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Original Article

Morphological characteristics and DNA barcode of *Leptaulax koreanus* Nomura, Kon, Johki & Lee (Coleoptera, Passalidae), an endemic species of Korea

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ABSTRACT

Leptaulax koreanus (Nomura, Kon, Johki & Lee), an endemic species of Korea, inhabits only in the Gwangneung Forest in Pocheon, Gyeonggi-do. It was reported as a new species in 1993 by Nomura et al. In this study, its external morphological features were investigated and described, and its DNA barcode was obtained and presented as part of the basic research for the conservation of this species.

Introduction

The family Passalidae is taxonomically classified into Insecta, Coleoptera, and Scarabaeoidea, and about 640 described species have been reported worldwide (Reyes-Castillo et al 2005; Reyes-Castillo and Jimenez-Ferbans 2016). They mostly inhabit tropical regions and mainly act as decomposers, consuming the cambium in the sapwood of dead timber in a climax forest (Arnett et al 2002). Passalidae is considered an indicator species of a climax forest in a forest transition (Choi 2015).

The *L. koreanus*, which is an endemic species of Korea, is known to inhabit only Gwangneung Forest in Pocheon, Gyeonggi-do (Ministry of Environment 2005). The species has a limited habitat and is vulnerable to environmental change. Thus, it is highly likely to become extinct, if not protected. Hence, there is a need to study the conservation of *L. koreanus.*

This study was carried out to understand the ecological interactions of *L. koreanus* in relation to its development by rearing it under laboratory conditions, to generate the basic data necessary for establishing its conservation measures.

Materials and methods

Collecting

To investigate the external morphological characteristics and the developmental characteristics of *L. koreanus*, a total of 150 adults were collected at six times from June 2015 to March 2016 in Gwangneung Forest in Pocheon, Gyeonggi-do (Figure 1). They were not attracted to light or cup traps, and thus, a hand axe was used for the collection after visually checking the dead timbers. Materials examined in this study are now preserved in the Systematic

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Investigation of morphological characteristics of L. koreanus

A stereoscopic microscope (Nikon C-LEDS, Nikon Co., China) was used to observe the specimens and their genitalia, and a DSLR camera (Canon EOS 600D, Canon Inc., Japan) and a Z-stack program (Z-Stack Combine System, Delta Bio, Korea) were used to obtain photographs of the specimens. The size of each part of the adult was measured using Vernier Calipers (M500-182M, Hando, China), and their microstructures were photographed using a stereoscopic microscope (Leica M205 C, Leica Co., Singapore). Also, the term of morphological description was followed as the method by Cano (2014) in this study.

DNA barcoding

In this study, COI gene of *L. koreanus* was extracted for DNA barcoding. Protocols was followed as Canadian Center for DNA Barcoding (Biodiversity Institute of Ontario, University of Guelph) and the LCO1490/HCO2198 (Folmer et al 1994) primer were used for amplification of mtDNA. Also, the LCO1490F/MHem_R1 and MHemF1/HCO2198R were used for mini barcode. Polymerase chain reaction condition is as follows: at 94°C for 5 min, 5 cycles of 94°C at 30 s/45°C at 30 s/72°C at 1 min, 40 cycles of 94°C at 30 s/51°C at 30 s/72°C at 1 min, and 72°C at 7 min.

Contig assemblies were checked in visual for errors with CodonCode Aligner version 2.0.6 (CodonCode Co., Centerville, MA, USA) after the amplification.

Results

Collection survey of L. koreanus

Since the first report of *L. koreanus* in Gwangneung Forest by Nomura et al (1993), this species was not reported from anywhere else except for Gwangneung Forest.

From May 2015 to September 2016, a total of 32 habitats of *L. koreanus* were identified in Gwangneung Forest through a collection survey. It was found widely distributed on Mt. Yongam connected to Soribong, an area under the control of the Korea National Arboretum, behind the Forestry Production Technology Institute (Figure 2).

