diagnosis. This species is similar to *C. leptodeta* Meyrick, but it can be distinguished by the conspicuous, dark-brown submedian fascia of the forewing in both of the male and female, and the blackish brown ground color of the hindwing in the male. The male genitalia of *C. lineata* are very similar to those of *C. leptodeta*, but the

phallus is longer and slenderer. Moreover, the male genitalia (lateral aspect) differ by having a slightly narrower dorsum and a downward curved posterior margin of the ampulla.



FIGURES 12–13. Morphological features of larva. 12, Larva (a, dorsal aspect; b, ventral aspect; c, lateral aspect); 13, Head and thorax (a, lateral aspect; b, ventral aspect).

Description. Adult. Male (Fig. 1). Head (Fig. 3): Small, sclerites light brown; vertex densely clothed with yellowish gray hairs; compound eyes large; interocular index 0.85–0.90 mm; ocelli absent; labial palpus short, three-segmented; antennae (Fig. 4) filiform, with 19 flagellomeres, less than 0.4 forewing length, scape rough, covered with long hairs. Thorax: Light brown; notum covered with brownish black scales. Legs with femora, tibiae, and tarsi clothed in long brown hairs; tarsi and apical and medial spurs covered in shiny brown scales; epiphysis absent (Fig. 7a). Wingspan 7.6–8.2 mm. Forewing (Fig. 5) short and narrow, L/W ratio 3.35, costa straight, gently curved beyond 0.8 length, apex slightly pointed; termen short and arched to posterior margin, discal cell 0.63 times as long as wing, 8 separate veins originating at discal cell; accessory and intercalary cells absent; Sc terminating at 0.6 length of costa; R_2 + R_3 fused, originating at distal corner of anterior part of discal cell; R_4 originated at corner of anterior part of cell, reaching apex; R_5 absent; M_1 and M_2 parallel; M_2, M_3 originating at distal corner of posterior part of discal cell; CuA_1 and CuA_2 parallel; basal part of A_1+A_2 looped. Upperside of forewing with ground color creamy-white with dark-brown overscaling; scales (Fig. 6) slightly narrowed; apical margin usually produced into four to seven weak rounded laciniations. Hindwing (Fig. 5) narrow, L/W ratio 4.6; costa straight, apex straightly curved to termen; median cell 0.58 times as long as wing; Sc+R_1 straight to 0.8 length of costa; Rs terminating at apex; M_1 and M_2 parallel to termen, M_2, M_3 originating at distal margin of discal cell; CuA_1 and CuA_2 parallel. Hindwing covered with dark-brown scales; postmarginal part with long brown hairs. Abdomen: Male genitalia (Figs. 8, 10) with dorsum narrow; posterior margin of ampulla arched, club-shaped, with sparse short setae and small projection; harpe rectangular with small projection; transtilla short; vinculum slightly narrowed; saccus long and slender, 0.92 times height of ring. In dorso-ventral aspect, uncus concave; gnathos and juxta absent; valva somewhat long and wide; phallus slender, long, 0.95 times height of genitalia.

Female (Fig. 2). Head: Vertex densely clothed with whitish tufted hairs. Thorax: Notum covered with white hairs. Wingspan 8.1–10.0 mm. Upperside of forewing with ground color whitish gray. Hindwing covered with light brown scales; long white hairs on postmarginal part. Corethrogyne densely clothed with yellowish hairs. Abdomen: Female genitalia (Figs. 9, 11) with papillae anales slightly narrowed, apical part concave with short setae. Apophyses posteriores thick, 1.27 times length of apophyses anteriores. Ductus bursae well sclerotized.

