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Taxonomic review of the genus *Zeiraphera* Treitschke (Lepidoptera: Tortricidae) in Korea, with description of a new speciesSat-Byul Shin<sup>a</sup>, Bong-Kyu Byun<sup>b,\*</sup><sup>a</sup>Natural Environmental Restoration Institute, Daejeon, South Korea<sup>b</sup>Department of Biological Science and Biotechnology, Hannam University, Daejeon, South Korea

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## ABSTRACT

This study was carried out to review the genus *Zeiraphera* in Korea. In this study, a total of eight species of the genus *Zeiraphera*, belonging to the tribe Eucosmini, were recognized from Korea, with description of a new species, *Zeiraphera subvirinea* sp. nov. The wing patterns, and male and female genitalic structures for the known species of the genus are examined and redescribed. Key for the species is given. Known food plants and life histories, when available, were reviewed and listed.

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## Introduction

The genus *Zeiraphera* belongs to the tribe Eucosmini, which is the second largest tribe in the subfamily Olethreutinae under the family Tortricidae with more than 1600 described species of 116 genera worldwide (Brown 2005). As we well know, the family Tortricidae comprises small to medium-sized moths. Due to their unique sitting posture, they are called as bell moths.

The members of the genus *Zeiraphera* have a wide host ranges, mainly *Quercus* sp. (Fagaceae), *Abies* sp. (Pinaceae), and various coniferous trees (Bradley et al 1979; Ford 1949; Issiki and Mutuura 1961; Liu and Pai 1977; Styles 1959; Suzuki and Komai 1984; Oku 1961). Their larvae tie needles or roll leaves of forest plants. They often attack the various plant species in forests and parks. For example, the Spruce bud moth, *Zeiraphera ratzeburgiana* (Saxesen 1840), is a notorious pest of coniferous trees, including *Picea sitchensis* (Bong) Carr., *Picea smithiana*, *Pinus sylvestris* (Wall.) Boiss., *Pinus pinea* (Linn.), and *Abies cephalonica* (Loudon), from Europe to East Russia. The larvae penetrate into the buds, feed on the needles, and move onto the growing point. Females sometimes attack the blossom, causing severe damage to the young cone (Carroll et al

1993). The members of the genus usually have one generation a year and hibernate in the egg stage (Medvedev 1987).

The first record of the genus *Zeiraphera* in Korea was *Zeiraphera griseana* (Hübner), which was listed in the “List of Forest Insect Pests in Korea” (Ko 1969). Park (1983a,b) made a list with only one known species from Korea. Park and Ahn (1987) reported a newly recorded species from Korea, *Zeiraphera fulvomixtana* Kawabe. Byun and Park (1992) added a species, *Zeiraphera virinea* Falkovitsh as new to Korea. Recently, Byun (2011) reported a species, *Zeiraphera lariciana* Kawabe, 1980, for the first time from North Korea, based on the material of Hungarian Natural History Museum, Budapest, Hungary (HNHM). Later, Byun et al (2014) added a newly recorded species, *Zeiraphera subcorticana* (Snellen 1883), and the genus comprising seven species from Korea was known to date. However, there is no comprehensive review of the genus to date. Therefore, this study was aimed to clarify the fauna of the genus in Korea and enumerate them with taxonomic arrangement and all available material with data.

In the present study, the genus *Zeiraphera* in the Korean peninsula was critically reviewed with a description of a new species. In addition, the North Korean material of the genus was examined, based on the material of HNHM, when the second author visited HNHM in 2006.

In this paper, a total of eight species are recognized from Korea, including a new species. All the known species are enumerated

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with illustration of available adult, male, and female genitalia, providing the identification keys.

## Materials and methods

Most specimens examined herein were collected mainly by light traps or sweeping nets in the field and are now preserved in the entomological collection of Department of Biological Science & Biotechnology, Hannam University, Dajeon, Korea (EHNU). Besides the specimens collected, all available specimens in the main collections of Korea National Insect Collection, Korea National Arboretum, Pocheon, Korea (KNIC); National Academy of Agricultural Science, Wanju, Korea; Center for Insect Systematics, Kangwon National University, Chuncheon, Korea (CIS/KNU); and HNHM were also examined.

For the morphological examination, external characters including head, thorax, wing pattern, venation, and genitalia of both sexes were carefully examined with a stereomicroscope (ZEISS 2000-C, Carl Zeiss AG, Göttingen, Germany). All the known taxa from Korea are redescribed and revised with recent taxonomic treatment, including their distributional range, localities of each species, and biological information.

Dissection and slide mounting methods for genitalia were similar to those of Holloway et al (1987). Characters of the genitalia and wings were examined with a stereomicroscope (Leica M205 A, Leica Microsystems GmbH, Wetzlar, Germany) at 7.8–160×.

## Taxonomic accounts

Order Lepidoptera Linnaeus, 1758

Family Tortricidae Latreille, 1803

Subfamily Olethreutinae Walsingham, 1895

Genus *Zeiraphera* Treitschke, 1829

Type species: *Tortrix corticana* Hübner, [1813]

= *Sinusia* Caradga, 1916: 61.

= *Charlotta* Forbes, 1923: 379.

