

A Review of the Genus *Grapholita* (Lepidoptera, Tortricidae) in North Korea

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ABSTRACT

In North Korea, the first report of the family Tortricidae, comprising 34 species, was made in 1969. It includes three species of the genus *Grapholita* (*G. inopinata*, *G. molesta*, and *G. turionana*). Among them, *G. turionana* is now placed under the genus *Blastesthia*. In the present study, a total of four species of the genus *Grapholita* are recognized from North Korea, based on material deposited in the Hungarian Natural History Museum, Hungary. Of them, *Grapholita molesta* (Busck), is reported for the first time from North Korea. In the present study, *G. inopinata* was not found. All the known species are enumerated with illustrations of adults and genitalia. Also a key for the genus is given.

Keywords: *Grapholita*, Tortricidae, Lepidoptera, taxonomy, Korea

INTRODUCTION

Genus *Grapholita* was established by Treitschke in 1829 based on *Tortrix lunulana* [Denis & Schiffermüller], 1775, and is comprised of more than 125 described species worldwide (Brown, 2005). It has been known as a serious agricultural pest, especially *G. molesta* (Busck), which attacks apples and allied plants as an internal and external feeders (Bae and Park, 1997). In Korea, Bae and Park (1997) reviewed seven species of *Grapholita* from the southern part of the Korean peninsula. However, it has been very poorly studied in North Korea to date.

In North Korea, the first report of the family Tortricidae, comprising 34 species, was made by Zhu (1969). It includes three species of the genus *Grapholita* (*G. inopinata*, *G. molesta*, and *G. turionana*). Among them, *G. turionana* is now placed under the genus *Blastesthia* by Brown (2005).

Later, Park and Byun (1991) reported 26 species of the family Tortricidae from North Korea, with the material deposited in the Hungarian Natural History Museum, Budapest, Hungary (HNHM). However, there was no additional species for the genus in their report.

Jaros et al. (1992) reported 28 new records of Tortricidae

from Korea, based on the material Czech Academy of Sciences, Prague, Czech Republic (CAS). Byun et al. (1998) enumerated 350 species of Korean Tortricidae, citing 63 species of Tortricinae and 40 species of Olethreutinae which had been identified in North Korea. Later Razowski (1999) provided a list of Korean Tortricidae with additional data, indicating 176 species of the Tortricidae from North Korea, based on previous reports and the specimens at Polish Academy of Sciences, Krakow, Poland (PAS). Despite these studies, only one species, *G. delineana*, was added by Razowski (1999). Also, several reports on North Korean Olethreutinae were presented recently, based on the material of HNHM (Byun, 2009, 2011a, 2011b, 2011c). But there has been no further study on the tribe Grapholitini after Razowski (1999). Consequently, three species of the genus were known from North Korea, but there are no previous reports with detailed information on this matter.

Although *Grapholitha inopinata* (Heinrich) was listed in North Korea by Zhu (1969), which might be cited after Danilevsky and Kuznetsov (1968), we could not find this material during the course of this study. The aim of the present study is to review the genus *Grapholita* of North Korea, based on the material deposited in HNHM, in order to update

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our knowledge of the fauna of Tortricinae of North Korea using recent data. All the examined material for each species is enumerated, with localities and available information, including distributional ranges and host plants.

MATERIALS AND METHODS

Material examined in this study was based on the collection in the HNHM. Genitalia of the species were mounted in Euparal media. Images were captured using an iCM 3.0 IMT i-Solution Inc. digital camera (Vancouver, Canada) attached to a Nikon MMZ 800 microscope (Yokohama, Japan). The color standard for the description of adults was based on the Menthien Handbook of Colour (Kornerup and Wanscher, 1978). Abbreviation used in this study is as follows: TL, type locality; GS, genitalia slide number.