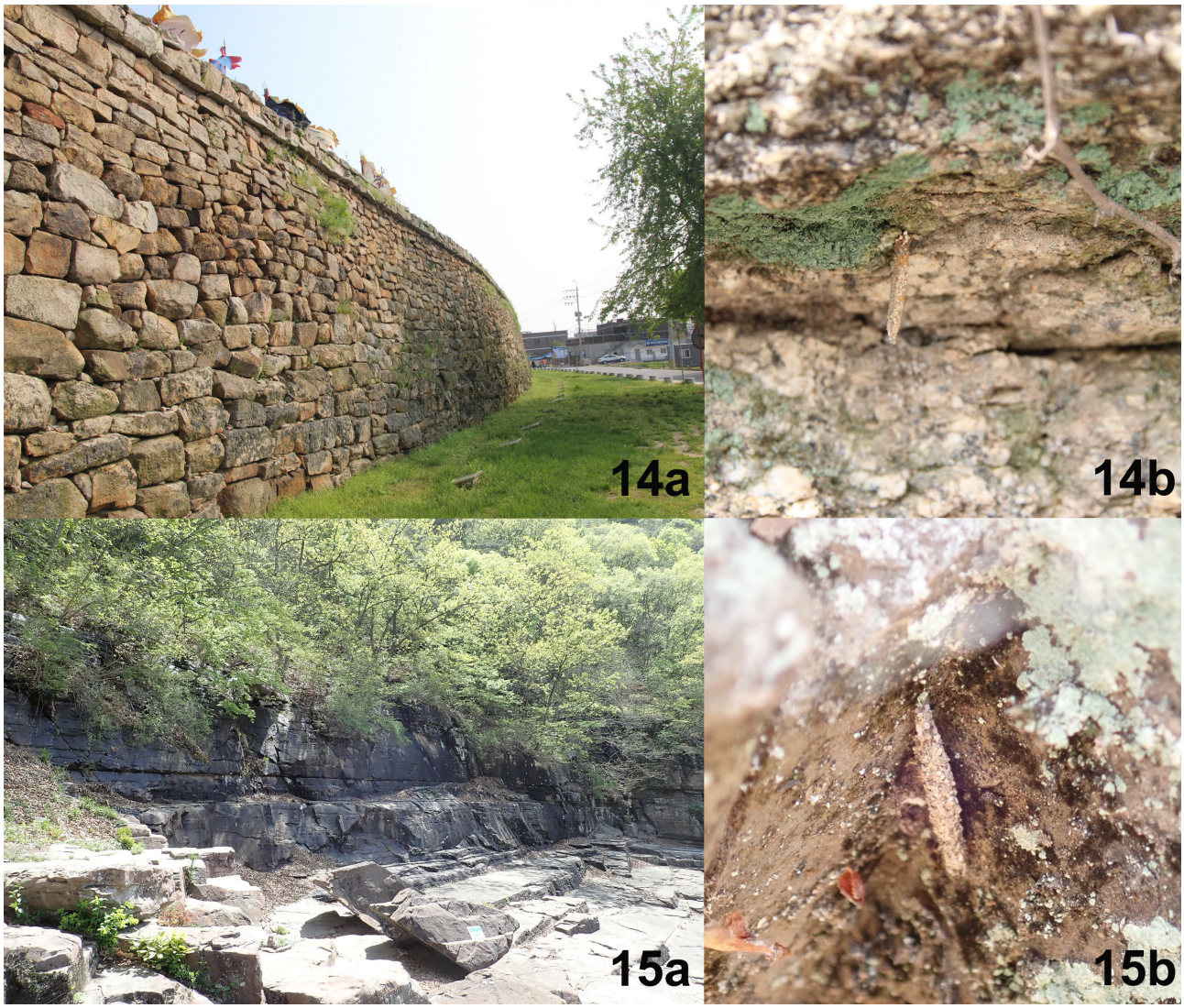
Larva (Figs. 12, 13). Length 4.9 mm. Head slightly enlarged, dark brown, labrum narrow, brownish yellow, epicranial notch weak, concave; antenna very short. Dorsal aspect of thorax dark brown, prothoracic shield well

sclerotized, thoracic legs short, brown. Abdomen yellow, anal shield dark-brown. Abdominal and anal prolegs reddish brown; abdominal prolegs and anal proleg very short. Anal shield weak sclerotized. Crochets in two parallel rows perpendicular to long axis of larva.

Larval case (Figs. 14b, 15b). Length 7.5–10.5 mm. Consisting of the tiny particles of sand held together with silk.

Distribution. Korea.

DNA barcodes. DNA barcode sequences were obtained from nine specimens of *Ceratosticha lineata* and four specimens of *C. leptodeta* Meyrick. The DNA barcodes were compared to those of two Japanese specimens (*C. leptodeta* Meyrick and *Ceratosticha* sp.) downloaded from Genbank. The barcodes of *C. lineata*, *C. leptodeta*, and *Ceratosticha* sp. were analyzed using a neighbor joining tree (Fig. 16). Interspecific pairwise genetic distance ranged from 11.32 to 9.78% among the three species. The maximum intraspecific variation ranged from 1.87 to 0.56% (Table 2).