Antenna with scales on dorsal and ventral parts of the flagellum, vertex with slightly regular short and long scales. Labial palpus curved upward slightly, broadened medially, narrowed beyond middle to top. Forewing with discal cell divided by R and M. Valva elongate with numerous setae along the costa and ventral margin, cucullus covered with numerous setae. Basal projection of valva biramose. Holarctic in distribution, species diverse in East and Southeast Asia (Medvedev 1987).

### Keys to the species of the genus *Zeiraphera* in Korea

The following key was slightly modified after Bae et al (2012).

- (1) Forewing with large whitish marking on dorsum.....  
     ..... *Z. subcorticana* (Snellen 1883)  
     - Forewing with not large whitish marking on dorsum..... 2
- (2) Forewing with large whitish marking near costa.....  
     ..... *Zeiraphera demutana* (Walsingham 1900)  
     - Forewing without large whitish marking near costa..... 3
- (3) Forewing ground color not mixed with greenish scales.....  
     ..... 4  
     - Forewing ground color mixed with greenish scales..... 6
- (4) Forewing ground color of forewing gray or whitish sprinkled and suffused gray .....  
     ..... *Z. griseana* (Hübner 1799)

- Forewing ground color not suffused gray color..... 5
- (5) Forewing ground color dark yellowish green in male, more tinged with yellowish orange in female.....  
     ..... *Z. fulvomixtana* Kawabe, 1974  
     - Forewing ground color of forewing with ochreous suffusions..... 7
- (6) Forewing with medial area dark brownish triangle.....  
     ..... *Z. virinea* Falkovitsh, 1965  
     - Forewing with thick tornal dash dark brownish, apex blackish brown dot.....  
     ..... *Z. subvirinea* sp. nov.
- (7) Ground color of forewing creamy, slightly glossy, with pale ochreous suffusions and similar or brownish strigulation.....  
     ..... *Zeiraphera rufimitrana* (Herrich-Schäffer 1847)  
     - Forewing ground color deep ochreous suffusions and antemedial area dark brown.....  
     ..... *Z. laricana* Kawabe, 1980

***Zeiraphera demutana* (Walsingham 1900)** 참나무애기잎말이나방  
*Crocidosema demutana* Walsingham, 1900: 441. TL: Japan.  
*Zeiraphera demutana*: Byun et al, 1996: 194–196.

**Adult** (Figure 1A). Wingspan 16–20 mm. Antenna dark brown. Head creamy white; vertex covered with rough scale light yellow. Labial palpus white; median segment dark brown with rough scales apically, and outer surface irrorated with grayish brown. Forewing rectangular, with creamy ground color, with the exception of patch area dark brown color. From apex to costal margin with short string of white, large whitish ellipse near costa. Basal area greenish white, inner margin of medial area white patch with claviform dark brown spot. Hindwing yellowish brown.

**Male genitalia** (Figure 2A). Uncus short, triangular, apex emarginated terminally. Socii broad and drooping. Gnathos weakly sclerotized. Valva slender, curved, with long scale-like hairs on its outer surface; sacculus narrow with rough hairs; cucullus long, roundly prominent, narrow before apex. Aedeagus broad and short; comuti a bunch of numerous transparent spines.

**Female genitalia** (Figure 3A). Papillae anales flat, oblong with long and short hairs. Apophyses posteriores two times as long as apophyses anteriores. Sterigma cup shaped. Ductus bursae with sclerotized area near sterigma. Corpus bursae with two signa very well sclerotized, conical.

**Material examined.** <S. Korea> [Gyeonggi-do (GG)] 1♀, Gwanggleung, 8 VII 1992 (K.T. Park and B.K. Byun), gen. slide. no. CIS/3345-coll. KNIC; 1♂, Gwangrung, GG, 27 VI 1986 (M.K. Ko), gen. slide. no. CIS/3791; 1♀, Mt. Godae, Yeoncheon-gun, 11–12 VII 2000 (Paek et al), gen. slide. no. HNU/5063; 1ex, Mt. Kalbong, Gapyeong, 9 VII 2011 (B.W. Lee)-EHNU. [Gangwon-do (GW)] 1♂, Seomyun, Yagyang, GW, 10 VII 1987 (K.T. Park), gen. slide. no. HNU/5051-coll. KNIC.

**Distribution.** Korea (South), Japan, China.

**Host plant.** Unknown in Korea.

**Remarks.** This species was first reported by Byun et al (1996) from South Korea.

***Zeiraphera fulvomixtana* Kawabe, 1974** 좁은날개애기잎말이나방  
*Zeiraphera fulvomixtana* Kawabe, 1974: 98. TL: Japan (Doaiguchi).  
*Zeiraphera fulvomixtana*: Park and Ahn, 1987: 182.

**Adult** (Figure 1B). Wingspan 16 mm. Head, antenna, and palpus pale. Labial palpus with long dark yellow ventral scales, dark brown scales medially. Forewing with ground color dark yellow, a round creamy spot on 3/4 of costa. Apex with a circular dot, light brown color. Inner margin at antemedial area dark brown small dot. Medial area with meniscoidal sculpture, dark brown. Termen at

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