Also, two specimens of *L. koreanus* were collected in the areas ranging from Naegok-ri, Jinjeop-eup to Jeondochi hill in Namyangju, which is near the Gwangneung Forest.

Morphological characteristics of L. koreanus

Adult. (Figures 3–6) The adult *L. koreanus* is 21.86–24.21 mm long and is morphologically flat as an adaptation to fit into the narrow spaces under the barks of dead timbers. It has a glossy black body, short and thick mandibles, one interior tooth, clypeus with dense, yellowish brown hair, and frons with a very complex shape and a well-developed denticle. The antenna club has three segments, and compound eyes are located on both sides of the head. The ocular canthus is thick and extends up to one-third of the compound eyes. The pronotum has a smooth surface and a deep groove vertically in the center, with multiple punctures on both sides. The femurs are thick and well developed, and the hind legs are comparatively small. The elytra have multiple well-developed strias from the upper part to the lower part. The elytra were further identified to have fine line-up punctures. The inner surface of the elytra also has numerous, fine, irregularly arranged punctures (Table 1 and Figure 4).

The hindwing is made of a thin membrane and has a structure that can be folded once at the one-third position of the cubital vein (arrow). When the wing is not spread, it is folded under the elytra (Figure 6)

Male genitalia. Male genitalia are round, about 2 mm, small, covered with thin membranes with the sides slightly curved (Figure 7).

Larvae. The larvae of *L. koreanus* were found to pass through three instars. The color of the larvae is milky white, and the

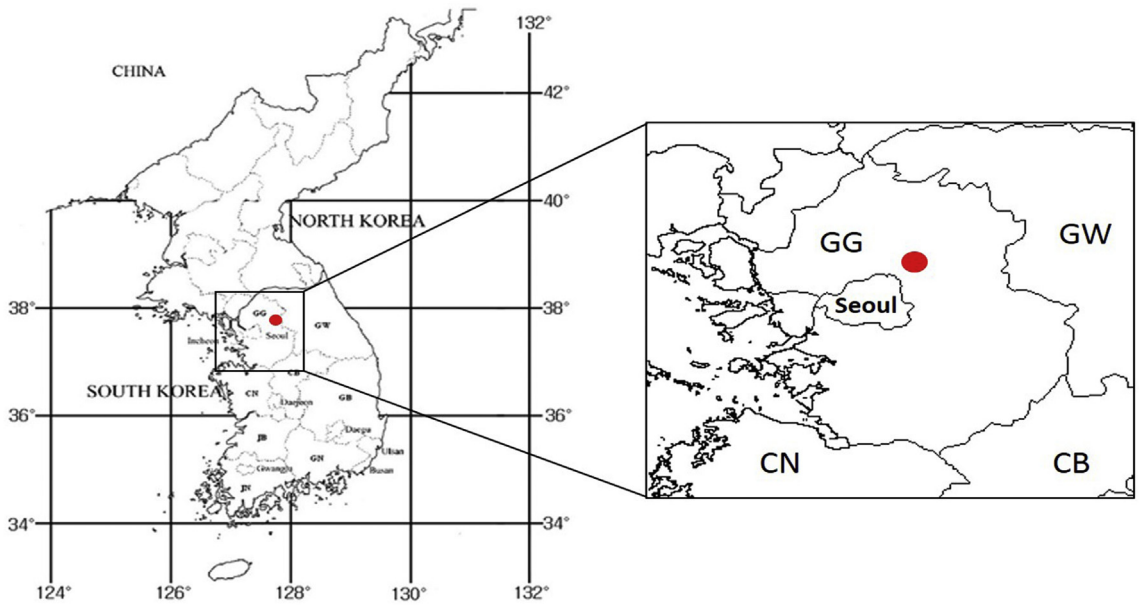

Figure 1. Distribution map of *L. koreanus* in Korea.

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