SYSTEMATIC ACCOUNTS

Order Lepidoptera Linnaeus, 1758
 Family Tortricidae Latreille, 1803
 Genus *Grapholita* Treitschke, 1829

Grapholita Treitschke, 1829: 232. Type species: *Tortrix lunulana* [Denis & Schiffermüller], 1775=*Pyralis dorsana* Fabricius, 1775.

The genus *Grapholita* can be separated from the other related genera of the tribe Grapholitini by combination of the following characters: Coremata well developed by two lateral clusters of long scales on membrane between abdominal segments VIII–IX in male; ductus bursae of female genitalia with well sclerotized cingulum in form of angular plate or short conical structure (Bae and Park, 1997).

Key to the genus *Grapholita* Treitschke in North Korea

1. Head ochreous, vertex brownish gray, suffused with dark gray. Dorsal blotch of forewing distinct, consisting of two pairs of long striae *G. delineana*
- Head with vertex dark gray or fuscous. Dorsal blotch of forewing indistinct, with no two pairs of long striae; variation present in hindwing 2
2. Hindwing in male slightly concaved near dorsum at lower termen *G. dimorpha*
- Hindwing in male not concaved, with large, grayish pale-yellowish brown patch in outer area near termen *G. molesta*

Grapholita delineana Walker (Figs. 1A, 2C)

Grapholita delineana Walker, 1863: 389. TL: China.
Grapholita apicatana Walker, 1863: 390.
Grapholita sinana Felder, 1874: 11, Pl. 137, fig. 42.
Grapholita tetragrammana Staudinger, 1880: 259.
Grapholita mundana Christoph, 1881: 420.
Grapholita terstrigana Ragonot, 1894: 217.
Laspeyresia quadristriana Walsingham, 1900: 432.

Material examined. 1 ♀, Prov. South Pyongan, Bongwari, 45 km from Pyongyang, 16–17 Aug 1971, Harvatovich S, Papp J, GS 077; 1 ♀, Prov. South Pyongan, Pyongyang Hotel garden, 31 Aug 1971, Harvatovich S, Papp J, GS 079.

Description. Adult (Fig. 1A). Wingspan 11–12 mm. The species differs from others by the presence of four whitish parallel lines arising from the dorso-middle part of the forewing. It is one of the common species which is easily collected on *Humulus* spp. from May to September in Korea. Larvae bore into the stem and makes galls (Bae and Park, 1997). Moths usually fly at day time.

Female genitalia (Fig. 2C): Papillae anales narrow with numerous short hairs. Sterigma subquadrate in shape. Ostium bursae broad, rounded at entrance, funnel-like in outline. Ductus bursae as long as half of corpus bursae, wide in diameter, well sclerotized from entrance to middle, then slightly widened towards corpus bursae. Corpus bursae large, ovate, somewhat long, having two different signa: one with wide tongue-like and the other nail-shaped. Ductus seminalis ovate, balloon-shaped with a slightly narrow entrance, somewhat wider in diameter than ductus bursae, originating from before the entrance of corpus bursae.

Distribution. Korea (S, N), China, Taiwan, Japan, Russia (Far East), India (Assam), New Guinea, Iran, Europe.

Host plant. *Humulus japonicus* S. et Z., *H. lupulus* L., and *Cannabis sativa* L. (Cannabinaceae) (Park, 1983). *Cannabis sativa* L. (Cannabinaceae) (Liu, 1983). *Humulus scandens* (Cannabinaceae) (Liu and Li, 2002).

Remarks. It has two generations per year and hibernates as larva within cocoon in soil or between seeds. Generally one individual of larva is able to eat seven or eight immature seeds. Larvae attack *Cannabis sativa* L. seriously until early August (Liu, 1983). This species was listed by Razowski (1999) without enough information, including only one locality as Thesong (a lake near the district of Kanso). In this study, we provide more detail information for the species.

Grapholita dimorpha Komai (Figs. 1B, 2A)

Grapholita dimorpha Komai, 1979: 133, figs. 1, 2, 4, 6. TL: Japan (Honshu).