FIGURES 14–15. Microhabitat and larval cases. 14, Microhabitat in ramparts (Korea, Haemi-castle, Seosan-si, Chungcheongnam-do, 1.v.2015, 36.71184722, 126.5470167, 36 m); 15, Microhabitat in valleys (Korea, Ulsan, Ulju-gun, 19.iv.2018, 35.61522778, 129.172925, 536 m).

Etymology. The specific name is derived from the Latin *lineata* (= line), referring to the forewing pattern.

Remarks. Larvae of this species construct cases of tiny particles of sand. They were found in wet conditions between rocks or gaps in ramparts, stone pagodas, etc. (Figs. 14, 15). Adults emerged from late May to early July. The 134 larvae collected during this project produced 91 females and 43 males.

TABLE 2. Kimura 2-parameter distances for DNA barcode sequences of the 16 speciemens in genus *Ceratosticha*. Pairwise distances between species are given for each species pair.

Scientific name	Intraspecific pairwise	Interspecific pairwise
C. lineata **sp. n.**	0.00–1.87	10.82–11.32
C. leptodeta Meyrick	0.00–0.56	9.78–11.32
Ceratosticha sp.	-	9.78–10.82

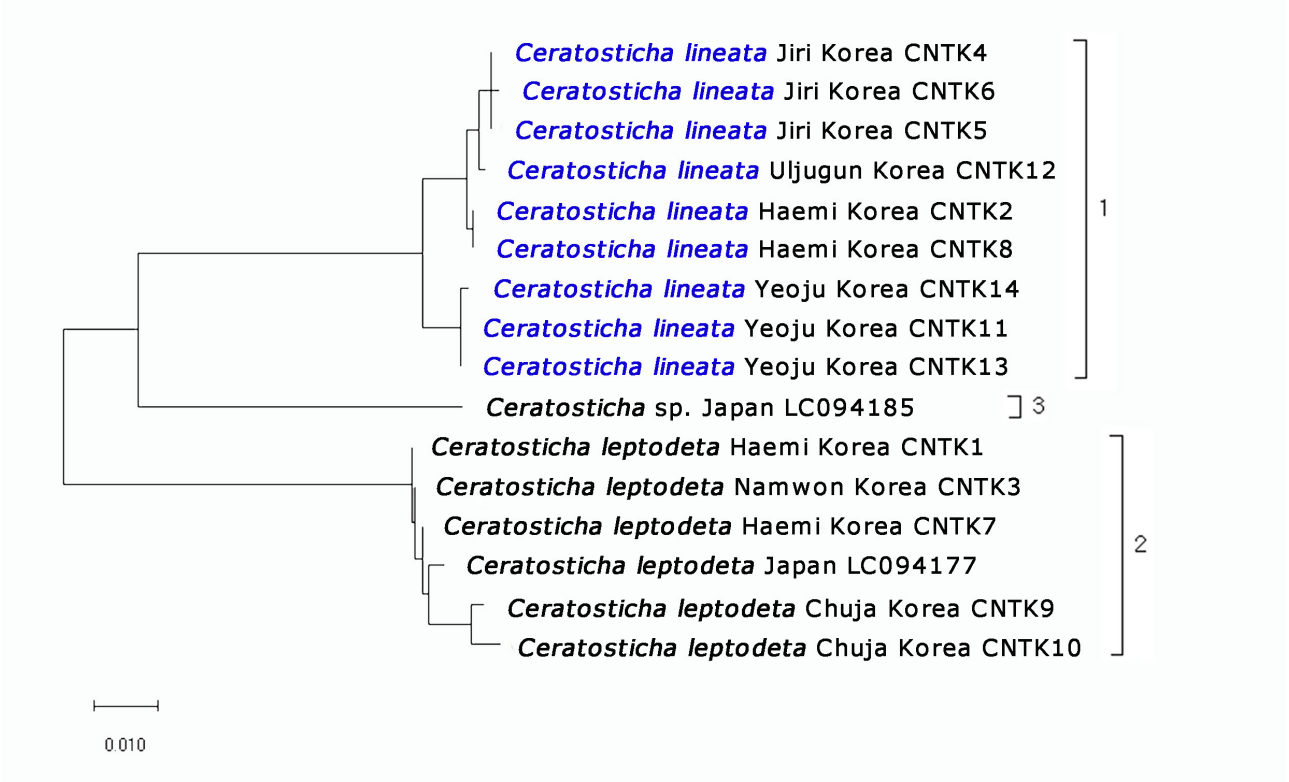


FIGURE 16. Neighbor-joining tree for three species of *Ceratosticha*. Branch lengths represent the number of substitutions per site as percentage.

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