Fig. 1. Adults of *Grapholita*: A, *G. delineana*; B, *G. dimorpha*; C, *G. molesta*.

Material examined. 1♂, Prov. South Pyongan, Pyongyang, Hotel garden, 14 Aug 1971, Horvatovich S, Papp J, GS 085; 1ex, Prov. South Pyongan, Pyongyang, Hotel garden, 5 Aug 1971, Horvatovich S, Papp J.

Description. Adult (Fig. 1B). Wingspan 11–14 mm. This species is very similar to *G. molesta*, but it can be distinguished by the following characters: male with hindwing rather convex at tornal area; slightly arched costa of valve in male genitalia; VII sternite with convex caudal margin (Bae and Park, 1997).

Male genitalia (Fig. 2A): Uncus atrophied, somewhat narrowed terminally. Valva narrow, deeply concave at lower middle area, with costa gently curved downwards; cucullus soatulate, rather broad and rounded terminally, covering with numerous stout spines along lower marginal area; sacculus narrow, a bit thick bearing long hairs ventrally, with a wide semi-circle cavity basally. Aedeagus wide basally, slightly curved, narrowed terminally; cornuti with a series of short filiform thorns.

Distribution. Korea (S, N: new record), Japan.

Host plant. Japan: *Prunus salicina* Lindley and *Chaenomeles speciosa* (Sweek) (Rosaceae) in Japan (Komai, 1979).

***Grapholita inopinata* (Heinrich, 1928)**

Grapholitha inopinata Heinrich, 1928: 91, fig. a, b.

Material examined. Unknown.

Description. Wingspan, 10–11 mm. This species has been known as Northeast Asian species. In this study, we could not find its specimens from North Korea in HNHM.

Distribution. Korea (uncertain), China, Japan, Russia.

Host plant. *Malus pumila* M., *Pyrus* sp., *Crataegus pinnatifida* Bunge, *Malus asiatica* Nakai., *Malus baccata* B. (Rosaceae) (Liu, 1983; Liu and Li, 2002).

Remarks. It has two generations per year in China, and hibernates as matured larva between branches or stems. Adults emerge in late May to late June. Female adults lay eggs singly on each fruit. Eggs hatch in about 6 days. Newly hatched larvae feed into fruit, and thereby the injured area turns reddish brown. Larvae are fully grown after about 18 days. Mature larvae come out from fruit to find any gap to pupate by making a cocoon. Pupae emerge after 8–10 days. Moths appear from mid-July to mid-August. Larvae of second generation mature until late September and begin to hibernate (Liu, 1983; Liu and Li, 2002). During the course of the pre-

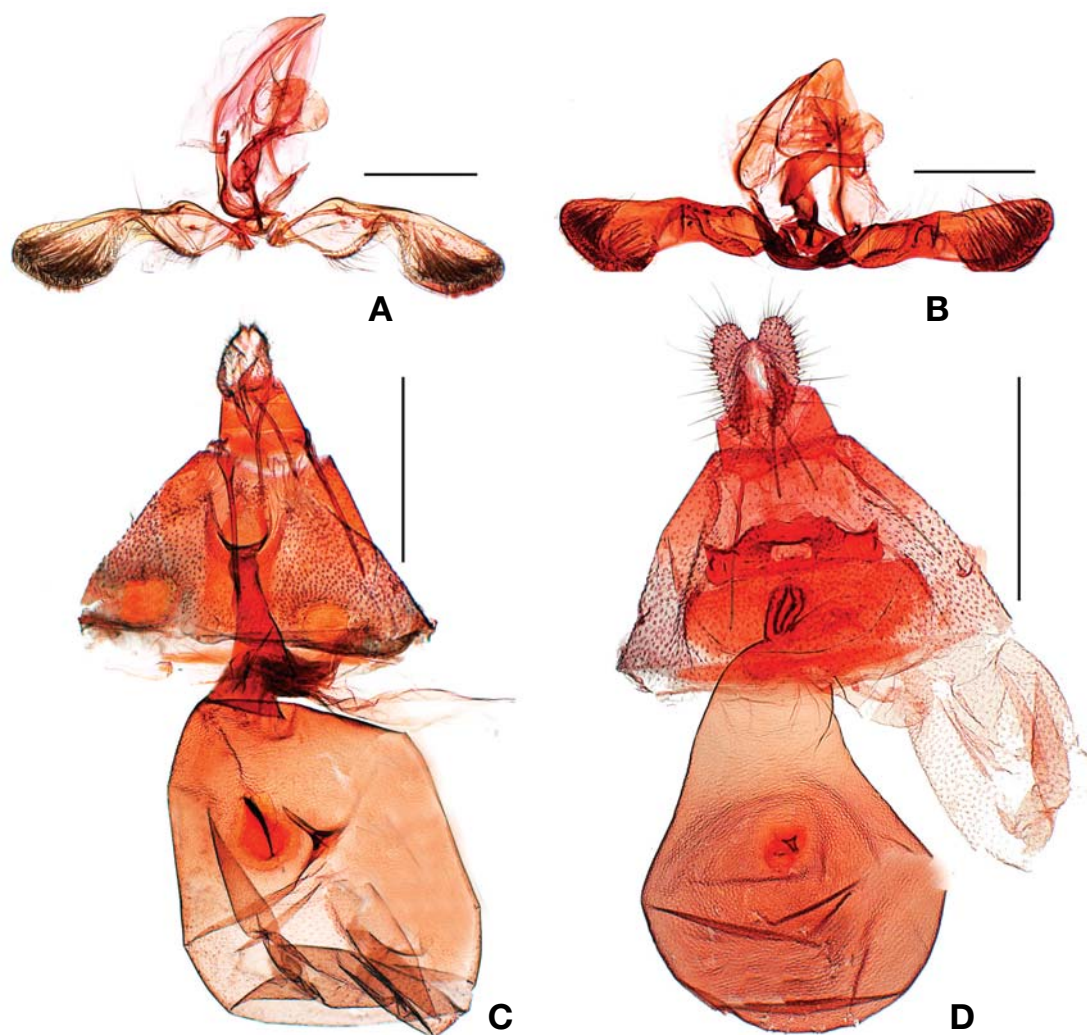


Fig. 2. Male and female genitalia: A, Male genitalia of *Grapholita dimorpha*; B, Male genitalia of *G. molesta*; C, Female genitalia of *G. delineana*; D, Female genitalia of *G. molesta*. Scale bars: A–D=0.5 mm.

sent study, no specimen in HNHM was found from North Korea.

***Grapholita molesta* (Busck) (Figs. 1C, 2B, D)**

Laspeyresia molesta Busck, 1916: 373. TL: America (Virginia).

Material examined. 1 ♀, Prov. South Pyongan, Pyongyang Hotel garden, 12 Aug 1971, Harvatovich S, Papp J, GS 017; 1 ♂, Prov. South Pyongan, Pyongyang, Hotel garden, 12 Aug 1971, Horvatovich S, Papp J, GS 076.

Description. Adult (Fig. 1C). Wingspan 12–14 mm. This species is one of the cosmopolitan species. It is quite similar externally, but can be distinguished by the hindwing with grayish pale-yellowish brown patch and straight costa of

valva in male genitalia.

Male genitalia (Fig. 2B): Uncus atrophied, somewhat pointed and slightly emarginated terminally. Valva narrow, strongly concaved at medio-ventral area, with costa nearly straight; cucullus spatulate, rather broad and rounded terminally, having stout spines along lower and lateral margin; sacculus narrow, weakly sclerotized. Aedeagus broader basally, slightly curved at middle, narrowed beyond middle; cornuti consisting of a series of short spines.

Female genitalia (Fig. 2D): Papillae anales broad, broader posteriorly. Apophyses anetriores as long as half of apophyses posteriors. Stergma large, strongly sclerotized, with two shortly projections post-laterally, slightly emarginated before these projections. Ostium bursae small, quadrate in outline. Ductus bursae very short, well sclerotized inside. Ductus

seminalis large, ovate, rather broad at entrance, originated from the entrance of corpus bursae. Corpus bursae large, pear shaped, with two small thorn like signa of differing size.

Distribution. Korea (S, N), China, Taiwan, Japan, Europe, America (North), Mexico, Australia.

Host plant. *Prunus persica* (L.) Batsch, *Malus pumila* M., *Prunus avium* L., *Prunus serrulata* var. *spontanea* W., *Pyrus serotina* R., *Prunus salicina* Lindley, *Prunus mume* S. et Z., *Prunus armeniaca* var. *ansu* Max., *Eriobotrya japonica* L., *Crataegus* sp. (Rosaceae), and *Diospyros kaki* T. (Ebenaceae) (Park, 1983). It can be categorized as three kinds due to its damaged part 1) *Myrica rubra* S. et Z., *Prunus persica*, *Prunus armeniaca* var. *ansu* Max., *Prunus* spp., *Rosa rugosa* T. (Rosaceae): new branch; 2) *Eriobotrya japonica*, *Malus pumila* M., *Prunus armeniaca* var. *ansu* Max., *Prunus persica*, *Prunus* spp., *Pyrus* sp. (Rosaceae): fruit; 3) *Eriobotrya japonica* (Rosaceae): dead branch (Liu, 1983).

Remarks. The species completes three or four generations a year in pear farms in China and overwinters as matured larva within a grayish white cocoon at base of trunks, fruit boxes, stones, and between bark. Female adults lay eggs beneath new leaves. Hatched larvae bore into new branches. Larvae of the second generation appear in July to August. In severe infestations, fruits may be surrounded by blackish frass, which is a specific symptom distinguished from other species (Liu, 1983; Liu and Li, 2002).

DISCUSSION

Genus *Grapholita* is one of the complex groups of Tortricidae. It has been well investigated in the southern part of the Korean peninsula (Bae and Park, 1997). However, it has been poorly studied to date in North Korea. Recently the author examined the materials of North Korea deposited in HNHM and reviewed the genus using all available specimens for the genus. Also, a little known species, *G. delineana*, and a newly recorded species, *G. molesta*, are documented in North Korea, including their taxonomic information, distributional ranges, and host plants with available data. In this study, four species were recognized from North Korea. However, *G. inopinata* is still doubtful. We could not find any specimen for the species during the course of the present study. It needs further study in the future, especially in terms of its distributional range in the northern part of the Korean peninsula.

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REFERENCES

- Bae YS, Park KT, 1997. Systematic study of the genus *Grapholita* Treitschke (Lepidoptera, Tortricidae) from Korea. Korean Journal of Biological Sciences, 1:539-547.
- Brown JW, 2005. Tortricidae (Lepidoptera). In: World catalogue of insects 5 (Ed., Landry B). Apollo Books, Stenstrup, pp. 1-741.
- Busck A, 1916. *Laspeyresia molesta* n. sp. Journal of Agricultural Research, Department of Agriculture, Washington, DC, pp. 1-373.
- Byun BK, 2009. The first report of the genus *Tetramoera* Dikonoff (Lepidoptera: Tortricidae) with description of a new species from the Korean peninsula. Journal of Asia-Pacific Entomology, 12:317-318.
- Byun BK, 2011a. A review of the genus *Spilonota* Stephens (Lepidoptera: Tortricidae) in North Korea. Entomological Research, 41:242-246.
- Byun BK, 2011b. Four newly recorded species of subfamily Olethreutinae (Lepidoptera: Tortricidae) from North Korea. Entomological Research, 41:24-27.
- Byun BK, 2011c. Two species of the subfamily Olethreutinae (Lepidoptera: Tortricidae) new to the Korean Peninsula. Journal of Asia-Pacific Entomology, 14:155-157.
- Byun BK, Bae YS, Park KT, 1998. Illustrated catalogue of Tortricidae in Korea (Lepidoptera). Junghaengsa Publisher, Seoul, pp. 1-317.
- Christoph H, 1881. Neue Lepidopteren des Amurgebietes. Bulletin de la Societe Imperiale des Naturalistes de Moscou, 56:405-436.
- Danilevsky AS, Kuznetsov VI, 1968. Listovertki-Tortricidae: Triba plodozhorki Laspeyresiini. Fauna SSSR, Nasekomye Tsheshuekrylye (novaya seria), 5:1-635.
- Felder C, Felder R, Rogenhofen AF, 1874-1875. Reise der österreichischen Fregatte Novara um die Erde (Zoologische Theil). Wien, Kaiserlich, 1874: Pls. 1075-1107, 1108-1120; 1875: Pls 1121-1140, Erklärung 1871-1810, Inhalt-verzeichnis 1871-1820.
- Heinrich C, 1928. A new apple moth from Manchuria (Lepidoptera: Olethreutidae). Proceedings of the Entomological Society of Washington, 30:91-92.
- Jaros J, Spitzer K, Havelka J, Park KT, 1992. Synecological and biogeographical outlines of Lepidoptera communities in North Korea. Insecta Koreana, 9:78-104.
- Komai F, 1979. A new species of the genus *Grapholita* Treits-

- chke from Japan allied to the oriental fruit moth, *Grapholita molesta* (Busck) (Lepidoptera, Tortricidae). *Applied Entomology and Zoology*, 14:133-136.
- Kornerup A, Wanscher JH, 1978. *Methuen handbook of colour*. 3rd ed. Methuen, London, pp. 1-243.
- Liu YQ, 1983. Cochyliidae and Tortricidae. In: *Iconographia Heterocerorum Sinicorum* (Ed., Liu YQ). Science Press, Beijing, pp. 28-56.
- Liu YQ, Li GW, 2002. Insecta, Lepidoptera, Tortricidae. In: *Fauna sinica*, Vol. 27 (Eds., Editorial Committee of Fauna Sinica, Chinese Academy Sciences). Science Press, Beijing, pp. 1-463.
- Park KT, 1983. Microlepidoptera of Korea. *Insecta Koreana*, 3: 1-189.
- Park KT, Byun BK, 1991. Contribution to a knowledge of Lepidoptera of North Korea. Tortricidae. *Insecta Koreana*, 8:85-90.
- Ragonot EL, 1894. Notes synonymiques sur les Microlépidoptères et descriptions d'espèces peu connues ou inédites. *Annales de la Societe Entomologique de France*, 63:161-226.
- Razowski J, 1999. Tortricidae of Korea: a faunistic and zoogeographical approach (Insecta: Lepidoptera). *SHILAP Revista de Lepidopterologica*, 27:69-123.
- Staudinger O, 1880. Lepidopteren-Fauna Kleinasien's. Besorbrasoff, *Horae Societas entomologica Rossica*, St. Petersburg, pp. 159-435.
- Treitschke F, 1829. Die Schmetterlinge von Europa (Fortsetzung des Ochseneimer'schen Werkes). Gerhard Fleischer, Leipzig, pp. 1-252.
- Walker F, 1863. List of specimens of lepidopterous insects in the collection of the British Museum. British Museum, London, pp. 287-561.
- Walsingham L, 1900. Asiatic Tortricidae. *The Annals and Magazine of Natural History*, 7:368-469, 481-490.
- Zhu DR, 1969. Taxonomic checklist of insects in North Korea. Science Press, Pyongyang.

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